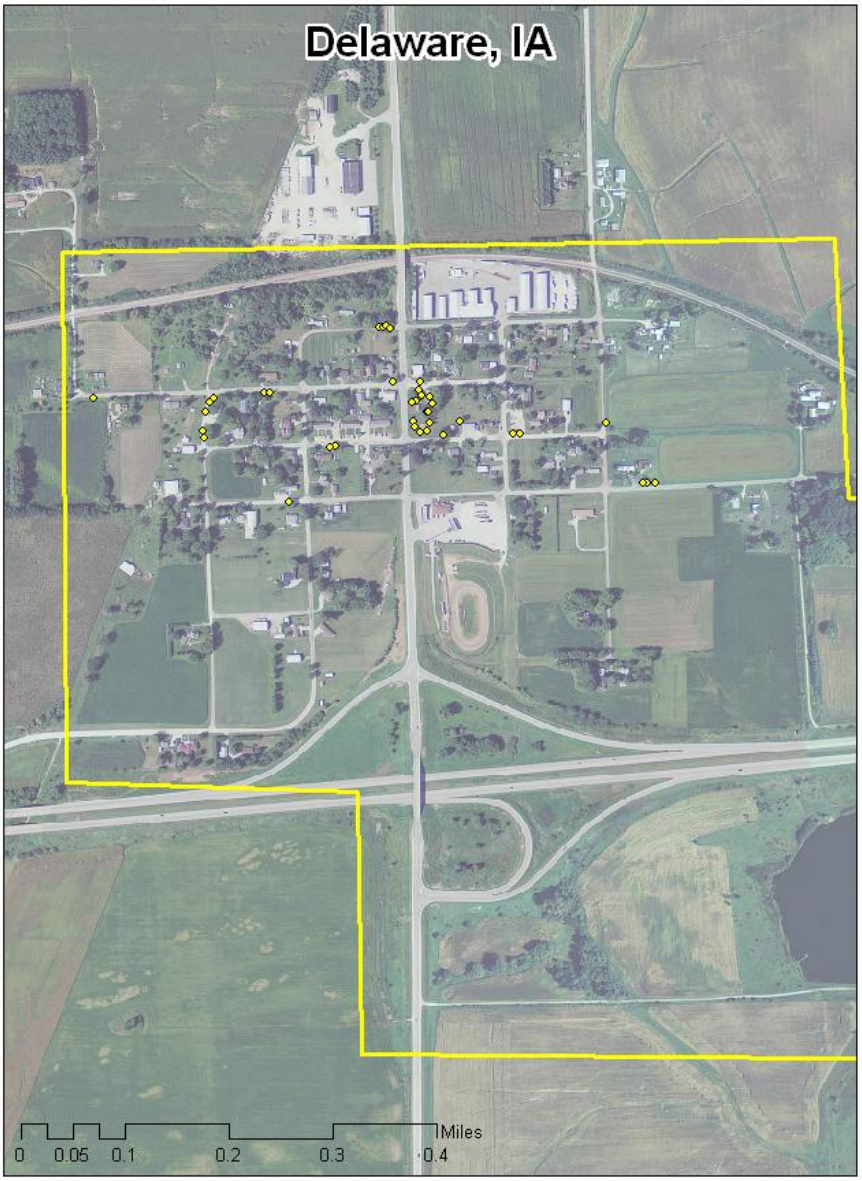
# DELAWARE, IA




2010 Management Plan

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# Executive Summary

**Overview:**

This plan was developed to assist the City of Delaware with help in managing its urban forest, including budgeting and future planning. Trees can provide a multitude of benefits to the community, and sound management allows communities 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 that kills all species of native ash trees. There is a strong possibility that over 18% of Delaware's city-managed ash trees could 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 several years mitigating public safety issues.

**Inventory and Results:**

In the summer of 2011, a street tree inventory was conducted using an integrated Global Positioning System (GPS) data collector. This involved a complete inventory of street trees within the City's Right-of-Way and some parkland. Below are some key findings of the 38 trees inventoried.

- Delaware street trees provide roughly $6,707 of annual benefits, an average of $176 per tree.
- The top three species groups are: Maples (42%), Ash (18%) and Apple (8%).
- Approximately 24% of trees are in need of some type of management.
- For various reasons, 3 trees are recommended for removal.

**Recommendations:**

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

- All trees should be pruned on a routine schedule- one third of the city every other year.
- None of the ash trees surveys showed any signs or symptoms consistent with an EAB infestation (i.e. canopy dieback, epicormic branching, splitting bark, "D" shaped exit holes and woodpecker damage.)
- Plant a diverse mix of trees that *does not include*: ash, soft maple, autumn olive, black locust, black walnut, boxelder, Chinese elm, Siberian elm, cottonwood, poplar and tree-of-heaven.
- Check ash trees with a visual survey yearly.

# Introduction

This plan was developed to assist Delaware with the management, budgeting and future planning of their urban forest. Across the state, forestry budgets continue to decrease with a great proportion 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 Delaware, these costs can be extended over several years and public safety issues from dead and dying ash trees can be mitigated.

Trees are an important component of Delaware's infrastructure and are one of the greatest assets to the community. Through research, it has been shown that trees provide a community with numerous public benefits including: improved air quality, storm water runoff interception, energy conservation, lower traffic speeds, increased property values, reduced crime, improved mental health and creating a desirable place to live. It is essential that these benefits be maintained for the people of Delaware and future generations through sound urban forestry management.

Good urban forestry management involves setting goals and developing management strategies to achieve these goals. An essential start to developing management strategies is to have a comprehensive public tree inventory. This inventory supplies information that can be used for maintenance, removal schedules, tree planting and budgeting. Basing actions on this information will help meet Delaware's urban forestry goals.

# Inventory

In the summer of 2011, a tree inventory was conducted that included the city-owned street trees and some park trees. The tree data was collected using a handheld Global Positioning System (GPS) receiver/data logger. This devise records Geographic Information System (GIS) coordinates with an accuracy of 3 meters. The data can then 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 collector was written to be compatible with a state-of-the-art software suite called i-Tree. This software was developed by the USDA Forest Service to quantify the structure of community trees and the environmental services that trees provide. This software is in the public domain and can be accessed for free.

To quantify the urban forest structure and its benefits, specific data is collected for each tree. This data includes: location, land use, tree species, diameter at 4.5 ft (DBH), 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 by the data loggers was downloaded and analyzed by software developed by the USDA Forest service called *Street Tree Resource Analysis Tool for Urban forestry Management (STRATUM)*. This is software is also part of the i-Tree suite. The following are results from the i-Tree STRATUM analysis of Delaware's inventory data.

## ***Annual Benefits***

### Annual Energy Benefits:

Trees conserve energy by shading buildings and blocking winds. Delaware's trees reduce energy related costs by approximately $1,570 annually (Appendix A, Table 1). These savings are both in Electricity (7.6 MWh) and in Natural Gas (1,014 Therms).

### Annual Storm water Benefits:

Delaware's trees intercept about 84,822 gallons of rainfall and snow melt per year (Appendix A, Table 2). This interception provides $2,299 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 that emit volatile organic matter (ozone). In Delaware, it is estimated that trees remove 101 lbs. of air pollution (ozone ($O_3$), particulate matter less than 10 microns ($PM_{10}$), carbon monoxide (CO), nitrogen dioxide ($NO_2$), and sulfur dioxide ($SO_2$)) per year with a net value of $285 (Appendix A, Table 3).

### Annual Carbon Benefits:

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. Of the 38 trees inventoried, the amount of carbon stored amounts to approximately 342,732 total lbs of $CO_2$ (Appendix A, Table 4). Those trees are sequestering about 21,889 lbs of carbon per year (Appendix A, Table 5). The benefits these trees provide from summer shading and from reductions in household wind infiltration in the winter result in approximately 12,751 fewer lbs of $CO_2$ being released into the atmosphere (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. Delaware receives approximately $2,293 in annual social benefits from its street trees (Appendix A, Table 6).

### Financial Summary of all Benefits:

According to the USDA Forest Service i-Tree STRATUM analysis, Delaware's trees provide $6,707 of benefits annually. Benefits of individual trees vary based on size, species, health and location. On average, each of the 38 trees in Delaware's inventory provides approximately $176 annually (Appendix A, Table 7).

## ***Forest Structure***

### Species Distribution:

There were at the very lease 15 different tree species surveyed. The distribution of trees by genus is as follows:

| Genus | # of trees | % of total |
|---|---|---|
| Maple (*acer*) | 16 | 42.1% |
| Ash (*fraxius*) | 7 | 18.4% |
| Apple (*malus*) | 3 | 7.9% |
| Honeylocust (*gleditsia*) | 2 | 5.3% |
| Elm (*ulmus*) | 2 | 5.3% |
| Birch (*betula*) | 2 | 5.3% |
| Cherry (*prunus*) | 1 | 2.6% |
| Willow (*Salix*) | 1 | 2.6% |
| Pine (*Pinus*) | 1 | 2.6% |
| Buckthorn (*rhamnus*) | 1 | 2.6% |
| Aspen (*populus*) | 1 | 2.6% |
| White Mulberry (*morus*) | 1 | 2.6% |
| | 38 | 100.0% |

**Size Distribution:**

The table below summarizes distribution of surveyed trees by their diameter in inches when measured at 4.5 above the ground. The size distribution is fairly flat with fairly equal numbers of trees throughout the different size distributions. See Appendix A, Figure 2 for a breakdown of size distributions by species.

| Size Classes (inches of diameter at 4.5 feet) | # of trees | % of trees |
|---|---|---|
| 0 - 3 | 4 | 10.5% |
| 3 - 6 | 6 | 15.8% |
| 6 - 12 | 7 | 18.4% |
| 12 - 18 | 6 | 15.8% |
| 18 - 24 | 4 | 10.5% |
| 24 - 30 | 4 | 10.5% |
| 30 - 36 | 4 | 10.5% |
| 36 - 42 | 0 | 0.0% |
| 42+ | 3 | 7.9% |
| | 38 | 100.0% |

**Condition: Foliage and Wood:**

Leaf condition is a good indicator of the overall health of urban trees. The foliage condition results for Delaware indicated that 89% of the trees were in good health and 11% in fair health. (Appendix A, Figure 3). Leaf health is largely a function of climatic factors during the growing season which affect the ability of diseases to take hold. Last summer was not to cool and damp, so leaf diseases, like anthracnose, was not a serious factor and the leaves stayed pretty healthy throughout the summer.

The condition of the wood in urban trees is another important indicator of tree health. The wood forms the structural support system for the leaves and branches. Extensive decay in the main stem makes a tree structurally unsafe which may lead to them becoming safety hazards. In Delaware, 58% of the surveyed trees had stems in good health, 37% in fair health, 3% in poor health and 2% dead or dying. (Appendix A, Figure 4). The 5% in poor, or dead or dying, condition should be assessed more carefully. Most of the trees with poor wood condition are being recommended for removal due to public safety concerns. The 37% in fair health is to a large extent a reflection of having many larger maple trees which tend to have problems with decay or cracking in their main stems as they get older. The City is already heavily weighted with maples (42%), so encourage less planting in this genus.

## Management Needs:

Each surveyed tree was assessed for recommended maintenance needs. The following tables list the specific management needs and recommendations. (See Appendix B, figure 5).

| Priority Task | # of trees | % of trees |
|---|---|---|
| none | 29 | 76.3% |
| clean | 4 | 10.5% |
| remove | 3 | 7.9% |
| stake/train | 2 | 5.3% |
| | 38 | 100.0% |

| Maintenance Recommendation | # of trees | % of trees |
|---|---|---|
| None | 28 | 73.7% |
| mature tree (routine) | 7 | 18.4% |
| young tree (routine) | 3 | 7.9% |
| | 38 | 100.0% |

Land Use and Location:

The majority of Delaware's surveyed trees are in single family residential neighborhoods (Appendix A, Figure 6 & Appendix A, Figure 7). The following describes the land use and locations for the street and park trees.

| Land Use | |
|---|---|
| Park/vacant/other | 74% |
| Single family residential | 26% |

| Location | |
|---|---|
| Other maintained locations (e.g. parks) | 61% |
| Back yard | 11% |
| Front yard | 15% |
| Other unmaintained locations | 13% |

# Recommendations

## Risk Management:

Hazardous trees can be a significant threat to both people and property. Trees that are dead or dying, or that have 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**:

A total of 3 trees are recommended for removal for one reason or another. One of those trees is already dead. This tree could become hazardous as it breaks apart from decay. (One tree was an invasive exotic buckthorn and one was a volunteer tree growing in a bad place.)

## Pruning Cycle:

Proper pruning can extend the life and improve the overall health of trees, and can reduce public safety issues. In the Management Needs section of the Findings there are four main maintenance issues to be addressed: routine pruning (stake/train), crown cleaning (clean), crown raising (raise), and crown reduction (reduce). 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. Staking and training is recommended for younger trees so they can develop good architecture. It is recommended that all trees be pruned on a routine schedule every five to seven years.

| Priority Task | # of trees | % of trees |
|---|---|---|
| none | 29 | 76.3% |
| clean | 4 | 10.5% |
| remove | 3 | 7.9% |
| stake/train | 2 | 5.3% |
| | 38 | 100.0% |

## Planting:

Most of the planting over the next six years should replace the trees that are recommended for removal. It is recommended to plant two trees for every tree removed since survival rates will not be 100%. It is not essential that the new trees be planted in the same location as the trees being removed. However, maintaining the same number of trees helps ensure continuation of the benefits of the existing forest in Delaware.

Since most insects and diseases target a particular genus (e.g. ash) or species (e.g. green ash) of trees, it is important to always plant a diverse mix of species. Current diversity recommendations advise that any genus (e.g. maple, oak or ash) not make up more than 20% of the urban forest. Any single species (e.g. silver maple, sugar maple, white oak or bur oak) not make up more than 10% of the total urban forest. Presently, the forest is heavily planted with Maple (42%) and Ash (18%) (Appendix A, Figure 1). No more of these two species should be planted until their percentages are lowered below 20%. 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, and willow. I noticed that white poplar was recommended in your City Tree Ordinance. This tree can become invasive so should probably be taken off of your list.

**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 (EAB) Plan

**EAB Quarantines:**

EAB is an extremely destructive plant pest and it is responsible for the death and decline of many millions ash trees throughout the Eastern United States and Canada. Ash in both forestlands and urban settings constitutes a very significant portion of the canopy cover. 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 its spread beyond its known locations 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 urban 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 your budget permits, all removed ash trees should be replaced. All trees should meet the restrictions in your city's ordinance (Appendix C). The new plantings should be a diverse mix and should not include ash, 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's other than ash will be prioritized by hazardous or emergency situations only.

## Private Ash Trees:

It is strongly recommended that private property owners start removing ash trees on their property as trees are infested with Emerald Ash Borer. Trees that are on private property are part of Delaware's urban forest. Private property owners should be given direction to the proper species to plant, spacing, and location. Delaware has a city ordinance for trees.

# Budget

Purposed Budget Increase:

EAB could potentially kill all of the ash trees in Delaware within a decade after its arrival. It is recommended that the City apply for grants to fund replacement tree planting. 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. There were a total of 7 ash trees surveyed. We recommend a planting program that will help to offset the loss of these ash trees assuming they will all die when an EAB infestation hits sometime in the future. You should replant 2 trees for every ash tree you currently have which would be 14 total trees to plant. Additionally remove trees that were recommended for removal (3 total) throughout the City (Appendix B, Figure 5). Finally, we recommend that the City adopt a policy of allocating somewhere between $2 to $4 per capita per year into a forestry budget to be used for planting, removals and maintenance of Delaware's urban forest.

**Recommended Budget: $3850.**

**FY 2011 Budget**

Removal: $500
Planting: $300
Routine trimming: $100
Watering & Maintenance: $75

**FY 2012 Budget**

Removal: $500
Planting: $300
Routine trimming: $100
Watering & Maintenance: $75

**FY 2013 Budget**

Removal: $500
Planting: $200
Routine trimming: $100
Watering & Maintenance: $50

**FY 2014 Budget**

Planting: $200
Routine trimming: $100
Watering & Maintenance: $50

**FY 2015 Budget**

Planting: $200
Routine trimming: $100
Watering & Maintenance: $50

**FY 2016 Budget**

Planting: $200
Routine trimming: $100
Watering & Maintenance: $50

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# Appendix A: i-Tree Data

**Table 1: Annual Energy Benefits**

## Annual Energy Benefits of Public Trees by Species

10/18/2011

| Species | Total Electricity (MWh) | Electricity ($) | Total Natural Gas (Therms) | Natural Gas ($) | Total ($) | Standar d Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|
| Silver maple | 3.4 | 261 | 445.0 | 436 | 697 | (N/A) | 29.0 | 44.4 | 63.34 |
| Green ash | 1.2 | 88 | 146.5 | 144 | 231 | (N/A) | 15.8 | 14.7 | 38.55 |
| Boxelder | 0.1 | 7 | 13.2 | 13 | 20 | (N/A) | 7.9 | 1.3 | 6.80 |
| Apple | 0.0 | 4 | 8.2 | 8 | 12 | (N/A) | 7.9 | 0.7 | 3.89 |
| Norway maple | 0.3 | 20 | 40.4 | 40 | 60 | (N/A) | 5.3 | 3.8 | 29.89 |
| River birch | 0.2 | 16 | 33.7 | 33 | 49 | (N/A) | 5.3 | 3.1 | 24.47 |
| Honeylocust | 0.4 | 32 | 55.0 | 54 | 86 | (N/A) | 5.3 | 5.5 | 42.79 |
| American elm | 0.6 | 45 | 71.4 | 70 | 115 | (N/A) | 5.3 | 7.3 | 57.34 |
| White ash | 0.3 | 23 | 43.0 | 42 | 66 | (N/A) | 2.6 | 4.2 | 65.60 |
| White mulberry | 0.0 | 2 | 3.8 | 4 | 5 | (N/A) | 2.6 | 0.3 | 5.40 |
| Eastern white pine | 0.1 | 10 | 14.6 | 14 | 24 | (N/A) | 2.6 | 1.5 | 24.14 |
| Quaking aspen | 0.3 | 25 | 46.9 | 46 | 71 | (N/A) | 2.6 | 4.5 | 70.91 |
| Black cherry | 0.2 | 15 | 31.6 | 31 | 46 | (N/A) | 2.6 | 2.9 | 46.14 |
| Buckthorn | 0.1 | 6 | 12.8 | 13 | 18 | (N/A) | 2.6 | 1.2 | 18.19 |
| Willow | 0.3 | 24 | 47.4 | 46 | 71 | (N/A) | 2.6 | 4.5 | 70.84 |
| Other street trees | 0.0 | 0 | 0.0 | 0 | 0 | (N/A) | 0.0 | 0.0 | 0.00 |
| Citywide total | 7.6 | 577 | 1,013.6 | 993 | 1,570 | (N/A) | 100.0 | 100.0 | 41.32 |

**Table 2: Annual Stormwater Benefits**

## Annual Stormwater Benefits of Public Trees by Species

10/18/2011

| Species | Total rainfall interception (Gal) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|
| Silver maple | 48,837 | 1,324 | (N/A) | 29.0 | 57.6 | 120.33 |
| Green ash | 8,202 | 222 | (N/A) | 15.8 | 9.7 | 37.05 |
| Boxelder | 578 | 16 | (N/A) | 7.9 | 0.7 | 5.23 |
| Apple | 145 | 4 | (N/A) | 7.9 | 0.2 | 1.31 |
| Norway maple | 2,491 | 68 | (N/A) | 5.3 | 2.9 | 33.76 |
| River birch | 1,172 | 32 | (N/A) | 5.3 | 1.4 | 15.88 |
| Honeylocust | 4,865 | 132 | (N/A) | 5.3 | 5.7 | 65.93 |
| American elm | 4,554 | 123 | (N/A) | 5.3 | 5.4 | 61.71 |
| White ash | 3,225 | 87 | (N/A) | 2.6 | 3.8 | 87.40 |
| White mulberry | 69 | 2 | (N/A) | 2.6 | 0.1 | 1.86 |
| Eastern white pine | 1,539 | 42 | (N/A) | 2.6 | 1.8 | 41.70 |
| Quaking aspen | 3,943 | 107 | (N/A) | 2.6 | 4.7 | 106.85 |
| Black cherry | 1,174 | 32 | (N/A) | 2.6 | 1.4 | 31.82 |
| Buckthorn | 264 | 7 | (N/A) | 2.6 | 0.3 | 7.17 |
| Willow | 3,764 | 102 | (N/A) | 2.6 | 4.4 | 102.01 |
| Other street trees | 0 | 0 | (N/A) | 0.0 | 0.0 | 0.00 |
| Citywide total | 84,822 | 2,299 | (N/A) | 100.0 | 100.0 | 60.50 |

**Table 3: Annual Air Quality Benefits**

## Annual Air Quality Benefits of Public Trees by Species

10/18/2011

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Silver maple | 8.8 | 1.5 | 4.3 | 0.4 | 47 | 16.1 | 2.4 | 2.3 | 15.5 | 101 | -4.7 | -18 | 46.6 | 131 | (N/A) | 28.9 | 11.89 |
| Green ash | 0.6 | 0.1 | 0.4 | 0.0 | 4 | 5.4 | 0.8 | 0.8 | 5.2 | 34 | 0.0 | 0 | 13.4 | 38 | (N/A) | 15.8 | 6.27 |
| Boxelder | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.5 | 0.1 | 0.1 | 0.4 | 3 | 0.0 | 0 | 1.1 | 3 | (N/A) | 7.9 | 0.99 |
| Apple | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.2 | 0.0 | 0.0 | 0.2 | 1 | 0.0 | 0 | 0.5 | 2 | (N/A) | 7.9 | 0.51 |
| Norway maple | 0.5 | 0.1 | 0.2 | 0.0 | 3 | 1.3 | 0.2 | 0.2 | 1.2 | 8 | -0.1 | 0 | 3.6 | 10 | (N/A) | 5.3 | 5.15 |
| River birch | 0.1 | 0.0 | 0.1 | 0.0 | 1 | 1.0 | 0.1 | 0.1 | 1.0 | 6 | 0.0 | 0 | 2.5 | 7 | (N/A) | 5.3 | 3.47 |
| Honeylocust | 0.9 | 0.2 | 0.4 | 0.0 | 5 | 2.0 | 0.3 | 0.3 | 1.9 | 12 | -0.8 | -3 | 5.2 | 14 | (N/A) | 5.3 | 7.22 |
| American elm | 2.2 | 0.4 | 1.0 | 0.1 | 12 | 2.7 | 0.4 | 0.4 | 2.7 | 17 | 0.0 | 0 | 9.9 | 29 | (N/A) | 5.3 | 14.46 |
| White ash | 0.4 | 0.1 | 0.2 | 0.0 | 2 | 1.5 | 0.2 | 0.2 | 1.4 | 9 | 0.0 | 0 | 3.9 | 11 | (N/A) | 2.6 | 11.18 |
| White mulberry | 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) | 2.6 | 0.71 |
| Eastern white pine | 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) | 2.6 | 2.82 |
| Quaking aspen | 0.5 | 0.1 | 0.2 | 0.0 | 3 | 1.6 | 0.2 | 0.2 | 1.5 | 10 | 0.0 | 0 | 4.4 | 12 | (N/A) | 2.6 | 12.48 |
| Black cherry | 0.4 | 0.1 | 0.2 | 0.0 | 2 | 1.0 | 0.1 | 0.1 | 0.9 | 6 | 0.0 | 0 | 2.9 | 8 | (N/A) | 2.6 | 8.35 |
| Buckthorn | 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) | 2.6 | 2.55 |
| Willow | 0.9 | 0.1 | 0.4 | 0.0 | 5 | 1.6 | 0.2 | 0.2 | 1.5 | 10 | -0.2 | -1 | 4.7 | 14 | (N/A) | 2.6 | 13.58 |
| Other street trees | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | (N/A) | 0.0 | 0.00 |
| Citywide total | 15.6 | 2.6 | 7.7 | 0.7 | 84 | 36.0 | 5.3 | 5.0 | 34.4 | 225 | -6.4 | -24 | 100.9 | 285 | (N/A) | 100.0 | 7.50 |

**Table 4: Annual Carbon Stored**

## Stored CO2 Benefits of Public Trees by Species

10/18/2011

| Species | Total Stored CO2 (lbs) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|
| Silver maple | 208,993 | 1,567 | (N/A) | 29.0 | 61.0 | 142.50 |
| Green ash | 21,542 | 162 | (N/A) | 15.8 | 6.3 | 26.93 |
| Boxelder | 454 | 3 | (N/A) | 7.9 | 0.1 | 1.13 |
| Apple | 369 | 3 | (N/A) | 7.9 | 0.1 | 0.92 |
| Norway maple | 7,962 | 60 | (N/A) | 5.3 | 2.3 | 29.86 |
| River birch | 2,201 | 17 | (N/A) | 5.3 | 0.6 | 8.26 |
| Honeylocust | 12,423 | 93 | (N/A) | 5.3 | 3.6 | 46.58 |
| American elm | 41,278 | 310 | (N/A) | 5.3 | 12.0 | 154.79 |
| White ash | 8,458 | 63 | (N/A) | 2.6 | 2.5 | 63.43 |
| White mulberry | 178 | 1 | (N/A) | 2.6 | 0.1 | 1.33 |
| Eastern white pine | 1,170 | 9 | (N/A) | 2.6 | 0.3 | 8.78 |
| Quaking aspen | 15,773 | 118 | (N/A) | 2.6 | 4.6 | 118.30 |
| Black cherry | 6,743 | 51 | (N/A) | 2.6 | 2.0 | 50.57 |
| Buckthorn | 908 | 7 | (N/A) | 2.6 | 0.3 | 6.81 |
| Willow | 14,280 | 107 | (N/A) | 2.6 | 4.2 | 107.10 |
| Other street trees | 0 | 0 | (N/A) | 0.0 | 0.0 | 0.00 |
| Citywide total | 342,732 | 2,570 | (N/A) | 100.0 | 100.0 | 67.64 |

**Table 5: Annual Carbon Sequestered**

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

10/18/2011

| Species | Sequestered (lb) | Sequestered ($) | Decomposition Release (lb) | Maintenance Release (lb) | Total Released ($) | Avoided (lb) | Avoided ($) | Net Total (lb) | Total ($) | Standar d Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Silver maple | 14,911 | 112 | -1,003 | -2 | -8 | 5,760 | 43 | 19,666 | 147 | (N/A) | 29.0 | 56.8 | 13.41 |
| Green ash | 2,413 | 18 | -103 | -1 | -1 | 1,937 | 15 | 4,246 | 32 | (N/A) | 15.8 | 12.3 | 5.31 |
| Boxelder | 129 | 1 | -2 | -1 | 0 | 165 | 1 | 292 | 2 | (N/A) | 7.9 | 0.8 | 0.73 |
| Apple | 85 | 1 | -2 | -1 | 0 | 80 | 1 | 162 | 1 | (N/A) | 7.9 | 0.5 | 0.41 |
| Norway maple | 475 | 4 | -38 | 0 | 0 | 447 | 3 | 884 | 7 | (N/A) | 5.3 | 2.6 | 3.31 |
| River birch | 448 | 3 | -11 | 0 | 0 | 352 | 3 | 789 | 6 | (N/A) | 5.3 | 2.3 | 2.96 |
| Honeylocust | 1,531 | 11 | -60 | 0 | 0 | 699 | 5 | 2,170 | 16 | (N/A) | 5.3 | 6.3 | 8.14 |
| American elm | 732 | 5 | -198 | 0 | -1 | 989 | 7 | 1,522 | 11 | (N/A) | 5.3 | 4.4 | 5.71 |
| White ash | 845 | 6 | -41 | 0 | 0 | 518 | 4 | 1,323 | 10 | (N/A) | 2.6 | 3.8 | 9.92 |
| White mulberry | 38 | 0 | -1 | 0 | 0 | 37 | 0 | 74 | 1 | (N/A) | 2.6 | 0.2 | 0.56 |
| Eastern white pine | 116 | 1 | -6 | 0 | 0 | 216 | 2 | 326 | 2 | (N/A) | 2.6 | 0.9 | 2.45 |
| Quaking aspen | 857 | 6 | -76 | 0 | -1 | 552 | 4 | 1,333 | 10 | (N/A) | 2.6 | 3.9 | 10.00 |
| Black cherry | 478 | 4 | -32 | 0 | 0 | 335 | 3 | 781 | 6 | (N/A) | 2.6 | 2.3 | 5.86 |
| Buckthorn | 114 | 1 | -4 | 0 | 0 | 124 | 1 | 233 | 2 | (N/A) | 2.6 | 0.7 | 1.75 |
| Willow | 370 | 3 | -69 | 0 | -1 | 539 | 4 | 840 | 6 | (N/A) | 2.6 | 2.4 | 6.30 |
| Other street trees | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (N/A) | 0.0 | 0.0 | 0.00 |
| Citywide total | 23,542 | 177 | -1,645 | -7 | -12 | 12,751 | 96 | 34,640 | 260 | (N/A) | 100.0 | 100.0 | 6.84 |

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

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

10/18/2011

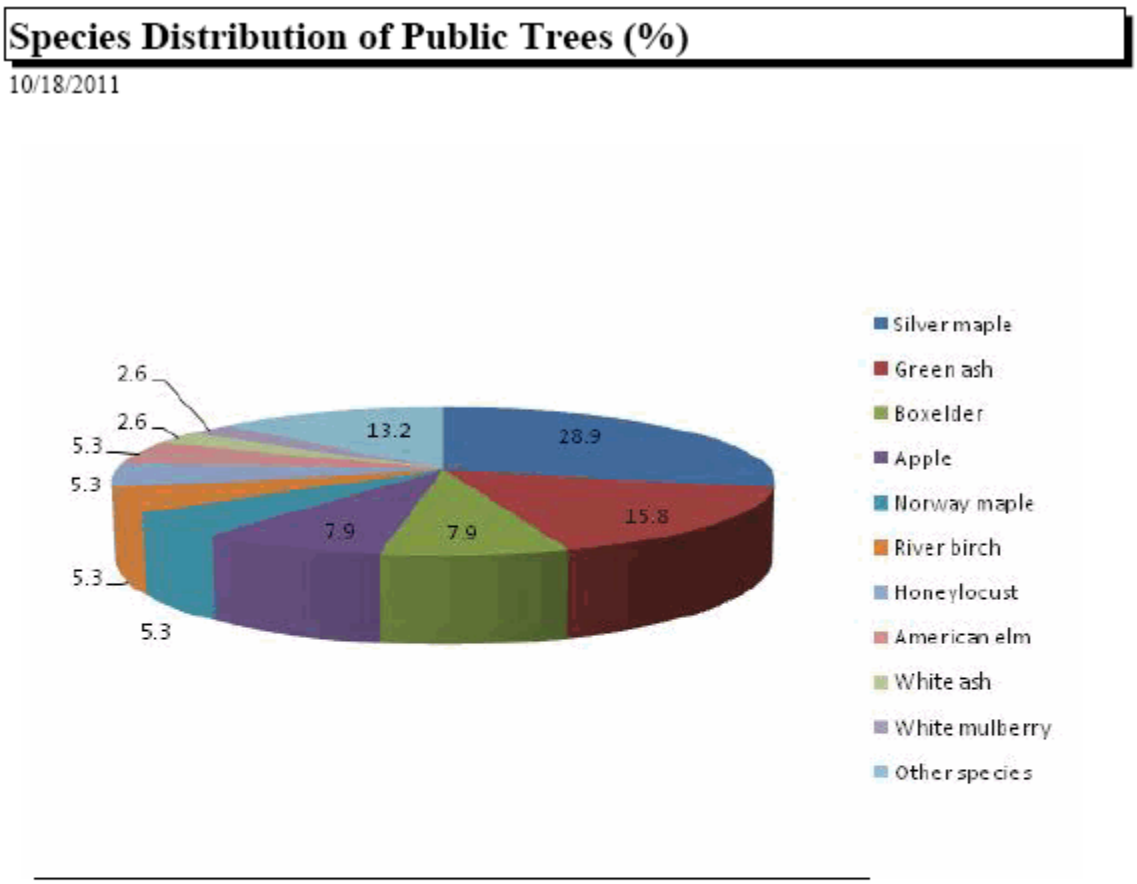
| Species | Total ($) | Standar d Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|
| Silver maple | 1,132 | (N/A) | 29.0 | 49.4 | 102.87 |
| Green ash | 252 | (N/A) | 15.8 | 11.0 | 42.06 |
| Boxelder | 54 | (N/A) | 7.9 | 2.3 | 17.87 |
| Apple | 4 | (N/A) | 7.9 | 0.2 | 1.38 |
| Norway maple | 46 | (N/A) | 5.3 | 2.0 | 22.89 |
| River birch | 52 | (N/A) | 5.3 | 2.3 | 26.22 |
| Honeylocust | 397 | (N/A) | 5.3 | 17.3 | 198.26 |
| American elm | 89 | (N/A) | 5.3 | 3.9 | 44.30 |
| White ash | 101 | (N/A) | 2.6 | 4.4 | 101.35 |
| White mulberry | 2 | (N/A) | 2.6 | 0.1 | 2.06 |
| Eastern white pine | 32 | (N/A) | 2.6 | 1.4 | 32.32 |
| Quaking aspen | 66 | (N/A) | 2.6 | 2.9 | 65.59 |
| Black cherry | 29 | (N/A) | 2.6 | 1.3 | 28.80 |
| Buckthorn | 6 | (N/A) | 2.6 | 0.3 | 6.40 |
| Willow | 31 | (N/A) | 2.6 | 1.4 | 31.46 |
| Other street trees | 0 | (±NaN) | 0.0 | 0.0 | 0.00 |
| Citywide total | 2,293 | (N/A) | 100.0 | 100.0 | 60.34 |

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

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

10/18/20

| Species | Energy | $CO_2$ | Air Quality | Stormwater | Aesthetic/Other | Total ($) | Standard Error | % of Total $ |
|---|---|---|---|---|---|---|---|---|
| Silver maple | 697 | 147 | 131 | 1,324 | 1,132 | 3,430 | (±0) | 51.1 |
| Green ash | 231 | 32 | 38 | 222 | 252 | 775 | (±0) | 11.6 |
| Boxelder | 20 | 2 | 3 | 16 | 54 | 95 | (±0) | 1.4 |
| Apple | 12 | 1 | 2 | 4 | 4 | 22 | (±0) | 0.3 |
| Norway maple | 60 | 7 | 10 | 68 | 46 | 190 | (±0) | 2.8 |
| River birch | 49 | 6 | 7 | 32 | 52 | 146 | (±0) | 2.2 |
| Honeylocust | 86 | 16 | 14 | 132 | 397 | 645 | (±0) | 9.6 |
| American elm | 115 | 11 | 29 | 123 | 89 | 367 | (±0) | 5.5 |
| White ash | 66 | 10 | 11 | 87 | 101 | 275 | (±0) | 4.1 |
| White mulberry | 5 | 1 | 1 | 2 | 2 | 11 | (±0) | 0.2 |
| Eastern white pine | 24 | 2 | 3 | 42 | 32 | 103 | (±0) | 1.5 |
| Quaking aspen | 71 | 10 | 12 | 107 | 66 | 266 | (±0) | 4.0 |
| Black cherry | 46 | 6 | 8 | 32 | 29 | 121 | (±0) | 1.8 |
| Buckthorn | 18 | 2 | 3 | 7 | 6 | 36 | (±0) | 0.5 |
| Willow | 71 | 6 | 14 | 102 | 31 | 224 | (±0) | 3.3 |
| Other street trees | 0 | 0 | 0 | 0 | 0 | 0 | (±0) | 0.0 |
| Citywide Total | 1,570 | 260 | 285 | 2,299 | 2,293 | 6,707 | (±0) | 100.0 |

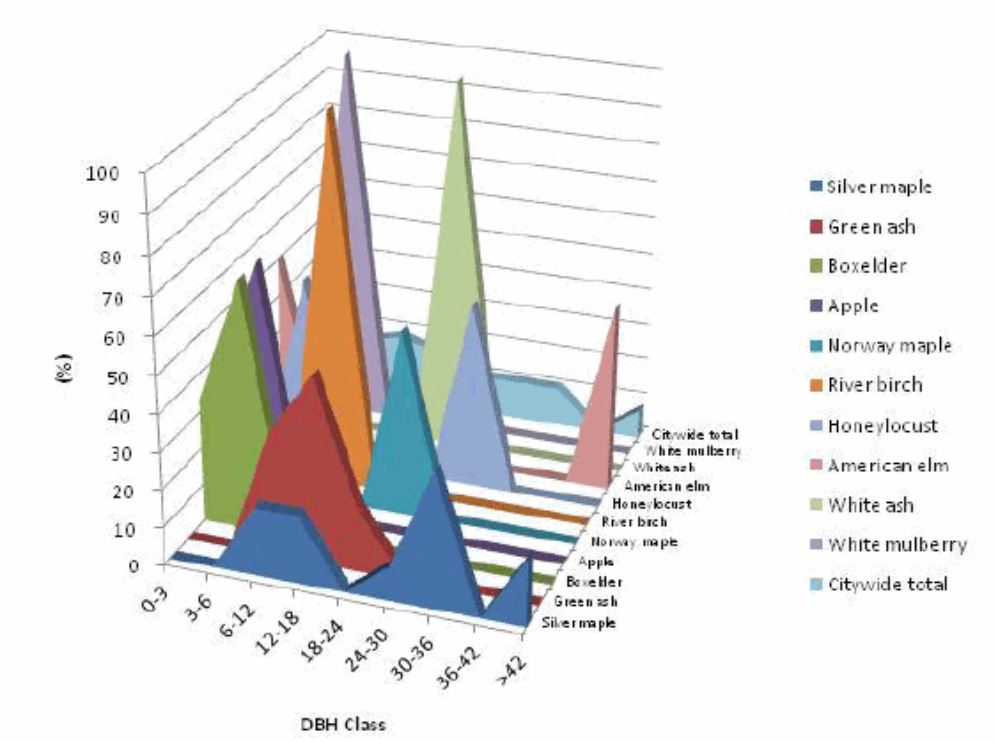



| Species | Percent |
|---|---|
| Silver maple | 28.9 |
| Green ash | 15.8 |
| Boxelder | 7.9 |
| Apple | 7.9 |
| Norway maple | 5.3 |
| River birch | 5.3 |
| Honeylocust | 5.3 |
| American elm | 5.3 |
| White ash | 2.6 |
| White mulberry | 2.6 |
| Other species | 13.2 |
| Total | 100.0 |

**Figure 1: Species Distribution**

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

10/18/2011




| | 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 | 18.2 | 18.2 | 0.0 | 9.1 | 36.4 | 0.0 | 18.2 |
| Green ash | 0.0 | 0.0 | 33.3 | 50.0 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Boxelder | 33.3 | 66.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Apple | 33.3 | 66.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Norway maple | 50.0 | 0.0 | 0.0 | 0.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| River birch | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Honeylocust | 0.0 | 50.0 | 0.0 | 0.0 | 0.0 | 50.0 | 0.0 | 0.0 | 0.0 |
| American elm | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 50.0 |
| White ash | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| White mulberry | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Citywide total | 10.5 | 15.8 | 18.4 | 15.8 | 10.5 | 10.5 | 10.5 | 0.0 | 7.9 |

**Figure 2: Relative Age Class**

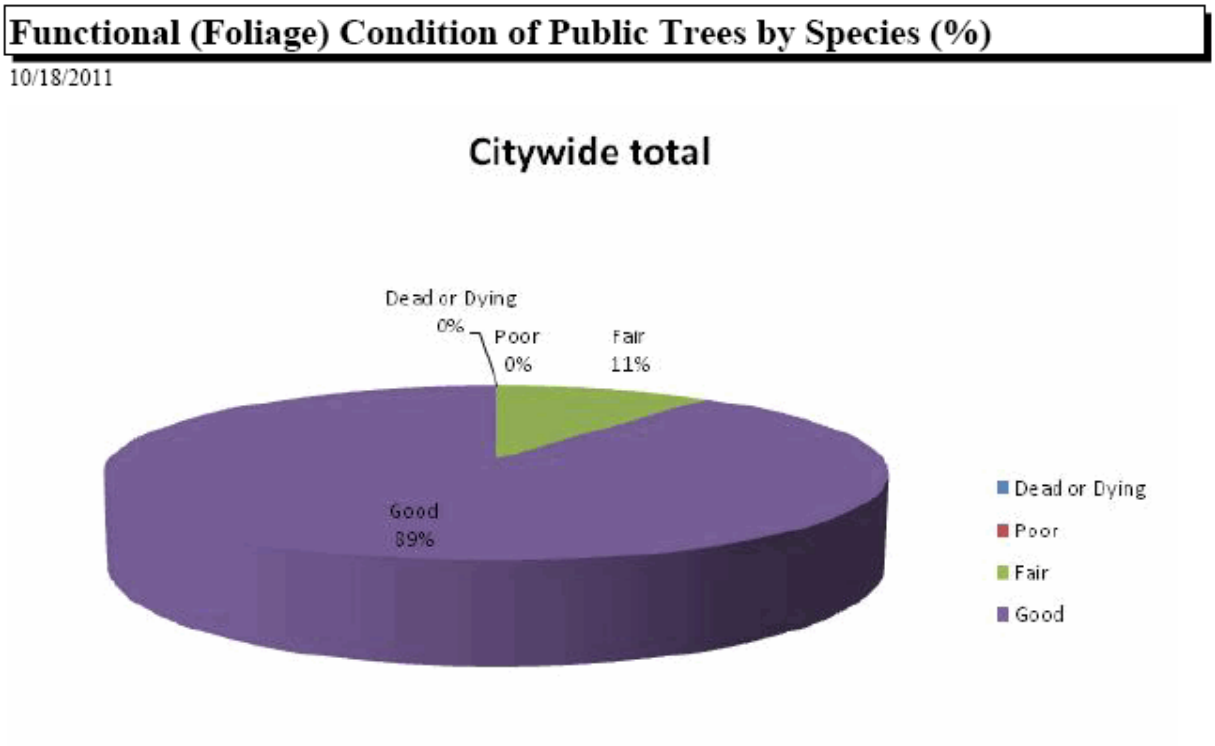



**Figure 3: Foliage Condition**

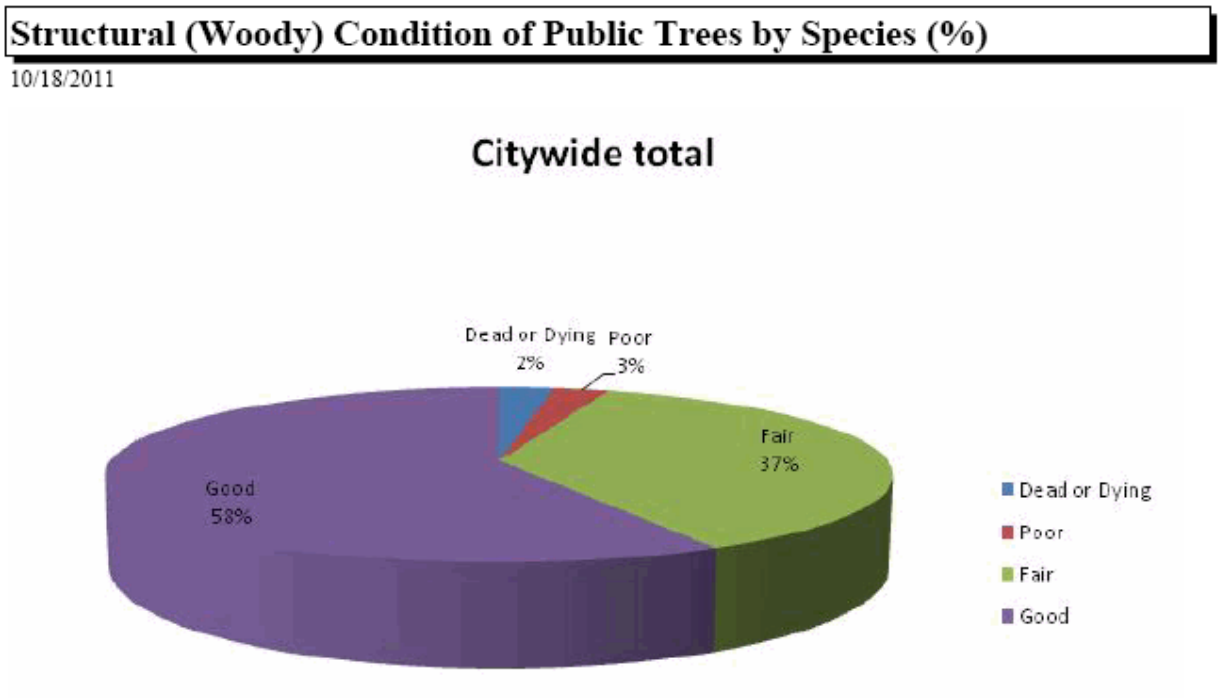
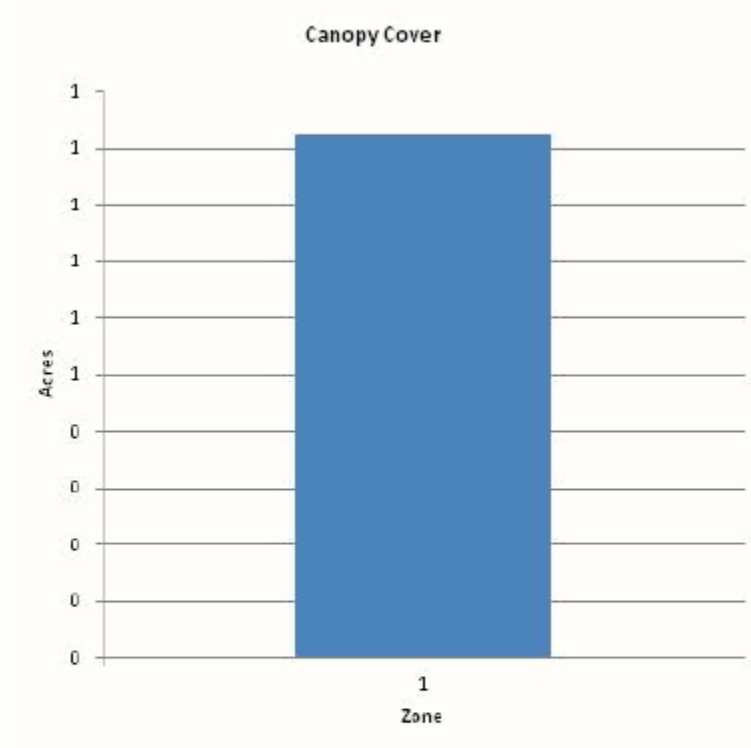



**Figure 4: Wood Condition**

## Canopy Cover of Public Trees (Acres)

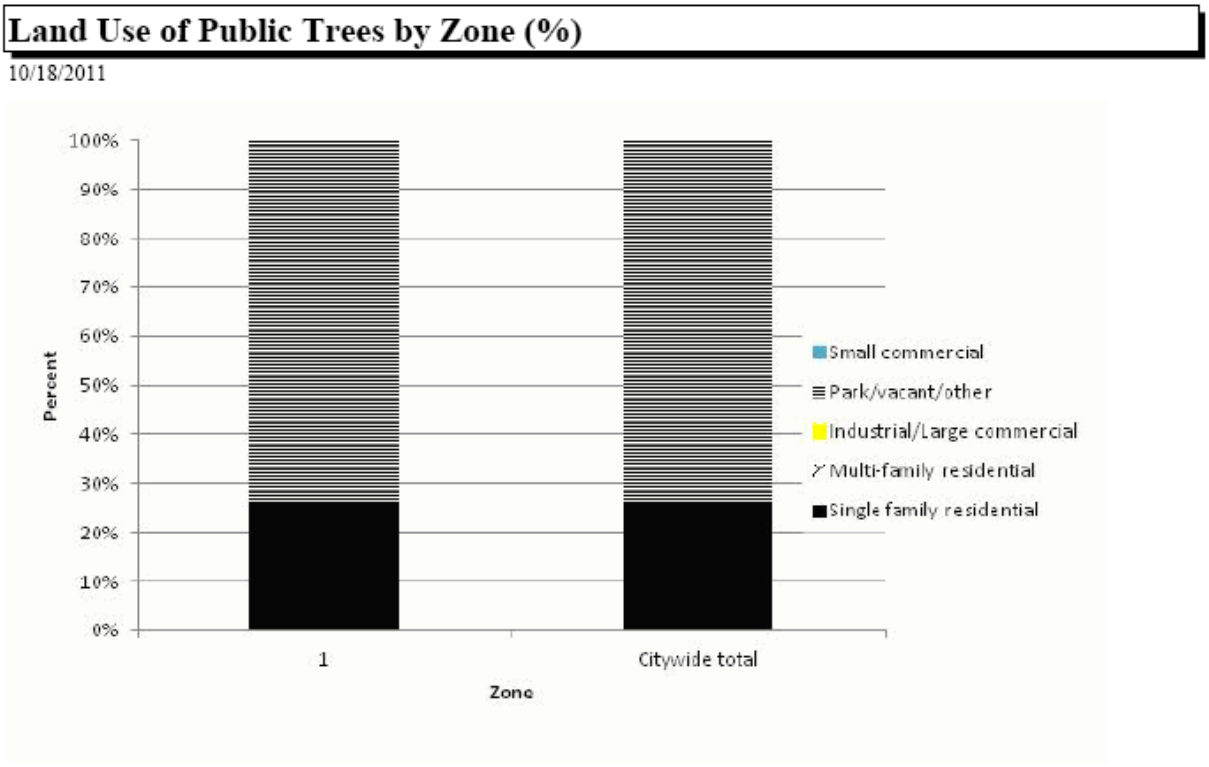
10/18/2011




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

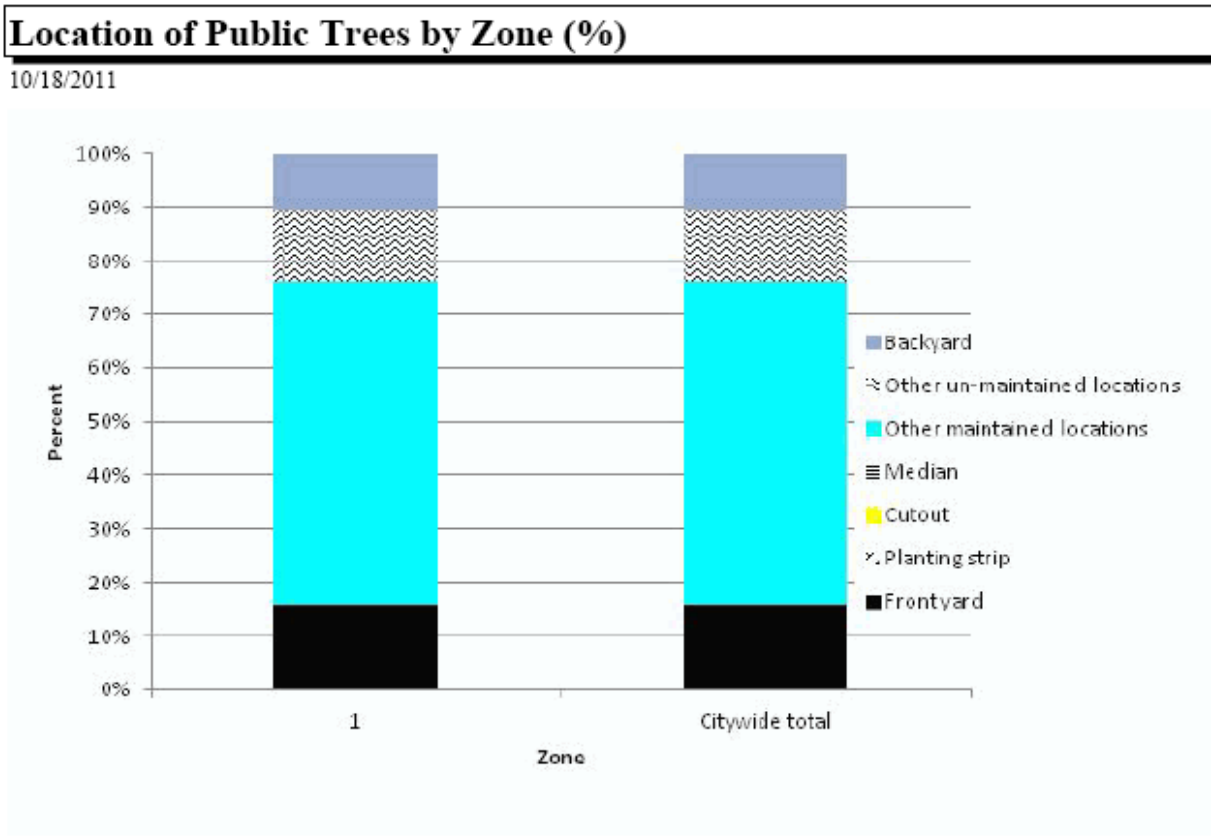
| | Total Land Area | Total Street and Sidewalk Area | Total Canopy Cover | Canopy Cover as % of Total Land Area | Canopy Cover as % of Total Streets and Sidewalks |
|---|---|---|---|---|---|
| Citywide | 0 | 0 | 1 | | |

**Figure 5: Canopy Cover in Acres**




| Zone | Single family residential | Multi-family residential | Industrial/ Large commercial | Park/vacant/ other | Small commercial |
|---|---|---|---|---|---|
| 1 | 26.3 | 0.0 | 0.0 | 73.7 | 0.0 |
| Citywide total | 26.3 | 0.0 | 0.0 | 73.7 | 0.0 |

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




| Zone | Front yard | Planting strip | Cutout | Median | Other maintained locations | Other un-maintained locations | Backyard |
|---|---|---|---|---|---|---|---|
| 1 | 15.8 | 0.0 | 0.0 | 0.0 | 60.5 | 13.2 | 10.5 |
| Citywide total | 15.8 | 0.0 | 0.0 | 0.0 | 60.5 | 13.2 | 10.5 |

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

# Appendix B: ArcGIS Mapping

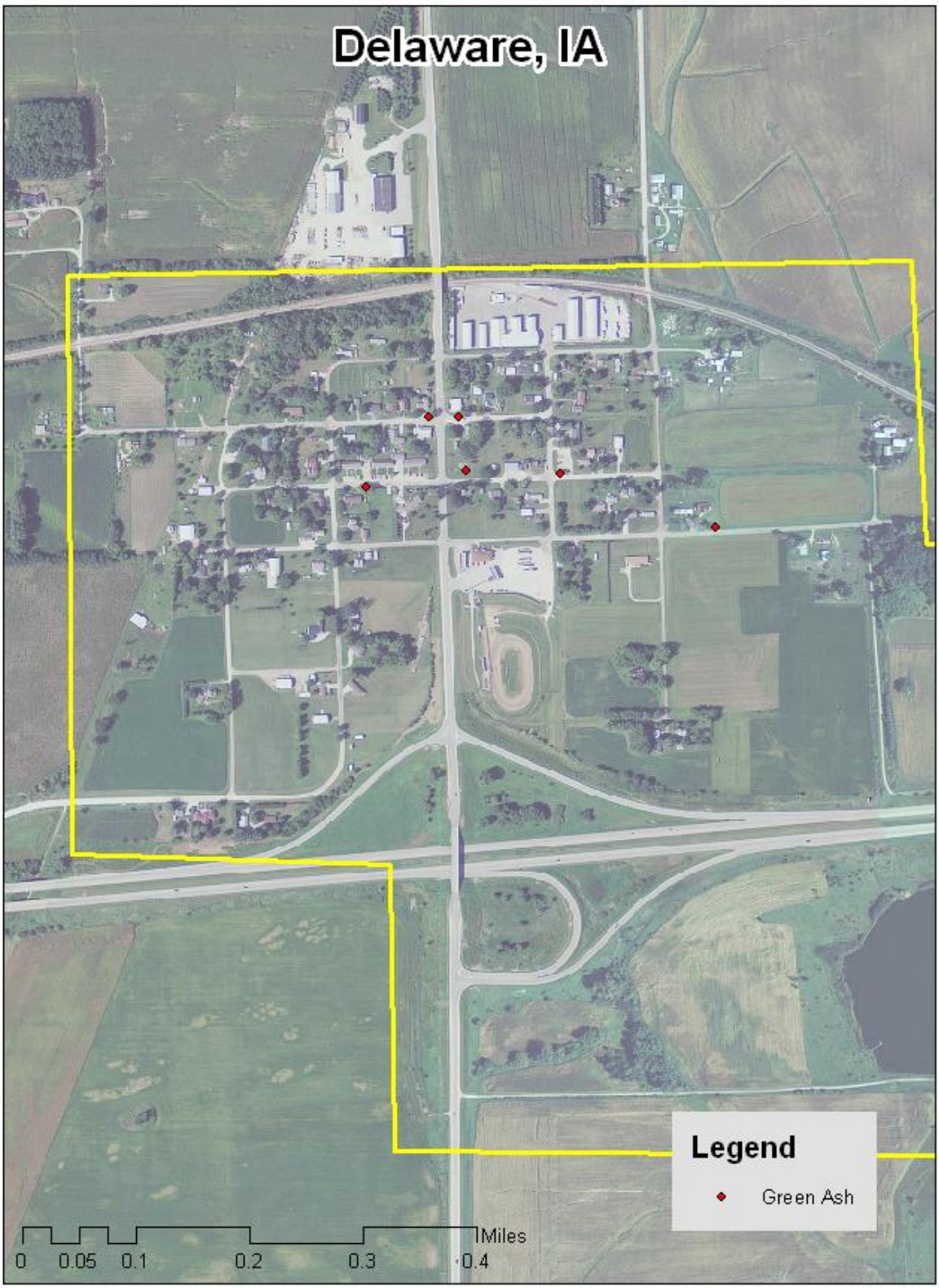



**Figure 1: Location of Ash Trees**

## NO SIGNS OR SYMPTOMS OF EAB

**Figure 2: Location of EAB symptoms**

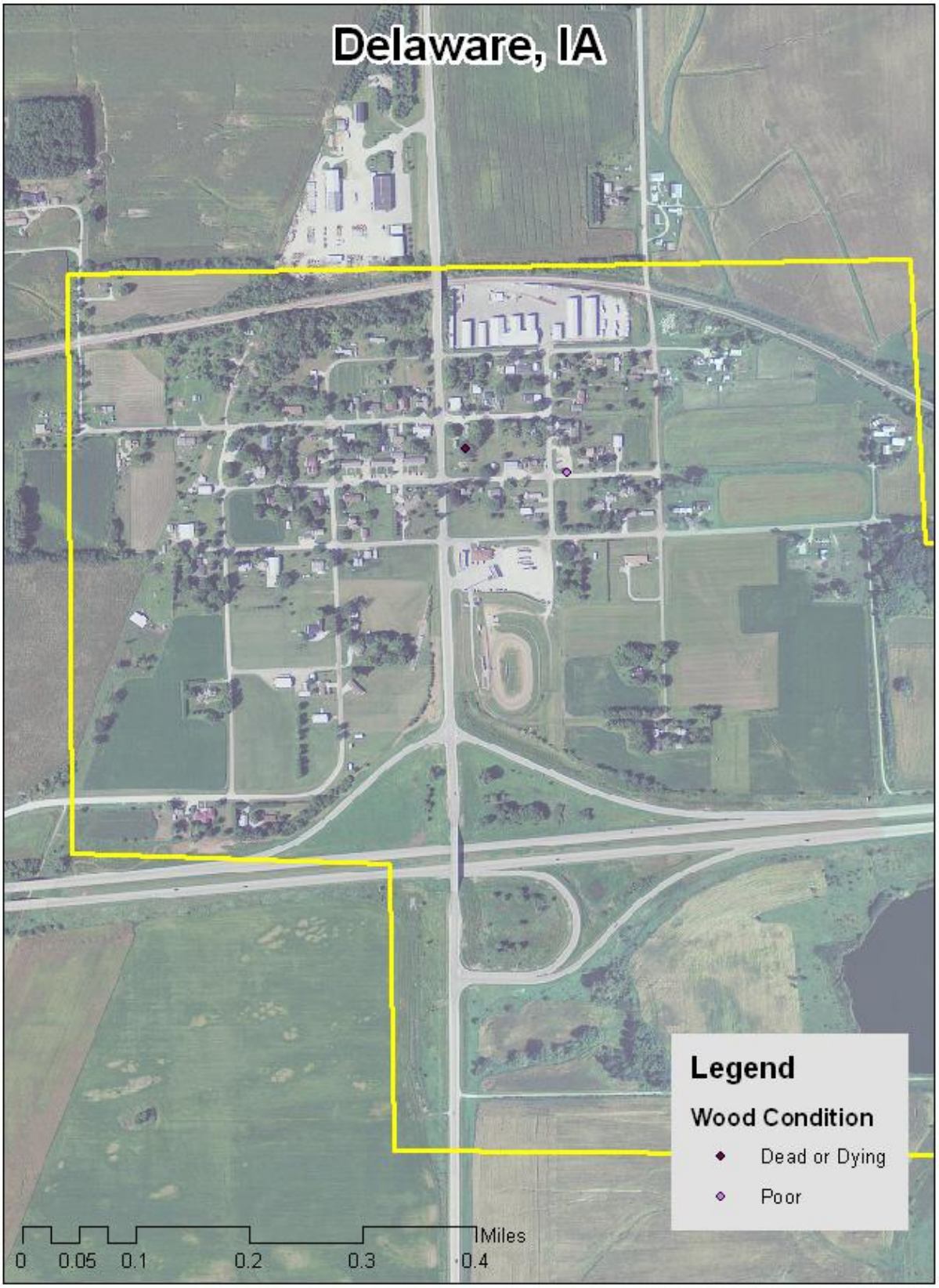



**Figure 3: Location of Poor Condition Trees**

## NO PRIORITY OF MAINTENANCE

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

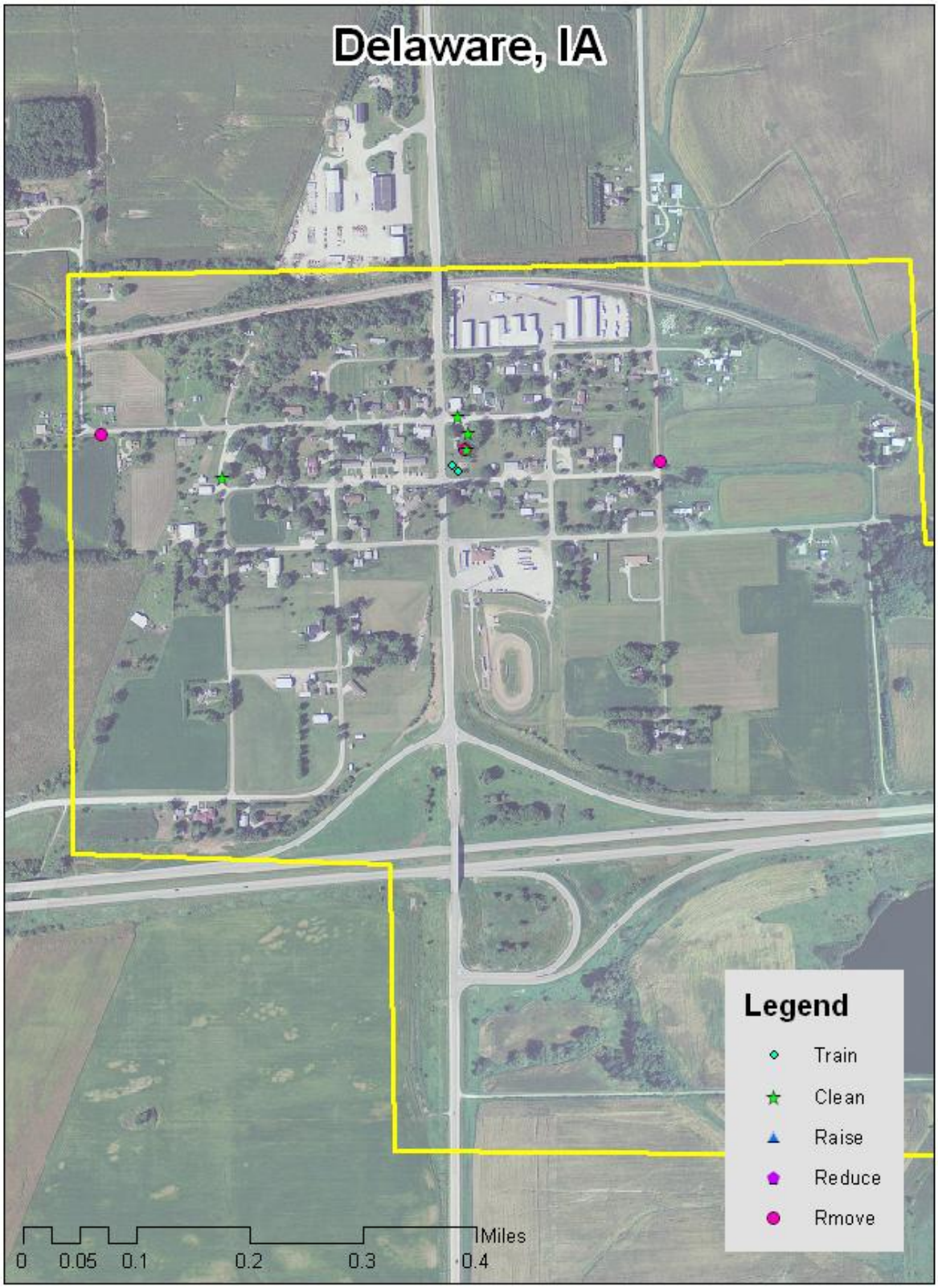



**Figure 5: Maintenance Tasks *City ownership of the trees recommended for removal should be verified prior to any removal***

# Appendix C:  Delaware's Tree Ordinances

**According to Bev, there are no ordinances pertaining to City trees.**

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

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

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