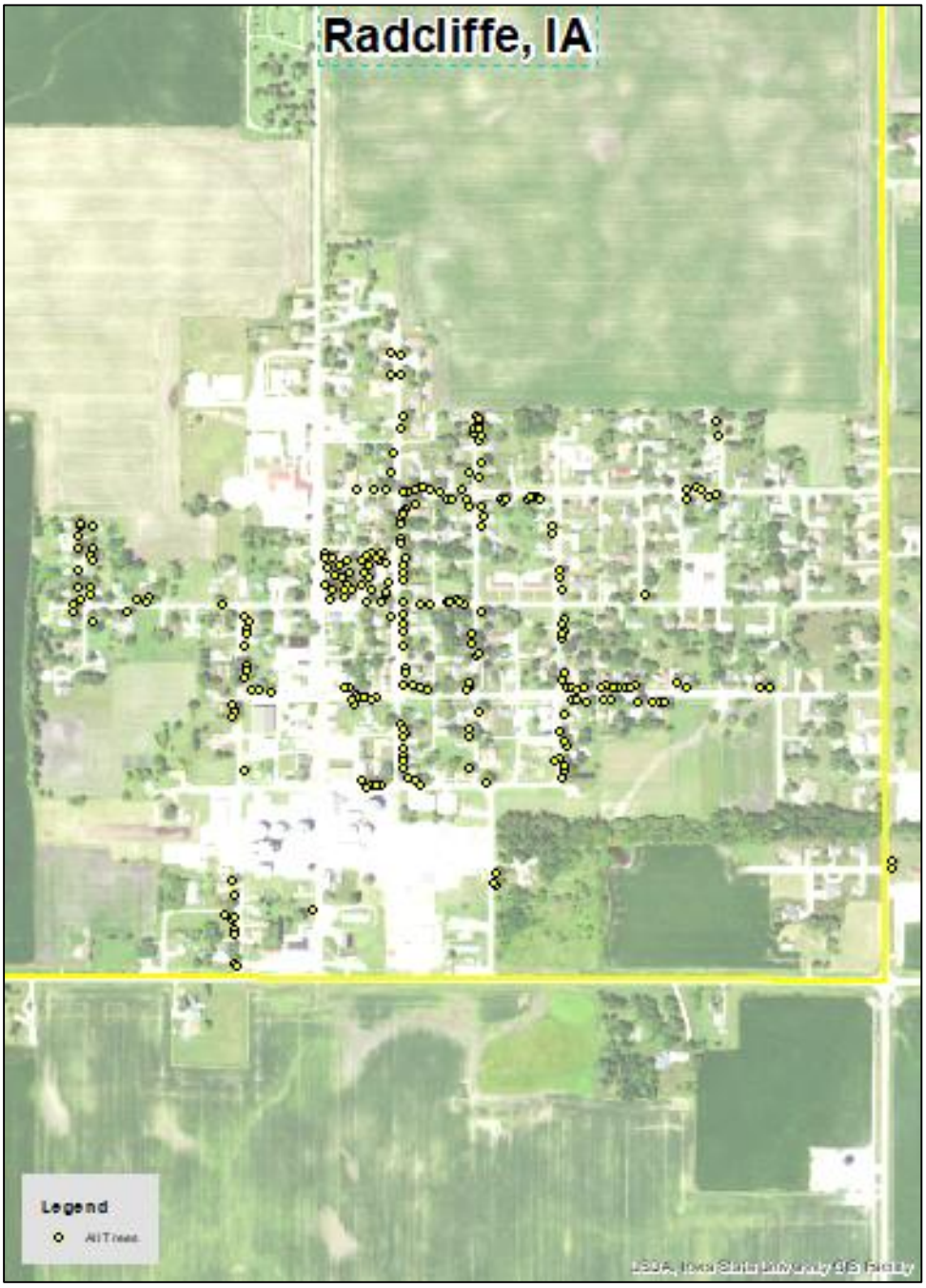
Radcliffe, IA



2020 Urban Forest Management Plan
Prepared by Iowa Department of Natural Resources

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Executive Summary

Overview

This plan was developed to assist the City of Radcliffe 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 13% of Radcliffe'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 2019, 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 256 trees inventoried.

- Radcliffe's trees provide $50,224 of benefits annually, an average of $196 a tree
- There are at least 30 species of trees
- The top three genera are: Maple 46%, Ash 13%, and Walnut 8%
- 46% of trees are in need of some type of management
- 23 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 23 trees needing removal, 6 trees are high priority ("critical concern" or "immediate" ratings) and should be addressed immediately *City ownership of the trees recommended for removal should be verified prior to any removal*
- 3 of the 35 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

Introduction

This plan was developed to assist Radcliffe 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 or treatment and replacement planting. With proper planning and management of the current canopy in Radcliffe, these costs can be extended over years and public safety issues from dead and dying ash trees mitigated.

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

Inventory

In 2019, 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

The data collected for the 256 city trees was entered into the USDA Forest service program Street Tree Resource Analysis Tool for Urban forestry Management as part of the i-Tree suite. The following are results from the i-Tree STREETS analysis. Fin

Annual Benefits

Annual Energy Benefits

Trees conserve energy by shading buildings and blocking winds. Radcliffe's trees reduce energy related costs by approximately $13,437 annually (Appendix A, Table 1). These savings are both in Electricity (64 MWh) and in Natural Gas (8,726 Therms).

Annual Stormwater Benefits

Radcliffe's trees intercept about 720,823 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $19,534 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 Radcliffe, it is estimated that trees remove 839 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 $2,363 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Radcliffe, trees sequester about 236,640 lbs of carbon a year with an associated value of $1,775 (Appendix A, Table 5). In addition, the trees store 2,894,625 lbs of carbon, with a yearly benefit of $21,710 (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. Radcliffe receives $13,116 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, Radcliffe's trees provide $50,224 of benefits annually. Benefits of individual trees vary based on size, species, health and location, but on average each of the 256 trees in Radcliffe provide approximately $196 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Radcliffe has at least 30 different tree species along city streets and parks (Appendix A, Figure 1). The distribution of the most prevalent trees by genera is as follows:

Maple	117	46%
Ash	35	13%

Walnut	20	8%
Spruce	19	7%

Age Class

Most of Radcliffe's trees (55%) are larger than 18 inches in diameter at 4.5 ft (Appendix A, Figure 2). Only 7% of its trees are below the size of 6 inches. This indicates an imbalanced population that is skewed towards larger (older) trees and in need of more young trees to sustain the canopy over time.

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 Radcliffe indicate that 92% of the trees are in good or fair health, with just 8% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 89% of Radcliffe's trees are in good health for wood condition (appendix A, Figure 4 & Appendix B, Figure 3).

Management Needs

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

Need	No. trees
Crown Cleaning	43
Crown Raising	17
Tree Staking	9
Tree Removal	23
Crown Reduction	29

Canopy Cover

The total canopy with both private and public trees is 6%, 37 acres. The canopy cover included in the Radcliffe inventory includes approximately 7 acres (Appendix A, Figure 4).

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.

<u>Hazardous trees</u>

Radcliffe has 3 critical concern trees that need immediate attention. 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.

<u>Poor tree species</u>

After the removal of the critical concern trees, trees in poor health should be assessed for removal (Appendix B, Figure 3 & Appendix B, Figure 4). There are 29 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 Radcliffe.

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 (46%) (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, as outlined in section 151.02 of the city ordinance (Appendix C). All trees planted must meet the restrictions in city ordinance 151.02 (Appendix C).

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.

Six Year Maintenance Plan

Year 1

Removal: 6 critical concerns and trees flagged for immediate maintenance needed
Trimming/Crown Maintenance: 37 trees flagged for immediate or critical concern maintenance needs

Year 2

Removal: 17 trees flagged for routine removal

Planting and Replacement: 10 trees in open locations from year one removals
Trimming/Crown Maintenance: 58 trees flagged for routine maintenance needs

Year 3

Removal: Begin removing ash in poor health, small ash trees
*Or saving for ash tree treatment and/or future ash removal
Planting and Replacement: 10 trees to be planted in open locations and locations from previous removals
Trimming/Crown Maintenance: Initiate regular 3-year inspection and pruning cycle on all city trees as needed.

Year 4

Planting and Replacement: 10 trees to be planted in open locations and locations from previous removals
Trimming/Crown Maintenance: Continue regular 3-year inspection and pruning cycle on all city trees as needed.

Year 5

Planting and Replacement: 10 trees to be planted in open locations and locations from previous removals
Trimming/Crown Maintenance: Continue regular 3-year inspection and pruning cycle on all city trees as needed.

Year 6

Planting and Replacement: 10 trees to be planted in open locations and locations from previous removals
Trimming/Crown Maintenance: Continue regular 3-year inspection and pruning cycle on all city trees as needed.

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 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. 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 151.02 (Appendix C). 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 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 preventative treatments are not being used. City Code 151.06 states "If it is determined with reasonable certainty that any such condition exists (trees or shrubs in the City reported or suspected to be infected with or damaged by any disease or insect or disease pests) on private property and that the danger to other trees or to adjoining property or passing motorists or

pedestrians is imminent, the Council shall notify by certified mail the owner, occupant or person in charge of such property to correct such condition by treatment or removal within fourteen (14) days of said notification. If such owner, occupant or person in charge of said property fails to comply within 14 days of receipt of notice, the Council may cause the condition to be corrected and the cost assessed against the property."

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Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Annual Energy Benefits of Public Trees

4/9/2020

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	12.4	944	1,773.0	1,738	2,681	(N/A)	18.4	20.0	57.05
Green ash	9.8	744	1,296.2	1,270	2,014	(N/A)	12.5	15.0	62.94
Silver maple	10.2	772	1,324.3	1,298	2,070	(N/A)	12.5	15.4	64.69
Black walnut	4.8	367	686.8	673	1,040	(N/A)	7.8	7.7	52.00
Sugar maple	5.8	441	783.5	768	1,209	(N/A)	6.6	9.0	71.13
Red maple	3.1	239	401.1	393	632	(N/A)	6.6	4.7	37.19
Blue spruce	1.3	102	166.4	163	265	(N/A)	4.3	2.0	24.10
Apple	0.9	65	127.7	125	191	(N/A)	3.9	1.4	19.06
Honeylocust	2.7	204	354.6	348	552	(N/A)	3.5	4.1	61.30
Northern hackberry	2.1	162	288.6	283	445	(N/A)	3.1	3.3	55.60
Pear	0.4	29	58.5	57	86	(N/A)	2.3	0.6	14.36
Spruce	0.6	48	77.5	76	124	(N/A)	2.3	0.9	20.62
Littleleaf linden	1.1	80	139.5	137	217	(N/A)	2.0	1.6	43.36
American basswood	1.5	111	209.7	206	316	(N/A)	1.6	2.4	79.06
Black maple	1.1	86	159.6	156	243	(N/A)	1.6	1.8	60.68
White ash	0.8	64	99.8	98	162	(N/A)	1.2	1.2	53.94
River birch	0.6	48	96.0	94	142	(N/A)	1.2	1.1	47.28
Catalpa	0.5	40	76.2	75	115	(N/A)	0.8	0.9	57.32
Tulip tree	0.2	14	27.5	27	41	(N/A)	0.8	0.3	20.64
Eastern cottonwood	0.9	70	122.1	120	190	(N/A)	0.8	1.4	94.83
Northern red oak	0.2	18	28.7	28	46	(N/A)	0.8	0.3	22.98
Norway spruce	0.3	25	44.3	43	69	(N/A)	0.8	0.5	34.32
Willow	0.6	49	94.8	93	142	(N/A)	0.8	1.1	70.84
American sycamore	0.9	70	122.1	120	190	(N/A)	0.8	1.4	94.83
Eastern redbud	0.2	14	25.3	25	39	(N/A)	0.8	0.3	19.50
Eastern red cedar	0.2	17	32.9	32	49	(N/A)	0.8	0.4	24.57
Ginkgo	0.1	5	9.9	10	15	(N/A)	0.4	0.1	14.72
Swamp white oak	0.1	8	16.9	17	24	(N/A)	0.4	0.2	24.47
Bur oak	0.4	33	59.0	58	91	(N/A)	0.4	0.7	91.02
Boxelder	0.2	15	23.9	23	39	(N/A)	0.4	0.3	38.63
Total	64.4	4,885	8,726.3	8,552	13,437	(N/A)	100.0	100.0	52.49

Table 2: Annual Stormwater Benefits

Annual Stormwater Benefits of Public Trees

4/9/2020

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	114,678	3,108	(N/A)	18.4	15.9	66.12
Green ash	116,997	3,171	(N/A)	12.5	16.2	99.08
Silver maple	143,787	3,897	(N/A)	12.5	19.9	121.77
Black walnut	51,474	1,395	(N/A)	7.8	7.1	69.75
Sugar maple	76,055	2,061	(N/A)	6.6	10.6	121.24
Red maple	20,212	548	(N/A)	6.6	2.8	32.22
Blue spruce	16,967	460	(N/A)	4.3	2.4	41.80
Apple	3,068	83	(N/A)	3.9	0.4	8.31
Honeylocust	31,822	862	(N/A)	3.5	4.4	95.82
Northern hackberry	19,576	531	(N/A)	3.1	2.7	66.31
Pear	1,340	36	(N/A)	2.3	0.2	6.05
Spruce	7,346	199	(N/A)	2.3	1.0	33.18
Littleleaf linden	8,512	231	(N/A)	2.0	1.2	46.13
American basswood	20,086	544	(N/A)	1.6	2.8	136.09
Black maple	11,468	311	(N/A)	1.6	1.6	77.70
White ash	6,550	178	(N/A)	1.2	0.9	59.17
River birch	5,545	150	(N/A)	1.2	0.8	50.09
Catalpa	5,181	140	(N/A)	0.8	0.7	70.21
Tulip tree	1,216	33	(N/A)	0.8	0.2	16.47
Eastern cottonwood	14,478	392	(N/A)	0.8	2.0	196.17
Northern red oak	1,361	37	(N/A)	0.8	0.2	18.44
Norway spruce	7,574	205	(N/A)	0.8	1.1	102.63
Willow	7,529	204	(N/A)	0.8	1.0	102.01
American sycamore	14,478	392	(N/A)	0.8	2.0	196.17
Eastern redbud	674	18	(N/A)	0.8	0.1	9.13
Eastern red cedar	3,269	89	(N/A)	0.8	0.5	44.30
Ginkgo	301	8	(N/A)	0.4	0.0	8.17
Swamp white oak	586	16	(N/A)	0.4	0.1	15.88
Bur oak	7,239	196	(N/A)	0.4	1.0	196.17
Boxelder	1,456	39	(N/A)	0.4	0.2	39.46
Citywide total	720,823	19,534	(N/A)	100.0	100.0	76.31

Table 3: Annual Air Quality Benefits

Annual Air Quality Benefits of Public Trees

4/9/2020

Species	Deposition (lb)				Total Depos. ($)	Avoided (lb)				Total Avoided ($)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($) Standard Error	% of Total Trees	Avg. $/tree
	O_3	NO_2	PM_{10}	SO_2		NO_2	PM_{10}	VOC	SO_2							
Norway maple	23.3	4.0	11.5	1.0	126	60.1	8.7	8.3	56.4	373	-5.5	-21	167.9	478 (N/A)	18.4	10.18
Green ash	17.1	2.7	7.9	0.8	90	46.4	6.8	6.5	44.4	290	0.0	0	132.6	380 (N/A)	12.5	11.89
Silver maple	26.1	4.4	12.8	1.2	141	47.9	7.0	6.7	46.0	300	-14.3	-54	137.8	387 (N/A)	12.5	12.09
Black walnut	5.9	0.9	2.9	0.3	32	23.3	3.4	3.2	21.9	145	0.0	0	61.8	176 (N/A)	7.8	8.81
Sugar maple	12.4	2.1	5.9	0.5	66	27.6	4.0	3.8	26.3	172	-9.6	-36	73.2	203 (N/A)	6.6	11.92
Red maple	3.9	0.7	1.9	0.2	21	14.8	2.2	2.1	14.3	93	-1.4	-5	38.5	108 (N/A)	6.6	6.36
Blue spruce	2.1	0.4	1.8	0.3	14	6.2	0.9	0.9	6.1	39	-6.1	-23	12.7	31 (N/A)	4.3	2.79
Apple	0.8	0.1	0.4	0.0	4	4.2	0.6	0.6	3.9	26	0.0	0	10.6	30 (N/A)	3.9	3.01
Honeylocust	6.3	1.0	2.8	0.3	33	12.7	1.9	1.8	12.2	79	-5.0	-19	33.9	94 (N/A)	3.5	10.41
Northern hackberry	3.1	0.5	1.6	0.1	17	10.2	1.5	1.4	9.7	63	0.0	0	28.1	80 (N/A)	3.1	10.02
Pear	0.3	0.1	0.2	0.0	2	1.9	0.3	0.3	1.7	12	0.0	0	4.6	13 (N/A)	2.3	2.20
Spruce	0.8	0.2	0.7	0.1	5	2.9	0.4	0.4	2.8	18	-2.5	-9	5.8	14 (N/A)	2.3	2.37
Littleleaf linden	1.3	0.2	0.6	0.1	7	5.0	0.7	0.7	4.8	31	-0.6	-2	12.8	36 (N/A)	2.0	7.15
American basswood	3.1	0.5	1.4	0.1	16	7.1	1.0	1.0	6.6	44	-2.5	-9	18.3	51 (N/A)	1.6	12.69
Black maple	3.0	0.5	1.4	0.1	16	5.5	0.8	0.8	5.2	34	-1.0	-4	16.2	46 (N/A)	1.6	11.54
White ash	0.6	0.1	0.3	0.0	3	3.9	0.6	0.6	3.8	25	0.0	0	9.9	28 (N/A)	1.2	9.27
River birch	1.0	0.2	0.5	0.0	6	3.1	0.4	0.4	2.9	19	-0.3	-1	8.4	24 (N/A)	1.2	7.93
Catalpa	0.5	0.1	0.3	0.0	3	2.5	0.4	0.4	2.4	16	0.0	0	6.6	19 (N/A)	0.8	9.34
Tulip tree	0.0	0.0	0.0	0.0	0	0.9	0.1	0.1	0.9	6	0.0	0	2.1	6 (N/A)	0.8	2.99
Eastern cottonwood	2.7	0.4	1.2	0.1	14	4.4	0.6	0.6	4.2	27	0.0	0	14.3	42 (N/A)	0.8	20.79
Northern red oak	0.2	0.0	0.1	0.0	1	1.1	0.2	0.2	1.1	7	-0.3	-1	2.5	7 (N/A)	0.8	3.47
Norway spruce	0.9	0.2	0.7	0.1	6	1.6	0.2	0.2	1.5	10	-4.2	-16	1.2	0 (N/A)	0.8	-0.06
Willow	1.7	0.3	0.8	0.1	9	3.1	0.5	0.4	2.9	19	-0.4	-1	9.5	27 (N/A)	0.8	13.58
American sycamore	2.7	0.4	1.2	0.1	14	4.4	0.6	0.6	4.2	27	0.0	0	14.3	42 (N/A)	0.8	20.79
Eastern redbud	0.2	0.0	0.1	0.0	1	0.9	0.1	0.1	0.8	6	0.0	0	2.3	7 (N/A)	0.8	3.33
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)	0.8	2.19
Ginkgo	0.0	0.0	0.0	0.0	0	0.3	0.0	0.0	0.3	2	0.0	0	0.8	2 (N/A)	0.4	2.12
Swamp white oak	0.1	0.0	0.0	0.0	0	0.5	0.1	0.1	0.5	3	0.0	0	1.2	3 (N/A)	0.4	3.47
Bur oak	1.2	0.2	0.5	0.1	6	2.1	0.3	0.3	2.0	13	0.0	0	6.6	19 (N/A)	0.4	19.04
Boxelder	0.1	0.0	0.1	0.0	1	0.9	0.1	0.1	0.9	6	-0.1	0	2.3	6 (N/A)	0.4	6.37
Citywide total	122.2	20.6	60.3	5.8	660	306.5	44.7	42.6	291.6	1,911	-55.7	-209	838.7	2,363 (N/A)	100.0	9.23

Table 4: Annual Carbon Stored

Stored CO2 Benefits of Public Trees

4/9/2020

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	383,610	2,877	(N/A)	18.4	13.3	61.21
Green ash	578,812	4,341	(N/A)	12.5	20.0	135.66
Silver maple	652,530	4,894	(N/A)	12.5	22.5	152.94
Black walnut	188,632	1,415	(N/A)	7.8	6.5	70.74
Sugar maple	372,159	2,791	(N/A)	6.6	12.9	164.19
Red maple	44,862	336	(N/A)	6.6	1.5	19.79
Blue spruce	13,010	98	(N/A)	4.3	0.4	8.87
Apple	12,546	94	(N/A)	3.9	0.4	9.41
Honeylocust	81,297	610	(N/A)	3.5	2.8	67.75
Northern hackberry	47,179	354	(N/A)	3.1	1.6	44.23
Pear	5,222	39	(N/A)	2.3	0.2	6.53
Spruce	5,194	39	(N/A)	2.3	0.2	6.49
Littleleaf linden	27,221	204	(N/A)	2.0	0.9	40.83
American basswood	115,423	866	(N/A)	1.6	4.0	216.42
Black maple	31,781	238	(N/A)	1.6	1.1	59.59
White ash	15,801	119	(N/A)	1.2	0.5	39.50
River birch	16,991	127	(N/A)	1.2	0.6	42.48
Catalpa	16,915	127	(N/A)	0.8	0.6	63.43
Tulip tree	2,069	16	(N/A)	0.8	0.1	7.76
Eastern cottonwood	95,241	714	(N/A)	0.8	3.3	357.15
Northern red oak	3,782	28	(N/A)	0.8	0.1	14.18
Norway spruce	10,833	81	(N/A)	0.8	0.4	40.62
Willow	28,560	214	(N/A)	0.8	1.0	107.10
American sycamore	95,241	714	(N/A)	0.8	3.3	357.15
Eastern redbud	3,051	23	(N/A)	0.8	0.1	11.44
Eastern red cedar	2,204	17	(N/A)	0.8	0.1	8.27
Ginkgo	474	4	(N/A)	0.4	0.0	3.56
Swamp white oak	1,101	8	(N/A)	0.4	0.0	8.26
Bur oak	39,259	294	(N/A)	0.4	1.4	294.44
Boxelder	3,624	27	(N/A)	0.4	0.1	27.18
Citywide total	2,894,625	21,710	(N/A)	100.0	100.0	84.80

Table 5: Annual Carbon Sequestered

Annual CO Benefits of Public Trees

4/9/2020

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
Norway maple	16,346	123	-1,841	-130	-15	20,857	156	35,232	264 (N/A)	18.4	14.9	5.62
Green ash	20,022	150	-2,778	-104	-22	16,440	123	33,580	252 (N/A)	12.5	14.2	7.87
Silver maple	45,129	338	-3,133	-115	-24	17,064	128	58,945	442 (N/A)	12.5	24.9	13.82
Black walnut	12,002	90	-906	-51	-7	8,107	61	19,153	144 (N/A)	7.8	8.1	7.18
Sugar maple	15,712	118	-1,786	-67	-14	9,754	73	23,612	177 (N/A)	6.6	10.0	10.42
Red maple	5,985	45	-215	-27	-2	5,283	40	11,025	83 (N/A)	6.6	4.7	4.86
Blue spruce	1,002	8	-62	-21	-1	2,254	17	3,172	24 (N/A)	4.3	1.3	2.16
Apple	1,296	10	-60	-12	-1	1,447	11	2,671	20 (N/A)	3.9	1.1	2.00
Honeylocust	2,668	20	-391	-21	-3	4,512	34	6,768	51 (N/A)	3.5	2.9	5.64
Northern hackberry	2,452	18	-227	-20	-2	3,581	27	5,787	43 (N/A)	3.1	2.4	5.43
Pear	580	4	-25	-6	0	637	5	1,186	9 (N/A)	2.3	0.5	1.48
Spruce	567	4	-25	-10	0	1,055	8	1,587	12 (N/A)	2.3	0.7	1.98
Littleleaf linden	3,121	23	-131	-11	-1	1,770	13	4,750	36 (N/A)	2.0	2.0	7.12
American basswood	6,170	46	-554	-18	-4	2,446	18	8,044	60 (N/A)	1.6	3.4	15.08
Black maple	0	0	-153	-11	-1	1,908	14	1,744	13 (N/A)	1.6	0.7	3.27
White ash	1,832	14	-76	-7	-1	1,416	11	3,166	24 (N/A)	1.2	1.3	7.91
River birch	1,164	9	-82	-7	-1	1,056	8	2,131	16 (N/A)	1.2	0.9	5.33
Catalpa	1,319	10	-81	-5	-1	883	7	2,115	16 (N/A)	0.8	0.9	7.93
Tulip tree	418	3	-10	-2	0	318	2	723	5 (N/A)	0.8	0.3	2.71
Eastern cottonwood	1,391	10	-457	-11	-4	1,547	12	2,470	19 (N/A)	0.8	1.0	9.26
Northern red oak	336	3	-18	-3	0	393	3	709	5 (N/A)	0.8	0.3	2.66
Norway spruce	443	3	-52	-6	0	557	4	943	7 (N/A)	0.8	0.4	3.53
Willow	0	0	-137	-9	-1	1,077	8	932	7 (N/A)	0.8	0.4	3.49
American sycamore	1,391	10	-457	-11	-4	1,547	12	2,470	19 (N/A)	0.8	1.0	9.26
Eastern redbud	276	2	-15	-2	0	314	2	574	4 (N/A)	0.8	0.2	2.15
Eastern red cedar	43	0	-11	-4	0	374	3	402	3 (N/A)	0.8	0.2	1.51
Ginkgo	58	0	-2	-1	0	111	1	165	1 (N/A)	0.4	0.1	1.24
Swamp white oak	224	2	-5	-1	0	176	1	393	3 (N/A)	0.4	0.2	2.95
Bur oak	912	7	-188	-5	-1	734	6	1,453	11 (N/A)	0.4	0.6	10.90
Boxelder	418	3	-17	-2	0	336	3	735	6 (N/A)	0.4	0.3	5.51
Citywide total	143,279	1,075	-13,896	-699	-109	107,956	810	236,640	1,775 (N/A)	100.0	100.0	6.93

Table 6: Annual Social and Aesthetic Benefits

Annual Aesthetic/Other Benefits of Public Trees

4/9/2020

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	1,549	(N/A)	18.4	11.8	32.96
Green ash	1,615	(N/A)	12.5	12.3	50.45
Silver maple	3,381	(N/A)	12.5	25.8	105.66
Black walnut	1,018	(N/A)	7.8	7.8	50.91
Sugar maple	1,513	(N/A)	6.6	11.5	88.98
Red maple	852	(N/A)	6.6	6.5	50.14
Blue spruce	268	(N/A)	4.3	2.0	24.37
Apple	74	(N/A)	3.9	0.6	7.39
Honeylocust	623	(N/A)	3.5	4.7	69.18
Northern hackberry	348	(N/A)	3.1	2.7	43.50
Pear	32	(N/A)	2.3	0.2	5.41
Spruce	160	(N/A)	2.3	1.2	26.69
Littleleaf linden	328	(N/A)	2.0	2.5	65.65
American basswood	403	(N/A)	1.6	3.1	100.68
Black maple	0	(N/A)	1.6	0.0	0.00
White ash	229	(N/A)	1.2	1.7	76.28
River birch	112	(N/A)	1.2	0.9	37.44
Catalpa	115	(N/A)	0.8	0.9	57.69
Tulip tree	57	(N/A)	0.8	0.4	28.56
Eastern cottonwood	87	(N/A)	0.8	0.7	43.45
Northern red oak	31	(N/A)	0.8	0.2	15.65
Norway spruce	73	(N/A)	0.8	0.6	36.67
Willow	0	(N/A)	0.8	0.0	0.00
American sycamore	87	(N/A)	0.8	0.7	43.45
Eastern redbud	16	(N/A)	0.8	0.1	7.76
Eastern red cedar	14	(N/A)	0.8	0.1	6.84
Ginkgo	7	(N/A)	0.4	0.1	6.77
Swamp white oak	26	(N/A)	0.4	0.2	26.22
Bur oak	58	(N/A)	0.4	0.4	58.34
Boxelder	39	(N/A)	0.4	0.3	39.36
Citywide total	13,116	(N/A)	100.0	100.0	51.23

Table 7: Summary of Benefits in Dollars

Total Annual Benefits of Public Trees by Species ($)

4/9/2020

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Norway maple	2,681	264	478	3,108	1,549	8,081	(N/A)	16.1
Green ash	2,014	252	380	3,171	1,615	7,432	(N/A)	14.8
Silver maple	2,070	442	387	3,897	3,381	10,177	(N/A)	20.3
Black walnut	1,040	144	176	1,395	1,018	3,773	(N/A)	7.5
Sugar maple	1,209	177	203	2,061	1,513	5,163	(N/A)	10.3
Red maple	632	83	108	548	852	2,223	(N/A)	4.4
Blue spruce	265	24	31	460	268	1,047	(N/A)	2.1
Apple	191	20	30	83	74	398	(N/A)	0.8
Honeylocust	552	51	94	862	623	2,181	(N/A)	4.3
Northern hackberry	445	43	80	531	348	1,447	(N/A)	2.9
Pear	86	9	13	36	32	177	(N/A)	0.4
Spruce	124	12	14	199	160	509	(N/A)	1.0
Littleleaf linden	217	36	36	231	328	847	(N/A)	1.7
American basswood	316	60	51	544	403	1,374	(N/A)	2.7
Black maple	243	13	46	311	0	613	(N/A)	1.2
White ash	162	24	28	178	229	620	(N/A)	1.2
River birch	142	16	24	150	112	444	(N/A)	0.9
Catalpa	115	16	19	140	115	405	(N/A)	0.8
Tulip tree	41	5	6	33	57	143	(N/A)	0.3
Eastern cottonwood	190	19	42	392	87	729	(N/A)	1.5
Northern red oak	46	5	7	37	31	126	(N/A)	0.3
Norway spruce	69	7	0	205	73	354	(N/A)	0.7
Willow	142	7	27	204	0	380	(N/A)	0.8
American sycamore	190	19	42	392	87	729	(N/A)	1.5
Eastern redbud	39	4	7	18	16	84	(N/A)	0.2
Eastern red cedar	49	3	4	89	14	159	(N/A)	0.3
Ginkgo	15	1	2	8	7	33	(N/A)	0.1
Swamp white oak	24	3	3	16	26	73	(N/A)	0.1
Bur oak	91	11	19	196	58	375	(N/A)	0.7
Boxelder	39	6	6	39	39	129	(N/A)	0.3
Citywide Total	13,437	1,775	2,363	19,534	13,116	50,224	(N/A)	100.0

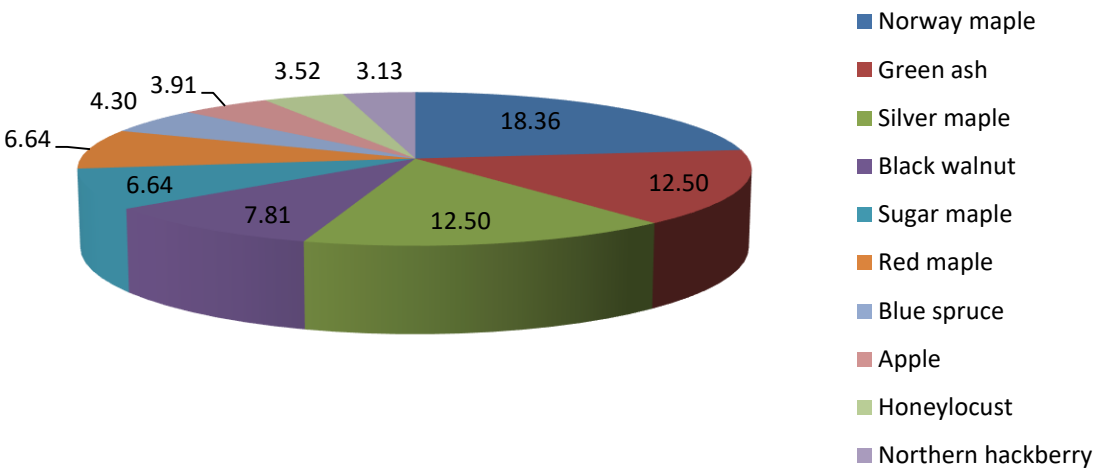

Figure 1: Species Distribution

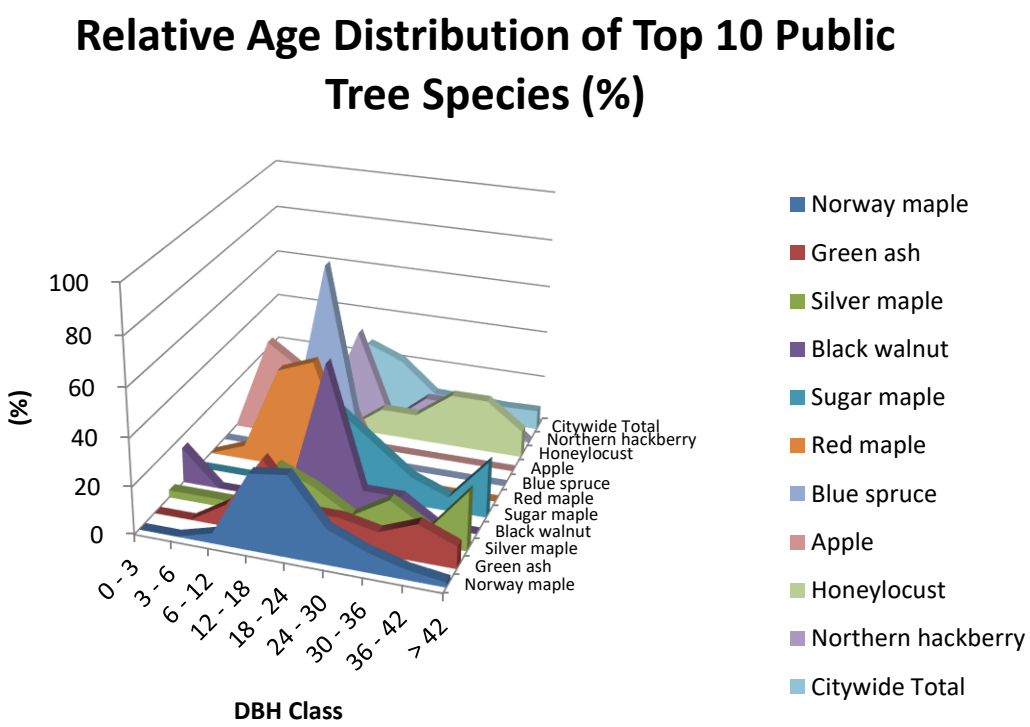

Figure 2: Relative Age Class

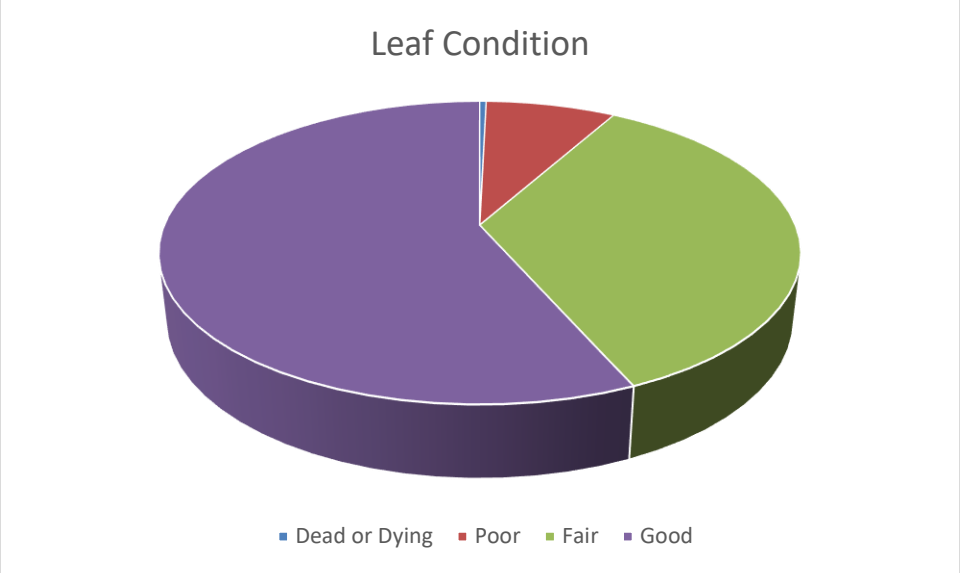

Figure 3: Foliage Condition

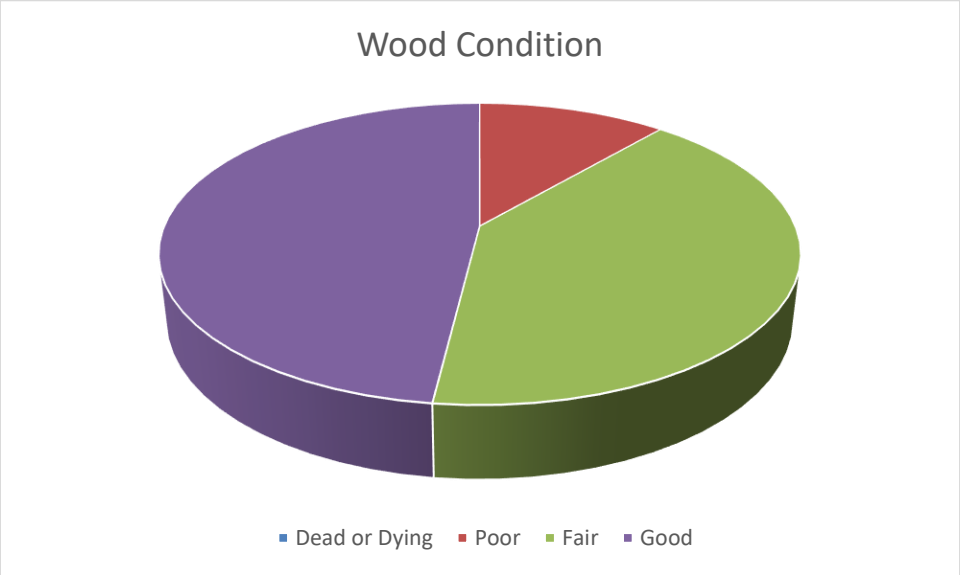

Figure 4: Wood Condition

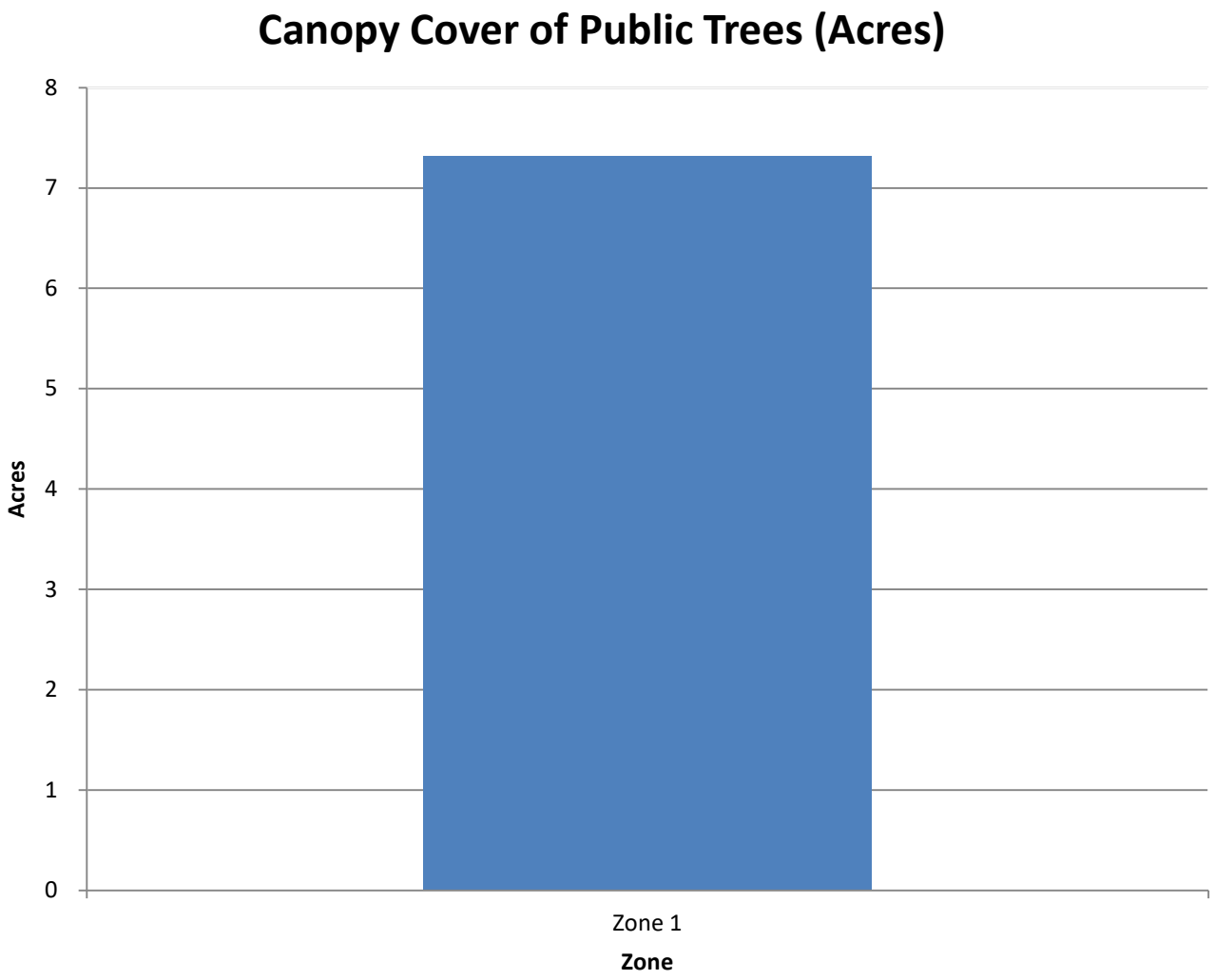

Figure 5: Canopy Cover in Acres

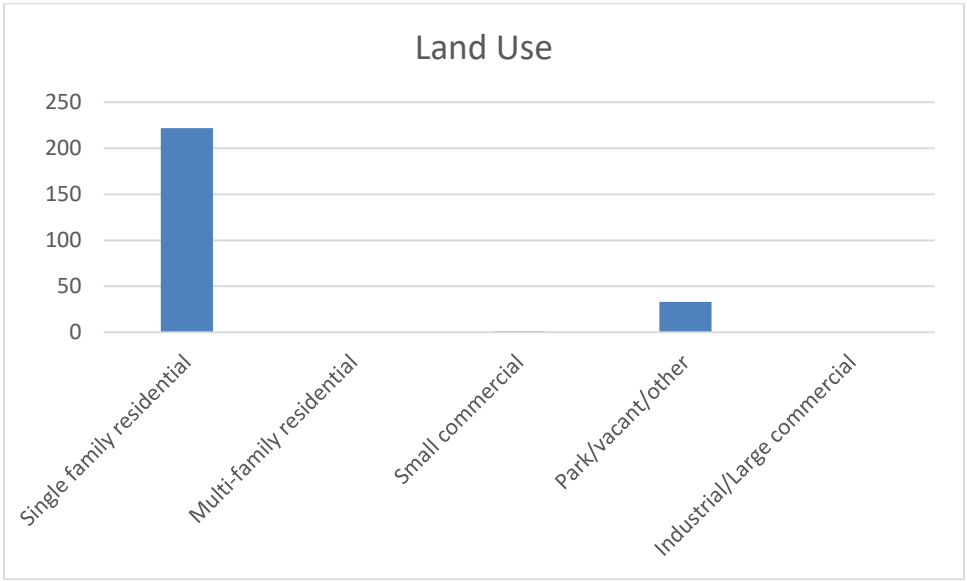

Figure 6: Land Use of city/park trees

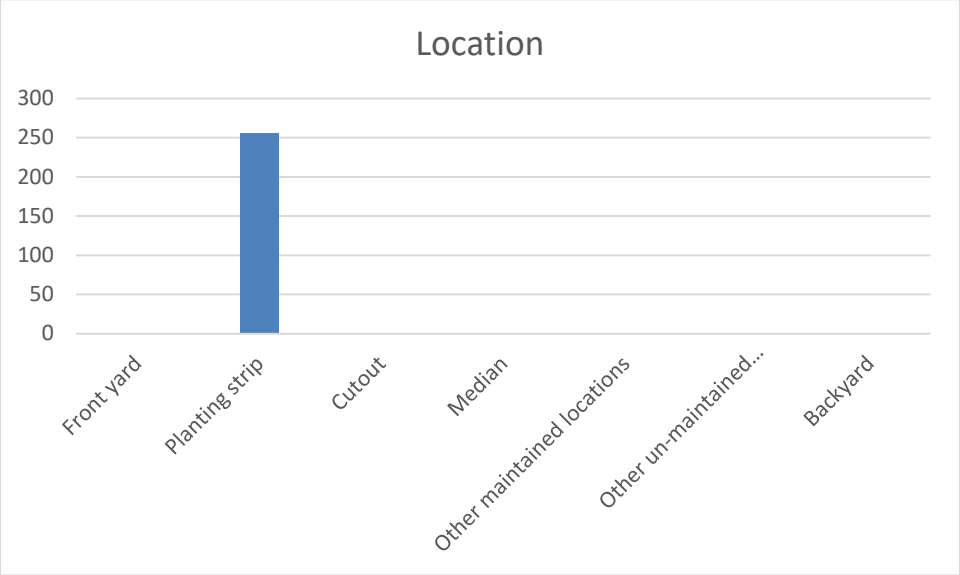

Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping

Figure 1: Location of Ash Trees

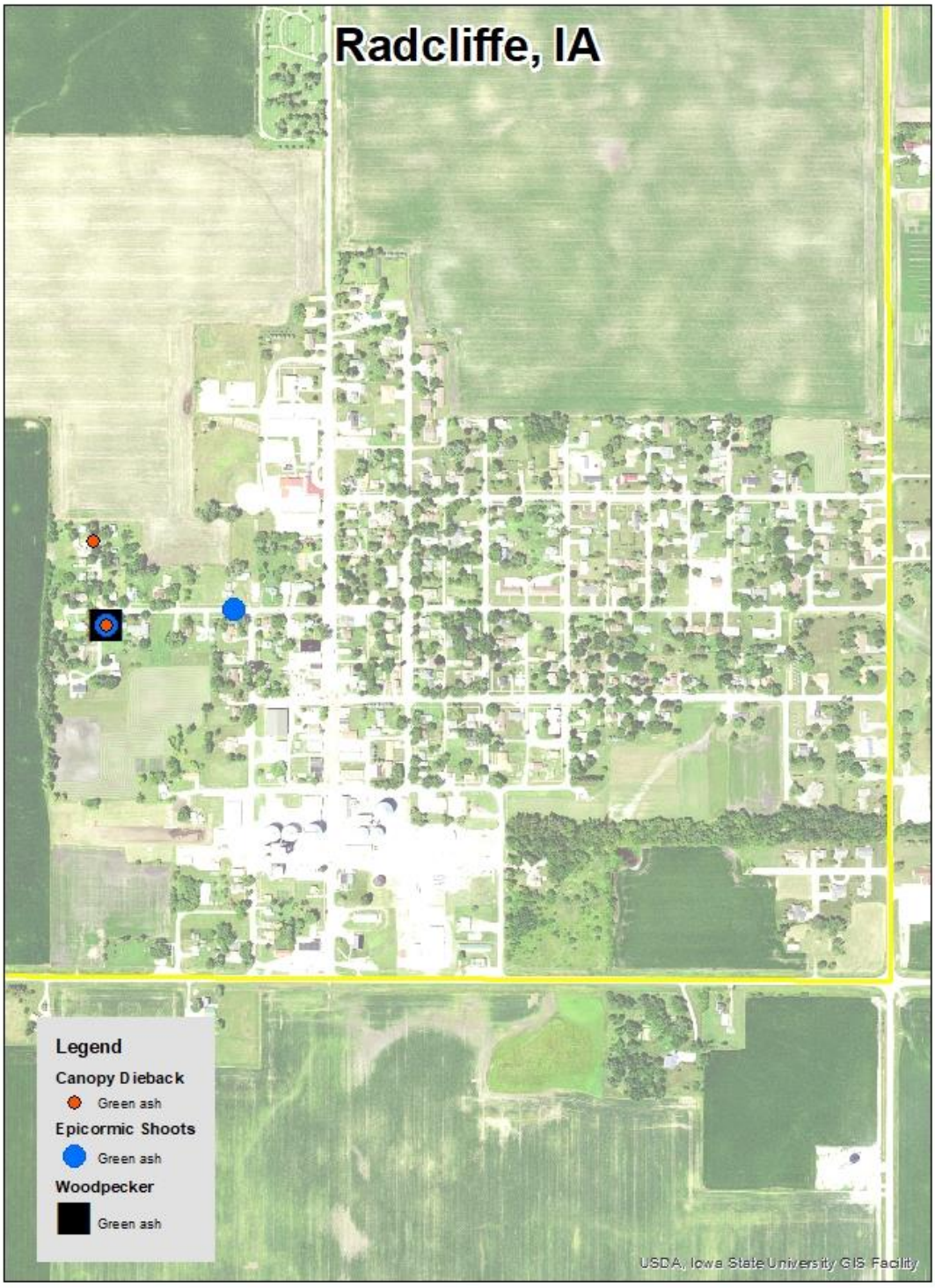

Figure 2: Location of EAB symptoms

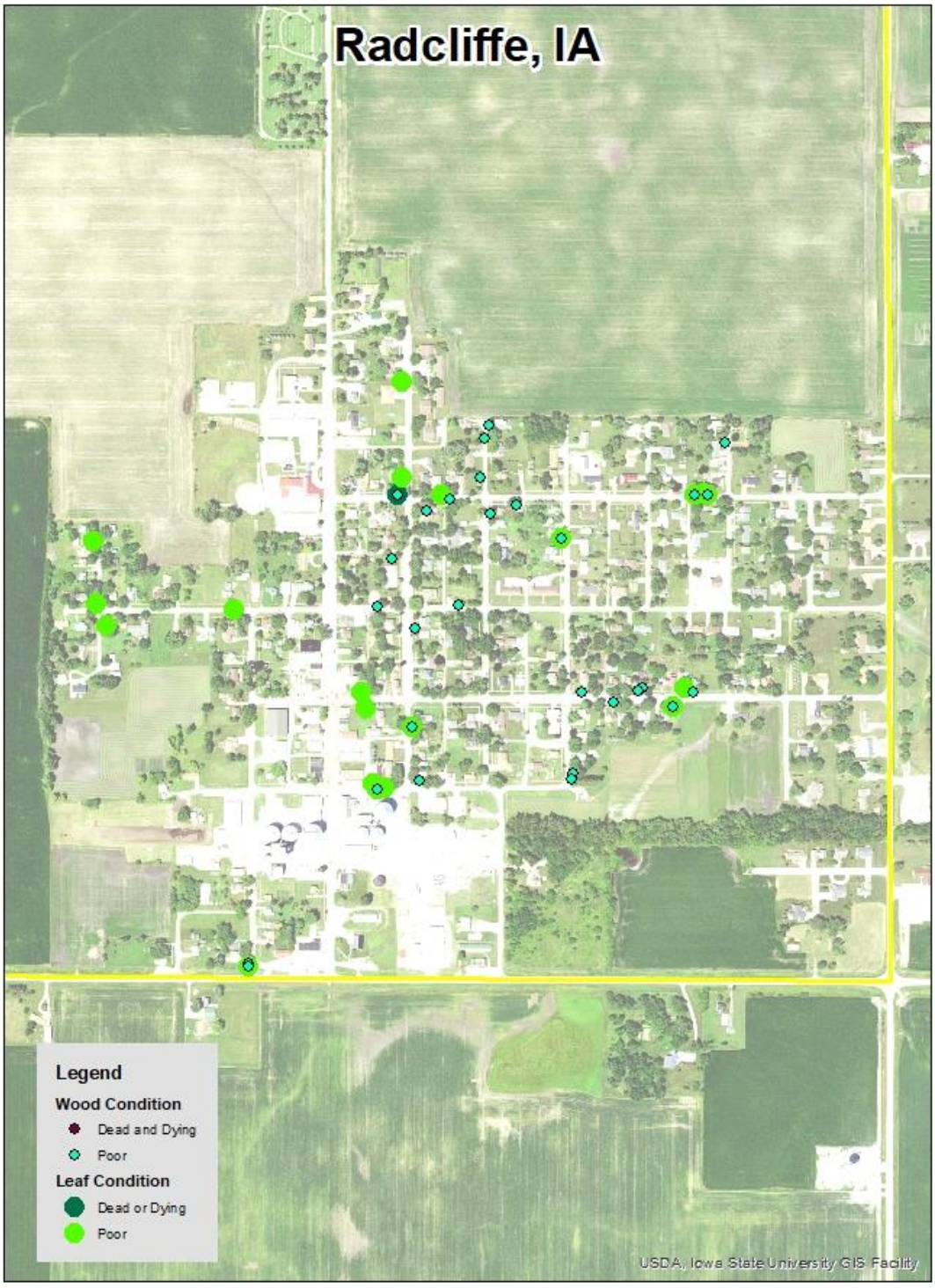

Figure 3: Location of Poor Condition Trees

Figure 4: Location of Trees with Recommended Maintenance

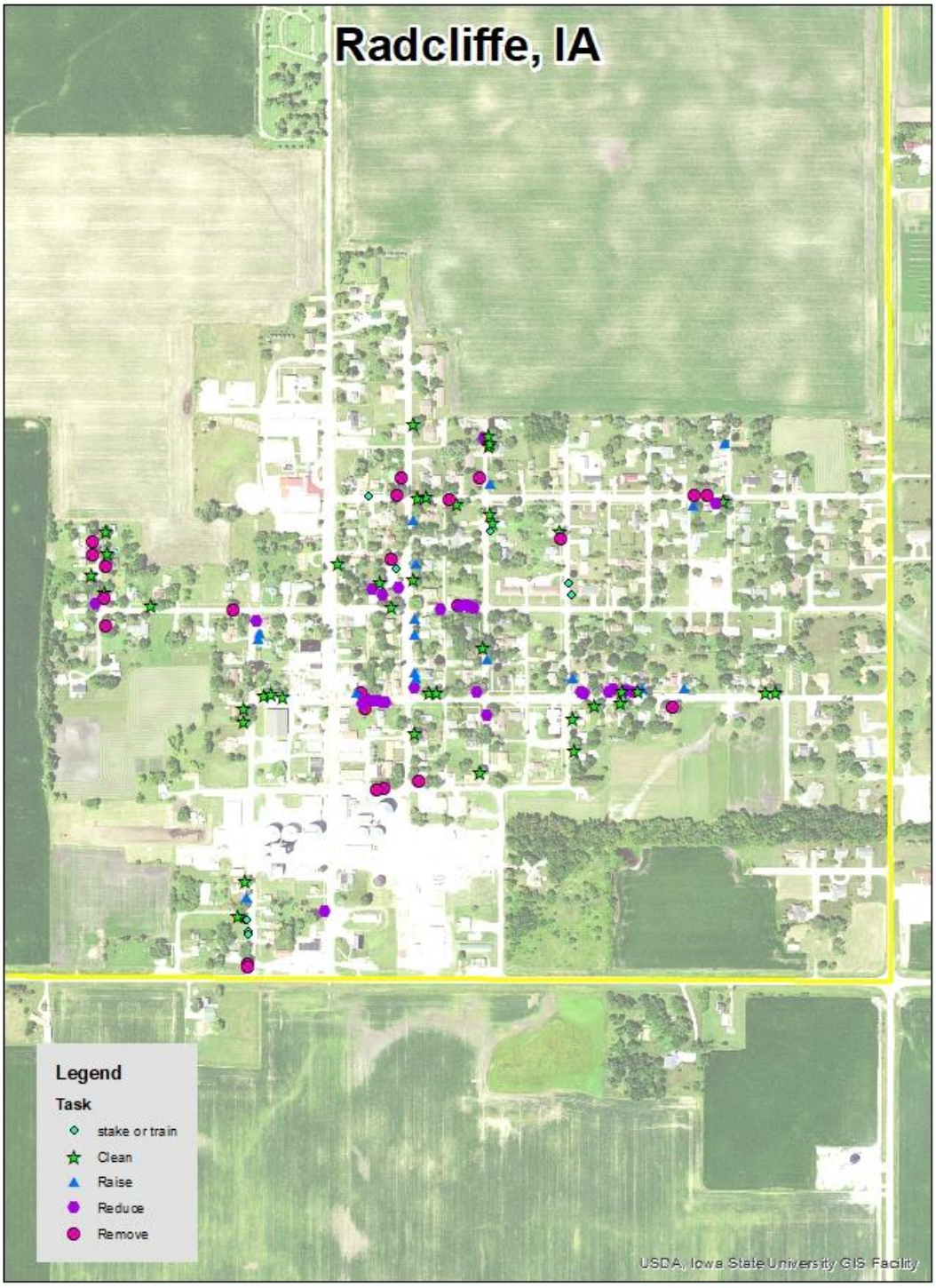

Figure 5: Maintenance Tasks *City ownership of the trees recommended for removal should be verified prior to any removal*

Appendix C: Radcliffe Tree Ordinances

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

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

If you need accommodations because of disability to access the services of this Agency, please contact the Director at 515-725-8200.