2014 Urban Forest Management Plan

# Aurora, Iowa

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# Community Tree Inventory

Aurora, Iowa

## Summary

This plan was developed to assist the City of Aurora with 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 on wood shipping crates that kills all species of ash trees (does not include mountain ash). There is a strong possibility that 17.5% of Aurora's city owned trees (ash) will die once EAB becomes established in the community. With proper planning and management, the costs of removing dead and dying trees can be extended over years, mitigating public safety issues.

## Inventory & Results

In 2014, a tree inventory was conducted using Global Positioning System (GPS) data collectors. --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. The inventory was a complete inventory of street and park trees. Below are some key findings of the **229 trees inventoried.**

## Inventory Overview

- Aurora's trees provide $38,050 of benefits annually, an average of $166 a tree
- There are over 33 species of trees
- The top three genus are: Maple 42.4%, Ash 17.5%, Pine 7%
- 29% of trees are in need of some type of management
- 4 trees are recommended for removal.

## General Recommendations

The following are key recommendations from the inventory:

- Of the 4 trees needing removal, **3 trees are over 24 inches in diameter at 4.5 ft and must be addressed** immediately. None of the 4 removals are ash trees.
  **City ownership of the trees recommended for removal should be verified prior to any removal*
- After the removal of the 4 critical concern trees, ash trees in poor health should be assessed for removal.
- 3 of the 40 ash trees should be re-evaluated at a later date, 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 does NOT include: ash, maple, cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut.
- Check ash trees with a visual survey yearly

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.

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 woodpecker damage.

## Detailed Inventory Results

The data collected for the 229 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

**1. Annual Energy Benefits:** Trees conserve energy by shading buildings and blocking winds. Aurora's trees reduce energy related costs by approximately $9,343 annually. These savings are both in Electricity (44.72 MWh) and in Natural Gas (6,070 Therms).

**2. Annual Stormwater Benefits:** Aurora's trees intercept about 534,890 gallons of rainfall or snowmelt a year. This interception provides $14,495 of benefits to the city.

**3. 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 Aurora, it is estimated that trees remove 570 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 $1,591.

**4. Annual Carbon Benefits:** Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Aurora trees sequester about 122,756 lbs of carbon dioxide (CO2) a year with an associated value of $921. In addition, the trees store 2,038,755 lbs of carbon, with a yearly benefit of $15,290.

**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. Aurora receives $11,214 in annual social benefits from trees.

**Financial Summary of all Benefits:** According to the USDA Forest Service i-Tree STRATUM analysis, Aurora's trees provide **$38,050 of benefits annually.** Benefits of individual trees vary based on size, species, health and location, but **on average each of the 229 trees in Aurora provide approximately $166 annually.**

Table 1: Annual Benefits of Public Trees

| Benefits | Per Tree | Cumulative |
|---|---|---|
| Energy | $40.80 | $9,343.31 |
| $CO_2$ | $6.14 | $1,405.87 |
| Air Quality | $6.95 | $1,590.69 |
| Stormwater | $63.30 | $14,495.51 |
| Aesthetic/Other | $48.97 | $11,214.32 |
| **Total ($)** | **$166.16** | **$38,049.70** |

## Forest Structure

**1. Species & Genus Distribution:** Aurora has over 33 different tree species along city streets and parks. The following figures and tables show the distribution of the 13 most common trees by genus and the ten most common species. 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, and it is recommended that they should not be planted until this percentage can be lowered.

Figure 1: Common Tree Genus by Percentage

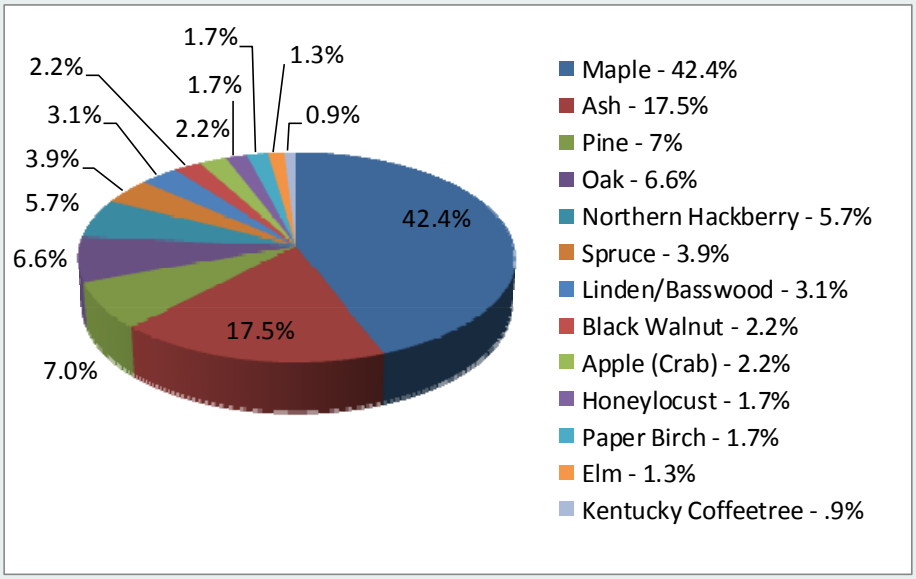


Figure 2: Common Tree Species by Percentage

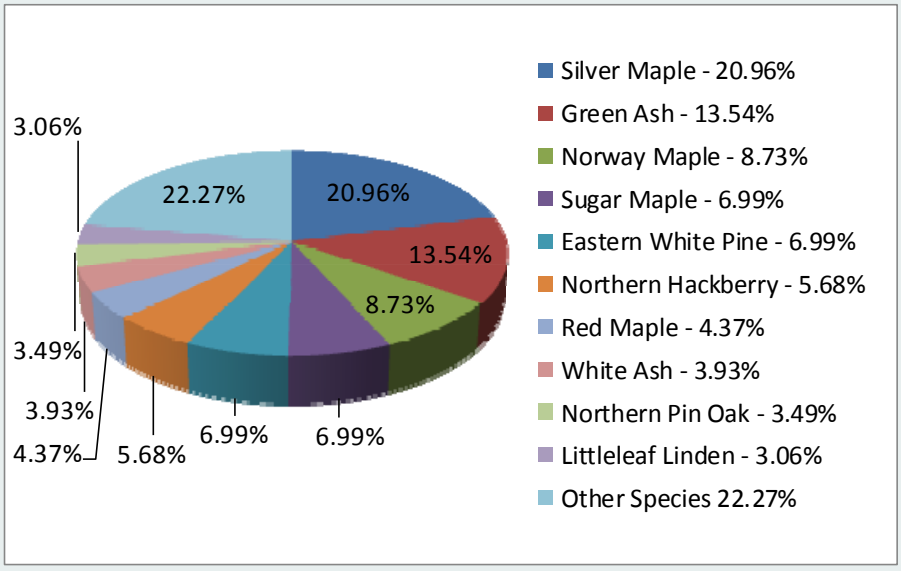


Table 2: Tree Genus

| Genus | No. of Trees |
|---|---|
| Maple | 97 |
| Ash | 40 |
| Pine | 16 |
| Oak | 15 |
| Northern Hackberry | 13 |
| Spruce | 9 |
| Linden/Basswood | 7 |
| Black Walnut | 5 |
| Apple (Crab) | 5 |
| Honeylocust | 4 |
| Elm | 3 |
| Kentucky Coffeetree | 2 |

**2. Age Class:** Aurora has a good balance of age classes. 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. Aurora's size curve is on the smaller size, indicating a younger than average stand.

Figure 3: Age Distribution of Top 10 Public Tree Species (by Percentage)

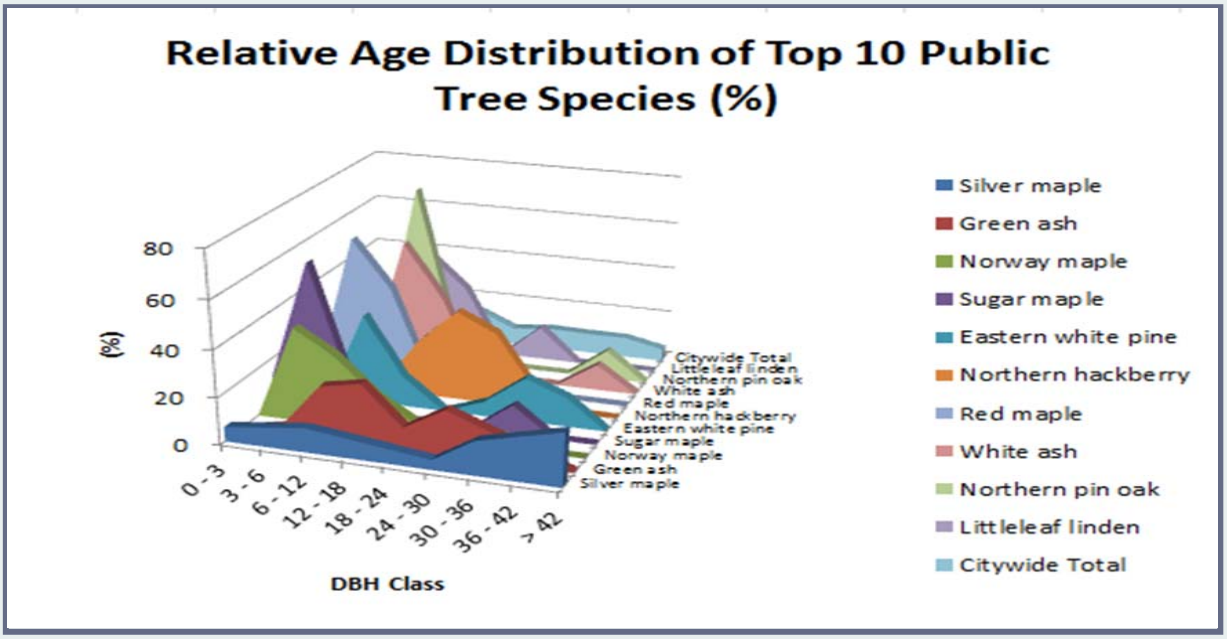


Table 3: Relative Age Distribution

| Relative Age Distribution of Top 10 Public Tree Species (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | DBH class (in) | | | | | | | | |
| Species | 0 - 3 | 3 - 6 | 6 - 12 | 12 - 18 | 18 - 24 | 24 - 30 | 30 - 36 | 36 - 42 | >42 |
| Silver maple | 6.25 | 8.33 | 10.42 | 8.33 | 6.25 | 4.17 | 14.58 | 18.75 | 22.92 |
| Green ash | 0.00 | 3.23 | 22.58 | 25.81 | 9.68 | 19.35 | 12.90 | 6.45 | 0.00 |
| Norway maple | 0.00 | 40.00 | 30.00 | 15.00 | 5.00 | 5.00 | 5.00 | 0.00 | 0.00 |
| Sugar maple | 12.50 | 62.50 | 12.50 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 |
| Eastern white pine | 12.50 | 0.00 | 37.50 | 12.50 | 0.00 | 6.25 | 18.75 | 12.50 | 0.00 |
| Northern hackberry | 0.00 | 0.00 | 0.00 | 23.08 | 38.46 | 30.77 | 7.69 | 0.00 | 0.00 |
| Red maple | 0.00 | 60.00 | 40.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| White ash | 0.00 | 0.00 | 55.56 | 33.33 | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 |
| Northern pin oak | 0.00 | 0.00 | 75.00 | 12.50 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 |
| Littleleaf linden | 0.00 | 14.29 | 42.86 | 28.57 | 0.00 | 14.29 | 0.00 | 0.00 | 0.00 |
| Citywide Total | 6.55 | 18.34 | 21.40 | 14.41 | 7.42 | 9.17 | 8.73 | 8.73 | 5.24 |

**3. 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 Aurora indicate that 98% of the trees are in fair-good health, with only 2% of the foliage in poor health, dead or dying. Similarly, 88% of Aurora's trees are in fair-good health for wood condition. Wood condition that is in poor health, dead or dying is about 12% of the population. This 12% is an estimate of trees that need management follow up soon.

**4. Management Needs:** The following management needs for Aurora's urban trees are outlined in Table 4. The table outlines the specific management needs of the street and park trees by number of trees and percent of the canopy.

- 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.
- Tree staking includes staking, training, mulching, etc.

Table 4: Management Needs

| Technique | No of Trees | Percentage |
|---|---|---|
| Crown Cleaning | 56 | 24.5% |
| Crown Raising | 3 | 1.31% |
| Tree Staking | 1 | .44% |
| Tree Removal | 4 | 1.75% |
| Crown Reduction | 1 | .44% |

Table 5: Land Use

| | |
|---|---|
| Single Family Residential | 18.78% |
| Park/Vacant/Other | 78.6% |
| Industrial/Large Commercial | 0% |
| Small Commercial | 2.62% |
| Multifamily Residential | 0% |

Table 6: Location Type

| | |
|---|---|
| Planting Strip | 17.5% |
| Other Maintained Location (Park) | 77.7% |
| Front Yard | 4.8% |
| Cutout (Surrounded by Pavement) | 0% |

**5. Canopy Cover:** Aurora occupies 366 acres. The total tree canopy with both private and public trees is approximately 25 acres, about 7%.

**6. Land Use and Location:** The majority of Aurora's city and park trees are in the city park. Table 5 & Table 6 describe the land use and locations for the street and park trees.

## Recommendations

**1. 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.

**2. Hazardous Trees:** Aurora has 4 critical concern trees that need immediate removal. These trees can be seen on the Location of Trees with Recommended Maintenance map (Appendix B, Image 4 & Image 5). It is recommended to start with the large diameter critical concern trees first. There are 3 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 maintenance that do not include trimming. There is a total of 1 tree with these needs.

**3. Poor Tree Species:** After the removal of the critical concern trees, ash trees in poor health should be assessed for removal (Appendix B, Image 3 & Appendix B, Image 4). Of the 4 removals, none are ash trees. There are a total of 40 ash trees, and 2 of those have signs and symptoms that have

been associated with EAB. In addition, there are 22 trees that are in poor health. *City ownership of the trees recommended for removal should be verified prior to any removal.

**4. 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.

**5. 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%. 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 Aurora.

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 (42.4%). Maple 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. All trees planted must meet the restrictions in the city tree ordinance.

The importance of species diversity was brought to the forefront with the loss of the American elm from Dutch elm disease. When one genus (Maple) makes up a majority of the species (Norway Maple, Silver Maple, Sugar Maple) in a planting it is an unbalanced population. These unbalanced populations leave the population open to destruction from diseases and pests. Unfortunately, the lessons of the American elm are only recently being heeded. Communities typically replaced lost elms with a small but reliable selection of ash and Norway and silver maple. This left cities in the predicament they are finding themselves in now as they stand to lose a large percentage of their ash trees to the emerald ash borer.

**6. Continual Monitoring:** It is important to continuously check the health of all trees. Due to the imminent threat of Emerald Ash Borer to ash trees, it is recommended that 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. For a list of forest health threats, please visit the Iowa DNR's website at http://www.iowadnr.gov/Environment/Forestry/ForestHealth

## Six Year Maintenance Plan with No Additional Funding

**Year 1:** Removal: 3 largest critical concern trees (0 ash of critical concern) or saving for ash tree treatment

Planting and Replacement: 4 trees to be planted in open locations

Visual Survey for signs and symptoms of EAB

**Year 2:** Removal: 1 critical concern trees of all species and 2 ash in poor health or saving for ash tree treatment

Planting and Replacement: 4 trees in open locations from year one removals

Routine pruning: Contract to trim 1/3 of the city trees

Visual Survey for signs and symptoms of EAB

**Year 3:** Removal: 3 ash in poor health or saving for ash tree treatment

Planting and Replacement: 4 trees to be planted in open locations and locations from previous removals

Visual Survey for signs and symptoms of EAB

**Year 4:** Removal: any new critical concern trees and/or 3 ash in poor health or saving for ash tree treatment

Planting and Replacement: 4 trees in open locations from previous removals

Routine pruning: Contract to trim 1/3 of the city trees

Visual Survey for signs and symptoms of EAB

**Year 5:** Removal: 3 trees (new critical concern trees and/or ash in poor health) or saving for ash tree treatment

Planting and Replacement: 4 trees to be planted in open locations and locations from previous removals

Visual Survey for signs and symptoms of EAB

**Year 6:** Removal: 3 trees (new critical concern trees and/or ash in poor health) or saving for ash tree treatment

Planting and Replacement: 4 trees in open locations from previous removals

Routine pruning: Contract to trim 1/3 of the city trees

Visual Survey for signs and symptoms of EAB

Reduction of ash over 6 years: Approximately 14 ash trees removed (35% of ash). It will take nearly 13 years to remove all the ash with the current budget. EAB could potentially kill all ash within 4 years of its arrival. ** To remove all ash trees within 6 years, and do nothing else, the budget would need to be increased to $6,100 a year.

# Emerald Ash Borer Plan

### 1. Ash Tree Removal

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

### 2. Treatment of Ash Trees

Chemical treatment can be effective, spreading 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/


Emerald Ash Borer Beetle next to D-shaped exit holes.

### 3. 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.

### 4. 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.

### 5. Canopy Replacement

As budget permits, all removed ash trees will be replaced. All trees will meet the restrictions in the city ordinance. The new plantings will be a diverse mix and will not include ash, maple, cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut.

### 6. 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.

**7. Monitoring (repeated)**

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 die-back, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

**8. Private Ash Trees**

It is strongly recommended that private property owners start removing ash trees or treating healthy trees they desire to preserve on their property upon arrival of EAB or confirmed within 15 miles. Refer to City Ordinance for more information on private trees.

# Proposed Budget

Total $21,000 over 6 years ($3,500/year)

**FY 2015 Budget**

Removal @ $700/tree: $2,100 *Or saving for ash tree treatment

Planting @ $100/tree: $400

Watering & Maintenance @ $50/tree: $500

**FY 2016 Budget**

Removal: $2,100 *Or saving for ash tree treatment

Planting: $400

Contract 1/3 trimming: $500

Watering & Maintenance: $500

**FY 2017 Budget**

Removal: $2,100 *Or saving for ash tree treatment

Planting: $400

Watering & Maintenance: $500

**FY 2018 Budget**

Removal: $2,100 *Or saving for ash tree treatment

Planting: $400

Contract 1/3 trimming: $500

Watering & Maintenance: $500

**FY 2019 Budget**

Removal: $2,100 *Or saving for ash tree treatment

Planting: $400

Watering & Maintenance: $500

**FY 2020 Budget**

Removal: $2,100 *Or saving for ash tree treatment

Planting: $400

Contract 1/3 trimming: $500

Watering & Maintenance: $500

*Reduction of ash over 6 years: Approximately 14 ash trees removed (35% of ash). It will take nearly 13 years to remove all the ash with the current budget.

Proposed Budget Increase

EAB could potentially kill all ash trees in Aurora within 4 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to $6,100 a year. Additionally, it is recommended that Aurora apply for grants to fund replacement trees. Utility Company grants are usually between $500 and $10,000 for community-based, tree-planting projects that include parks, gateways, cemeteries, nature trails, libraries, nursing homes, and schools.

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# Appendix A: i-Tree Data

## Table 1: Annual Energy Benefits

| Annual Energy Benefits of Public Trees by Species | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | Total Electricity (MWh) | Electricity ($) | Total Natural Gas (Therms) | Natural Gas ($) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
| Silver maple | 14.39 | 1,092.44 | 1,895.78 | 1,857.86 | 2,950.30 | (N/A) | 20.96 | 31.58 | 61.46 |
| Green ash | 7.76 | 588.66 | 1,043.87 | 1,022.99 | 1,611.65 | (N/A) | 13.54 | 17.25 | 51.99 |
| Norway maple | 2.55 | 193.37 | 373.51 | 366.04 | 559.41 | (N/A) | 8.73 | 5.99 | 27.97 |
| Sugar maple | 1.30 | 98.53 | 177.12 | 173.57 | 272.11 | (N/A) | 6.99 | 2.91 | 17.01 |
| Eastern white pine | 1.72 | 130.20 | 235.15 | 230.44 | 360.64 | (N/A) | 6.99 | 3.86 | 22.54 |
| Northern hackberry | 4.23 | 321.30 | 601.89 | 589.85 | 911.15 | (N/A) | 5.68 | 9.75 | 70.09 |
| Red maple | 0.66 | 49.98 | 97.39 | 95.44 | 145.42 | (N/A) | 4.37 | 1.56 | 14.54 |
| White ash | 1.79 | 136.20 | 213.93 | 209.65 | 345.85 | (N/A) | 3.93 | 3.70 | 38.43 |
| Northern pin oak | 1.19 | 89.99 | 178.02 | 174.46 | 264.45 | (N/A) | 3.49 | 2.83 | 33.06 |
| Littleleaf linden | 0.95 | 72.21 | 131.08 | 128.46 | 200.67 | (N/A) | 3.06 | 2.15 | 28.67 |
| Black walnut | 1.02 | 77.14 | 138.13 | 135.37 | 212.51 | (N/A) | 2.18 | 2.27 | 42.50 |
| Apple | 0.27 | 20.69 | 39.85 | 39.05 | 59.74 | (N/A) | 2.18 | 0.64 | 11.95 |
| Spruce | 0.01 | 1.10 | 2.66 | 2.61 | 3.71 | (N/A) | 1.75 | 0.04 | 0.93 |
| Northern red oak | 0.87 | 65.89 | 123.36 | 120.90 | 186.78 | (N/A) | 1.75 | 2.00 | 46.70 |
| Paper birch | 0.35 | 26.58 | 49.18 | 48.20 | 74.77 | (N/A) | 1.75 | 0.80 | 18.69 |
| Honeylocust | 1.23 | 93.29 | 156.45 | 153.32 | 246.61 | (N/A) | 1.75 | 2.64 | 61.65 |
| Blue spruce | 0.23 | 17.52 | 34.57 | 33.88 | 51.39 | (N/A) | 1.31 | 0.55 | 17.13 |
| Norway spruce | 0.19 | 14.35 | 25.26 | 24.76 | 39.10 | (N/A) | 0.87 | 0.42 | 19.55 |
| American elm | 0.54 | 40.68 | 69.28 | 67.89 | 108.57 | (N/A) | 0.87 | 1.16 | 54.28 |
| Swamp white oak | 0.24 | 18.20 | 30.28 | 29.68 | 47.88 | (N/A) | 0.87 | 0.51 | 23.94 |
| Other City Trees | 8.88 | 673.81 | 1,192.06 | 1,168.22 | 1,842.03 | (N/A) | 25.76 | 19.71 | 30.57 |
| Total | 44.72 | 3,394.34 | 6,070.38 | 5,948.97 | 9,343.31 | (N/A) | 100.00 | 100.00 | 40.80 |

## Table 2: Annual Stormwater Benefits

| Annual Stormwater Benefits of Public Trees by Species | | | | | | |
|---|---|---|---|---|---|---|
| Species | Total Rainfall Interception (Gal) | Total ($) | Standard Error | % of Total Tree Numbers | % of Total $ | Avg. $/tree |
| Silver maple | 225,630.37 | 6,114.58 | (N/A) | 20.96 | 42.18 | 127.39 |
| Green ash | 84,020.74 | 2,276.96 | (N/A) | 13.54 | 15.71 | 73.45 |
| Norway maple | 19,052.64 | 516.33 | (N/A) | 8.73 | 3.56 | 25.82 |
| Sugar maple | 13,177.48 | 357.11 | (N/A) | 6.99 | 2.46 | 22.32 |
| Eastern white pine | 34,375.76 | 931.58 | (N/A) | 6.99 | 6.43 | 58.22 |
| Northern hackberry | 35,899.88 | 972.89 | (N/A) | 5.68 | 6.71 | 74.84 |
| Red maple | 3,324.76 | 90.10 | (N/A) | 4.37 | 0.62 | 9.01 |
| White ash | 15,938.45 | 431.93 | (N/A) | 3.93 | 2.98 | 47.99 |
| Northern pin oak | 8,689.20 | 235.48 | (N/A) | 3.49 | 1.62 | 29.43 |
| Littleleaf linden | 7,738.52 | 209.71 | (N/A) | 3.06 | 1.45 | 29.96 |
| Black walnut | 10,130.95 | 274.55 | (N/A) | 2.18 | 1.89 | 54.91 |
| Apple | 941.17 | 25.51 | (N/A) | 2.18 | 0.18 | 5.10 |
| Spruce | 194.96 | 5.28 | (N/A) | 1.75 | 0.04 | 1.32 |
| Northern red oak | 9,619.54 | 260.69 | (N/A) | 1.75 | 1.80 | 65.17 |
| Paper birch | 3,105.58 | 84.16 | (N/A) | 1.75 | 0.58 | 21.04 |
| Honeylocust | 10,703.78 | 290.07 | (N/A) | 1.75 | 2.00 | 72.52 |
| Blue spruce | 3,324.26 | 90.09 | (N/A) | 1.31 | 0.62 | 30.03 |
| Norway spruce | 4,653.39 | 126.11 | (N/A) | 0.87 | 0.87 | 63.05 |
| American elm | 4,170.03 | 113.01 | (N/A) | 0.87 | 0.78 | 56.50 |
| Swamp white oak | 1,421.30 | 38.52 | (N/A) | 0.87 | 0.27 | 19.26 |
| Other City Trees | 80,631.12 | 2,185.10 | (N/A) | 25.76 | 15.07 | 38.18 |
| Citywide total | 534,889.73 | 14,495.51 | (N/A) | 100.00 | 100.00 | 63.30 |

**Annual Air Quality Benefits of Public Trees by Species**

| Species | Deposition O3 (lb) | Deposition NO2 (lb) | Deposition PM10 (lb) | Deposition SO2 (lb) | Total Deposition ($) | Avoided NO2 (lb) | Avoided PM10 (lb) | Avoided VOC (lb) | Avoided SO2 (lb) | Total Avoided ($) | BVOC Emissions (lb) | BVOC Emissions ($) | Total (lb) | Total ($) | Standard Error | % of Total Trees | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Silver maple | 42.42 | 7.19 | 20.50 | 1.88 | 227.81 | 67.87 | 9.93 | 9.48 | 65.10 | 424.57 | - 22.59 | - 84.70 | 201.80 | 567.68 | (N/A) | 20.96 | 11.83 |
| Green ash | 10.30 | 1.65 | 4.95 | 0.46 | 54.91 | 36.87 | 5.38 | 5.13 | 35.15 | 230.08 | 0.00 | 0.00 | 99.89 | 284.99 | (N/A) | 13.54 | 9.19 |
| Norway maple | 3.26 | 0.56 | 1.71 | 0.14 | 17.92 | 12.41 | 1.79 | 1.70 | 11.56 | 76.74 | - 0.82 | - 3.09 | 32.32 | 91.57 | (N/A) | 8.73 | 4.58 |
| Sugar maple | 1.67 | 0.28 | 0.86 | 0.07 | 9.12 | 6.17 | 0.90 | 0.86 | 5.88 | 38.51 | - 1.33 | - 4.99 | 15.37 | 42.64 | (N/A) | 6.99 | 2.67 |
| Eastern white pine | 4.05 | 0.80 | 3.30 | 0.50 | 26.62 | 8.17 | 1.19 | 1.14 | 7.77 | 50.95 | - 19.31 | - 72.42 | 7.62 | 5.15 | (N/A) | 6.99 | 0.32 |
| Northern hackberry | 5.03 | 0.87 | 2.67 | 0.23 | 27.76 | 20.44 | 2.96 | 2.82 | 19.20 | 126.82 | 0.00 | 0.00 | 54.22 | 154.58 | (N/A) | 5.68 | 11.89 |
| Red maple | 0.36 | 0.06 | 0.23 | 0.02 | 2.11 | 3.20 | 0.46 | 0.44 | 2.98 | 19.77 | - 0.16 | - 0.60 | 7.59 | 21.28 | (N/A) | 4.37 | 2.13 |
| White ash | 2.36 | 0.38 | 1.14 | 0.11 | 12.61 | 8.27 | 1.23 | 1.17 | 8.13 | 52.26 | 0.00 | 0.00 | 22.79 | 64.86 | (N/A) | 3.93 | 7.21 |
| Northern pin oak | 1.42 | 0.24 | 0.76 | 0.06 | 7.84 | 5.81 | 0.84 | 0.79 | 5.38 | 35.85 | - 0.37 | - 1.38 | 14.94 | 42.30 | (N/A) | 3.49 | 5.29 |
| Littleleaf linden | 1.15 | 0.20 | 0.60 | 0.05 | 6.32 | 4.56 | 0.66 | 0.63 | 4.32 | 28.37 | - 0.59 | - 2.20 | 11.59 | 32.50 | (N/A) | 3.06 | 4.64 |
| Black walnut | 1.13 | 0.18 | 0.56 | 0.05 | 6.05 | 4.84 | 0.71 | 0.67 | 4.61 | 30.19 | 0.00 | 0.00 | 12.74 | 36.24 | (N/A) | 2.18 | 7.25 |
| Apple | 0.22 | 0.04 | 0.11 | 0.01 | 1.22 | 1.32 | 0.19 | 0.18 | 1.23 | 8.19 | 0.00 | 0.00 | 3.31 | 9.40 | (N/A) | 2.18 | 1.88 |
| Spruce | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.08 | 0.01 | 0.01 | 0.07 | 0.46 | - 0.07 | - 0.27 | 0.10 | 0.20 | (N/A) | 1.75 | 0.05 |
| Northern red oak | 2.08 | 0.36 | 1.00 | 0.09 | 11.21 | 4.18 | 0.61 | 0.58 | 3.93 | 25.94 | - 3.02 | - 11.31 | 9.82 | 25.84 | (N/A) | 1.75 | 6.46 |
| Paper birch | 0.27 | 0.04 | 0.15 | 0.01 | 1.51 | 1.68 | 0.24 | 0.23 | 1.59 | 10.44 | 0.00 | 0.00 | 4.22 | 11.95 | (N/A) | 1.75 | 2.99 |
| Honeylocust | 2.00 | 0.33 | 0.93 | 0.09 | 10.60 | 5.75 | 0.85 | 0.81 | 5.57 | 36.12 | - 1.45 | - 5.43 | 14.87 | 41.29 | (N/A) | 1.75 | 10.32 |
| Blue spruce | 0.43 | 0.09 | 0.37 | 0.05 | 2.90 | 1.12 | 0.16 | 0.15 | 1.04 | 6.95 | - 1.19 | - 4.46 | 2.24 | 5.39 | (N/A) | 1.31 | 1.80 |
| Norway spruce | 0.57 | 0.11 | 0.45 | 0.07 | 3.69 | 0.89 | 0.13 | 0.12 | 0.86 | 5.59 | - 2.88 | - 10.81 | 0.32 | - 1.53 | (N/A) | 0.87 | - 0.76 |
| American elm | 0.32 | 0.06 | 0.20 | 0.01 | 1.86 | 2.52 | 0.37 | 0.35 | 2.43 | 15.81 | 0.00 | 0.00 | 6.27 | 17.68 | (N/A) | 0.87 | 8.84 |
| Swamp white oak | 0.22 | 0.04 | 0.12 | 0.01 | 1.21 | 1.12 | 0.17 | 0.16 | 1.09 | 7.06 | - 0.06 | - 0.22 | 2.86 | 8.06 | (N/A) | 0.87 | 4.03 |
| Other City Trees | 12.18 | 2.06 | 6.40 | 0.62 | 67.02 | 42.16 | 6.16 | 5.87 | 40.24 | 263.22 | - 9.62 | - 36.08 | 106.07 | 294.16 | (N/A) | 25.76 | 4.61 |
| Citywide Total | 85.61 | 14.52 | 43.56 | 4.21 | 466.80 | 212.87 | 31.03 | 29.60 | 202.57 | 1,327.39 | - 54.27 | - 203.50 | 569.69 | 1,590.69 | (N/A) | 100.00 | 6.95 |

**Annual CO2 Benefits of Public Trees by Species**

| Species | Sequestered (lb) | Sequestered ($) | Decomposition Release(lb) | Maintenance Release (lb) | Total Release ($) | Avoided (lb) | Avoided ($) | Net Total (lb) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Silver maple | 69,295.25 | 519.71 | - 5,058.56 | - 171.80 | - 1.29 | 24,142.67 | 181.07 | 88,207.56 | 661.56 | (N/A) | 20.96 | 47.06 | 13.78 |
| Green ash | 17,881.35 | 134.11 | - 1,627.69 | - 80.93 | - 0.61 | 13,009.33 | 97.57 | 29,182.07 | 218.87 | (N/A) | 13.54 | 15.57 | 7.06 |
| Norway maple | 4,106.40 | 30.80 | - 273.10 | - 28.08 | - 0.21 | 4,273.53 | 32.05 | 8,078.76 | 60.59 | (N/A) | 8.73 | 4.31 | 3.03 |
| Sugar maple | 2,890.12 | 21.68 | - 247.25 | - 17.16 | - 0.13 | 2,177.57 | 16.33 | 4,803.28 | 36.02 | (N/A) | 6.99 | 2.56 | 2.25 |
| Eastern white pine | 809.96 | 6.07 | - 234.39 | - 37.83 | - 0.28 | 2,877.33 | 21.58 | 3,415.08 | 25.61 | (N/A) | 6.99 | 1.82 | 1.60 |
| Northern hackberry | 4,983.11 | 37.37 | - 342.94 | - 37.83 | - 0.28 | 7,100.68 | 53.26 | 11,703.02 | 87.77 | (N/A) | 5.68 | 6.24 | 6.75 |
| Red maple | 893.46 | 6.70 | - 27.42 | - 8.19 | - 0.06 | 1,104.54 | 8.28 | 1,962.38 | 14.72 | (N/A) | 4.37 | 1.05 | 1.47 |
| White ash | 2,391.41 | 17.94 | - 202.23 | - 16.77 | - 0.13 | 3,009.92 | 22.57 | 5,182.34 | 38.87 | (N/A) | 3.93 | 2.76 | 4.32 |
| Northern pin oak | 1,729.64 | 12.97 | - 117.64 | - 13.26 | - 0.10 | 1,988.74 | 14.92 | 3,587.47 | 26.91 | (N/A) | 3.49 | 1.91 | 3.36 |
| Littleleaf linden | 2,876.15 | 21.57 | - 123.91 | - 11.51 | - 0.09 | 1,595.74 | 11.97 | 4,336.48 | 32.52 | (N/A) | 3.06 | 2.31 | 4.65 |
| Black walnut | 2,442.06 | 18.32 | - 174.90 | - 10.73 | - 0.08 | 1,704.78 | 12.79 | 3,961.22 | 29.71 | (N/A) | 2.18 | 2.11 | 5.94 |
| Apple | 419.40 | 3.15 | - 17.99 | - 4.29 | - 0.03 | 457.25 | 3.43 | 854.37 | 6.41 | (N/A) | 2.18 | 0.46 | 1.28 |
| Spruce | 14.14 | 0.11 | - 0.08 | - 0.78 | - 0.01 | 24.30 | 0.18 | 37.58 | 0.28 | (N/A) | 1.75 | 0.02 | 0.07 |
| Northern red oak | 517.23 | 3.88 | - 224.36 | - 11.70 | - 0.09 | 1,456.08 | 10.92 | 1,737.25 | 13.03 | (N/A) | 1.75 | 0.93 | 3.26 |
| Paper birch | 882.23 | 6.62 | - 43.27 | - 4.49 | - 0.03 | 587.31 | 4.40 | 1,421.79 | 10.66 | (N/A) | 1.75 | 0.76 | 2.67 |
| Honeylocust | 3,370.70 | 25.28 | - 120.30 | - 9.36 | - 0.07 | 2,061.64 | 15.46 | 5,302.68 | 39.77 | (N/A) | 1.75 | 2.83 | 9.94 |
| Blue spruce | 197.72 | 1.48 | - 14.34 | - 4.49 | - 0.03 | 387.15 | 2.90 | 566.04 | 4.25 | (N/A) | 1.31 | 0.30 | 1.42 |
| Norway spruce | 259.58 | 1.95 | - 35.97 | - 3.71 | - 0.03 | 317.03 | 2.38 | 536.94 | 4.03 | (N/A) | 0.87 | 0.29 | 2.01 |
| American elm | 563.63 | 4.23 | - 46.94 | - 4.68 | - 0.04 | 898.95 | 6.74 | 1,410.96 | 10.58 | (N/A) | 0.87 | 0.75 | 5.29 |
| Swamp white oak | 391.37 | 2.94 | - 17.53 | - 2.15 | - 0.02 | 402.20 | 3.02 | 773.89 | 5.80 | (N/A) | 0.87 | 0.41 | 2.90 |
| Other City Trees | 16,055.27 | 120.41 | - 1,139.46 | - 97.89 | - 0.73 | 14,891.08 | 111.68 | 29,709.00 | 222.82 | | 25.76 | 15.85 | 3.62 |
| Citywide Total | 122,756.15 | 920.67 | - 9,802.43 | - 518.90 | - 3.89 | 75,014.04 | 562.61 | 187,448.86 | 1,405.87 | (N/A) | 100.00 | 100.00 | 6.14 |

## Table 5: Annual Carbon Stored

| Stored CO2 Benefits of Public Trees by Species | | | | | | |
|---|---|---|---|---|---|---|
| Species | Total stored CO2 (lbs) | Total ($) | Stand. Error | % of Total Trees | % of Total $ | Avg. $/tree |
| Silver maple | 1,053,251.14 | 7,899.38 | (N/A) | 20.96 | 51.66 | 164.57 |
| Green ash | 339,101.10 | 2,543.26 | (N/A) | 13.54 | 16.63 | 82.04 |
| Norway maple | 55,729.80 | 417.97 | (N/A) | 8.73 | 2.73 | 20.90 |
| Sugar maple | 50,031.27 | 375.23 | (N/A) | 6.99 | 2.45 | 23.45 |
| Eastern white pine | 48,827.34 | 366.21 | (N/A) | 6.99 | 2.39 | 22.89 |
| Northern hackberry | 71,445.24 | 535.84 | (N/A) | 5.68 | 3.50 | 41.22 |
| Red maple | 5,713.47 | 42.85 | (N/A) | 4.37 | 0.28 | 4.29 |
| White ash | 42,131.30 | 315.98 | (N/A) | 3.93 | 2.07 | 35.11 |
| Northern pin oak | 24,508.32 | 183.81 | (N/A) | 3.49 | 1.20 | 22.98 |
| Littleleaf linden | 25,689.47 | 192.67 | (N/A) | 3.06 | 1.26 | 27.52 |
| Black walnut | 36,437.35 | 273.28 | (N/A) | 2.18 | 1.79 | 54.66 |
| Apple | 3,748.32 | 28.11 | (N/A) | 2.18 | 0.18 | 5.62 |
| Spruce | 9.89 | 0.07 | (N/A) | 1.75 | 0.00 | 0.02 |
| Northern red oak | 46,741.48 | 350.56 | (N/A) | 1.75 | 2.29 | 87.64 |
| Paper birch | 9,014.06 | 67.61 | (N/A) | 1.75 | 0.44 | 16.90 |
| Honeylocust | 25,061.87 | 187.96 | (N/A) | 1.75 | 1.23 | 46.99 |
| Blue spruce | 2,988.30 | 22.41 | (N/A) | 1.31 | 0.15 | 7.47 |
| Norway spruce | 7,492.77 | 56.20 | (N/A) | 0.87 | 0.37 | 28.10 |
| American elm | 9,779.87 | 73.35 | (N/A) | 0.87 | 0.48 | 36.67 |
| Swamp white oak | 3,641.00 | 27.31 | (N/A) | 0.87 | 0.18 | 13.65 |
| Other City Trees | 237,243.98 | 1,779.33 | (N/A) | 25.76 | 11.64 | 29.49 |
| Citywide total | 2,038,755.53 | 15,290.67 | (N/A) | 100.00 | 100.00 | 66.77 |

## Table 6: Annual Social and Aesthetic Benefits

| Annual Aesthetic/Other Benefit of Public Trees by Species | | | | | |
|---|---|---|---|---|---|
| Species | Total ($) | Stand. Error | % of Total Trees | % of Total $ | Avg. $/tree |
| Silver maple | 5,114.32 | (N/A) | 20.96 | 45.61 | 106.55 |
| Green ash | 1,531.16 | (N/A) | 13.54 | 13.65 | 49.39 |
| Norway maple | 452.41 | (N/A) | 8.73 | 4.03 | 22.62 |
| Sugar maple | 310.69 | (N/A) | 6.99 | 2.77 | 19.42 |
| Eastern white pine | 194.95 | (N/A) | 6.99 | 1.74 | 12.18 |
| Northern hackberry | 706.92 | (N/A) | 5.68 | 6.30 | 54.38 |
| Red maple | 163.04 | (N/A) | 4.37 | 1.45 | 16.30 |
| White ash | 358.33 | (N/A) | 3.93 | 3.20 | 39.81 |
| Northern pin oak | 196.49 | (N/A) | 3.49 | 1.75 | 24.56 |
| Littleleaf linden | 320.34 | (N/A) | 3.06 | 2.86 | 45.76 |
| Black walnut | 220.33 | (N/A) | 2.18 | 1.96 | 44.07 |
| Apple | 23.71 | (N/A) | 2.18 | 0.21 | 4.74 |
| Spruce | 23.04 | (N/A) | 1.75 | 0.21 | 5.76 |
| Northern red oak | 40.09 | (N/A) | 1.75 | 0.36 | 10.02 |
| Paper birch | 101.89 | (N/A) | 1.75 | 0.91 | 25.47 |
| Honeylocust | 788.91 | (N/A) | 1.75 | 7.03 | 197.23 |
| Blue spruce | 53.37 | (N/A) | 1.31 | 0.48 | 17.79 |
| Norway spruce | 32.01 | (N/A) | 0.87 | 0.29 | 16.01 |
| American elm | 87.79 | (N/A) | 0.87 | 0.78 | 43.90 |
| Swamp white oak | 41.90 | (N/A) | 0.87 | 0.37 | 20.95 |
| Other City Trees | 2,288.20 | (N/A) | 25.76 | 20.40 | 38.16 |
| Citywide Total | 11,214.32 | (N/A) | 100.00 | 100.00 | 48.97 |

## Table 7: Summary of Benefits in Dollars

| Average Annual Benefits of Public Trees by Species ($/tree) | | | | | | |
|---|---|---|---|---|---|---|
| Species | Energy | CO2 | Air Quality | Stormwater | Aesthetic/Other | Total |
| Silver maple | 61.46 | 13.78 | 11.83 | 127.39 | 106.55 | 321.01 |
| Green ash | 51.99 | 7.06 | 9.19 | 73.45 | 49.39 | 191.08 |
| Norway maple | 27.97 | 3.03 | 4.58 | 25.82 | 22.62 | 84.02 |
| Sugar maple | 17.01 | 2.25 | 2.67 | 22.32 | 19.42 | 63.66 |
| Eastern white pine | 22.54 | 1.60 | 0.32 | 58.22 | 12.18 | 94.87 |
| Northern hackberry | 70.09 | 6.75 | 11.89 | 74.84 | 54.38 | 217.95 |
| Red maple | 14.54 | 1.47 | 2.13 | 9.01 | 16.30 | 43.46 |
| White ash | 38.43 | 4.32 | 7.21 | 47.99 | 39.81 | 137.76 |
| Northern pin oak | 33.06 | 3.36 | 5.29 | 29.43 | 24.56 | 95.70 |
| Littleleaf linden | 28.67 | 4.65 | 4.64 | 29.96 | 45.76 | 113.68 |
| Black walnut | 42.50 | 5.94 | 7.25 | 54.91 | 44.07 | 154.67 |
| Apple | 11.95 | 1.28 | 1.88 | 5.10 | 4.74 | 24.95 |
| Spruce | 0.93 | 0.07 | 0.05 | 1.32 | 5.76 | 8.13 |
| Northern red oak | 46.70 | 3.26 | 6.46 | 65.17 | 10.02 | 131.61 |
| Paper birch | 18.69 | 2.67 | 2.99 | 21.04 | 25.47 | 70.86 |
| Honeylocust | 61.65 | 9.94 | 10.32 | 72.52 | 197.23 | 351.66 |
| Blue spruce | 17.13 | 1.42 | 1.80 | 30.03 | 17.79 | 68.16 |
| Norway spruce | 19.55 | 2.01 | - 0.76 | 63.05 | 16.01 | 99.86 |
| American elm | 54.28 | 5.29 | 8.84 | 56.50 | 43.90 | 168.81 |
| Swamp white oak | 23.94 | 2.90 | 4.03 | 19.26 | 20.95 | 71.07 |
| Other City Trees | 397.47 | 47.11 | 59.98 | 496.29 | 496.07 | 1,496.93 |
| Citywide Total | 40.80 | 6.14 | 6.95 | 63.30 | 48.97 | 166.16 |

## Figure 1: Species Distribution

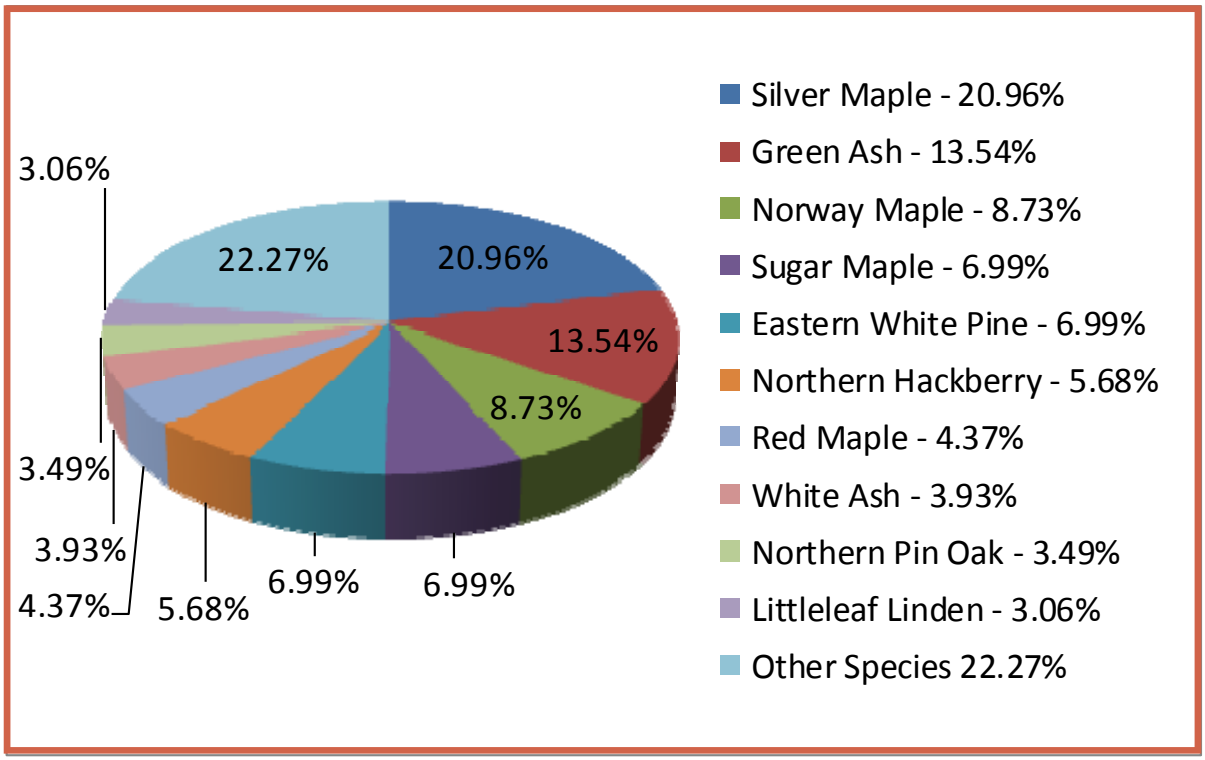


Figure 2: Relative Age Class

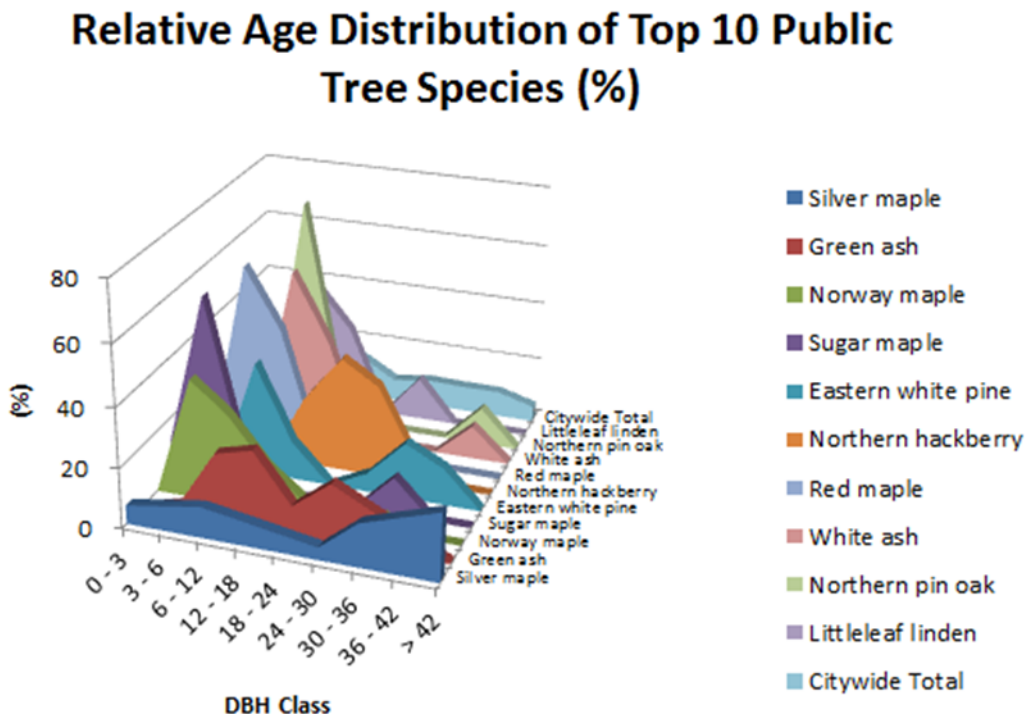



Table 8: Relative Age Class

| Relative Age Distribution of Top 10 Public Tree Species (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | DBH class (in) | | | | | | | | |
| Species | 0 - 3 | 3 - 6 | 6 - 12 | 12 - 18 | 18 - 24 | 24 - 30 | 30 - 36 | 36 - 42 | > 42 |
| Silver maple | 6.25 | 8.33 | 10.42 | 8.33 | 6.25 | 4.17 | 14.58 | 18.75 | 22.92 |
| Green ash | 0.00 | 3.23 | 22.58 | 25.81 | 9.68 | 19.35 | 12.90 | 6.45 | 0.00 |
| Norway maple | 0.00 | 40.00 | 30.00 | 15.00 | 5.00 | 5.00 | 5.00 | 0.00 | 0.00 |
| Sugar maple | 12.50 | 62.50 | 12.50 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 |
| Eastern white pine | 12.50 | 0.00 | 37.50 | 12.50 | 0.00 | 6.25 | 18.75 | 12.50 | 0.00 |
| Northern hackberry | 0.00 | 0.00 | 0.00 | 23.08 | 38.46 | 30.77 | 7.69 | 0.00 | 0.00 |
| Red maple | 0.00 | 60.00 | 40.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| White ash | 0.00 | 0.00 | 55.56 | 33.33 | 0.00 | 0.00 | 0.00 | 11.11 | 0.00 |
| Northern pin oak | 0.00 | 0.00 | 75.00 | 12.50 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 |
| Littleleaf linden | 0.00 | 14.29 | 42.86 | 28.57 | 0.00 | 14.29 | 0.00 | 0.00 | 0.00 |
| Citywide Total | 6.55 | 18.34 | 21.40 | 14.41 | 7.42 | 9.17 | 8.73 | 8.73 | 5.24 |

Figure 3: Foliage Condition

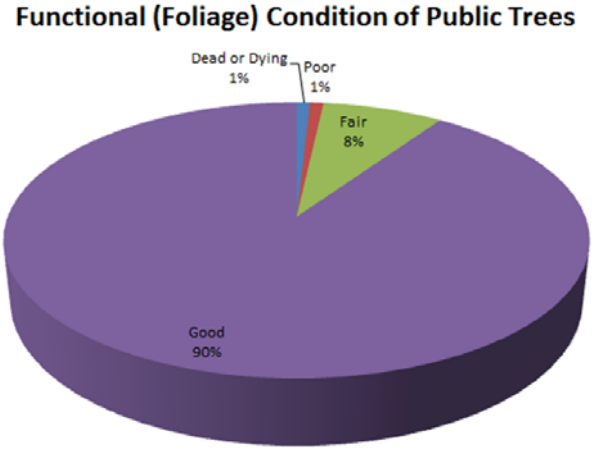



Figure 4: Wood Condition

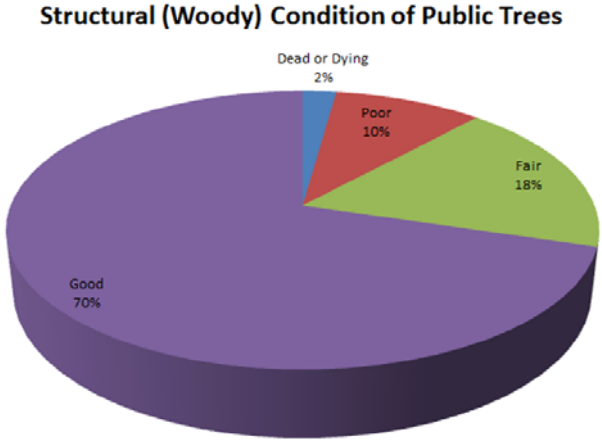


Figure 5: Land Use of City/Park Trees

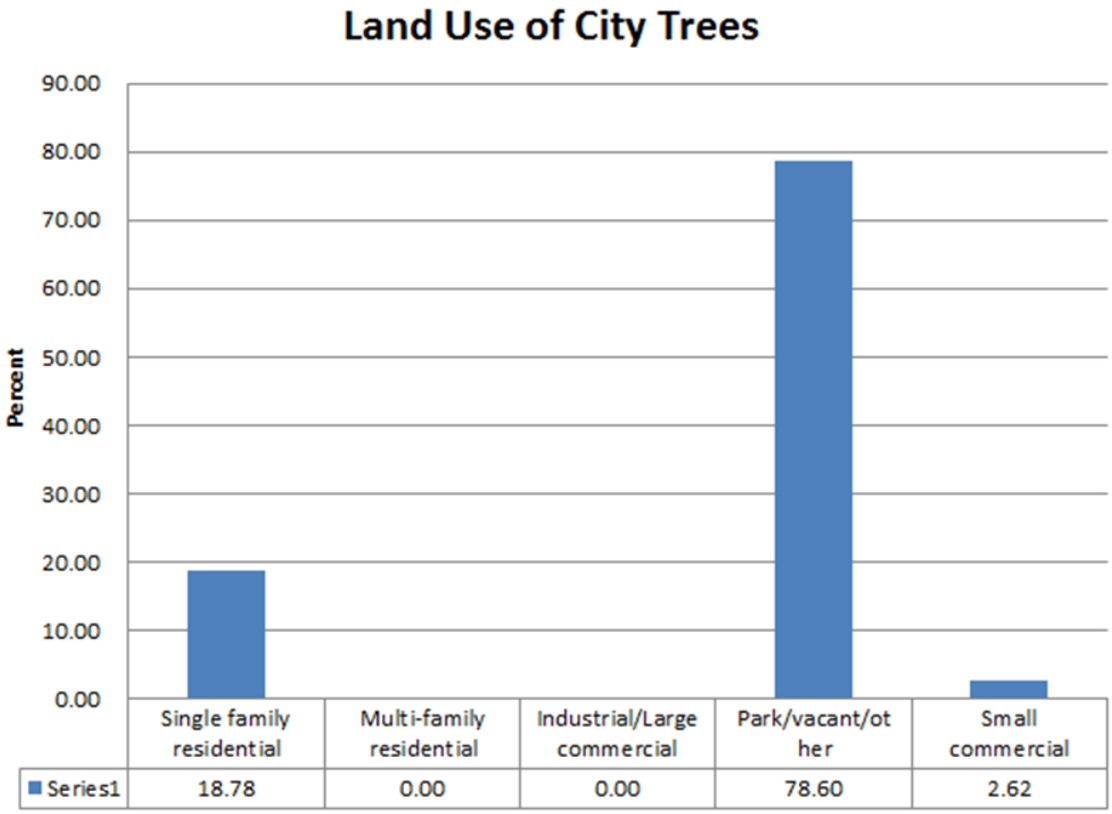
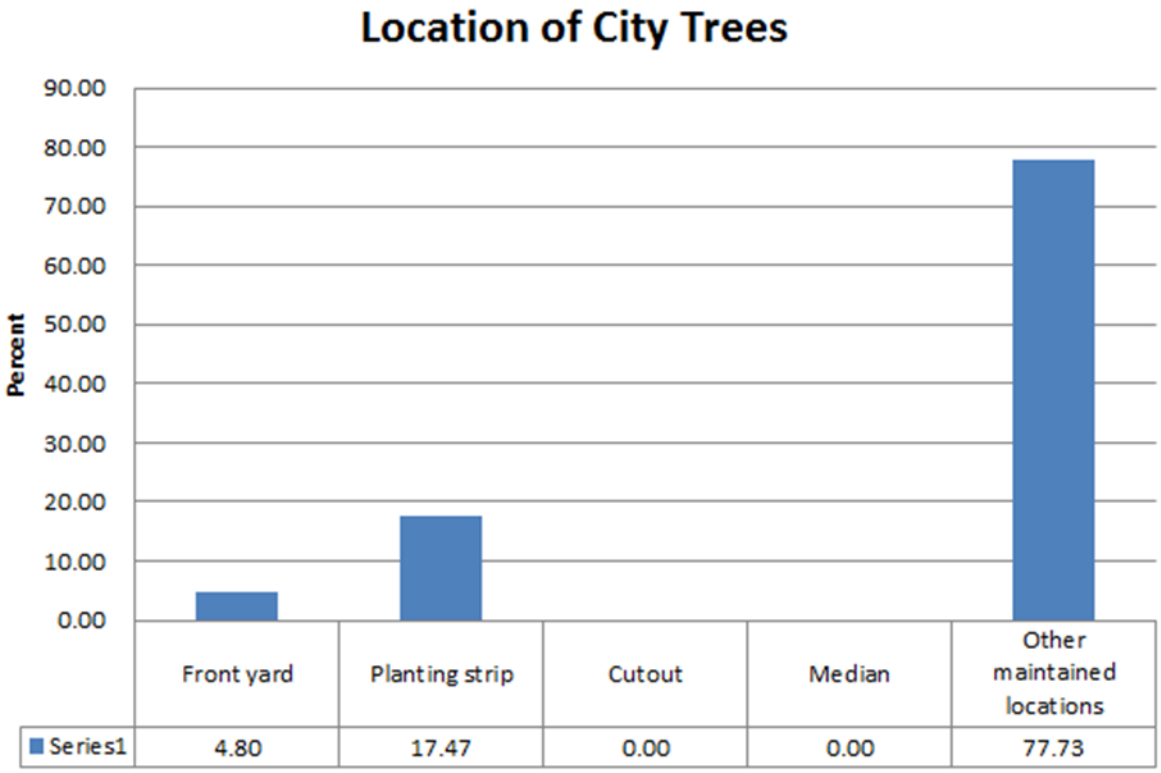



Figure 6: Location of City/Park Trees



# Appendix B: ArcGIS Mapping

Image 1: Location of Ash Trees

Image 2: Location of EAB Symptoms

Image 3: Location of Poor Condition Ash Trees

Image 4: Location of Trees with Recommended Maintenance

Image 5: Maintenance Tasks

Image 6: Good Condition Ash Trees

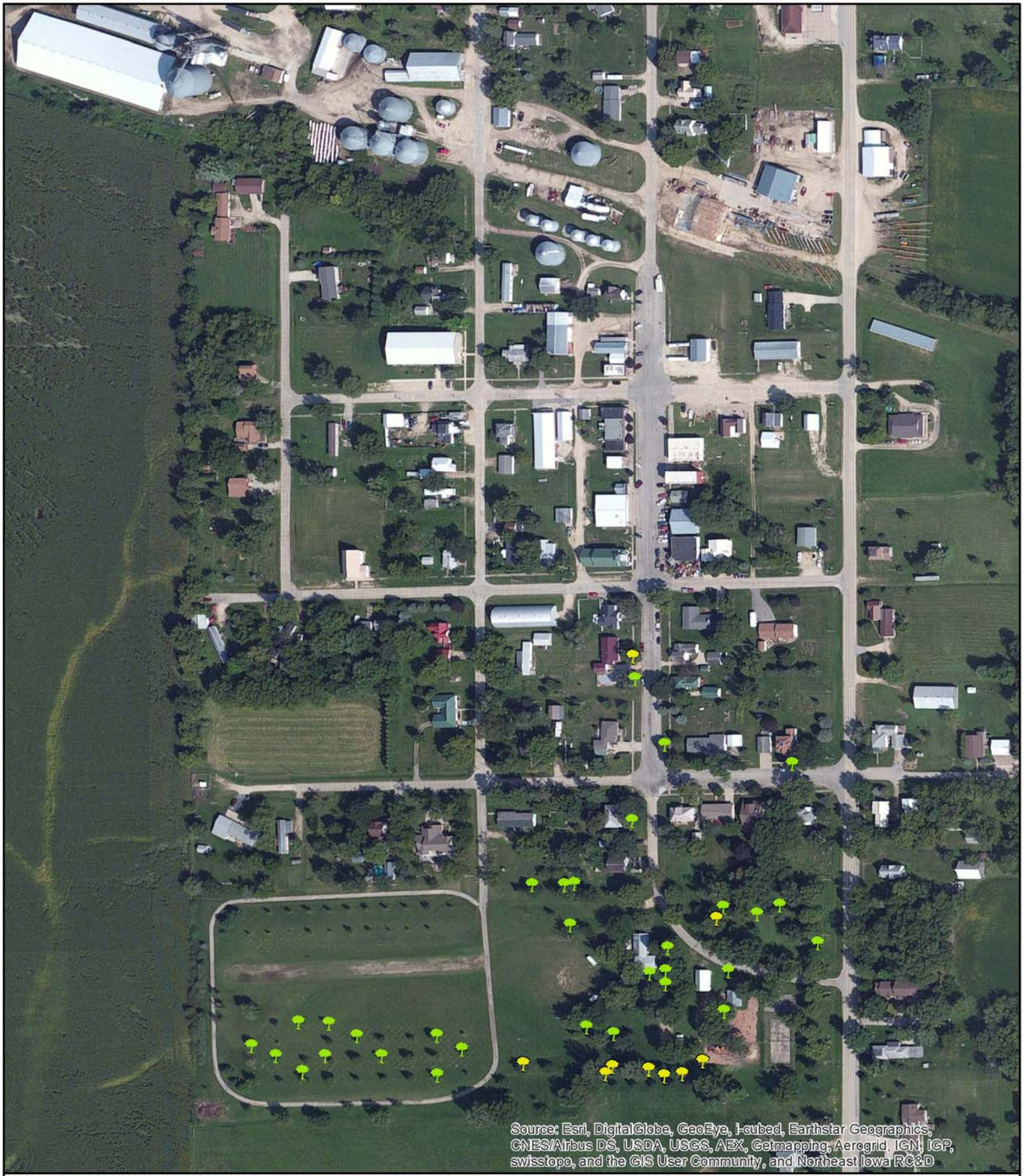



Image 1. Location of Ash Trees

**Legend**

- Green ash
- Ash
- White ash
- Black ash

**Aurora, Iowa**

0 0.025 0.05 0.1 Miles

N

Map created by Northeast Iowa RC&D
11/13/2014


Image 2. Location of Trees with One or More Symptoms of EAB
(Canopy Dieback, Epicormic Shoots, Woodpecker Damage, Bark Splitting, or D-Shaped Exit Holes)

**Legend**

EAB Symptoms

City Limits

**Aurora, Iowa**

0 0.025 0.05 0.1 Miles

N

Map created by Northeast Iowa RC&D
11/13/2014


Image 3. Location of Poor Condition Ash Trees
(Wood and/or Leaves are Dead/Dying or in Poor Condition)

**Legend**

Dead or Dying  Poor

**Aurora, Iowa**

0  0.025  0.05  0.1 Miles

N

Map created by Northeast Iowa RC&D
11/13/2014

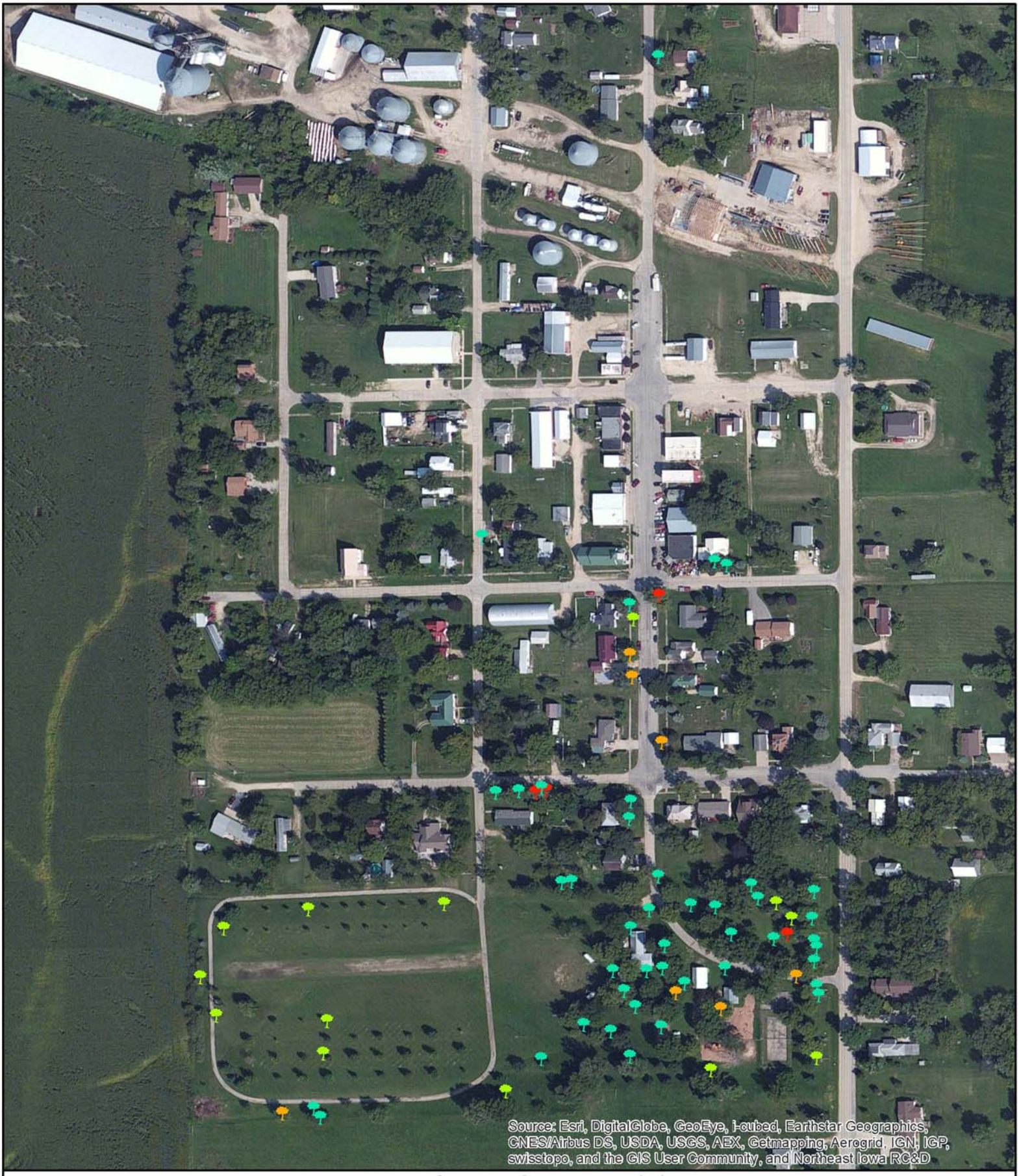



Image 4. Location of Trees with Recommended Maintenance

## Aurora, Iowa

**Legend**

- Critical Concern
- Mature Tree Immediate
- Mature Tree Routine
- Young Tree Immediate
- Young Tree Routine

N

0 0.02 0.04 0.08 Miles

Map created by Northeast Iowa RC&D
11/13/2014


Image 5. Location of Maintenance Tasks

## Aurora, Iowa

**Legend**

Clean | Raise | Reduce | Remove* | Stake/Train | Treat pest/disease

*City owned trees recommended for removal should be verified prior to any removal

N

0 0.02 0.04 0.08 Miles

Map created by Northeast Iowa RC&D
11/20/2014


Location of Good Condition Ash Trees
(Wood and Leaves are in Good Condition, Trees Show No Symptoms of EAB, and No Wires are Conflicting)

**Legend**

- Green ash
- Ash
- White ash
- Black ash

**Aurora, Iowa**

0 0.02 0.04 0.08 Miles

N

Map created by Northeast Iowa RC&D
12/3/2014

# Appendix C: Suitable Shade Tree Lists

## Shade Trees for Iowa

This document lists several shade tree selections suitable for the Iowa landscape. Nursery and landscape professionals have eliminated green, white, black, pumpkin, and blue ash from their inventories and designs since they are susceptible to the emerald ash borer, which kills ash trees. This destructive pest has been found in several states in the upper Midwest.

While not all-inclusive, this list does describe many useful species, many which are also pest-resistant. Not all trees appearing on this list will "work" in every landscape situation. Great care must be taken to carefully match trees to sites (including above- and below-ground spatial and environmental constraints) and to complement species existing nearby so that a diverse tree canopy will be maintained. *A healthy and diverse tree population is the best defense against current and future tree pests.*

| **Deciduous Shade Trees** | **Height/Width** | **Growth Habit** |
|---|---|---|
| Alder | | |
| Manchurian alder – *Alnus hirsuta* | | |
| 'Harbin' (**Prairie Horizon**®) | 40'/30' | Upright |
| Amur maackia – *Maackia amurensis* | 25'/25' | Upright-spreading |
| Baldcypresses | | |
| Baldcypress –*Taxodium distichum* | | |
| 'Mickelson' (**Shawnee Brave**®) | 55'/20' | Narrow-pyramid |
| 'JFS-SGPN' (**Green Whisper**™) | 55'/30' | Pyramidal |
| Birches | | |
| Asian white birch – *Betula platyphylla* | | |
| 'VerDale' (**Prairie Vision**®) | 35'/30' | Upright-oval |
| Gray birch – *Betula populifolia* | | |
| 'Whitespire Sr.' | 40'/25' | Pyramidal-oval |
| Hybrid birch – *Betula* × | | |
| 'Penci-2' (**Royal Frost**®) | 40'/25' | Pyramidal |
| River birch – *Betula nigra* | | |
| 'Cully' (**Heritage**®) | 45'/30' | Oval |
| Whitebarked Himalayan birch – *Betula utilis* | | |
| 'Madison' (**White Satin**™) | 35'/20' | Broadly-pyramidal |

| | Height/Width | Growth Habit |
|---|---|---|
| Coffeetree | | |
| Kentucky coffeetree – *Gymnocladus dioicus* | | |
| 'Espresso' | 50'/35' | Oval |
| Cork trees | | |
| Cork tree – *Phellodendron* species | | |
| 'Longenecker' (**Eye Stopper™**) | 40'/35' | Rounded |
| 'His Majesty' | 40'/35' | Vase-shaped |
| Elms | | |
| American elm – *Ulmus americana* | | |
| 'Jefferson' | 70'/50' | Vase-shaped |
| 'Princeton' | 60'/40' | Vase-shaped |
| 'Lewis & Clark' (**Prairie Expedition™**) | 60'/50' | Umbrella-shaped |
| 'New Harmony' | 70'/70' | Vase-shaped |
| 'Valley Forge' | 70'/70' | Vase-shaped |
| Asian Elm Cultivars and Hybrids | | |
| 'Morton' (**Accolade™**) | 70'/60' | Vase-shaped |
| 'Morton Glossy' (**Triumph™**) | 55'/45' | Vase-shaped |
| 'New Horizon' | 55'/40' | Upright-oval |
| 'Prospector' | 40'/30' | Vase-shaped |
| 'Discovery' | 50'/40' | Vase-shaped |
| European and Eurasian Hybrid Elm Cultivars | | |
| 'Patriot' | 50'/40' | Stiff vase-shaped |
| Filbert | | |
| Turkish filbert – *Corylus colurna* | 40'/30' | Pyramidal |
| Gingkoes | | |
| Ginkgo – *Ginkgo biloba* | | |
| 'Autumn Gold' | 45'/35' | Broadly-pyramidal |
| 'Halka' | 45'/40' | Oval |
| 'Magyar' | 60'/40' | Upright-oval |
| 'PNI 2720' (**Princeton Sentry®**) | 40'/15' | Narrow-pyramidal |
| 'JFS-UGA2' (**Golden Colonnade®**) | 45'/25' | Narrow-oval |
| 'The President' (**Presidential Gold®**) | 50'/40' | Broadly-pyramidal |

| | Height/Width | Growth Habit |
|---|---|---|
| **Hackberries** | | |
| Hackberry – *Celtis occidentalis* | | |
| 'JFS-KSU1' (**Prairie Sentinel™**) | 45'/12' | Columnar |
| 'Chicagoland' | 50'/40' | Broadly-pyramidal |
| 'Prairie Pride' | 50'/40' | Oval |
| **Honeylocusts** | | |
| Honeylocust – *Gleditsia triacanthos* var. *inermis* | | |
| 'Draves' (**Street Keeper™**) | 45'/20' | Narrow-upright |
| 'Harve' (**Northern Acclaim™**) | 45'/35' | Upright-spreading |
| 'Skycole' (**Skyline®**) | 50'/35' | Pyramidal |
| **Hornbeams** | | |
| European hornbeam – *Carpinus betulus* | | |
| 'JFS-KW1CB' (**Emerald Avenue®**) | 40'/30' | Broadly-pyramidal |
| 'Windy City' | 45'/40' | Upright-spreading |
| **Hophornbeam** | | |
| American hophornbeam – *Ostrya virginiana* | 40'/25' | Upright-oval |
| **Horsechestnuts** | | |
| Common horsechestnut – *Aesculus hippocastanum* | | |
| 'Baumannii' | 50'/40' | Broadly-oval |
| Red horsechestnut – *Aesculus* × *carnea* | | |
| 'Briotii' | 30'/35' | Round |
| 'Fort McNair' | 30'/30' | Round |
| **Lindens** | | |
| American linden – *Tilia americana* | | |
| 'Boulevard' | 60'/30' | Pyramidal |
| 'Continental Appeal' | 50'/30' | Narrow-oval |
| 'Wandell' (**Legend®**) | 40'/30' | Broad-pyramidal |
| 'McKSentry' (**American Sentry®**) | 45'/30' | Pyramidal |
| 'Lincoln' | 35'/25' | Pyramidal |
| 'Redmond' | 50'/35' | Pyramidal |
| Hybrid Linden – *Tilia* × *flavescens* (*americana* × *cordata*) | | |
| 'Glenleven' | 50'/30' | Pyramidal |

| | Height/Width | Growth Habit |
|---|---|---|
| Littleleaf linden – *Tilia cordata* | | |
| 'Baileyi' (**Shamrock®**) | 40'/30' | Pyramidal |
| 'Corzam' (**Corinthian®**) | 45'/15' | Narrow-pyramid |
| 'Ronald' (**Norlin™**) | 40'/30' | Pyramidal |
| Mongolian linden – *Tilia mongolica* | | |
| 'Harvest Gold' | 30-40'/25-30' | Upright-oval |
| Silver linden – *Tilia tomentosa* | | |
| 'PNI 6051' (**Green Mountain®**) | 45'/35' | Broad-pyramidal |
| 'Sterling' | 45'/35' | Broad-pyramidal |
| Magnolias | | |
| Cucumbertree – *Magnolia acuminata* | 50-80'/40-60' | Upright-oval |
| Maples | | |
| Black maple – *Acer nigrum* | 60'/60' | Round-spreading |
| Freeman maple – *Acer × freemanii* | | |
| 'Jeffersred' (**Autumn Blaze®**) | 50'/45' | Broadly-oval |
| 'DTR 102' (**Autumn Fantasy®**) | 40'/30' | Broadly-oval |
| 'Marmo' | 50'/30' | Upright-oval |
| 'Bailston' (**Matador™**) | 40'/30' | Upright-oval |
| 'Morgan' ('Indian Summer') | 45'/40' | Rounded |
| 'Sienna' (**Sienna Glen®**) | 45'/35' | Pyramidal |
| 'UMNAF#1' (**Firefall™**) | 50'/30' | Upright-oval |
| Hybrid maple – *Acer truncatum × platanoides* | | |
| 'Warrenred' (**Pacific Sunset®**) | 30'/25' | Upright-spreading |
| 'JFS-KW202' (**Crimson Sunset™**) | 35'/25' | Upright-oval |
| Miyabe maple – *Acer miyabei* | | |
| 'Morton' (**State Street™**) | 45'/30' | Upright-oval |
| 'JFS-KW3AMI' (**Rugged Ridge™**) | 55'/40' | Upright-oval |
| Norway maple – *Acer platanoides* | | |
| 'Columnarbroad' (**Parkway®**) | 40'/25' | Oval |
| 'Deborah' | 45'/40' | Rounded |
| 'Emerald Queen' | 50'/40' | Oval-upright |
| 'Ezestre' (**Easy Street™**) | 40'/20' | Narrow-pyramidal |
| 'Fairview' | 45'/35' | Upright-oval |

| | Height/Width | Growth Habit |
|---|---|---|
| 'Pond' (**Emerald Lustre™**) | 45'/40' | Rounded |
| 'Princeton Gold' | 35'/30' | Oval |
| Red maple – *Acer rubrum* | | |
| 'Bailcraig' (**Scarlet Jewell™**) | 50'/30' | Upright |
| 'Franksred' (**Red Sunset®**) | 45'/35' | Upright-oval |
| 'Magnificent Magenta' (**Burgundy Belle®**) | 50'/40' | Oval |
| 'Frank Jr.' (**Redpointe™**) | 45'/30' | Pyramidal |
| 'New World' | 40'/20' | Narrow-oval |
| 'Polara' (**Rubyfrost™**) | 45'/40' | Broadly-oval |
| 'Somerset' | 45'/35' | Broadly-oval |
| Sugar maple – *Acer saccharum* | | |
| 'Autumn Splendor' | 45'/40' | Broadly-oval |
| 'JFS-KW8' (**Autumn Fest™**) | 50'/35' | Upright-oval |
| 'JFS-Caddo2' (**Flashfire™**) | 45'/40' | Broadly-oval |
| 'Bailsta' (**Fall Fiesta™**) | 50'/50' | Upright-rounded |
| 'Commemoration' | 50'/35' | Oval-rounded |
| 'Endowment' | 50'/20' | Columnar |
| 'Legacy' | 50'/35' | Oval |
| 'Morton' (**Crescendo™**) | 40'/30' | Broadly-oval |
| 'Green Mountain' | 45'/35' | Broadly-oval |
| Planetrees | | |
| London planetree – *Platanus × acerifolia* | | |
| 'Bloodgood' | 50'/40' | Broadly-pyramidal |
| 'Morton Circle' (**Exclamation™**) | 55'/35' | Upright-pyramidal |
| Oaks | | |
| Bur oak – *Quercus macrocarpa* | 50-80'/40-80' | Spreading |
| 'JFS-KW3' (**Urban Pinnacle™**) | 55'/25' | Narrow-pyramidal |
| Chinkapin oak – *Quercus muehlenbergii* | 45'/45' | Round |
| English/white oak – *Quercus bimundorum* | | |
| 'Crimschmidt' (**Crimson Spire™**) | 45'/15' | Columnar |
| 'Midwest' (**Prairie Stature™**) | 50'/40' | Broadly-pyramidal |
| Hybrid oak – *Quercus ×* | | |
| 'Clemons' (**Heritage®**) | 40-50'/40-50' | Broadly-pyramidal |
| 'Long' (**Regal Prince®**) | 45'/18' | Narrow-oval |

| | Height/Width | Growth Habit |
|---|---|---|
| Red oak – *Quercus rubra* | 60-75'/60' | Spreading |
| Shingle oak – *Quercus imbricaria* | 50'/40' | Broadly-oval |
| Swamp white oak – *Quercus bicolor* | 60'/60' | Round |
| White oak – *Quercus alba* | 50-70'/40-80' | Spreading |
| S weetgums | | |
| Sweetgum – *Liquidambar styraciflua* | | |
| 'Clydesform' (**Emerald Sentinel**®) | 30'/12' | Narrow-pyramid |
| 'Moraine' | 40'/25' | Pyramidal |

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Compiled by Jeff Iles, Department of Horticulture, Iowa State University
10-January-2013

## Small-stature Trees for Iowa

This document lists several small-stature tree selections suitable for the Iowa landscape. Nursery and landscape professionals have eliminated green, white, black, pumpkin, and blue ash from their inventories and designs since they are susceptible to the emerald ash borer, which kills ash trees. This destructive pest has been found in several states in the upper Midwest.

While not all-inclusive, this list does describe many useful species, many which are also pest-resistant. Not all trees appearing on this list will "work" in every landscape situation. Great care must be taken to carefully match trees to sites (including above- and below-ground spatial and environmental constraints) and to complement species existing nearby so that a diverse tree canopy will be maintained. *A healthy and diverse tree population is the best defense against current and future tree pests.*

| **Deciduous Small-stature Trees** | **Height/Width** | **Growth Habit** |
|---|---|---|
| Amur maackia – *Maackia amurensis* | 20'/20' | Upright-spreading |
| Cherries | | |
| Sargent cherry – *Prunus sargentii* | | |
| 'JFS-KW58' (**Pink Flair**®) | 25'/15' | Upright |
| 'Hokkaido Normandale' (**Spring Wonder**™) | 25'/20' | Upright-spreading |
| Crabapples – *Malus* species | | |
| 'Adirondack' | 18'/12' | Vase-shaped |
| 'Beeson' (**May's Delight**®) | 8'/8' | Upright-spreading |
| 'Hub Tures' (**Spring Sensation**™) | 10'/12' | Wide-spreading |
| 'JFS-KW5' (**Royal Raindrops**®) | 20'/15' | Upright-spreading |
| 'Malusquest' (**Pink Sparkles**®) | 15'/12' | Upright |
| 'Orange Crush' | 15'/15' | Round-spreading |
| Dogwoods | | |
| Corneliancherry dogwood – *Cornus mas* | 20'/20' | Round-spreading |
| Gray dogwood – *Cornus racemosa* | | |
| 'Jade' (**Snow Mantle**™) | 15'/8' | Upright-spreading |
| Pagoda dogwood – *Cornus alternifolia* | 20'/20' | Spreading |

| | Height/Width | Growth Habit |
|---|---|---|
| Hophornbeams | | |
| American hophornbeam – *Ostrya virginiana* | 25'/20' | Upright-spreading |
| Hornbeams | | |
| American hornbeam – *Carpinus caroliniana* | | |
| 'J.N. Strain' | 25'/25' | Spreading |
| 'J.N. Upright' (**Firespire™**) | 20'/10' | Upright |
| Lilacs | | |
| Japanese tree lilac – *Syringa reticulata* | | |
| 'Bailnce' (**Snowdance™**) | 18'/20' | Round-spreading |
| 'Ivory Silk' | 25'/15' | Upright |
| Pekin lilac – *Syringa reticulata* subsp. *pekinensis* | | |
| 'Morton' (**China Snow®**) | 20'/20' | Upright-spreading |
| 'SunDak' (**Copper Curls®**) | 20'/15' | Upright-spreading |
| Magnolias | | |
| Loebner magnolia – *Magnolia* × *loebneri* | | |
| 'Merrill' | 25'/25' | Upright-spreading |
| 'Ruth' (**Spring Welcome®**) | 20'/20' | Round-spreading |
| Maples | | |
| Tatarian maple – *Acer tataricum* | | |
| 'GarAnn' (**Hot Wings®**) | 20'/25' | Round-spreading |
| Three-flower maple –*Acer triflorum* | 25'/25' | Upright-spreading |
| Pears | | |
| Callery pear – *Pyrus calleryana* | | |
| 'Glen's Form' (**Chanticleer®**) | 40'/15' | Narrow-pyramid |
| Ussurian pear – *Pyrus ussuriensis* | | |
| 'MorDak' (**Prairie Gem®**) | 25'/20' | Oval |
| 'Bailfrost' (**Mountain Frost®**) | 20'/15' | Upright-oval |
| Redbud | | |
| American redbud – *Cercis canadensis* | | |
| 'Pink Trim' (**Northern Herald™**) | 25'/25' | Spreading |

Serviceberries

| | | |
|---|---|---|
| Allegheny serviceberry – *Amelanchier laevis* | | |
| 'Cumulus' | 20'/15' | Upright-spreading |
| 'JFS-Arb' (**Spring Flurry**®) | 28'/20' | Upright-oval |
| | | |
| Apple serviceberry – *Amelanchier* × *grandiflora* | | |
| 'Autumn Brilliance' | 20'/15' | Upright-spreading |
| 'Strata' | 20'/20' | Horizontal |

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10-January-2013

The inventory was funded in part through a grant from the Iowa Department of Natural Resources to assist communities in Eastern Iowa with planning and managing their urban tree resources and development of response to the presence of EAB and other tree pests and problems.