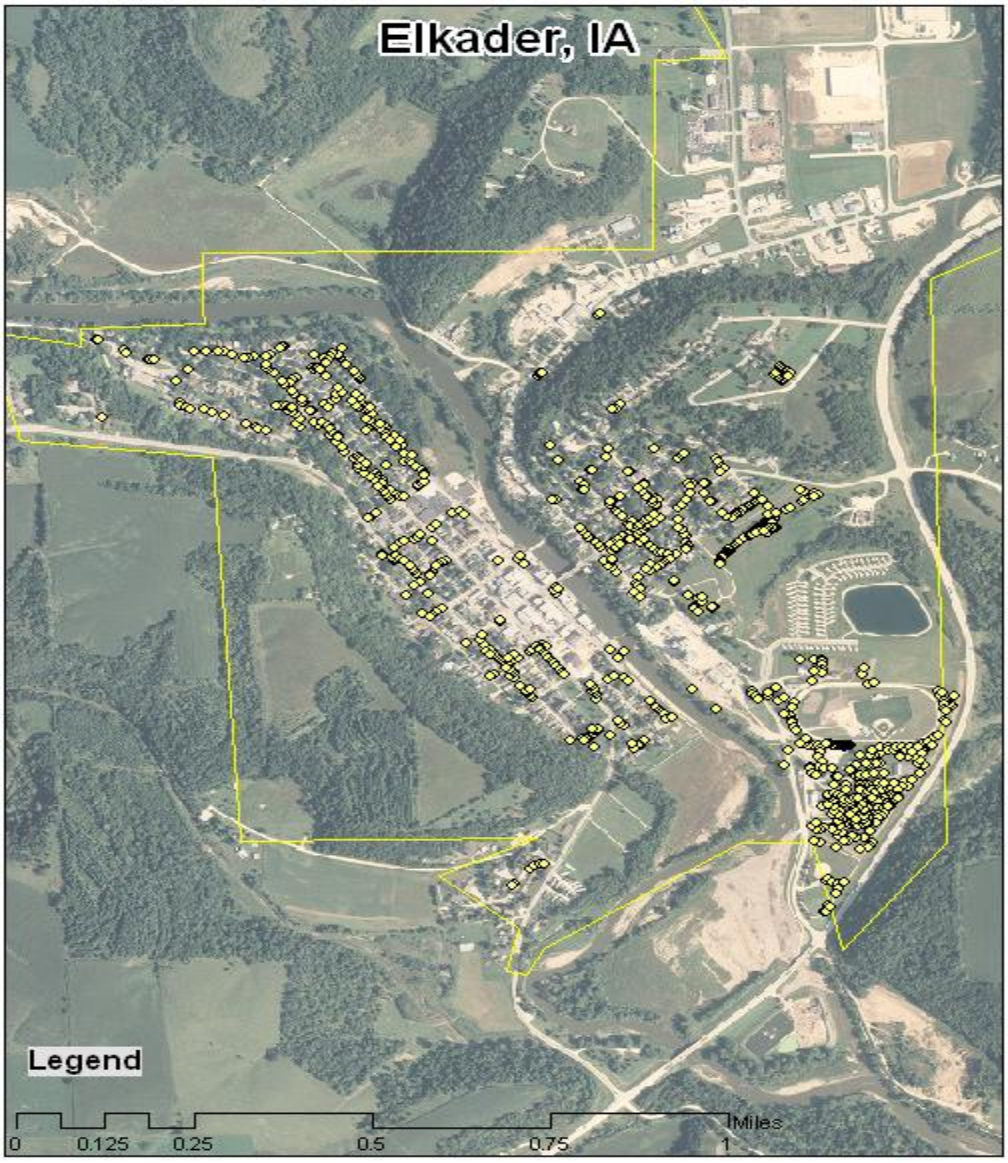
# ELKADER, IA




## 2010 Management Plan

Provided by Northeast Iowa R,C&D
Prepared by Beyer Forestry Services
In cooperation with the Iowa DNR Forestry Bureau

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# Executive Summary

## Overview

This plan was developed to assist the City of Elkader 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 14% (253 ash trees) of Elkader's city owned trees 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 2009, 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 1,766 trees inventoried.

- Elkader's trees provide $301,083 of benefits annually, an average of $170 a tree
- There are over 43species of trees
- The top three genus are: Maple 33%, Evergreen/conifer 20%, and Ash 14%
- 33% of trees are in need of some type of management
- 30 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 30 trees needing removal, 18 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*
- 8 of the 253 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, evergreen, Autumn olive, black locust, black walnut, boxelder, Chinese elm, Siberian elm, cottonwood, poplar, tree of heaven, or willow.
- Check ash trees with a visual survey yearly

# Introduction

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

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

# Inventory

In 2009, 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 1,766 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. Elkader's trees reduce energy related costs by approximately $81,440 annually (Appendix A, Table 1). These savings are both in Electricity (387.7 MWh) and in Natural Gas (53,076.9 Therms).

### Annual Stormwater Benefits

Elkader's trees intercept about 4,667,153 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $126,489 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 Elkader, it is estimated that trees remove 4,770.9 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 $13,136 (Appendix A, Table 3).

### Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Elkader, trees sequester about 1,276,927 lbs of carbon a year with an associated value of $9,577 (Appendix A, Table 5). In addition, the trees store 16,181,150 lbs of carbon, with a yearly benefit of $121,359 (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. Elkader receives $70,441 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, Elkader's trees provide $301,083 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 1,766 trees in Elkader provide approximately $170 annually (Appendix A, Table 7).

## ***Forest Structure***

### Species Distribution

Elkader has over 43 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genus is as follows:

| Genus | # of Trees | % of Total |
|---|---|---|
| | | |
| Maple | 584 | 33 |
| Evergreen/Conifer | 358 | 20 |
| Ash | 253 | 14 |
| Oak | 118 | 7 |
| Black Walnut | 98 | 6 |
| Locust | 74 | 4 |
| Apple/Crabapple | 56 | 3 |
| Hackberry | 54 | 3 |
| Elm | 38 | 2 |
| Basswood/Linden | 26 | 1 |
| Boxelder | 22 | 1 |
| Birch | 22 | 1 |
| Broadleaf Deciduous | 20 | 1 |
| Cottonwood | 18 | 1 |
| Lilac | 14 | 1 |

### Age Class

Most of Elkader's trees (48%) are between 12 and 30 inches in diameter at 4.5 ft (Appendix A, Figure 2). For age, a Bell Curve is preferred and shows the highest amount of trees around 24 inches in diameter at 4.5 ft. Elkader's size curve is on the larger side, indicating an older than average stand.

### Condition: Wood and Foliage

Both wood condition and leaf condition are good indicators of the overall health of the urban forest. The foliage condition results for Elkader indicate that 97% of the trees are in good health, with none of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 82% of Elkader'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 5% of the population. This 5% is an estimate of trees that need immediate 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 | 488 | 28% |
| Crown Reduction | 50 | 3% |
| Tree Removal | 30 | 2% |
| Crown Raising | 8 | <1% |

### Canopy Cover

The canopy cover of Elkader is approximately 44 acres (Appendix A, Figure 4). According to the 2000 census, Elkader occupies 896 acres. Thus the canopy cover on city land is about 5%.

### Land Use and Location

The majority of Elkader's city and park trees are in maintained locations 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 | 50% |
| Park/vacant/other | 48% |
| Small commercial | 2% |

| Location | |
|---|---|
| Other maintained locations | 53% |
| Planting strip | 42% |
| Front yard | 5% |

## 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

Elkader has 24 critical concern trees that need immediate removal. These trees can be seen on the Location of Trees with Recommended Maintenance map (Appendix B, Figure 4). It is recommended to start with the large diameter critical concern trees first. There are 18 trees over 24 inches in diameter at 4.5 ft that should be addressed immediately. Please refer to the six year maintenance plan at the end of this section. After all of the critical concern trees are addressed, there should be follow up on the trees marked as needing immediate maintenance. There are a total of 74 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). Of the 30 removals, 2 are ash trees. There are a total of 253 ash trees, and 8 of those have signs and symptoms that have been associated with EAB. In addition, there are 60 trees that have major structural problems. *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 6 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 Elkader.

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 (33%) (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: Autumn olive, black locust, black walnut, boxelder, Chinese elm, Siberian elm, cottonwood, poplar, tree of heaven, or willow.

### 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.

## 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. The new plantings will be a diverse mix and will not include ash, maple, Autumn olive, black locust, black walnut, boxelder, Chinese elm, Siberian elm, cottonwood, poplar, tree of heaven, or willow.

### 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 as ash trees in the city are infected with Emerald Ash Borer. Trees on private property are a vital component of Elkader's urban forest. It is strongly recommended that Elkader develop a new city tree ordinance to guide citizens on what trees to plant, proper location, and proper maintenance needed to maintain healthy trees. Elkader currently has a city ordinance that needs to be expanded to include more information for citizens of Elkader.

# PROPOSED WORK SCHEDULE AND ESTIMATED COSTS

## Year 1 -

| | |
|---|---|
| Remove 30 recommended "Remove" trees plus 17 ash trees | $23,500 |
| Plant 56 trees in open locations | $11,200 |
| Check for visual signs of Emerald Ash Borer | |

## Year 2

| | |
|---|---|
| Remove 47 ash trees | $23,500 |
| Plant 56 trees in open locations | $11,200 |
| Prune 1/3 of city trees | $4,300 |
| Check for visual signs of Emerald Ash Borer | |

## Year 3

| | |
|---|---|
| Remove 47 ash trees | $23,500 |
| Plant 56 trees in open locations | $11,200 |
| Check for visual signs of Emerald Ash Borer | |

## Year 4

| | |
|---|---|
| Remove 47 ash trees | $23,500 |
| Plant 56 trees in open locations | $11,200 |
| Prune 1/3 of city trees | $4,300 |
| Check for visual signs of EAB | |

## Year 5

| | |
|---|---|
| Remove 47 ash trees | $23,500 |
| Plant 56 trees in open locations | $11,200 |
| Check for visual signs of EAB | |

## Year 6

| | |
|---|---|
| Remove 46 ash trees | $23,000 |
| Plant 55 trees in open locations | $11,000 |
| Prune 1/3 of city trees | $4,300 |
| Check for visual signs of Emerald Ash Borer | |

**Purposed Budget Increase**

EAB could potentially kill all ash trees in Elkader within 4 years of its arrival. To remove all ash trees and hazardous trees, replace the trees removed, and properly prune the city trees within 6 years the budget would need to be increased to **$36,700** a year. Spreading the work over 10 years would require an annual budget of approximately $22,000. An optimistic view would be that the emerald ash borer won't attack for 15 years, which would require a budget of $14,700 a year to accomplish the work. It is recommended that Elkader 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.

Elkader has 253 ash trees just on city property. When the emerald ash borer arrives, the removal of these trees will put a tremendous strain on city finances. Developing a plan now to gradually remove and replace these trees will reduce the pressure on city resources and improve the health and condition of Elkader's urban forest.

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# **Appendix** A: i-Tree Data

**Table 1: Annual Energy Benefits**

## Annual Energy Benefits of Public Trees by Species

8/27/2010

| Species | Total Electricity (MWh) | Electricity ($) | Total Natural Gas (Therms) | Natural Gas ($) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|
| Green ash | 62.9 | 4,775 | 8,628.3 | 8,456 | 13,231 | (N/A) | 13.0 | 16.3 | 57.78 |
| Norway maple | 44.6 | 3,381 | 6,454.0 | 6,325 | 9,706 | (N/A) | 11.0 | 11.9 | 50.03 |
| Sugar maple | 40.3 | 3,062 | 5,357.2 | 5,250 | 8,312 | (N/A) | 9.6 | 10.2 | 48.89 |
| Northern white cedar | 15.2 | 1,150 | 2,010.3 | 1,970 | 3,120 | (N/A) | 7.8 | 3.8 | 22.61 |
| Eastern white pine | 14.1 | 1,067 | 1,840.9 | 1,804 | 2,871 | (N/A) | 6.2 | 3.5 | 26.10 |
| Silver maple | 26.7 | 2,025 | 3,436.4 | 3,368 | 5,393 | (N/A) | 6.0 | 6.6 | 50.87 |
| Black walnut | 23.0 | 1,746 | 3,118.6 | 3,056 | 4,802 | (N/A) | 5.4 | 5.9 | 50.02 |
| Bur oak | 23.8 | 1,804 | 3,268.1 | 3,203 | 5,007 | (N/A) | 4.8 | 6.2 | 59.60 |
| Honeylocust | 16.7 | 1,268 | 2,202.0 | 2,158 | 3,426 | (N/A) | 4.2 | 4.2 | 46.30 |
| Black maple | 15.0 | 1,138 | 2,074.3 | 2,033 | 3,171 | (N/A) | 4.1 | 3.9 | 44.04 |
| Apple | 8.5 | 645 | 1,336.7 | 1,310 | 1,955 | (N/A) | 3.2 | 2.4 | 34.91 |
| Northern hackberry | 17.0 | 1,288 | 2,376.5 | 2,329 | 3,617 | (N/A) | 3.1 | 4.4 | 66.98 |
| Blue spruce | 5.9 | 447 | 821.2 | 805 | 1,252 | (N/A) | 2.4 | 1.5 | 29.81 |
| Red maple | 6.5 | 492 | 863.5 | 846 | 1,338 | (N/A) | 1.8 | 1.6 | 41.83 |
| Chinese elm | 7.3 | 555 | 989.3 | 969 | 1,524 | (N/A) | 1.5 | 1.9 | 58.62 |
| White ash | 7.7 | 587 | 947.8 | 929 | 1,516 | (N/A) | 1.4 | 1.9 | 63.17 |
| Spruce | 3.4 | 255 | 442.0 | 433 | 688 | (N/A) | 1.4 | 0.9 | 28.68 |
| Boxelder | 5.1 | 386 | 708.6 | 694 | 1,080 | (N/A) | 1.3 | 1.3 | 49.11 |
| Littleleaf linden | 5.2 | 392 | 746.9 | 732 | 1,124 | (N/A) | 1.3 | 1.4 | 51.11 |
| Northern red oak | 4.3 | 323 | 599.8 | 588 | 911 | (N/A) | 1.1 | 1.1 | 45.54 |
| Eastern cottonwood | 4.8 | 364 | 657.6 | 644 | 1,009 | (N/A) | 1.0 | 1.2 | 56.03 |
| Other street trees | 30.0 | 2,274 | 4,196.7 | 4,113 | 6,386 | (N/A) | 8.7 | 7.8 | 41.74 |
| Citywide total | 387.7 | 29,425 | 53,076.9 | 52,015 | 81,440 | (N/A) | 100.0 | 100.0 | 46.12 |

**Table 2: Annual Stormwater Benefits**

## Annual Stormwater Benefits of Public Trees by Species

8/27/2010

| Species | Total rainfall interception (Gal) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|
| Green ash | 783,986 | 21,247 | (N/A) | 13.0 | 16.8 | 92.78 |
| Norway maple | 437,295 | 11,852 | (N/A) | 11.0 | 9.4 | 61.09 |
| Sugar maple | 467,758 | 12,677 | (N/A) | 9.6 | 10.0 | 74.57 |
| Northern white cedar | 314,621 | 8,527 | (N/A) | 7.8 | 6.7 | 61.79 |
| Eastern white pine | 294,100 | 7,971 | (N/A) | 6.2 | 6.3 | 72.46 |
| Silver maple | 331,130 | 8,974 | (N/A) | 6.0 | 7.1 | 84.66 |
| Black walnut | 261,091 | 7,076 | (N/A) | 5.4 | 5.6 | 73.71 |
| Bur oak | 278,366 | 7,544 | (N/A) | 4.8 | 6.0 | 89.81 |
| Honeylocust | 169,038 | 4,581 | (N/A) | 4.2 | 3.6 | 61.91 |
| Black maple | 138,412 | 3,751 | (N/A) | 4.1 | 3.0 | 52.10 |
| Apple | 46,883 | 1,271 | (N/A) | 3.2 | 1.0 | 22.69 |
| Northern hackberry | 169,268 | 4,587 | (N/A) | 3.1 | 3.6 | 84.95 |
| Blue spruce | 98,838 | 2,679 | (N/A) | 2.4 | 2.1 | 63.78 |
| Red maple | 56,439 | 1,530 | (N/A) | 1.8 | 1.2 | 47.80 |
| Chinese elm | 87,934 | 2,383 | (N/A) | 1.5 | 1.9 | 91.66 |
| White ash | 92,399 | 2,504 | (N/A) | 1.4 | 2.0 | 104.34 |
| Spruce | 73,450 | 1,991 | (N/A) | 1.4 | 1.6 | 82.94 |
| Boxelder | 60,345 | 1,635 | (N/A) | 1.3 | 1.3 | 74.34 |
| Littleleaf linden | 60,559 | 1,641 | (N/A) | 1.3 | 1.3 | 74.60 |
| Northern red oak | 45,424 | 1,231 | (N/A) | 1.1 | 1.0 | 61.55 |
| Eastern cottonwood | 50,287 | 1,363 | (N/A) | 1.0 | 1.1 | 75.72 |
| Other street trees | 349,531 | 9,473 | (N/A) | 8.7 | 7.5 | 61.91 |
| Citywide total | 4,667,153 | 126,489 | (N/A) | 100.0 | 100.0 | 71.62 |

**Table 3: Annual Air Quality Benefits**

## Annual Air Quality Benefits of Public Trees by Species

8/27/2010

| Species | Deposition (lb) $O_3$ | $NO_2$ | $PM_{10}$ | $SO_2$ | Total Depos. ($) | Avoided (lb) $NO_2$ | $PM_{10}$ | VOC | $SO_2$ | Total Avoided ($) | BVOC Emissions (lb) | BVOC Emissions ($) | Total (lb) | Total ($) | Standard Error | % of Total Trees | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Green ash | 111.5 | 17.8 | 51.5 | 5.0 | 588 | 300.5 | 43.7 | 41.7 | 285.1 | 1,872 | 0.0 | 0 | 856.8 | 2,460 | (N/A) | 13.0 | 10.74 |
| Norway maple | 92.1 | 15.9 | 45.0 | 4.1 | 497 | 216.3 | 31.2 | 29.7 | 202.1 | 1,339 | -21.4 | -80 | 615.0 | 1,756 | (N/A) | 11.0 | 9.05 |
| Sugar maple | 66.9 | 11.4 | 32.8 | 3.0 | 361 | 190.9 | 27.9 | 26.6 | 182.7 | 1,193 | -52.3 | -196 | 489.8 | 1,357 | (N/A) | 9.6 | 7.98 |
| Northern white cedar | 37.3 | 7.4 | 30.1 | 4.6 | 244 | 71.6 | 10.5 | 10.0 | 68.6 | 448 | -175.4 | -658 | 64.8 | 35 | (N/A) | 7.8 | 0.25 |
| Eastern white pine | 35.1 | 7.0 | 28.2 | 4.3 | 230 | 66.2 | 9.7 | 9.3 | 63.6 | 414 | -163.3 | -613 | 60.1 | 31 | (N/A) | 6.2 | 0.29 |
| Silver maple | 51.7 | 8.8 | 26.1 | 2.3 | 281 | 125.1 | 18.4 | 17.5 | 120.7 | 785 | -28.5 | -107 | 342.1 | 958 | (N/A) | 6.0 | 9.04 |
| Black walnut | 34.4 | 5.5 | 16.2 | 1.5 | 182 | 109.5 | 16.0 | 15.2 | 104.2 | 683 | 0.0 | 0 | 302.6 | 865 | (N/A) | 5.4 | 9.02 |
| Bur oak | 38.0 | 6.1 | 17.8 | 1.7 | 201 | 113.6 | 16.5 | 15.8 | 107.7 | 707 | 0.0 | 0 | 317.2 | 909 | (N/A) | 4.8 | 10.82 |
| Honeylocust | 32.2 | 5.3 | 14.8 | 1.5 | 170 | 78.8 | 11.5 | 11.0 | 75.6 | 493 | -24.8 | -93 | 206.0 | 570 | (N/A) | 4.2 | 7.71 |
| Black maple | 34.5 | 5.9 | 16.0 | 1.5 | 183 | 71.7 | 10.4 | 9.9 | 67.9 | 446 | -11.4 | -43 | 206.5 | 587 | (N/A) | 4.1 | 8.15 |
| Apple | 16.7 | 2.8 | 7.6 | 0.8 | 88 | 42.1 | 6.0 | 5.7 | 38.5 | 258 | -0.1 | 0 | 120.0 | 346 | (N/A) | 3.2 | 6.18 |
| Northern hackberry | 27.3 | 4.7 | 13.7 | 1.2 | 148 | 81.6 | 11.8 | 11.3 | 77.0 | 507 | 0.0 | 0 | 228.7 | 655 | (N/A) | 3.1 | 12.14 |
| Blue spruce | 17.0 | 3.4 | 13.5 | 2.1 | 111 | 28.2 | 4.1 | 3.9 | 26.7 | 175 | -38.1 | -143 | 60.7 | 143 | (N/A) | 2.4 | 3.41 |
| Red maple | 13.8 | 2.4 | 6.4 | 0.6 | 74 | 30.7 | 4.5 | 4.3 | 29.4 | 192 | -4.6 | -17 | 87.5 | 248 | (N/A) | 1.8 | 7.76 |
| Chinese elm | 12.1 | 1.9 | 5.6 | 0.5 | 64 | 34.8 | 5.1 | 4.8 | 33.1 | 217 | 0.0 | 0 | 98.0 | 281 | (N/A) | 1.5 | 10.81 |
| White ash | 17.4 | 2.8 | 7.9 | 0.8 | 91 | 35.9 | 5.3 | 5.1 | 35.0 | 226 | 0.0 | 0 | 110.1 | 317 | (N/A) | 1.4 | 13.23 |
| Spruce | 8.9 | 1.8 | 7.1 | 1.1 | 58 | 15.9 | 2.3 | 2.2 | 15.2 | 99 | -42.6 | -160 | 11.8 | -3 | (N/A) | 1.4 | -0.11 |
| Boxelder | 8.3 | 1.3 | 3.8 | 0.4 | 44 | 24.4 | 3.5 | 3.4 | 23.0 | 151 | -2.9 | -11 | 65.2 | 184 | (N/A) | 1.2 | 8.38 |
| Littleleaf linden | 11.1 | 1.9 | 5.4 | 0.5 | 60 | 25.1 | 3.6 | 3.4 | 23.5 | 155 | -5.2 | -20 | 69.3 | 196 | (N/A) | 1.2 | 8.89 |
| Northern red oak | 9.7 | 1.7 | 4.7 | 0.4 | 52 | 20.4 | 3.0 | 2.8 | 19.3 | 127 | -14.0 | -53 | 48.1 | 127 | (N/A) | 1.1 | 6.34 |
| Eastern cottonwood | 5.9 | 0.9 | 2.9 | 0.3 | 31 | 22.9 | 3.3 | 3.2 | 21.7 | 143 | 0.0 | 0 | 61.1 | 174 | (N/A) | 1.0 | 9.67 |
| Other street trees | 59.0 | 10.4 | 34.0 | 4.0 | 337 | 143.8 | 20.9 | 19.9 | 135.7 | 894 | -78.3 | -294 | 349.5 | 937 | (N/A) | 8.7 | 6.12 |
| Citywide total | 740.8 | 126.9 | 391.1 | 42.1 | 4,096 | 1,850.0 | 269.4 | 256.9 | 1,756.6 | 11,526 | -662.9 | -2,486 | 4,770.9 | 13,136 | (N/A) | 100.0 | 7.44 |

**Table 4: Annual Carbon Stored**

## Stored CO2 Benefits of Public Trees by Species

8/27/2010

| Species | Total Stored CO2 (lbs) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|
| Green ash | 3,721,027 | 27,908 | (N/A) | 13.0 | 23.0 | 121.87 |
| Norway maple | 1,524,718 | 11,435 | (N/A) | 11.0 | 9.4 | 58.95 |
| Sugar maple | 1,974,791 | 14,811 | (N/A) | 9.6 | 12.2 | 87.12 |
| Northern white | 443,920 | 3,329 | (N/A) | 7.8 | 2.7 | 24.13 |
| Eastern white pine | 414,367 | 3,108 | (N/A) | 6.2 | 2.6 | 28.25 |
| Silver maple | 1,171,362 | 8,785 | (N/A) | 6.0 | 7.2 | 82.88 |
| Black walnut | 1,139,160 | 8,544 | (N/A) | 5.4 | 7.0 | 89.00 |
| Bur oak | 1,259,879 | 9,449 | (N/A) | 4.8 | 7.8 | 112.49 |
| Honeylocust | 413,838 | 3,104 | (N/A) | 4.2 | 2.6 | 41.94 |
| Black maple | 370,902 | 2,782 | (N/A) | 4.1 | 2.3 | 38.64 |
| Apple | 261,054 | 1,958 | (N/A) | 3.2 | 1.6 | 34.96 |
| Northern | 419,817 | 3,149 | (N/A) | 3.1 | 2.6 | 58.31 |
| Blue spruce | 147,881 | 1,109 | (N/A) | 2.4 | 0.9 | 26.41 |
| Red maple | 149,131 | 1,118 | (N/A) | 1.8 | 0.9 | 34.95 |
| Chinese elm | 402,686 | 3,020 | (N/A) | 1.5 | 2.5 | 116.16 |
| White ash | 277,003 | 2,078 | (N/A) | 1.4 | 1.7 | 86.56 |
| Spruce | 109,297 | 820 | (N/A) | 1.4 | 0.7 | 34.16 |
| Boxelder | 295,821 | 2,219 | (N/A) | 1.3 | 1.8 | 100.85 |
| Littleleaf linden | 235,781 | 1,768 | (N/A) | 1.3 | 1.5 | 80.38 |
| Northern red oak | 214,377 | 1,608 | (N/A) | 1.1 | 1.3 | 80.39 |
| Eastern | 188,946 | 1,417 | (N/A) | 1.0 | 1.2 | 78.73 |
| Other street trees | 474,183 | 7,840 | (N/A) | 8.7 | 6.5 | 51.24 |
| Citywide total | 16,181,150 | 121,359 | (N/A) | 100.0 | 100.0 | 68.72 |

**Table 5: Annual Carbon Sequestered**

## Annual $CO_2$ Benefits of Public Trees by Species

8/27/2010

| Species | Sequestered (lb) | Sequestered ($) | Decomposition Release (lb) | Maintenance Release (lb) | Total Released ($) | Avoided (lb) | Avoided ($) | Net Total (lb) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Green ash | 140,180 | 1,051 | -17,861 | -45 | -134 | 105,528 | 791 | 227,803 | 1,709 | (N/A) | 13.0 | 17.8 | 7.46 |
| Norway maple | 41,715 | 313 | -7,319 | -38 | -55 | 74,730 | 560 | 109,089 | 818 | (N/A) | 11.0 | 8.5 | 4.22 |
| Sugar maple | 94,986 | 712 | -9,479 | -33 | -71 | 67,665 | 507 | 153,139 | 1,149 | (N/A) | 9.6 | 12.0 | 6.76 |
| Northern white cedar | 10,912 | 82 | -2,131 | -27 | -16 | 25,415 | 191 | 34,169 | 256 | (N/A) | 7.8 | 2.7 | 1.86 |
| Eastern white pine | 13,483 | 101 | -1,989 | -21 | -15 | 23,570 | 177 | 35,042 | 263 | (N/A) | 6.2 | 2.7 | 2.39 |
| Silver maple | 96,851 | 726 | -5,623 | -21 | -42 | 44,749 | 336 | 135,957 | 1,020 | (N/A) | 6.0 | 10.7 | 9.62 |
| Black walnut | 52,237 | 392 | -5,468 | -19 | -41 | 38,581 | 289 | 85,331 | 640 | (N/A) | 5.4 | 6.7 | 6.67 |
| Bur oak | 53,767 | 403 | -6,047 | -16 | -45 | 39,868 | 299 | 87,571 | 657 | (N/A) | 4.8 | 6.9 | 7.82 |
| Honeylocust | 26,723 | 200 | -1,986 | -14 | -15 | 28,025 | 210 | 52,747 | 396 | (N/A) | 4.2 | 4.1 | 5.35 |
| Black maple | 9,796 | 73 | -1,780 | -14 | -13 | 25,153 | 189 | 33,155 | 249 | (N/A) | 4.1 | 2.6 | 3.45 |
| Apple | 7,740 | 58 | -1,253 | -11 | -9 | 14,253 | 107 | 20,729 | 155 | (N/A) | 3.2 | 1.6 | 2.78 |
| Northern hackberry | 21,374 | 160 | -2,015 | -11 | -15 | 28,464 | 213 | 47,813 | 359 | (N/A) | 3.1 | 3.7 | 6.64 |
| Blue spruce | 2,522 | 19 | -710 | -8 | -5 | 9,885 | 74 | 11,689 | 88 | (N/A) | 2.4 | 0.9 | 2.09 |
| Red maple | 5,881 | 44 | -716 | -6 | -5 | 10,877 | 82 | 16,036 | 120 | (N/A) | 1.8 | 1.3 | 3.76 |
| Chinese elm | 16,366 | 123 | -1,933 | -5 | -15 | 12,257 | 92 | 26,685 | 200 | (N/A) | 1.5 | 2.1 | 7.70 |
| White ash | 21,438 | 161 | -1,330 | -5 | -10 | 12,979 | 97 | 33,083 | 248 | (N/A) | 1.4 | 2.6 | 10.34 |
| Spruce | 1,735 | 13 | -525 | -5 | -4 | 5,640 | 42 | 6,846 | 51 | (N/A) | 1.4 | 0.5 | 2.14 |
| Boxelder | 20,357 | 153 | -1,420 | -4 | -11 | 8,532 | 64 | 27,464 | 206 | (N/A) | 1.3 | 2.2 | 9.36 |
| Littleleaf linden | 11,126 | 83 | -1,132 | -4 | -9 | 8,672 | 65 | 18,662 | 140 | (N/A) | 1.3 | 1.5 | 6.36 |
| Northern red oak | 4,513 | 34 | -1,029 | -4 | -8 | 7,138 | 54 | 10,619 | 80 | (N/A) | 1.1 | 0.8 | 3.98 |
| Eastern cottonwood | 11,566 | 87 | -907 | -4 | -7 | 8,047 | 60 | 18,703 | 140 | (N/A) | 1.0 | 1.5 | 7.79 |
| Other street trees | 39,396 | 295 | -5,018 | -30 | -38 | 50,247 | 377 | 84,595 | 634 | (N/A) | 8.7 | 6.6 | 4.15 |
| Citywide total | 704,666 | 5,285 | -77,670 | -344 | -585 | 650,275 | 4,877 | 1,276,927 | 9,577 | (N/A) | 100.0 | 100.0 | 5.42 |

**Table 6: Annual Social and Aesthetic Benefits**

## Annual Aesthetic/Other Benefits of Public Trees by Species

8/27/2010

| Species | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|
| Green ash | 11,178 | (N/A) | 13.0 | 15.9 | 48.81 |
| Norway maple | 4,132 | (N/A) | 11.0 | 5.9 | 21.30 |
| Sugar maple | 9,639 | (N/A) | 9.6 | 13.7 | 56.70 |
| Northern white cedar | 2,348 | (N/A) | 7.8 | 3.3 | 17.01 |
| Eastern white pine | 2,525 | (N/A) | 6.2 | 3.6 | 22.96 |
| Silver maple | 8,247 | (N/A) | 6.0 | 11.7 | 77.80 |
| Black walnut | 4,419 | (N/A) | 5.4 | 6.3 | 46.04 |
| Bur oak | 4,369 | (N/A) | 4.8 | 6.2 | 52.01 |
| Honeylocust | 6,097 | (N/A) | 4.2 | 8.7 | 82.40 |
| Black maple | 1,327 | (N/A) | 4.1 | 1.9 | 18.43 |
| Apple | 458 | (N/A) | 3.2 | 0.7 | 8.18 |
| Northern hackberry | 2,838 | (N/A) | 3.1 | 4.0 | 52.56 |
| Blue spruce | 385 | (N/A) | 2.4 | 0.6 | 9.17 |
| Red maple | 775 | (N/A) | 1.8 | 1.1 | 24.21 |
| Chinese elm | 1,313 | (N/A) | 1.5 | 1.9 | 50.51 |
| White ash | 2,218 | (N/A) | 1.4 | 3.2 | 92.40 |
| Spruce | 351 | (N/A) | 1.4 | 0.5 | 14.64 |
| Boxelder | 1,306 | (N/A) | 1.3 | 1.9 | 59.34 |
| Littleleaf linden | 1,119 | (N/A) | 1.3 | 1.6 | 50.86 |
| Northern red oak | 329 | (N/A) | 1.1 | 0.5 | 16.47 |
| Eastern cottonwood | 976 | (N/A) | 1.0 | 1.4 | 54.24 |
| Other street trees | 4,092 | (N/A) | 8.7 | 5.8 | 26.74 |
| Citywide total | 70,441 | (N/A) | 100.0 | 100.0 | 39.89 |

**Table 7: Summary of Benefits in Dollars**

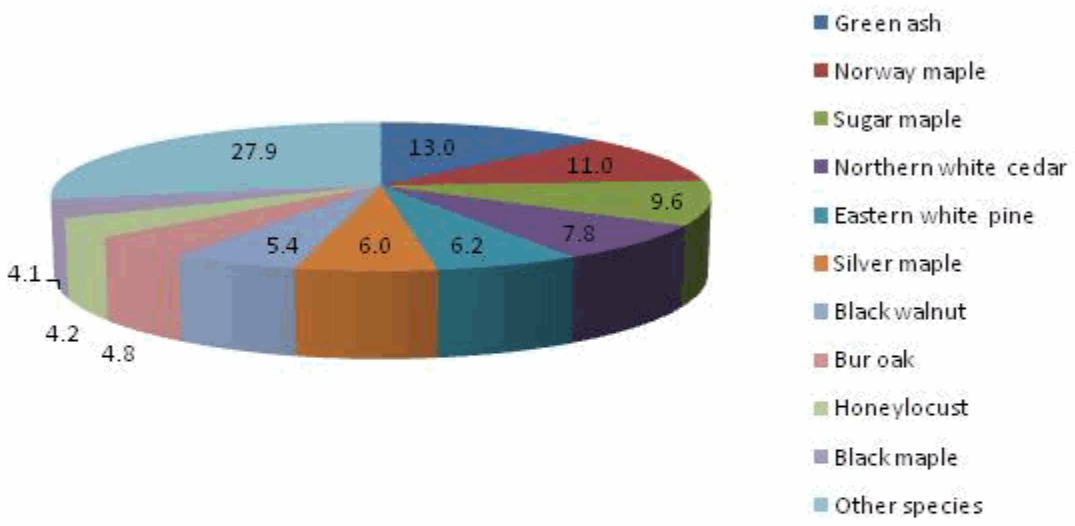
## Total Annual Benefits of Public Trees by Species ($)

8/27/201

| Species | Energy | $CO_2$ | Air Quality | Stormwater | Aesthetic/Other | Total ($) | Standard Error | % of Total $ |
|---|---|---|---|---|---|---|---|---|
| Green ash | 13,231 | 1,709 | 2,460 | 21,247 | 11,178 | 49,825 | (±0) | 16.5 |
| Norway maple | 9,706 | 818 | 1,756 | 11,852 | 4,132 | 28,263 | (±0) | 9.4 |
| Sugar maple | 8,312 | 1,149 | 1,357 | 12,677 | 9,639 | 33,134 | (±0) | 11.0 |
| Northern white cedar | 3,120 | 256 | 35 | 8,527 | 2,348 | 14,285 | (±0) | 4.7 |
| Eastern white pine | 2,871 | 263 | 31 | 7,971 | 2,525 | 13,661 | (±0) | 4.5 |
| Silver maple | 5,393 | 1,020 | 958 | 8,974 | 8,247 | 24,592 | (±0) | 8.2 |
| Black walnut | 4,802 | 640 | 865 | 7,076 | 4,419 | 17,803 | (±0) | 5.9 |
| Bur oak | 5,007 | 657 | 909 | 7,544 | 4,369 | 18,485 | (±0) | 6.1 |
| Honeylocust | 3,426 | 396 | 570 | 4,581 | 6,097 | 15,071 | (±0) | 5.0 |
| Black maple | 3,171 | 249 | 587 | 3,751 | 1,327 | 9,085 | (±0) | 3.0 |
| Apple | 1,955 | 155 | 346 | 1,271 | 458 | 4,185 | (±0) | 1.4 |
| Northern hackberry | 3,617 | 359 | 655 | 4,587 | 2,838 | 12,057 | (±0) | 4.0 |
| Blue spruce | 1,252 | 88 | 143 | 2,679 | 385 | 4,547 | (±0) | 1.5 |
| Red maple | 1,338 | 120 | 248 | 1,530 | 775 | 4,011 | (±0) | 1.3 |
| Chinese elm | 1,524 | 200 | 281 | 2,383 | 1,313 | 5,702 | (±0) | 1.9 |
| White ash | 1,516 | 248 | 317 | 2,504 | 2,218 | 6,803 | (±0) | 2.3 |
| Spruce | 688 | 51 | -3 | 1,991 | 351 | 3,079 | (±0) | 1.0 |
| Boxelder | 1,080 | 206 | 184 | 1,635 | 1,306 | 4,412 | (±0) | 1.5 |
| Littleleaf linden | 1,124 | 140 | 196 | 1,641 | 1,119 | 4,220 | (±0) | 1.4 |
| Northern red oak | 911 | 80 | 127 | 1,231 | 329 | 2,678 | (±0) | 0.9 |
| Eastern cottonwood | 1,009 | 140 | 174 | 1,363 | 976 | 3,662 | (±0) | 1.2 |
| Other street trees | 6,386 | 634 | 937 | 9,473 | 4,092 | 21,522 | (±0) | 7.1 |
| Citywide Total | 81,440 | 9,577 | 13,136 | 126,489 | 70,441 | 301,083 | (±0) | 100.0 |

## Species Distribution of Public Trees (%)

8/27/2010

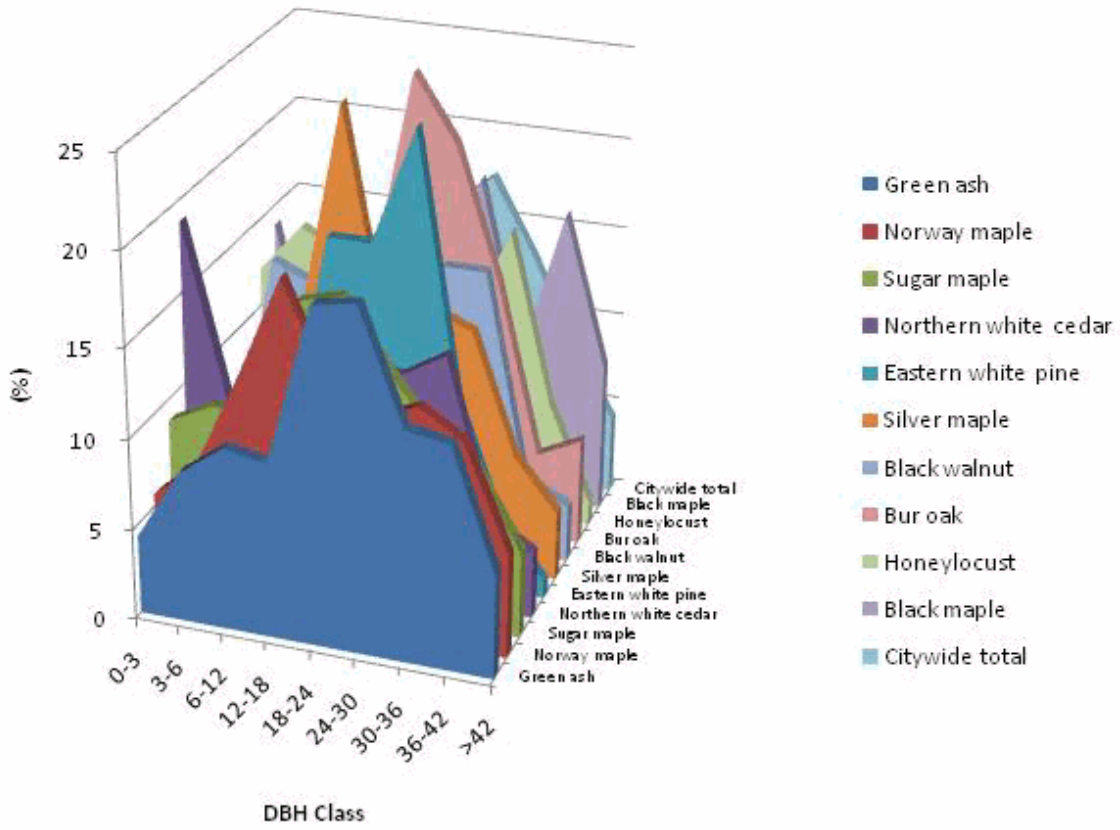



| Species | Percent |
|---|---|
| Green ash | 13.0 |
| Norway maple | 11.0 |
| Sugar maple | 9.6 |
| Northern white cedar | 7.8 |
| Eastern white pine | 6.2 |
| Silver maple | 6.0 |
| Black walnut | 5.4 |
| Bur oak | 4.8 |
| Honeylocust | 4.2 |
| Black maple | 4.1 |
| Other species | 27.9 |
| Total | 100.0 |

**Figure 1: Species Distribution**

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

8/27/2010




| | DBH class (in) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | 0-3 | 3-6 | 6-12 | 12-18 | 18-24 | 24-30 | 30-36 | 36-42 | >42 |
| Green ash | 4.4 | 8.3 | 10.0 | 9.6 | 18.3 | 18.8 | 12.7 | 12.2 | 5.7 |
| Norway maple | 5.7 | 7.7 | 12.9 | 18.6 | 13.4 | 11.9 | 12.9 | 11.3 | 5.7 |
| Sugar maple | 8.8 | 10.0 | 10.0 | 16.5 | 17.1 | 13.5 | 10.6 | 8.8 | 4.7 |
| Northern white cedar | 18.8 | 9.4 | 10.1 | 14.5 | 12.3 | 12.3 | 13.8 | 5.1 | 3.6 |
| Eastern white pine | 13.6 | 4.5 | 6.4 | 18.2 | 18.2 | 24.5 | 10.0 | 3.6 | 0.9 |
| Silver maple | 3.8 | 9.4 | 12.3 | 24.5 | 12.3 | 14.2 | 13.2 | 6.6 | 3.8 |
| Black walnut | 2.1 | 14.6 | 13.5 | 17.7 | 13.5 | 15.6 | 15.6 | 4.2 | 3.1 |
| Bur oak | 2.4 | 2.4 | 10.7 | 13.1 | 25.0 | 21.4 | 14.3 | 4.8 | 6.0 |
| Honeylocust | 12.2 | 14.9 | 13.5 | 13.5 | 10.8 | 10.8 | 16.2 | 6.8 | 1.4 |
| Black maple | 13.9 | 4.2 | 13.9 | 9.7 | 6.9 | 18.1 | 8.3 | 16.7 | 8.3 |
| Citywide total | 7.0 | 8.4 | 10.5 | 15.3 | 15.5 | 17.4 | 13.3 | 8.3 | 4.3 |

**Figure 2: Relative Age Class**

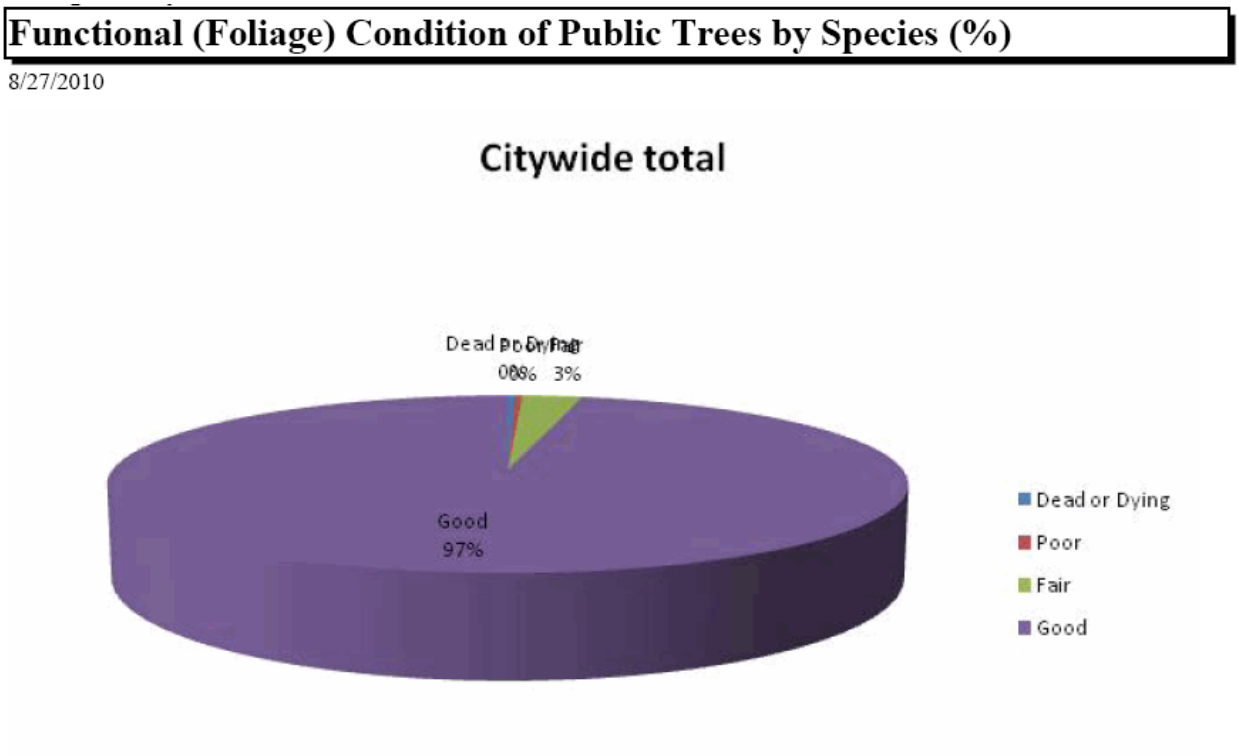



**Figure 3: Foliage Condition**

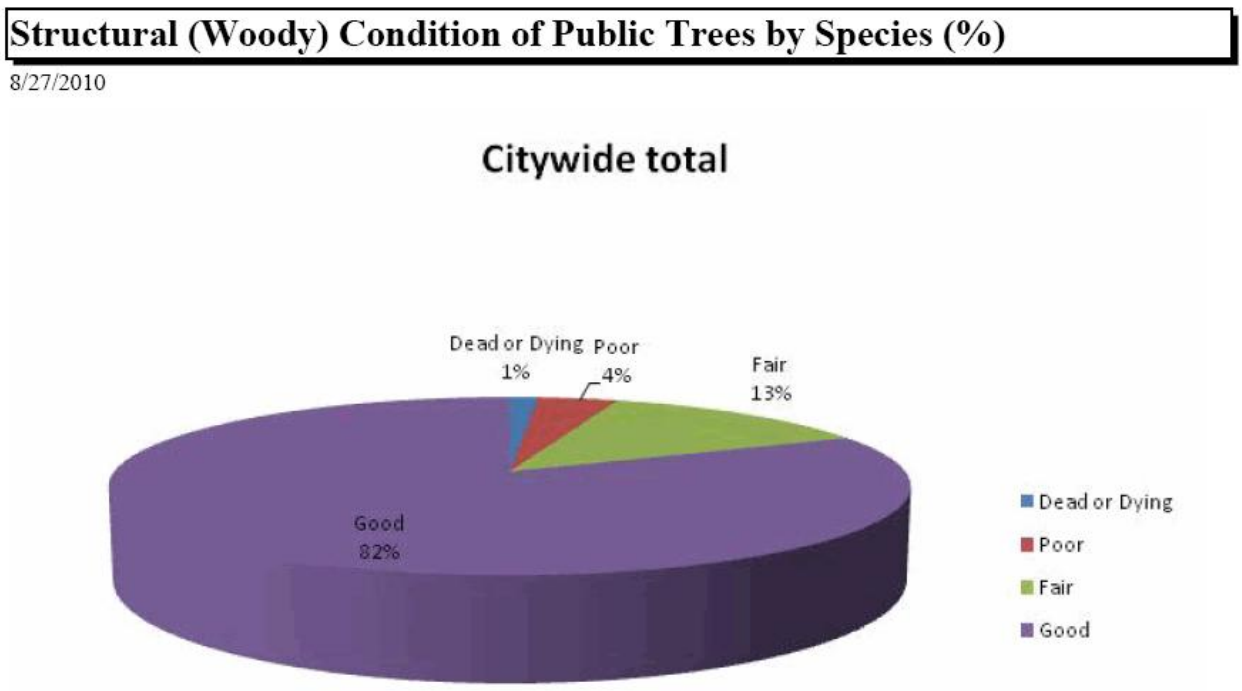
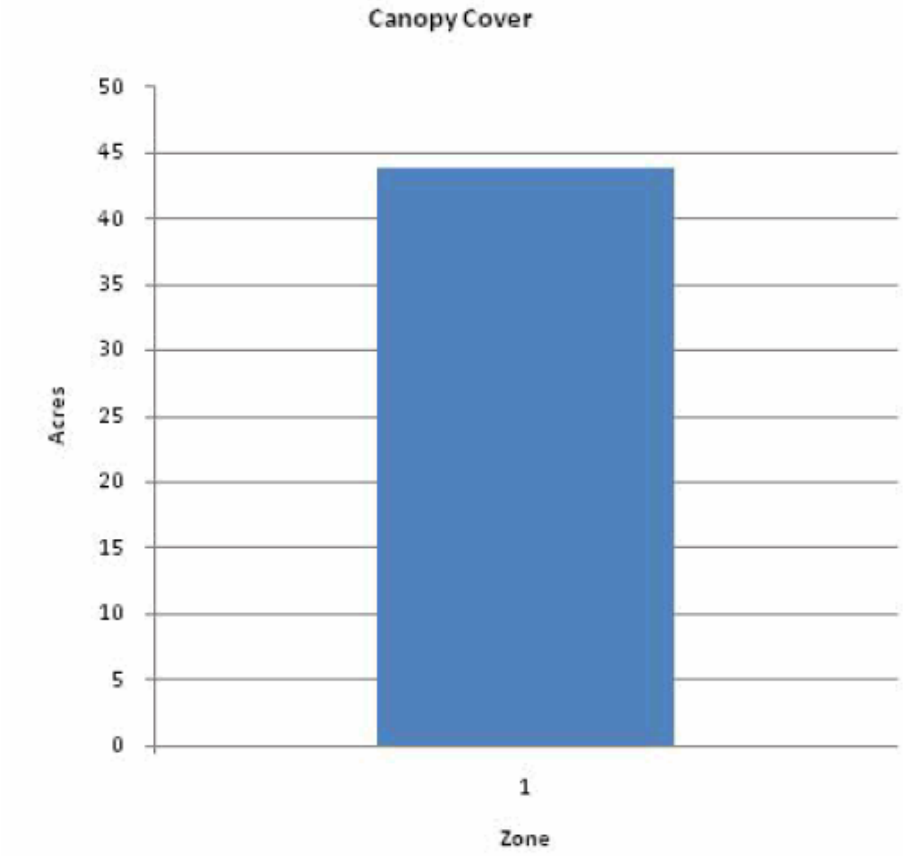



**Figure 4: Wood Condition**

# Canopy Cover of Public Trees (Acres)

8/27/2010



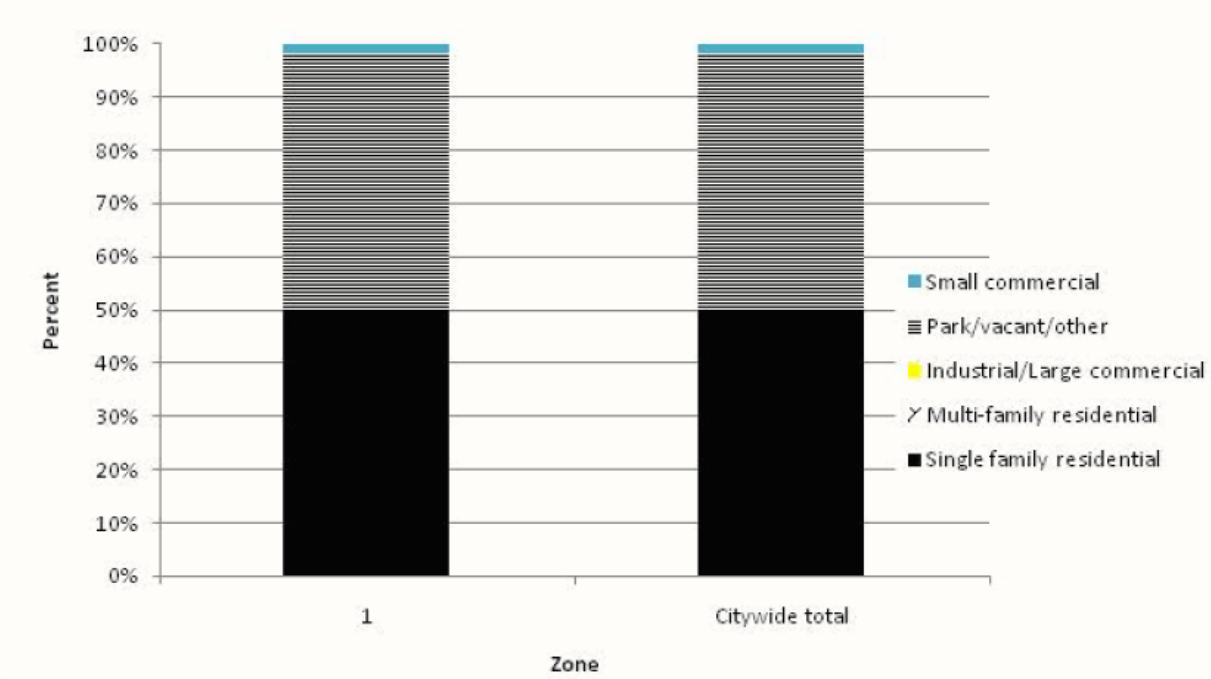

| Zone | Acres | % of Total Canopy Cover |
|---|---|---|
| 1 | 44 | 100.0 |
| Citywide total | 44 | 100.0 |

| | 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 | 44 | | |

**Figure 5: Canopy Cover in Acres**

## Land Use of Public Trees by Zone (%)

8/27/2010

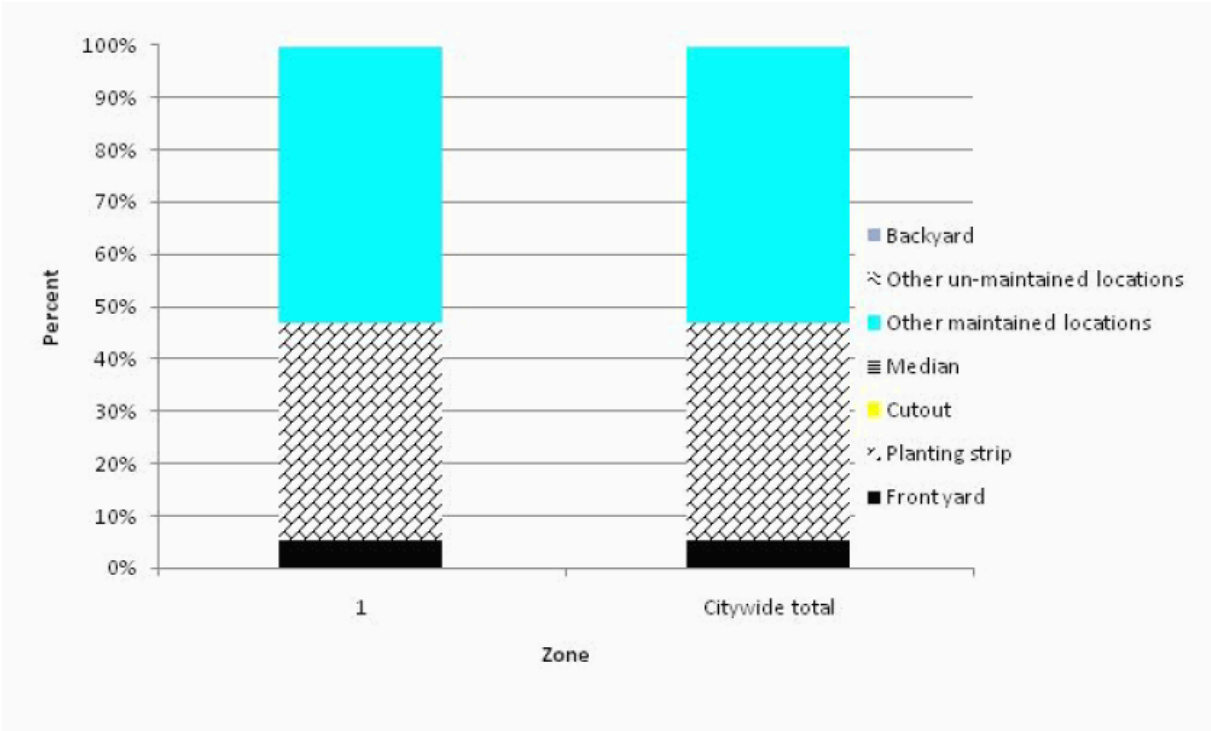



| Zone | Single family residential | Multi-family residential | Industrial/ Large commercial | Park/vacant/ other | Small commercial |
|---|---|---|---|---|---|
| 1 | 49.7 | 0.0 | 0.0 | 48.6 | 1.7 |
| Citywide total | 49.7 | 0.0 | 0.0 | 48.6 | 1.7 |

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

## Location of Public Trees by Zone (%)

8/27/2010




| Zone | Front yard | Planting strip | Cutout | Median | Other maintained locations | Other un-maintained locations | Backyard |
|---|---|---|---|---|---|---|---|
| 1 | 5.3 | 41.6 | 0.0 | 0.0 | 52.9 | 0.1 | 0.1 |
| Citywide total | 5.3 | 41.6 | 0.0 | 0.0 | 52.9 | 0.1 | 0.1 |

**Figure 7: Location of city/park trees**

# Appendix B: ArcGIS Mapping

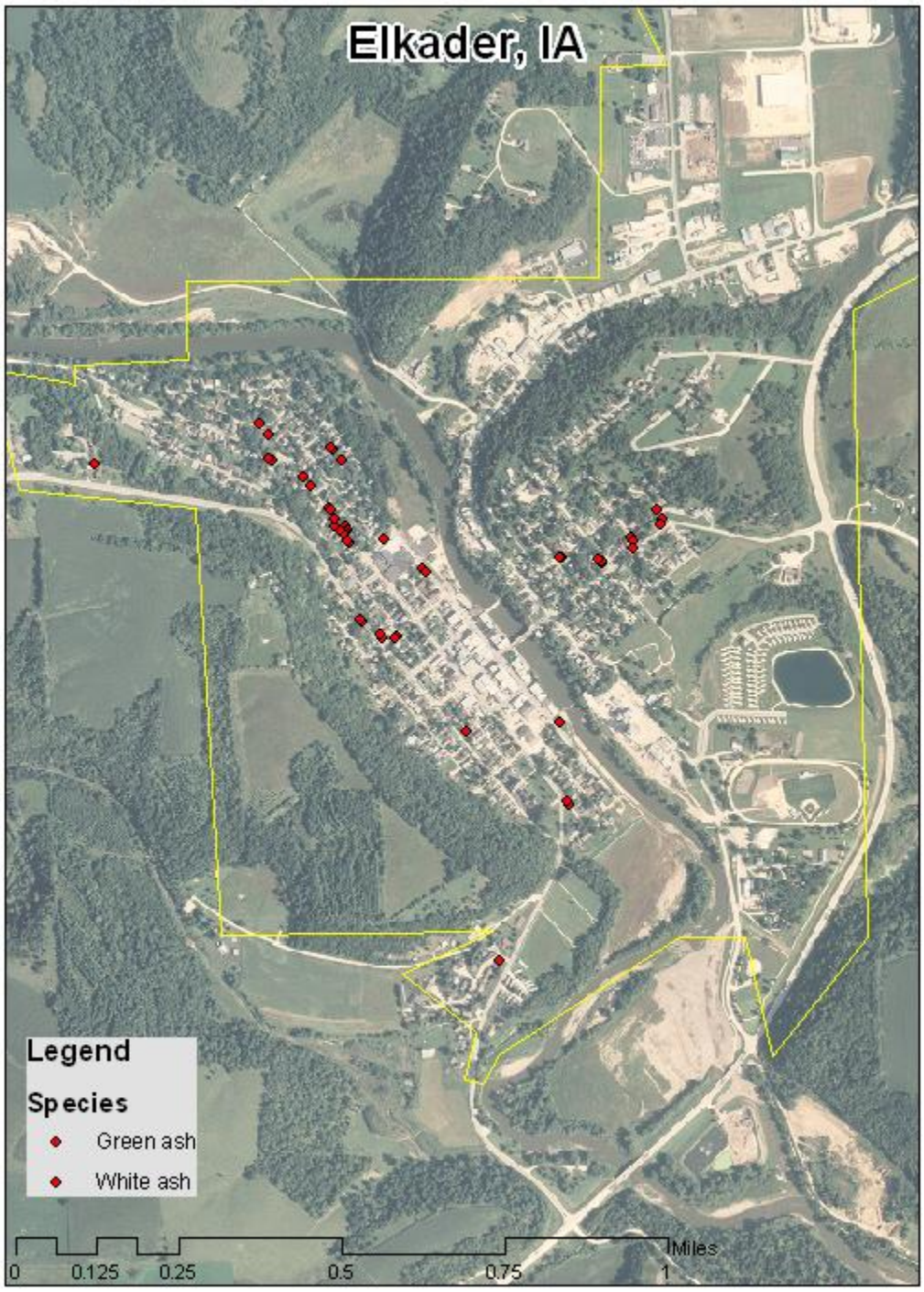



**Figure 1: Location of Ash Trees**


**Figure 2: Location of EAB symptoms**

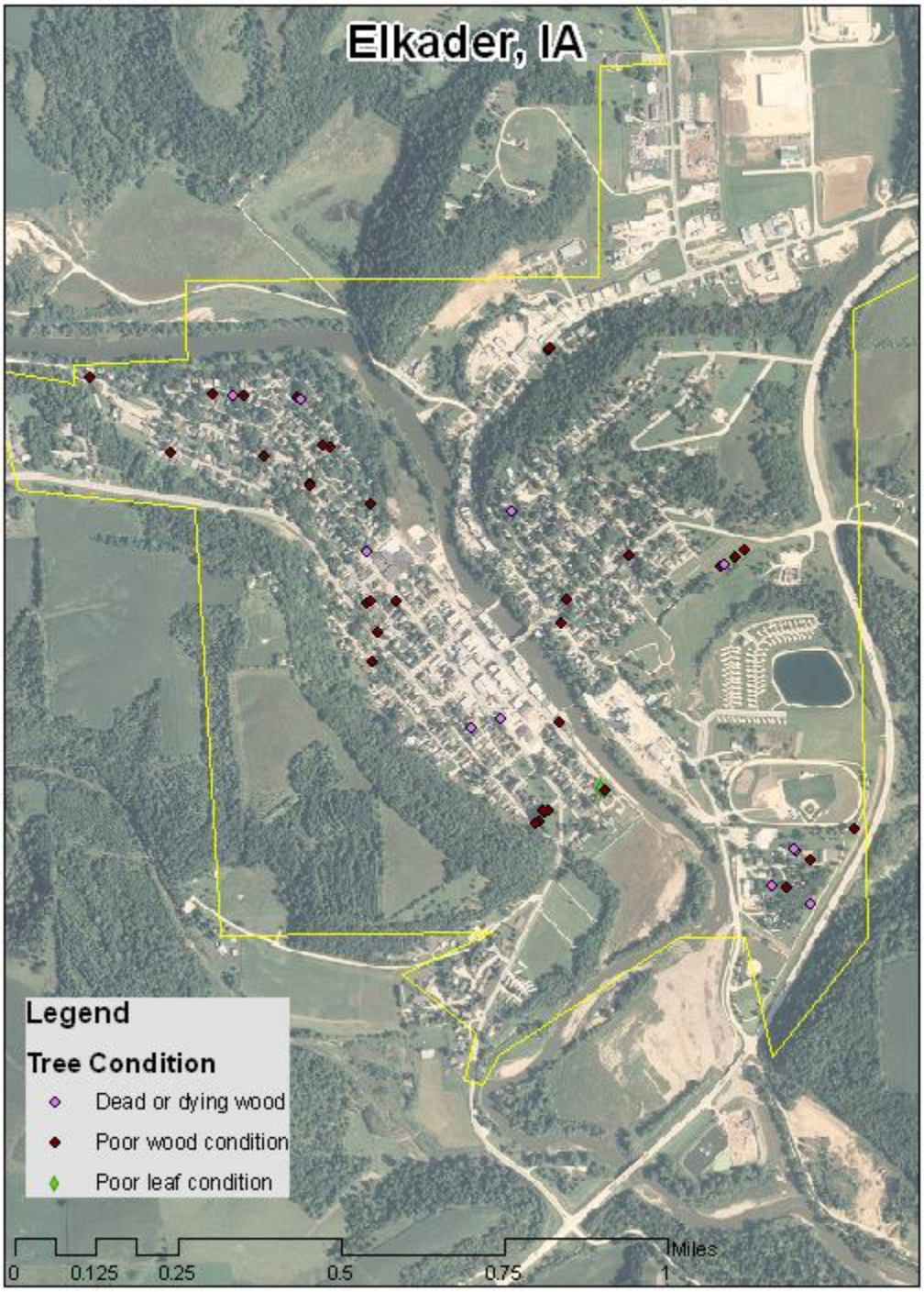



**Figure 3: Location of Poor Condition Trees**

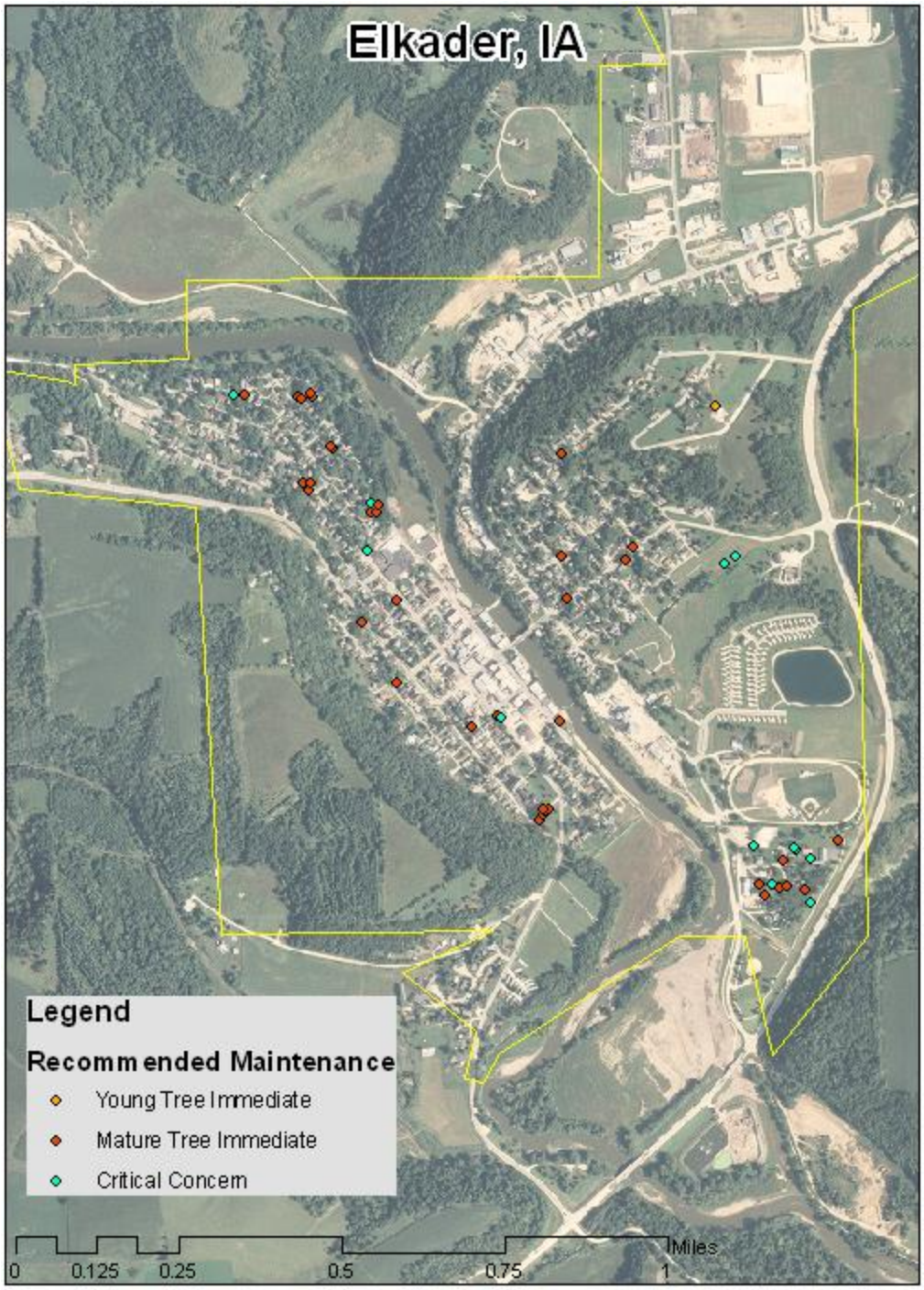



**Figure 4: Location of Trees with Recommended Maintenance**

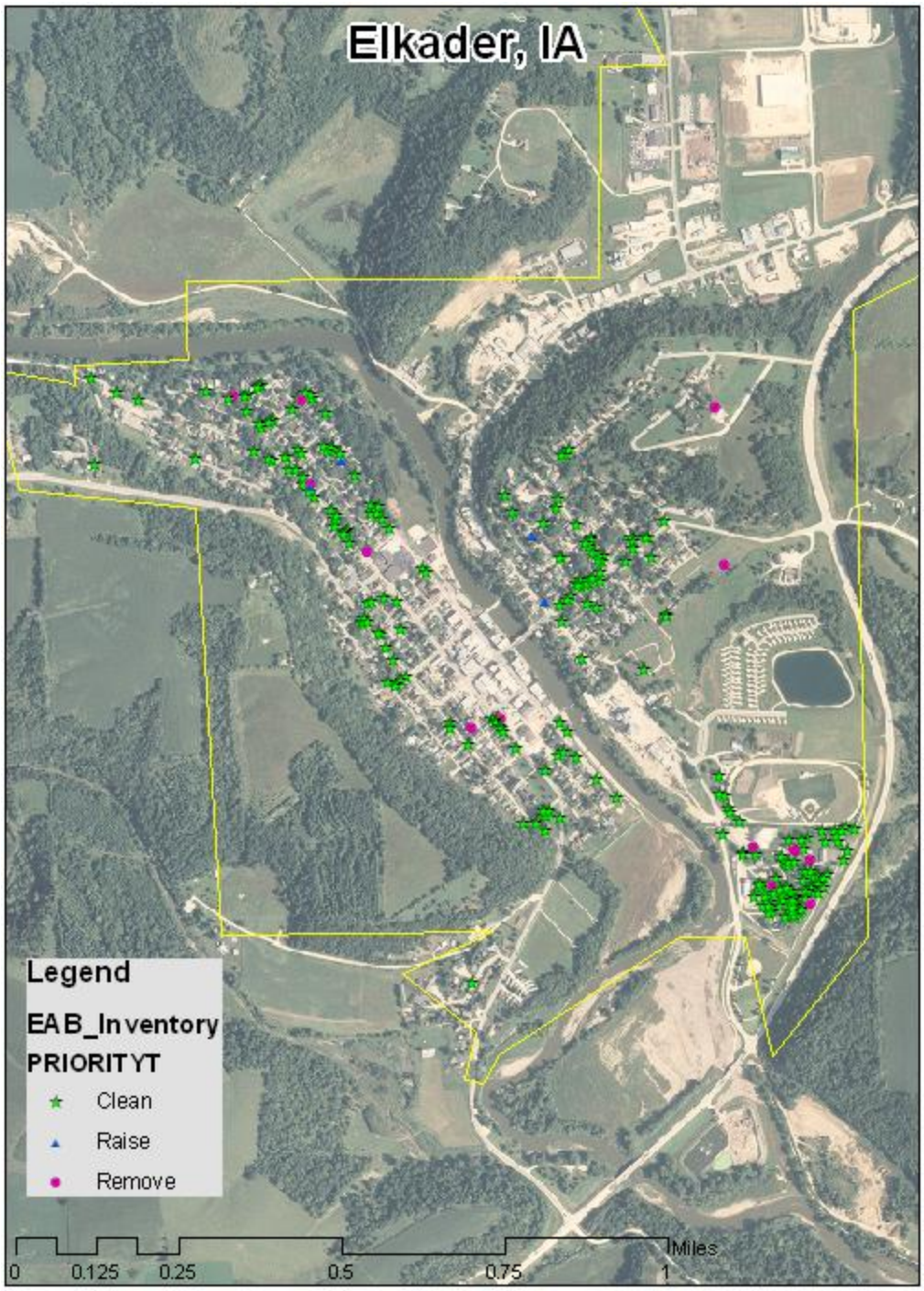



**Figure 5: Maintenance Tasks *City ownership of the trees recommended for removal should be verified prior to any removal***

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

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

If you need accommodations because of disability to access the services of this Agency, please contact Director Richard Leopold at 515-281-5918.