Royal, IA

2016 Urban Forest Management Plan
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Executive Summary

Overview

This plan was developed to assist the city of Royal 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 48% of Royal's city owned trees (ash) will die once EAB becomes established in the community, unless preventative treatment is used. With proper planning and management, the costs of removing dead and dying trees can be extended over years, mitigating public safety issues.

Inventory and Results

In 2015, a tree inventory was conducted using Global Positioning System (GPS) data collectors. The inventory was a complete inventory of street and park trees. Below are some key findings of the 396 trees inventoried.

- Royal's trees provide $70,876 of benefits annually, an average of $179 a tree
- There are over 27 species of trees
- The top three genera are: Ash 48%, Maple 24%, and Spruce 11%
- 14% of trees are in need of some type of management
- 7 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 7 trees needing removal, 4 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*
- 17 of the 190 ash trees should be carefully examined, as they have one or more symptoms that could be related to an EAB infestation
- All trees should be pruned on a routine schedule- one third of the city every other year
- Plant a diverse mix of trees that do not include: ash, maple, cottonwood, poplar, box elder, Chinese elm, evergreen, willow or black walnut
- Check ash trees with a visual survey yearly
- With a yearly budget of $5,000 it would take almost 27 years to remove ash – Suggestion: request a budget of at least $10,000 annually and apply for grants to plant replacement trees

Introduction

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

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

Inventory

In 2015, a tree inventory was conducted that included 100% of the city-owned street and park trees. 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 and 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 396 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. Royal's trees reduce energy related costs by approximately $18,999 annually (Appendix A, Table 1). These savings are both in Electricity (91 MWh) and in Natural Gas (12,339.6 Therms).

Annual Stormwater Benefits

Royal's trees intercept about 1,013,765 gallons of rainfall or snow melt a year (Appendix A, Table 2). This interception provides $27,473 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 Royal, it is estimated that trees remove 1,147 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 $3,218 (Appendix A, Table 3).

Annual Carbon Benefits

Carbon sequestration and storage reduce the amount of carbon in the atmosphere, mitigating climate change. In Royal, trees sequester about 194,529 lbs. of carbon a year with an associated value of $1,459 (Appendix A, Table 5). In addition, the trees store 3,760,156 lbs. of carbon, with a yearly benefit of $28,201 (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. Royal receives $19,728 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, Royal's trees provide $70,876 of benefits annually. Benefits of individual trees vary based on size, species, health and location,

but on average each of the 396 trees in Royal provides approximately $179 annually (Appendix A, Table 7).

Forest Structure

Species Distribution

Royal has over 30 different tree species along city streets and in parks (Appendix A, Figure 1). The distribution of trees by genera is as follows:

Ash	190	48.0%
Maple	95	24.0%
Spruce	45	11.4%
Honeylocust	8	2.0%
Pine	8	2.0%
Oak	6	1.5%
Linden	6	1.5%
Cherry	5	1.3%
Apple	5	1.3%
Cottonwood	4	1.0%
Walnut	4	1.0%
Mulberry	3	0.8%
Mountain Ash	3	0.8%
Cedar	2	0.5%
Aspen	1	0.3%
Birch	1	0.2%
Hackberry	1	0.3%
Elm	1	0.2%
Dogwood	1	0.3%
Other Large Evergreen	5	1.3%
Other Small Deciduous	1	0.3%

Age Class

A large proportion of Royal's trees (40%) 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. Royal's size curve is high in the middle, indicating that tree planting should increase.

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 Royal indicate that 93% of the trees are in good health, with only 2% of the foliage in poor health, dead or dying (Appendix A, Figure 3 & Appendix B, Figure 3). Similarly, 54% of Royal's trees are in good health for wood condition (appendix A,

Figure 4 & Appendix B, Figure 3). Wood condition that is in poor health, dead or dying is about 7% of the population. This 7% is an estimate for trees that need management follow up.

Management Needs

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

Crown Cleaning	33	8%
Crown Raising	2	<1%
Tree Staking	8	2%
Tree Removal	7	2%
Crown Reduction	5	1%

Canopy Cover

The canopy cover of Royal is approximately 10 acres (Appendix A, Figure 5). According to the 2010 census, Royal occupies 192 acres. Thus the canopy cover on city land is about 5%.

Land Use and Location

The majority of Royal's city and park trees are in planting strips (with or without sidewalks) 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	44%
Industrial/Large commercial	1%

Location	
Planting strip	42%
Front yard	58%

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

Royal has 4 critical concern (hazard) trees that need immediate removal. These trees can be seen on the Location of Trees with Recommended Maintenance map (Appendix B, Figure 4). It

is recommended to start with the large diameter critical concern trees first. Of these 4 trees, 2 are over 24 inches in diameter at 4.5 ft. and should therefore be addressed immediately. Please refer to the six year maintenance plan at the end of this section. After all of the removal trees are addressed, there should be follow up on the critical concern trees marked as needing maintenance. There are a total of 30 additional trees with these needs.

Poor tree species

After the removal and maintenance of the critical concern trees, ash trees in poor health should be assessed for removal (Appendix B, Figure 3 & Appendix B, Figure 4). Of the 4 critical concern trees that need to be removed as soon as possible, one is ash trees; 2 additional ash trees are in need of removal within the next few years. There are 8 ash trees in addition to these three that have poor wood condition - these trees should be prioritized for removal next. After taking all of these trees into account, 15 remaining ash trees show signs and symptoms of EAB and should therefore be monitored closely. *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 Royal.

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 (24%) (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. *All trees planted must meet the restrictions in city ordinance chapter 4, article 9 (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.

PROPOSED WORK SCHEDULE AND ESTIMATED COSTS

Total $23,290 over 6 years ($3,882/year average)

YEAR 1	**ESTIMATED COSTS**
Remove: 4 critical concern trees, including 1 ash tree	$2,800
Plant: 5 trees in open locations	$750
Inspect: ash trees for signs of Emerald Ash Borer	

YEAR 2

Remove: 3 trees designated as needing removal, including 2 ash trees	$2,100
Plant: 5 trees in open locations and locations from previous removals	$750
Prune: 1/3 of city owned trees	$230
Inspect: ash trees for signs of Emerald Ash Borer	

YEAR 3

Remove: 4 ash trees in poor health	$2,800
Plant: 6 trees in open locations and locations from previous removals	$900
Inspect: ash trees for signs of Emerald Ash Borer	

YEAR 4

Remove: 4 trees (any new critical concern trees or ash in poor health)	$2,800
**Or saving for ash tree treatment and/or future ash removal*	
Plant: 5 trees in open locations and locations from previous removals	$750
Prune: 1/3 of city owned trees	$230
Inspect: ash trees for signs of Emerald Ash Borer	

YEAR 5

Remove: 5 trees (any new critical concern trees or ash in poor health)	$3,500
**Or saving for ash tree treatment and/or future ash removal*	
Plant: 7 trees in open locations and locations from previous removals	$1,050
Inspect: ash trees for signs and symptoms of EAB	

YEAR 6

Remove: 5 trees (any new critical concern trees or ash in poor health)	$3,500
**Or saving for ash tree treatment and/or future ash removal*	
Plant: 6 trees in open locations and locations from previous removals	$900
Prune: 1/3 of city owned trees	$230
Inspect: ash trees for signs of Emerald Ash Borer	

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

*Reduction of ash over 6 years: Approximately 11 ash trees should be removed (approximately 6% of ash), including trees with poor wood structure and those displaying multiple symptoms of EAB. If $5,000 per year were devoted solely to the removal of ash trees and excluded removal, replanting and maintenance of other species, it would take nearly 27 years to remove all of the ash trees in Royal. EAB could potentially kill all ash within 4 to 15 years of its arrival. Treatment of ash would alter the cost and timeline and treatment price varies greatly by tree size and state location.

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 an 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 chapter 4, article 9 (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.

Proposed Budget Increase

EAB could potentially kill all ash trees in Royal within 4 years of its arrival. The total cost of maintaining, removing, and replanting Royal's current population of city trees, which would include removing and replanting all of the city's ash trees, is estimated at around $173,000. If the city had a budget of $10,000 per year, this work could be accomplished in a little over 17 years. Additionally, it is recommended that Royal apply for grants to fund replacement trees. Utility Company grants are usually between $500 and $10,000 for community-based, tree-planting projects that include parks, gateways, cemeteries, nature trails, libraries, nursing homes, and schools.

Another option being considered by many communities is to treat a number of selected trees, either to maintain those trees in the landscape or to delay their removal – to reduce the costs and number of trees that need to be removed all at once. Trunk injection is administered every two years for the life of the tree. If treatment is discontinued, the tree dies. For instance, the average diameter for the ash tree population of Royal is 21 inches; at $15 per inch, it would cost an average of approximately $315 per tree every two years, for as many years as the tree is preserved. While treatment is cheaper than removal in the short-run, it is more expensive in the long run, as it would only take 6 years of treatment per tree to exceed the cost of removal and replacement ($945 for treatment over a six-year period, compared with $850 for one-time removal and replacement, on average). Furthermore, treatment does not cure the tree of the devastation associated with emerald ash borer, but rather delays its onset for as long as treatment is carried out. Whether or not the treatment option is selected, there will be an increased cost of dealing with ash trees if EAB is found in Royal; therefore, it is suggested that the budget be increased to plan for this regardless of how the problem is addressed.

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Appendix A: i-Tree Data

Table 1: Annual Energy Benefits

Royal

Annual Energy Benefits of Public Trees

12/9/2015

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	48.9	3,708	6,604.8	6,473	10,181	(N/A)	48.0	53.6	53.58
Norway maple	8.6	653	1,219.9	1,196	1,849	(N/A)	9.3	9.7	49.96
Silver maple	12.6	959	1,669.1	1,636	2,595	(N/A)	9.3	13.7	70.12
Norway spruce	2.6	200	329.9	323	523	(N/A)	5.8	2.8	22.74
Spruce	1.6	119	215.9	212	330	(N/A)	4.8	1.7	17.38
Sugar maple	2.9	218	379.6	372	590	(N/A)	2.8	3.1	53.61
Honeylocust	2.4	182	313.8	308	490	(N/A)	2.0	2.6	61.24
Red pine	1.2	94	162.4	159	253	(N/A)	2.0	1.3	31.60
Maple	1.0	75	128.4	126	201	(N/A)	2.0	1.1	25.12
American basswood	0.7	50	88.7	87	137	(N/A)	1.3	0.7	27.48
Black cherry	1.0	75	151.2	148	223	(N/A)	1.3	1.2	44.54
Apple	0.6	47	101.7	100	147	(N/A)	1.3	0.8	29.37
Conifer Evergreen Large	0.7	54	93.5	92	146	(N/A)	1.3	0.8	29.20
Blue spruce	0.5	35	64.4	63	99	(N/A)	1.0	0.5	24.65
Black walnut	0.9	65	116.9	115	180	(N/A)	1.0	0.9	44.88
Cottonwood	1.6	125	224.1	220	345	(N/A)	1.0	1.8	86.17
Mountain ash	0.3	25	50.3	49	75	(N/A)	0.8	0.4	24.84
Northern red oak	0.1	8	16.6	16	24	(N/A)	0.8	0.1	8.15
Mulberry	0.6	45	94.9	93	138	(N/A)	0.8	0.7	46.14
Eastern red cedar	0.2	12	24.4	24	36	(N/A)	0.5	0.2	18.02
Oak	0.1	7	14.2	14	21	(N/A)	0.5	0.1	10.65
Boxelder	0.5	41	75.1	74	115	(N/A)	0.5	0.6	57.27
Swamp white oak	0.0	0	0.8	1	1	(N/A)	0.3	0.0	1.10
Quaking aspen	0.4	29	53.7	53	82	(N/A)	0.3	0.4	82.02
River birch	0.2	18	29.5	29	47	(N/A)	0.3	0.2	46.78
Elm	0.3	20	38.1	37	57	(N/A)	0.3	0.3	57.32
Northern hackberry	0.4	33	60.8	60	92	(N/A)	0.3	0.5	92.23
Broadleaf Deciduous Small	0.0	2	3.8	4	5	(N/A)	0.3	0.0	5.40
Littleleaf linden	0.1	6	12.5	12	18	(N/A)	0.3	0.1	18.25
Dogwood	0.0	0	0.6	1	1	(N/A)	0.3	0.0	0.87
Total	91.0	6,906	12,339.6	12,093	18,999	(N/A)	100.0	100.0	47.98

Table 2: Annual Stormwater Benefits

Royal

Annual Stormwater Benefits of Public Trees

12/9/2015

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	503,646	13,649	(N/A)	48.0	49.7	71.84
Norway maple	76,796	2,081	(N/A)	9.3	7.6	56.25
Silver maple	194,097	5,260	(N/A)	9.3	19.1	142.16
Norway spruce	39,388	1,067	(N/A)	5.8	3.9	46.41
Spruce	18,964	514	(N/A)	4.8	1.9	27.05
Sugar maple	25,392	688	(N/A)	2.8	2.5	62.56
Honeylocust	23,606	640	(N/A)	2.0	2.3	79.96
Red pine	25,594	694	(N/A)	2.0	2.5	86.70
Maple	6,998	190	(N/A)	2.0	0.7	23.71
American basswood	8,970	243	(N/A)	1.3	0.9	48.62
Black cherry	5,363	145	(N/A)	1.3	0.5	29.07
Apple	3,142	85	(N/A)	1.3	0.3	17.03
Conifer Evergreen Large	13,415	364	(N/A)	1.3	1.3	72.71
Blue spruce	6,924	188	(N/A)	1.0	0.7	46.91
Black walnut	7,255	197	(N/A)	1.0	0.7	49.15
Cottonwood	23,710	643	(N/A)	1.0	2.3	160.64
Mountain ash	1,196	32	(N/A)	0.8	0.1	10.80
Northern red oak	567	15	(N/A)	0.8	0.1	5.12
Mulberry	3,522	95	(N/A)	0.8	0.3	31.82
Eastern red cedar	2,294	62	(N/A)	0.5	0.2	31.08
Oak	626	17	(N/A)	0.5	0.1	8.48
Boxelder	7,277	197	(N/A)	0.5	0.7	98.61
Swamp white oak	12	0	(N/A)	0.3	0.0	0.33
Quaking aspen	5,491	149	(N/A)	0.3	0.5	148.79
River birch	1,409	38	(N/A)	0.3	0.1	38.19
Elm	2,591	70	(N/A)	0.3	0.3	70.21
Northern hackberry	4,984	135	(N/A)	0.3	0.5	135.08
Broadleaf Deciduous Small	69	2	(N/A)	0.3	0.0	1.86
Littleleaf linden	461	12	(N/A)	0.3	0.0	12.48
Dogwood	7	0	(N/A)	0.3	0.0	0.20
Citywide total	1,013,765	27,473	(N/A)	100.0	100.0	69.38

Table 3: Annual Air Quality Benefits

Royal

Annual Air Quality Benefits of Public Trees

12/9/2015

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								
Green ash	61.2	9.8	29.8	2.7	327	232.5	33.9	32.3	221.4	1,450	0.0	0	623.7	1,778	(N/A)	48.0	9.36
Norway maple	15.4	2.7	7.6	0.7	83	41.5	6.0	5.7	39.0	258	-3.6	-14	115.0	327	(N/A)	9.3	8.85
Silver maple	35.3	6.0	17.1	1.6	190	59.6	8.7	8.3	57.1	373	-18.4	-69	175.4	494	(N/A)	9.3	13.34
Norway spruce	4.4	0.9	3.7	0.5	29	12.3	1.8	1.7	11.9	77	-17.2	-64	20.1	42	(N/A)	5.8	1.83
Spruce	1.9	0.4	1.8	0.2	13	7.5	1.1	1.0	7.1	46	-6.5	-25	14.4	35	(N/A)	4.8	1.85
Sugar maple	2.9	0.5	1.6	0.1	16	13.6	2.0	1.9	13.0	85	-2.4	-9	33.2	92	(N/A)	2.8	8.37
Honeylocust	4.5	0.7	2.1	0.2	24	11.3	1.7	1.6	10.9	71	-3.4	-13	29.6	82	(N/A)	2.0	10.24
Red pine	3.0	0.6	2.4	0.4	20	5.8	0.9	0.8	5.6	36	-13.2	-49	6.4	7	(N/A)	2.0	0.86
Maple	1.5	0.3	0.7	0.1	8	4.7	0.7	0.7	4.5	29	-0.5	-2	12.5	35	(N/A)	2.0	4.40
American basswood	1.4	0.2	0.7	0.1	8	3.2	0.5	0.4	3.0	20	-1.2	-4	8.3	23	(N/A)	1.3	4.60
Black cherry	1.9	0.3	0.9	0.1	10	4.8	0.7	0.7	4.4	30	0.0	0	13.9	40	(N/A)	1.3	7.99
Apple	1.0	0.2	0.5	0.0	5	3.1	0.4	0.4	2.8	19	0.0	0	8.5	24	(N/A)	1.3	4.87
Conifer Evergreen Large	1.5	0.3	1.3	0.2	10	3.4	0.5	0.5	3.2	21	-6.1	-23	4.8	9	(N/A)	1.3	1.72
Blue spruce	1.0	0.2	0.8	0.1	6	2.2	0.3	0.3	2.1	14	-2.6	-10	4.5	11	(N/A)	1.0	2.65
Black walnut	0.7	0.1	0.4	0.0	4	4.1	0.6	0.6	3.9	25	0.0	0	10.3	29	(N/A)	1.0	7.27
Cottonwood	4.0	0.6	1.8	0.2	21	7.9	1.1	1.1	7.5	49	0.0	0	24.1	70	(N/A)	1.0	17.42
Mountain ash	0.3	0.0	0.2	0.0	2	1.6	0.2	0.2	1.5	10	0.0	0	4.1	12	(N/A)	0.8	3.88
Northern red oak	0.1	0.0	0.0	0.0	0	0.5	0.1	0.1	0.5	3	-0.1	0	1.2	3	(N/A)	0.8	1.10
Mulberry	1.3	0.2	0.6	0.1	7	3.0	0.4	0.4	2.7	18	0.0	0	8.7	25	(N/A)	0.8	8.35
Eastern red cedar	0.4	0.1	0.3	0.0	3	0.8	0.1	0.1	0.7	5	-1.3	-5	1.3	3	(N/A)	0.5	1.40
Oak	0.0	0.0	0.0	0.0	0	0.5	0.1	0.1	0.4	3	0.0	0	1.1	3	(N/A)	0.5	1.54
Boxelder	1.1	0.2	0.5	0.0	6	2.6	0.4	0.4	2.4	16	-0.3	-1	7.2	21	(N/A)	0.5	10.29
Swamp white oak	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)	0.3	0.14
Quaking aspen	0.8	0.1	0.4	0.0	4	1.9	0.3	0.3	1.8	12	0.0	0	5.5	16	(N/A)	0.3	15.71
River birch	0.2	0.0	0.1	0.0	1	1.1	0.2	0.2	1.1	7	-0.1	0	2.8	8	(N/A)	0.3	7.92
Elm	0.3	0.0	0.1	0.0	1	1.3	0.2	0.2	1.2	8	0.0	0	3.3	9	(N/A)	0.3	9.34
Northern hackberry	0.9	0.1	0.4	0.0	5	2.1	0.3	0.3	2.0	13	0.0	0	6.1	18	(N/A)	0.3	17.54
Broadleaf Deciduous Small	0.0	0.0	0.0	0.0	0	0.1	0.0	0.0	0.1	1	0.0	0	0.3	1	(N/A)	0.3	0.71
Littleleaf linden	0.0	0.0	0.0	0.0	0	0.4	0.1	0.1	0.4	2	0.0	0	0.9	3	(N/A)	0.3	2.55
Dogwood	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)	0.3	0.11
Citywide total	147.1	24.6	75.7	7.5	804	433.2	63.2	60.2	412.3	2,701	-76.8	-288	1,147.1	3,218	(N/A)	100.0	8.13

Table 4: Annual Carbon Stored

Royal

Stored CO2 Benefits of Public Trees

12/9/2015

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	2,023,552	15,177	(N/A)	48.0	53.8	79.88
Norway maple	254,030	1,905	(N/A)	9.3	6.8	51.49
Silver maple	836,622	6,275	(N/A)	9.3	22.2	169.59
Norway spruce	40,155	301	(N/A)	5.8	1.1	13.09
Spruce	13,226	99	(N/A)	4.8	0.4	5.22
Sugar maple	82,783	621	(N/A)	2.8	2.2	56.44
Honeylocust	57,202	429	(N/A)	2.0	1.5	53.63
Red pine	32,865	246	(N/A)	2.0	0.9	30.81
Maple	16,765	126	(N/A)	2.0	0.4	15.72
American basswood	57,099	428	(N/A)	1.3	1.5	85.65
Black cherry	30,008	225	(N/A)	1.3	0.8	45.01
Apple	16,209	122	(N/A)	1.3	0.4	24.31
Conifer Evergreen La	14,541	109	(N/A)	1.3	0.4	21.81
Blue spruce	6,725	50	(N/A)	1.0	0.2	12.61
Black walnut	21,622	162	(N/A)	1.0	0.6	40.54
Cottonwood	133,811	1,004	(N/A)	1.0	3.6	250.90
Mountain ash	4,853	36	(N/A)	0.8	0.1	12.13
Northern red oak	1,050	8	(N/A)	0.8	0.0	2.62
Mulberry	20,228	152	(N/A)	0.8	0.5	50.57
Eastern red cedar	1,379	10	(N/A)	0.5	0.0	5.17
Oak	1,047	8	(N/A)	0.5	0.0	3.93
Boxelder	41,620	312	(N/A)	0.5	1.1	156.07
Swamp white oak	17	0	(N/A)	0.3	0.0	0.13
Quaking aspen	25,943	195	(N/A)	0.3	0.7	194.57
River birch	3,624	27	(N/A)	0.3	0.1	27.18
Elm	8,458	63	(N/A)	0.3	0.2	63.43
Northern hackberry	13,507	101	(N/A)	0.3	0.4	101.30
Broadleaf Deciduous	178	1	(N/A)	0.3	0.0	1.33
Littleleaf linden	1,025	8	(N/A)	0.3	0.0	7.68
Dogwood	14	0	(N/A)	0.3	0.0	0.10
Citywide total	3,760,156	28,201	(N/A)	100.0	100.0	71.22

Table 5: Annual Carbon Sequestered

Royal

Annual CO Benefits of Public Trees

12/9/2015

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	109,706	823	-9,713	-503	-4	0	0	99,490	746 (N/A)	48.0	51.1	3.93
Norway maple	10,555	79	-1,222	-92	-1	0	0	9,241	69 (N/A)	9.3	4.8	1.87
Silver maple	57,529	431	-4,017	-145	-1	0	0	53,367	400 (N/A)	9.3	27.4	10.82
Norway spruce	2,707	20	-193	-44	0	0	0	2,470	19 (N/A)	5.8	1.3	0.81
Spruce	1,478	11	-63	-28	0	0	0	1,386	10 (N/A)	4.8	0.7	0.55
Sugar maple	5,403	41	-397	-28	0	0	0	4,977	37 (N/A)	2.8	2.6	3.39
Honeylocust	4,508	34	-275	-19	0	0	0	4,215	32 (N/A)	2.0	2.2	3.95
Red pine	1,565	12	-158	-23	0	0	0	1,384	10 (N/A)	2.0	0.7	1.30
Maple	1,215	9	-81	-9	0	0	0	1,125	8 (N/A)	2.0	0.6	1.05
American basswood	2,900	22	-274	-8	0	0	0	2,617	20 (N/A)	1.3	1.3	3.93
Black cherry	1,225	9	-144	-14	0	0	0	1,066	8 (N/A)	1.3	0.5	1.60
Apple	1,299	10	-78	-9	0	0	0	1,212	9 (N/A)	1.3	0.6	1.82
Conifer Evergreen Large	865	6	-70	-13	0	0	0	782	6 (N/A)	1.3	0.4	1.17
Blue spruce	423	3	-32	-9	0	0	0	383	3 (N/A)	1.0	0.2	0.72
Black walnut	1,974	15	-104	-9	0	0	0	1,861	14 (N/A)	1.0	1.0	3.49
Cottonwood	3,358	25	-642	-19	0	0	0	2,697	20 (N/A)	1.0	1.4	5.06
Mountain ash	495	4	-23	-4	0	0	0	468	4 (N/A)	0.8	0.2	1.17
Northern red oak	157	1	-5	-2	0	0	0	150	1 (N/A)	0.8	0.1	0.38
Mulberry	478	4	-97	-10	0	0	0	372	3 (N/A)	0.8	0.2	0.93
Eastern red cedar	83	1	-7	-3	0	0	0	73	1 (N/A)	0.5	0.0	0.27
Oak	211	2	-5	-1	0	0	0	205	2 (N/A)	0.5	0.1	0.77
Boxelder	2,567	19	-200	-8	0	0	0	2,359	18 (N/A)	0.5	1.2	8.85
Swamp white oak	5	0	0	0	0	0	0	5	0 (N/A)	0.3	0.0	0.04
Quaking aspen	960	7	-125	-4	0	0	0	831	6 (N/A)	0.3	0.4	6.23
River birch	386	3	-17	-2	0	0	0	367	3 (N/A)	0.3	0.2	2.75
Elm	660	5	-41	-3	0	0	0	616	5 (N/A)	0.3	0.3	4.62
Northern hackberry	616	5	-65	-4	0	0	0	547	4 (N/A)	0.3	0.3	4.10
Broadleaf Deciduous Smal	38	0	-1	-1	0	0	0	37	0 (N/A)	0.3	0.0	0.27
Littleleaf linden	223	2	-5	-1	0	0	0	217	2 (N/A)	0.3	0.1	1.63
Dogwood	9	0	0	0	0	0	0	8	0 (N/A)	0.3	0.0	0.06
Citywide total	213,597	1,602	-18,053	-1,015	-8	0	0	194,529	1,459 (N/A)	100.0	100.0	3.68

Table 6: Annual Social and Aesthetic Benefits

Royal

Annual Aesthetic/Other Benefits of Public Trees

12/9/2015

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Green ash	9,580	(N/A)	48.0	48.6	50.42
Norway maple	1,039	(N/A)	9.3	5.3	28.08
Silver maple	4,292	(N/A)	9.3	21.8	116.01
Norway spruce	657	(N/A)	5.8	3.3	28.56
Spruce	417	(N/A)	4.8	2.1	21.97
Sugar maple	604	(N/A)	2.8	3.1	54.90
Honeylocust	1,015	(N/A)	2.0	5.1	126.88
Red pine	320	(N/A)	2.0	1.6	40.03
Maple	176	(N/A)	2.0	0.9	22.03
American basswood	187	(N/A)	1.3	0.9	37.45
Black cherry	73	(N/A)	1.3	0.4	14.62
Apple	77	(N/A)	1.3	0.4	15.36
Conifer Evergreen Large	221	(N/A)	1.3	1.1	44.13
Blue spruce	86	(N/A)	1.0	0.4	21.56
Black walnut	190	(N/A)	1.0	1.0	47.45
Cottonwood	228	(N/A)	1.0	1.2	57.09
Mountain ash	28	(N/A)	0.8	0.1	9.43
Northern red oak	19	(N/A)	0.8	0.1	6.44
Mulberry	29	(N/A)	0.8	0.1	9.60
Eastern red cedar	35	(N/A)	0.5	0.2	17.51
Oak	34	(N/A)	0.5	0.2	16.91
Boxelder	147	(N/A)	0.5	0.7	73.49
Swamp white oak	3	(N/A)	0.3	0.0	2.74
Quaking aspen	67	(N/A)	0.3	0.3	66.60
River birch	39	(N/A)	0.3	0.2	39.16
Elm	58	(N/A)	0.3	0.3	57.69
Northern hackberry	73	(N/A)	0.3	0.4	72.66
Broadleaf Deciduous Small	2	(N/A)	0.3	0.0	2.06
Littleleaf linden	31	(N/A)	0.3	0.2	31.20
Dogwood	0	(N/A)	0.3	0.0	0.03
Citywide total	19,728	(N/A)	100.0	100.0	49.82

Table 7: Summary of Benefits in Dollars

Royal

Total Annual Benefits of Public Trees by Species ($)

12/9/2015

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error	% of Total $
Green ash	10,181	746	1,778	13,649	9,580	35,933	(N/A)	50.7
Norway maple	1,849	69	327	2,081	1,039	5,365	(N/A)	7.6
Silver maple	2,595	400	494	5,260	4,292	13,041	(N/A)	18.4
Norway spruce	523	19	42	1,067	657	2,308	(N/A)	3.3
Spruce	330	10	35	514	417	1,307	(N/A)	1.8
Sugar maple	590	37	92	688	604	2,011	(N/A)	2.8
Honeylocust	490	32	82	640	1,015	2,258	(N/A)	3.2
Red pine	253	10	7	694	320	1,284	(N/A)	1.8
Maple	201	8	35	190	176	610	(N/A)	0.9
American basswood	137	20	23	243	187	610	(N/A)	0.9
Black cherry	223	8	40	145	73	489	(N/A)	0.7
Apple	147	9	24	85	77	342	(N/A)	0.5
Conifer Evergreen Large	146	6	9	364	221	745	(N/A)	1.1
Blue spruce	99	3	11	188	86	386	(N/A)	0.5
Black walnut	180	14	29	197	190	609	(N/A)	0.9
Cottonwood	345	20	70	643	228	1,306	(N/A)	1.8
Mountain ash	75	4	12	32	28	150	(N/A)	0.2
Northern red oak	24	1	3	15	19	64	(N/A)	0.1
Mulberry	138	3	25	95	29	291	(N/A)	0.4
Eastern red cedar	36	1	3	62	35	137	(N/A)	0.2
Oak	21	2	3	17	34	77	(N/A)	0.1
Boxelder	115	18	21	197	147	497	(N/A)	0.7
Swamp white oak	1	0	0	0	3	4	(N/A)	0.0
Quaking aspen	82	6	16	149	67	319	(N/A)	0.5
River birch	47	3	8	38	39	135	(N/A)	0.2
Elm	57	5	9	70	58	199	(N/A)	0.3
Northern hackberry	92	4	18	135	73	322	(N/A)	0.5
Broadleaf Deciduous Sn	5	0	1	2	2	10	(N/A)	0.0
Littleleaf linden	18	2	3	12	31	66	(N/A)	0.1
Dogwood	1	0	0	0	0	1	(N/A)	0.0
Citywide Total	18,999	1,459	3,218	27,473	19,728	70,876	(N/A)	100.0

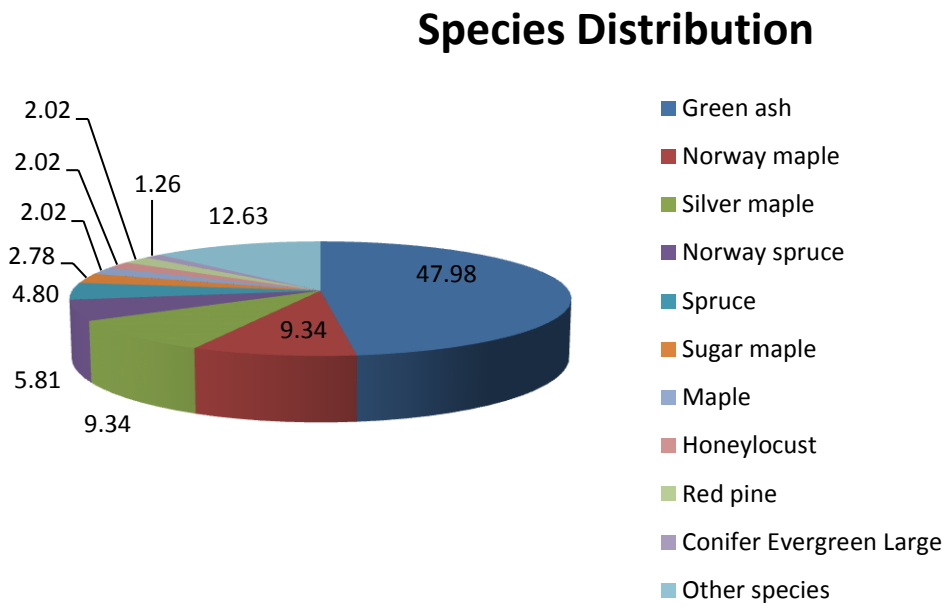
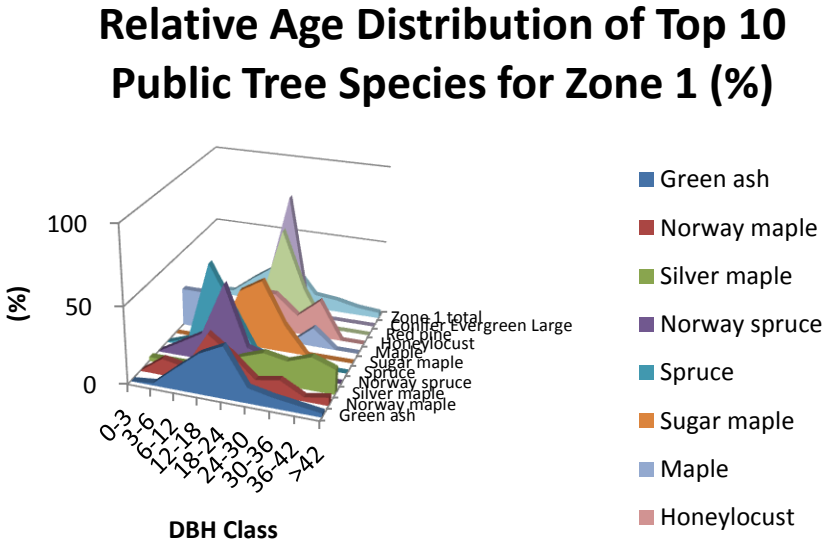


Figure 1: Species Distribution (%)



Species Name	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Green ash	0.00	1.58	14.21	26.32	33.68	10.00	6.84	4.74	2.63
Norway maple	0.00	10.81	8.11	32.43	21.62	8.11	10.81	2.70	5.41
Silver maple	2.70	2.70	2.70	5.41	13.51	18.92	16.22	21.62	16.22
Norway spruce	0.00	8.70	17.39	52.17	13.04	8.70	0.00	0.00	0.00
Spruce	0.00	5.26	57.89	31.58	5.26	0.00	0.00	0.00	0.00
Sugar maple	0.00	0.00	0.00	36.36	45.45	18.18	0.00	0.00	0.00
Maple	25.00	25.00	12.50	25.00	0.00	0.00	12.50	0.00	0.00
Honeylocust	0.00	0.00	12.50	25.00	25.00	12.50	25.00	0.00	0.00
Red pine	0.00	0.00	0.00	12.50	62.50	25.00	0.00	0.00	0.00
Conifer Evergreen Large	0.00	0.00	0.00	20.00	80.00	0.00	0.00	0.00	0.00
Zone 1 total	2.78	3.54	14.90	25.00	27.27	9.60	8.08	5.05	3.79

Figure 2: Relative Age Class (%)

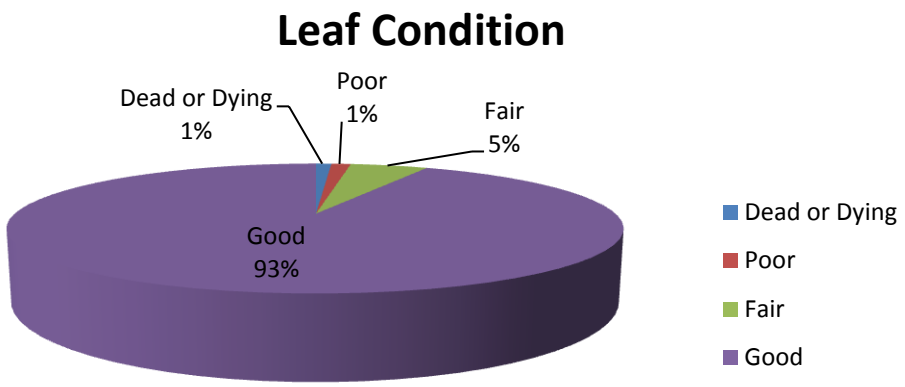


Figure 3: Foliage Condition

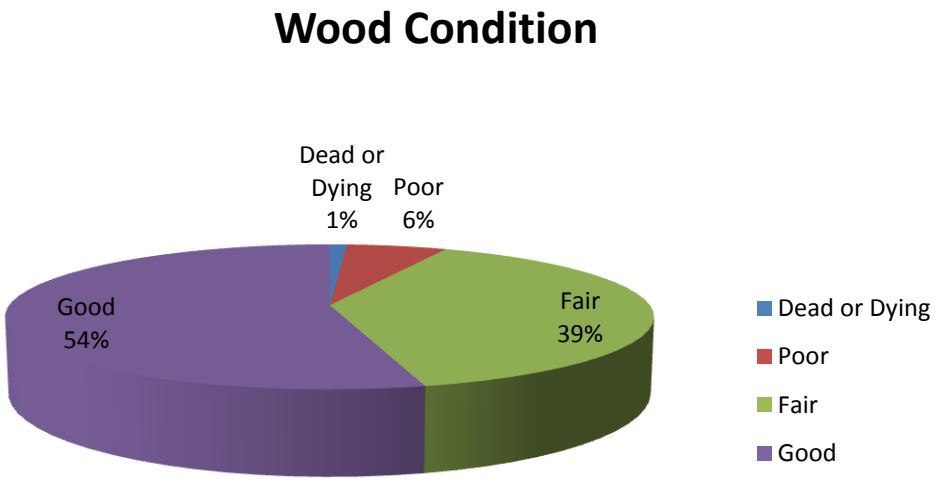


Figure 4: Wood Condition

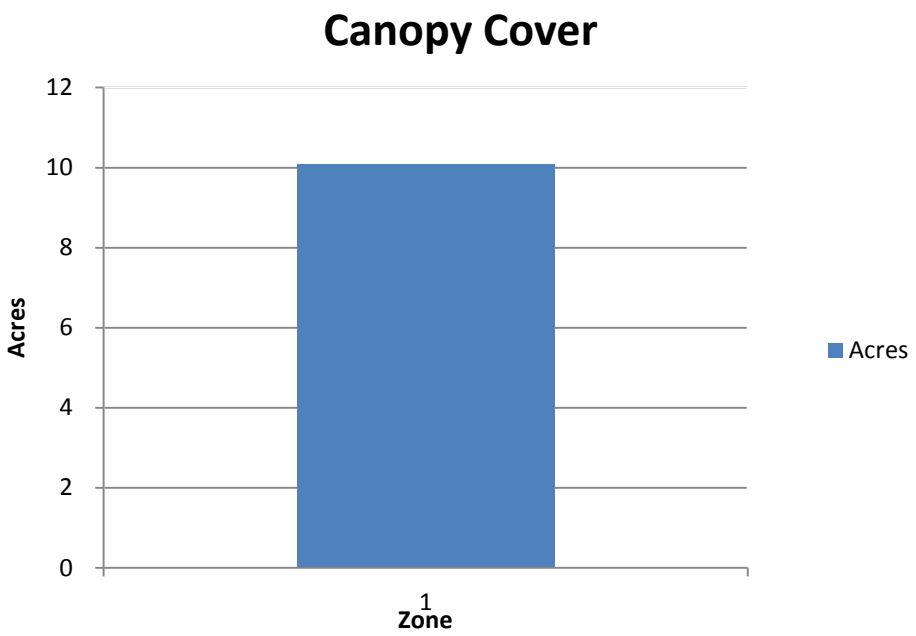


Figure 5: Canopy Cover in Acres

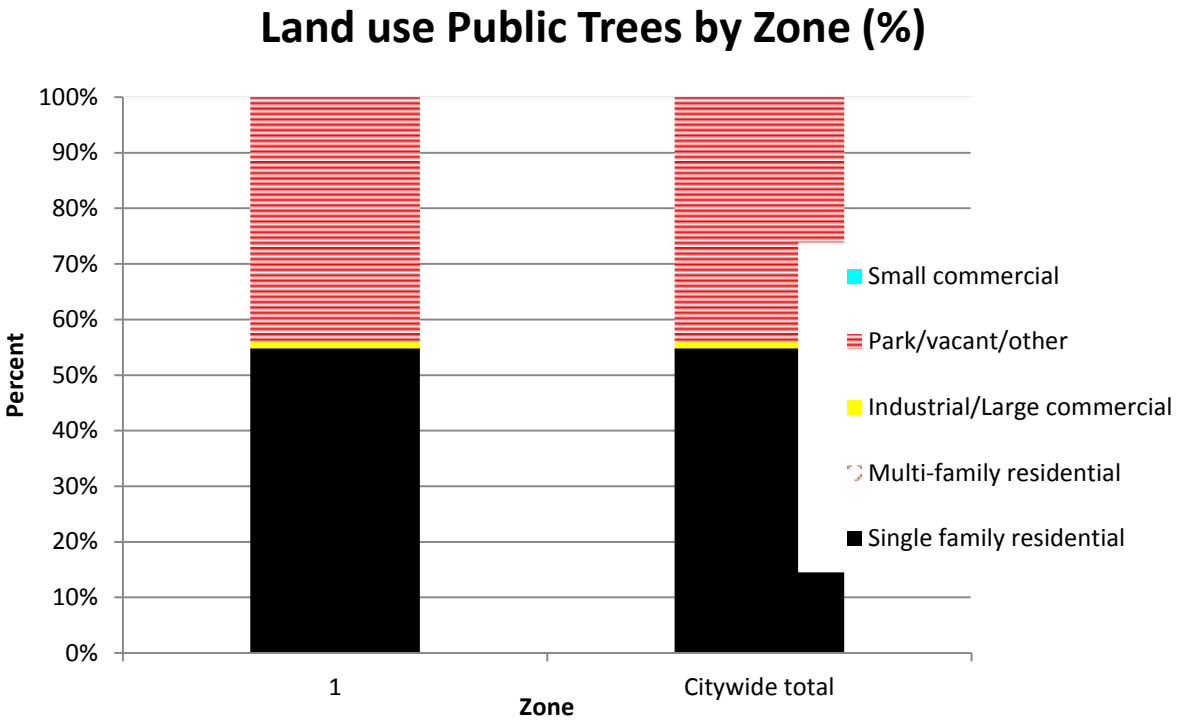


Figure 6: Land Use of city/park trees

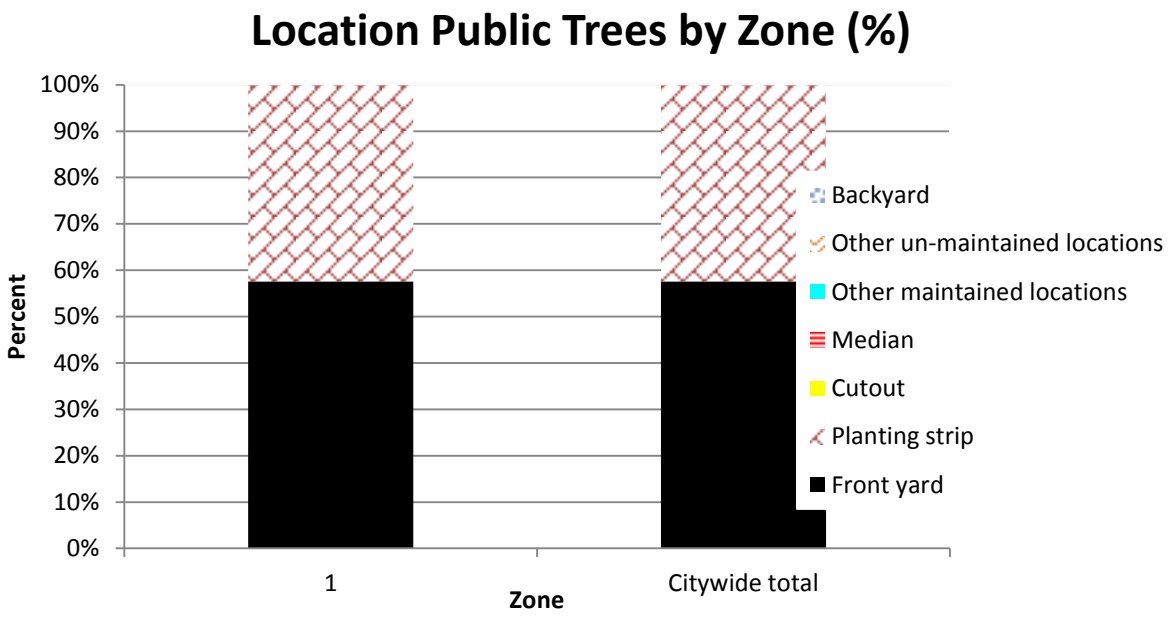


Figure 7: Location of city/park trees

Appendix B: ArcGIS Mapping

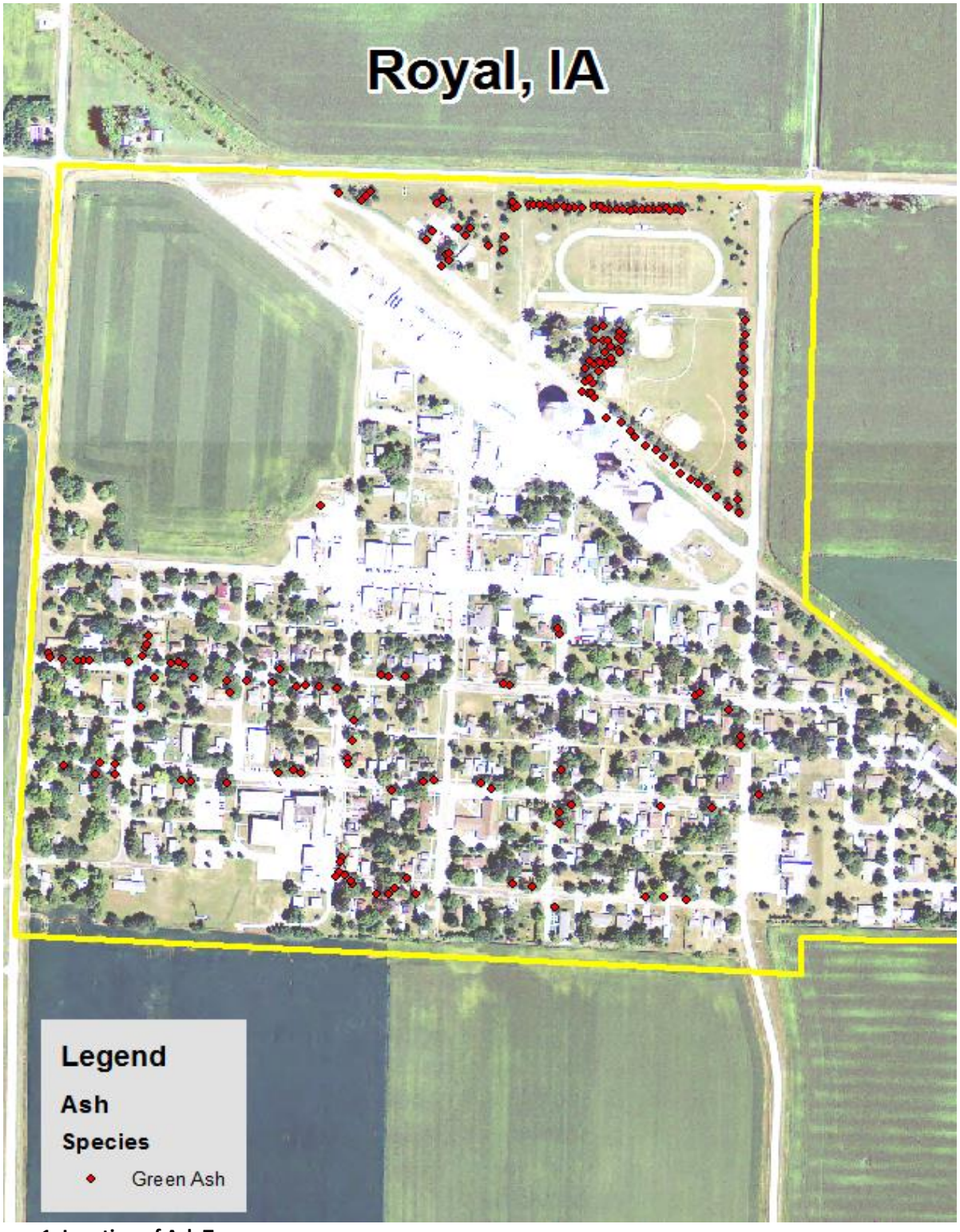


Figure 1: Location of Ash Trees

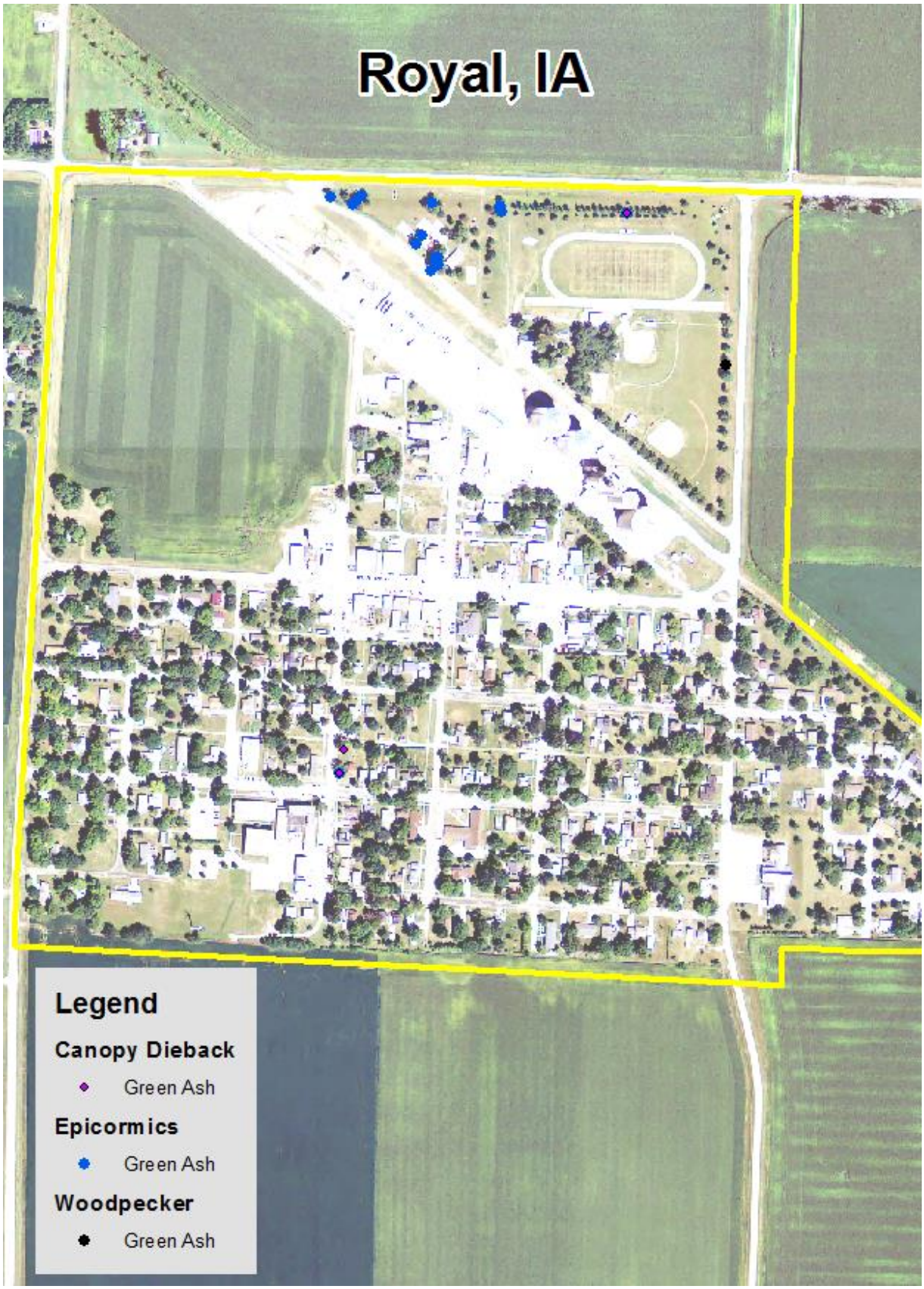


Figure 2: Location of EAB symptoms

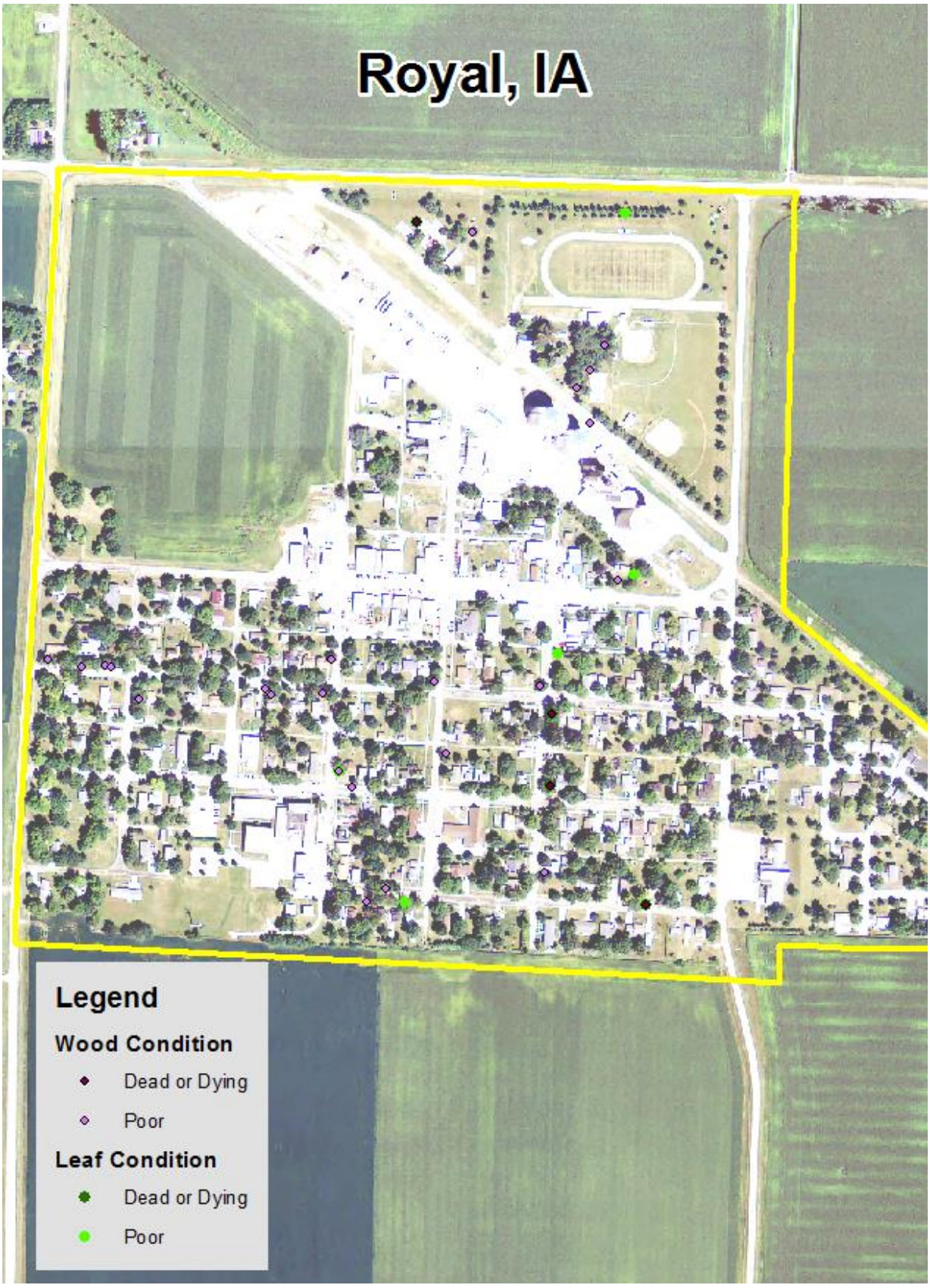


Figure 3: Location of Poor Condition Trees

Figure 4: Location of Trees with Recommended Maintenance

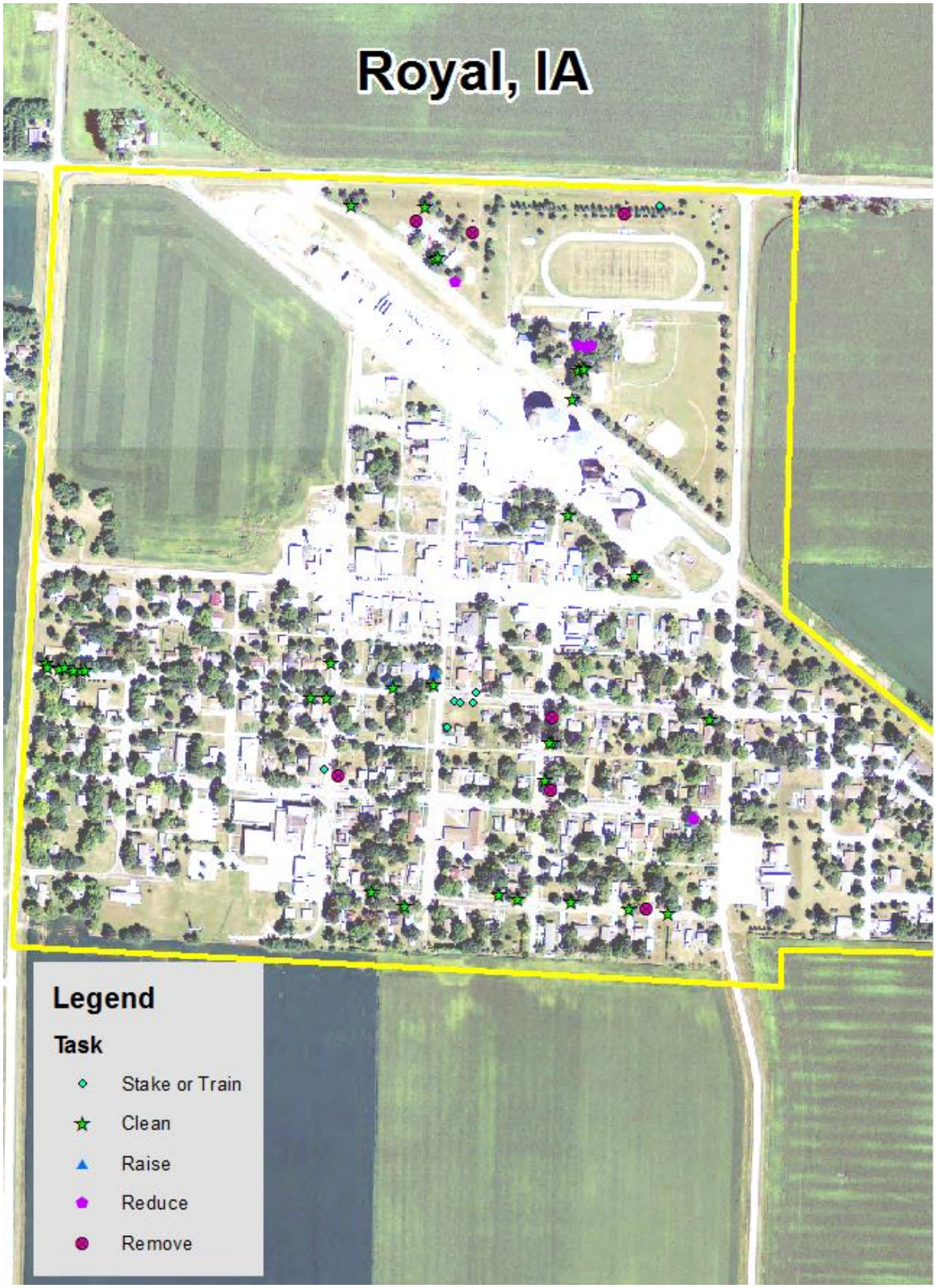


Figure 5: Maintenance Tasks *City ownership of the trees recommended for removal should be verified prior to any removal*

Appendix C: Royal Tree Ordinances

TITLE VI

CHAPTER 4: TREES

ARTICLE 9 - GENERAL PROVISIONS

9.01 DEFINITIONS. For use in this chapter, the following term is defined:

1. "Parking" means 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.

9.02 ARBORICULTURAL SPECIFICATIONS AND STANDARDS OF PRACTICE.

1. SPACING. All trees hereafter planted shall be planted inside the property lines and not between the sidewalk and the curb.

2. PLANTING. The following regulations shall be followed in the planting of trees within the city.

   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 tip 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. Trees shall be trimmed or pruned according to the following:

   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 precut 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 wound 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.

   g. Improperly healed scars, where callous growth is not established, are to be traced and painted, unless the city designates other treatment.

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

9.03 REMOVAL OF TREES. The city shall have removed, on the order of the council, any tree on the streets of the city 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 constitute a danger to the public or which may otherwise be declared a nuisance.
(Code of Iowa, Sec. 364.12(2c))

9.04 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 fifteen (15) feet above the surface of the street and eight (8) feet above the sidewalks.
(Code of Iowa, Sec. 364.12(2c))

9.05 TRIMMING TREES TO BE SUPERVISED. It shall be unlawful for any person to trim or cut any tree in a street or public place unless the work is done under the supervision of the city.

9.06 ASSESSMENT. If the abutting property owner fails to trim the trees as required in this chapter, the city may serve notice on the abutting property owner requiring him to do so within ten (10) days. If he fails to trim the trees within that time, the city may perform the required action and assess the costs against the abutting property for collection in the same manner as a property tax.

(Code of Iowa, Sec. 364.12(2d&e))

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