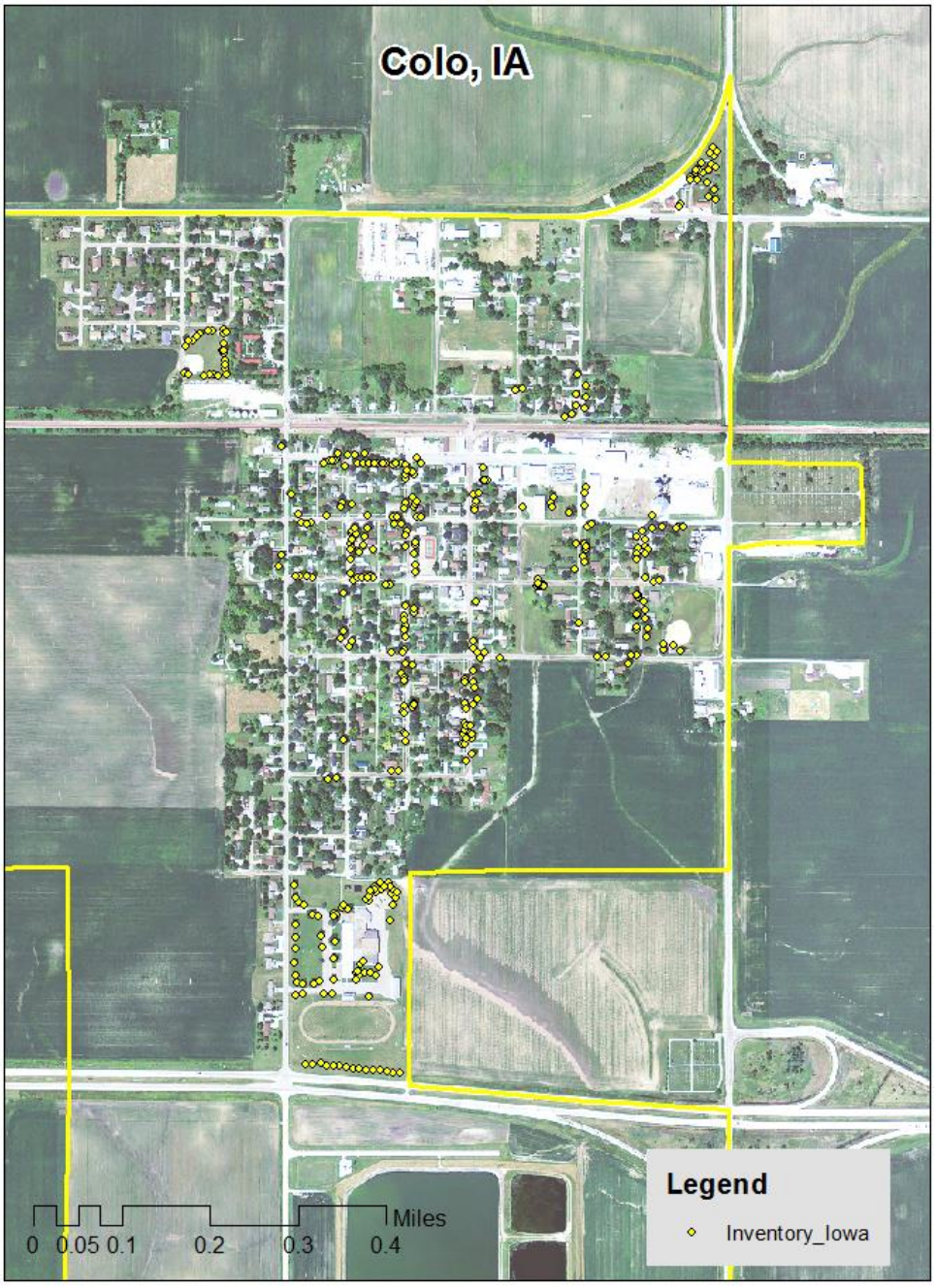
Colo, IA



2014 Management Plan
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Executive Summary

Overview

This plan was developed to assist the City of Colo 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 23% of Colo's city owned trees (ash) will die once EAB becomes established in the community. With proper planning and management, the costs of removing dead and dying trees can be extended over years, mitigating public safety issues.

Inventory and Results

In 2013, 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 373 trees inventoried.

- Colo's trees provide $68,308 of benefits annually, an average of $183 a tree
- There are over 27 species of trees
- The top three genus are: Maple 26%, Ash 32%, and Oak 9%
- 24% of trees are in need of some type of management
- 9 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 9 trees needing removal, 7 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*
- 14 of the 85 ash trees are in need of follow up because they are displaying signs and symptoms associated with EAB
- All trees should be pruned on a routine schedule- one third of the city every other year
- Plant a diverse mix of trees that do not include: ash, maple, 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 16 years to remove ash – Suggestion: request a budget increase to $10,000 annually and apply for grants to plant replacement trees

Introduction

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

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

Inventory

In 2013, a tree inventory was conducted that included 100% of the city owned trees on both streets and parks. The tree data was collected using a handheld Global Positioning System (GPS) receiver. The data collector gives Geographic Information Systems (GIS) coordinates with an accuracy of 3 meters, which can be used in Arc GIS as an active GIS data layer. Because the inventory is a digital document the data can be updated with new information and become a working document.

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

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

Inventory Results

The data collected for the 373 city trees was entered into the USDA Forest service program Street Tree Resource Analysis Tool for Urban forestry Management (STRATUM), part of the i-Tree suite. The following are results from the i-Tree STRATUM analysis.

Annual Benefits

Annual Energy Benefits

Trees conserve energy by shading buildings and blocking winds. Colo's trees reduce energy related costs by approximately $18,147 annually (Appendix A, Table 1). These savings are both in Electricity (86.6 MWh) and in Natural Gas (11,812.8 Therms).

Annual Stormwater Benefits

Colo's trees intercept about 977,534 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $26,493of benefits to the city.

Annual Air Quality Benefits

Air quality is a persistent public health issue in Iowa. The urban forest improves air quality by removing pollutants, lowering air temperature, and reducing energy consumption, which in turn reduces emissions from power plants, and emitting volatile organic mater (ozone). In Colo, it is estimated that trees remove 1,128 lbs of air pollution (ozone (O_3), particulate matter less than 10 microns (PM10), carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2)) per year with a net value of $3,191 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Colo, trees sequester about 317,827lbs of carbon a year with an associated value of $2,384 (Appendix A, Table 4). In addition, the trees store 3,874,397lbs of carbon, with a yearly benefit of $29,058 (Appendix A, Table 5).

Annual Aesthetics Benefits

Social benefits of trees are hard to capture. The analysis does have a calculation for this area that includes: aesthetic value, property values, lowered rates of mental illness and crime, city livability and much more. Colo receives $18,094 in annual social benefits from trees (Appendix A, Table 6).

Financial Summary of all Benefits

According to the USDA Forest Service i-Tree STRATUM analysis, Colo's trees provide $68,308 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 373 trees in Colo provide approximately $183 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Colo has over 46 different tree species and 27 genera along city streets and parks (Appendix A, Figure 1).
The distribution of trees by genus is as follows:

Maple	96	26%
Ash	85	23%
Oak	35	9%
Spruce	25	7%
Hackberry	23	6%
Dougwood	23	6%
Walnut	22	6%
Apple (crabapple)	17	5%
Honey Locust	12	3%
Linden	11	3%
Elm	10	3%
Poplar/Aspen	6	2%
Catalpa	5	1%
Ohio Buckeye	3	1%
Pine	3	1%
Plum/Cherry	3	1%
Boardleaf Other	2	1%
Ketucky coffeetree	2	1%
Tuliptree	2	1%
Mulberry	2	1%
Pear	2	1%
Birch	1	<1%
Redbud	1	<1%
Ginkgo	1	<1%
Cedar	1	<1%
Sycamore	1	<1%
Mountain Ash	1	<1%

Age Class

Most of Colo's trees (39%) are between 6 and 18 inches in diameter at 4.5 ft (Appendix A, Figure 2). For age, it is preferred that the highest amounts of trees are in the smallest size category (a downward slope) to prepare for natural mortality and to maintain canopy cover. Colo's size curve is on the smaller side, indicating a younger than average stand.

Condition: Wood and Foliage

Both wood condition and leaf condition are good indicators of the overall health of the urban forest. The foliage condition results for Colo indicate that 80% of the trees are in good health, with only 1% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Also, 45% of Colo'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 11% of the population. This 11% 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 Raising	3	1%
Crown Cleaning	5	1%
Tree Removal	9	2%

Canopy Cover

The canopy cover of Colo is approximately 10 acres (Appendix A, Figure 4). According to the 2010 census, Colo occupies 679 acres. Thus the canopy cover on city land is about 1%.

Land Use and Location

The majority of Colo's city and park trees are in planting strips in single family residential neighborhoods (Appendix A, Figure 6 & Appendix A, Figure7). The following describes the land use and locations for the street and park trees.

Land Use	
Single family residential	55%
Park/vacant/other	37%
Small commercial	7%
Industrial/Large commercial	1%

Location	
Front yard	68%
Planting strip	32%

Recommendations

Risk Management

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

Hazardous trees

Colo has 3 poor condition trees that need immediate removal. These trees can be seen on the Location of Trees with Recommended Maintenance map (Appendix B, Figure 4). Then it is recommended to move to other removal and poor condition trees needing trimming. Please refer to the six year maintenance plan at the end of this section.

Poor tree species

After the removal of the poor condition trees, ash trees in poor health should be assessed for removal (Appendix B, Figure 3 & Appendix B, Figure 4). Of the 9 removals, 2 are ash trees. There are a total of 85 ash trees, and 14 of those have signs and symptoms that have been associated with EAB although non we suspect. In addition, there are 9 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 Colo.

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 (26%) (Appendix A, Figure 1). Maples should not be planted until this percentage can be lowered to 20% or less. Also, ash trees have not been recommended since 2002, due to the threat of EAB. Other species to avoid because they are public nuisances include: cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut. All trees planted must meet the restrictions in city ordinance.

Continual Monitoring

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

Six Year Maintenance Plan with <u>No Additional Funding</u>

Year 1

Removal: 5 poor condition tree
Planting and Replacement: 6 trees to be planted in open locations
Visual Survey for signs and symptoms of EAB

Year 2

Removal: 4 other trees
Planting and Replacement: 5 trees in open locations from year one removals
Routine trimming: Contract to trim 1/3 of the city trees
Visual Survey for signs and symptoms of EAB

Year 3

Removal: Removal of any new critical concern trees and ash in poor health or save for ash treatment
Planting and Replacement: 10 trees to be planted in open locations and locations from previous removals
Visual Survey for signs and symptoms of EAB

Year 4

Removal: Removal of any new critical concern trees and ash in poor health or save for ash treatment
Planting and Replacement: 6 trees in open locations from previous removals
Routine trimming: Contract to trim 1/3 of the city trees
Visual Survey for signs and symptoms of EAB

Year 5

Removal: Removal of any new critical concern trees and ash in poor health or save for ash treatment
Planting and Replacement: 10 trees to be planted in open locations and locations from previous removals
Visual Survey for signs and symptoms of EAB

Year 6

Removal: Removal of any new critical concern trees and ash in poor health or save for ash treatment
Planting and Replacement: 6 trees in open locations from previous removals
Routine trimming: Contract to trim 1/3 of the city trees
Visual Survey for signs and symptoms of EAB

*Reduction of ash over 6 years: Approximately 2 to 26 ash trees removed (approximately 30% of ash). It will take approximately 16 years to remove all ash with the current budget. EAB could potentially kill all ash within 4 years of its arrival.
** To remove all ash trees within 6 years, the budget would need to be increased to $19,500 a year. If the budget were increased to $10,000 a year all ash could be removed in 13 years.

Emerald Ash Borer Plan

Ash Tree Removal

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

Treatment of Ash Trees

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

EAB Quarantines

EAB is an extremely destructive plant pest and it is responsible for the death and decline of over 25 million ash trees. Ash in both forested and urban settings constitute a significant portion of the canopy cover in the United States. Current tools to detect, control, suppress and eradicate this pest are not as robust as the USDA would desire. In order to stay ahead of this hard to detect beetle, the USDA is attempting to contain the beetle before it spreads beyond its known positions by regulating articles.

A regulated article under the USDA's quarantine includes any of the following items:
- emerald ash borer
- firewood of all hardwood species (for example ash, oak, maple and hickory)
- nursery stock and green lumber of ash
- any other ash material, whether living, dead, cut or fallen, including logs, stumps, roots, branches, as well as composted and not composted chips of the genus ash (Mountain ash is not included)

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

Wood Disposal

A very important aspect of planning is determining how wood infested with EAB will be handled, keeping in mind that quarantines will restrict its movement. Consider who will cut

and haul the dead and dying trees? Is there an accessible, secured site big enough to store and sort the hundreds of trees and the associated brush and chips? How will wood be disposed of or utilized? Do you have equipment capable of handling the amount and size of ash trees your tree inventory has identified? Once your county is under quarantine for EAB, contact USDA-APHIS-PPQ at 515-251-4083 or visit the website http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/regulatory.shtml. Wood waste can be disposed of as you normally would if your county is not part of a quarantine.

Canopy Replacement

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

Postponed Work

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

Monitoring

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

Private Ash Trees

It is strongly recommended that private property owners start removing ash trees on their property upon arrival of EAB or treat ash when EAB is known within 15 miles.

Budget

Current Budget
Total $42,000 over 6 years ($7,000/year)

FY 2014 Budget
Removal: $5,000
Planting: $600
Watering & Maintenance: $200

FY 2015 Budget
Removal: $4,000
Planting: $500
Routine trimming: $1,700
Watering & Maintenance: $200

FY 2016 Budget
Removal: $6,000
Planting: $1000
Watering & Maintenance: $200

FY 2017 Budget
Removal: $6,000
Planting: $1000
Routine trimming: $1,700
Watering & Maintenance: $200

FY 2018 Budget
Removal: $6,000
Planting: $1000
Watering & Maintenance: $200

FY 2019 Budget
Removal: $6,000
Planting: $1000
Routine trimming: $1,700
Watering & Maintenance: $200

*** It will take approximately 16 years to remove all ash with the current budget.**

Purposed Budget Increase

EAB could potentially kill all ash trees in Colo within 4 years of its arrival. To remove all ash trees within 6 years the budget would need to be increased to $14,000 a year. If the budget were increased to $10,000 a year all ash could be removed within 8 years. Additionally, it is recommended that Colo apply for grants to fund replacement trees. Utility Company grants are usually between $500 and $10,000 for community-based, tree-planting projects that include parks, gateways, cemeteries, nature trails, libraries, nursing homes, and schools.

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Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Colo

Annual Energy Benefits of Public Trees by Species

1/27/2014

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	25.2	1,915	3,400.1	3,332	5,247	(N/A)	22.5	28.9	62.47
Norway maple	10.2	778	1,467.0	1,438	2,215	(N/A)	10.5	12.2	56.80
Silver maple	9.2	696	1,182.0	1,158	1,855	(N/A)	7.5	10.2	66.24
Northern hackberry	6.7	510	930.1	912	1,422	(N/A)	6.2	7.8	61.81
Northern red oak	1.4	108	184.8	181	289	(N/A)	6.2	1.6	12.58
Black walnut	6.8	512	914.3	896	1,408	(N/A)	5.9	7.8	64.02
Apple	0.5	35	81.2	80	115	(N/A)	4.6	0.6	6.76
Honeylocust	4.0	305	522.6	512	817	(N/A)	3.2	4.5	68.08
Blue spruce	0.7	53	113.4	111	164	(N/A)	3.2	0.9	13.70
Sugar maple	2.7	202	350.1	343	545	(N/A)	2.4	3.0	60.55
Spruce	0.6	48	90.5	89	137	(N/A)	2.1	0.8	17.13
American basswood	3.2	239	446.9	438	677	(N/A)	2.1	3.7	84.64
Black maple	1.7	127	229.6	225	352	(N/A)	1.6	1.9	58.73
White oak	0.8	57	95.6	94	151	(N/A)	1.6	0.8	25.17
Elm	1.7	125	223.9	219	345	(N/A)	1.6	1.9	57.49
Amur maple	0.4	28	64.2	63	91	(N/A)	1.3	0.5	18.19
Red maple	0.8	64	109.6	107	172	(N/A)	1.3	1.0	34.33
Catalpa	1.0	79	143.8	141	220	(N/A)	1.3	1.2	44.03
Norway spruce	0.4	27	52.6	52	78	(N/A)	1.3	0.4	15.69
Maple	0.3	25	50.3	49	75	(N/A)	1.1	0.4	18.69
Other street trees	8.3	633	1,160.2	1,137	1,770	(N/A)	12.3	9.8	38.48
Citywide total	86.6	6,570	11,812.8	11,577	18,147	(N/A)	100.0	100.0	48.65

Table 2: Annual Stormwater Benefits

Colo

Annual Stormwater Benefits of Public Trees by Species

1/27/2014

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	310,578	8,417	(N/A)	22.5	31.8	100.21
Norway maple	97,901	2,653	(N/A)	10.5	10.0	68.03
Silver maple	122,415	3,318	(N/A)	7.5	12.5	118.49
Northern hackberry	60,219	1,632	(N/A)	6.2	6.2	70.96
Northern red oak	8,986	244	(N/A)	6.2	0.9	10.59
Black walnut	79,703	2,160	(N/A)	5.9	8.2	98.19
Apple	1,595	43	(N/A)	4.6	0.2	2.54
Honeylocust	47,249	1,281	(N/A)	3.2	4.8	106.71
Blue spruce	8,347	226	(N/A)	3.2	0.9	18.85
Sugar maple	28,613	775	(N/A)	2.4	2.9	86.16
Spruce	9,688	263	(N/A)	2.1	1.0	32.82
American basswood	47,627	1,291	(N/A)	2.1	4.9	161.35
Black maple	15,938	432	(N/A)	1.6	1.6	71.99
White oak	4,772	129	(N/A)	1.6	0.5	21.56
Elm	15,997	434	(N/A)	1.6	1.6	72.26
Amur maple	1,322	36	(N/A)	1.3	0.1	7.17
Red maple	5,083	138	(N/A)	1.3	0.5	27.55
Catalpa	14,116	383	(N/A)	1.3	1.4	76.51
Norway spruce	3,920	106	(N/A)	1.3	0.4	21.25
Maple	1,887	51	(N/A)	1.1	0.2	12.79
Other street trees	91,576	2,482	(N/A)	12.3	9.4	53.95
Citywide total	977,534	26,493	(N/A)	100.0	100.0	71.03

Table 3: Annual Air Quality Benefits

Colo

Annual Air Quality Benefits of Public Trees by Species

1/27/2014

Species	Deposition (lb) O_3	NO_2	PM_{10}	SO_2	Total Depos. ($)	Avoided (lb) NO_2	PM_{10}	VOC	SO_2	Total Avoided ($)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($)	Standard Error	% of Total Trees	Avg. $/tree
Green ash	42.5	6.8	19.7	1.9	225	120.0	17.5	16.7	114.3	749	0.0	0	339.4	973	(N/A)	22.5	11.59
Norway maple	20.4	3.5	10.0	0.9	110	49.6	7.2	6.8	46.5	307	-4.7	-18	140.1	400	(N/A)	10.5	10.24
Silver maple	20.6	3.5	10.2	0.9	111	43.0	6.3	6.0	41.5	270	-11.1	-42	121.0	339	(N/A)	7.5	12.12
Northern hackberry	9.6	1.7	4.9	0.4	52	32.2	4.7	4.5	30.5	201	0.0	0	88.5	253	(N/A)	6.2	11.00
Northern red oak	1.6	0.3	0.8	0.1	9	6.7	1.0	0.9	6.5	42	-2.1	-8	15.7	43	(N/A)	6.2	1.85
Black walnut	10.9	1.7	5.1	0.5	57	32.1	4.7	4.5	30.6	200	0.0	0	90.1	258	(N/A)	5.9	11.72
Apple	0.2	0.0	0.1	0.0	1	2.4	0.3	0.3	2.1	14	0.0	0	5.6	16	(N/A)	4.6	0.93
Honeylocust	9.3	1.5	4.2	0.4	49	18.9	2.8	2.6	18.2	118	-7.4	-28	50.6	140	(N/A)	3.2	11.64
Blue spruce	0.8	0.2	0.8	0.1	5	3.5	0.5	0.5	3.2	21	-2.6	-10	6.8	17	(N/A)	3.2	1.42
Sugar maple	3.8	0.6	1.9	0.2	20	12.6	1.8	1.8	12.0	79	-3.0	-11	31.7	88	(N/A)	2.4	9.76
Spruce	1.0	0.2	0.9	0.1	7	3.1	0.4	0.4	2.9	19	-3.9	-15	5.2	11	(N/A)	2.1	1.41
American basswood	7.6	1.3	3.6	0.3	41	15.2	2.2	2.1	14.3	94	-6.2	-23	40.5	112	(N/A)	2.1	13.99
Black maple	4.1	0.7	1.9	0.2	22	8.0	1.2	1.1	7.6	50	-1.3	-5	23.4	66	(N/A)	1.6	11.08
White oak	0.3	0.0	0.2	0.0	2	3.5	0.5	0.5	3.4	22	0.0	0	8.5	24	(N/A)	1.6	3.98
Elm	1.7	0.3	0.9	0.1	9	7.9	1.1	1.1	7.5	49	0.0	0	20.6	58	(N/A)	1.6	9.75
Amur maple	0.2	0.0	0.1	0.0	1	1.9	0.3	0.3	1.7	11	0.0	0	4.5	13	(N/A)	1.3	2.55
Red maple	0.9	0.1	0.4	0.0	5	4.0	0.6	0.6	3.8	25	-0.3	-1	10.1	28	(N/A)	1.3	5.69
Catalpa	2.0	0.3	0.9	0.1	11	5.0	0.7	0.7	4.7	31	0.0	0	14.5	42	(N/A)	1.3	8.32
Norway spruce	0.4	0.1	0.4	0.0	3	1.7	0.2	0.2	1.6	11	-1.2	-5	3.5	9	(N/A)	1.3	1.75
Maple	0.2	0.0	0.1	0.0	1	1.6	0.2	0.2	1.5	10	-0.1	0	3.9	11	(N/A)	1.1	2.76
Other street trees	15.1	2.6	7.8	0.8	83	40.0	5.8	5.5	37.8	249	-11.0	-41	104.4	290	(N/A)	12.3	6.31
Citywide total	153.2	25.6	74.9	7.1	824	412.9	60.1	57.3	392.3	2,573	-55.1	-207	1,128.4	3,191	(N/A)	100.0	8.55

Table 4: Annual Carbon Stored

Colo

Stored CO2 Benefits of Public Trees by Species

1/27/2014

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	1,411,981	10,590	(N/A)	22.5	36.4	126.07
Norway maple	336,313	2,522	(N/A)	10.5	8.7	64.68
Silver maple	482,105	3,616	(N/A)	7.5	12.4	129.14
Northern	149,168	1,119	(N/A)	6.2	3.9	48.64
Northern red oak	27,592	207	(N/A)	6.2	0.7	9.00
Black walnut	359,340	2,695	(N/A)	5.9	9.3	122.50
Apple	5,197	39	(N/A)	4.6	0.1	2.29
Honeylocust	120,891	907	(N/A)	3.2	3.1	75.56
Blue spruce	3,128	23	(N/A)	3.2	0.1	1.96
Sugar maple	107,270	805	(N/A)	2.4	2.8	89.39
Spruce	8,702	65	(N/A)	2.1	0.2	8.16
American	294,636	2,210	(N/A)	2.1	7.6	276.22
Black maple	43,351	325	(N/A)	1.6	1.1	54.19
White oak	10,459	78	(N/A)	1.6	0.3	13.07
Elm	55,805	419	(N/A)	1.6	1.4	69.76
Amur maple	4,540	34	(N/A)	1.3	0.1	6.81
Red maple	10,550	79	(N/A)	1.3	0.3	15.83
Catalpa	67,456	506	(N/A)	1.3	1.7	101.18
Norway spruce	2,197	16	(N/A)	1.3	0.1	3.30
Maple	3,319	25	(N/A)	1.1	0.1	6.22
Other street trees	168,009	2,778	(N/A)	12.3	9.6	60.39
Citywide total	3,874,397	29,058	(N/A)	100.0	100.0	77.90

Table 5: Annual Carbon Sequestered

Colo

Annual CO_2 Benefits of Public Trees by Species

1/27/2014

Species	Sequestered (lb)	Sequestered ($)	Decomposition Release (lb)	Maintenance Release (lb)	Total Released ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	56,992	427	-6,778	-16	-51	42,321	317	92,520	694	(N/A)	22.5	29.1	8.26
Norway maple	13,711	103	-1,614	-8	-12	17,186	129	29,275	220	(N/A)	10.5	9.2	5.63
Silver maple	36,235	272	-2,314	-5	-17	15,390	115	49,306	370	(N/A)	7.5	15.5	13.21
Northern hackberry	7,588	57	-716	-4	-5	11,275	85	18,142	136	(N/A)	6.2	5.7	5.92
Northern red oak	2,065	15	-132	-4	-1	2,390	18	4,318	32	(N/A)	6.2	1.4	1.41
Black walnut	15,263	114	-1,725	-4	-13	11,324	85	24,857	186	(N/A)	5.9	7.8	8.47
Apple	761	6	-25	-3	0	783	6	1,516	11	(N/A)	4.6	0.5	0.67
Honeylocust	9,041	68	-580	-2	-4	6,737	51	15,196	114	(N/A)	3.2	4.8	9.50
Blue spruce	426	3	-15	-2	0	1,179	9	1,588	12	(N/A)	3.2	0.5	0.99
Sugar maple	5,739	43	-515	-2	-4	4,461	33	9,684	73	(N/A)	2.4	3.1	8.07
Spruce	684	5	-42	-2	0	1,068	8	1,709	13	(N/A)	2.1	0.5	1.60
American basswood	15,062	113	-1,414	-2	-11	5,286	40	18,932	142	(N/A)	2.1	6.0	17.75
Black maple	483	4	-208	-1	-2	2,816	21	3,090	23	(N/A)	1.6	1.0	3.86
White oak	1,520	11	-50	-1	0	1,266	9	2,735	21	(N/A)	1.6	0.9	3.42
Elm	3,924	29	-268	-1	-2	2,773	21	6,428	48	(N/A)	1.6	2.0	8.03
Amur maple	569	4	-22	-1	0	621	5	1,167	9	(N/A)	1.3	0.4	1.75
Red maple	1,462	11	-51	-1	0	1,418	11	2,829	21	(N/A)	1.3	0.9	4.24
Catalpa	2,363	18	-324	-1	-2	1,750	13	3,789	28	(N/A)	1.3	1.2	5.68
Norway spruce	326	2	-11	-1	0	594	4	909	7	(N/A)	1.3	0.3	1.36
Maple	499	4	-16	-1	0	563	4	1,045	8	(N/A)	1.1	0.3	1.96
Other street trees	16,583	124	-1,778	-9	-13	13,996	105	28,792	216	(N/A)	12.3	9.1	4.69
Citywide total	191,299	1,435	-18,597	-73	-140	145,199	1,089	317,827	2,384	(N/A)	100.0	100.0	6.39

Table 6: Annual Social and Aesthetic Benefits

Colo

Annual Aesthetic/Other Benefits of Public Trees by Species

1/27/2014

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	4,504	(N/A)	22.5	24.9	53.62
Norway maple	1,289	(N/A)	10.5	7.1	33.05
Silver maple	2,860	(N/A)	7.5	15.8	102.13
Northern hackberry	1,110	(N/A)	6.2	6.1	48.27
Northern red oak	194	(N/A)	6.2	1.1	8.45
Black walnut	1,213	(N/A)	5.9	6.7	55.15
Apple	38	(N/A)	4.6	0.2	2.26
Honeylocust	2,273	(N/A)	3.2	12.6	189.44
Blue spruce	237	(N/A)	3.2	1.3	19.75
Sugar maple	601	(N/A)	2.4	3.3	66.73
Spruce	186	(N/A)	2.1	1.0	23.30
American basswood	947	(N/A)	2.1	5.2	118.39
Black maple	66	(N/A)	1.6	0.4	10.98
White oak	183	(N/A)	1.6	1.0	30.44
Elm	338	(N/A)	1.6	1.9	56.38
Amur maple	32	(N/A)	1.3	0.2	6.40
Red maple	221	(N/A)	1.3	1.2	44.26
Catalpa	197	(N/A)	1.3	1.1	39.36
Norway spruce	94	(N/A)	1.3	0.5	18.80
Maple	90	(N/A)	1.1	0.5	22.39
Other street trees	1,420	(N/A)	12.3	7.9	30.87
Citywide total	18,094	(N/A)	100.0	100.0	48.51

Table 7: Summary of Benefits in Dollars

Average Annual Benefits of Public Trees by Species

Species	Energy	CO2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Green ash	5,247	694	973	8,417	4,504	$19,835.78	(±0)	29.04
Norway maple	2,215	220	400	2,653	1,289	$6,776.78	(±0)	9.92
Silver maple	1,855	370	339	3,318	2,860	$8,741.18	(±0)	12.80
Northern hackberry	1,422	136	253	1,632	1,110	$4,552.96	(±0)	6.67
Northern red oak	289	32	43	244	194	$802.15	(±0)	1.17
Black walnut	1,408	186	258	2,160	1,213	$5,226.27	(±0)	7.65
Apple	115	11	16	43	38	$223.89	(±0)	0.33
Honeylocust	817	114	140	1,281	2,273	$4,624.46	(±0)	6.77
Blue spruce	164	12	17	226	237	$656.58	(±0)	0.96
Sugar maple	545	73	88	775	601	$2,081.48	(±0)	3.05
Spruce	137	13	11	263	186	$610.09	(±0)	0.89
American basswood	677	142	112	1,291	947	$3,168.91	(±0)	4.64
Black maple	352	23	66	432	66	$939.84	(±0)	1.38
White oak	151	21	24	129	183	$507.42	(±0)	0.74
Elm	345	48	58	434	338	$1,223.43	(±0)	1.79
Amur maple	91	9	13	36	32	$180.30	(±0)	0.26
Red maple	172	21	28	138	221	$580.33	(±0)	0.85
Catalpa	220	28	42	383	197	$869.51	(±0)	1.27
Norway spruce	78	7	9	106	94	$294.25	(±0)	0.43
Maple	75	8	11	51	90	$234.35	(±0)	0.34
Other street trees	1,770	216	290	2,482	1,420	$6,178.37	(±0)	9.04
Citywide total	18,147	2,384	3,191	26,493	18,094	$68,308.30	(±0)	100.00

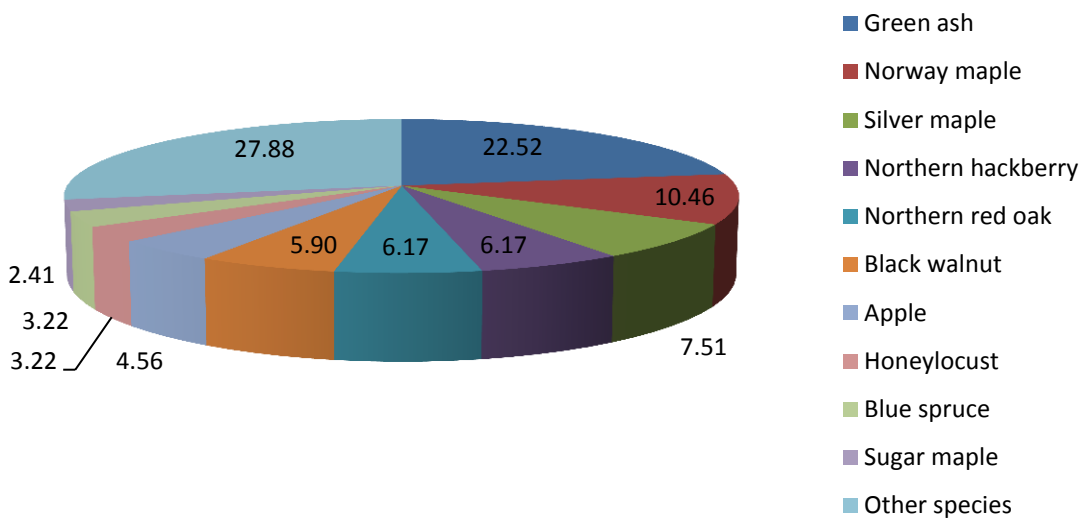

Figure 1: Species Distribution

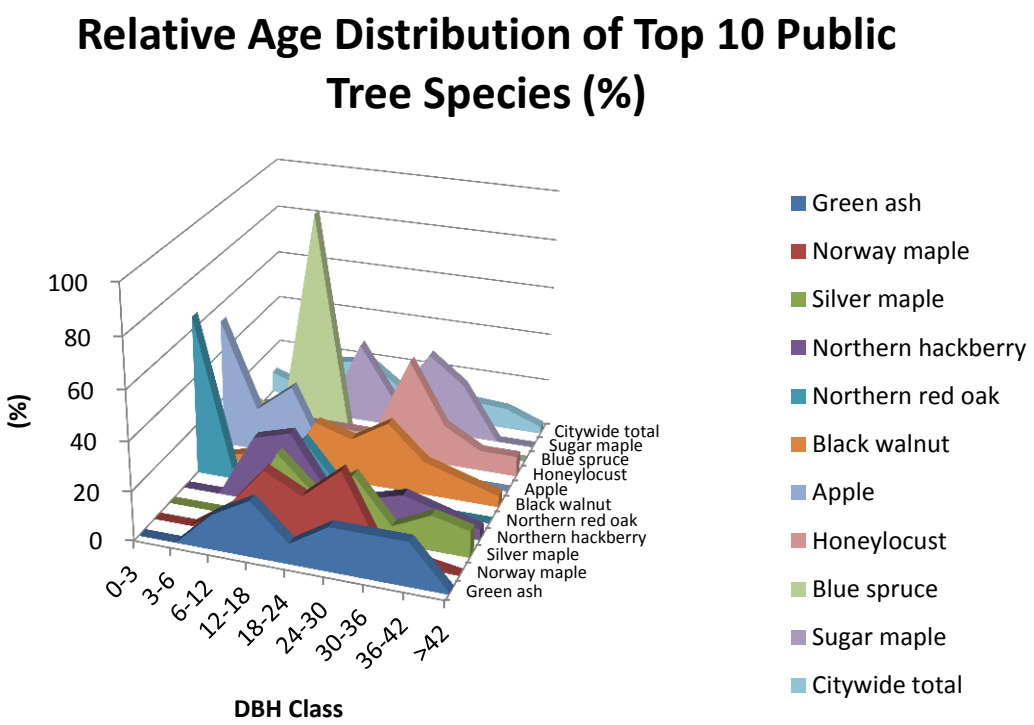

Figure 2: Relative Age Class

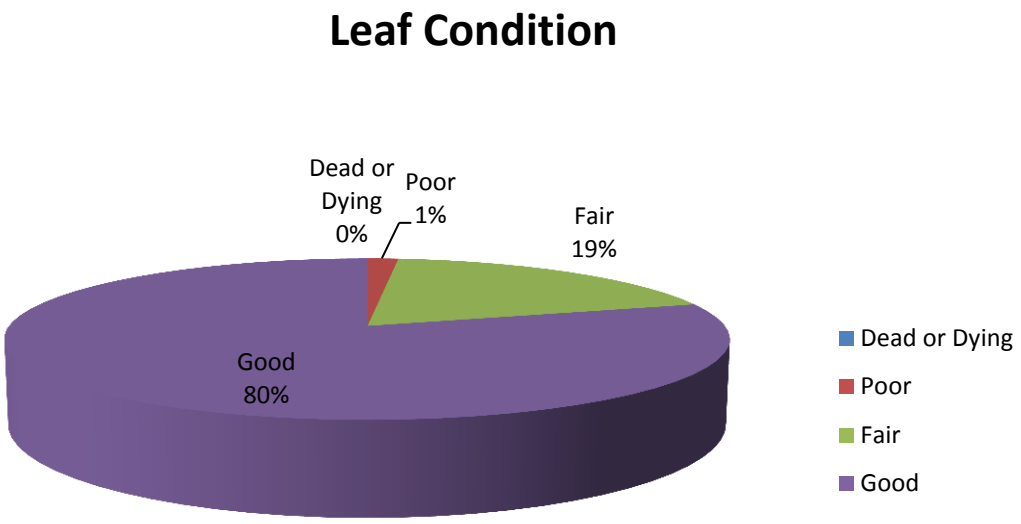

Figure 3: Foliage Condition

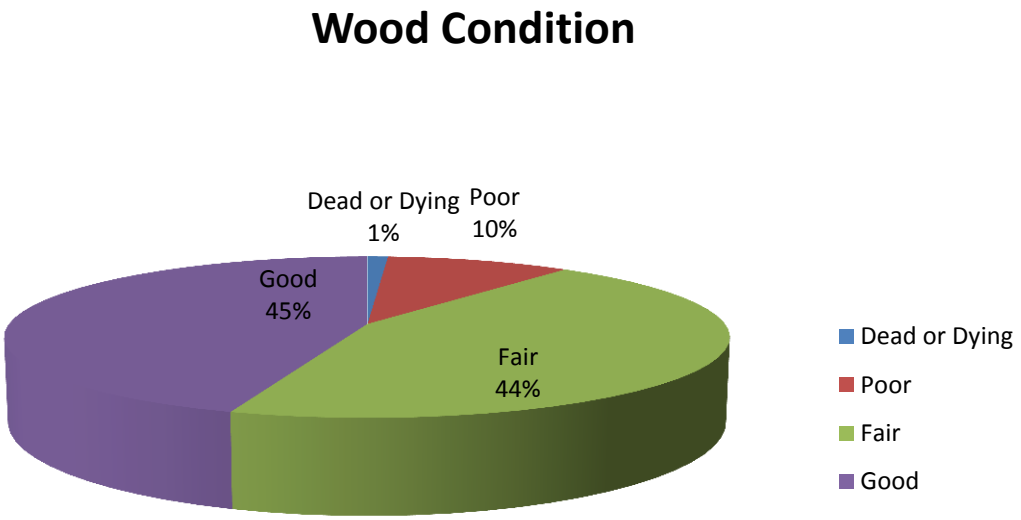

Figure 4: Wood Condition

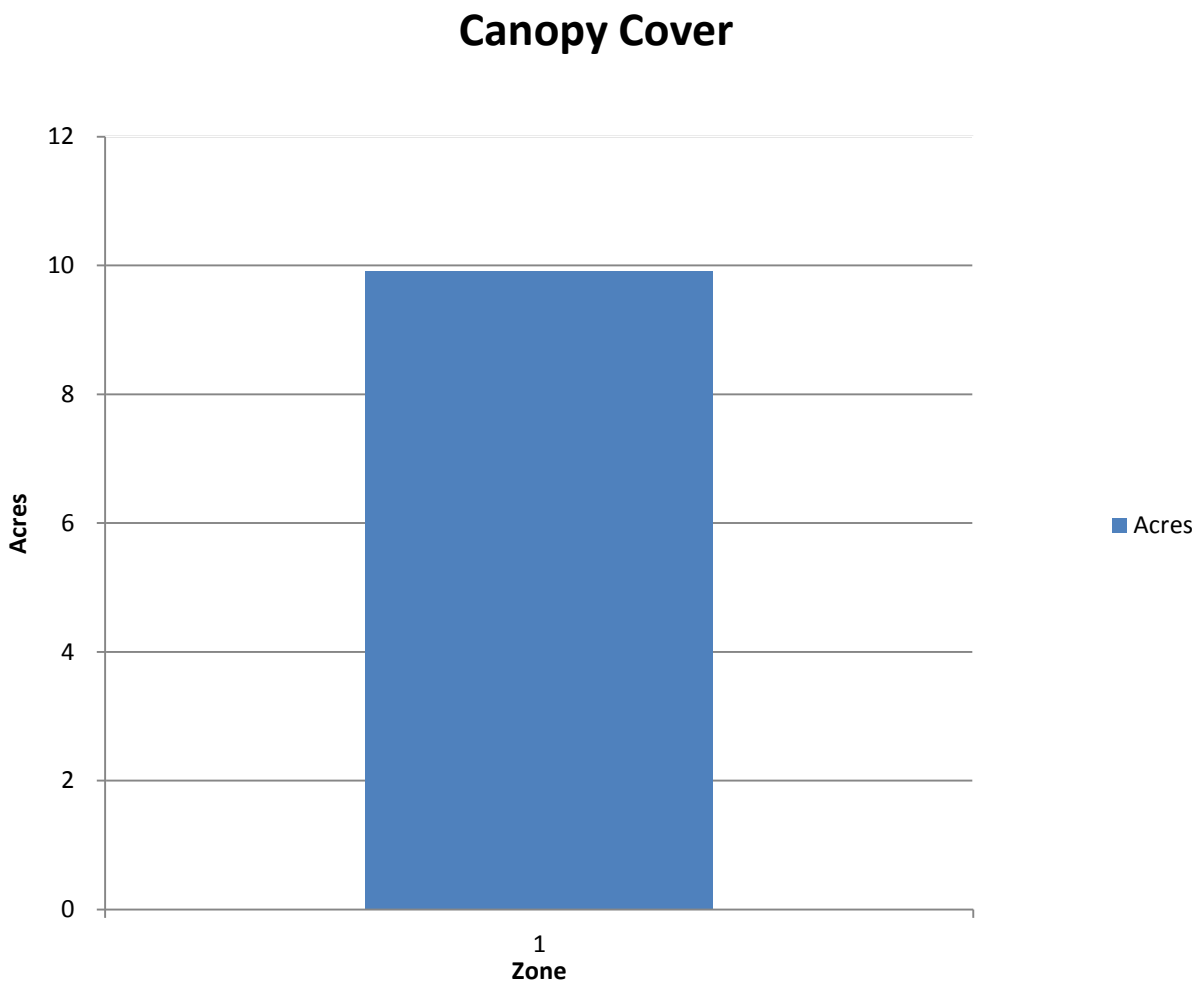

Figure 5: Canopy Cover in Acres

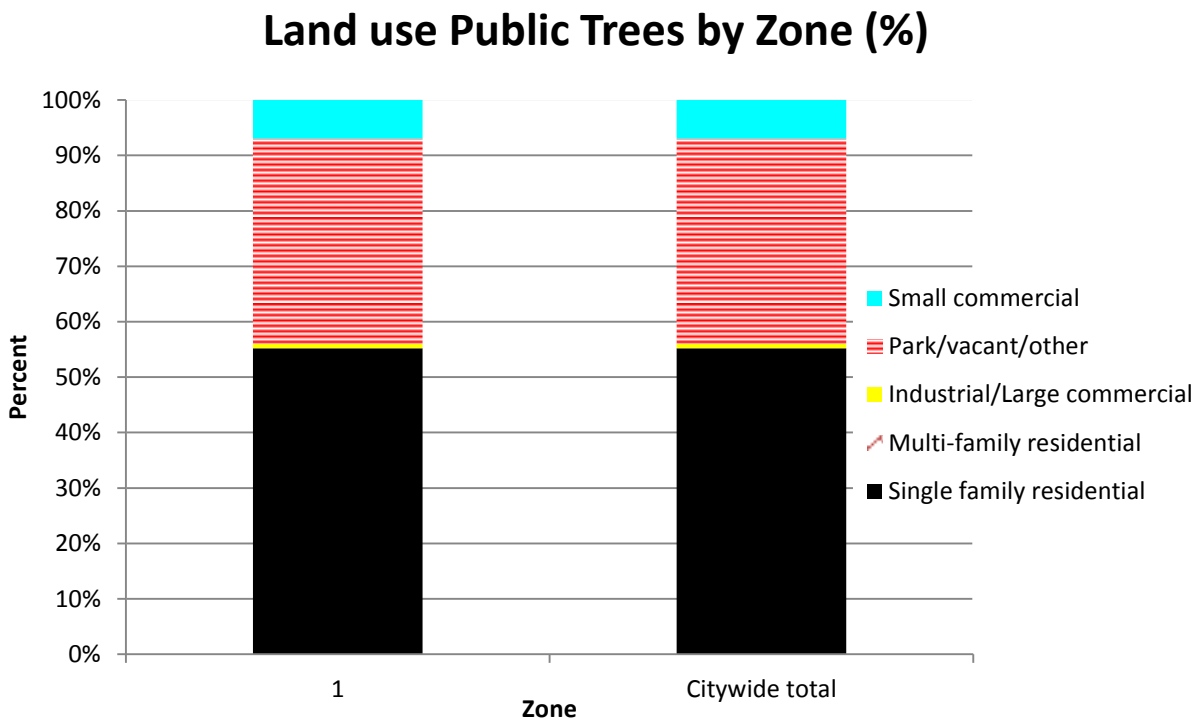

Figure 6: Land Use of city/park trees

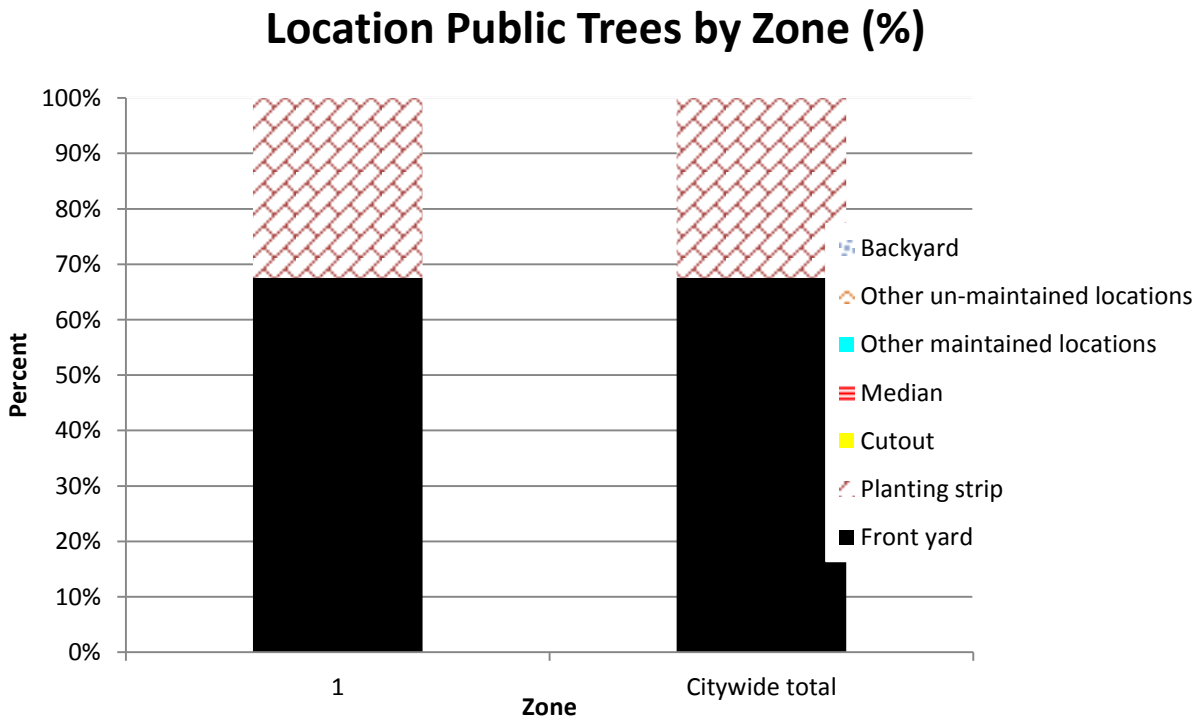

Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping

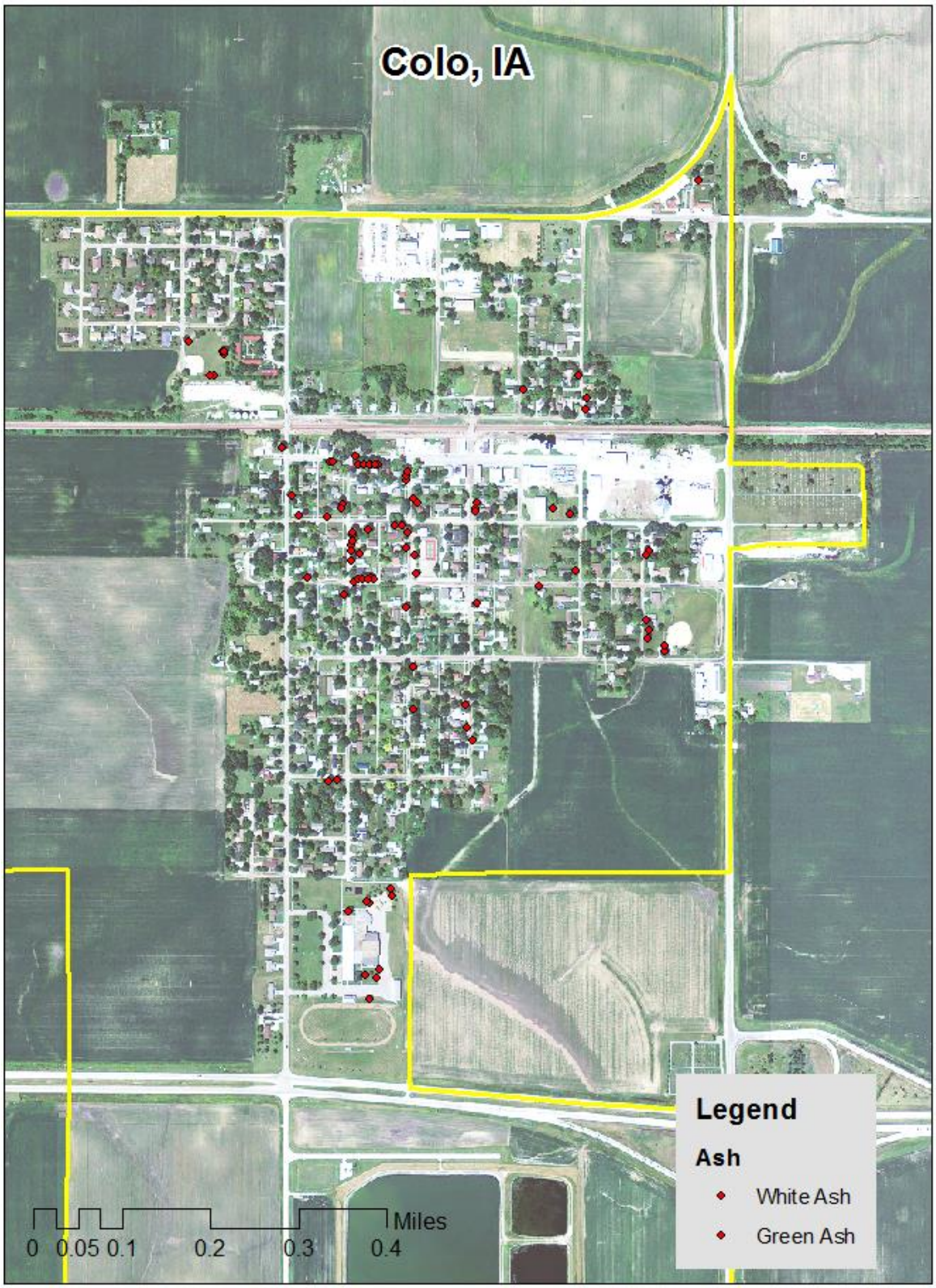

Figure 1: Location of Ash Trees

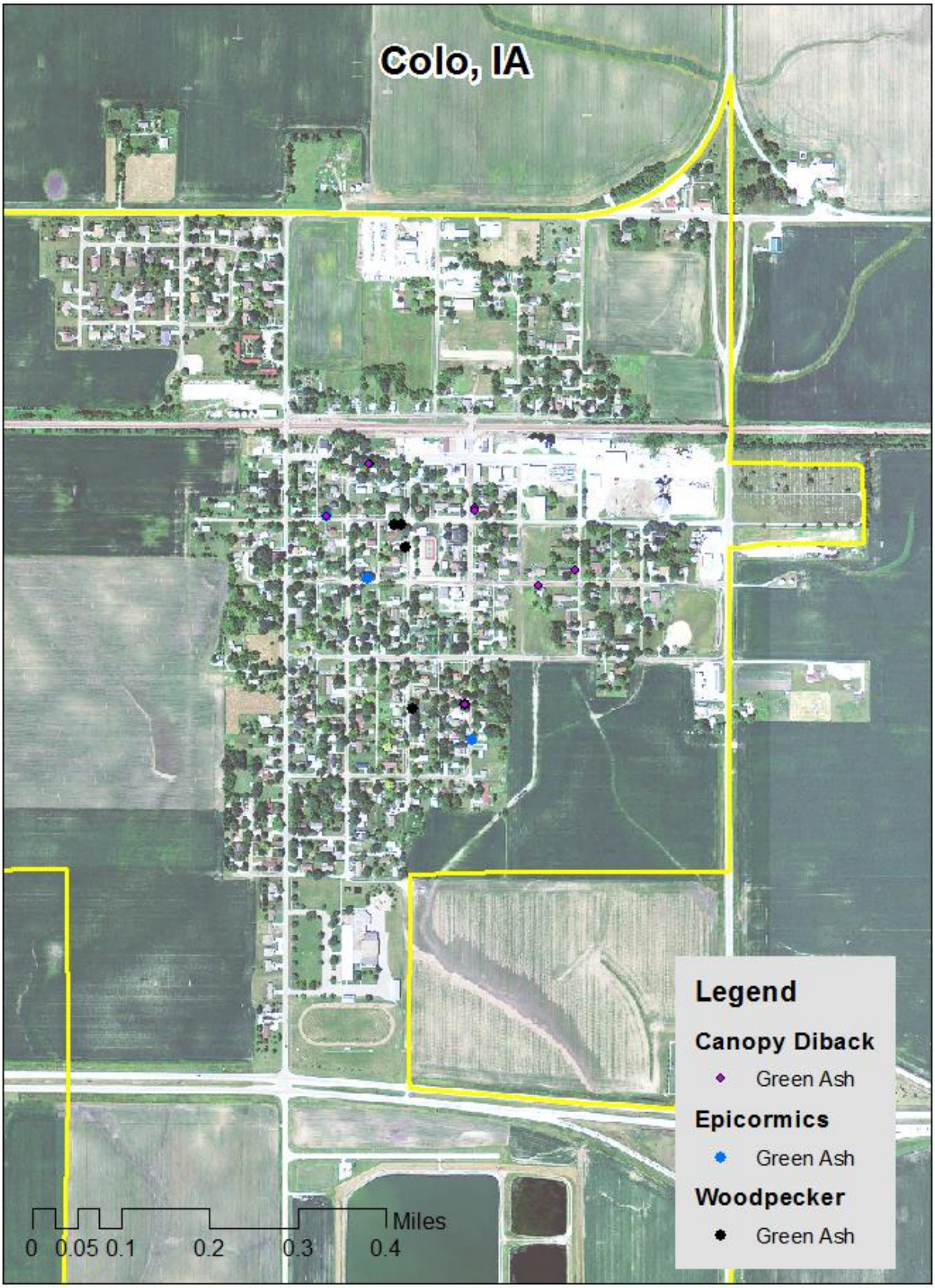

Figure 2: Location of EAB symptoms

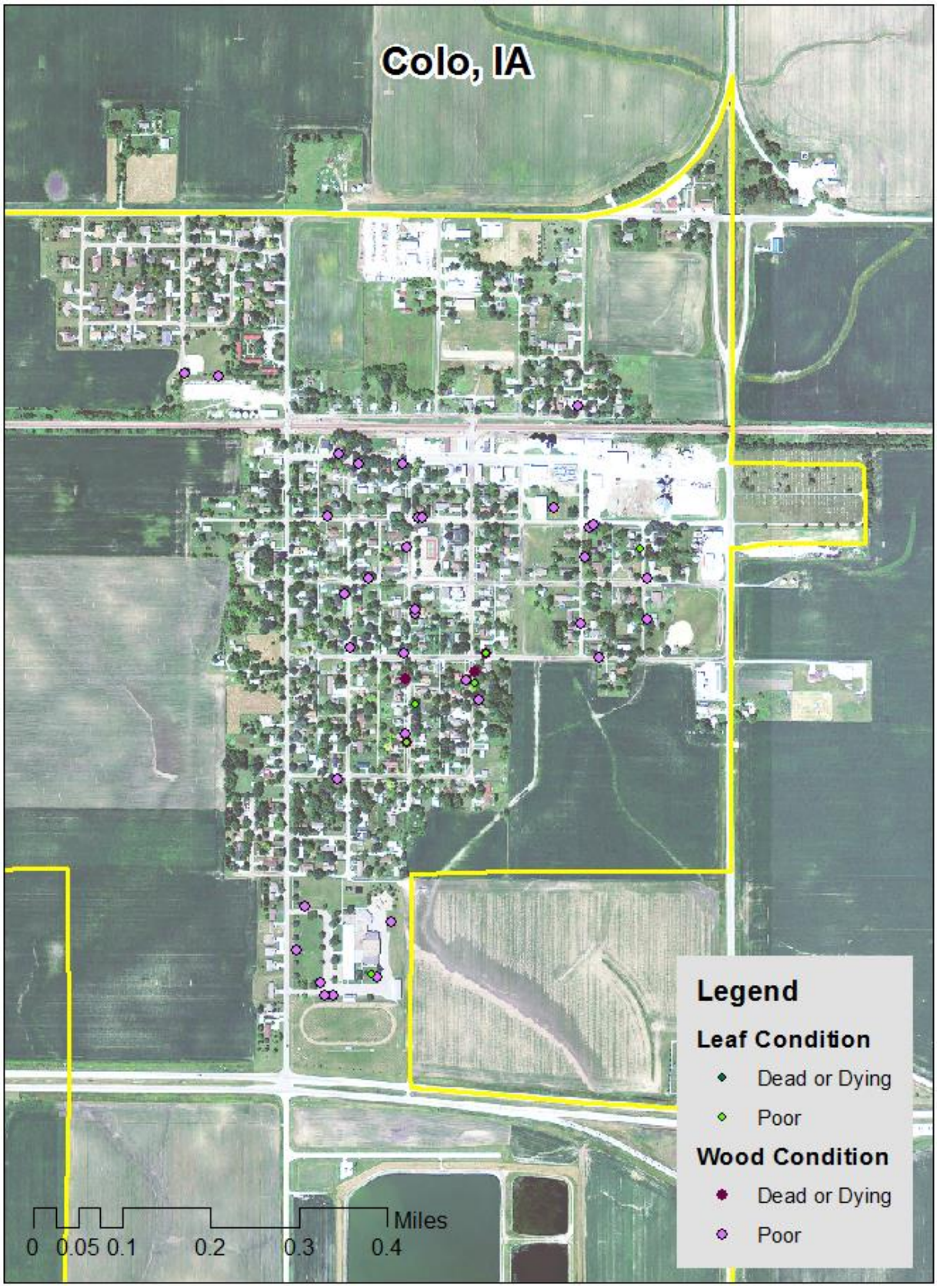

Figure 3: Location of Poor Condition Trees

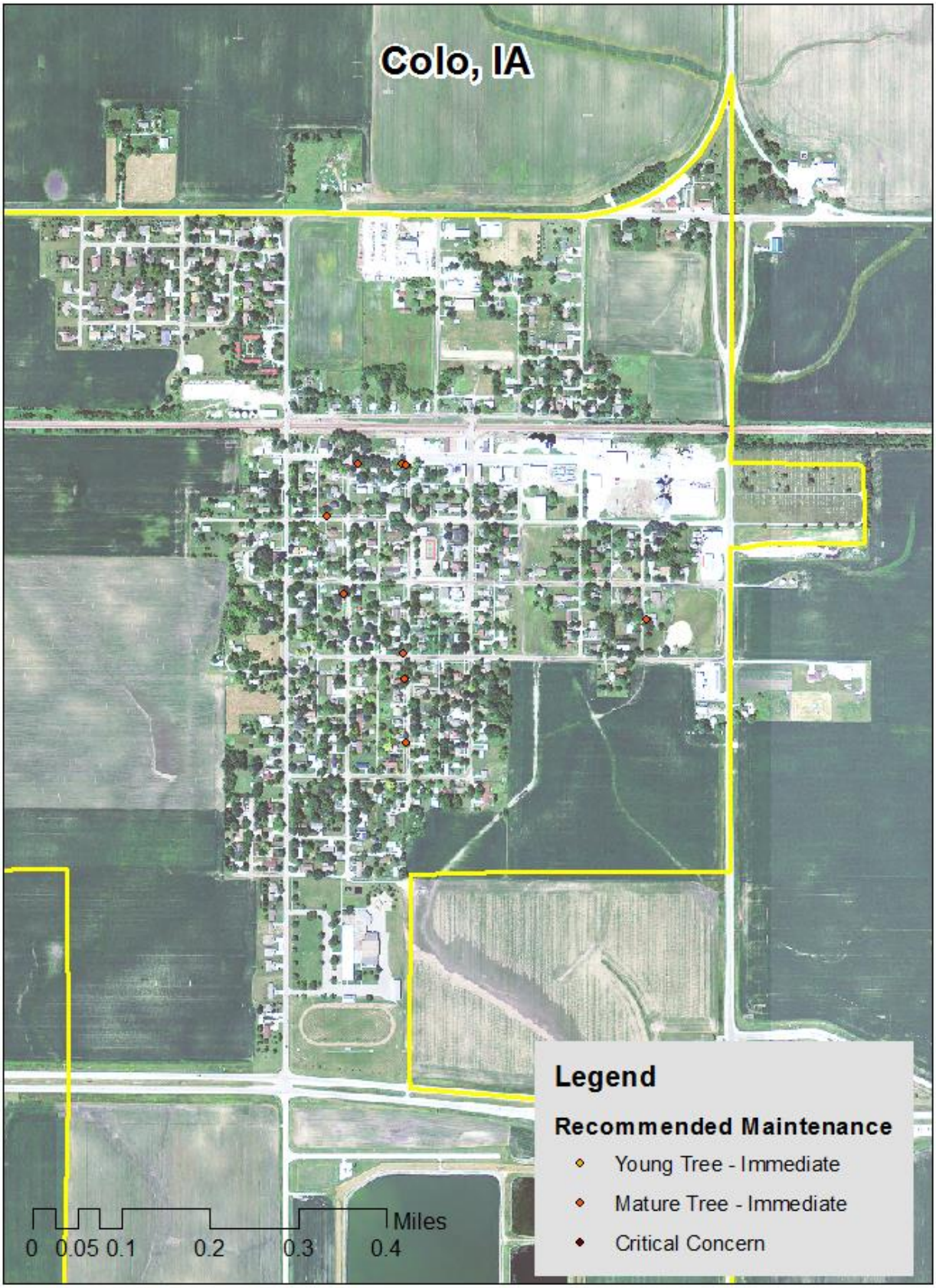

Figure 4: Location of Trees with Recommended Maintenance

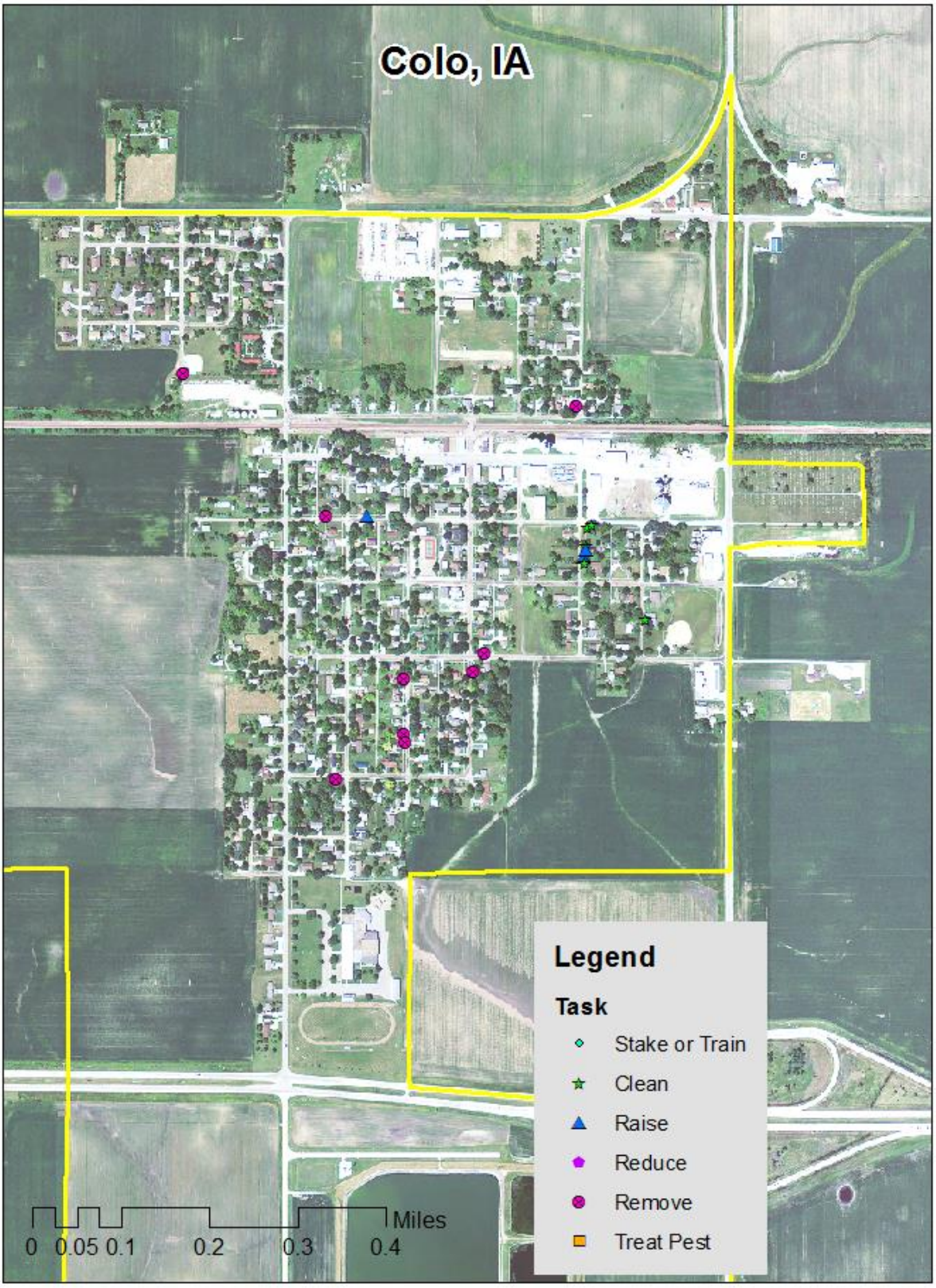

Figure 5: Maintenance Tasks *City ownership of the trees recommended for removal should be verified prior to any removal*

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