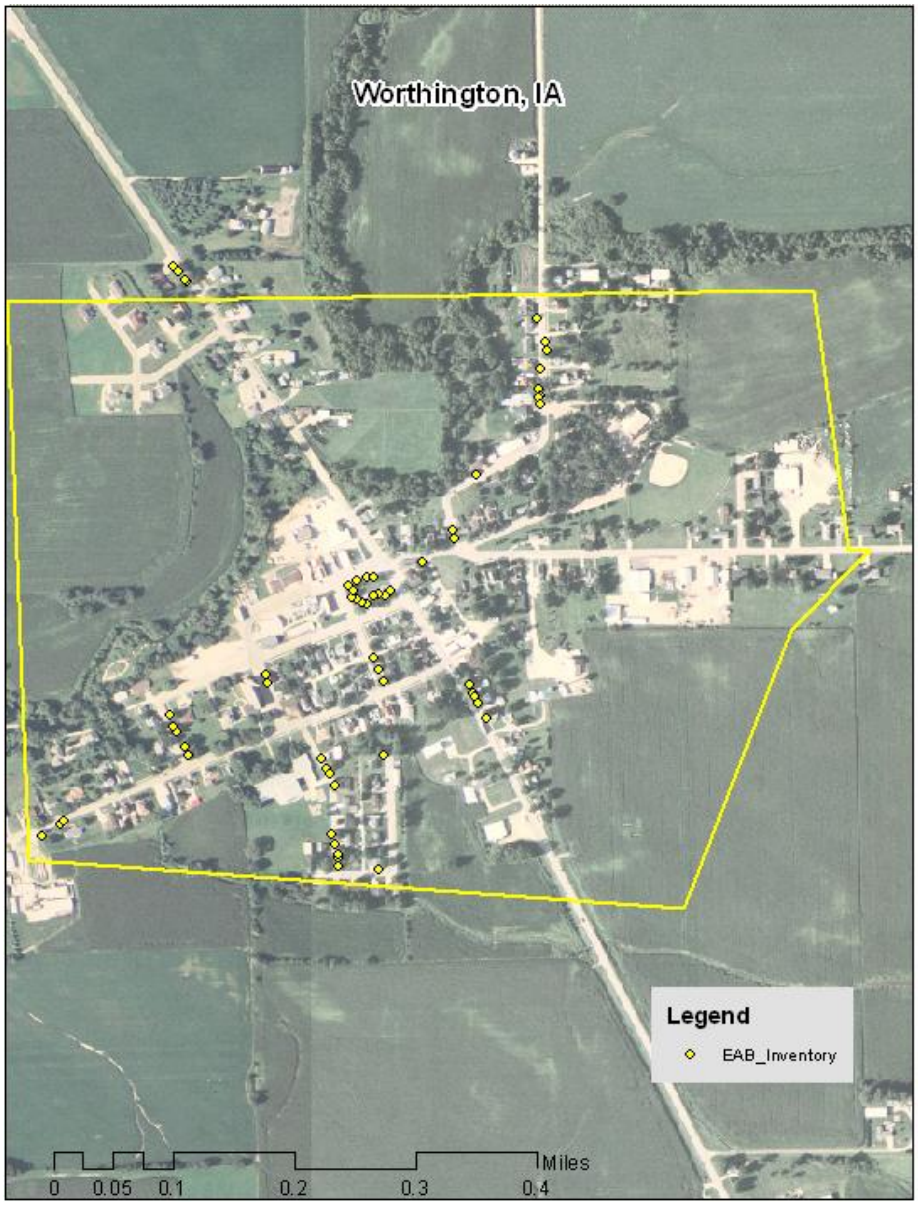
WORTHINGTON, IA



2011 Management Plan

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Executive Summary

Overview:

This plan was developed to assist the City of Worthington with managing its urban forest, including budgeting and future planning. Trees can provide a multitude of benefits to the community, and sound management allows communities to best take advantage of these benefits. Management is especially important considering the serious threats posed by forest pests such as the emerald ash borer (EAB). EAB is an invasive insect imported from Eastern Asia that kills all species of our native ash trees. There is a strong possibility that over 13% of Worthington's city-managed ash trees could die once EAB becomes established in the community. With proper planning and management, the costs of removing dead and dying trees can be extended over several years mitigating public safety issues.

Inventory and Results:

In the summer of 2011, a street tree inventory was conducted using an integrated Global Positioning System (GPS) data collector. This involved a complete inventory of street trees within the City's Right-of-Way and some parkland. Below are some key findings of the 116 trees inventoried.

- Worthington street trees provide roughly $15,350 of annual benefits, an average of $132 per tree.
- The top three species groups are: Maples (31%), Ash (13%) and Lilac (11%).
- Approximately 27% of trees are in need of some type of management.
- For various reasons, 6 trees are recommended for removal.

Recommendations:

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

- One of the 15 ash trees inventoried is in need of follow up checking because it is displaying signs and symptoms associated with EAB.
- All trees should be pruned on a routine schedule- one third of the city every other year.
- Plant a diverse mix of trees that *does not include*: ash, soft maple, autumn olive, black locust, black walnut, boxelder, Chinese elm, Siberian elm, cottonwood, poplar and tree-of-heaven.
- Check ash trees with a visual survey yearly.

Introduction

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

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

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

Inventory

In the summer of 2010, a tree inventory was conducted that included the city-owned street trees and some park trees. The tree data was collected using a handheld Global Positioning System (GPS) receiver/data logger. This devise records Geographic Information System (GIS) coordinates with an accuracy of 3 meters. The data can then be used in Arc GIS as an active GIS data layer. Because the inventory is a digital document the data can be updated with new information and become a working document.

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

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

Inventory Results

The data collected by the data loggers was downloaded and analyzed by software developed by the USDA Forest service called *Street Tree Resource Analysis Tool for Urban forestry Management (STRATUM)*. This is software is also part of the i-Tree suite. The following are results from the i-Tree STRATUM analysis of Worthington's inventory data.

Annual Benefits

Annual Energy Benefits:

Trees conserve energy by shading buildings and blocking winds. Worthington's trees reduce energy related costs by approximately $2,831 annually (Appendix A, Table 1). These savings are both in Electricity (13.8 MWh) and in Natural Gas (1,824 Therms).

Annual Storm water Benefits:

Worthington's trees intercept about 143,309 gallons of rainfall and snow melt per year (Appendix A, Table 2). This interception provides $3,884 of benefits to the city.

Annual Air Quality Benefits:

Air quality is a persistent public health issue in Iowa. The urban forest improves air quality by removing pollutants, lowering air temperature, and reducing energy consumption, which in turn reduces emissions from power plants that emit volatile organic matter (ozone). In Worthington, it is estimated that trees remove 175 lbs. of air pollution (ozone (O_3), particulate matter less than 10 microns (PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2)) per year with a net value of $491 (Appendix A, Table 3).

Annual Carbon Benefits:

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. Of the 116 trees inventoried, the amount of carbon stored amounts to approximately 552,329 total lbs of CO_2 (Appendix A, Table 4) . Those trees are sequestering about 31,629 lbs of carbon per year (Appendix A, Table 5). The benefits these trees provide from summer shading and from reductions in household wind infiltration in the winter result in approximately 23,067 fewer lbs of CO_2 being released into the atmosphere (Appendix A Table 5).

Annual Aesthetics Benefits:

Social benefits of trees are hard to capture. The analysis does have a calculation for this area that includes: aesthetic value, property values, lowered rates of mental illness and crime, city livability and much more. Worthington receives approximately $3,592 in annual social benefits from its street trees (Appendix A, Table 6).

Financial Summary of all Benefits:

According to the USDA Forest Service i-Tree STRATUM analysis, Worthington's trees provide $15,350 of benefits annually. Benefits of individual trees vary based on size, species, health and location. On average, each of the 116 trees in Worthington's inventory provides approximately $132 annually (Appendix A, Table 7).

Forest Structure

Species Distribution:

There were over 28 different tree species surveyed. The distribution of trees by genus is as follows:

Genus	# of trees	% of total
Maple (*acer*)	36	31.0%
Ash (*fraxius*)	15	12.9%
Lilac (*Syringa*)	13	11.2%
Pine (*Pinus*)	9	7.8%
Apple (*malus*)	8	6.9%
Oak (*quercus*)	6	5.2%
Spruce (*picea*)	5	4.3%
Hackberry *(Celtis)*	5	4.3%
Other broadleaves	5	4.3%
Linden (*tilia*)	4	3.4%
Elm (*ulmus*)	4	3.4%
Arborvitae (*Thuja*)	2	1.7%
Walnut (*juglans*)	2	1.7%
Mountain Ash (*sorbus*)	1	0.9%
Ohio Buckeye (*aesculus*)	1	0.9%
	116	100.0%

Size Distribution:

The table below summarizes distribution of surveyed trees by their diameter in inches when measured at 4.5 feet above the ground. Trees between 18" and 24" in diameter were most abundant (25.9%). The City's trees are found in a typical "bell shaped" distribution. It would be nicer if the distribution were "flatter" with a greater proportion of trees in the small size classes. Also, it appears the trees are generally getting older. So, new recruits should be planted to prepare for the day when the older trees start dying. See Appendix A, Figure 2 for a breakdown of size distributions by species.

Size Classes (inches of diameter at 4.5 feet)	# of trees	% of trees
0 - 3	7	6.0%
3 - 6	10	8.6%
6 - 12	20	17.2%
12 - 18	28	24.1%
18 - 24	30	25.9%
24 - 30	13	11.2%
30 - 36	8	6.9%
	116	100.0%

Condition: Wood and Foliage:

Leaf condition is a good indicator of the overall health of urban trees. The foliage condition results for Worthington indicated that 81% of the trees were in good health, 19% in fair health and <1% dead or dying. (Appendix A, Figure 3). Leaf health is largely a function of climatic factors during the growing season. Cool and humid conditions tend to encourage more leaf diseases.

The condition of the wood in urban trees is another important indicator of tree health. The wood forms the structural support system for the leaves and branches. Extensive decay in the main stem makes a tree structurally unsafe which leads to a tree becoming a safety hazard. In Worthington, 52% of the surveyed trees were in good health, 43% in fair health and 5% in poor health or dead or dying (Appendix A, Figure 4). The 5% in poor should be assessed more carefully. Several of these trees with poor wood condition are being recommended for removal due to public safety concerns. The 43% in fair health is to a large extent a reflection of having so many older maple (mostly Norway maple) trees which tend to have problems with decay or cracking in their main stem. The City already has too many maple trees, so please encourage far less planting of Norway maple; at least for awhile.

Management Needs:

Each surveyed tree was assessed for recommended maintenance needs. The following tables list the specific management needs and recommendations. Of the 6 trees recommended for removal, none were judged to be of critical concern for public safety (See Appendix B, figure 4).

Priority Task	# of trees	% of trees
none	85	73.3%
stake/train	8	6.9%
clean	8	6.9%
raise	7	6.0%
remove	6	5.2%
reduce	2	1.7%
	116	100.0%

Maintenance Recommendation	# of trees	% of trees
mature tree (routine)	76	65.5%
young tree (routine)	37	31.9%
mature tree (immediate)	2	1.7%
young tree (immediate)	1	0.9%
	116	100.0%

Land Use and Location:

The majority of Worthington's surveyed trees are 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.

<u>Land Use</u>

Single family residential	71%
Park/vacant/other	25%
Multi-family residential	2%

<u>Location</u>

Front yard	47%
Planting strip	22%
Back yard	6%
Other maintained locations	25%

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:

A total of 6 trees are recommended for removal for one reason or another. Of those, 2 trees had leaves and canopy that were dead or dying and 2 had poor wood condition or showed signs of severe decay. These trees with severe decay could easily break off or topple over in storms or under ice and snow loads. Some of the trees were recommended for removal because they blocked the view for traffic or were growing in a bad location or were volunteer trees of poor species (E.g. Siberian elm, walnut, etc.)

Poor tree species:

Ash trees in poor health should be assessed for removal (Appendix B, Figure 2). Of the 6 trees recommended for removal, 1 tree was an ash with poor wood condition and 1 tree was a Siberian elm and 1 was a black walnut.

Pruning Cycle:

Proper pruning can extend the life and improve the overall health of trees, and can reduce public safety issues. In the Management Needs section of the Findings there are four main maintenance issues to be addressed: routine pruning (stake/train), crown cleaning (clean), crown raising (raise), and crown reduction (reduce). Crown cleaning removes dead, diseased, and damaged limbs. Crown raising is the removal of lower branches that are 2 inches in diameter or larger in the case of providing clearance for pedestrians or vehicles. Crown reduction is removing individual limbs from structures or utility wires. Staking and training is recommended for younger trees so they can develop good architecture. It is recommended that all trees be pruned on a routine schedule every five to seven years.

Priority Task	# of trees	% of trees
none	85	73.3%
stake/train	8	6.9%
clean	8	6.9%
raise	7	6.0%
remove	6	5.2%
reduce	2	1.7%
	116	100.0%

Planting:

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

Since most insects and diseases target a particular genus (e.g. ash) or species (e.g. green ash) of trees, it is important to always plant a diverse mix of species. Current diversity recommendations advise that any genus (e.g. maple, oak or ash) not make up more than 20% of the urban forest. Any single species (e.g. silver maple, sugar maple, white oak or bur oak) not make up more than 10% of the total urban forest. Presently, the forest is heavily planted with Maple (31%) (Appendix A, Figure 1). Maples should not be planted until this percentage is dramatically lowered. Ash trees have not been recommended since 2002, due to the threat of EAB. Other species to avoid because they are public nuisances include: Autumn olive, black locust, black walnut, boxelder, Chinese elm, Siberian elm, cottonwood, poplar, tree of heaven, and willow. I noticed that white poplar was recommended in your City Tree Ordinance. This tree can become invasive so should probably be taken off of your list.

Continual Monitoring:

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

Emerald Ash Borer (EAB) Plan

EAB Quarantines:

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

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

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

Wood Disposal:

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

Canopy Replacement:

As your budget permits, all removed ash trees should be replaced. All trees should meet the restrictions in your city's ordinance (Appendix C). The new plantings should be a diverse mix and should not include ash, Autumn olive, black locust, black walnut, boxelder, Chinese elm, Siberian elm, cottonwood, poplar, tree of heaven, or willow.

Postponed Work:

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

Private Ash Trees:

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

Budget

Purposed Budget Increase:

EAB could potentially kill all of the ash trees in Worthington within a decade after its arrival. It is recommended that the City apply for grants to fund replacement tree planting. Utility Company grants are usually between $500 and $10,000 for community-based, tree-planting projects that include parks, gateways, cemeteries, nature trails, libraries, nursing homes, and schools. There were a total of 15 ash trees surveyed. We recommend that at least 1/2 (8 trees) of them be removed and replaced over the next 6 years. You should replant 2 trees for everyone removed. Remove ash trees where they occur in groups throughout the City (Appendix B, Figure 1). We recommend that the City adopt a policy of allocating somewhere between $2 to $4 per capita per year into a forestry budget to be used for planting, removals and maintenance of Worthington's urban forest.

Recommended Budget: $7,800 total over 6 years.

FY 2011 Budget
- Removal: $1000
- Planting: $400
- Routine trimming: $300
- Watering & Maintenance: $100

FY 2012 Budget
- Removal: $1000
- Planting: $400
- Routine trimming: $300
- Watering & Maintenance: $100

FY 2013 Budget
- Removal: $500
- Planting: $200
- Routine trimming: $4000
- Watering & Maintenance: $50

FY 2014 Budget
- Removal: $500
- Planting: $200
- Routine trimming: $4000
- Watering & Maintenance: $50

FY 2015 Budget
- Removal: $500
- Planting: $200
- Routine trimming: $4000
- Watering & Maintenance: $50

FY 2016 Budget
- Removal: $500
- Planting: $200
- Routine trimming: $4000
- Watering & Maintenance: $50

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Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Annual Energy Benefits of Public Trees by Species

8/13/2010

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Silver maple	3.4	255	460.1	451	706	(N/A)	19.0	24.9	64.19
Norway maple	2.0	148	266.5	261	409	(N/A)	17.2	14.5	40.92
Green ash	1.8	136	215.6	211	347	(N/A)	12.1	12.3	49.63
Black walnut	1.0	78	133.9	131	209	(N/A)	8.6	7.4	41.78
Bur oak	2.1	157	278.9	273	430	(N/A)	8.6	15.2	86.02
Honeylocust	1.3	96	165.4	162	258	(N/A)	6.9	9.1	64.41
Conifer Evergreen Small	0.0	2	4.9	5	7	(N/A)	3.5	0.3	3.62
Eastern red cedar	0.2	17	32.9	32	49	(N/A)	3.5	1.7	24.57
Red maple	0.0	3	5.2	5	8	(N/A)	1.7	0.3	7.85
Sugar maple	0.2	18	26.9	26	44	(N/A)	1.7	1.6	44.11
Conifer Evergreen Large	0.1	10	14.6	14	24	(N/A)	1.7	0.9	24.14
Northern hackberry	0.5	37	65.9	65	101	(N/A)	1.7	3.6	101.20
White ash	0.1	7	13.3	13	20	(N/A)	1.7	0.7	20.10
Apple	0.2	14	24.7	24	38	(N/A)	1.7	1.4	38.13
Blue spruce	0.0	2	4.9	5	7	(N/A)	1.7	0.3	6.94
Scotch pine	0.1	4	9.5	9	14	(N/A)	1.7	0.5	13.58
Pin oak	0.3	25	46.0	45	71	(N/A)	1.7	2.5	70.52
Northern red oak	0.2	15	23.3	23	38	(N/A)	1.7	1.3	37.72
Lilac	0.0	2	3.8	4	5	(N/A)	1.7	0.2	5.40
American elm	0.2	19	27.5	27	46	(N/A)	1.7	1.6	45.87
Other street trees	0.0	0	0.0	0	0	(N/A)	0.0	0.0	0.00
Citywide total	13.8	1,044	1,823.9	1,787	2,831	(N/A)	100.0	100.0	48.81

Table 2: Annual Stormwater Benefits

Annual Stormwater Benefits of Public Trees by Species

8/13/2010

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Silver maple	44,207	1,198	(N/A)	19.0	30.9	108.92
Norway maple	13,338	361	(N/A)	17.2	9.3	36.15
Green ash	14,283	387	(N/A)	12.1	10.0	55.30
Black walnut	8,284	225	(N/A)	8.6	5.8	44.90
Bur oak	29,601	802	(N/A)	8.6	20.7	160.45
Honeylocust	12,051	327	(N/A)	6.9	8.4	81.65
Conifer Evergreen Small	367	10	(N/A)	3.5	0.3	4.97
Eastern red cedar	3,269	89	(N/A)	3.5	2.3	44.30
Red maple	137	4	(N/A)	1.7	0.1	3.72
Sugar maple	1,367	37	(N/A)	1.7	1.0	37.05
Conifer Evergreen Large	1,539	42	(N/A)	1.7	1.1	41.70
Northern hackberry	6,492	176	(N/A)	1.7	4.5	175.96
White ash	614	17	(N/A)	1.7	0.4	16.63
Apple	666	18	(N/A)	1.7	0.5	18.06
Blue spruce	256	7	(N/A)	1.7	0.2	6.95
Scotch pine	595	16	(N/A)	1.7	0.4	16.14
Pin oak	3,590	97	(N/A)	1.7	2.5	97.30
Northern red oak	1,193	32	(N/A)	1.7	0.8	32.34
Lilac	69	2	(N/A)	1.7	0.1	1.86
American elm	1,391	38	(N/A)	1.7	1.0	37.69
Other street trees	0	0	(N/A)	0.0	0.0	0.00
Citywide total	143,309	3,884	(N/A)	100.0	100.0	66.96

Table 3: Annual Air Quality Benefits

Annual Air Quality Benefits of Public Trees by Species

8/13/2010

Species	Deposition (lb) O_3	NO_2	PM_{10}	SO_2	Total Depos. ($)	Avoided (lb) NO_2	PM_{10}	VOC	SO_2	Total Avoided ($)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($)	Standard Error	% of Total Trees	Avg. $/tree
Silver maple	7.4	1.3	3.7	0.3	40	16.0	2.3	2.2	15.2	100	-4.1	-16	44.3	124	(N/A)	19.0	11.30
Norway maple	2.2	0.4	1.2	0.1	12	9.3	1.4	1.3	8.9	58	-0.6	-2	24.1	68	(N/A)	17.2	6.81
Green ash	1.4	0.2	0.8	0.1	8	8.3	1.2	1.2	8.1	52	0.0	0	21.3	60	(N/A)	12.1	8.61
Black walnut	0.8	0.1	0.4	0.0	4	4.8	0.7	0.7	4.6	30	0.0	0	12.2	34	(N/A)	8.6	6.88
Bur oak	5.3	0.9	2.4	0.2	28	9.8	1.4	1.4	9.4	61	0.0	0	30.7	89	(N/A)	8.6	17.82
Honeylocust	2.3	0.4	1.1	0.1	12	5.9	0.9	0.8	5.7	37	-1.7	-6	15.5	43	(N/A)	6.9	10.75
Conifer Evergreen Small	0.0	0.0	0.0	0.0	0	0.2	0.0	0.0	0.1	1	-0.2	-1	0.2	0	(N/A)	3.4	0.20
Eastern red cedar	0.7	0.1	0.5	0.1	4	1.1	0.2	0.1	1.0	7	-1.8	-7	2.0	4	(N/A)	3.4	2.19
Red maple	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)	1.7	1.12
Sugar maple	0.1	0.0	0.1	0.0	1	1.1	0.2	0.2	1.1	7	-0.1	0	2.6	7	(N/A)	1.7	7.08
Conifer Evergreen Large	0.2	0.0	0.1	0.0	1	0.6	0.1	0.1	0.6	4	-0.5	-2	1.2	3	(N/A)	1.7	2.82
Northern hackberry	1.2	0.2	0.6	0.1	7	2.3	0.3	0.3	2.2	14	0.0	0	7.2	21	(N/A)	1.7	20.98
White ash	0.0	0.0	0.0	0.0	0	0.4	0.1	0.1	0.4	3	0.0	0	1.0	3	(N/A)	1.7	2.91
Apple	0.2	0.0	0.1	0.0	1	0.9	0.1	0.1	0.8	5	0.0	0	2.3	7	(N/A)	1.7	6.56
Blue spruce	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	1	-0.1	0	0.3	1	(N/A)	1.7	0.75
Scotch pine	0.1	0.0	0.1	0.0	0	0.3	0.0	0.0	0.3	2	-0.2	-1	0.6	1	(N/A)	1.7	1.48
Pin oak	0.6	0.1	0.3	0.0	3	1.6	0.2	0.2	1.5	10	-1.1	-4	3.5	9	(N/A)	1.7	9.04
Northern red oak	0.2	0.0	0.1	0.0	1	0.9	0.1	0.1	0.9	6	-0.3	-1	2.1	6	(N/A)	1.7	5.79
Lilac	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)	1.7	0.71
American elm	0.1	0.0	0.1	0.0	0	1.1	0.2	0.2	1.1	7	0.0	0	2.7	8	(N/A)	1.7	7.68
Other street trees	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0	(N/A)	0.0	0.00
Citywide total	22.8	3.8	11.5	1.1	124	65.1	9.5	9.1	62.3	407	-10.7	-40	174.6	491	(N/A)	100.0	8.46

Table 4: Annual Carbon Stored

Stored CO2 Benefits of Public Trees by Species

8/13/2010

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Silver maple	177,708	1,333	(N/A)	19.0	32.2	121.16
Norway maple	36,431	273	(N/A)	17.2	6.6	27.32
Green ash	47,974	360	(N/A)	12.1	8.7	51.40
Black walnut	24,444	183	(N/A)	8.6	4.4	36.67
Bur oak	182,768	1,371	(N/A)	8.6	33.1	274.15
Honeylocust	28,767	216	(N/A)	6.9	5.2	53.94
Conifer Evergreen	86	1	(N/A)	3.5	0.0	0.32
Eastern red cedar	2,204	17	(N/A)	3.5	0.4	8.27
Red maple	218	2	(N/A)	1.7	0.0	1.64
Sugar maple	3,624	27	(N/A)	1.7	0.7	27.18
Conifer Evergreen	1,170	9	(N/A)	1.7	0.2	8.78
Northern	20,513	154	(N/A)	1.7	3.7	153.84
White ash	1,035	8	(N/A)	1.7	0.2	7.76
Apple	3,037	23	(N/A)	1.7	0.6	22.78
Blue spruce	43	0	(N/A)	1.7	0.0	0.32
Scotch pine	257	2	(N/A)	1.7	0.1	1.93
Pin oak	15,239	114	(N/A)	1.7	2.8	114.29
Northern red oak	3,595	27	(N/A)	1.7	0.7	26.96
Lilac	178	1	(N/A)	1.7	0.0	1.33
American elm	3,037	23	(N/A)	1.7	0.6	22.78
Other street trees	0	0	(N/A)	0.0	0.0	0.00
Citywide total	552,329	4,142	(N/A)	100.0	100.0	71.42

Table 5: Annual Carbon Sequestered

Annual CO_2 Benefits of Public Trees by Species

8/13/2010

Species	Sequestered (lb)	Sequestered ($)	Decomposition Release (lb)	Maintenance Release (lb)	Total Released ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Silver maple	13,705	103	-853	-2	-6	5,641	42	18,490	139	(N/A)	19.0	33.8	12.61
Norway maple	3,413	26	-175	-2	-1	3,271	25	6,508	49	(N/A)	17.2	11.9	4.88
Green ash	3,632	27	-230	-1	-2	3,007	23	6,407	48	(N/A)	12.1	11.7	6.86
Black walnut	2,284	17	-117	-1	-1	1,717	13	3,883	29	(N/A)	8.6	7.1	5.82
Bur oak	3,584	27	-877	-1	-7	3,465	26	6,170	46	(N/A)	8.6	11.3	9.26
Honeylocust	3,833	29	-138	-1	-1	2,111	16	5,805	44	(N/A)	6.9	10.6	10.88
Conifer Evergreen	27	0	0	0	0	53	0	79	1	(N/A)	3.5	0.1	0.29
Eastern red cedar	86	1	-11	0	0	374	3	448	3	(N/A)	3.5	0.8	1.68
Red maple	39	0	-1	0	0	60	0	98	1	(N/A)	1.7	0.2	0.73
Sugar maple	319	2	-17	0	0	391	3	693	5	(N/A)	1.7	1.3	5.19
Conifer Evergreen	116	1	-6	0	0	216	2	326	2	(N/A)	1.7	0.6	2.45
Northern hackberry	709	5	-98	0	-1	809	6	1,419	11	(N/A)	1.7	2.6	10.65
White ash	182	1	-5	0	0	156	1	332	2	(N/A)	1.7	0.6	2.49
Apple	268	2	-15	0	0	308	2	561	4	(N/A)	1.7	1.0	4.21
Blue spruce	12	0	0	0	0	48	0	60	0	(N/A)	1.7	0.1	0.45
Scotch pine	53	0	-1	0	0	94	1	146	1	(N/A)	1.7	0.3	1.09
Pin oak	1,491	11	-73	0	-1	562	4	1,980	15	(N/A)	1.7	3.6	14.85
Northern red oak	281	2	-17	0	0	329	2	592	4	(N/A)	1.7	1.1	4.44
Lilac	38	0	-1	0	0	37	0	74	1	(N/A)	1.7	0.1	0.56
American elm	222	2	-15	0	0	418	3	625	5	(N/A)	1.7	1.1	4.68
Other street trees	0	0	0	0	0	0	0	0	0	(N/A)	0.0	0.0	0.00
Citywide total	34,291	257	-2,651	-11	-20	23,067	173	54,696	410	(N/A)	100.0	100.0	7.07

Table 6: Annual Social and Aesthetic Benefits

Annual Aesthetic/Other Benefits of Public Trees by Species

8/13/2010

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Silver maple	1,086	(N/A)	19.0	30.2	98.76
Norway maple	347	(N/A)	17.2	9.7	34.72
Green ash	342	(N/A)	12.1	9.5	48.82
Black walnut	222	(N/A)	8.6	6.2	44.36
Bur oak	247	(N/A)	8.6	6.9	49.33
Honeylocust	881	(N/A)	6.9	24.5	220.20
Conifer Evergreen Small	27	(N/A)	3.5	0.7	13.37
Eastern red cedar	27	(N/A)	3.5	0.8	13.68
Red maple	7	(N/A)	1.7	0.2	7.28
Sugar maple	40	(N/A)	1.7	1.1	39.54
Conifer Evergreen Large	32	(N/A)	1.7	0.9	32.32
Northern hackberry	78	(N/A)	1.7	2.2	78.41
White ash	33	(N/A)	1.7	0.9	33.42
Apple	15	(N/A)	1.7	0.4	15.48
Blue spruce	12	(N/A)	1.7	0.3	12.31
Scotch pine	15	(N/A)	1.7	0.4	15.42
Pin oak	116	(N/A)	1.7	3.2	116.38
Northern red oak	24	(N/A)	1.7	0.7	24.08
Lilac	2	(N/A)	1.7	0.1	2.06
American elm	37	(N/A)	1.7	1.0	36.79
Other street trees	0	(±NaN)	0.0	0.0	0.00
Citywide total	3,592	(N/A)	100.0	100.0	61.94

Table 7: Summary of Benefits in Dollars

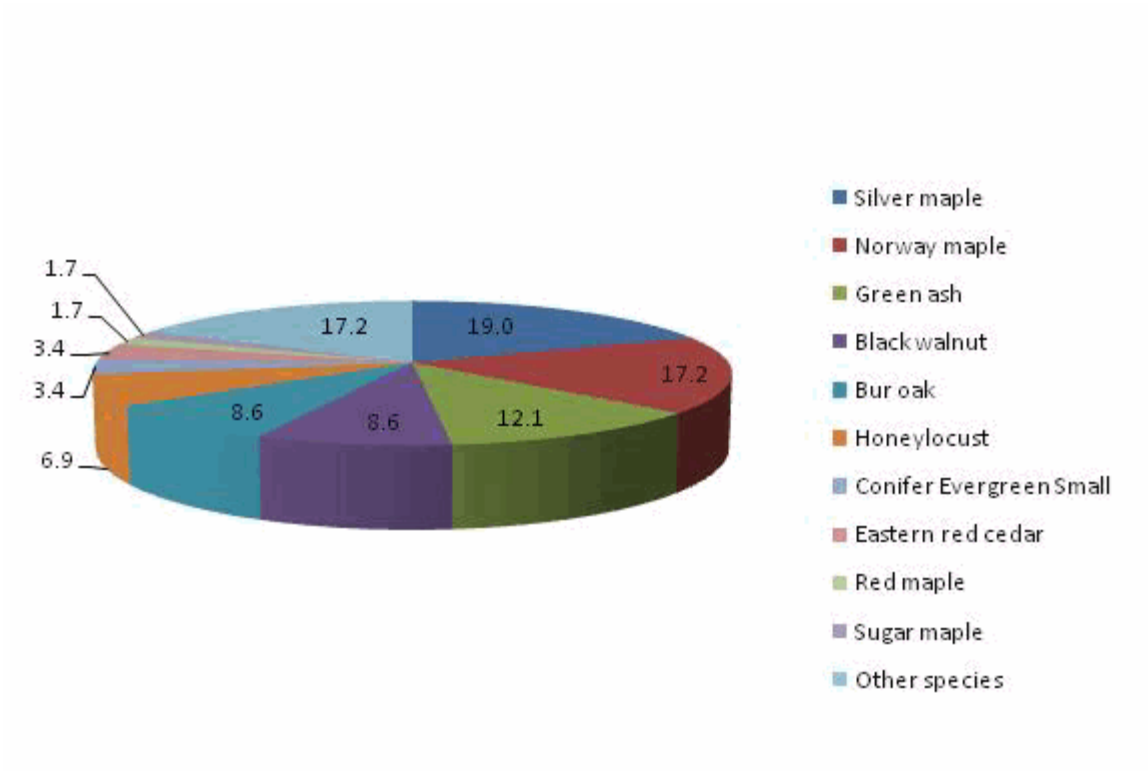
Annual Benefits of Public Trees by Species ($/tree)

8/13/2010

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error
Silver maple	64.19	12.61	11.30	108.92	98.76	295.78	(N/A)
Norway maple	40.92	4.88	6.81	36.15	34.72	123.48	(N/A)
Green ash	49.63	6.86	8.61	55.30	48.82	169.21	(N/A)
Black walnut	41.78	5.82	6.88	44.90	44.36	143.75	(N/A)
Bur oak	86.02	9.26	17.82	160.45	49.33	322.87	(N/A)
Honeylocust	64.41	10.88	10.75	81.65	220.20	387.90	(N/A)
Conifer Evergreen	3.62	0.29	0.20	4.97	13.37	22.45	(N/A)
Eastern red cedar	24.57	1.68	2.19	44.30	13.68	86.42	(N/A)
Red maple	7.85	0.73	1.12	3.72	7.28	20.71	(N/A)
Sugar maple	44.11	5.19	7.08	37.05	39.54	132.98	(N/A)
Conifer Evergreen	24.14	2.45	2.82	41.70	32.32	103.42	(N/A)
Northern hackberry	101.20	10.65	20.98	175.96	78.41	387.19	(N/A)
White ash	20.10	2.49	2.91	16.63	33.42	75.56	(N/A)
Apple	38.13	4.21	6.56	18.06	15.48	82.44	(N/A)
Blue spruce	6.94	0.45	0.75	6.95	12.31	27.41	(N/A)
Scotch pine	13.58	1.09	1.48	16.14	15.42	47.71	(N/A)
Pin oak	70.52	14.85	9.04	97.30	116.38	308.09	(N/A)
Northern red oak	37.72	4.44	5.79	32.34	24.08	104.37	(N/A)
Lilac	5.40	0.56	0.71	1.86	2.06	10.59	(N/A)
American elm	45.87	4.68	7.68	37.69	36.79	132.72	(N/A)
Other street trees	0.00	0.00	0.00	0.00	0.00	0.00	(N/A)

Species Distribution of Public Trees (%)

8/13/2010

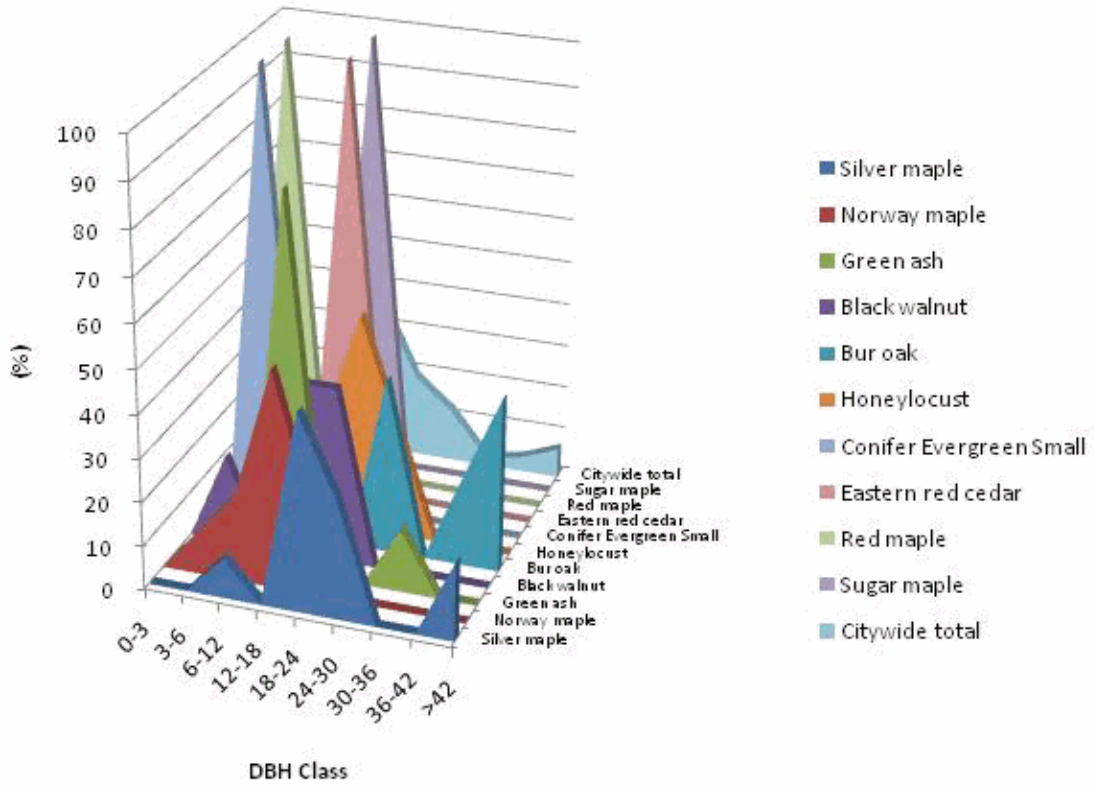


Species	Percent
Silver maple	19.0
Norway maple	17.2
Green ash	12.1
Black walnut	8.6
Bur oak	8.6
Honeylocust	6.9
Conifer Evergreen Small	3.4
Eastern red cedar	3.4
Red maple	1.7
Sugar maple	1.7
Other species	17.2
Total	100.0

Figure 1: Species Distribution

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

8/13/2010



	DBH class (in)								
Species	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Silver maple	0.0	0.0	9.1	0.0	45.5	27.3	0.0	0.0	18.2
Norway maple	0.0	10.0	20.0	50.0	20.0	0.0	0.0	0.0	0.0
Green ash	0.0	0.0	0.0	85.7	0.0	0.0	14.3	0.0	0.0
Black walnut	0.0	20.0	0.0	40.0	40.0	0.0	0.0	0.0	0.0
Bur oak	0.0	0.0	0.0	0.0	0.0	40.0	0.0	20.0	40.0
Honeylocust	0.0	0.0	0.0	25.0	50.0	25.0	0.0	0.0	0.0
Conifer Evergreen	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eastern red cedar	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Red maple	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sugar maple	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Citywide total	0.0	12.1	8.6	36.2	19.0	12.1	1.7	3.4	6.9

Figure 2: Relative Age Class

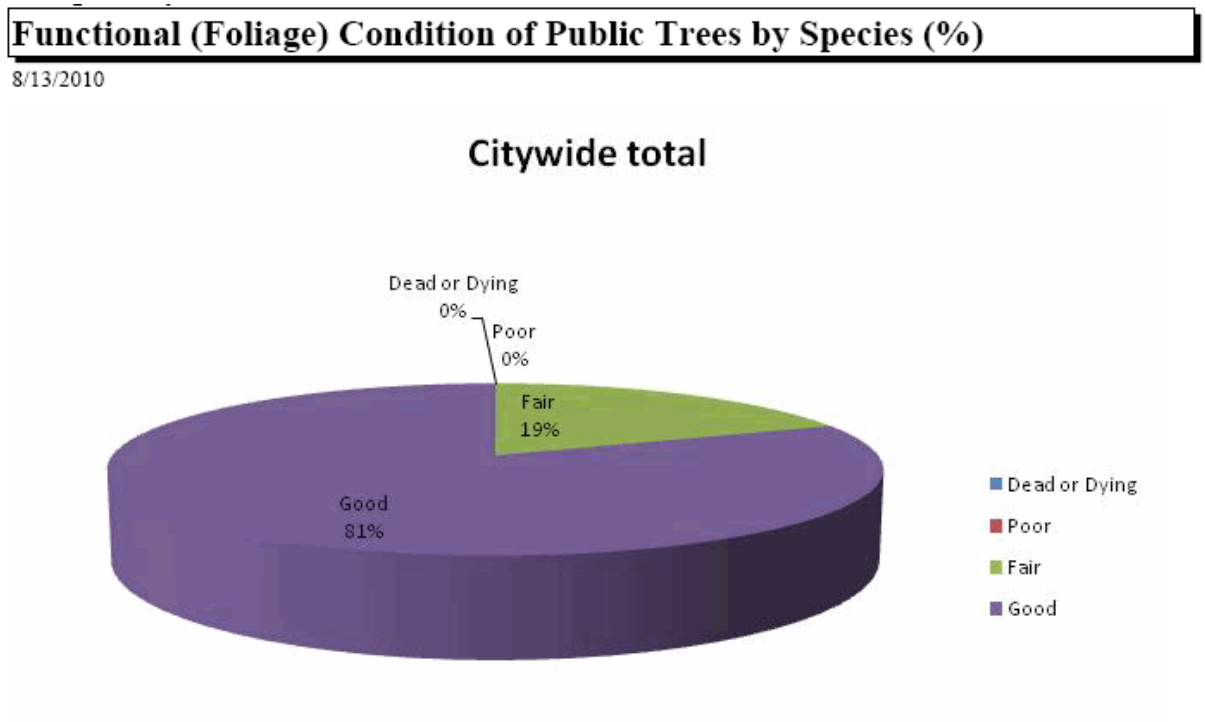


Figure 3: Foliage Condition

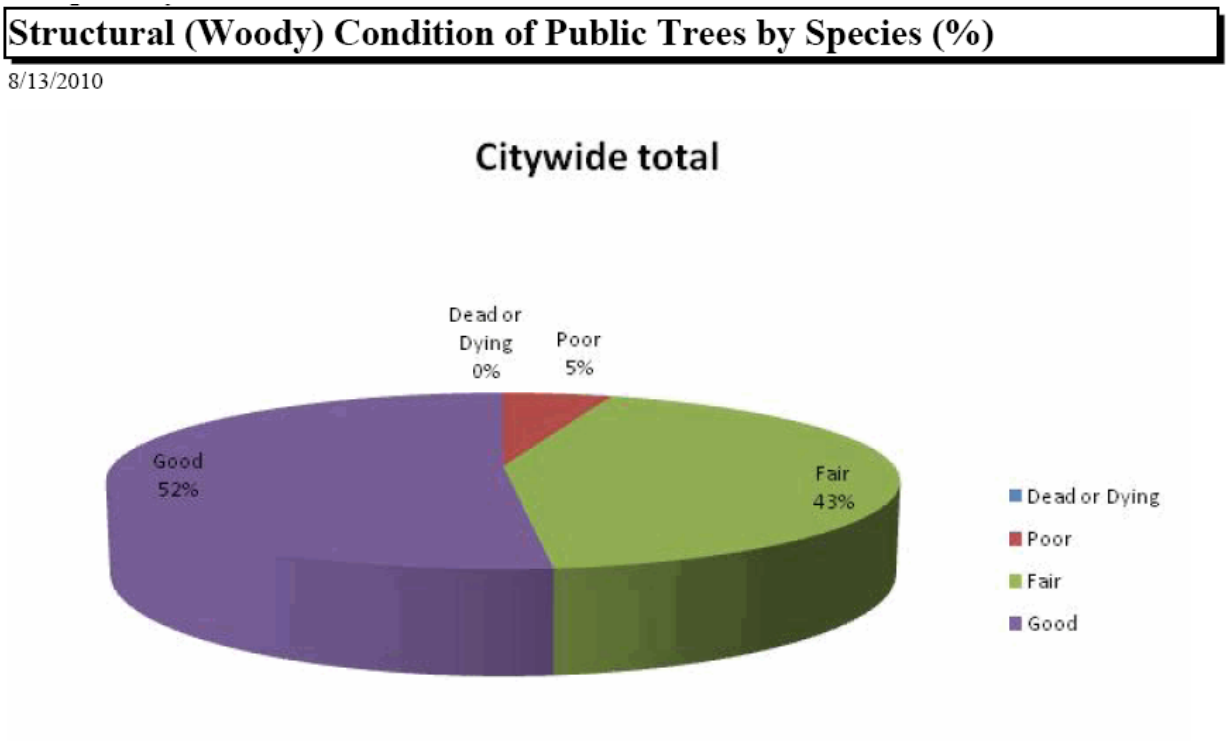
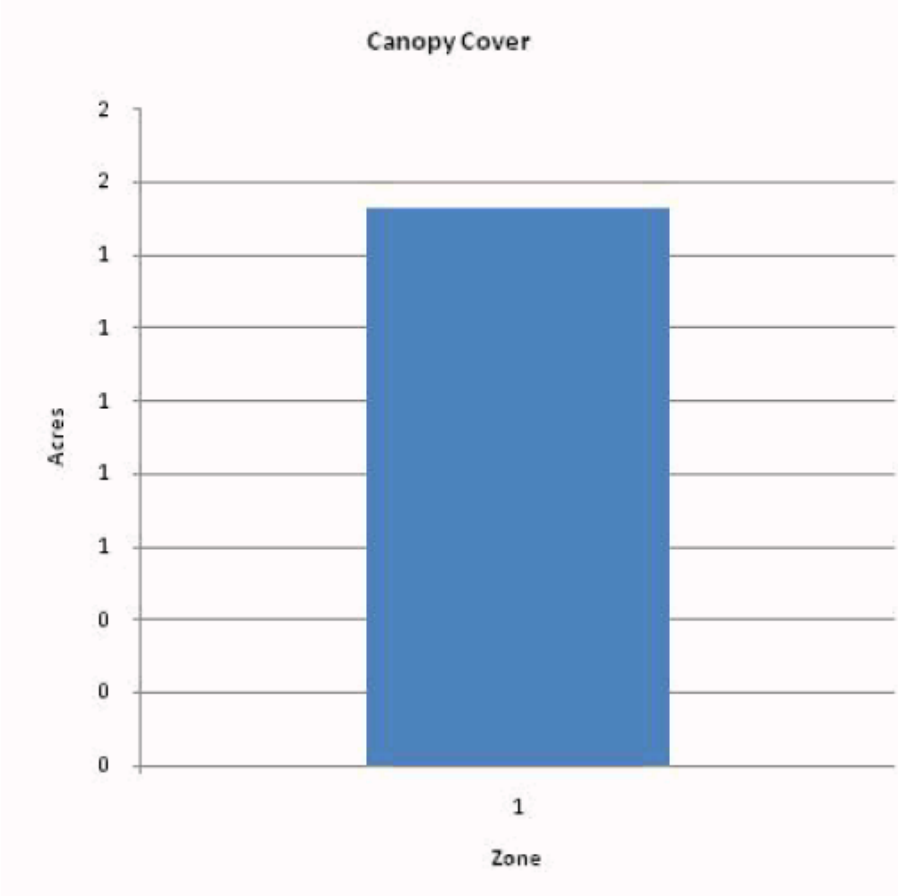


Figure 4: Wood Condition

Canopy Cover of Public Trees (Acres)

8/13/2010



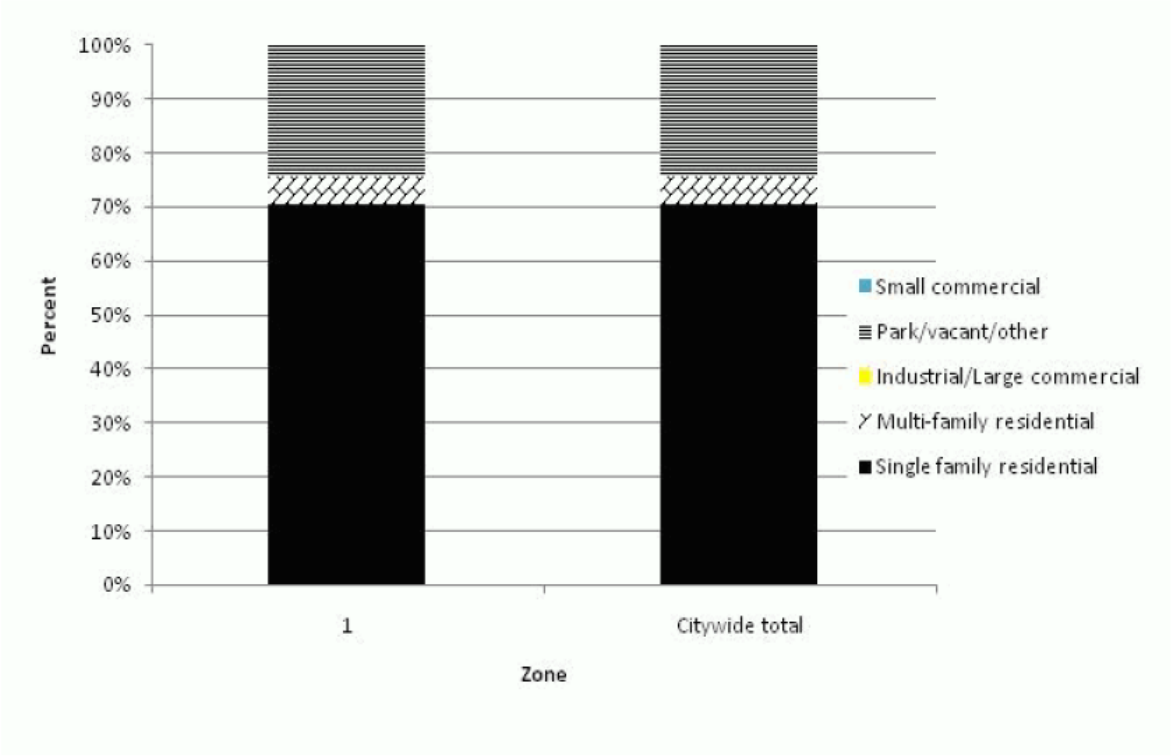
Zone	Acres	% of Total Canopy Cover
1	2	100.0
Citywide total	2	100.0

	Total Land Area	Total Street and Sidewalk Area	Total Canopy Cover	Canopy Cover as % of Total Land Area	Canopy Cover as % of Total Streets and Sidewalks
Citywide	0	0	2		

Figure 5: Canopy Cover in Acres

Land Use of Public Trees by Zone (%)

8/13/2010

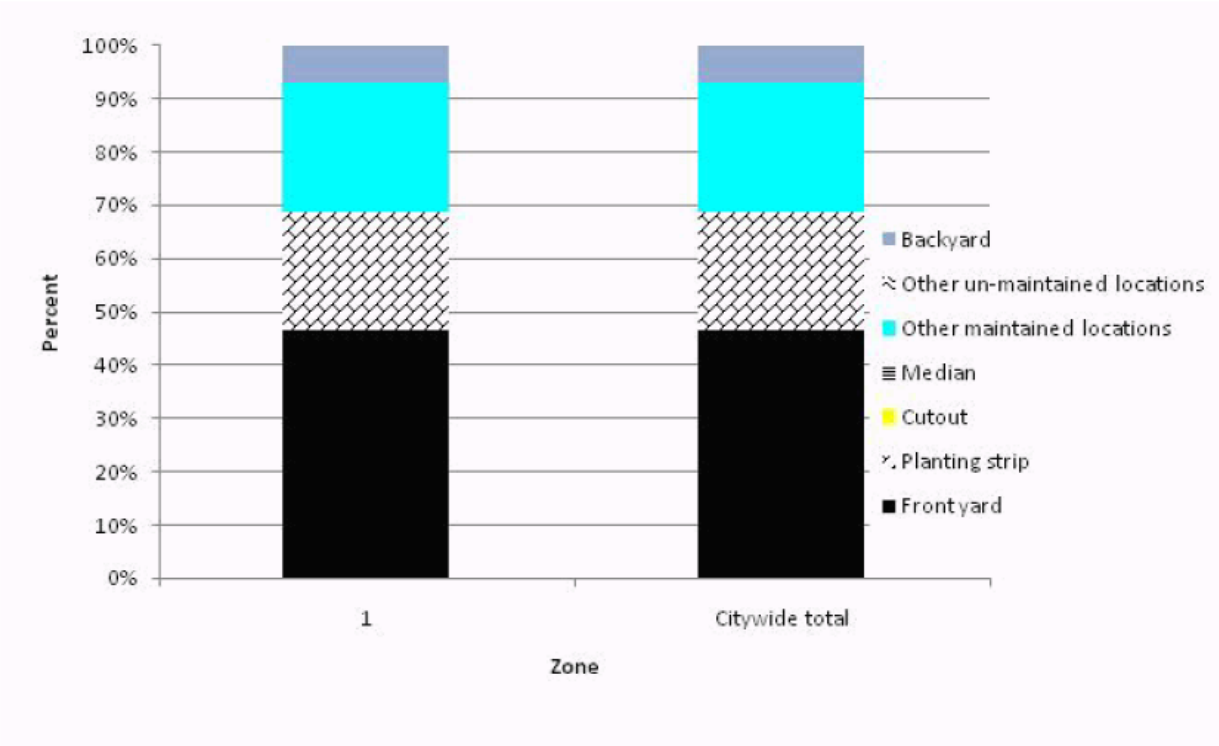


Zone	Single family residential	Multi-family residential	Industrial/ Large commercial	Park/vacant/ other	Small commercial
1	70.7	5.2	0.0	24.1	0.0
Citywide total	70.7	5.2	0.0	24.1	0.0

Figure 6: Land Use of city/park trees

Location of Public Trees by Zone (%)

8/13/2010



Zone	Front yard	Planting strip	Cutout	Median	Other maintained locations	Other un-maintained locations	Backyard
1	46.6	22.4	0.0	0.0	24.1	0.0	6.9
Citywide total	46.6	22.4	0.0	0.0	24.1	0.0	6.9

Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping

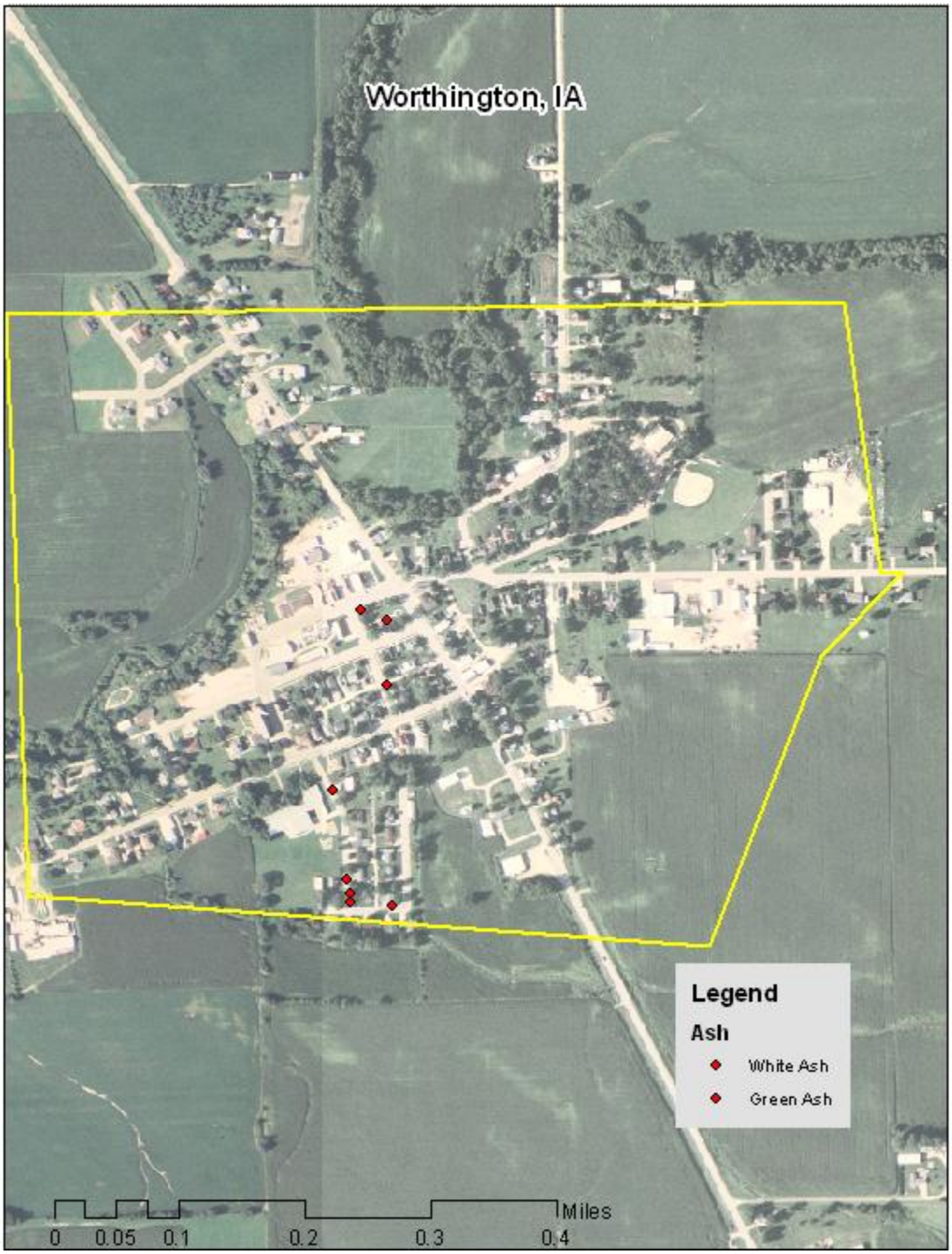


Figure 1: Location of Ash Trees

Figure 2: Location of EAB symptoms

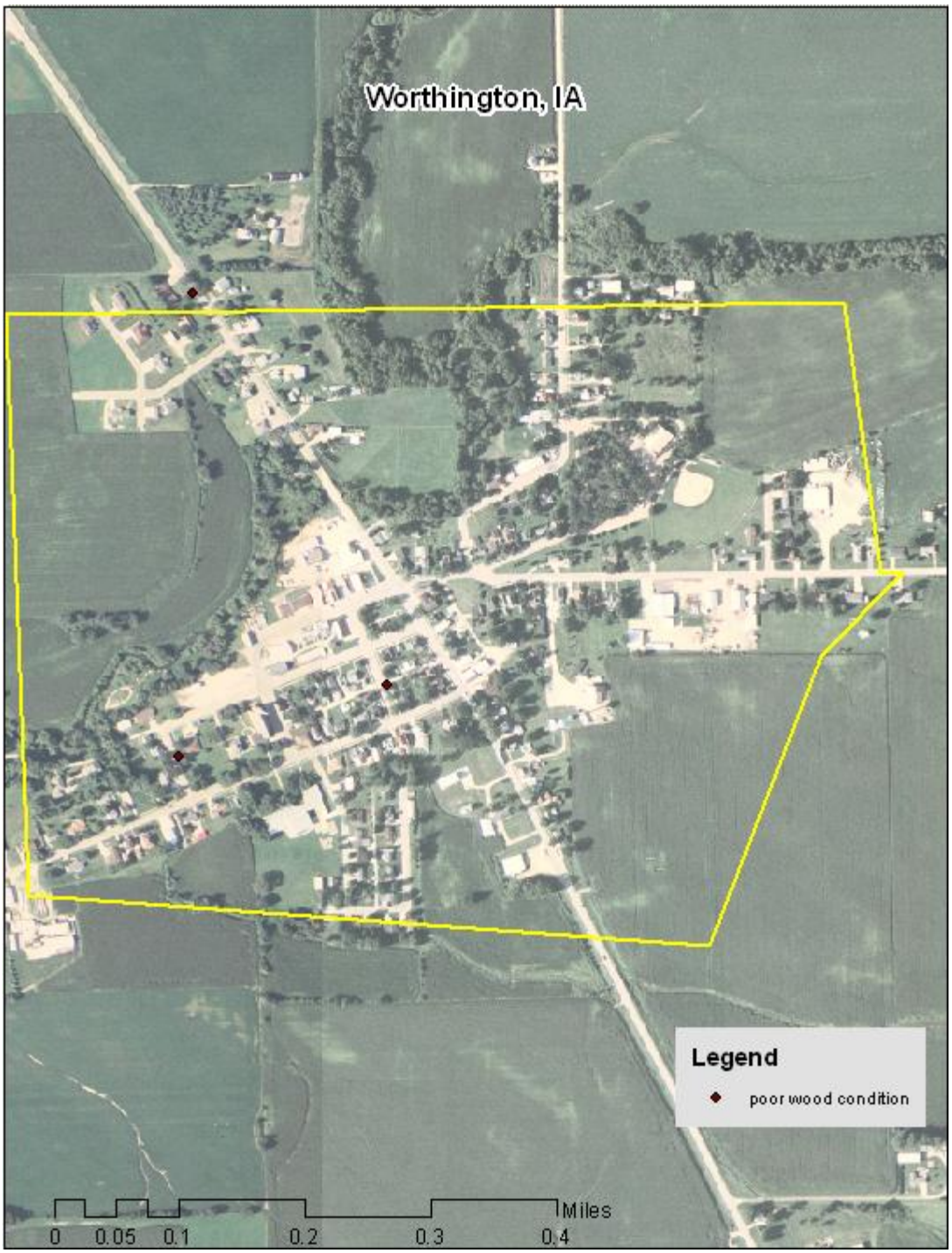


Figure 3: Location of Poor Condition Trees

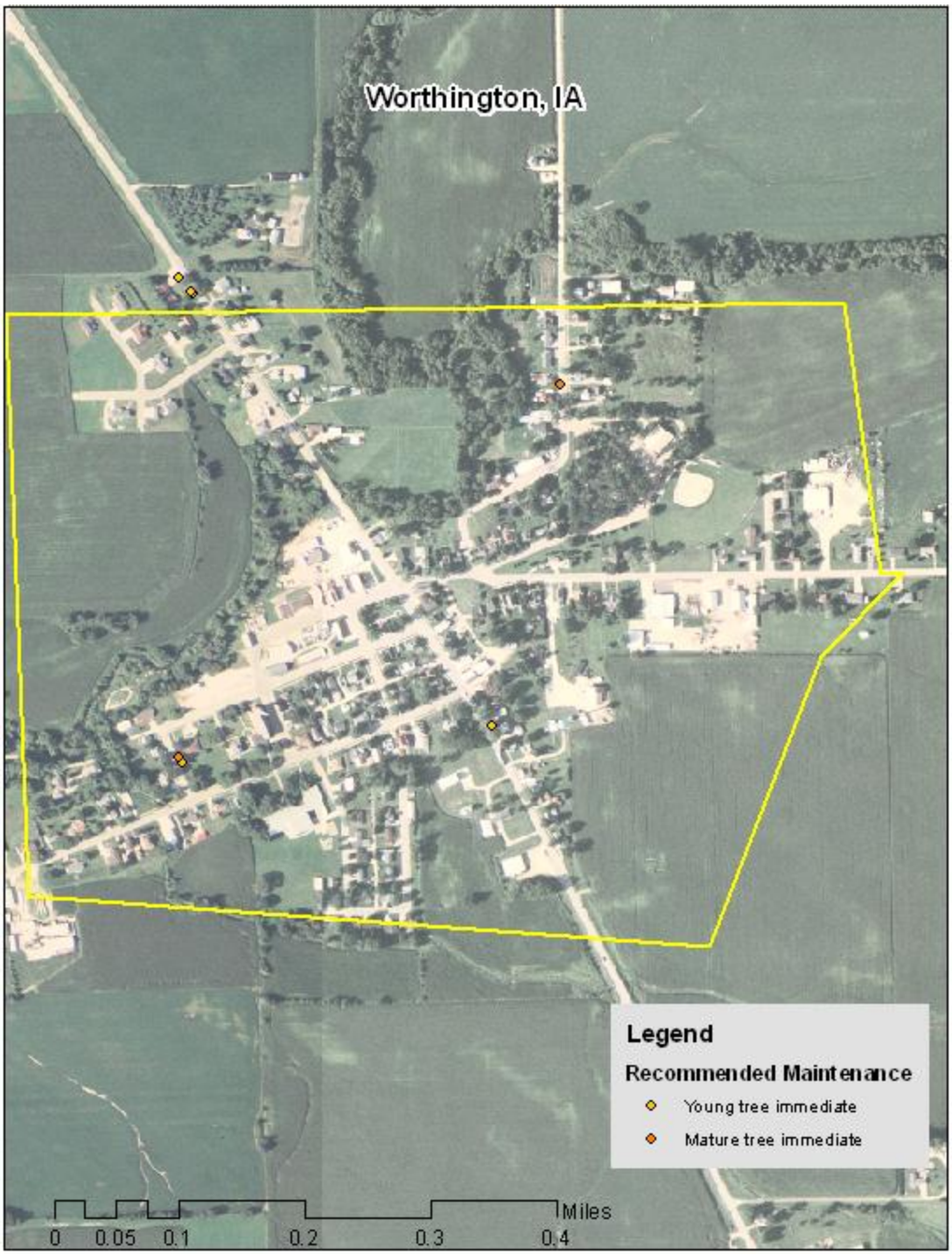


Figure 4: Location of Trees with Recommended Maintenance

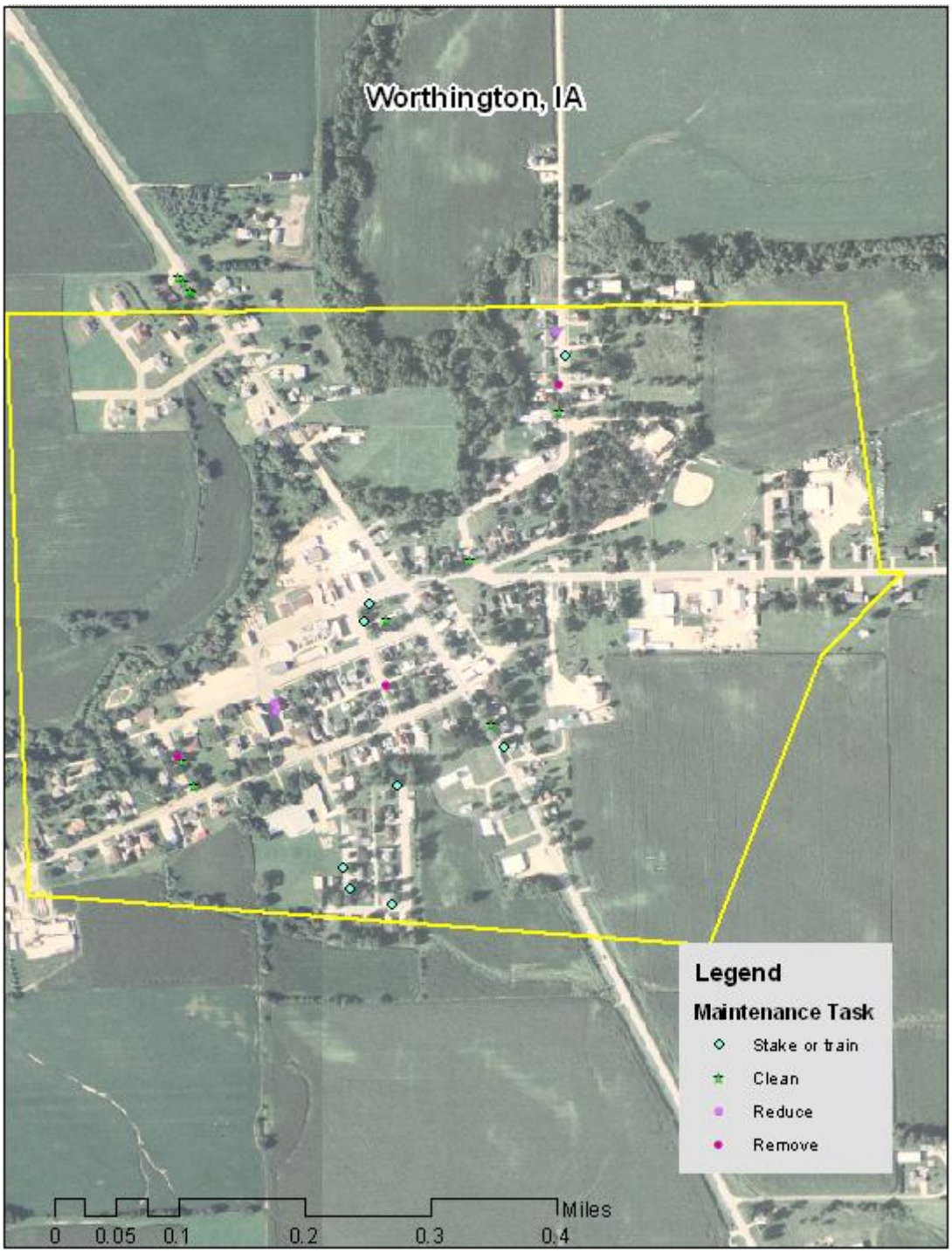


Figure 5: Maintenance Tasks ***City ownership of the trees recommended for removal should be verified prior to any removal****

Appendix C: Worthington Tree Ordinances

TITLE III COMMUNITY PROTECTION
CHAPTER 2 NUISANCES

3-2-1 DEFINITIONS. For use in this ordinance, the following terms are defined:

1. The term "nuisance" means whatever is injurious to health, indecent, or unreasonably offensive to the senses or an obstacle to the free use of property, so as essentially to unreasonably interfere with the comfortable enjoyment of life or property. The following are declared to be nuisances:

(Ord. No.162, Passed October 17, 2005)
(Code of Iowa, Sec. 657.1)

h. Cotton-bearing cottonwood trees and all other cotton-bearing poplar trees in the City.

l. Trees infected with Dutch elm disease.
(Code of Iowa, Sec. 657.2(13))

TITLE VI PHYSICAL ENVIRONMENT
CHAPTER 13 TREES

6-13-1 Purpose
6-13-2 Definitions
6-13-3 Arboricultural Specifications and Standards of Practice
6-13-4 Removal of Trees
6-13-5 Duty to Trim Trees
6-13-6 Trimming of Trees Under Supervision of City
6-13-7 Penalty

6-13-1 PURPOSE. The purpose of this Ordinance is to beautify and preserve the appearance of the City by requiring street trees to be uniformly located and maintained. The primary responsibility for maintaining street trees is placed upon the abutting property owner or the owner's agent, but the City shall supervise any cutting or trimming of said trees.

6-13-2 DEFINITIONS. For use in this Ordinance, the following terms are defined:

1. The term "person" shall mean any individual, firm, corporation, trust, association or any other organized group.

2. The term "street" shall mean the entire width between property lines of avenues or highways.

3. The term "parking" shall mean that part of the street, avenue or highway in the City not covered by sidewalk and lying between the lot line and the curb line; or, on unpaved streets, that part of the street, avenue or highway lying between the lot line and that portion of the street usually traveled by vehicular traffic.

4. The term "property owner" shall mean a person owning private property in the City as shown by the County Auditor's plats of the City.

5. The term "public property" shall mean any and all property located within the confines of the City and owned by the City or held in the name of the City by any of the departments, commissions or agencies within the City government.

6-13-3 ARBORICULTURAL SPECIFICATIONS AND STANDARDS OF PRACTICE.

1. Spacing. All trees hereafter planted in any street shall be planted midway between the outer line of the sidewalk and the curb. In the event a curb line is not established, trees shall be planted on a line seven (7) feet from the property line.

2. Planting.

a. Size. All trees planted on the streets shall be of sufficient size to warrant satisfactory results and stand the abuse common to street trees.

b. Grade. Unless otherwise allowed for substantial reasons, all standard sized trees shall have comparatively straight trunks, well-developed leaders, and top and root characteristics of the species or variety showing evidence of proper nursery pruning. All trees must be free of insect, disease, mechanical injuries and other objectionable features at the time of planting. To compensate for any serious loss of roots, the top of the tree should be reduced by thinning or cutting back as determined by the growth characteristics of the tree species. The leader shall not be cut off in such trimming.

c. Planting. Trees shall not be planted on the parking if it is less than nine (9) feet in width, or contains less than eighty-one (81) square feet of exposed soil surface. Trees shall not be planted closer than twenty (20) feet to street intersections (property lines extended) and ten (10) feet to driveways. If it is at all possible, trees should be planted inside the property lines and not between the sidewalk and the curb.

d. Method of Support. Trees may be guyed or supported in an upright position according to accepted arboricultural practices. The guys or supports shall be fastened in such a way that they will not girdle or cause serious injury to the trees or endanger public safety.

3. Trimming or Pruning.

a. All cuts are to be made sufficiently close to the parent stem so that healing can readily start under normal conditions.

b. All dead and diseased wood shall be removed.

c. All limbs one inch in diameter or more must be pre-cut to prevent splitting. All branches in danger of injuring the tree in falling shall be lowered by ropes.

d. A crossed or rubbing branch shall be removed where practicable, but removal shall not leave large holes in the general outline of the tree. Crossed or rubbing branches may be cabled apart.

e. All cuts, old or new, one inch in diameter or more, shall be painted with an approved tree would dressing. On old wounds, care shall be taken to paint exposed wood only.

f. Where there is a known danger of transmitting disease by tools, said tools shall be disinfected with alcohol before use on another tree.
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g. Improperly healed scars, where callous growth is not established, are to be traced and painted, unless the City designates other treatment.

h. No topping or dehorning of trees shall be permitted except by special written permission of the City. Trees becoming stag-headed may have the dead portions removed back to sound green wood, with a property forty-five (45) degree cut only.

i. Elm wood trimmed, pruned or removed shall not be used for any purpose, but shall be disposed of immediately by burning or burying.

6-13-4 REMOVAL OF TREES. The City shall remove, on the order of the Council, any tree on the streets of this municipality which interferes with the making of improvements or with travel thereon. He shall additionally remove any trees on the street, not on private property, which have become diseased, or which constitutes a danger to the public, or which may otherwise be declared a nuisance.

6-13-5 DUTY TO TRIM TREES. The owner or agent of the abutting property shall keep the trees on, or overhanging, the street trimmed so that all branches will be at least fourteen (14) feet above the surface of the street and nine (9) feet above the sidewalks.

6-13-6 TRIMMING OF TREES UNDER SUPERVISION OF CITY. Except as allowed in Section 6-13-4, no person may trim or cut any tree in a street or public place unless the work is done under the supervision of the City.

6-13-7 PENALTY. Anyone violating any of the provisions of this Ordinance shall be subject to the provisions of Chapter 1-3 of this Code.