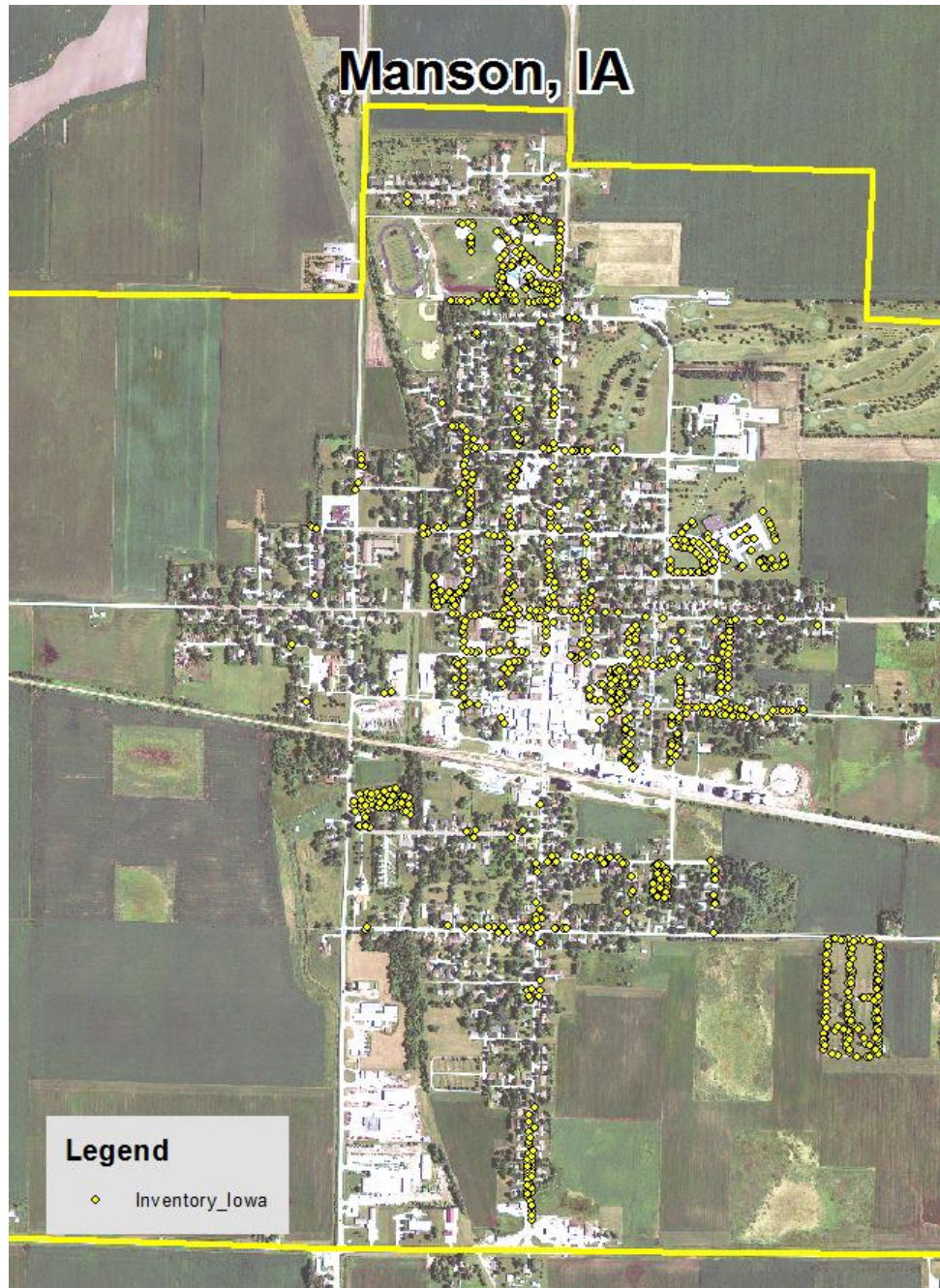


# Manson, IA



2016 Urban Forest Management Plan  
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# Executive Summary

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## Overview

This plan was developed to assist the City of Manson with managing its urban forest, including budgeting and future planning. Trees can provide a multitude of benefits to the community, and sound management allows a community to best take advantage of these benefits. Management is especially important considering the serious threats posed by forest pests such as the emerald ash borer (EAB). EAB is an invasive insect imported from Eastern Asia on wood shipping crates that kills all species of ash trees (this does not include mountain ash). There is a strong possibility that 18% of Manson's city owned trees (ash) will die once EAB becomes established in the community, unless preventative treatment is used. With proper planning and management, the costs of removing dead and dying trees can be extended over years, mitigating public safety issues.

## Inventory and Results

In 2015, a tree inventory was conducted using Global Positioning System (GPS) data collectors. The inventory was a complete inventory of street and park trees. Below are some key findings of the 1,127 trees inventoried.

- Manson's trees provide \$178,147 of benefits annually, an average of \$158 a tree
- There are over 45 species of trees
- The top three genera are: Maple 34%, Ash 18%, and Spruce 17%
- 3% of trees are in need of some type of management
- 18 trees are recommended for removal

## Recommendations

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

- Of the 18 trees needing removal, 10 trees are over 24 inches in diameter at 4.5 ft and must be addressed immediately [\\*City ownership of the trees recommended for removal should be verified prior to any removal\\*](#)
- 204 of the 4 ash trees should be carefully examined, as they have one or more symptoms that could be related to an EAB infestation
- All trees should be pruned on a routine schedule- one third of the city every other year
- Plant a diverse mix of trees that do not include: ash, maple, cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut
- Check ash trees with a visual survey yearly
- With the current budget it could take 23 years to remove ash – Suggestion: request a budget increase and apply for grants to plant replacement trees

## Introduction

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

Trees are an important component of Manson's infrastructure and one of the greatest assets to the community. The benefits of trees are immense. Trees provide the community with improved air quality, stormwater runoff interception, energy conservation, lower traffic speeds, increased property values, reduced crime, improved mental health and create a desirable place to live, to name just a few benefits. It is essential that these benefits be maintained for the people of Manson and future generations through good urban forestry management.

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

## Inventory

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In 2015, a tree inventory was conducted that included 100% of the city owned trees on both streets and parks. The tree data was collected using a handheld Global Positioning System (GPS) receiver. The data collector gives Geographic Information Systems (GIS) coordinates with an accuracy of 3 meters, which can be used in Arc GIS as an active GIS data layer. Because the inventory is a digital document the data can be updated with new information and become a working document.

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

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

## Inventory Results

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The data collected for the 1,127 city trees were entered into the USDA Forest service program STREETS, part of the i-Tree suite. The following are results from the i-Tree STREETS analysis.

### **Annual Benefits**

#### **Annual Energy Benefits**

Trees conserve energy by shading buildings and blocking winds. Manson's trees reduce energy related costs by approximately \$46,542 annually (Appendix A, Table 1). These savings are both in Electricity (224.1 MWh) and in Natural Gas (30,135.5 Therms).

#### **Annual Stormwater Benefits**

Manson's trees intercept about 2,489,621 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides \$67,469 of benefits to the city.

#### **Annual Air Quality Benefits**

Air quality is a persistent public health issue in Iowa. The urban forest improves air quality by removing pollutants, lowering air temperature, and reducing energy consumption, which in turn reduces emissions from power plants, and emitting volatile organic matter (ozone). In Manson, it is estimated that trees remove 2695 lbs of air pollution (ozone (O<sub>3</sub>), particulate matter less than 10 microns (PM<sub>10</sub>), carbon monoxide (CO), nitrogen dioxide (NO<sub>2</sub>), and sulfur dioxide (SO<sub>2</sub>)) per year with a net value of \$7,427 (Appendix A, Table 3).

#### **Annual Carbon Benefits**

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Manson, trees sequester about 473,669 lbs of carbon a year with an associated value of \$3,553 (Appendix A, Table 5). In addition, the trees store 7,712,917 lbs of carbon, with a yearly benefit of \$57,847 (Appendix A, Table 4).

#### **Annual Aesthetics Benefits**

Social benefits of trees are hard to capture. The analysis does have a calculation for this area that includes: aesthetic value, property values, lowered rates of mental illness and crime, city livability and much more. Manson receives \$53,157 in annual social benefits from trees (Appendix A, Table 6).

#### **Financial Summary of all Benefits**

According to the USDA Forest Service i-Tree STREETS analysis, Manson's trees provide \$178,147 of benefits annually. Benefits of individual trees vary based on size, species, health and

location, but on average each of the 1,127 trees in Manson provide approximately \$158 annually (Appendix A, Table 7).

## **Forest Structure**

### **Species Distribution**

Manson has over 45 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

|                 |     |     |
|-----------------|-----|-----|
| Maple           | 378 | 34% |
| Ash             | 204 | 18% |
| Spruce          | 186 | 17% |
| Apple (Crab)    | 117 | 10% |
| Linden/Basswood | 60  | 5%  |
| Honey Locust    | 49  | 4%  |
| Hackberry       | 32  | 1%  |
| Arborvitae      | 25  | 2%  |
| Oak             | 16  | 1%  |
| Walnut          | 10  | 1%  |
| Cedar           | 6   | <1% |
| Birch           | 5   | <1% |
| Willow          | 5   | <1% |
| Elm             | 4   | <1% |
| Pear            | 4   | <1% |
| Buckeye         | 3   | <1% |
| Mulberry        | 3   | <1% |
| Hickory         | 2   | <1% |
| Mountain Ash    | 2   | <1% |
| Pine            | 2   | <1% |
| Poplar          | 2   | <1% |
| Sycamore        | 2   | <1% |
| Cottonwood      | 1   | <1% |
| Dogwood         | 1   | <1% |
| Lilac           | 1   | <1% |
| Redbud          | 1   | <1% |
| Tulip Tree      | 1   | <1% |
| Quaking Aspen   | 1   | <1% |

### **Age Class**

Most of Manson's trees (32%) are between 12 and 24 inches in diameter at 4.5 ft (Appendix A, Figure 2). For age, it is preferred that the highest amounts of trees are in the smallest size category (a downward slope) to prepare for natural mortality and to maintain canopy cover. Manson's size curve indicates a middle aged stand.

## Condition: Wood and Foliage

Both wood condition and leaf condition are good indicators of the overall health of the urban forest. The foliage condition results for Manson indicate that 92% of the trees are in good health, with only 2% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 68% of Manson's trees are in good health for wood condition (appendix A, Figure 4 & Appendix B, Figure 3). Wood condition that is in poor health, dead or dying is about 7% of the population. This 7% is an estimate of trees that need management follow up.

## Management Needs

The following outlines the specific management needs of the street and park trees by number of trees and percent of canopy (Appendix B, Figure 3).

|                |    |     |
|----------------|----|-----|
| Crown Cleaning | 19 | 2%  |
| Tree Removal   | 18 | 2%  |
| Tree Staking   | 1  | <1% |

## Canopy Cover

The total canopy with both private and public trees is 10%, 201 acres. The canopy cover included in the Manson inventory includes approximately 24 acres (Appendix A, Figure 4).

## Land Use and Location

The majority of Manson's city and park trees are in planting strips 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

|                           |     |
|---------------------------|-----|
| Single family residential | 51% |
| Park/vacant/other         | 48% |
| Small commercial          | 1%  |
| Multifamily residential   | 1%  |

### Location

|                 |     |
|-----------------|-----|
| Front yard/park | 71% |
| Planting strip  | 28% |
| Median          | 1%  |

## Recommendations

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## **Risk Management**

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

### Hazardous trees

Manson has 5 critical concern trees that need immediate removal. These trees can be seen on the Location of Trees with Recommended Maintenance map (Appendix B, Figure 4). It is recommended to start with the large diameter critical concern trees first. There are 13 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.

### Poor tree species

After the removal of the critical concern trees, ash trees in poor health should be assessed for removal (Appendix B, Figure 3 & Appendix B, Figure 4). Of the 18 removals, 5 are ash trees. There are a total of 204 ash trees, and 4 of those have signs and symptoms that have been associated with EAB. In addition, there are 22 ash trees that are in poor health. *\*City ownership of the trees recommended for removal should be verified prior to any removal\**

## **Pruning Cycle**

Proper pruning can extend the life and good health of trees, as well as reduce public safety issues. In the Management Needs section of the Findings there are four main maintenance issues to be addressed: routine pruning, crown cleaning, crown raising, and crown reduction. Crown cleaning removes dead, diseased, and damaged limbs. Crown raising is the removal of lower branches that are 2 inches in diameter or larger in the case of providing clearance for pedestrians or vehicles. Crown reduction is removing individual limbs from structures or utility wires. It is recommended that all trees be pruned on a routine schedule every five to seven years. Please refer to the six year maintenance plan for further information.

## **Planting**

Most of the planting over the next 5 years will replace the trees that are removed. It is recommended to plant 1.2 trees for every tree removed, since survival rates will not be 100%. Please refer to the six year maintenance plan at the end of this section. It is not essential that the new trees be planted in the same location of the trees being removed. However, maintaining the same number of trees helps ensure continuation of the benefits of the existing forest in Manson.

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 (34%) (Appendix A, Figure 1). Maples should not be planted until this percentage can be lowered. Also, ash trees have not been recommended since 2002, due to the threat of EAB. Other species to avoid because they are public nuisances include: cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut.

### **Continual Monitoring**

Due to the threat of EAB, it is important to continuously check the health of ash trees. It is recommended that ash trees be checked with a visual survey every year for tree decline and for the following signs and symptoms: canopy dieback, epicormic shoots, bark splitting, D-shaped borer exit holes, and wood pecker damage.

## **Emerald Ash Borer Plan**

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### **Ash Tree Removal**

Tree removal will be prioritized with dead, dying, hazardous trees to be removed first (Appendix B, Figure 4). Next will be all ash in poor condition and displaying signs and symptoms of EAB (Appendix B, Figure 2 & Appendix B, Figure 3). *\*City ownership of the tree recommended for removal should be verified prior to any removal\**

### **Treatment of Ash Trees**

Chemical treatment can be effective tool for communities to spread removal costs out over several years while allowing trees to continue to provide benefits. However, treatment is not recommended if EAB is more than 15 miles away from the community. For more information on the cost of treatment strategies visit <http://extension.entm.purdue.edu/treecomputer/>

### **EAB Quarantines**

EAB is an extremely destructive plant pest and it is responsible for the death and decline of millions of ash trees. Ash in both forested and urban settings constitute a significant portion of the canopy cover in the United States. Current tools to detect, control, suppress and eradicate this pest are not as robust as the USDA would desire. In order to stay ahead of this hard to detect beetle, the USDA is attempting to contain the beetle before it spreads beyond its known positions by regulating articles.

A regulated article under the USDA's quarantine includes any of the following items:

- emerald ash borer
- firewood of all hardwood species (for example ash, oak, maple and hickory)
- nursery stock and green lumber of ash
- any other ash material, whether living, dead, cut or fallen, including logs, stumps, roots, branches, as well as composted and not composted chips of the genus ash (Mountain ash is not included)

In addition, any other article, product or means of conveyance not listed above may be designated as a regulated article if a USDA inspector determines that it presents a risk of spreading EAB once a quarantine is in effect for your county.

### **Wood Disposal**

A very important aspect of planning is determining how wood infested with EAB will be handled, keeping in mind that quarantines will restrict its movement. Consider who will cut and haul the dead and dying trees? Is there an accessible, secured site big enough to store and sort the hundreds of trees and the associated brush and chips? How will wood be disposed of or utilized? Do you have equipment capable of handling the amount and size of ash trees your tree inventory has identified? Once your county is under quarantine for EAB, contact USDA-APHIS-PPQ at 515-251-4083 or visit the website [http://www.aphis.usda.gov/plant\\_health/plant\\_pest\\_info/emerald\\_ash\\_b/regulatory.shtml](http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/regulatory.shtml). Wood waste can be disposed of as you normally would if your county is not part of a quarantine.

### **Canopy Replacement**

As budget permits, all removed trees will be replaced. All trees will meet the restrictions in city ordinance.

### **Postponed Work**

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

### **Monitoring**

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

### **Private Ash Trees**

It is strongly recommended that private property owners start removing ash trees on their property upon arrival of EAB if they are not using a treatment method.

# Budget

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## Six Year Maintenance Plan and Estimate Cost

### **YEAR 1**

### **ESTIMATED COSTS**

|                                                       |         |
|-------------------------------------------------------|---------|
| Remove 5 Critical Concern trees and 5 immediate trees | \$7,000 |
| Plant 12 trees in open locations                      | \$1,800 |
| Inspect ash trees for signs of Emerald Ash Borer      |         |

### **YEAR 2**

|                                                  |         |
|--------------------------------------------------|---------|
| Remove 9 tree trees                              | \$6,300 |
| Plant 10 trees in open locations                 | \$1,500 |
| Prune 1/3 of city owned trees                    | \$1,000 |
| Inspect ash trees for signs of Emerald Ash Borer |         |

### **YEAR 3**

|                                                                      |         |
|----------------------------------------------------------------------|---------|
| 10- removal of any new critical concern trees and ash in poor health |         |
| *Or saving for ash tree treatment and/or future ash removal          | \$7,000 |
| Plant 12 trees in open locations                                     | \$1,800 |
| Inspect ash trees for signs of EAB                                   |         |

### **YEAR 4**

|                                                                     |         |
|---------------------------------------------------------------------|---------|
| 9- removal of any new critical concern trees and ash in poor health |         |
| *Or saving for ash tree treatment and/or future ash removal         | \$6,300 |
| Plant 13 trees in open locations                                    | \$1,500 |
| Prune 1/3 of city owned trees                                       | \$1,000 |
| Inspect ash trees for signs of EAB                                  |         |

### **YEAR 5**

|                                                                      |         |
|----------------------------------------------------------------------|---------|
| 10- removal of any new critical concern trees and ash in poor health |         |
| *Or saving for ash tree treatment and/or future ash removal          | \$7,700 |
| Plant 13 trees in open locations                                     | \$1,800 |
| Inspect ash trees for signs of EAB                                   |         |

### **YEAR 6**

|                                                                      |         |
|----------------------------------------------------------------------|---------|
| 10- removal of any new critical concern trees and ash in poor health |         |
| *Or saving for ash tree treatment and/or future ash removal          | \$6,300 |

|                                  |         |
|----------------------------------|---------|
| Plant 14 trees in open locations | \$1,500 |
| Prune 1/3 of city owned trees    | \$1,000 |

Estimated costs based on average costs of \$700/tree for removal, \$150/tree for planting and maintenance, and \$15/tree for pruning.

Reduction of ash over 6 years: Approximately 43 ash trees removed (approximately 21% of ash). It will take approximately 23 years to remove all ash with the current budget. EAB could potentially kill all ash within 4 to 15 years of its arrival. Treatment of ash would alter the cost and timeline. Treatment prices varies greatly by tree size and state location.

### Purposed Budget Increase

EAB could potentially kill all ash trees in Manson within 4 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to about \$145,000 a year. Additionally, it is recommended that Manson apply for grants to fund replacement trees. Utility Company grants are usually between \$500 and \$10,000 for community-based, tree-planting projects that include parks, gateways, cemeteries, nature trails, libraries, nursing homes, and schools.

Another option being considered by many communities is treating a number of selected trees, either to maintain those trees in the landscape or to delay their removal – to spread out the costs and number of trees needing removed all at once. Trunk injection is administered every two years for the life of the tree. If treatment is discontinued, the tree dies. For instance, in this treatment scenario, the average ash diameter is 20 inches and at \$15 per inch, about 4 trees could be treated per year (every other year treatment). This would be 8 trees selected for treatment, and Manson would still need \$22,800 for removal. Alternatively, if there are 15 treatable trees, it would cost approximately \$2,250 a year for treatment and leave \$22,000 for removal. These are alternatives to straight removal of ash trees. However, whether or not the treatment option is selected, there will be an increased cost of dealing with ash trees if EAB is found in Manson. It is suggested to consider increasing the budget to plan for this.

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## Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

### Manson

#### Annual Energy Benefits of Public Trees

12/22/2015

| Species                 | Total Electricity<br>(MWh) | Electricity<br>(\$) | Total Natural<br>Gas (Therms) | Natural<br>Gas (\$) | Total<br>(\$) | Standard<br>Error | % of Total<br>Trees | % of<br>Total \$ | Avg.<br>\$/tree |
|-------------------------|----------------------------|---------------------|-------------------------------|---------------------|---------------|-------------------|---------------------|------------------|-----------------|
| Green ash               | 54.3                       | 4,122               | 7,220.8                       | 7,076               | 11,198        | (N/A)             | 17.9                | 24.1             | 55.71           |
| Silver maple            | 48.6                       | 3,686               | 6,325.2                       | 6,199               | 9,884         | (N/A)             | 13.2                | 21.2             | 66.34           |
| Norway maple            | 26.9                       | 2,041               | 3,692.1                       | 3,618               | 5,659         | (N/A)             | 11.6                | 12.2             | 43.20           |
| Spruce                  | 17.9                       | 1,359               | 2,323.6                       | 2,277               | 3,636         | (N/A)             | 11.2                | 7.8              | 28.85           |
| Apple                   | 7.9                        | 599                 | 1,236.3                       | 1,212               | 1,810         | (N/A)             | 10.4                | 3.9              | 15.47           |
| Honeylocust             | 13.5                       | 1,028               | 1,785.7                       | 1,750               | 2,778         | (N/A)             | 4.4                 | 6.0              | 56.69           |
| Sugar maple             | 11.7                       | 886                 | 1,520.9                       | 1,491               | 2,376         | (N/A)             | 4.4                 | 5.1              | 48.50           |
| Blue spruce             | 1.2                        | 92                  | 185.7                         | 182                 | 273           | (N/A)             | 4.1                 | 0.6              | 5.94            |
| Littleleaf linden       | 5.4                        | 411                 | 744.9                         | 730                 | 1,141         | (N/A)             | 3.0                 | 2.5              | 33.56           |
| Northern hackberry      | 10.4                       | 789                 | 1,439.7                       | 1,411               | 2,200         | (N/A)             | 2.8                 | 4.7              | 68.75           |
| American basswood       | 5.0                        | 380                 | 709.9                         | 696                 | 1,075         | (N/A)             | 2.3                 | 2.3              | 41.36           |
| Northern white cedar    | 2.6                        | 195                 | 354.5                         | 347                 | 543           | (N/A)             | 2.2                 | 1.2              | 21.71           |
| Maple                   | 1.6                        | 118                 | 224.1                         | 220                 | 338           | (N/A)             | 2.0                 | 0.7              | 14.70           |
| Red maple               | 1.7                        | 131                 | 225.2                         | 221                 | 352           | (N/A)             | 1.1                 | 0.8              | 29.34           |
| Norway spruce           | 1.2                        | 92                  | 158.4                         | 155                 | 247           | (N/A)             | 1.1                 | 0.5              | 20.61           |
| Amur maple              | 0.8                        | 64                  | 135.2                         | 132                 | 196           | (N/A)             | 1.0                 | 0.4              | 17.82           |
| Northern red oak        | 1.5                        | 112                 | 201.6                         | 198                 | 310           | (N/A)             | 1.0                 | 0.7              | 28.16           |
| Black walnut            | 2.8                        | 213                 | 383.9                         | 376                 | 590           | (N/A)             | 0.9                 | 1.3              | 58.95           |
| Eastern red cedar       | 0.6                        | 46                  | 90.1                          | 88                  | 134           | (N/A)             | 0.5                 | 0.3              | 22.39           |
| Willow                  | 1.4                        | 104                 | 205.7                         | 202                 | 306           | (N/A)             | 0.4                 | 0.7              | 61.12           |
| Swamp white oak         | 0.4                        | 27                  | 48.1                          | 47                  | 74            | (N/A)             | 0.4                 | 0.2              | 18.43           |
| Pear                    | 0.2                        | 15                  | 33.3                          | 33                  | 47            | (N/A)             | 0.4                 | 0.1              | 11.80           |
| Conifer Evergreen Large | 0.0                        | 1                   | 2.0                           | 2                   | 3             | (N/A)             | 0.3                 | 0.0              | 0.93            |
| White ash               | 0.3                        | 25                  | 36.8                          | 36                  | 61            | (N/A)             | 0.3                 | 0.1              | 20.47           |
| Mulberry                | 0.6                        | 43                  | 81.0                          | 79                  | 122           | (N/A)             | 0.3                 | 0.3              | 40.80           |
| Boxelder                | 0.2                        | 15                  | 26.8                          | 26                  | 41            | (N/A)             | 0.3                 | 0.1              | 13.67           |
| Paper birch             | 0.0                        | 3                   | 4.6                           | 5                   | 7             | (N/A)             | 0.3                 | 0.0              | 2.38            |
| Ohio buckeye            | 0.3                        | 26                  | 46.3                          | 45                  | 71            | (N/A)             | 0.2                 | 0.2              | 35.62           |
| River birch             | 0.0                        | 1                   | 1.6                           | 2                   | 2             | (N/A)             | 0.2                 | 0.0              | 1.10            |
| American sycamore       | 0.8                        | 59                  | 107.4                         | 105                 | 164           | (N/A)             | 0.2                 | 0.4              | 82.02           |
| Elm                     | 0.7                        | 53                  | 97.1                          | 95                  | 148           | (N/A)             | 0.2                 | 0.3              | 74.17           |
| Black spruce            | 0.1                        | 10                  | 16.4                          | 16                  | 26            | (N/A)             | 0.2                 | 0.1              | 13.08           |
| Black poplar            | 0.7                        | 54                  | 100.5                         | 99                  | 153           | (N/A)             | 0.2                 | 0.3              | 76.46           |
| Mountain ash            | 0.4                        | 28                  | 49.3                          | 48                  | 76            | (N/A)             | 0.2                 | 0.2              | 38.13           |
| Austrian pine           | 0.2                        | 12                  | 20.0                          | 20                  | 31            | (N/A)             | 0.2                 | 0.1              | 15.73           |
| Catalpa                 | 0.9                        | 66                  | 118.0                         | 116                 | 182           | (N/A)             | 0.2                 | 0.4              | 91.02           |
| Dogwood                 | 0.0                        | 2                   | 3.8                           | 4                   | 5             | (N/A)             | 0.1                 | 0.0              | 5.40            |
| Quaking aspen           | 0.0                        | 0                   | 0.5                           | 0                   | 1             | (N/A)             | 0.1                 | 0.0              | 0.66            |
| Eastern cottonwood      | 0.4                        | 29                  | 53.7                          | 53                  | 82            | (N/A)             | 0.1                 | 0.2              | 82.02           |
| Eastern redbud          | 0.0                        | 2                   | 3.8                           | 4                   | 5             | (N/A)             | 0.1                 | 0.0              | 5.40            |
| American elm            | 0.4                        | 29                  | 52.8                          | 52                  | 80            | (N/A)             | 0.1                 | 0.2              | 80.37           |
| Japanese tree lilac     | 0.0                        | 0                   | 0.6                           | 1                   | 1             | (N/A)             | 0.1                 | 0.0              | 0.87            |
| Siberian elm            | 0.1                        | 7                   | 13.6                          | 13                  | 20            | (N/A)             | 0.1                 | 0.0              | 20.49           |
| Bur oak                 | 0.2                        | 18                  | 27.0                          | 26                  | 44            | (N/A)             | 0.1                 | 0.1              | 44.23           |
| Tulip tree              | 0.2                        | 18                  | 27.0                          | 26                  | 44            | (N/A)             | 0.1                 | 0.1              | 44.23           |
| Total                   | 224.1                      | 17,009              | 30,135.5                      | 29,533              | 46,542        | (N/A)             | 100.0               | 100.0            | 41.37           |

Table 2: Annual Stormwater Benefits

**Manson****Annual Stormwater Benefits of Public Trees**

12/22/2015

| Species                 | Total rainfall interception (Gal) | Total (\$) | Standard Error | % of Total Trees | % of Total \$ | Avg. \$/tree |
|-------------------------|-----------------------------------|------------|----------------|------------------|---------------|--------------|
| Green ash               | 558,137                           | 15,126     | (N/A)          | 17.9             | 22.4          | 75.25        |
| Silver maple            | 669,933                           | 18,155     | (N/A)          | 13.2             | 26.9          | 121.85       |
| Norway maple            | 201,724                           | 5,467      | (N/A)          | 11.6             | 8.1           | 41.73        |
| Spruce                  | 347,777                           | 9,425      | (N/A)          | 11.2             | 14.0          | 74.80        |
| Apple                   | 33,139                            | 898        | (N/A)          | 10.4             | 1.3           | 7.68         |
| Honeylocust             | 136,201                           | 3,691      | (N/A)          | 4.4              | 5.5           | 75.33        |
| Sugar maple             | 110,148                           | 2,985      | (N/A)          | 4.4              | 4.4           | 60.92        |
| Blue spruce             | 12,822                            | 347        | (N/A)          | 4.1              | 0.5           | 7.55         |
| Littleleaf linden       | 46,934                            | 1,272      | (N/A)          | 3.0              | 1.9           | 37.41        |
| Northern hackberry      | 88,900                            | 2,409      | (N/A)          | 2.8              | 3.6           | 75.29        |
| American basswood       | 45,626                            | 1,236      | (N/A)          | 2.3              | 1.8           | 47.56        |
| Northern white cedar    | 53,803                            | 1,458      | (N/A)          | 2.2              | 2.2           | 58.32        |
| Maple                   | 8,388                             | 227        | (N/A)          | 2.0              | 0.3           | 9.88         |
| Red maple               | 10,316                            | 280        | (N/A)          | 1.1              | 0.4           | 23.30        |
| Norway spruce           | 20,162                            | 546        | (N/A)          | 1.1              | 0.8           | 45.53        |
| Amur maple              | 3,450                             | 93         | (N/A)          | 1.0              | 0.1           | 8.50         |
| Northern red oak        | 13,056                            | 354        | (N/A)          | 1.0              | 0.5           | 32.17        |
| Black walnut            | 32,689                            | 886        | (N/A)          | 0.9              | 1.3           | 88.59        |
| Eastern red cedar       | 8,832                             | 239        | (N/A)          | 0.5              | 0.4           | 39.89        |
| Willow                  | 13,681                            | 371        | (N/A)          | 0.4              | 0.5           | 74.15        |
| Swamp white oak         | 1,897                             | 51         | (N/A)          | 0.4              | 0.1           | 12.85        |
| Pear                    | 666                               | 18         | (N/A)          | 0.4              | 0.0           | 4.51         |
| Conifer Evergreen Large | 146                               | 4          | (N/A)          | 0.3              | 0.0           | 1.32         |
| White ash               | 1,989                             | 54         | (N/A)          | 0.3              | 0.1           | 17.97        |
| Mulberry                | 2,507                             | 68         | (N/A)          | 0.3              | 0.1           | 22.65        |
| Boxelder                | 1,274                             | 35         | (N/A)          | 0.3              | 0.1           | 11.51        |
| Paper birch             | 207                               | 6          | (N/A)          | 0.3              | 0.0           | 1.87         |
| Ohio buckeye            | 1,995                             | 54         | (N/A)          | 0.2              | 0.1           | 27.03        |
| River birch             | 24                                | 1          | (N/A)          | 0.2              | 0.0           | 0.33         |
| American sycamore       | 10,981                            | 298        | (N/A)          | 0.2              | 0.4           | 148.79       |
| Elm                     | 9,830                             | 266        | (N/A)          | 0.2              | 0.4           | 133.19       |
| Black spruce            | 1,582                             | 43         | (N/A)          | 0.2              | 0.1           | 21.44        |
| Black poplar            | 9,433                             | 256        | (N/A)          | 0.2              | 0.4           | 127.82       |
| Mountain ash            | 1,333                             | 36         | (N/A)          | 0.2              | 0.1           | 18.06        |
| Austrian pine           | 1,801                             | 49         | (N/A)          | 0.2              | 0.1           | 24.40        |
| Catalpa                 | 14,478                            | 392        | (N/A)          | 0.2              | 0.6           | 196.17       |
| Dogwood                 | 69                                | 2          | (N/A)          | 0.1              | 0.0           | 1.86         |
| Quaking aspen           | 18                                | 0          | (N/A)          | 0.1              | 0.0           | 0.48         |
| Eastern cottonwood      | 5,491                             | 149        | (N/A)          | 0.1              | 0.2           | 148.79       |
| Eastern redbud          | 69                                | 2          | (N/A)          | 0.1              | 0.0           | 1.86         |
| American elm            | 4,551                             | 123        | (N/A)          | 0.1              | 0.2           | 123.33       |
| Japanese tree lilac     | 7                                 | 0          | (N/A)          | 0.1              | 0.0           | 0.20         |
| Siberian elm            | 620                               | 17         | (N/A)          | 0.1              | 0.0           | 16.81        |
| Bur oak                 | 1,466                             | 40         | (N/A)          | 0.1              | 0.1           | 39.72        |
| Tulip tree              | 1,466                             | 40         | (N/A)          | 0.1              | 0.1           | 39.72        |
| Citywide total          | 2,489,621                         | 67,469     | (N/A)          | 100.0            | 100.0         | 59.97        |

**Table 3: Annual Air Quality Benefits**

Manson

**Annual Air Quality Benefits of Public Trees**

12/22/2015

| Species                 | Deposition (lb) |                 |                  |                 | Total<br>Depos.<br>(\$) | Avoided (lb)    |                  |       |                 | Total<br>Avoided<br>(\$) | BVOC<br>Emissions<br>(lb) | BVOC<br>Emissions<br>(\$) | Total<br>(lb) | Total<br>Standard<br>(\$)<br>Error | % of Total<br>Trees | Avg.<br>\$/tree |
|-------------------------|-----------------|-----------------|------------------|-----------------|-------------------------|-----------------|------------------|-------|-----------------|--------------------------|---------------------------|---------------------------|---------------|------------------------------------|---------------------|-----------------|
|                         | O <sub>3</sub>  | NO <sub>2</sub> | PM <sub>10</sub> | SO <sub>2</sub> |                         | NO <sub>2</sub> | PM <sub>10</sub> | VOC   | SO <sub>2</sub> |                          |                           |                           |               |                                    |                     |                 |
| Green ash               | 66.4            | 10.6            | 32.3             | 3.0             | 355                     | 257.4           | 37.6             | 35.9  | 246.1           | 1,608                    | 0.0                       | 0                         | 689.4         | 1,963 (N/A)                        | 17.9                | 9.77            |
| Silver maple            | 111.0           | 18.8            | 54.9             | 4.9             | 600                     | 228.3           | 33.5             | 32.0  | 219.7           | 1,430                    | -56.9                     | -214                      | 646.1         | 1,816 (N/A)                        | 13.2                | 12.19           |
| Norway maple            | 36.2            | 6.2             | 18.5             | 1.6             | 197                     | 128.8           | 18.7             | 17.9  | 122.0           | 802                      | -8.9                      | -34                       | 341.0         | 966 (N/A)                          | 11.6                | 7.37            |
| Spruce                  | 40.7            | 8.1             | 33.1             | 5.0             | 267                     | 84.1            | 12.3             | 11.8  | 81.1            | 527                      | -170.4                    | -639                      | 105.8         | 155 (N/A)                          | 11.2                | 1.23            |
| Apple                   | 9.5             | 1.6             | 4.6              | 0.4             | 51                      | 39.1            | 5.6              | 5.3   | 35.8            | 240                      | -0.1                      | 0                         | 101.7         | 290 (N/A)                          | 10.4                | 2.48            |
| Honeylocust             | 26.0            | 4.3             | 12.0             | 1.2             | 138                     | 63.9            | 9.4              | 8.9   | 61.3            | 400                      | -19.7                     | -74                       | 167.3         | 464 (N/A)                          | 4.4                 | 9.46            |
| Sugar maple             | 13.6            | 2.3             | 7.0              | 0.6             | 74                      | 55.0            | 8.1              | 7.7   | 52.9            | 344                      | -10.9                     | -41                       | 136.2         | 378 (N/A)                          | 4.4                 | 7.71            |
| Blue spruce             | 1.2             | 0.2             | 1.2              | 0.1             | 8                       | 5.9             | 0.9              | 0.8   | 5.5             | 37                       | -4.0                      | -15                       | 11.8          | 30 (N/A)                           | 4.1                 | 0.65            |
| Littleleaf linden       | 7.3             | 1.3             | 3.7              | 0.3             | 40                      | 25.9            | 3.8              | 3.6   | 24.6            | 161                      | -3.7                      | -14                       | 66.8          | 188 (N/A)                          | 3.0                 | 5.52            |
| Northern hackberry      | 12.9            | 2.2             | 6.7              | 0.6             | 71                      | 49.9            | 7.2              | 6.9   | 47.2            | 310                      | 0.0                       | 0                         | 133.6         | 381 (N/A)                          | 2.8                 | 11.91           |
| American basswood       | 5.5             | 0.9             | 2.8              | 0.2             | 30                      | 24.2            | 3.5              | 3.3   | 22.7            | 150                      | -4.9                      | -18                       | 58.3          | 161 (N/A)                          | 2.3                 | 6.21            |
| Northern white cedar    | 6.3             | 1.3             | 5.1              | 0.8             | 42                      | 12.3            | 1.8              | 1.7   | 11.7            | 77                       | -31.0                     | -116                      | 9.9           | 2 (N/A)                            | 2.2                 | 0.07            |
| Maple                   | 1.1             | 0.2             | 0.6              | 0.0             | 6                       | 7.5             | 1.1              | 1.0   | 7.1             | 47                       | -0.5                      | -2                        | 18.2          | 51 (N/A)                           | 2.0                 | 2.22            |
| Red maple               | 1.8             | 0.3             | 0.9              | 0.1             | 10                      | 8.2             | 1.2              | 1.1   | 7.8             | 51                       | -0.7                      | -3                        | 20.7          | 58 (N/A)                           | 1.1                 | 4.84            |
| Norway spruce           | 2.3             | 0.5             | 1.9              | 0.3             | 15                      | 5.7             | 0.8              | 0.8   | 5.5             | 36                       | -9.8                      | -37                       | 8.0           | 14 (N/A)                           | 1.1                 | 1.18            |
| Amur maple              | 0.9             | 0.2             | 0.5              | 0.0             | 5                       | 4.2             | 0.6              | 0.6   | 3.8             | 26                       | 0.0                       | 0                         | 10.7          | 30 (N/A)                           | 1.0                 | 2.77            |
| Northern red oak        | 2.6             | 0.4             | 1.3              | 0.1             | 14                      | 7.0             | 1.0              | 1.0   | 6.7             | 44                       | -3.7                      | -14                       | 16.5          | 44 (N/A)                           | 1.0                 | 4.00            |
| Black walnut            | 4.2             | 0.7             | 2.0              | 0.2             | 22                      | 13.4            | 2.0              | 1.9   | 12.7            | 84                       | 0.0                       | 0                         | 37.0          | 106 (N/A)                          | 0.9                 | 10.58           |
| Eastern red cedar       | 1.8             | 0.4             | 1.4              | 0.2             | 12                      | 2.9             | 0.4              | 0.4   | 2.7             | 18                       | -4.9                      | -18                       | 5.4           | 12 (N/A)                           | 0.5                 | 1.92            |
| Willow                  | 2.8             | 0.5             | 1.4              | 0.1             | 15                      | 6.7             | 1.0              | 0.9   | 6.2             | 41                       | -0.7                      | -2                        | 19.0          | 54 (N/A)                           | 0.4                 | 10.84           |
| Swamp white oak         | 0.2             | 0.0             | 0.1              | 0.0             | 1                       | 1.7             | 0.2              | 0.2   | 1.6             | 10                       | -0.1                      | 0                         | 4.1           | 12 (N/A)                           | 0.4                 | 2.89            |
| Pear                    | 0.1             | 0.0             | 0.1              | 0.0             | 1                       | 1.0             | 0.1              | 0.1   | 0.9             | 6                        | 0.0                       | 0                         | 2.3           | 7 (N/A)                            | 0.4                 | 1.63            |
| Conifer Evergreen Large | 0.0             | 0.0             | 0.0              | 0.0             | 0                       | 0.1             | 0.0              | 0.0   | 0.0             | 0                        | -0.1                      | 0                         | 0.1           | 0 (N/A)                            | 0.3                 | 0.05            |
| White ash               | 0.1             | 0.0             | 0.1              | 0.0             | 1                       | 1.5             | 0.2              | 0.2   | 1.5             | 10                       | 0.0                       | 0                         | 3.7           | 10 (N/A)                           | 0.3                 | 3.43            |
| Mulberry                | 0.8             | 0.1             | 0.4              | 0.0             | 4                       | 2.7             | 0.4              | 0.4   | 2.6             | 17                       | 0.0                       | 0                         | 7.5           | 21 (N/A)                           | 0.3                 | 7.15            |
| Boxelder                | 0.1             | 0.0             | 0.1              | 0.0             | 0                       | 0.9             | 0.1              | 0.1   | 0.9             | 6                        | -0.1                      | 0                         | 2.1           | 6 (N/A)                            | 0.3                 | 1.99            |
| Paper birch             | 0.0             | 0.0             | 0.0              | 0.0             | 0                       | 0.2             | 0.0              | 0.0   | 0.2             | 1                        | 0.0                       | 0                         | 0.4           | 1 (N/A)                            | 0.3                 | 0.35            |
| Ohio buckeye            | 0.3             | 0.0             | 0.2              | 0.0             | 2                       | 1.6             | 0.2              | 0.2   | 1.5             | 10                       | -0.1                      | 0                         | 4.0           | 11 (N/A)                           | 0.2                 | 5.69            |
| River birch             | 0.0             | 0.0             | 0.0              | 0.0             | 0                       | 0.0             | 0.0              | 0.0   | 0.0             | 0                        | 0.0                       | 0                         | 0.1           | 0 (N/A)                            | 0.2                 | 0.14            |
| American sycamore       | 1.6             | 0.3             | 0.7              | 0.1             | 8                       | 3.7             | 0.5              | 0.5   | 3.5             | 23                       | 0.0                       | 0                         | 10.9          | 31 (N/A)                           | 0.2                 | 15.71           |
| Elm                     | 1.4             | 0.2             | 0.6              | 0.1             | 7                       | 3.4             | 0.5              | 0.5   | 3.2             | 21                       | 0.0                       | 0                         | 9.9           | 28 (N/A)                           | 0.2                 | 14.19           |
| Black spruce            | 0.2             | 0.0             | 0.2              | 0.0             | 1                       | 0.6             | 0.1              | 0.1   | 0.6             | 4                        | -0.6                      | -2                        | 1.3           | 3 (N/A)                            | 0.2                 | 1.53            |
| Black poplar            | 1.3             | 0.2             | 0.6              | 0.1             | 7                       | 3.4             | 0.5              | 0.5   | 3.2             | 21                       | 0.0                       | 0                         | 9.8           | 28 (N/A)                           | 0.2                 | 14.09           |
| Mountain ash            | 0.4             | 0.1             | 0.2              | 0.0             | 2                       | 1.7             | 0.3              | 0.2   | 1.7             | 11                       | 0.0                       | 0                         | 4.6           | 13 (N/A)                           | 0.2                 | 6.56            |
| Austrian pine           | 0.2             | 0.0             | 0.2              | 0.0             | 1                       | 0.7             | 0.1              | 0.1   | 0.7             | 5                        | -0.6                      | -2                        | 1.5           | 4 (N/A)                            | 0.2                 | 1.82            |
| Catalpa                 | 2.3             | 0.4             | 1.0              | 0.1             | 12                      | 4.2             | 0.6              | 0.6   | 4.0             | 26                       | 0.0                       | 0                         | 13.1          | 38 (N/A)                           | 0.2                 | 19.04           |
| Dogwood                 | 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)                            | 0.1                 | 0.71            |
| Quaking aspen           | 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)                            | 0.1                 | 0.08            |
| Eastern cottonwood      | 0.8             | 0.1             | 0.4              | 0.0             | 4                       | 1.9             | 0.3              | 0.3   | 1.8             | 12                       | 0.0                       | 0                         | 5.5           | 16 (N/A)                           | 0.1                 | 15.71           |
| Eastern redbud          | 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)                            | 0.1                 | 0.71            |
| American elm            | 0.5             | 0.1             | 0.3              | 0.0             | 3                       | 1.8             | 0.3              | 0.3   | 1.7             | 11                       | 0.0                       | 0                         | 4.9           | 14 (N/A)                           | 0.1                 | 14.10           |
| Japanese tree lilac     | 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)                            | 0.1                 | 0.11            |
| Siberian elm            | 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)                            | 0.1                 | 2.97            |
| Bur oak                 | 0.1             | 0.0             | 0.1              | 0.0             | 1                       | 1.1             | 0.2              | 0.2   | 1.1             | 7                        | 0.0                       | 0                         | 2.6           | 7 (N/A)                            | 0.1                 | 7.42            |
| Tulip tree              | 0.1             | 0.0             | 0.1              | 0.0             | 1                       | 1.1             | 0.2              | 0.2   | 1.1             | 7                        | 0.0                       | 0                         | 2.6           | 7 (N/A)                            | 0.1                 | 7.42            |
| Citywide total          | 364.6           | 62.6            | 197.1            | 20.4            | 2,028                   | 1,064.4         | 155.4            | 148.2 | 1,015.3         | 6,644                    | -332.1                    | -1,245                    | 2,695.9       | 7,427 (N/A)                        | 100.0               | 6.60            |

Table 4: Annual Carbon Stored

**Manson****Stored CO2 Benefits of Public Trees**

12/22/2015

| Species              | Total Stored<br>CO2 (lbs) | Total<br>(\$) | Standard<br>Error | % of Total<br>Trees | % of<br>Total \$ | Avg.<br>\$/tree |
|----------------------|---------------------------|---------------|-------------------|---------------------|------------------|-----------------|
| Green ash            | 2,172,271                 | 16,292        | (N/A)             | 17.9                | 28.2             | 81.05           |
| Silver maple         | 2,391,030                 | 17,933        | (N/A)             | 13.2                | 31.0             | 120.35          |
| Norway maple         | 601,022                   | 4,508         | (N/A)             | 11.6                | 7.8              | 34.41           |
| Spruce               | 419,153                   | 3,144         | (N/A)             | 11.2                | 5.4              | 24.95           |
| Apple                | 153,321                   | 1,150         | (N/A)             | 10.4                | 2.0              | 9.83            |
| Honeylocust          | 331,392                   | 2,485         | (N/A)             | 4.4                 | 4.3              | 50.72           |
| Sugar maple          | 389,293                   | 2,920         | (N/A)             | 4.4                 | 5.0              | 59.59           |
| Blue spruce          | 5,709                     | 43            | (N/A)             | 4.1                 | 0.1              | 0.93            |
| Littleleaf linden    | 159,430                   | 1,196         | (N/A)             | 3.0                 | 2.1              | 35.17           |
| Northern hackberry   | 188,257                   | 1,412         | (N/A)             | 2.8                 | 2.4              | 44.12           |
| American basswood    | 198,601                   | 1,490         | (N/A)             | 2.3                 | 2.6              | 57.29           |
| Northern white cedar | 78,832                    | 591           | (N/A)             | 2.2                 | 1.0              | 23.65           |
| Maple                | 15,362                    | 115           | (N/A)             | 2.0                 | 0.2              | 5.01            |
| Red maple            | 21,336                    | 160           | (N/A)             | 1.1                 | 0.3              | 13.33           |
| Norway spruce        | 23,632                    | 177           | (N/A)             | 1.1                 | 0.3              | 14.77           |
| Amur maple           | 15,269                    | 115           | (N/A)             | 1.0                 | 0.2              | 10.41           |
| Northern red oak     | 55,528                    | 416           | (N/A)             | 1.0                 | 0.7              | 37.86           |
| Black walnut         | 136,791                   | 1,026         | (N/A)             | 0.9                 | 1.8              | 102.59          |
| Eastern red cedar    | 5,787                     | 43            | (N/A)             | 0.5                 | 0.1              | 7.23            |
| Willow               | 46,061                    | 345           | (N/A)             | 0.4                 | 0.6              | 69.09           |
| Swamp white oak      | 4,280                     | 32            | (N/A)             | 0.4                 | 0.1              | 8.02            |
| Pear                 | 2,171                     | 16            | (N/A)             | 0.4                 | 0.0              | 4.07            |
| Conifer Evergreen La | 7                         | 0             | (N/A)             | 0.3                 | 0.0              | 0.02            |
| White ash            | 4,043                     | 30            | (N/A)             | 0.3                 | 0.1              | 10.11           |
| Mulberry             | 12,817                    | 96            | (N/A)             | 0.3                 | 0.2              | 32.04           |
| Boxelder             | 1,538                     | 12            | (N/A)             | 0.3                 | 0.0              | 3.84            |
| Paper birch          | 210                       | 2             | (N/A)             | 0.3                 | 0.0              | 0.52            |
| Ohio buckeye         | 4,725                     | 35            | (N/A)             | 0.2                 | 0.1              | 17.72           |
| River birch          | 34                        | 0             | (N/A)             | 0.2                 | 0.0              | 0.13            |
| American sycamore    | 51,886                    | 389           | (N/A)             | 0.2                 | 0.7              | 194.57          |
| Elm                  | 47,716                    | 358           | (N/A)             | 0.2                 | 0.6              | 178.94          |
| Black spruce         | 1,120                     | 8             | (N/A)             | 0.2                 | 0.0              | 4.20            |
| Black poplar         | 41,716                    | 313           | (N/A)             | 0.2                 | 0.5              | 156.43          |
| Mountain ash         | 6,074                     | 46            | (N/A)             | 0.2                 | 0.1              | 22.78           |
| Austrian pine        | 1,161                     | 9             | (N/A)             | 0.2                 | 0.0              | 4.35            |
| Catalpa              | 78,517                    | 589           | (N/A)             | 0.2                 | 1.0              | 294.44          |
| Dogwood              | 178                       | 1             | (N/A)             | 0.1                 | 0.0              | 1.33            |
| Quaking aspen        | 12                        | 0             | (N/A)             | 0.1                 | 0.0              | 0.09            |
| Eastern cottonwood   | 25,943                    | 195           | (N/A)             | 0.1                 | 0.3              | 194.57          |
| Eastern redbud       | 178                       | 1             | (N/A)             | 0.1                 | 0.0              | 1.33            |
| American elm         | 12,245                    | 92            | (N/A)             | 0.1                 | 0.2              | 91.84           |
| Japanese tree lilac  | 14                        | 0             | (N/A)             | 0.1                 | 0.0              | 0.10            |
| Siberian elm         | 908                       | 7             | (N/A)             | 0.1                 | 0.0              | 6.81            |
| Bur oak              | 3,672                     | 28            | (N/A)             | 0.1                 | 0.0              | 27.54           |
| Tulip tree           | 3,672                     | 28            | (N/A)             | 0.1                 | 0.0              | 27.54           |
| Citywide total       | 7,712,917                 | 57,847        | (N/A)             | 100.0               | 100.0            | 51.42           |

**Table 5: Annual Carbon Sequestered**

Manson

**Annual CO<sub>2</sub> Benefits of Public Trees**

12/22/2015

| Species                 | Sequestered (lb) | Sequestered (\$) | Decomposition Release (lb) | Maintenance Release (lb) | Total Released (\$) | Avoided (lb) | Avoided (\$) | Net Total (lb) | Total Standard (\$) | % of Total Trees | % of Total \$ | Avg. \$/tree |
|-------------------------|------------------|------------------|----------------------------|--------------------------|---------------------|--------------|--------------|----------------|---------------------|------------------|---------------|--------------|
| Green ash               | 124,308          | 932              | -10,427                    | -547                     | -4                  | 0            | 0            | 113,334        | 850 (N/A)           | 17.9             | 23.9          | 4.23         |
| Silver maple            | 188,553          | 1,414            | -11,477                    | -517                     | -4                  | 0            | 0            | 176,559        | 1,324 (N/A)         | 13.2             | 37.3          | 8.89         |
| Norway maple            | 42,034           | 315              | -2,887                     | -258                     | -2                  | 0            | 0            | 38,889         | 292 (N/A)           | 11.6             | 8.2           | 2.23         |
| Spruce                  | 20,278           | 152              | -2,012                     | -327                     | -2                  | 0            | 0            | 17,939         | 135 (N/A)           | 11.2             | 3.8           | 1.07         |
| Apple                   | 10,171           | 76               | -738                       | -121                     | -1                  | 0            | 0            | 9,313          | 70 (N/A)            | 10.4             | 2.0           | 0.60         |
| Honeylocust             | 29,830           | 224              | -1,594                     | -108                     | -1                  | 0            | 0            | 28,129         | 211 (N/A)           | 4.4              | 5.9           | 4.31         |
| Sugar maple             | 22,890           | 172              | -1,869                     | -119                     | -1                  | 0            | 0            | 20,903         | 157 (N/A)           | 4.4              | 4.4           | 3.20         |
| Blue spruce             | 677              | 5                | -28                        | -24                      | 0                   | 0            | 0            | 625            | 5 (N/A)             | 4.1              | 0.1           | 0.10         |
| Littleleaf linden       | 15,716           | 118              | -767                       | -64                      | 0                   | 0            | 0            | 14,885         | 112 (N/A)           | 3.0              | 3.1           | 3.28         |
| Northern hackberry      | 11,913           | 89               | -904                       | -92                      | -1                  | 0            | 0            | 10,917         | 82 (N/A)            | 2.8              | 2.3           | 2.56         |
| American basswood       | 12,824           | 96               | -953                       | -57                      | 0                   | 0            | 0            | 11,813         | 89 (N/A)            | 2.3              | 2.5           | 3.41         |
| Northern white cedar    | 2,174            | 16               | -378                       | -54                      | 0                   | 0            | 0            | 1,742          | 13 (N/A)            | 2.2              | 0.4           | 0.52         |
| Maple                   | 2,295            | 17               | -74                        | -18                      | 0                   | 0            | 0            | 2,202          | 17 (N/A)            | 2.0              | 0.5           | 0.72         |
| Red maple               | 2,966            | 22               | -102                       | -16                      | 0                   | 0            | 0            | 2,848          | 21 (N/A)            | 1.1              | 0.6           | 1.78         |
| Norway spruce           | 1,065            | 8                | -113                       | -22                      | 0                   | 0            | 0            | 929            | 7 (N/A)             | 1.1              | 0.2           | 0.58         |
| Amur maple              | 1,455            | 11               | -73                        | -12                      | 0                   | 0            | 0            | 1,370          | 10 (N/A)            | 1.0              | 0.3           | 0.93         |
| Northern red oak        | 1,398            | 10               | -267                       | -19                      | 0                   | 0            | 0            | 1,112          | 8 (N/A)             | 1.0              | 0.2           | 0.76         |
| Black walnut            | 6,655            | 50               | -657                       | -29                      | 0                   | 0            | 0            | 5,969          | 45 (N/A)            | 0.9              | 1.3           | 4.48         |
| Eastern red cedar       | 211              | 2                | -28                        | -11                      | 0                   | 0            | 0            | 173            | 1 (N/A)             | 0.5              | 0.0           | 0.22         |
| Willow                  | 2,250            | 17               | -221                       | -14                      | 0                   | 0            | 0            | 2,014          | 15 (N/A)            | 0.4              | 0.4           | 3.02         |
| Swamp white oak         | 673              | 5                | -23                        | -4                       | 0                   | 0            | 0            | 646            | 5 (N/A)             | 0.4              | 0.1           | 1.21         |
| Pear                    | 304              | 2                | -10                        | -4                       | 0                   | 0            | 0            | 290            | 2 (N/A)             | 0.4              | 0.1           | 0.54         |
| Conifer Evergreen Large | 11               | 0                | 0                          | -1                       | 0                   | 0            | 0            | 10             | 0 (N/A)             | 0.3              | 0.0           | 0.02         |
| White ash               | 624              | 5                | -21                        | -3                       | 0                   | 0            | 0            | 601            | 5 (N/A)             | 0.3              | 0.1           | 1.50         |
| Mulberry                | 535              | 4                | -62                        | -7                       | 0                   | 0            | 0            | 466            | 3 (N/A)             | 0.3              | 0.1           | 1.17         |
| Boxelder                | 294              | 2                | -9                         | -2                       | 0                   | 0            | 0            | 283            | 2 (N/A)             | 0.3              | 0.1           | 0.71         |
| Paper birch             | 79               | 1                | -1                         | -1                       | 0                   | 0            | 0            | 77             | 1 (N/A)             | 0.3              | 0.0           | 0.19         |
| Ohio buckeye            | 610              | 5                | -23                        | -3                       | 0                   | 0            | 0            | 584            | 4 (N/A)             | 0.2              | 0.1           | 2.19         |
| River birch             | 11               | 0                | 0                          | 0                        | 0                   | 0            | 0            | 10             | 0 (N/A)             | 0.2              | 0.0           | 0.04         |
| American sycamore       | 1,919            | 14               | -249                       | -9                       | 0                   | 0            | 0            | 1,662          | 12 (N/A)            | 0.2              | 0.4           | 6.23         |
| Elm                     | 1,572            | 12               | -229                       | -8                       | 0                   | 0            | 0            | 1,335          | 10 (N/A)            | 0.2              | 0.3           | 5.01         |
| Black spruce            | 92               | 1                | -5                         | -2                       | 0                   | 0            | 0            | 85             | 1 (N/A)             | 0.2              | 0.0           | 0.32         |
| Black poplar            | 1,816            | 14               | -200                       | -8                       | 0                   | 0            | 0            | 1,608          | 12 (N/A)            | 0.2              | 0.3           | 6.03         |
| Mountain ash            | 535              | 4                | -29                        | -4                       | 0                   | 0            | 0            | 502            | 4 (N/A)             | 0.2              | 0.1           | 1.88         |
| Austrian pine           | 103              | 1                | -6                         | -3                       | 0                   | 0            | 0            | 95             | 1 (N/A)             | 0.2              | 0.0           | 0.35         |
| Catalpa                 | 1,824            | 14               | -377                       | -10                      | 0                   | 0            | 0            | 1,437          | 11 (N/A)            | 0.2              | 0.3           | 5.39         |
| Dogwood                 | 38               | 0                | -1                         | -1                       | 0                   | 0            | 0            | 37             | 0 (N/A)             | 0.1              | 0.0           | 0.27         |
| Quaking aspen           | 3                | 0                | 0                          | 0                        | 0                   | 0            | 0            | 2              | 0 (N/A)             | 0.1              | 0.0           | 0.02         |
| Eastern cottonwood      | 960              | 7                | -125                       | -4                       | 0                   | 0            | 0            | 831            | 6 (N/A)             | 0.1              | 0.2           | 6.23         |
| Eastern redbud          | 38               | 0                | -1                         | -1                       | 0                   | 0            | 0            | 37             | 0 (N/A)             | 0.1              | 0.0           | 0.27         |
| American elm            | 454              | 3                | -59                        | -4                       | 0                   | 0            | 0            | 392            | 3 (N/A)             | 0.1              | 0.1           | 2.94         |
| Japanese tree lilac     | 9                | 0                | 0                          | 0                        | 0                   | 0            | 0            | 8              | 0 (N/A)             | 0.1              | 0.0           | 0.06         |
| Siberian elm            | 161              | 1                | -4                         | -1                       | 0                   | 0            | 0            | 156            | 1 (N/A)             | 0.1              | 0.0           | 1.17         |
| Bur oak                 | 445              | 3                | -18                        | -2                       | 0                   | 0            | 0            | 426            | 3 (N/A)             | 0.1              | 0.1           | 3.19         |
| Tulip tree              | 445              | 3                | -18                        | -2                       | 0                   | 0            | 0            | 426            | 3 (N/A)             | 0.1              | 0.1           | 3.19         |
| Citywide total          | 513,219          | 3,849            | -37,037                    | -2,512                   | -19                 | 0            | 0            | 473,669        | 3,553 (N/A)         | 100.0            | 100.0         | 3.16         |

Table 6: Annual Social and Aesthetic Benefits

**Manson****Annual Aesthetic/Other Benefits of Public Trees**

12/22/2015

| Species                 | Total (\$) | Standard Error | % of Total Trees | % of Total \$ | Avg. \$/tree |
|-------------------------|------------|----------------|------------------|---------------|--------------|
| Green ash               | 10,618     | (N/A)          | 17.9             | 20.0          | 52.82        |
| Silver maple            | 15,096     | (N/A)          | 13.2             | 28.4          | 101.31       |
| Norway maple            | 4,250      | (N/A)          | 11.6             | 8.0           | 32.44        |
| Spruce                  | 4,719      | (N/A)          | 11.2             | 8.9           | 37.45        |
| Apple                   | 561        | (N/A)          | 10.4             | 1.1           | 4.79         |
| Honeylocust             | 6,822      | (N/A)          | 4.4              | 12.8          | 139.22       |
| Sugar maple             | 2,508      | (N/A)          | 4.4              | 4.7           | 51.17        |
| Blue spruce             | 455        | (N/A)          | 4.1              | 0.9           | 9.90         |
| Littleleaf linden       | 1,702      | (N/A)          | 3.0              | 3.2           | 50.07        |
| Northern hackberry      | 1,702      | (N/A)          | 2.8              | 3.2           | 53.17        |
| American basswood       | 1,006      | (N/A)          | 2.3              | 1.9           | 38.70        |
| Northern white cedar    | 354        | (N/A)          | 2.2              | 0.7           | 14.16        |
| Maple                   | 393        | (N/A)          | 2.0              | 0.7           | 17.08        |
| Red maple               | 450        | (N/A)          | 1.1              | 0.8           | 37.49        |
| Norway spruce           | 254        | (N/A)          | 1.1              | 0.5           | 21.16        |
| Amur maple              | 83         | (N/A)          | 1.0              | 0.2           | 7.53         |
| Northern red oak        | 128        | (N/A)          | 1.0              | 0.2           | 11.61        |
| Black walnut            | 534        | (N/A)          | 0.9              | 1.0           | 53.41        |
| Eastern red cedar       | 76         | (N/A)          | 0.5              | 0.1           | 12.68        |
| Willow                  | 204        | (N/A)          | 0.4              | 0.4           | 40.73        |
| Swamp white oak         | 78         | (N/A)          | 0.4              | 0.1           | 19.45        |
| Pear                    | 17         | (N/A)          | 0.4              | 0.0           | 4.23         |
| Conifer Evergreen Large | 17         | (N/A)          | 0.3              | 0.0           | 5.76         |
| White ash               | 89         | (N/A)          | 0.3              | 0.2           | 29.76        |
| Mulberry                | 31         | (N/A)          | 0.3              | 0.1           | 10.32        |
| Boxelder                | 65         | (N/A)          | 0.3              | 0.1           | 21.76        |
| Paper birch             | 25         | (N/A)          | 0.3              | 0.0           | 8.42         |
| Ohio buckeye            | 65         | (N/A)          | 0.2              | 0.1           | 32.69        |
| River birch             | 5          | (N/A)          | 0.2              | 0.0           | 2.74         |
| American sycamore       | 133        | (N/A)          | 0.2              | 0.3           | 66.60        |
| Elm                     | 116        | (N/A)          | 0.2              | 0.2           | 58.01        |
| Black spruce            | 30         | (N/A)          | 0.2              | 0.1           | 15.13        |
| Black poplar            | 132        | (N/A)          | 0.2              | 0.2           | 66.10        |
| Mountain ash            | 31         | (N/A)          | 0.2              | 0.1           | 15.48        |
| Austrian pine           | 38         | (N/A)          | 0.2              | 0.1           | 18.77        |
| Catalpa                 | 117        | (N/A)          | 0.2              | 0.2           | 58.34        |
| Dogwood                 | 2          | (N/A)          | 0.1              | 0.0           | 2.06         |
| Quaking aspen           | 5          | (N/A)          | 0.1              | 0.0           | 5.26         |
| Eastern cottonwood      | 67         | (N/A)          | 0.1              | 0.1           | 66.60        |
| Eastern redbud          | 2          | (N/A)          | 0.1              | 0.0           | 2.06         |
| American elm            | 64         | (N/A)          | 0.1              | 0.1           | 64.36        |
| Japanese tree lilac     | 0          | (N/A)          | 0.1              | 0.0           | 0.03         |
| Siberian elm            | 22         | (N/A)          | 0.1              | 0.0           | 22.05        |
| Bur oak                 | 46         | (N/A)          | 0.1              | 0.1           | 45.86        |
| Tulip tree              | 46         | (N/A)          | 0.1              | 0.1           | 45.86        |
| Citywide total          | 53,157     | (N/A)          | 100.0            | 100.0         | 47.25        |

Table 7: Summary of Benefits in Dollars

**Manson****Total Annual Benefits of Public Trees by Species (\$)**

12/22/201

| Species                 | Energy | CO <sub>2</sub> | Air Quality | Stormwater | Aesthetic/Other | Total (\$) | Standard Error | % of Total \$ |
|-------------------------|--------|-----------------|-------------|------------|-----------------|------------|----------------|---------------|
| Green ash               | 11,198 | 850             | 1,963       | 15,126     | 10,618          | 39,755     | (N/A)          | 22.3          |
| Silver maple            | 9,884  | 1,324           | 1,816       | 18,155     | 15,096          | 46,275     | (N/A)          | 26.0          |
| Norway maple            | 5,659  | 292             | 966         | 5,467      | 4,250           | 16,633     | (N/A)          | 9.3           |
| Spruce                  | 3,636  | 135             | 155         | 9,425      | 4,719           | 18,069     | (N/A)          | 10.1          |
| Apple                   | 1,810  | 70              | 290         | 898        | 561             | 3,629      | (N/A)          | 2.0           |
| Honeylocust             | 2,778  | 211             | 464         | 3,691      | 6,822           | 13,965     | (N/A)          | 7.8           |
| Sugar maple             | 2,376  | 157             | 378         | 2,985      | 2,508           | 8,404      | (N/A)          | 4.7           |
| Blue spruce             | 273    | 5               | 30          | 347        | 455             | 1,111      | (N/A)          | 0.6           |
| Littleleaf linden       | 1,141  | 112             | 188         | 1,272      | 1,702           | 4,415      | (N/A)          | 2.5           |
| Northern hackberry      | 2,200  | 82              | 381         | 2,409      | 1,702           | 6,774      | (N/A)          | 3.8           |
| American basswood       | 1,075  | 89              | 161         | 1,236      | 1,006           | 3,568      | (N/A)          | 2.0           |
| Northern white cedar    | 543    | 13              | 2           | 1,458      | 354             | 2,370      | (N/A)          | 1.3           |
| Maple                   | 338    | 17              | 51          | 227        | 393             | 1,026      | (N/A)          | 0.6           |
| Red maple               | 352    | 21              | 58          | 280        | 450             | 1,161      | (N/A)          | 0.7           |
| Norway spruce           | 247    | 7               | 14          | 546        | 254             | 1,069      | (N/A)          | 0.6           |
| Amur maple              | 196    | 10              | 30          | 93         | 83              | 413        | (N/A)          | 0.2           |
| Northern red oak        | 310    | 8               | 44          | 354        | 128             | 844        | (N/A)          | 0.5           |
| Black walnut            | 590    | 45              | 106         | 886        | 534             | 2,160      | (N/A)          | 1.2           |
| Eastern red cedar       | 134    | 1               | 12          | 239        | 76              | 463        | (N/A)          | 0.3           |
| Willow                  | 306    | 15              | 54          | 371        | 204             | 949        | (N/A)          | 0.5           |
| Swamp white oak         | 74     | 5               | 12          | 51         | 78              | 219        | (N/A)          | 0.1           |
| Pear                    | 47     | 2               | 7           | 18         | 17              | 91         | (N/A)          | 0.1           |
| Conifer Evergreen Large | 3      | 0               | 0           | 4          | 17              | 24         | (N/A)          | 0.0           |
| White ash               | 61     | 5               | 10          | 54         | 89              | 219        | (N/A)          | 0.1           |
| Mulberry                | 122    | 3               | 21          | 68         | 31              | 246        | (N/A)          | 0.1           |
| Boxelder                | 41     | 2               | 6           | 35         | 65              | 149        | (N/A)          | 0.1           |
| Paper birch             | 7      | 1               | 1           | 6          | 25              | 40         | (N/A)          | 0.0           |
| Ohio buckeye            | 71     | 4               | 11          | 54         | 65              | 206        | (N/A)          | 0.1           |
| River birch             | 2      | 0               | 0           | 1          | 5               | 9          | (N/A)          | 0.0           |
| American sycamore       | 164    | 12              | 31          | 298        | 133             | 639        | (N/A)          | 0.4           |
| Elm                     | 148    | 10              | 28          | 266        | 116             | 569        | (N/A)          | 0.3           |
| Black spruce            | 26     | 1               | 3           | 43         | 30              | 103        | (N/A)          | 0.1           |
| Black poplar            | 153    | 12              | 28          | 256        | 132             | 581        | (N/A)          | 0.3           |
| Mountain ash            | 76     | 4               | 13          | 36         | 31              | 160        | (N/A)          | 0.1           |
| Austrian pine           | 31     | 1               | 4           | 49         | 38              | 122        | (N/A)          | 0.1           |
| Catalpa                 | 182    | 11              | 38          | 392        | 117             | 740        | (N/A)          | 0.4           |
| Dogwood                 | 5      | 0               | 1           | 2          | 2               | 10         | (N/A)          | 0.0           |
| Quaking aspen           | 1      | 0               | 0           | 0          | 5               | 7          | (N/A)          | 0.0           |
| Eastern cottonwood      | 82     | 6               | 16          | 149        | 67              | 319        | (N/A)          | 0.2           |
| Eastern redbud          | 5      | 0               | 1           | 2          | 2               | 10         | (N/A)          | 0.0           |
| American elm            | 80     | 3               | 14          | 123        | 64              | 285        | (N/A)          | 0.2           |
| Japanese tree lilac     | 1      | 0               | 0           | 0          | 0               | 1          | (N/A)          | 0.0           |
| Siberian elm            | 20     | 1               | 3           | 17         | 22              | 63         | (N/A)          | 0.0           |
| Bur oak                 | 44     | 3               | 7           | 40         | 46              | 140        | (N/A)          | 0.1           |
| Tulip tree              | 44     | 3               | 7           | 40         | 46              | 140        | (N/A)          | 0.1           |
| Citywide Total          | 46,542 | 3,553           | 7,427       | 67,469     | 53,157          | 178,147    | (N/A)          | 100.0         |

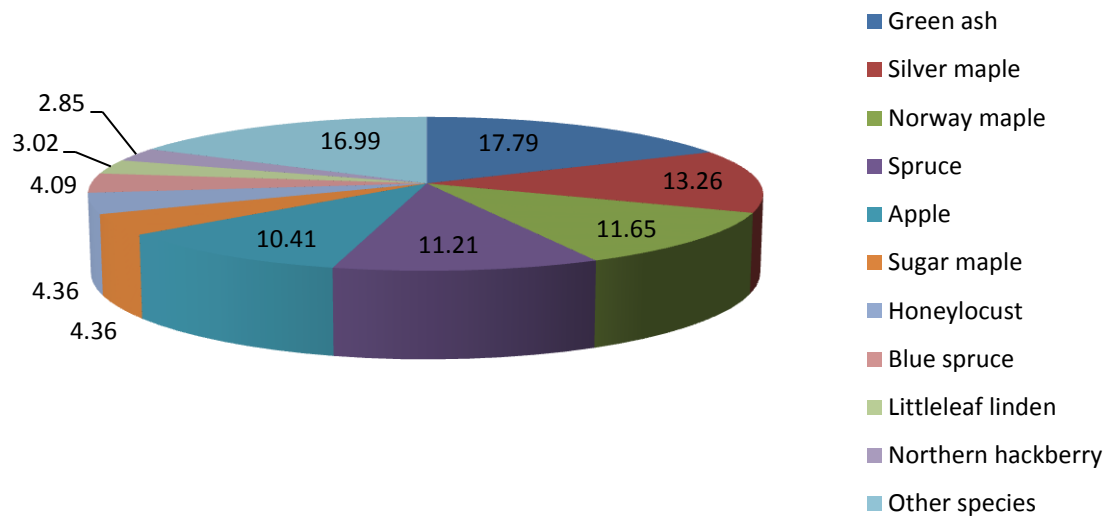


Figure 1: Species Distribution

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

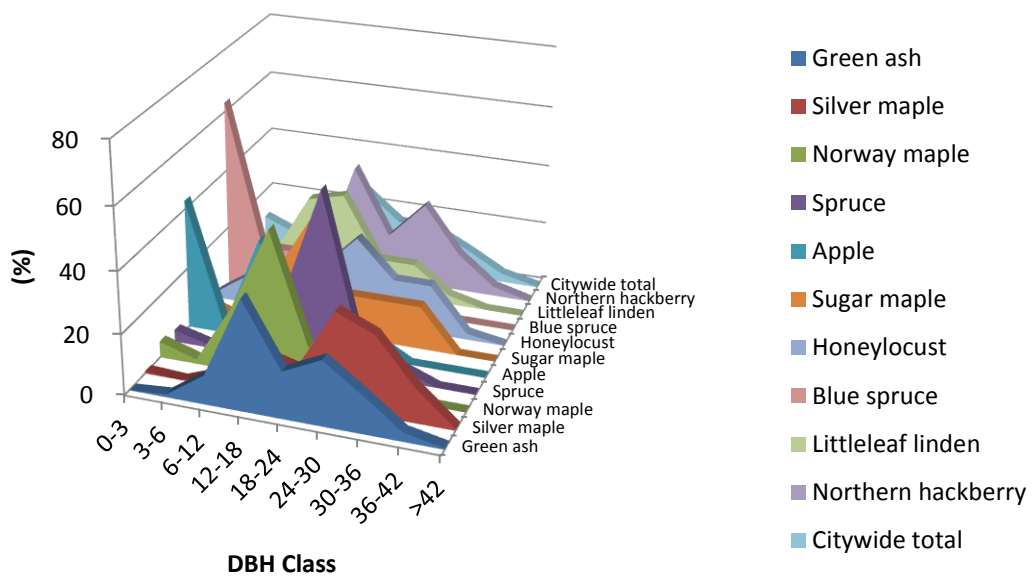


Figure 2: Relative Age Class

## Leaf Condition

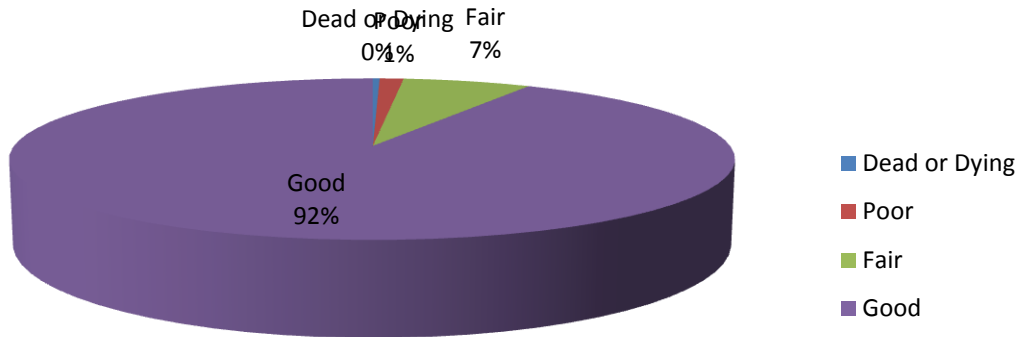


Figure 3: Foliage Condition

## Wood Condition

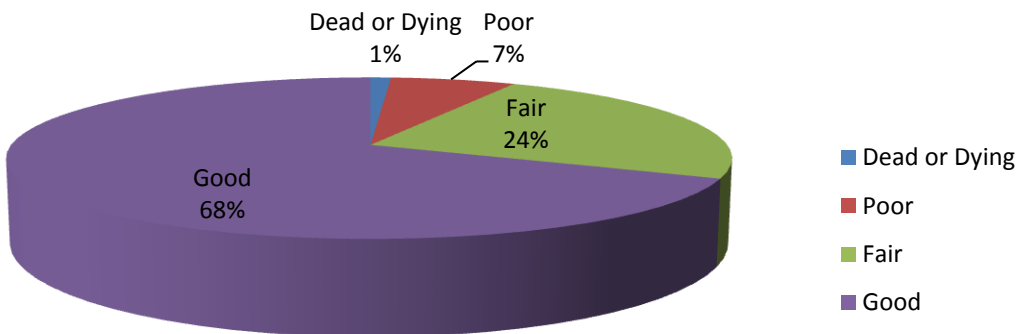


Figure 4: Wood Condition

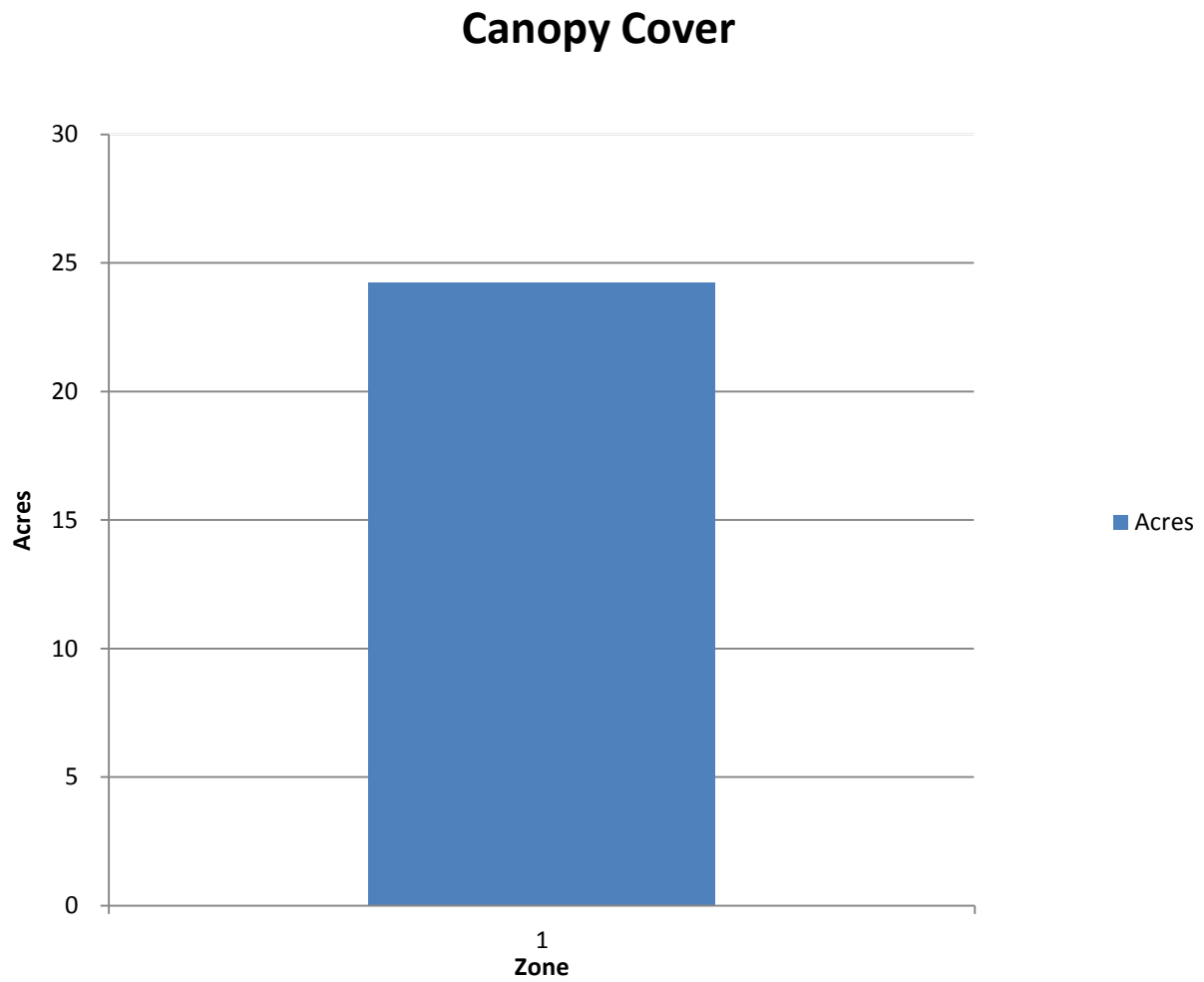
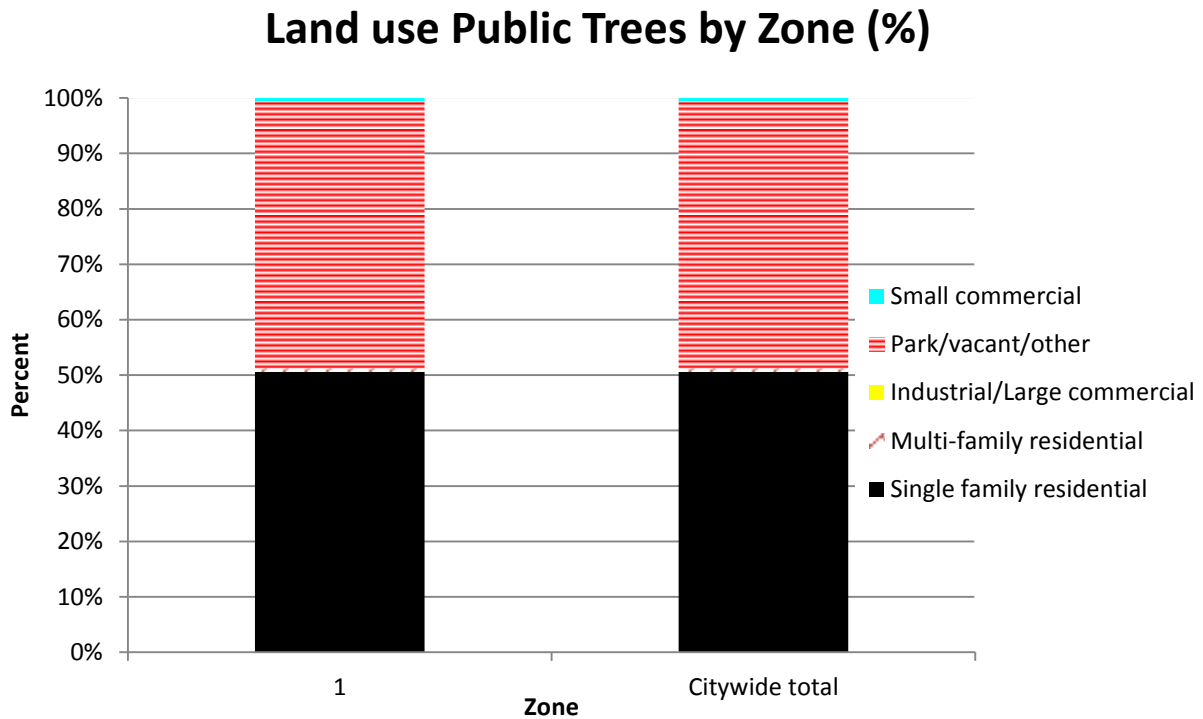
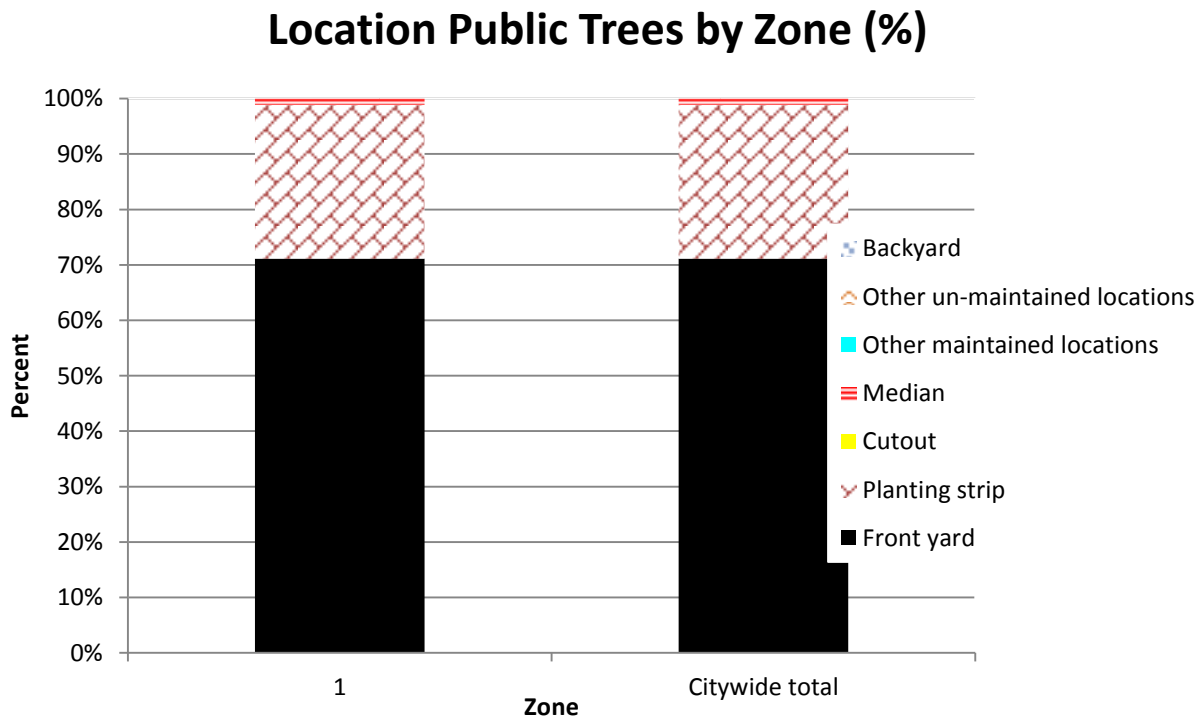


Figure 5: Canopy Cover in Acres



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



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

## Appendix B: ArcGIS Mapping

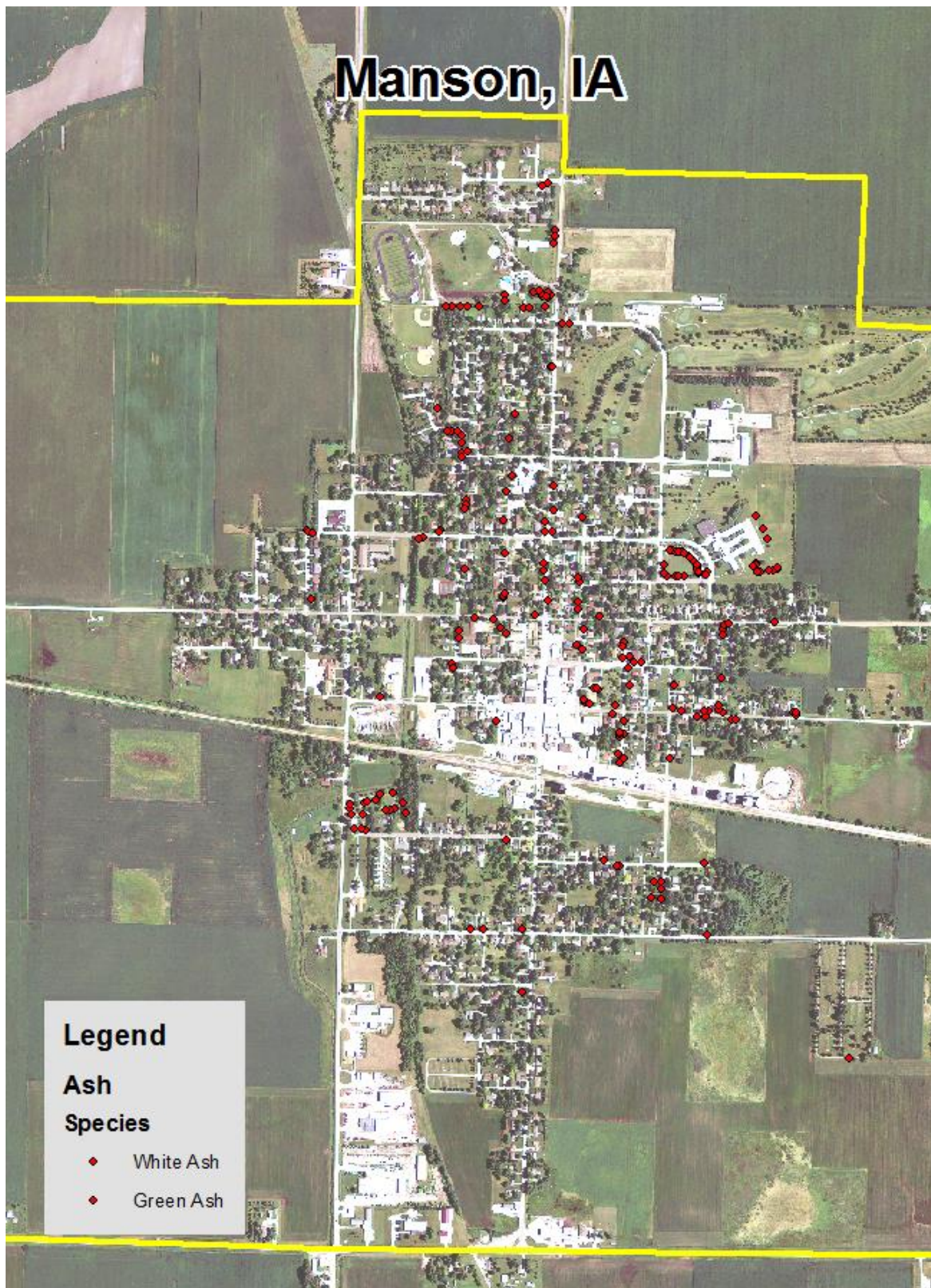


Figure 1: Location of Ash Trees

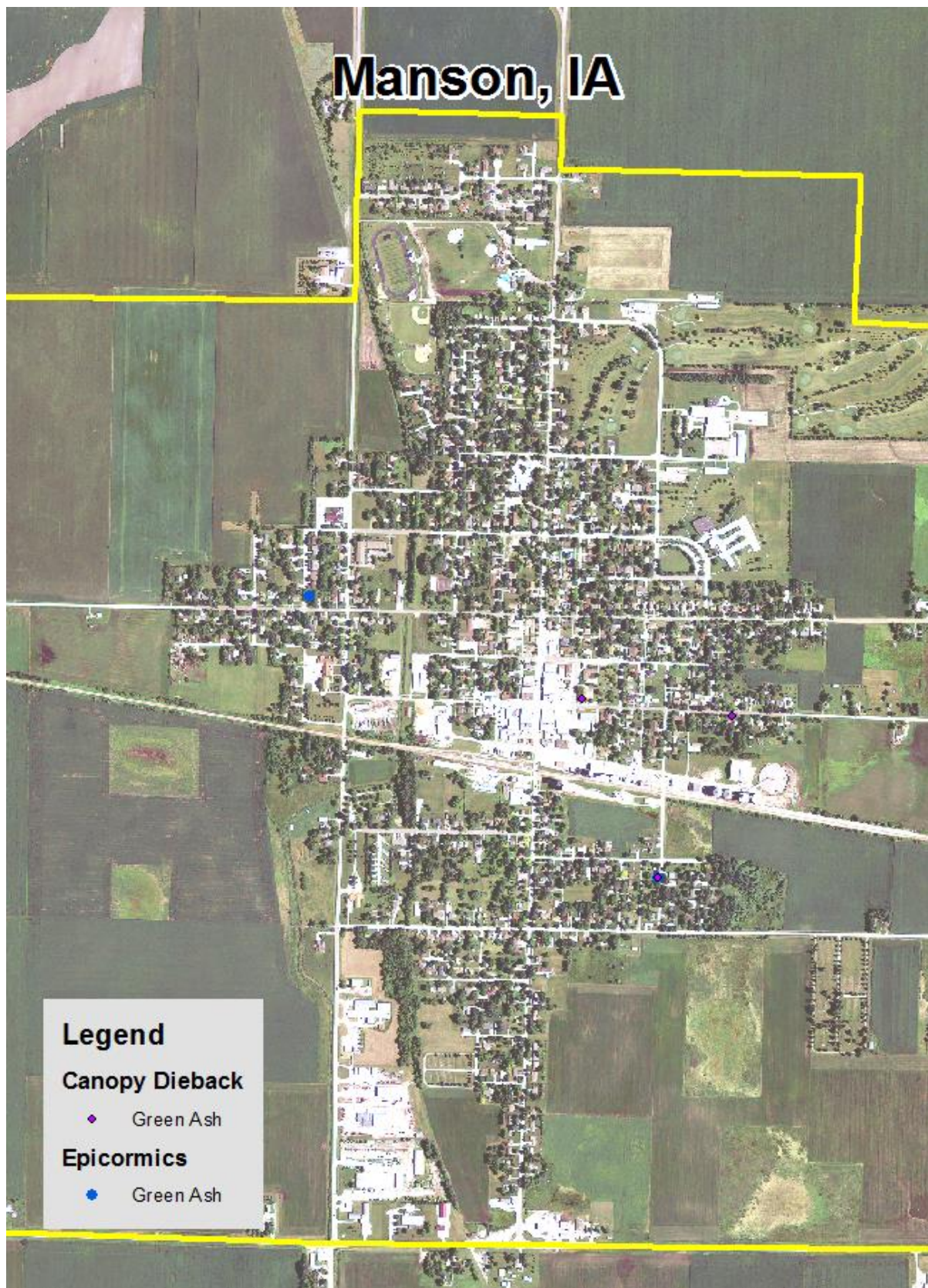


Figure 2: Location of EAB symptoms

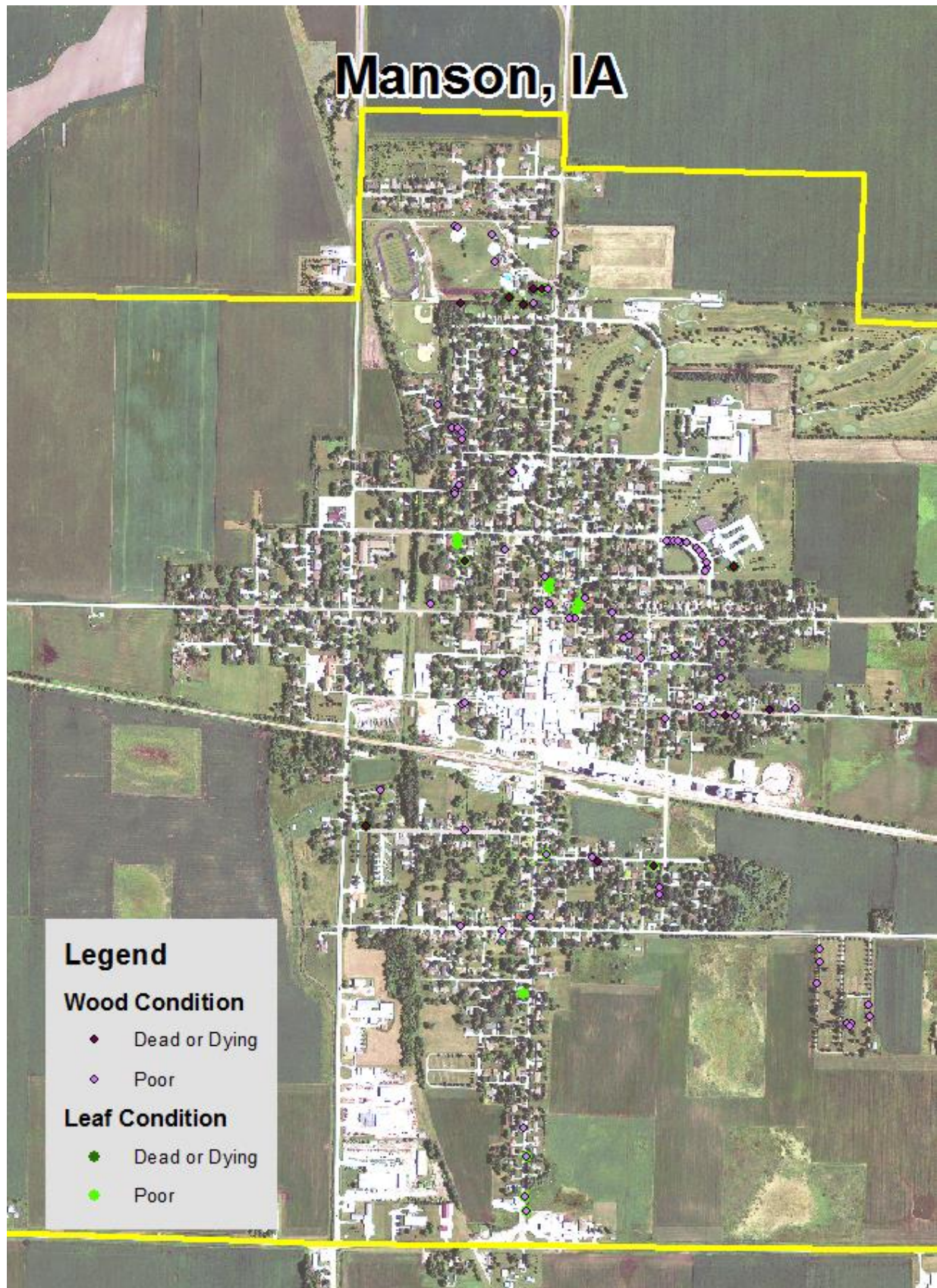


Figure 3: Location of Poor Condition Trees

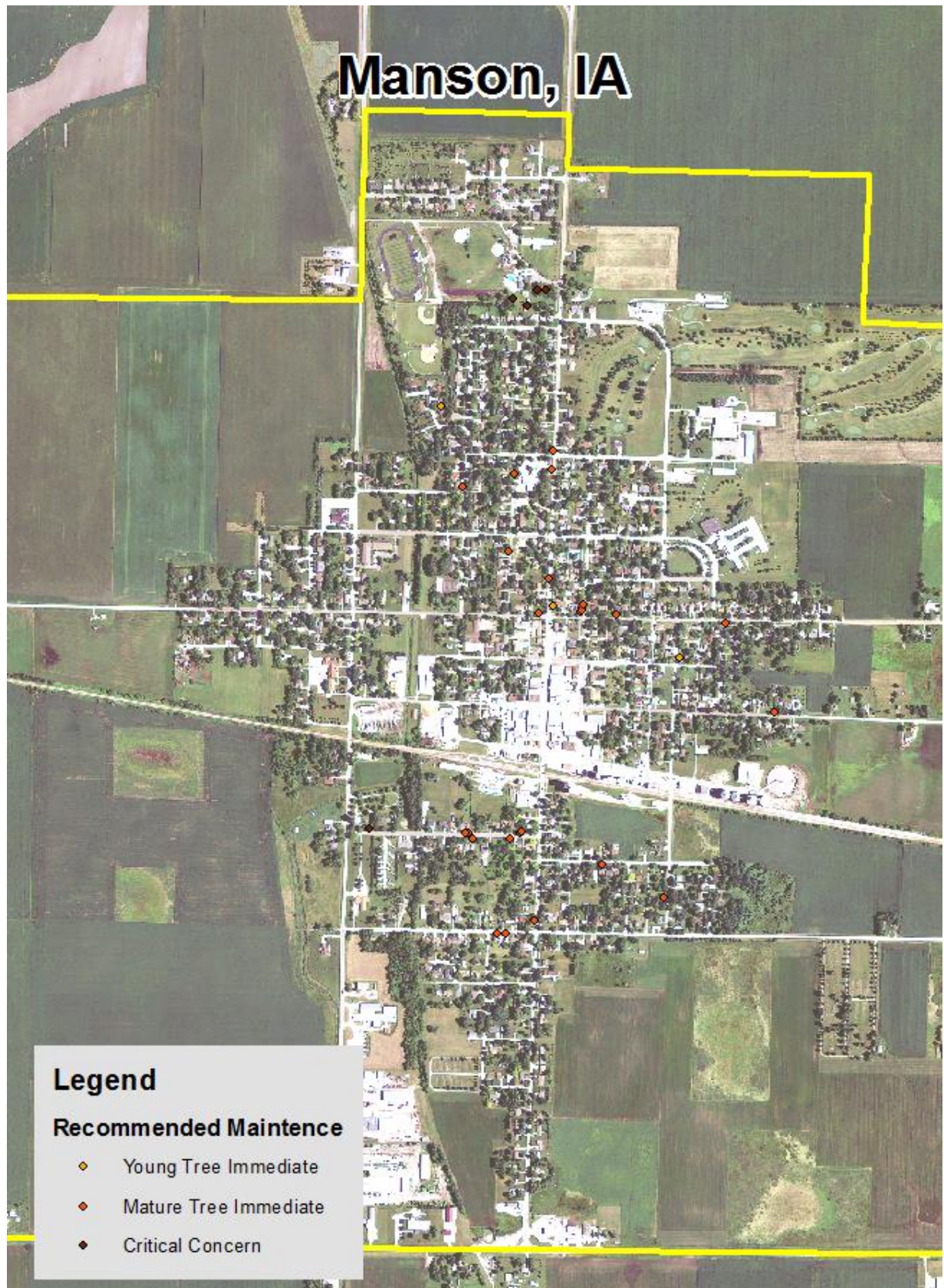
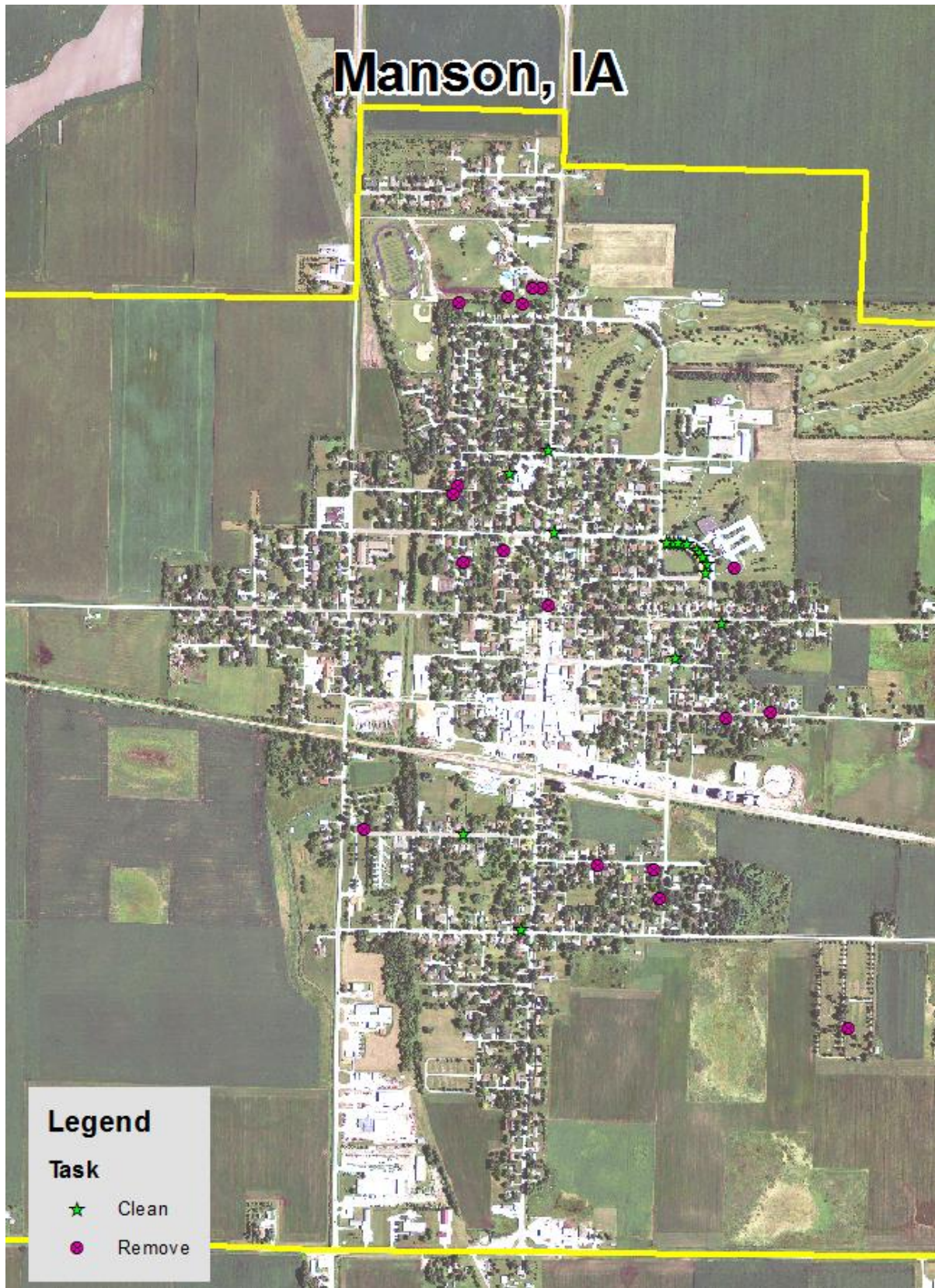


Figure 4: Location of Trees with Recommended Maintenance



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



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