Tree Management Plan

City of Ashland, Wisconsin

November 2018

Prepared for:

City of Ashland
2020 6th St E
Ashland, WI 54806

Prepared by:

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This document was funded in part by an urban forestry grant from the State of Wisconsin Department of Natural Resources Forestry program as authorized under s.23.097 Wis. Stat.

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Executive Summary

This plan was developed for the city of Ashland, Wisconsin by ArborPro, Inc., with a focus on the short- and long-term maintenance needs of all inventoried trees. ArborPro completed a inventory of public right-of-way and park trees to better understand the current state of the Urban Forest and to create a framework for future tree care and maintenance planning. This Tree Management Plan was developed by analyzing tree inventory data in relation to the City's current and future Urban Forestry goals. In addition to maintenance and planning needs, this report will address the economic, environmental, and social benefits that trees provide to the city of Ashland.

This management plan is intended to be reviewed, updated, and implemented by the Urban Forestry Coordinator. It is important that the plan be reviewed and updated on a yearly basis. Urban Forestry is not static; things change, goals change, and the City of Ashland must be proactive when managing its trees.

The inventory data associated with this management plan will be stored on the City computer network Urban Forestry File. The information will also be available on the City GIS map with the associated attribute data included for each tree.

Significant Findings from the Inventory

The August and September 2017 tree inventory included trees and stumps within City parks and along public street rights-of-way (ROW). A total of 4,378 sites were recorded during the inventory which included 4,348 trees and 30 stumps. Of the inventoried sites, 3,695 are located along street ROW's and 683 are in city parks. Analysis of the tree inventory found:

1. The five most common species found in Ashland's streets are: Green Ash (452 trees: 12.3%), Red Maple (322 trees: 8.7%), White Spruce (315 trees: 8.6 %), Silver Maple (241 trees: 6.5%), and Crabapple (203 trees: 5.5%).
2. The five most common species found in Ashland's parks are: Green Ash (128: 18.4%), White Spruce (48 trees: 6.9%), Hybrid Elm (36 trees: 5.2%), Crabapple (35 trees: 5.0%), and Arborvitae (35 trees: 5.0%).
3. The three most common young trees (under 6" DBH) are: Red Maple (145 trees: 3.3%), Crabapple (112 trees: 2.5%), and Japanese Tree Lilac (109 trees: 2.5%).
4. The three most common mature trees (over 25" DBH) are: Silver Maple (105 trees: 2.3%), Green Ash (13 trees: 0.2%), and American Linden (9 trees: 0.2%).
5. A total of 90 distinct species of trees were recorded during the inventory.
6. 87% of Ashland's tree population is in 'Fair' or better condition.
7. Trees provide approximately $376,977 in annual environmental benefits.
8. Total Environmental Benefits
    - Energy Savings: $108,079/year.

- Stormwater Interception: valued at $117,827/year.
- Carbon Sequestration: valued at $13,899/year.
- Improved Air Quality: $16,562/year.
- Improved property value associated with aesthetics: $120,620.

9. Total replacement cost for all trees is $2,951,447

Tree Maintenance Needs

Maintenance recommendations recorded during the tree inventory were removal (5%), pruning (94%), and stump removal (1%).

While tree maintenance can be very costly and time consuming, the benefits that trees provide justify the expense. Proper pruning and regular maintenance helps ensure that trees are providing maximum benefits throughout their life span. In addition to maximizing benefits, regular maintenance mitigates tree related risk by removing hazardous limbs, reduces future storm damage clean-up, removes limb conflicts on sidewalks and roadways, improves the overall appearance of urban trees and promotes proper growth patterns in young trees. Trees that pose the highest risk (Priority 1 removal and prunes) should be addressed first to properly mitigate risk and prioritize maintenance. After all Priority 1 trees have been completed the Priority 2 prunes and removals should be addressed.

Several high-risk trees (Priority 1 Prune and Removal) were recorded during the inventory that should be pruned or removed immediately to promote public safety.

Tree Removal and Maintenance Needs

Tree Removal	Priority 1 Removal = 36 trees Priority 2 Removal = 176 trees
Tree Pruning	Priority 1 Prune = 64 trees Priority 2 Prune = 264 trees
Routine Pruning Cycle	2,811 Trees Approximately 562 trees should be pruned each year
Young Tree Training Cycle (<8" dbh)	997 Trees Approximately 332 trees should be structurally pruned each year

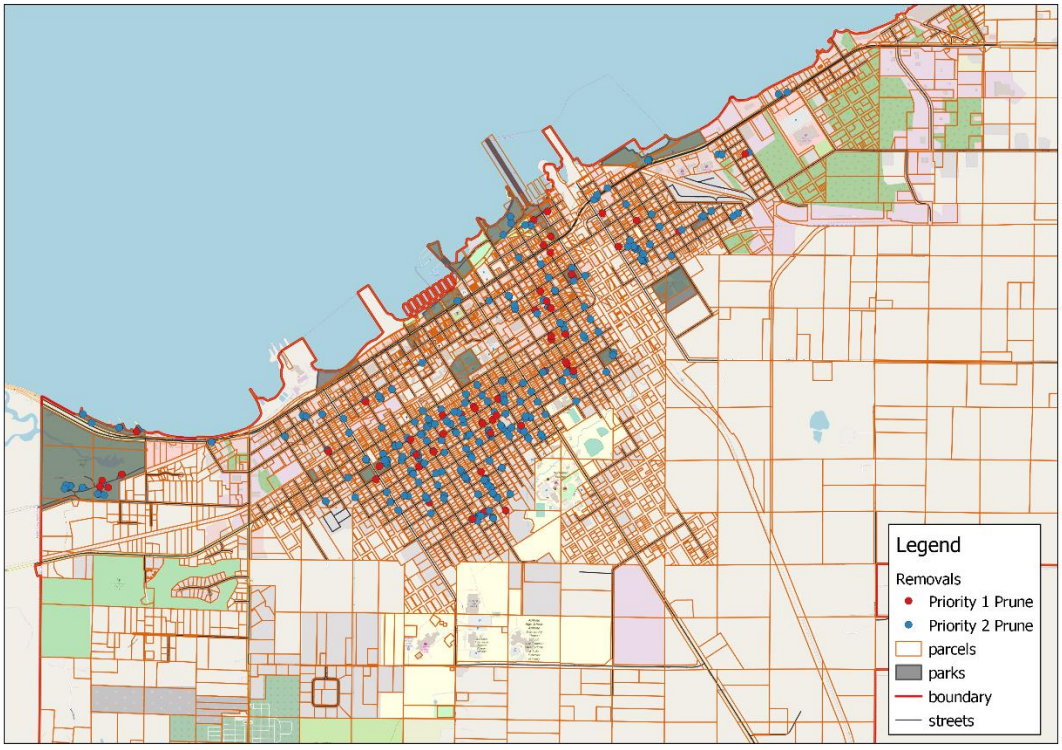
In addition to high priority maintenance and risk mitigation, the City of Ashland would greatly benefit from a routine pruning cycle. The length of this cycle may vary depending on budget and tree maintenance needs, but a five-year cycle is recommended for established trees. For young trees, a three-year young tree training cycle is recommended to improve the structure, health, and longevity of newly planted trees. Based on inventory data, at least 562 trees should be pruned

each year during the routine pruning cycle and at least 332 trees should be structurally pruned each year during the young tree training cycle.

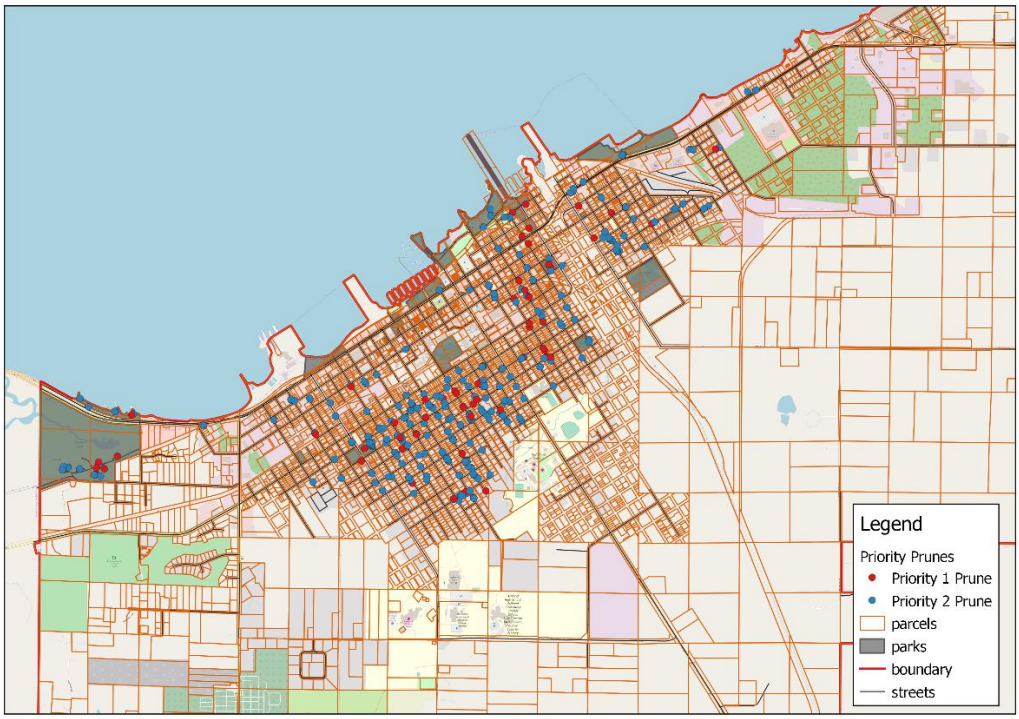
Maintaining a proactive pruning and tree training cycle means that young trees are visited every three years while established trees are pruned every five years. Ashland has a considerable number of newly planted trees and would benefit greatly from a tree training cycle. Proper tree training will reduce structural defects and maintenance needs as trees mature and become established. Investing the time and money to address these issues while trees are young will reduce future pruning costs and help ensure the longevity of newly planted trees. Long-term planning and maintenance cycles will be discussed at length later in this report.

In addition to regular maintenance, tree planting is an important part of a comprehensive tree management plan. Adding new trees to the landscape is necessary to promote canopy growth, offset loss of trees due to natural mortality and other causes, and to increase biodiversity. A variety of tree species should be planted throughout the city to reduce susceptibility to current and future pest outbreaks, offset tree loss due to disease and to increase the overall health of Ashland's urban forest. The availability of vacant planting sites and number of trees to be planted each year will be discussed in more detail later in this report.

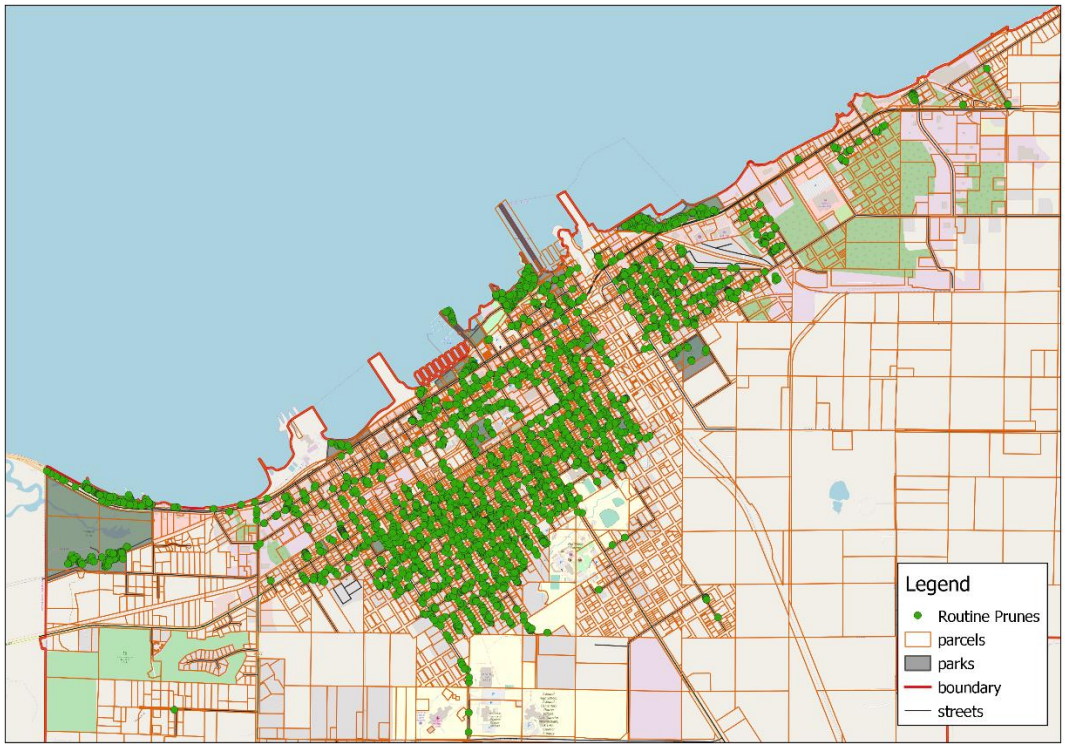
Priority Removals



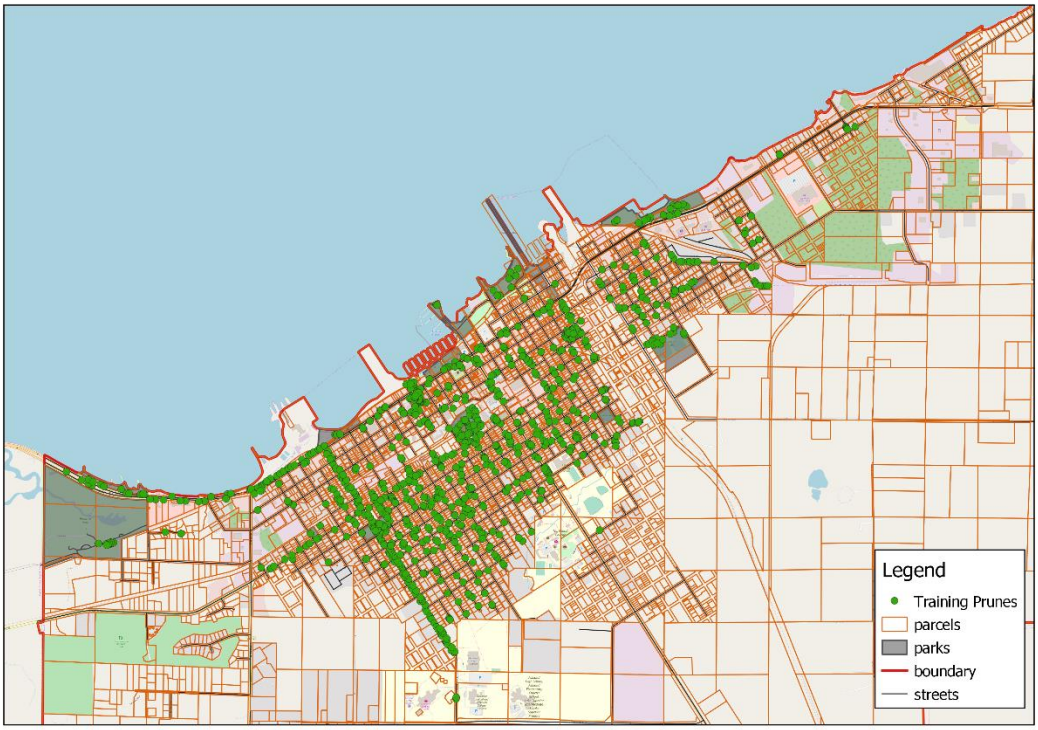
Priority Prunes



Routine Prunes



Training Prunes



Introduction

The City of Ashland is home to more than 8,000 full-time residents. The City is responsible for maintaining thousands of trees in parks, public spaces, and along city street Rights-of-Way. Ashland's trees provide a host of benefits to both residents and visitors. These benefits can only be maximized when trees are properly managed for long-term health and public safety.

Approach to Tree Management

The best approach to successfully managing an urban forest is to implement a proactive, organized program to set goals and monitor progress. The first steps in this process are to complete a tree inventory and to prioritize maintenance functions and goals to guide short- and long-term planning. These tools can be utilized to establish tree care priorities, generate strategic planting plans, draft cost-effective budgets based on projected needs, and ultimately reduce to a minimum the need for costly, reactive solutions to emergency situations.

In August and September 2017, Ashland worked with Arborpro to conduct a comprehensive tree inventory and develop a Tree Management Plan. This plan considers the size characteristics, condition, and species distribution of the inventoried trees and provides a prioritized system for the maintenance of all trees within the survey area. The following tasks were completed:

- Inventory of trees, vacant sites, and stumps along street ROW's and in public parks
- Analysis of tree inventory data
- Development of a plan that prioritizes the recommended tree maintenance

Trees are an important part of a community's green infrastructure, as essential as roads, bridges, or sewer mains. But trees, unlike other types of infrastructure perform better and gain value over time. They are the only infrastructure that improves with age. A tree management plan, like a stormwater, street, or sewer management plan, protects the important infrastructure on which we depend. The tree management plan outlines how Ashland will protect and care for one component of its green infrastructure – its trees. The management plan is divided into six sections:

- Section 1: Highlights and Results of Inventory Data
- Section 2: Benefits of a Healthy Urban Forest
- Section 3: Tree Management
- Section 4: City Staffing and Equipment
- Section 5: Emerald Ash Borer Management Strategies
- Section 6: Invasive Pests and Diseases

Section 1: Highlights and Results of Inventory Data

In August and September of 2017, ArborPro, Inc. assigned an ISA Certified Arborist to update its existing inventory of trees along City street rights-of-way and in public parks. The park trees inventoried only include those trees in open space use areas. Densely forested park areas were not included in this inventory. A total of 4,378 sites were collected which included 4,378 trees and 30 stumps. Table 1 shows a breakdown of sites collected by area.

Area	Count
Bay City Park	3
Bay View Park	113
Beaser Park	27
Central Railroad Park	66
Ellis Park	27
Hodgkins Park	24
Howard Pearson Plaza	46
Kreher RV Park	81
Marina Park	17
Maslowski Beach	112
Memorial Park	27
Menard Park	12
Pearson Park	17
Penn Park	4
Prentice Park	107
Total	**683**
Street Trees	3,695
Grand Total	**4,378**

Table 1: Trees collected by area

Park trees have been included in the total inventory and will not be treated differently than street trees for maintenance activities. Each park is included in the maintenance block in which it falls and trees in these parks will be pruned or removed at the same time as street trees when considering the five-year maintenance plan.

Methods of Data Collection

Tree inventory data were collected using ArborPro's proprietary software. The software, ArborPro version 3.5.1, is loaded on pen-based tablets and is equipped with geographic information systems (GIS) and uses aerial imagery and global position system (GPS).

The following data fields were collected at each tree location:

- Address
- Condition
- Grow space type
- Grow space size
- Hardscape Damage
- Mapping coordinates
- Observations
- Overhead utilities
- Recommended maintenance
- Side
- Species
- Tree diameter

- Notes

Assessment of Tree Inventory Data

Professional judgement based on experience and industry standards are used to determine maintenance recommendations. Data analysis is then used to summarize and make generalizations about the state of the inventoried urban forest. Understanding and recognizing these trends will help guide short- and long-term management planning. The following criteria of the inventoried tree population are summarized in this section of the management plan:

- Size characteristics
- Tree condition
- Species and genus distribution
- Hardscape damage

Size Characteristics

The general size of a tree provides insight into the age and value of the tree as well as the overall age of the urban forest. There are two industry-wide recognized size characteristics, height and diameter at breast height. While height is self-explanatory, diameter at breast height (DBH) is determined by the diameter of the tree at 4.5 feet above grade. DBH range distribution can be used to analyze the relative age distribution of an urban forest. This allows a city to adjust their planting plans to ensure that there are enough young trees to replace aging and over-mature trees. It is important that all age classes are adequately represented throughout the urban forest to ensure a healthy, vibrant tree canopy for future generations. Table 2 and Figure 1 illustrate the distribution of trees by diameter class.

DBH (inches)	Tree Count	%
00"-03"	678	15.5%
04"-06"	916	20.9%
07"-12"	1510	34.5%
13"-18"	806	18.4%
19"-24"	263	6.0%
25"-30"	123	2.8%
31"-36"	58	1.3%
37"-42"	21	0.5%
43+	3	0.1%
Total	**4,378**	

Table 2: Diameter class distribution by count and percentage

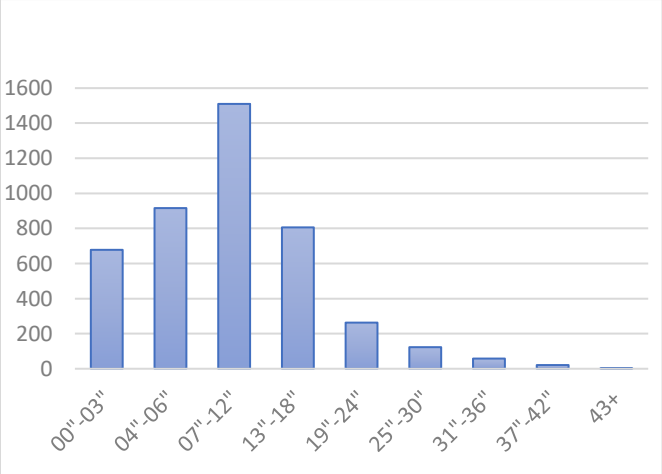


Figure 1: Diameter class distribution

Discussion

As can be seen by the above graph and table, Ashland has a desirable distribution of size classes throughout the city. There are many young trees that have been planted as well as a significant number of semi-mature and mature trees (7-18-inch dbh). As the older trees start to decline and be removed from the landscape, these younger trees will establish themselves as the dominant

source of canopy cover for the city. **Arborpro recommends continuing to plant new trees to further improve canopy cover.**

Tree Condition

Tree condition is not necessarily about desirability but is a subjective, qualitative, representation of overall health, vigor, and structure. Likewise, appearance is not a complete indication of overall condition. Table 3 and Figure 2 show the number of trees recorded in each condition as well as the percentage of the total population that they represent.

Excellent – The tree has no structural problems or damage from pests or disease. Many trees in this condition class are specimen trees for that species. Trees in this category are considered to be in 100% health.

Very Good – The tree has very minor structural problems or damage from diseases or pests; no significant mechanical damage; a full, balanced crown, and normal twig condition and vigor for its species. Trees in this category are considered to be in 90% health.

Tree Condition	Tree Count	%
Excellent	17	0.4%
Very Good	493	11.3%
Good	1,595	36.4%
Fair	1,715	39.2%
Poor	488	11.1%
Critical	1	0.0%
Dead	39	0.9%
Stump	30	0.7%
Total	**4,378**	

Table 3: Tree condition by count and percentage

Good – The tree has no major structural problems; no significant damage from diseases or pests; no significant mechanical damage; a full, balanced crown, and normal twig condition and vigor for its species. Trees in this category are considered to be 80-90% healthy.

Fair – The tree may exhibit the following characteristics: minor structural problems and/or mechanical damage; significant damage from non-fatal or disfiguring diseases; minor crown imbalance or thin crown; minor structural imbalance; or stunted growth compared to adjacent trees. Trees in this category are considered to be 60-80% healthy.

Poor – The tree can appear healthy, but may have structural defects. This classification also includes healthy trees that have unbalanced structures or have been topped. Trees in this category may also have severe mechanical damage, decay, severe crown dieback or poor vigor/failure to thrive. Trees in this category are considered to be 40-60% healthy.

Critical – The tree is in a physical state that requires immediate attention. Generally, these trees are recommended for a Priority One Removal. Trees in this category are considered to be 20-40% healthy.

Dead – This category refers only to trees that are completely dead. Trees in advanced states of decline but still alive are generally recorded as poor or critical but not dead.

Stump – Stumps that interfere with pedestrian traffic or pose a tripping hazard. Stumps are not included in dead tree count.

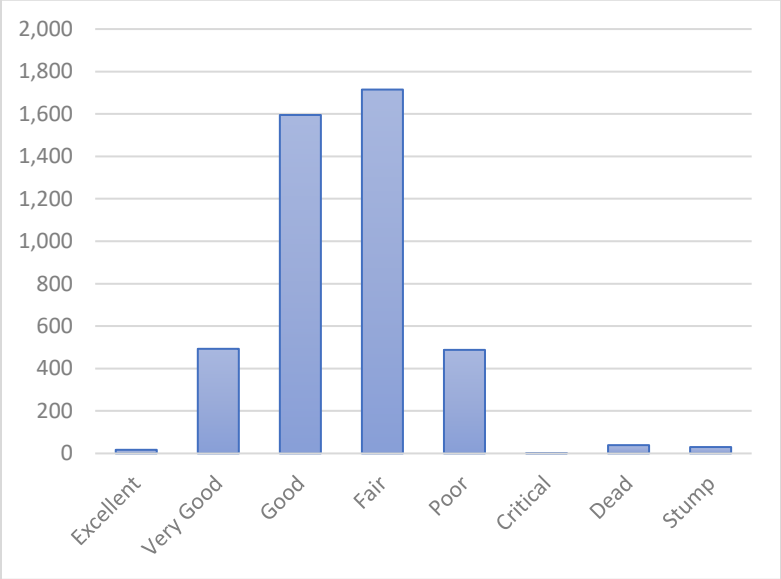
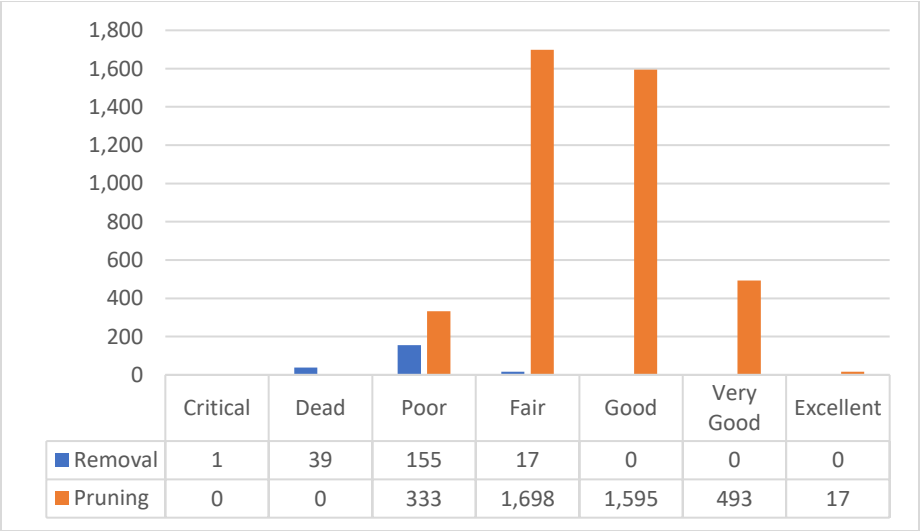


Figure 2: Tree condition by count and percentage

Discussion

A majority of trees in Ashland (87%) were observed to be in either 'Fair' or better condition at the time of the inventory. Therefore, the overall health and condition of the City's trees would be rated as Good. However, around 11% of the City's trees are in poor condition and another 1% are dead or considered to be in 'Critical' condition. All 'Critical' trees should be pruned or removed immediately to promote public safety and dead trees should be removed according to the maintenance schedule outlined later in this plan. Trees in 'Poor', 'Fair', 'Good', 'Very Good' or 'Excellent' condition should be pruned or removed according to the Recommended Maintenance categories that they were assigned at the time of the inventory. Figure 3 shows the maintenance recommendations by condition.



	Critical	Dead	Poor	Fair	Good	Very Good	Excellent
Removal	1	39	155	17	0	0	0
Pruning	0	0	333	1,698	1,595	493	17

Figure 3: Maintenance recommendations by condition

Species and Genus Distribution

Understanding species and genus distribution is important when determining which species should be planted and which ones are currently overrepresented in the urban forest. Biodiversity is extremely important to the overall health and longevity of a tree population. The Wisconsin DNR's accepted guideline for urban biodiversity is the 5-10-20 rule. This means that no species should represent more than 5%, no genus should represent more than 10% and no family should represent more than 20% of the total tree population. Figure 4 shows the distribution of genera representing 2% or more of the total tree population.

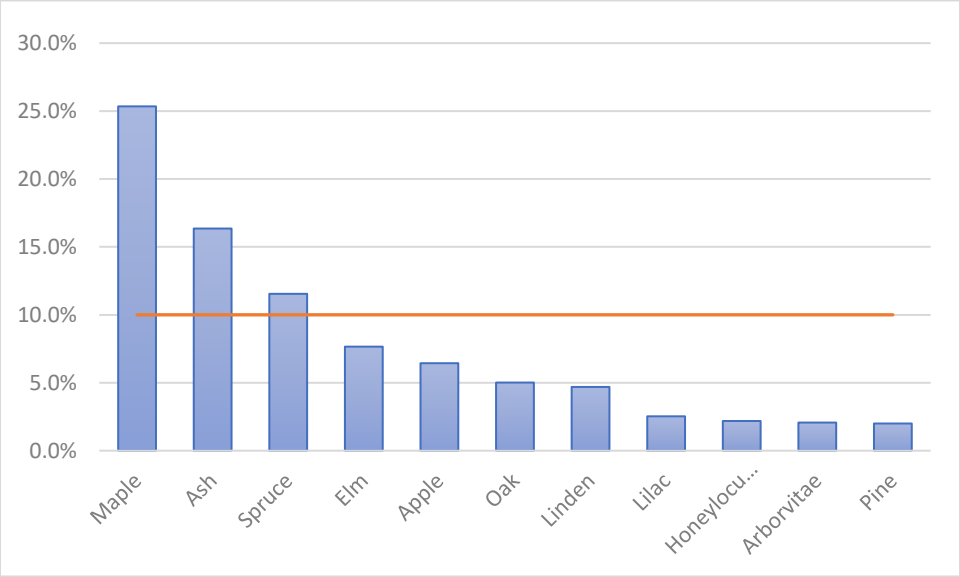


Figure 4: Genus distribution by count and percentage over 2%

Table 4 contains the top 10 most common trees in Ashland by count and percentage of the total tree population. A full species frequency report can be found in Appendix A.

Botanical Name	Common Name	Count	%
Fraxinus pennsylvanica	Green Ash	580	13.2%
Picea glauca	White Spruce	363	8.3%
Acer rubrum	Red Maple	345	7.9%
Acer saccharinum	Silver Maple	243	5.6%
Malus floribunda	Crabapple Species	238	5.4%
Ulmus x species	Hybrid Elm	213	4.9%
Acer saccharum	Sugar Maple	174	4.0%
Tilia americana	American Linden	148	3.4%
Quercus rubra	Red Oak	144	3.3%
Acer plantanoides	Norway Maple	139	3.2%

Table 4: Ten most common species by percentage of total population

When compared to the data collected in 2004, it is apparent that the percentage of the most common species in Ashland relative to the population as a whole has decreased. This means that Ashland has been increasing biodiversity by planting different species to offset the number of problem species (ash, silver maple, etc.) in its urban forest. For example, in 2004 green ash represented 19% of the total population while in 2017 it only represents 13.2% of the population. Figure 5 shows a comparison of the top ten species in 2004 to the current species distribution.

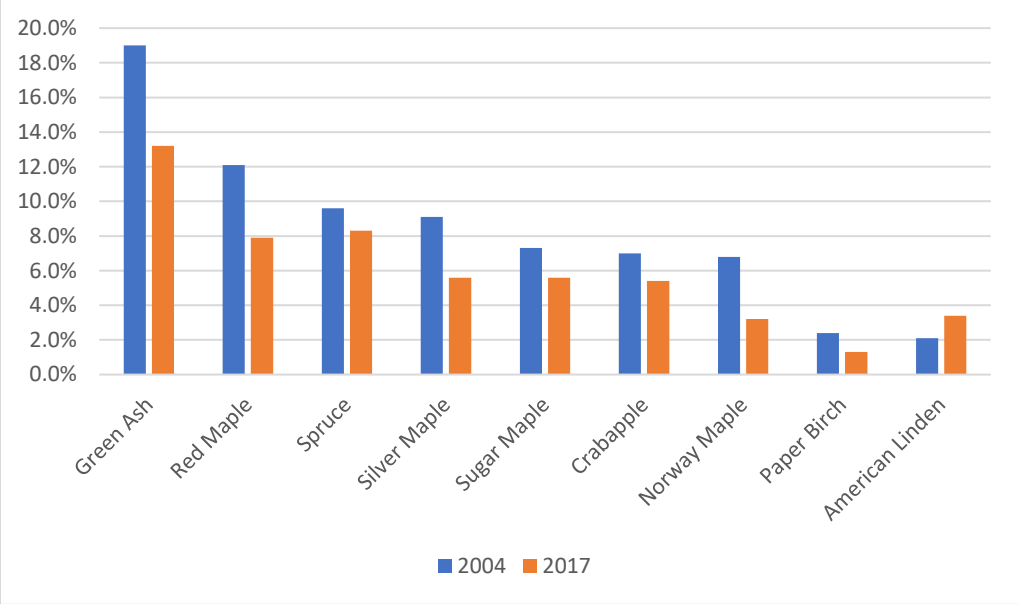


Figure 5: Comparison of species distribution from 2004 to 2017 as a percentage of the total population

Discussion

The City of Ashland maintains 90 distinct species of urban trees. The distribution of these trees across species, genus, and family trends toward ideal but could be improved over time. ArborPro recommends the City of Ashland discontinue planting maple, spruce, and ash trees as they all break the recommended 10% threshold for a particular genus. Trees in the genus maple make up nearly 8% of the City's urban forest. While it is common for most cities to have an excess of maple, it leaves Ashland susceptible to future outbreaks of insects and diseases. This risk can be mitigated by analyzing the current list of species being planted by the City and focusing on species that do well in the area and actively promote biodiversity in the landscape.

Conflicts with Hardscape

Hardscape damage was recorded where tree roots were actively interfering with sidewalks. When roots interfere with sidewalks they typically cause upheaval and may result in a tripping hazard. While root conflicts only affected 8.7% of the total tree population, these conflicts should be addressed to reduce the risk of a trip and fall accident.

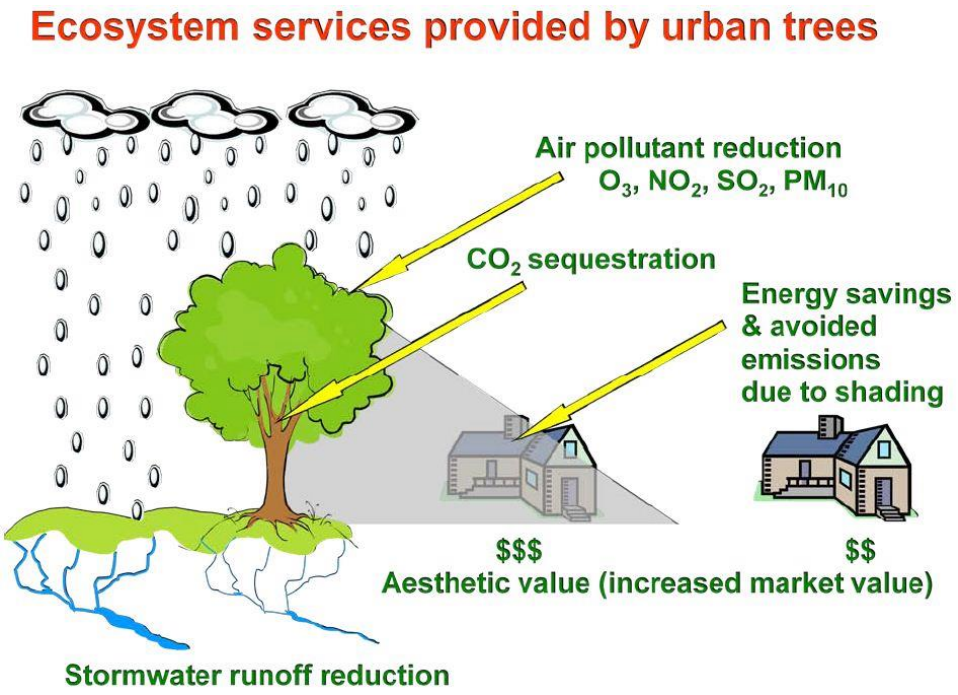
Hardscape Damage	Tree Count	%
None	3,997	91.3%
Sidewalk	381	8.7%
Total	**4,378**	

Table 5: Hardscape Damage by Count and Percentage

Section 2: Benefits of a Healthy Urban Forest

Trees provide a host of environmental, social, and economic benefits in urban areas. When properly maintained, trees can reduce pollution, improve mental health, and lower energy costs. It is important to understand the benefits trees provide as they can offset the cost associated with tree maintenance. A properly implemented tree maintenance program will maximize tree benefits in the urban setting, allowing trees to provide benefits that meet or exceed the time and money invested in maintenance activities.

The i-Tree Streets application was used to quantify the benefits provided by Ashland's trees. This application uses growth and benefit models designed around predominant urban trees to calculate the specific benefits that trees provide in dollar amounts. The benefits calculated by i-Tree Streets include energy conservation, air quality improvements, carbon dioxide (CO_2) reduction, stormwater control, and aesthetic/other. It creates annual benefit reports that demonstrate the value urban trees provide to the surrounding community.



Energy Conservation

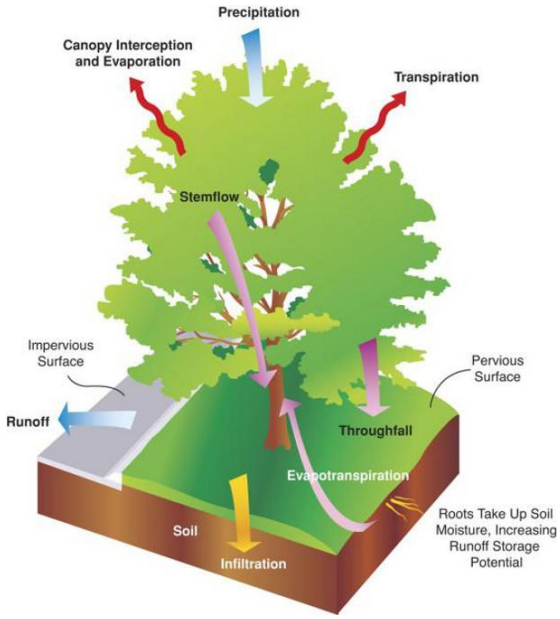
Public trees contribute to energy conservation by providing shade that reduces cooling costs in the summer and diverting wind to reduce heating costs in the winter. The savings in electricity and natural gas are converted into monetary values to illustrate the annual energy savings that trees provide. Ashland's trees account for a savings of $108,079 in energy consumption each year.

Air Quality

Trees improve air quality by removing a number of pollutants from the atmosphere, including ozone, nitrogen dioxide, and particulate matter. The estimated value of pollutants removed by the inventoried tree population each year is $16,562.

Carbon Dioxide Sequestration

It is well known that trees absorb carbon dioxide and release oxygen into the atmosphere as a product of photosynthesis. Carbon absorbed during this process is ultimately stored in the wood of trees. The amount of carbon sequestered by the inventoried tree population is valued at $13,899 annually.



Stormwater Control

Trees reduce the costs associated with diverting stormwater by intercepting rainfall before it hits the ground and enters the storm runoff system. This greatly reduces the strain placed on public stormwater runoff systems and can represent a significant monetary savings by reducing the amount of infrastructure needed to divert stormwater throughout the city. The estimated savings for the City in the management of stormwater runoff is $117,827 annually.

Aesthetic/Other

Trees provide many social and economic benefits that are classified as aesthetic/other in the i-Tree Streets application. The major economic benefit in this category is increased property values. Trees contribute to higher property values when compared to similar properties that do not have trees. The major social benefits provided by trees are lower crime rates, improved mental health, greater time spent in businesses with tree lined streets, and higher productivity in the workplace when a view of nature is available. The inventoried trees in Ashland contribute $120,620 annually in aesthetic/other benefits.

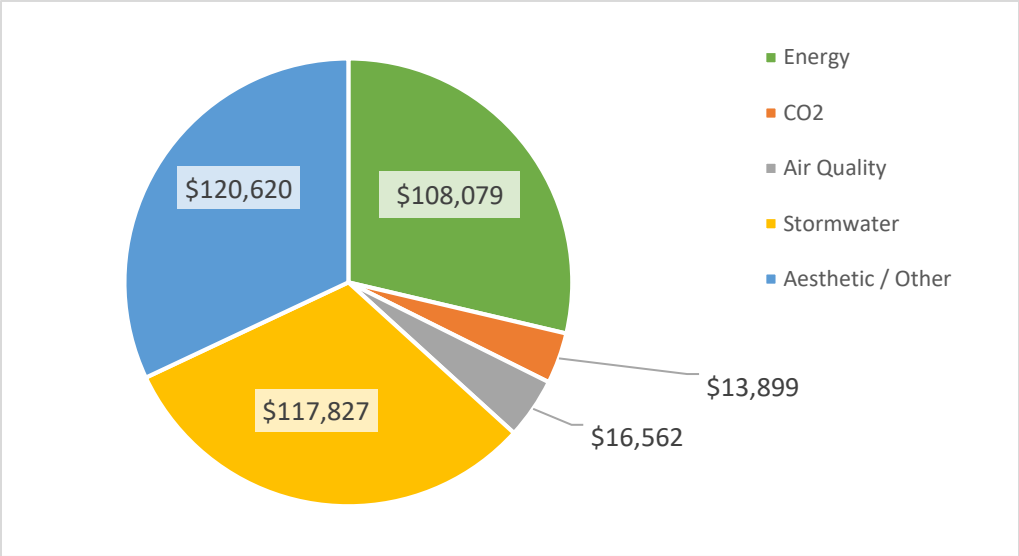


Figure 6: Annual monetary benefits provided by Ashland's trees

Total Replacement Value

In addition to Environmental Benefits, the City can consider the Total Replacement Value for its urban forest. Total Replacement Value is the amount of money it would take to completely replace the existing urban forest with trees of the same size. While this is a scenario that will likely never happen, it gives the City a specific dollar value of its trees in their current state. Replacement value differs from Environmental Benefits in that it shows how much the trees are worth instead of the dollar values that they provide in benefits. For example, a mature sugar maple could provide $2,100 in environmental benefits by reducing stormwater runoff, improving air quality, etc. but the total cost of replacing an 18" DBH sugar maple would be $24,270. According to i-Tree Streets, the total replacement cost for Ashland's trees is $2,951,447. Table 6 shows the breakdown of Replacement Value by Diameter Class.

DBH Class	Replacement Value
00"-03"	$79,839
04"-06"	$338,805
07"-12"	$796,896
13"-18"	$771,376
19"-24"	$401,898
25"-30"	$290,308
31"-36"	$158,321
37"-42"	$102,509
43+	$11,495
Total	**$2,951,447**

Table 6: Replacement Value by Diameter Class

Section 3: Tree Management

The purpose of this tree management plan is to provide a framework for the short- and long-term maintenance of Ashland's urban trees. It is also meant to complement and enhance the existing maintenance program. The main goal of this five-year program is to reduce risk by prioritizing maintenance while establishing a proactive pruning schedule.

It is also important to recognize that the tree inventory data provides a snapshot of the current conditions of Ashland's trees. Prioritized tree maintenance will help reduce the overall risk of tree related catastrophes. However, it is important to note that conditions can change drastically and routine maintenance should be coupled with the identification and monitoring of trees that may become hazardous in the future. The focus of this report is to identify and mitigate the trees that were deemed maintenance prioritizations at the time of the inventory while planning for the future through proactive maintenance.

Maintenance activities have been broken down into a five-year plan. In order to facilitate this plan, the City has been divided into five Maintenance Blocks based on naturally occurring street boundaries. A description of Maintenance Blocks can be found later in this report.

Recommended Maintenance and Tree Risk

Below is a description and summary of the maintenance recommendations for the entire inventory. As the names imply, Priority 1 pruning and removals pose the highest risk and should be dealt with first. Priority 2 pruning and removals should be considered after all Priority 1 pruning and removal has been completed. The remaining trees will be considered as either routine pruning or young tree training activities that can be proactively pruned on a five-year and three-year basis respectively. Following is a description for each maintenance recommendation.

Priority 1 Prune - Trees that require priority 1 pruning are recommended for trimming to remove hazardous deadwood, hangers, or broken branches. These trees have broken or hanging limbs, hazardous deadwood, and dead, dying, or diseased limbs or leaders greater than four inches in diameter. The number of trees in this category is unrelated to the previous chart. There are dead and poor trees that are small in size and not considered a priority one removal.

Maintenance	Tree Count	%
Priority 1 Prune	64	1.5%
Priority 1 Removal	36	0.8%
Priority 2 Prune	264	6.0%
Priority 2 Removal	176	4.0%
Routine Prune	2,811	64.2%
Training Prune	997	22.8%
Stump Removal	30	0.7%
Total	**4,378**	

Table 7: Recommended maintenance by tree count

Priority 1 Removal - Trees designated for removal that have defects which cannot be cost-effectively or practically treated. A majority of trees in this category have a large percentage of dead crown and pose an elevated level of risk for failure. Any hazards that cannot be mitigated with pruning that could be seen as potential dangers to persons or property and seen as potential liabilities would be in this category. Large dead and dying trees that are high liability risks are included in this category.

Priority 2 Prune - Trees that require priority 2 pruning are recommended for trimming to remove deadwood, correct structural problems, or resolve clearance issues. These trees do not pose as much risk as "Priority 1" trees.

Priority 2 Removal - Trees that should be removed but do not pose a liability as great as the first priority will be identified here. This category would need attention as soon as "Priority 1" trees are removed.

Routine Prune - These trees require routine horticultural pruning to correct structural problems or growth patterns, which would eventually obstruct traffic or interfere with utility wires or buildings. Trees in this category are large enough to require bucket truck access or manual climbing.

Training Prune - Young, large-growing trees that are still small must be pruned to correct or eliminate weak, interfering, or objectionable branches in order to minimize future maintenance requirements. These trees, up to 12 feet in height, can be worked with a pole-pruner by a person standing on the ground.

Stump Removal – Stumps that interfere with pedestrian traffic and pose a tripping hazard, typically located in high use areas.

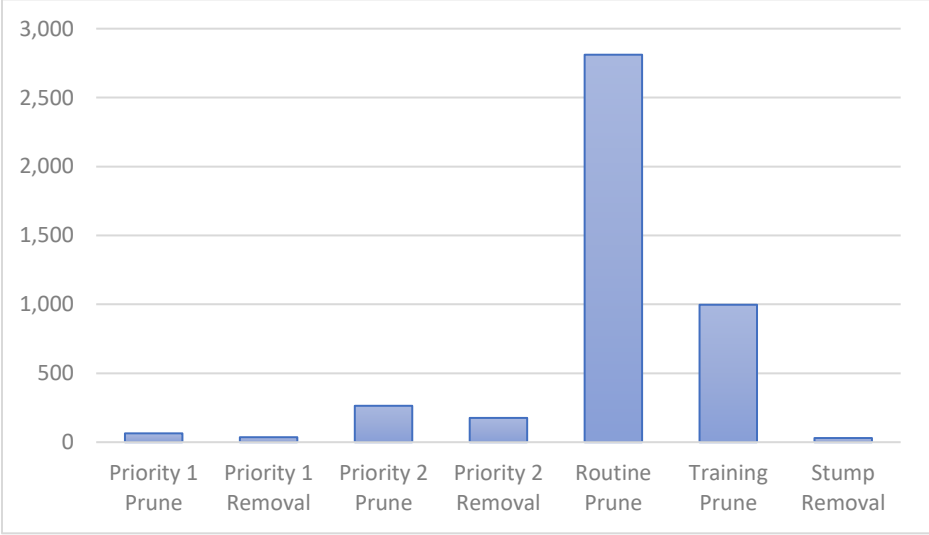


Figure 7: Breakdown of recommended maintenance

Priority and Proactive Maintenance

Not all communities are able to implement a proactive maintenance schedule and often rely on an on-demand response to hazardous or urgent situations. **However, a proactive program systematically reduces risk while improving the overall health of urban trees**. A proactive program will also help stabilize maintenance budgets and improve long-term planning.

In this plan, we chose to use a five-year cycle for routine tree trimming and a three-year cycle for young tree training. As previously explained, this involves pruning each tree every five years while conducting structural pruning on young trees every three years. These activities are considered proactive maintenance while trees in the Priority 1 and 2 categories are priority maintenance.

Priority Maintenance

Identifying and prioritizing the maintenance of a tree population allows tree work to be assigned based on observed risk. Once prioritized, the work can be approached systematically to mitigate risk by addressing the highest priority trees first. In this plan, all trees designated as Priority 1 prunes and removals will be considered first. Priority 2 prunes and removals will be considered after all Priority 1 trees have been addressed. Trees in the Routine Prune and Training Prune category will be entered into the proactive maintenance schedule discussed previously.

Priority Removals

While tree removal is often a last resort, there are situations where it cannot be avoided. In parks and other high-use areas, creating a safe environment is more important than preserving hazard trees that may have a social or cultural significance.

Trees in the Priority 1 Removal category pose a risk that cannot be mitigated through pruning. It is recommended that these trees be removed in the first year of the five-year maintenance plan. The inventory found a total of 36 trees that were assessed to be Priority 1 Removals. Figure 8 shows a breakdown of the number of Priority 1 removals by diameter class.

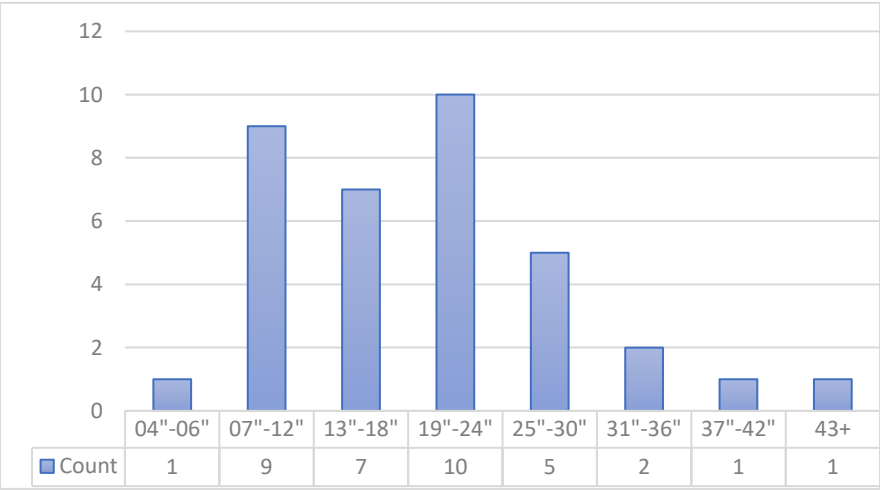


Figure 8: Priority 1 Removals by diameter class

Priority 2 Removals do not pose significant risk to people or property and should be addressed after all Priority 1 Removals have been completed. It is recommended that these trees be removed in the second year of the five-year maintenance plan. The inventory found a total of 176 Priority 2 Removals. Figure 9 shows a breakdown of the number of Priority 2 removals by diameter class.

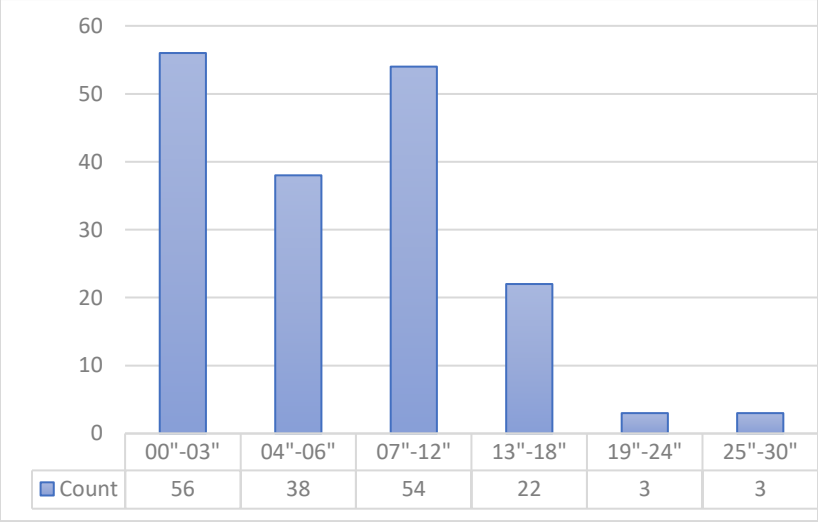


Figure 9: Priority 2 Removals by diameter class

Priority Pruning

Trees in the Priority 1 Prune category pose a high risk to public safety that can be mitigated through pruning. It is recommended that these trees be pruned in the first year of the five-year maintenance plan or sooner if possible. The inventory found a total of 64 Priority 1 Prunes. Figure 10 shows a breakdown of the number of Priority 1 Prunes by diameter class.

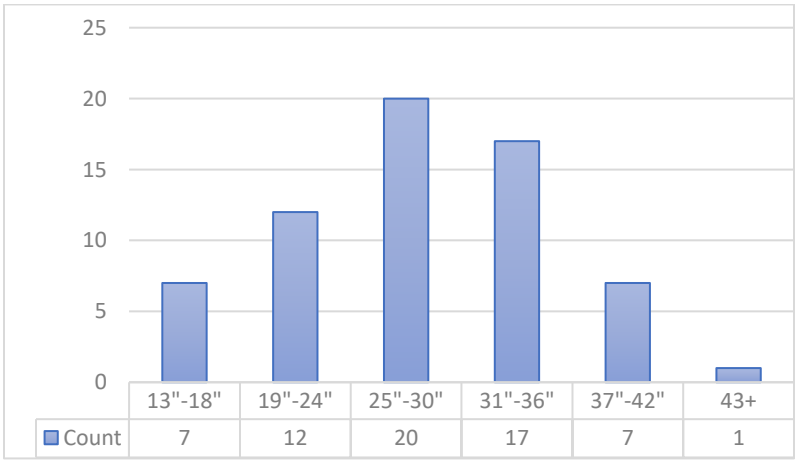


Figure 10: Priority 1 Prunes by diameter class

Trees in the Priority 2 Prune category pose a limited risk to public safety that can mitigated through pruning. It is recommended that these trees be pruned in the first and second year of the

five-year maintenance plan. The inventory found a total of 264 Priority 2 Prunes. Figure 11 shows a breakdown of the number of Priority 2 Prunes by diameter class.

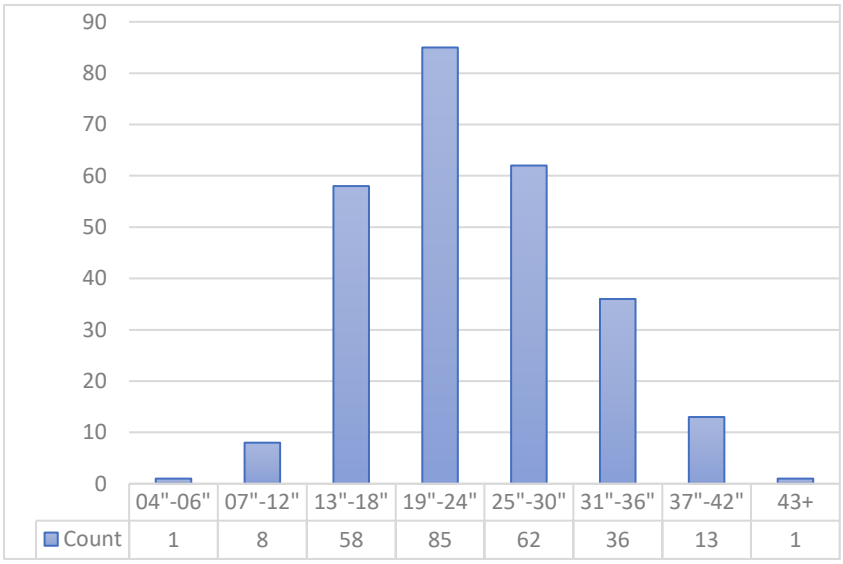


Figure 11: Priority 2 Prunes by diameter class

Proactive Maintenance

Proactive tree maintenance requires that trees are systematically managed over time. To accomplish this, trees are placed in a pruning cycle in which tree health and form are routinely addressed. While it may be costly to implement a routine pruning cycle, it will reduce both risk and maintenance costs over time. Maintaining a routine pruning cycle will allow the City to address minor maintenance needs on a regular basis. Over time this will reduce the number of emergency situations and will allow the City to regularly monitor potential problem trees.

Routine Pruning Cycle

The routine pruning cycle includes all trees that were entered as a Routine Prune during the inventory. These trees pose little to no risk and could benefit from regular pruning to mitigates tree related risk by removing hazardous limbs, reduce future storm damage clean-up, remove limb conflicts on sidewalks and roadways, improve the overall appearance of urban trees and promote proper growth patterns in young trees. The length of a routine pruning cycle depends on the size of the tree population and ArborPro recommends a five-year cycle for the trees included in the inventory. This means that approximately one-fifth of the tree population will need to be pruned each year. This number will fluctuate as trees are removed, priority maintenance is completed, and young trees grow into maturity. This report and five-year maintenance plan will only consider trees in the Routine Prune category at the time of the inventory for the routine pruning cycle.

The 2017 tree inventory found a total of 2,811 trees that would benefit from routine pruning. This means that approximately 562 trees (one-fifth of the total population) will need to be pruned each year, starting in year three of the five-year maintenance plan. The city has been broken up

into five maintenance blocks that coincide with the routine pruning plan. After all priority maintenance has been completed, each block can be pruned every five years to ensure that all trees are benefiting from proactive maintenance. Figure 12 shows a breakdown of the number of Routine Prunes by diameter class.

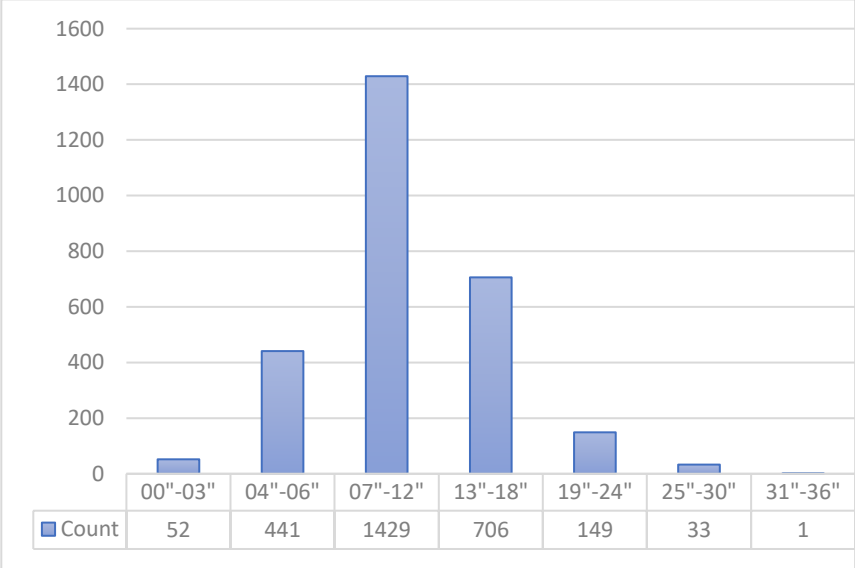


Figure 12: Routine Prunes by Diameter Class

Young Tree Training Cycle

Planting trees is necessary to increase canopy cover and to replace trees lost to natural causes (expected to be 1–3% per year)

Although the City of Ashland has an adequate number of newly planted trees, planting additional trees will help promote a healthy urban forest for years to come. It is also important to remember that older, more mature trees provide the most benefits to the community. The City must promote tree preservation and proactive tree care to ensure older trees survive as long as possible. One of Ashland's objectives is to have an uneven-aged distribution of trees at the street, neighborhood and citywide levels. **ArborPro recommends that Ashland support a strong planting and maintenance program to ensure that young, healthy trees are in place to fill in gaps in tree canopy and provide for gradual succession of older tree**s. Tree planting and tree care will allow the distribution to normalize over time.

Trees included in the Young Tree Training Cycle are typically less than 8 inches DBH and will benefit from structural pruning. Young trees tend to have higher growth rate and therefore require a shorter pruning cycle than mature trees. For this reason, ArborPro recommends a three-year cycle for young tree training.

Establishing a training cycle for young trees is equally important for Ashland Parks. A significant amount of money has been spent to plant new trees in many of the parks. Investing time and money to properly prune these trees will greatly reduce future structural problems and maintenance issues. Figure 13 illustrates the number of trees that would benefit from young tree training.

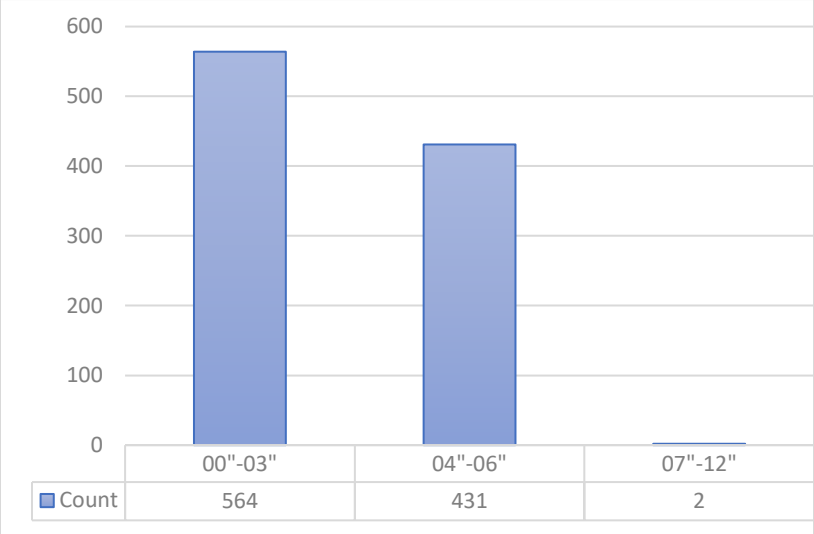


Figure 13: Number of trees in the young tree training cycle

The three-year young tree training cycle should begin on year three of the maintenance plan and will only include existing young trees for the sake of this management plan. One-third of young trees should be structurally pruned each year. In reality, the number of trees in the training cycle will fluctuate as new trees are planted and as older plantings become established and no longer require training. Therefore, the amount of money spent and the number of trees in the training cycle will not remain constant.

The inventory found a total of 997 trees under 8 inches DBH that would benefit from structural pruning. This means that approximately 333 trees (one-third of the total population) should be trained each year beginning in year three of the five-year maintenance plan. However, if budget allows, the young tree training cycle could be moved to year one to benefit all of the recently planted trees.

Tree Planting

Tree planting is a very important part of any comprehensive Urban Forestry Management Plan. Planting new trees will increase canopy cover, promote biodiversity, and offset the loss of trees due to natural mortality and storm related tree loss. A total of 629 vacant sites were recorded in core residential areas within the City of Ashland. This number includes 463 large vacant sites and 166 small vacant sites. The following criteria were used to determine vacant site size:

- Large tree: 40 feet tall or greater at maturity. Spacing should be 45 feet minimum.
- Medium tree: 30-40 feet tall at maturity. Spacing should be 35 feet minimum.

- Small tree: Less than 30 feet tall at maturity. Spacing should be 25 feet minimum.

Large tree planting sites generally meet the following guidelines:

- Terrace area width between curb and sidewalk at least 7 feet wide.
- Do not have any overhead power line conflicts.
- Are far enough away from buildings, other trees, etc. for mature growth without conflict.

Small to medium tree planting sites generally meet the following guidelines:

- Terrace area width less than 7 feet wide. 4 feet wide is recommended minimum width.
- May have overhead utility lines but will not conflict with mature small trees.
- May be in close proximity to buildings but no conflicts expected.

Currently, Ashland has set the goal of planting a minimum of 25 trees per year. This number is based on the Urban Forestry Budget and availability of City Staff to accommodate planting. It is recommended that the City increase the number of trees planted each year as the budget allows. At the rate of 25 trees per year, it will take roughly 25 years to fill the number of recorded vacancies.

Maintenance Blocks and Routine Pruning

In order to simplify and better organize routine pruning cycles, the city has been divided into five distinct maintenance blocks. These blocks can be used to direct work scheduling and ensure that all trees are regularly maintained. Starting in year three, after all priority maintenance has been addressed, routine pruning should start in Block 1 and move progressively through all five blocks until the entire city has been covered. The maintenance blocks can also be used to schedule young tree training in conjunction with routine pruning activities. All young trees can be trained in each block on a rotating basis at the same time that mature trees are being pruned. The blocks were created using city streets as natural boundaries to break the city into five similarly sized areas. The priority maintenance should be completed as a separate task and these blocks will only apply to routine pruning and young tree training activities. The image below shows the five maintenance blocks, a more detailed image of each block can be found in Appendix B.

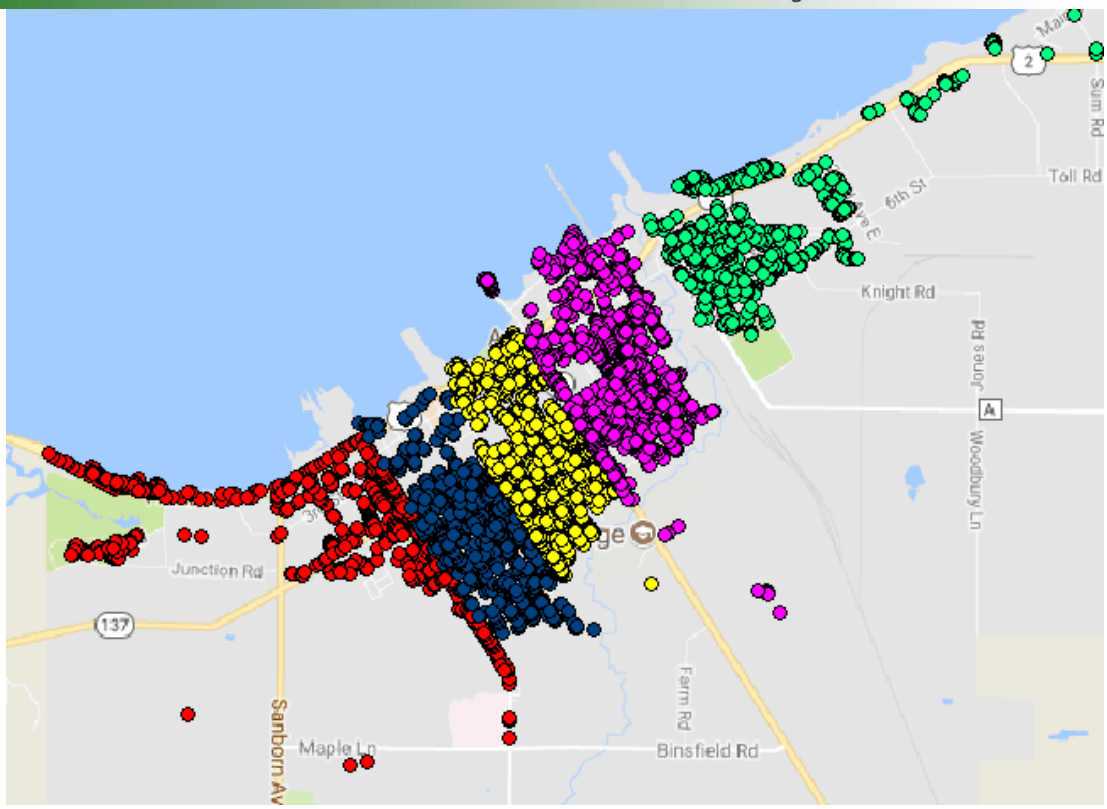


Figure 14: Maintenance Blocks for Routine Pruning

As mentioned above, maintenance blocks should only be used for routine pruning and young tree training activities. Prioritized maintenance should be completed independent of maintenance blocks to mitigate tree related risk in a timely manner. Table 8 shows the number of trees in the Routine Prune and Young Tree Train category by maintenance block.

Area	Routine Prune	Training Prune
Maintenance Block 1	411	212
Maintenance Block 2	598	199
Maintenance Block 3	606	243
Maintenance Block 4	697	215
Maintenance Block 5	495	128
Total	**2,807**	**997**

Table 8: Routine Maintenance by Area

Importance of Tree Maintenance

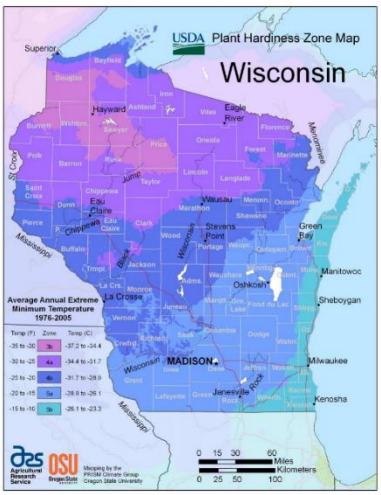
Trees are naturally occurring, organic organisms and are often treated as though they do not need human interference to thrive. While this may be true in undisturbed forests, it is certainly not true for urban trees. Urban trees require regular maintenance to maximize the benefits they provide. When maintenance is neglected, trees can pose a serious risk to people and property. Trees in poor health also represent a liability to the agencies tasked to maintain them. In addition, trees in urban environments are subject to many more stressors than trees in forests or rural areas. Urban trees grow in restricted spaces, are exposed to pollutants and road salt, are subject to soil compaction and can be easily damaged by mowers or other maintenance activities.

Proactive pruning and hazard mitigation greatly reduce the risk of tree failure and subsequent damage. In addition, proactive maintenance will prolong the life of a tree and reduce future maintenance costs. A well-maintained urban forest will be less susceptible to disease and disaster. Trees that are regularly pruned and maintained will not be as prone to disease as trees that have been neglected. When trees are pruned on a regular basis and removed when they become diseased or hazardous, it eliminates some of the pathways for potential pests and diseases. Many of these pests and diseases attack stressed trees or enter through open wounds or dead branches. Therefore, a well-maintained urban forest will be less likely to succumb to pest infestations. In addition, species selection is an important part of maintaining a healthy urban forest. Careful species selection will increase biodiversity and reduce the risk of a catastrophic pest infestation. Most pests have preferred hosts (EAB for example) so increasing biodiversity will limit the number of species that are susceptible to individual pests.

While it is impossible to predict when a natural disaster will strike, a level of disaster preparedness can be achieved through regular maintenance. Trees that have been pruned to remove dead or hanging limbs will be less likely to experience branch failure in high winds, thus reducing storm damage clean-up. Also, removing diseased or declining trees from the landscape will reduce the risk of whole tree failure in major storm events.

The importance of urban tree maintenance cannot be understated. A well-maintained urban forest will provide maximum benefits to the community while reducing the inherent risk of tree failure.

Tree Species Selection



Newly planted trees represent a significant investment of city resources. Selecting the proper species for the desired location will help ensure the long-term success of new trees. Trees should be selected based on their size at maturity, their ability to handle the stress of urban environments, and their compatibility with local weather conditions (often referred to by the USDA as Hardiness Zone). Ashland is in Zone 4b and trees should be selected based on their compatibility with this Hardiness Zone. In addition, a variety of species should be planted to promote biodiversity and reduce susceptibility to outbreaks of pests and diseases. A full page image of the Plant Hardiness Zone map can be found in Appendix F.

The city of Ashland maintains a planting list of acceptable tree species that is intended to guide species selection on the municipal level. While this list is fairly comprehensive, there is always room for improvement. ArborPro recommends limiting the number of maples trees on the planting list while adding new species from other genera to promote biodiversity. For example, white oak (*Quercus alba*) or tulip tree (*Liriodendron tulipifera*) could be added to the list to replace red maple. A few other species not currently on the list that grow well in Zone 4b are: red horsechestnut (*Aesculus x carnea*), European hornbeam *(Carpinus betulus*), katsura tree (*Cercidiphyllum japonicum*), yellowwood (*Cladastrus kentukea*), and hardy rubber tree *(Eucommia ulmoides*). Local nurseries are an excellent resource when looking for new species to plant. They often deal with surrounding municipalities and will know which trees are doing well as street trees in your area.

Tree Risk Assessment

Trees along city streets pose a higher risk of damage to property and people due to the abundance of targets such as cars, people, and houses.

Assessing risk related to tree failure is an essential part of maintaining a healthy, safe urban forest. While trees are not inherently dangerous, urban trees pose a higher risk of damage to persons or property due to their proximity to potential targets. A target is anything that can be damaged by falling limbs or whole tree failure such as people, houses, fences, vehicles, etc. The basic concept of risk assessment is to weigh the potential of failure against the presence and frequency of targets. For example, a tree in the middle of an abandoned field does not pose the same risk as a similar tree on the corner of a busy intersection.

The ultimate goal of a tree risk assessment is to determine whether tree related risk can be mitigated by pruning or if the tree must be removed. This assessment is based on the overall condition of the tree, the location of the tree relative to targets, and obvious signs of defects. Defects can range from root damage

to large pockets of decay and will help determine whether the risk can be mitigated or the tree should be removed.

The International Society of Aboriculture (ISA) is an excellent resource for information related to Tree Risk Assessment. The ISA has three basic levels of risk assessment and recommends defining the scope of work prior to choosing which method best fits the situation. The three levels of risk assessment are:

- Level 1: limited visual inspection
- Level 2: Basic
- Level 3: Advanced

A Level 1 visual inspection is often referred to as a "windshield assessment" because it can be done while driving through a survey area. Level 1 inspections are used only to find obvious hazard trees and should only be used in conjunction with more in-depth levels of assessment.

A Level 2 basic inspection involves a 360-degree, on-site inspection using only limited tools such as a sounding hammer. This level of inspection requires a qualified arborist to look for external defects and surrounding targets to evaluate risk. In addition to providing more in-depth analysis, Level 2 assessments are an affordable way to assess risk on a large population of trees. The data summarized in this management plan was collected using a Level 2 assessment

A Level 3 advanced inspection involves using specialized tools and expert opinions to collect detailed information on specific trees. These assessments are often done on high value trees or in areas with heavy traffic that pose significant risk to public safety. Level 3 inspections are costly and time consuming and should only be used when a determination cannot be accurately made using a Level 1 or 2 assessment.

The City of Ashland would benefit from training city staff to perform a Level 2 assessment based on ISA standards. This can be accomplished by having staff arborists become ISA Certified Arborists or by taking the Tree Risk Assessment Qualification (TRAQ) course through the ISA. Another option would be to schedule a training course on tree risk assessment with an ISA Certified Arborist. The ISA's website www.isa-abor.com is an excellent resource for information related to tree risk assessment. A full tree risk assessment form can also be found in Appendix C.

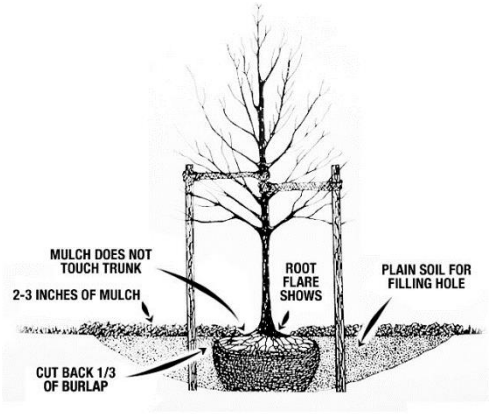
Importance of Updating Inventory Data

Trees are living organisms that change with time. Inventory data, however, is static and will not reflect the current state of an Urban Forest unless it is continually updated. Whenever a tree is removed, inspected, pruned or planted it should be updated in the inventory. If inventory data is not properly maintained it will quickly become obsolete and will ultimately be of little use.

Significant time and money has been invested in surveying Ashland's trees. The only way to protect this investment is to continually update the inventory.

Tree Planting

Tree planting is an important part of maintaining and cultivating a healthy urban forest. Newly planted trees will become the foundation of the urban tree canopy as older trees start to die and are removed from the landscape. However, tree planting is only a worthwhile activity when trees are properly selected, properly planted, and properly cared for as they become established. If trees are not properly planted and cared for they will only become a future problem and will not provide the benefits associated with healthy, mature trees.



When planting new trees:

- Consider the purpose of the tree that is being planted.
- Assess the site conditions and note any growth limitations or space requirements (ex. overhead utilities, proximity to buildings, existing tree canopy, etc).
- Select the best species for the site conditions
- Ensure that the tree is properly planted and have a plan in place for follow-up tree care.
- Monitor and record how newly planted species react to the site conditions and incorporate this information into future planting plans.
- When planting in right of ways provide information to the adjacent property owner on care and maintenance of the tree to encourage them to protect and water the newly planted tree.

Choosing Root Stock

There are three main types of nursery stock to choose from when planting new trees.

- Balled-and-Burlapped
- Bare Root
- Container Grown

Balled-and-Burlapped (B&B)

This type of nursery stock refers to trees that have been planted, dug up, and wrapped in burlap for delivery. This is the most common way that cities purchase and plant trees. B&B trees typically work well because the root ball is protected during transportation and they are relatively easy to plant. However, the balled-and-burlapped roots can be quite heavy and a dolly may be required to move them small distances.

The major downside to B&B stock is their susceptibility to planting stress. When the trees are dug up and burlapped, a lot of the fibrous root system does not make it into the root ball. In fact, some studies suggest up to 90% of the roots are left at the nursery. This will stunt growth for the first few years as the tree focuses on regenerating its root system. The general rule is one year per inch in caliper for newly planted B&B trees to regrow roots and become established. Some B&B trees will never recover from the planting stress and will die in the first two years.

Bare Root

This type of stock is called bare root because all of the soil is removed from the root ball at the time of harvest. A large cutting blade is dragged under the trees at a certain depth to cut the roots as they are removed from the soil.

The major advantage of bare root stock is that they are inexpensive and easy to transport. The lack of soil in the root ball makes them very light and easy to move around. Some municipalities have switched to bare root stock with varied success rates.

The downside of this type of nursery stock is the probability of root damage during harvest and transport. Tree's root systems are very delicate, the fibrous roots are not much larger than single-cell structures and are extremely fragile. Consequently, the mortality rate for bare root stock is much higher than balled-and-burlapped trees. They will also need to be staked during the planting process to provide stability as the roots become established.

Container Grown

This type of stock is exactly what it sounds like, a tree grown and transported in a container. There are many different types of containers but the most common is plastic. Container grown trees are easy to transport and will keep the root ball intact until the container is removed at the time of planting.

The major advantage of container grown trees is that the root system is kept intact throughout the growing, harvesting, and delivery process. Unlike B&B and bare root trees, container grown trees retain all of their fibrous roots up to the time of planting.

The downside of container grown trees is that they are subject to girdling roots. Roots become encircled, or girdled, as they attempt to grow outside the bounds of the container and are redirected around the inside the container. Also, they are more sensitive to drought stress after planting. This is due to the fact that the roots have been sheltered in the container and do not have a chance to harden off during the harvesting process.

In addition to all of the factors mentioned above, the actual planting location may dictate which type of stock is used. Bare root trees are better suited for planting in open spaces such as parks or front yards. Bare root trees are not as stable as B&B trees and may not do well in areas with excessive snow and snow removal operations as they are more easily uprooted.

The caliper (measured at 6”s above the root flair) is another factor to consider when purchasing nursery stock. The most common caliper used for new plantings is between 1.5”s and 2”s. A common misconception is that planting larger trees will provide more immediate shade and canopy. However, larger trees will actually take much longer to become established compared to a smaller caliper tree of the same species. Whereas a 2” tree will take roughly 2 years to establish roots, a 5” tree will require 5 years to become established. Often, a 2” tree will outgrow a 5” tree planted at the same time because the roots will establish quicker, allowing the tree to begin putting on trunk and canopy growth much sooner.

Tips for Planting Trees

To ensure that newly planted trees will survive the planting process:

- Handle trees with care during the transportation process. Avoid any damage to the trunk or branches when loading and unloading.
- Avoid storing trees for lengthy periods before planting and make sure the root ball is moist if they are not being immediately planted.
- Dig the hole 2 to 3 times the size of the root ball using hand tools when possible. When augers are used the sides of the hole can become compacted and will negatively affect root growth.

- Fill the hole with native soil when possible. If the native soil is undesirable, add soil amendments to improve soil structure. Gently tamp down the soil and add water to promote a proper mixture of air, water, and soil.
- Stake trees for the first year of growth to protect against wind and provide a barrier against mechanical damage from mowing.
- Add a thin layer of mulch, making sure not to let mulch build up around the trunk. Over mulching is extremely common and will do irreversible damage in the long run.

Newly Planted Tree Maintenance

Proper young tree maintenance is just as important as proper planting techniques. If trees are not cared for after planting there is little chance that they will survive and become established. Newly planted trees will require maintenance for several years after planting.

Water

Watering newly planted trees is the most important key to their survival. It will typically take at least two months of watering for a new tree to become established. The time of year and species of tree will dictate how much water should be applied after this period but the general rule is to keep soil moist in order to promote root growth.

Mulching

Applying mulch to newly planted trees has many benefits. Mulch will help retain soil moisture and regulate temperatures around the root ball. However, over mulching will have devastating effects on the long-term health of a tree so it is extremely important to avoid piling mulch around the trunk. Spread 3 to 4 inches of mulch around newly planted trees while ensuring the root flare is visible and mulch is not touching the trunk.

Protecting Trees in Construction Areas

Urban trees may be harmed in areas adjacent to construction work such as road and utility construction projects. To preserve and protect these trees special construction practices should be specified to protect trees. Knowing it is sometimes unavoidable to cause physical harm to a tree near construction there are steps that can be taken to reduce shock to the tree. Appendix I includes a document that discusses protection of trees near construction sites

Caring for Established Young Trees

Trees will take a few years to become established after planting. The general rule is that trees take a year for each inch in caliper when planted to become established. For example, if you are

planting a 2-inch caliper tree (caliper is the diameter at 6 inches above ground) it will take 2 years for the roots to become fully established. Established trees still require regular watering and will need structural pruning as they begin to grow. Structural pruning is done to establish a central leader, remove dead or diseased branches, remove crossing limbs, and to create an overall structure that will benefit the tree into maturity.

Community Outreach

The data collected and analyzed to develop this plan provides significant insight into Ashland's tree population. While this information can be used to better maintain the urban tree population, it is also very useful when developing a community outreach plan. The ability to quantify tree data and present the information to the public is an invaluable resource.

Tree inventory data can be used to quantify and justify the budgetary needs associated with maintaining urban trees. This is an excellent way to show the community how much it costs to properly maintain the trees in public parks and open spaces. The data can also help illustrate the costs associated with tree planting and the benefits these trees will provide in the future. Species data can be used to guide tree species selection and to help educate the public on the benefits of biodiversity. Understanding biodiversity is key to maintaining a healthy, pest-resistant urban tree canopy. When the public is educated on the benefits of biodiversity and species selection it will encourage them to put more thought into species selection on private property. Information in this plan can also be used to educate the public about invasive pests and the threat that they pose to urban trees. Providing information on potential and existing threats such as the Emerald Ash Borer will help give the community a better understanding of how and why these trees are being managed. A well-informed community will be more supportive of proactive tree management and will have a better understanding of the benefits trees provide.

There are a variety of ways to present information to the public. As technology advances it is becoming easier to engage the community and present information in a meaningful, easy to use platform. The Community Viewer offered with ArborPro's Tree Management Software is an excellent way to present tree inventory data to the public. Community Viewer allows residents to see general information about Ashland's tree population on their smartphone or any web enabled device. Hosting events such as an Arbor Day celebration is another way to involve the community. Planning volunteer tree plantings to coincide with these events allows community members to develop a connection with specific trees and parks. Local and state websites provide a useful outlet for articles, information, and educational materials to be presented to entire communities. The key to all of these tools is public awareness. To effectively implement a community outreach program, the public will first need to be aware of its existence. Once the community is aware of the benefits urban trees provide it will be much easier to foster an understanding of the key role trees play in everyday life.

Maintenance Cycle

Utilizing data from the 2017 tree inventory, ArborPro developed an annual maintenance schedule detailing the number and type of tasks to be completed each year. Budget projections were made by using average cost of tree work based on diameter class. These costs are not specific to the City of Ashland, they only represent average costs based on industry knowledge and experience.

Maintenance Plan

This summary will include all tree data collected during the inventory. It represents the total cost of maintaining all inventoried trees. A summary of the maintenance schedule is presented here and the complete table of estimated costs for this five-year plan can be found in Appendix E.

To implement this maintenance schedule the budget should be no less than $67,565 for Year One, $59,735 for Year Two, $60,815 for Year Three, $60,540 for Year Four, and $60,465 for Year Five of the maintenance plan.

The estimated costs assume contracting out the services. The City may be able to substantially reduce these costs if done with on staff personnel and equipment.

2019 $67,565	36 Priority 1 Removals 64 Priority 1 Prunes 30 Stump Removals 133 Priority 2 Prunes 25 Planted Trees
2020 $59,735	176 Priority 2 Removals 131 Priority 2 Prunes 25 Planted Trees
2021 $60,815	563 Routine Prunes 332 Young Tree Training Prunes 25 Planted Trees
2022 $60,540	562 Routine Prunes 333 Young Tree Training Prunes 25 Planted Trees
2023 $60,465	562 Routine Prunes 332 Young Tree Training Prunes 25 Planted Trees

Figure 15: Five Year Maintenance Plan

Section 4: City Staffing and Equipment

The City Public Works Department Streets and Parks Division is in charge of tree maintenance. Their duties in regard to urban forestry include tree planting, tree removal, tree maintenance, and storm damage clean-up. Most urban forestry related work is done with current City staff.

City Staffing

Managing a successful Urban Forestry Program is often more difficult than setting goals and working to achieve them. The agencies tasked with maintaining municipal trees have to deal

with funding, public support, staffing levels, and emergency response in addition to the daily forestry operations.

Currently, the Director of Public works oversees Urban Forestry operations on the departmental level. The Urban Forestry Coordinator reports to the Director of Public Works and is responsible for overseeing a majority of forestry operations. The Urban Forestry Coordinator writes and administers tree related grants; selects tree planting sites; oversees tree planting operations; performs tree inspections. This position is presently assigned to the Engineering Civil Technician and accounts for approximately 10% of this person's overall duties. Crews of Laborers and Equipment Operators perform a majority of the in-field work and report directly to the Urban Forestry Coordinator.

The City of Ashland should consider making the Urban Forestry Coordinator a full-time position. Having a dedicated Urban Forester would allow someone to focus solely on tree-related tasks. This person would be more invested in improving the Urban Forestry Program as it would be their main focus. However, employing a full-time Urban Forester requires long-term funding and is not always feasible. Many cities are moving towards contracting an outside agency to manage their trees on an as needed or part-time basis.

Training

While it may not be feasible to create a full-time position for an Urban Forester, providing training to field staff and supervisors is a more cost-effective alternative. This would include, but is not limited to:

- Attending conferences and webinars
- Providing in-house or external training
- Encouraging certification through the International Society of Aboriculture (ISA)

Providing training for field staff will help improve the Urban Forestry Program from the ground up. Properly trained staff will be better able to perform tree work and make decisions regarding individual tree maintenance.

City Equipment

The City Public Works Department has the necessary equipment to perform most urban forestry related work tasks. This available equipment includes bucket lift truck, backhoes, chain saws, pruning saws, dump trucks, stump grinder, and other miscellaneous equipment.

The City of Ashland may want to consider contracting out a portion of its tree work. Using contractors instead of City employees will reduce costs in the long run. Contractors represent a one-time cost whereas full-time employees require benefits and other recurring costs. In addition, hiring contractors does not require purchasing and maintaining expensive equipment like bucket trucks, chainsaws, chippers, etc. It also reduces the liability involved with tree work as all contractors are required to carry their own insurance and workman's compensation.

Scheduling Urban Forestry Work

- Tree planting – The City uses both in house and outside private contractor for tree planting. It depends on the size of the job and the availability of staff to perform the tree planting work.
- Tree pruning/maintenance – This work is normally done by City staff. Normally there is down time in the winter and early spring months to perform routine pruning work. Generally the focus is on removal of dead limbs and clearing for roadways and alley's. What is lacking is training pruning of young trees which is important in the early years following tree planting.
- At a minimum the City should perform at least one yearly hazard inspection of inventoried trees and other areas as deemed essential. Tree conditions can change rapidly due to storm events and disease. An annual tree inspection would identify any new hazard conditions that developed so that such hazards can be removed to protect persons and property.

Costs and Budget

The City typically budgets $10,000.00 per year for urban forestry operations. This funding is generally used to match grant funding, the costs of tree purchases, hiring out tree planting, hiring out tree pruning, and other urban forestry related tasks that City staff may not have time to perform or have the equipment and expertise to perform. Some capital street improvement projects include tree planting in the bid for the road improvement work.

In addition to the annual $10,000.00 budgeted for outside contracting services the City public works department performs many urban forestry related duties during a typical year. Based on the historical City wage and equipment data from 2016-2018 the average yearly cost charged to Urban forestry that Public works performed was $20,545.00.

Recommendations

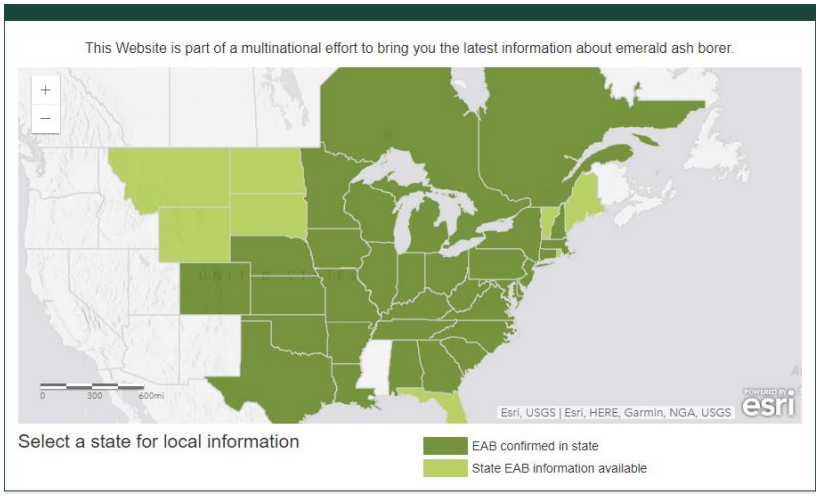
- City Public Works staff performing planting and pruning should attend available workshops or at least have detail drawings and factsheets available when performing the work.
- The initial work should be done under the guidance of one of the trained City staff so that all workers assigned know the proper procedures to follow.
- Implement a systematic approach to tree maintenance. Divide the City into districts that will be targeted in a specific year. That way it is known that a particular area has been attended to. Track this using GIS mapping.
- Increase training pruning of young trees to promote desired growth. Remove suckers; Select a central leader; Remove low branching as tree grows higher.

- Equipment needs do not appear to be a problem for the City.
- Perform annual or semi-annual inspections of inventoried trees. Update GIS mapping with findings.
- The City's annual budget of $10,000.00 per year does limit the number of trees that could be planted or pruned when hired out to private contractors. As long as the City staff can perform these duties following approved standards the amount of planting and pruning can be maximized. The key is to set aside time and have the properly trained staff to perform the work.
- Look for tree related grants.
  Check with local utility companies for tree planting funding as topped trees below these utilities are removed.

Section 5: Emerald Ash Borer Management Strategies

Emerald Ash Borer

Emerald ash borer is a small insect native to Asia. It was introduced to the United States in the 1990's through solid wood packing materials near Detroit, Michigan. Since its introduction to North America it has spread to 29 states, largely concentrated in the Midwest and Northeast. EAB has been confirmed in Wisconsin and surrounding states and will eventually necessitate a management strategy in Ashland. EAB attacks all species of ash trees by boring into the tree and disrupting nutrient flow, ultimately causing the tree to die. The insect is responsible for killing hundreds of millions of trees in North America and is constantly moving to new areas. The following image shows the distribution of EAB infestations by state.



Emerald Ash Borer Infestations by State
Photograph Courtesy of www.emeraldashborer.com

Identification

EAB Gallery
Photograph courtesy of Missouri Department of Conservation

The adult beetle is 3/8 to 5/8-inches long and is metallic green in color. The adult beetles may be seen from late May to early August when they emerge from the trees to feed on leaves. Leaf feeding does not significantly damage the trees but is an important part of the insect's life-cycle. The female beetles then lay eggs in the branches and trunk of ash trees. The eggs hatch into larvae and bore into the wood beneath the bark. Larvae are white in color and can only be seen by removing the bark to expose galleries beneath the bark. The larvae feed on the inner bark and phloem tissue which disrupts the flow of nutrients to the tree and does the most significant damage throughout the life-cycle of the insect. The larval feeding is directly responsible for tree mortality; adult feeding does little damage to the tree and has minimal effect on the overall health.

EAB is very difficult to detect and often goes unnoticed for years before the infestations are confirmed. This is because the insect spends a majority of its life-cycle inside the tree. Early warning signs of an infestation are: yellowing/thinning of the foliage, canopy dieback, drooping branches in the upper canopy, woodpecker damage to the bark, and the presence of epicormic shoots at the tree base or in branches. The most easily identifiable sign of an infestation are the D-shaped exit holes left by the beetles when they emerge from the tree as adults. However, during early phases of infestation these exit holes are often high up in the canopy and not easily identifiable by the naked eye. The early signs and symptoms (woodpecker damage, blonding of bark, etc.) of infestation are the most crucial to identify. By the time exit holes are visible at eye level the tree is already in the late stages of infestation and will likely die within a few years.

Ash Population

Emerald Ash Borer has yet to be identified within the city of Ashland but has been found in the state of Wisconsin. Ashland has taken a proactive approach by implementing an EAB Readiness Plan in 2009. The City has been removing inferior ash trees but still has a relatively large ash population. The inventory found 711 ash trees within the survey area which accounts for 16.3 % of the total inventoried population. Of the 711 trees, 112 are white ash (Fraxinus americana) 1 is a European ash (Fraxinus excelsior), 18 are blue ash (Fraxinus quadrangulate) and 580 are green ash (Fraxinus pennsylvanica). Table 7 shows a breakdown of ash trees by diameter class and condition.

		Diameter Class									
		00"-03"	04"-06"	07"-12"	13"-18"	19"-24"	25"-30"	31"-36"	37"-42"	43+	**Total**
Condition Class	Very Good	0	1	9	0	0	0	0	0	0	**10**
	Good	3	18	171	85	1	0	0	0	0	**278**
	Fair	7	20	140	151	40	8	1	0	0	**367**
	Poor	4	1	14	23	7	5	1	0	0	**55**
	Dead	0	0	0	1	0	0	0	0	0	**1**
	Total	**14**	**40**	**334**	**260**	**48**	**13**	**2**	**0**	**0**	**711**

Table 9. Ash tree distribution by diameter and condition class

A majority of Ashland's ash trees are under 18 inches in diameter and are in 'Fair' or 'Good' condition. Small diameter ash trees in poor condition are good candidates for removal. These trees would require treatment for decades and are already showing signs of decline.

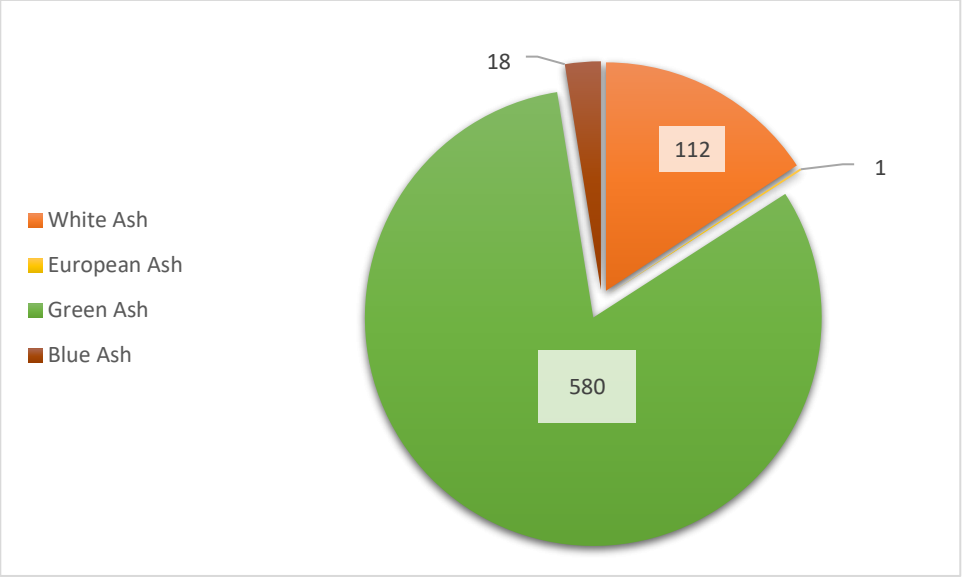


Figure 16: Species of ash by percentage

EAB Management Options

As previously mentioned, 711 ash trees were recorded in the city of Ashland. However, 19 of these trees were marked for removal at the time of the inventory. The cost of removing these 19 trees has already been accounted for in the annual budget so they will not be included in this section of the report. Only the remaining 692 ash trees will be considered in the following EAB management discussion. A breakdown of these trees by condition and diameter class can been seen in Table 10.

Diameter Class										
	00"-03"	04"-06"	07"-12"	13"-18"	19"-24"	25"-30"	31"-36"	37"-42"	43+	**Total**
Very Good	0	1	9	0	0	0	0	0	0	**10**
Good	3	18	171	85	1	0	0	0	0	**278**
Fair	3	20	140	151	40	8	1	0	0	**363**
Poor	1	1	9	17	7	5	1	0	0	**41**
Total	**7**	**40**	**329**	**253**	**48**	**13**	**2**	**0**	**0**	**692**

Table 10: Ash trees by diameter class and condition

There are three basic options for EAB management: treat all ash trees, remove all ash trees, and a combination of treatment and removal.

Strategy 1: Treat All Ash Trees

Treating all of Ashland's ash trees will reduce the annual mortality rate and stabilize removals. Treatment also allows these trees to continue providing benefits to the community into the foreseeable future. It will initially be cheaper than removing all of the ash trees but represents a recurring cost. EAB trunk injections need to be repeated every two years to remain effective; a process which becomes quite costly.

Trees under 6 inches in DBH are recommended for removal as they would need to be treated for their entire life span. Also, these trees are very easily and cost-effectively removed due to their small size.

In order to estimate treatment costs, the general price of $7 per inch DBH was used for trees 10 inches and smaller while $10 per inch DBH was used for trees 11 inches or larger at the time of the inventory.

Removal										
	00"-03"	04"-06"	07"-12"	13"-18"	19"-24"	25"-30"	31"-36"	37"-42"	43+	**Total**
Very Good	0	1	0	0	0	0	0	0	0	**1**
Good	3	18	0	0	0	0	0	0	0	**21**
Fair	3	20	0	0	0	0	0	0	0	**23**
Poor	1	1	0	0	0	0	0	0	0	**2**
	7	**40**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**47**
Treatment										
Very Good	0	0	9	0	0	0	0	0	0	**9**
Good	0	0	171	85	1	0	0	0	0	**257**
Fair	0	0	140	151	40	8	1	0	0	**340**
Poor	0	0	9	17	7	5	1	0	0	**39**
	0	**0**	**329**	**253**	**48**	**13**	**2**	**0**	**0**	**645**

Table 11: Strategy 1 - removal and treatment by diameter class

Activity	DBH	Cost/Tree	# of Trees	Total Cost
Removal	00"-03"	$25	7	$175
	04"-06"	$105	40	$4,200
	07"-12"	$220	0	$0
	13"-18"	$355	0	$0
	19"-24"	$525	0	$0
	25"-30"	$845	0	$0
	31"-36"	$1,140	0	$0
	37"-42"	$1,470	0	$0
	43+	$1,850	0	$0
Total			**47**	**$4,375**
Treatment	00"-03"	$7/Inch	0	$0
	04"-06"	$7/Inch	0	$0
	07"-12"	$7/Inch	329	$27,560
	13"-18"	$10/inch	253	$37,780
	19"-24"	$10/inch	48	$10,040
	25"-30"	$10/inch	13	$3,610
	31"-36"	$10/inch	2	$660
	37"-42"	$10/inch	0	$0
	43+	$10/inch	0	$0
Total			**645**	**$79,650**

*treatment is a recurring cost every two years

Table 12: Cost of removal and treatment

Strategy 2: Remove All Ash Trees

This strategy involves removing and replacing all of the ash trees in Ashland. This would represent a significant cost upfront and would remove all of the trees in 'Good' and 'Fair' condition that are still providing benefits. The main benefit to this strategy is that you are able to establish new trees and get a head start on replacing the canopy that will be lost due to EAB. The table below shows only the cost of removing all of the ash trees and does not include the cost of replanting once the trees are removed.

Removal										
	00"-03"	04"-06"	07"-12"	13"-18"	19"-24"	25"-30"	31"-36"	37"-42"	43+	**Total**
Very Good	0	1	9	0	0	0	0	0	0	**10**
Good	3	18	171	85	1	0	0	0	0	**278**
Fair	3	20	140	151	40	8	1	0	0	**363**
Poor	1	1	9	17	7	5	1	0	0	**41**
	7	**40**	**329**	**253**	**48**	**13**	**2**	**0**	**0**	**692**

Table 13: Strategy 2 - removal by diameter class

Activity	DBH	Cost/Tree	# of Trees	Total Cost
Removal	00"-03"	$25	7	$175
	04"-06"	$105	40	$4,200
	07"-12"	$220	329	$72,380
	13"-18"	$355	253	$89,815
	19"-24"	$525	48	$25,200
	25"-30"	$845	13	$10,985
	31"-36"	$1,140	2	$2,280
	37"-42"	$1,470	0	$0
	43+	$1,850	0	$0
Total			**692**	**$205,035**

Table 14: Cost of removal

Strategy 3: Combination of Treatment and Removal

This is the best option for the City of Ashland and has been shown to be the most cost-effective in the long run. It involves treating all of the ash trees in 'Very Good' and 'Good' condition and roughly half of the trees in 'Fair' condition. Trees in 'Poor' and 'Dead' condition are recommended for removal along with the remaining trees in 'Fair' condition. To implement this strategy, 420 trees would need to be treated while 272 would be removed. A few of the trees in 'Good' and 'Fair' condition (47 trees) are under 6 inches and could easily and cost-effectively be removed to reduce treatment costs. Trees under 6 inches would require treatment for the entirety of their life span and are recommended for removal.

	Removal									
	00"-03"	04"-06"	07"-12"	13"-18"	19"-24"	25"-30"	31"-36"	37"-42"	43+	**Total**
Very Good	0	1	0	0	0	0	0	0	0	**1**
Good	3	18	0	0	0	0	0	0	0	**21**
Fair	3	20	90	76	20	0	0	0	0	**209**
Poor	1	1	9	17	7	5	1	0	0	**41**
	7	**40**	**99**	**93**	**27**	**5**	**1**	**0**	**0**	**272**
	Treatment									
Very Good	0	0	9	0	0	0	0	0	0	**9**
Good	0	0	171	85	1	0	0	0	0	**257**
Fair	0	0	50	75	20	8	1	0	0	**154**
Poor	0	0	0	0	0	0	0	0	0	**0**
Dead	0	0	0	0	0	0	0	0	0	**0**
	0	**0**	**230**	**160**	**21**	**8**	**1**	**0**	**0**	**420**

Table 15: Strategy 3 - removal and treatment by diameter class

Activity	**DBH**	**Cost/Tree**	**# of Trees**	**Total Cost**
Removal	00"-03"	$25	7	$175
	04"-06"	$105	40	$4,200
	07"-12"	$220	99	$21,780
	13"-18"	$355	93	$33,015
	19"-24"	$525	27	$14,175
	25"-30"	$845	5	$4,225
	31"-36"	$1,140	1	$1,140
	37"-42"	$1,470	0	$0
	43+	$1,850	0	$0
Total			**272**	**$78,710**
Treatment	00"-03"	$7/Inch	0	$0
	04"-06"	$7/Inch	0	$0
	07"-12"	$7/Inch	230	$18,942
	13"-18"	$10/inch	160	$23,710
	19"-24"	$10/inch	21	$4,400
	25"-30"	$10/inch	8	$2,190
	31"-36"	$10/inch	1	$224
	37"-42"	$10/inch	0	$0
	43+	$10/inch	0	$0
Total			**420**	**$49,466**

*treatment is a recurring cost every two years

Table 16: Cost of removal

It is important that an EAB management strategy is implemented. Having a proactive management strategy that fits the needs of both the city and surrounding community will greatly reduce the financial burden of an EAB infestation.

Wood Utilization

Removing dead, dying, and diseased ash trees will create an excess of wood waste. Large scale removal operations create both wood chips and logs that will need to be disposed of. In the past, the City of Ashland has maintained a DNR approved burn site. It is recommended that the City look into finding additional sites to dispose of wood waste. It is safe to burn or chip wood that has been infested with Emerald Ash Borer. Many landscaping companies, nurseries, or even private residents are willing to take free mulch. A City mulch yard would provide residents access to free mulch while allowing Ashland to dispose of their wood chips for free.

Whole log wood waste will need to be burned (or chipped if small enough) if it is infested with EAB. The insect remains alive in the trunk even after the tree is removed and transporting logs will further the spread of EAB.

Emerald Ash Borer infestation is going to cause an influx of wood waste into the city of Ashland. In addition to municipal needs, private residents will be inquiring about ash disposal and it is very import that the City is prepared.

Section 6: Invasive Pests and Diseases

Due to the globalization of trade and economic activity, our cities and forests are being threatened by an ever-increasing number of non-native pests and diseases. A cursory examination of past infestations reveals the devastating effect that non-native insects and diseases have on local tree populations. For example, the American chestnut tree (Castenea dentata) was once a dominant feature in both rural and urban landscapes. However, the introduction of chestnut blight in the first half of the 20th century completely decimated entire populations of American chestnuts and has all but removed this beautiful tree from our landscapes. We have also seen Dutch Elm Disease (DED) and Emerald Ash Borer (EAB) have similarly devastating effects on our Nations elm and ash trees. It is important to understand the effects that non-native pests and diseases can have on the environment and to adopt a management strategy that best fits the needs of local, state, and federal agencies.

The main agency involved in keeping invasive pests out of the country is the United States Department of Agriculture's (USDA) Animal and Plant Inspections Service (APHIS). This agency maintains a website dedicated to the identification and eradication of invasive pests in the United States. Additionally, the Indiana Department of Natural Resources maintains an updated list of known pests and diseases on the state level. It is very important when managing community trees to routinely check this website for updates about invasive pests and diseases in your area.

The following are key pests and diseases known to affect trees in Indiana and surrounding areas at the time this management plan was created. It is not a complete list but outlines the major pests and diseases that pose a threat to the health and longevity of urban trees in the Indiana area.

Asian Longhorn Beetle

Asian Longhorn Beetle
Photograph courtesy of The Nature Conservancy

The Asian Longhorn Beetle (ALB, Anoplophora glabripennis) is a wood-boring beetle that entered the United States in solid wood packing material from Asia. There have been isolated ALB infestations in Chicago, New York, Massachusetts, Toronto, and Ohio. ALB has a wide variety of host species in the United States including poplar, plane tree, elm, birch, willow, and horsechestnut but prefers trees in the maple (Acer) genus. Since maples typically represent a substantial portion of street trees throughout the country, ALB infestations pose a very serious risk to urban tree populations.

Adult beetles are large (3/4 to 1 ½ long) and shiny black with white spots and long antennae. The antennae are usually 1 to 2 times the length of the body and have alternating bands of white and black. Adult beetles can be seen in late spring or fall during maturation feeding. However, infestations are often identified by the egg sites and exit holes left by the beetles. ALB has not been identified in Indiana but has been found in the surrounding states of Ohio and Illinois.

Emerald Ash Borer

The emerald ash borer (EAB, Agrilus planipennis) is a wood boring insect that entered the United States in packing material in Southeastern Michigan in 2002. EAB is responsible for the deaths of millions of ash trees nationwide and continues to spread throughout the country. Adult beetles are relatively small, typically 1/2 inch in length. Color varies but adults are usually a metallic green with green wing covers. As mentioned, the preferred hosts for EAB are all in the ash (fraxinus) Genus.

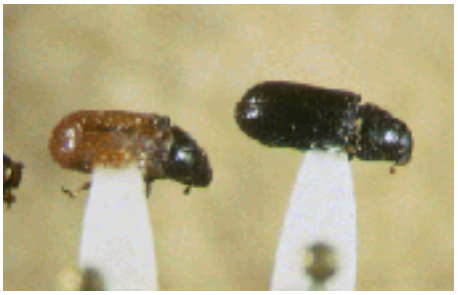
Emerald Ash Borer
Photograph Courtesy of NY DEC

Japanese Beetle

Japanese Beetle
Photo courtesy of Michigan DNR

Japanese beetles are 3/8" long and 1/4" wide and a brilliant metallic green in color. Their hard body makes them unpalatable to many predators, including birds. The beetles overwinter in the soil as a grub and the adult beetles emerge between May and July. Adult beetles feed on the leaves of trees, moving from the top of the tree downward. Japanese beetles can cause significant damage to newly planted trees by feeding on the foliage. The beetles are able to fly long distances which makes local beetle control difficult.

Pine Shoot Beetle


Pine Shoot Beetle
Photo courtesy of Indiana DNR

The pine shoot beetle was introduced to the US from Europe in 1992 on a Christmas tree plantation in Ohio. Adult beetles are brown to black and only 3.5 to 4.8mm in length. Pine trees are the preferred host but when populations are high they may also breed in spruce, fir, and larch. Adult beetles create galleries inside the tree before tunneling out and feeding on the crown of healthy pine trees.

Gypsy Moth

Gypsy Moth
Photograph Courtesy of University of Wisconsin

The Gypsy Moth (Lymantria dispar) is native to Europe and first arrived in the United States in 1869. It is considered to be one of the most destructive forest pests in the US. Early attempts to eradicate Gypsy Moths failed and the pest has spread throughout the eastern half of the country. Its caterpillars feed indiscriminately on over 300 species of trees and shrubs, causing significant defoliation. Males are slightly smaller than females and are brown with a darker brown pattern on the wings. Females are nearly white with dark, saw-toothed patterns on their wings and are unable to fly.

Thousand Cankers Disease


Walnut Twig Beetle
Photograph courtesy of Ohio State University

Thousand Cankers Disease is a disease complex involving a fungus transmitted by the walnut twig beetle. While this disease is not considered to be invasive it has been killing black walnut trees across the country since the 1990's. After the fungus is introduced by a beetle it kills small patches of tissue

under the bark, eventually leading to the development of a canker. The canker will eventually restrict the movement of nutrients and result in the death of the tree.

Oak Wilt

Oak Wilt is caused by the fungus Ceratocystis fagacearum and was first identified in 1944. The fungus is transmitted by a variety of common oak borers, root grafting, and pruning. The disease affects all oak trees but is most devastating to trees in the red oak subgenus (red oak, pin oak, scarlet oak, etc). The fungus clogs the vascular system of the tree resulting in decline, and ultimately death. The spread of oak wilt can be drastically slowed by pruning oak trees in the winter when the fungus is not active.

Oak Wilt
Photograph courtesy of Michigan DNR

Conclusions

Properly managing urban trees requires planning, communication, public support, and adequate funding. For these reasons, it is complicated and can only be accomplished through a well-defined vision for the future. The combination of priority and proactive maintenance detailed in this Tree Management Plan will create a framework for short- and long-term management that will help ensure a healthy, vibrant tree canopy for future generations. The city must balance the needs of its residents with a knowledge and understanding of tree management to create a safe, enjoyable experience for everyone

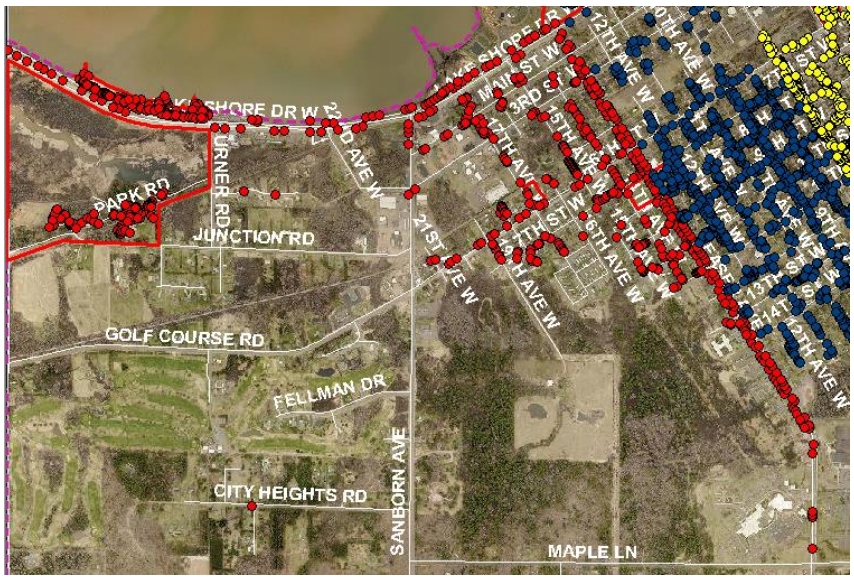
Appendix A – Species Distribution

Botanical Name	Common Name	Tree Count
Abies balsamea	Balsam Fir	41
Acer ginnala	Amur Maple	6
Acer negundo	Box Elder	52
Acer plantanoides	Norway Maple	139
Acer platanoides 'Crimson King'	Crimson King Maple	72
Acer rubrum	Red Maple	345
Acer saccharinum	Silver Maple	243
Acer saccharum	Sugar Maple	174
Acer x freemanii	Freeman Maple	71
Aesculus glabra	Ohio Buckeye	35
Aesculus hippocastanum	Common Horsechestnut	6
Amelanchier arborea	Downy Serviceberry	41
Amelanchier canadensis	Canadian Serviceberry	2
Betula nigra	River Birch	18
Betula papyrifera	Paper Birch	55
Betula populifolia	Gray Birch	3
Carpinus caroliniana	American Hornbeam	1
Carya tomentosa	Mockernut Hickory	2
Catalpa speciosa	Western Catalpa	1
Celtis occidentalis	Common Hackberry	55
Cercis canadensis	Eastern Redbud	1
Cornus alternifolia	Alternate-Leaf Dogwood	1
Crataegus crus-galli f. inermis	Thornless Hawthorn	8
Crataegus phaenopyrum	Washington Hawthorn	4
Fraxinus americana	White Ash	112
Fraxinus excelsior	European Ash	1
Fraxinus pennsylvanica	Green Ash	580
Fraxinus quadrangulata	Blue Ash	18
Ginkgo biloba	Maidenhair Tree	8
Gleditsia triacanthos f. inermis	Thornless Honey Locust	95
Gymnocladus dioica	Kentucky Coffee Tree	31
Juglans nigra	Black Walnut	19
Juniperus virginiana	Eastern Red Cedar	5
Larix laricina	Tamarack	15
Liriodendron tulipifera	Tulip Tree	1
Maackia amurensis	Manchurian Maackia	12
Malus domestica	Edible Apple Species	42
Malus floribunda	Crabapple Species	238
Ostrya virginiana	American Hophornbeam	32
Phellodendron amurense	Amur Corktree	9
Picea abies	Norway Spruce	41
Picea abies 'Pendula'	Weeping Norway Spruce	1
Picea glauca	White Spruce	363
Picea pungens	Colorado Spruce	97

Pinus banksiana	Jack Pine	1
Pinus nigra	Austrian Black Pine	1
Pinus ponderosa	Ponderosa Pine	1
Pinus resinosa	Red Pine	45
Pinus strobus	White Pine	31
Pinus sylvestris	Scotch Pine	8
Populus alba	White Poplar	8
Populus balsamifera	Balsam Poplar	4
Populus deltoides	Cottonwood	14
Populus grandidentata	Bigtooth Aspen	1
Populus nigra var. italica	Lombardy Poplar	4
Populus tremuloides	Quaking Aspen	26
Prunus americana	American Plum	1
Prunus cerasifera	Purple-Leafed Plum	5
Prunus domestica	Plum	8
Prunus maackii	Amur Chokecherry	11
Prunus persica	Peach	3
Prunus serrulata	Japanese Flowering Cherry	8
Prunus species	Stone Fruit Species	8
Prunus virginiana	Chokecherry	3
Prunus virginiana 'Canada Red'	Canada Red Cherry	7
Pyrus calleryana	Ornamental Pear	6
Pyrus communis	Edible Pear	5
Quercus alba	White Oak	2
Quercus bicolor	Swamp White Oak	23
Quercus macrocarpa	Bur Oak	39
Quercus palustris	Pin Oak	10
Quercus rubra	Red Oak	144
Rhamnus cathartica	Common Buckthorn	8
Robinia pseudoacacia	Black Locust	21
Salix babylonica	Weeping Willow	3
Salix discolor	Pussy Willow	1
Salix integra	Dappled Willow	1
Salix matsudana 'Tortuosa'	Corkscrew Willow	3
Salix nigra	Black Willow	21
Sorbus americana	American Mountain Ash	29
Stump	Stump	30
Syringa reticulata	Japanese Tree Lilac	110
Thuja occidentalis	American Arborvitae	90
Tilia americana	American Linden	148
Tilia cordata	Littleleaf Linden	56
Tsuga canadensis	Eastern Hemlock	1
Ulmus americana	American Elm	68
Ulmus pumila	Siberian Elm	48
Ulmus rubra	Slippery Elm	4
Ulmus x species	Hybrid Elm	213

Appendix B – Maintenance Blocks

Block 1



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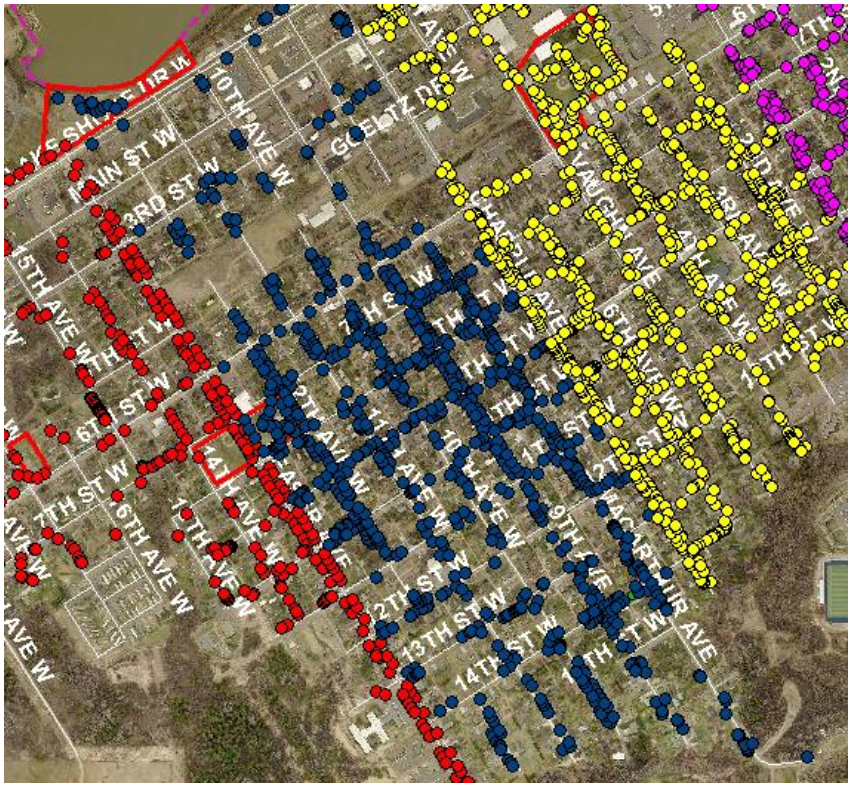

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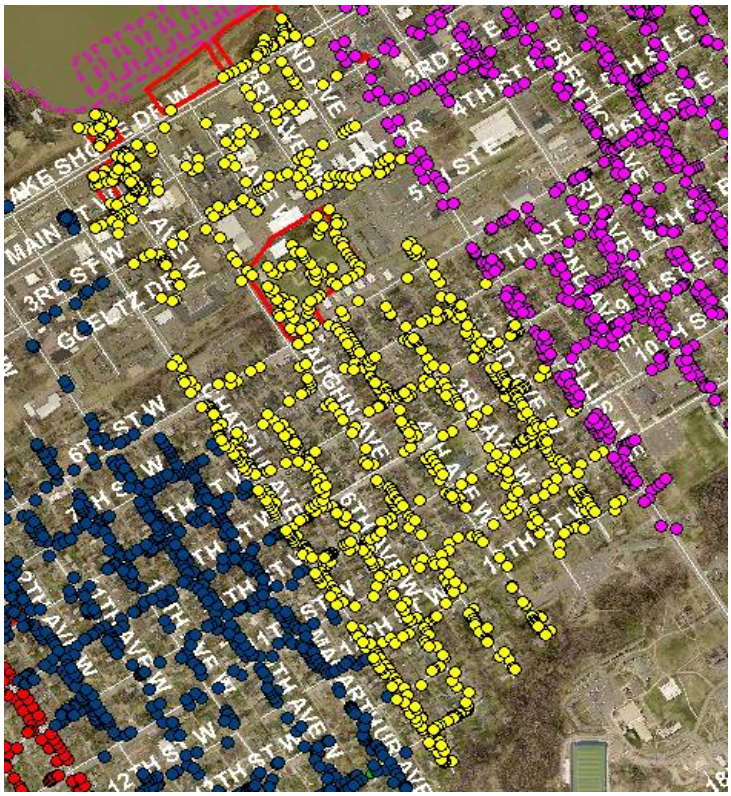

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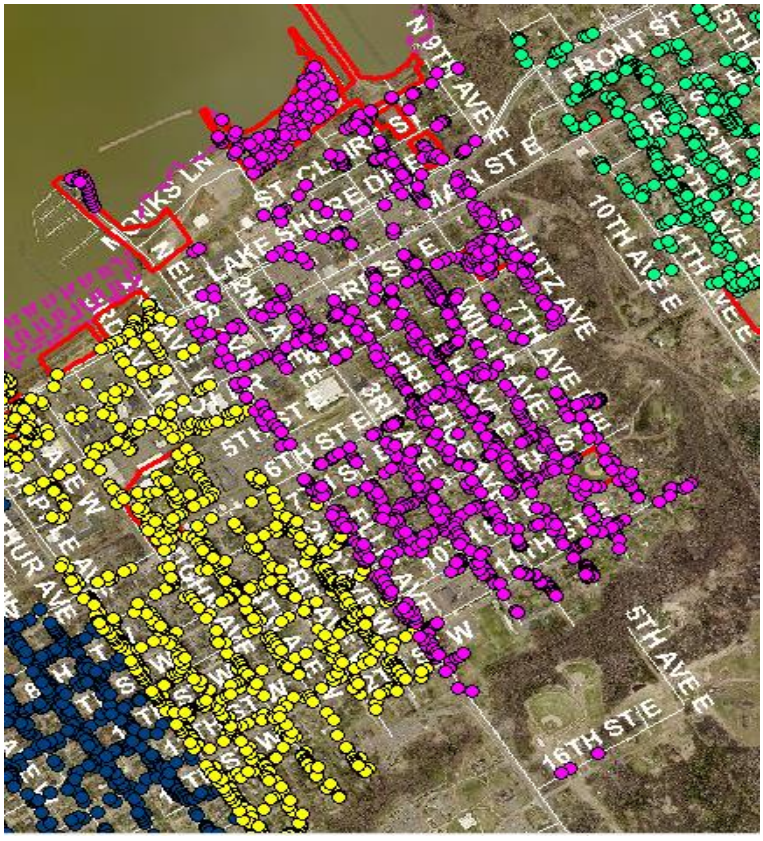


Block 5


N 29TH AVE E
MAIN ST E
26TH AVE E
TOLL RD
TOLL RD
SUM RD
RAIL DR
2ND AVE E
1ST ST E
CEDAR ST (PVT)
CARY ST
FRONT ST
15TH AVE E
14TH AVE E
13TH AVE E
12TH AVE E
11TH AVE E
10TH AVE E
KNIGHT RD
JONES RD

Appendix C – Risk Assessment Form

Basic Tree Risk Assessment Form

Client _____ Date_____ Time _____

Address/Tree location _____ Tree no. _____ Sheet _____ of _____

Tree species _____ dbh_____ Height _____ Crown spread dia. _____

Assessor(s) _____ Tools used_____ Time frame_____

Target Assessment

Target number	Target description	Target protection	Target zone: Target within drip line	Target within 1x Ht.	Target within 1.5 x Ht.	Occupancy rate (1 = rare, 2 = occasional, 3 = frequent, 4 = constant)	Practical to move target?	Restriction practical?
1								
2								
3								
4								

Site Factors

History of failures _____ Topography Flat Slope _____% Aspect _____

Site changes None Grade change Site clearing Changed soil hydrology Root cuts Describe _____

Soil conditions Limited volume Saturated Shallow Compacted Pavement over roots _____% Describe _____

Prevailing wind direction_____ Common weather Strong winds Ice Snow Heavy rain Describe_____

Tree Health and Species Profile

Vigor Low Normal High Foliage None (seasonal) None (dead) Normal _____% Chlorotic _____% Necrotic _____%

Pests/Biotic_____ Abiotic _____

Species failure profile Branches Trunk Roots Describe_____

Load Factors

Wind exposure Protected Partial Full Wind funneling _____ Relative crown size Small Medium Large

Crown density Sparse Normal Dense Interior branches Few Normal Dense Vines/Mistletoe/Moss _____

Recent or expected change in load factors_____

Tree Defects and Conditions Affecting the Likelihood of Failure

— Crown and Branches —

Unbalanced crown LCR _____%

Dead twigs/branches _____% overall Max. dia. _____

Broken/Hangers Number _____ Max. dia. _____

Over-extended branches

Pruning history

Crown cleaned Thinned Raised

Reduced Topped Lion-tailed

Flush cuts Other _____

Cracks _____ Lightning damage

Codominant _____ Included bark

Weak attachments _____ Cavity/Nest hole ____% circ.

Previous branch failures _____ Similar branches present

Dead/Missing bark Cankers/Galls/Burls Sapwood damage/decay

Conks Heartwood decay _____

Response growth_____

_____ Condition(s) of concern_____

Part Size _____ Fall Distance _____

Load on defect N/A Minor Moderate Significant

Likelihood of failure Improbable Possible Probable Imminent

Part Size _____ Fall Distance _____

Load on defect N/A Minor Moderate Significant

Likelihood of failure Improbable Possible Probable Imminent

— Trunk —

Dead/Missing bark Abnormal bark texture/color

Codominant stems Included bark Cracks

Sapwood damage/decay Cankers/Galls/Burls Sap ooze

Lightning damage Heartwood decay Conks/Mushrooms

Cavity/Nest hole _____% circ. Depth _____ Poor taper

Lean _____° Corrected?_____

Response growth _____

Condition(s) of concern_____

Part Size _____ Fall Distance _____

Load on defect N/A Minor Moderate Significant

Likelihood of failure Improbable Possible Probable Imminent

— Roots and Root Collar —

Collar buried/Not visible Depth_____ Stem girdling

Dead Decay Conks/Mushrooms

Ooze Cavity _____% circ.

Cracks Cut/Damaged roots Distance from trunk _____

Root plate lifting Soil weakness

Response growth_____

Condition(s) of concern_____

Part Size _____ Fall Distance _____

Load on defect N/A Minor Moderate Significant

Likelihood of failure Improbable Possible Probable Imminent

Page 1 of 2

Risk Categorization

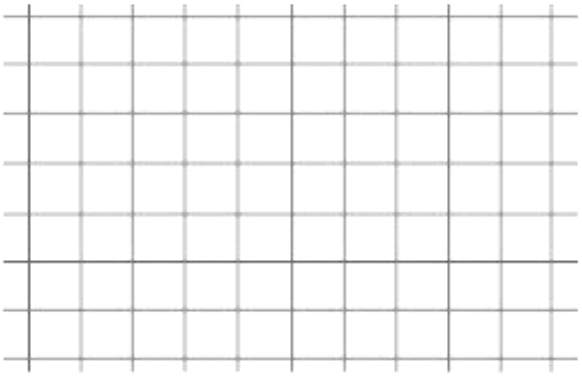
Target (Target number or description)	Tree part	Condition(s) of concern	Likelihood: Failure: Improbable	Failure: Possible	Failure: Probable	Failure: Imminent	Impact: Very low	Impact: Low	Impact: Medium	Impact: High	Failure & Impact (from Matrix 1): Unlikely	Failure & Impact: Somewhat likely	Failure & Impact: Likely	Failure & Impact: Very likely	Consequences: Negligible	Consequences: Minor	Consequences: Significant	Consequences: Severe	Risk rating (from Matrix 2)

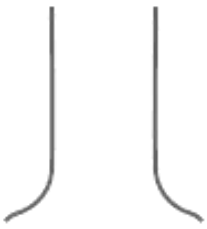
Matrix 1. Likelihood matrix.

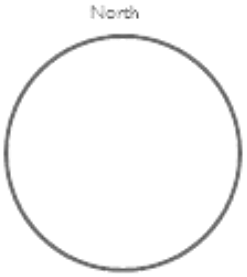
Likelihood of Failure	Likelihood of Impact			
	Very low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	Likely	Very likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2. Risk rating matrix.

Likelihood of Failure & Impact	Consequences of Failure			
	Negligible	Minor	Significant	Severe
Very likely	Low	Moderate	High	Extreme
Likely	Low	Moderate	High	High
Somewhat likely	Low	Low	Moderate	Moderate
Unlikely	Low	Low	Low	Low







Notes, explanations, descriptions

_____

_____

_____

_____

_____

Mitigation options

1. _____ Residual risk _____
2. _____ Residual risk _____
3. _____ Residual risk _____
4. _____ Residual risk _____

Overall tree risk rating Low / Moderate / High / Extreme /

Overall residual risk None / Low / Moderate / High / Extreme / Recommended inspection interval _____

Data /Final /Preliminary Advanced assessment needed /No /Yes-Type/Reason _____

Inspection limitations /None /Visibility /Access /Vines /Root collar buried Describe _____

Appendix D – iTree Streets Reports

Ashland

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

11/21/2017

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($)	Standard Error
Green ash	35.45	4.86	5.75	34.10	39.47	119.64	(N/A)
White Spruce	17.97	1.67	1.83	30.04	23.32	74.83	(N/A)
Red maple	22.79	2.62	3.61	17.06	28.04	74.10	(N/A)
Silver maple	60.20	11.33	10.77	102.94	89.93	275.17	(N/A)
Malus floribunda	16.35	1.67	2.46	6.98	6.26	33.72	(N/A)
Hybrid Elm	12.95	1.39	1.89	8.82	14.94	39.99	(N/A)
Sugar maple	30.67	3.52	4.64	26.15	29.29	94.28	(N/A)
American basswood	24.97	3.31	3.67	25.65	21.88	79.48	(N/A)
Northern red oak	18.93	2.10	2.72	16.26	13.08	53.08	(N/A)
Norway maple	33.38	3.78	5.47	30.81	27.90	101.35	(N/A)
White ash	37.98	5.47	6.48	39.75	55.00	144.69	(N/A)
Japanese tree lilac	4.32	0.45	0.57	1.47	1.56	8.37	(N/A)
Blue spruce	17.49	1.45	1.94	28.25	20.21	69.34	(N/A)
Honeylocust	19.36	2.13	2.88	12.28	25.98	62.63	(N/A)
Northern white cedar	14.08	1.28	1.23	24.70	18.13	59.42	(N/A)
Crimson king maple	29.23	3.45	4.65	24.51	26.86	88.70	(N/A)
Freeman maple	12.65	1.30	1.87	7.90	14.08	37.79	(N/A)
American elm	24.44	2.49	4.00	23.79	22.98	77.70	(N/A)
Littleleaf linden	11.56	1.73	1.77	8.21	18.56	41.83	(N/A)
Paper birch	22.27	3.02	3.45	18.74	28.80	76.28	(N/A)
Northern hackberry	19.24	1.48	2.72	12.15	17.76	53.35	(N/A)
Boxelder	31.95	4.94	5.17	37.57	37.78	117.41	(N/A)
Siberian elm	53.59	6.36	9.21	60.52	37.58	167.25	(N/A)
Red pine	16.67	1.51	1.74	25.62	20.30	65.84	(N/A)
Malus domestica	14.37	1.44	2.11	5.86	5.27	29.06	(N/A)
Norway spruce	21.90	2.12	1.26	50.00	26.11	101.40	(N/A)
Balsam fir	13.56	1.21	1.46	20.03	17.62	53.89	(N/A)
Downy Serviceberry	3.74	0.39	0.49	1.25	1.32	7.19	(N/A)
Bur oak	9.59	1.40	1.49	9.06	17.52	39.07	(N/A)
Ohio buckeye	29.94	3.54	4.77	24.48	27.41	90.15	(N/A)
Eastern hophornbeam	7.00	0.70	0.94	2.52	2.60	13.77	(N/A)
Eastern white pine	21.14	2.01	1.57	44.78	26.96	96.47	(N/A)
Kentucky coffeetree	5.63	0.86	0.84	4.49	13.96	25.78	(N/A)
American Mountain Ash	11.70	1.17	1.71	4.72	4.22	23.52	(N/A)
Quaking aspen	28.44	3.89	4.52	25.94	33.99	96.78	(N/A)
Swamp white oak	12.68	1.60	1.75	7.22	15.92	39.18	(N/A)
Black Willow	50.70	7.02	8.71	63.37	50.15	179.96	(N/A)
Black locust	40.28	4.76	6.76	36.69	33.52	122.00	(N/A)
Black walnut	22.52	3.03	3.49	22.13	28.54	79.72	(N/A)
River birch	14.13	1.75	1.97	8.42	16.94	43.21	(N/A)
Blue Ash	20.17	2.56	2.99	16.85	32.81	75.38	(N/A)
Tamarack	11.10	1.02	1.09	18.43	15.54	47.17	(N/A)
Eastern cottonwood	57.02	7.35	10.17	82.44	50.11	207.10	(N/A)
Manchurian Maackia	10.28	1.33	1.40	5.37	14.00	32.37	(N/A)
Amur Chokecherry	14.70	1.42	2.05	5.72	5.22	29.11	(N/A)
Common chokecherry	7.51	0.75	1.02	2.76	2.72	14.75	(N/A)
Pin oak	19.83	2.28	2.64	13.65	19.58	57.98	(N/A)
Amur corktree	11.55	1.45	1.59	6.51	14.72	35.83	(N/A)
White Poplar	55.88	7.71	9.50	74.08	54.67	201.84	(N/A)
Ginkgo	7.18	0.65	1.14	4.10	3.23	16.31	(N/A)
Pluml	3.03	0.31	0.41	1.07	0.83	5.66	(N/A)

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

11/21/2017

Species	Energy	CO_2	Air Quality	Stormwater	Aesthetic/Other	Total ($) Standard Error
Thornless Hawthorn	5.40	0.55	0.71	1.86	2.06	10.58 (N/A)
Kwanzan cherry	10.20	1.00	1.40	3.85	3.69	20.14 (N/A)
Common Buckthorn	11.87	1.49	1.64	6.77	14.95	36.72 (N/A)
Plum	2.57	0.27	0.33	0.82	0.79	4.79 (N/A)
Scotch pine	26.15	2.63	1.76	58.58	33.14	122.26 (N/A)
Common Horsechestnut	31.80	4.35	5.15	37.83	35.70	114.82 (N/A)
Amur maple	6.78	0.68	0.92	2.47	2.44	13.28 (N/A)
Callery pear	17.82	2.16	2.72	12.50	18.33	53.53 (N/A)
Cherry plum	2.68	0.28	0.35	0.87	0.84	5.02 (N/A)
Eastern red cedar	19.33	1.36	1.56	33.72	16.75	72.72 (N/A)
Edible Pear	4.26	0.53	0.57	1.96	6.80	14.11 (N/A)
Washington Hawthorn	7.47	0.74	1.02	2.77	2.64	14.63 (N/A)
Balsam Poplar	32.43	4.43	5.21	28.09	37.21	107.37 (N/A)
Black poplar	57.45	8.00	9.64	71.75	56.71	203.54 (N/A)
Slippery Elm	50.08	4.98	8.26	47.10	40.34	150.76 (N/A)
Corkscrew Willow	31.55	3.84	5.32	25.57	27.02	93.30 (N/A)
Gray Birch	2.38	0.34	0.35	1.87	8.42	13.35 (N/A)
Peach	0.87	0.10	0.11	0.20	0.03	1.31 (N/A)
Salix babylonica	65.55	8.99	11.46	96.40	60.66	243.07 (N/A)
Canadian Serviceberry	0.87	0.10	0.11	0.20	0.03	1.31 (N/A)
White oak	32.43	4.43	5.21	28.09	37.21	107.37 (N/A)
Mockernut Hickory	20.64	2.71	2.99	16.47	28.56	71.37 (N/A)
Alternate-Leaf Dogwood	0.87	0.10	0.11	0.20	0.03	1.31 (N/A)
American Hornbeam	1.10	0.09	0.14	0.33	2.74	4.40 (N/A)
Pussy willow	0.87	0.10	0.11	0.20	0.03	1.31 (N/A)
Eastern redbud	0.87	0.10	0.11	0.20	0.03	1.31 (N/A)
European Ash	20.10	2.49	2.91	16.63	33.42	75.55 (N/A)
Austrian pine	14.80	1.07	1.53	20.47	21.08	58.96 (N/A)
Tulip tree	5.82	0.91	0.87	4.65	14.73	26.98 (N/A)
Ponderosa pine	30.47	3.11	1.45	80.46	47.08	162.58 (N/A)
Jack Pine	24.51	2.22	2.89	41.85	25.23	96.70 (N/A)
Dappled Willow	0.87	0.10	0.11	0.20	0.03	1.31 (N/A)
Eastern hemlock	30.47	3.11	1.45	80.46	47.08	162.58 (N/A)
Northern catalpa	44.23	6.14	7.42	39.72	45.86	143.36 (N/A)
American Plum	18.19	1.74	2.55	7.17	6.40	36.05 (N/A)
Bigtooth Aspen	44.23	6.14	7.42	39.72	45.86	143.36 (N/A)
Citywide Total	24.86	3.19	3.81	27.10	27.74	86.70 (N/A)

Ashland

Total Annual Benefits, Net Benefits, and Costs for Public Trees

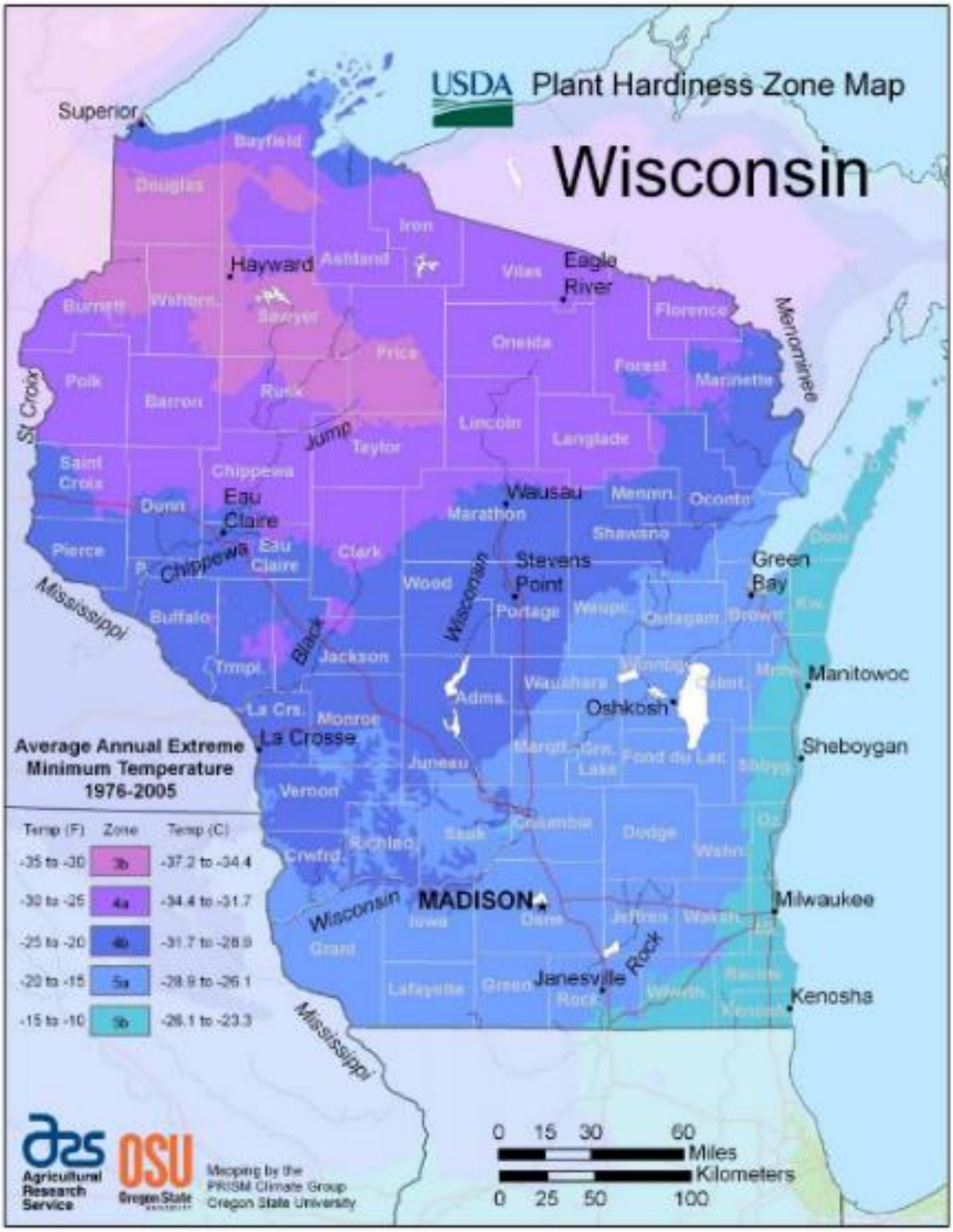
11/21/2017

Benefits	Total ($) Standard Error	$/tree Standard Error	$/capita Standard Error
Energy	108,079 (N/A)	24.86 (N/A)	0.00 (N/A)
CO2	13,889 (N/A)	3.19 (N/A)	0.00 (N/A)
Air Quality	16,562 (N/A)	3.81 (N/A)	0.00 (N/A)
Stormwater	117,827 (N/A)	27.10 (N/A)	0.00 (N/A)
Aesthetic/Other	120,620 (N/A)	27.74 (N/A)	0.00 (N/A)
Total Benefits	376,977 (N/A)	86.70 (N/A)	0.00 (N/A)
Costs			
Planting	0	0.00	0.00
Contract Pruning	0	0.00	0.00
Pest Management	0	0.00	0.00
Irrigation	0	0.00	0.00
Removal	0	0.00	0.00
Administration	0	0.00	0.00
Inspection/Service	0	0.00	0.00
Infrastructure Repairs	0	0.00	0.00
Litter Clean-up	0	0.00	0.00
Liability/Claims	0	0.00	0.00
Other Costs	0	0.00	0.00
Total Costs	0	0.00	0.00
Net Benefits	376,977 (N/A)	86.70 (N/A)	0.00 (N/A)
Benefit-cost ratio	0.00 (N/A)		

Appendix E – 5-year Budget

Year			2019		2020		2021		2022		2023		Five-Year
Activity	DBH	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	Cost
Priority 1 Removal	00"-03"	$25	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	04"-06"	$105	1	$105	0	$0	0	$0	0	$0	0	$0	$105
	07"-12"	$220	9	$1,980	0	$0	0	$0	0	$0	0	$0	$1,980
	13"-18"	$355	7	$2,485	0	$0	0	$0	0	$0	0	$0	$2,485
	19"-24"	$525	10	$5,250	0	$0	0	$0	0	$0	0	$0	$5,250
	25"-30"	$845	5	$4,225	0	$0	0	$0	0	$0	0	$0	$4,225
	31"-36"	$1,140	2	$2,280	0	$0	0	$0	0	$0	0	$0	$2,280
	37"-42"	$1,470	1	$1,470	0	$0	0	$0	0	$0	0	$0	$1,470
	43+	$1,850	1	$1,850	0	$0	0	$0	0	$0	0	$0	$1,850
Total			**36**	**$19,645**	**0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$19,645**
Priority 2 Removal	00"-03"	$25	0	$0	56	$1,400	0	$0	0	$0	0	$0	$1,400
	04"-06"	$105	0	$0	38	$3,990	0	$0	0	$0	0	$0	$3,990
	07"-12"	$220	0	$0	54	$11,880	0	$0	0	$0	0	$0	$11,880
	13"-18"	$355	0	$0	22	$7,810	0	$0	0	$0	0	$0	$7,810
	19"-24"	$525	0	$0	3	$1,575	0	$0	0	$0	0	$0	$1,575
	25"-30"	$845	0	$0	3	$2,535	0	$0	0	$0	0	$0	$2,535
	31"-36"	$1,140	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	37"-42"	$1,470	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43+	$1,850	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Total			**0**	**$0**	**176**	**$29,190**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$29,190**
Stump Removal	00"-03"	$25	6	$150	0	$0	0	$0	0	$0	0	$0	$150
	04"-06"	$25	4	$100	0	$0	0	$0	0	$0	0	$0	$100
	07"-12"	$25	8	$200	0	$0	0	$0	0	$0	0	$0	$200
	13"-18"	$40	6	$240	0	$0	0	$0	0	$0	0	$0	$240
	19"-24"	$60	4	$240	0	$0	0	$0	0	$0	0	$0	$240
	25"-30"	$85	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	31"-36"	$110	2	$220	0	$0	0	$0	0	$0	0	$0	$220
	37"-42"	$130	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43+	$160	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Total			**30**	**$1,150**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$1,150**
Priority 1 Prune	00"-03"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	04"-06"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	07"-12"	$75	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	13"-18"	$120	7	$840	0	$0	0	$0	0	$0	0	$0	$840
	19"-24"	$170	12	$2,040	0	$0	0	$0	0	$0	0	$0	$2,040
	25"-30"	$225	20	$4,500	0	$0	0	$0	0	$0	0	$0	$4,500
	31"-36"	$305	17	$5,185	0	$0	0	$0	0	$0	0	$0	$5,185
	37"-42"	$380	7	$2,660	0	$0	0	$0	0	$0	0	$0	$2,660
	43+	$590	1	$590	0	$0	0	$0	0	$0	0	$0	$590
Total			**64**	**$15,815**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$15,815**
Priority 2 Prune	00"-03"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	04"-06"	$30	1	$30	0	$0	0	$0	0	$0	0	$0	$30
	07"-12"	$75	4	$300	4	$300	0	$0	0	$0	0	$0	$600
	13"-18"	$120	29	$3,480	29	$3,480	0	$0	0	$0	0	$0	$6,960
	19"-24"	$170	43	$7,310	42	$7,140	0	$0	0	$0	0	$0	$14,450
	25"-30"	$225	31	$6,975	31	$6,975	0	$0	0	$0	0	$0	$13,950
	31"-36"	$305	18	$5,490	18	$5,490	0	$0	0	$0	0	$0	$10,980
	37"-42"	$380	6	$2,280	7	$2,660	0	$0	0	$0	0	$0	$4,940
	43+	$590	1	$590	0	$0	0	$0	0	$0	0	$0	$590
Total			**133**	**$26,455**	**131**	**$26,045**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$52,500**
Routine Prune	00"-03"	$20	0	$0	0	$0	10	$200	10	$200	10	$200	$600
	04"-06"	$30	0	$0	0	$0	88	$2,640	88	$2,640	88	$2,640	$7,920
	07"-12"	$75	0	$0	0	$0	286	$21,450	286	$21,450	286	$21,450	$64,350
	13"-18"	$120	0	$0	0	$0	141	$16,920	141	$16,920	141	$16,920	$50,760
	19"-24"	$170	0	$0	0	$0	30	$5,100	30	$5,100	30	$5,100	$15,300
	25"-30"	$225	0	$0	0	$0	7	$1,575	7	$1,575	7	$1,575	$4,725
	31"-36"	$305	0	$0	0	$0	1	$305	0	$0	0	$0	$305
	37"-42"	$380	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43+	$590	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Total			**0**	**$0**	**0**	**$0**	**563**	**$48,190**	**562**	**$47,885**	**562**	**$47,885**	**$143,960**
Young Tree Training	00"-03"	$20	0	$0	0	$0	188	$3,760	188	$3,760	188	$3,760	$11,280
	04"-06"	$30	0	$0	0	$0	143	$4,290	144	$4,320	144	$4,320	$12,930
	07"-12"	$75	0	$0	0	$0	1	$75	1	$75	0	$0	$150
Total			**0**	**$0**	**0**	**$0**	**332**	**$8,125**	**333**	**$8,155**	**332**	**$8,080**	**$24,360**
Tree Planting		$180	25	$4,500	25	$4,500	25	$4,500	25	$4,500	25	$4,500	$22,500
Cost Grand Total				**$67,565**		**$59,735**		**$60,815**		**$60,540**		**$60,465**	**$309,120**

Appendix F – Wisconsin Hardiness Zone Map



Appendix G – New Tree Planting

New Tree Planting

Information on proper practices for planting a tree with a nine-step approach to successful planting and establishment.

Purchasing a tree is a lifelong investment. How well this investment grows depends on the type of tree selected and the planting location, the care provided during planting, and the follow-up care after planting.

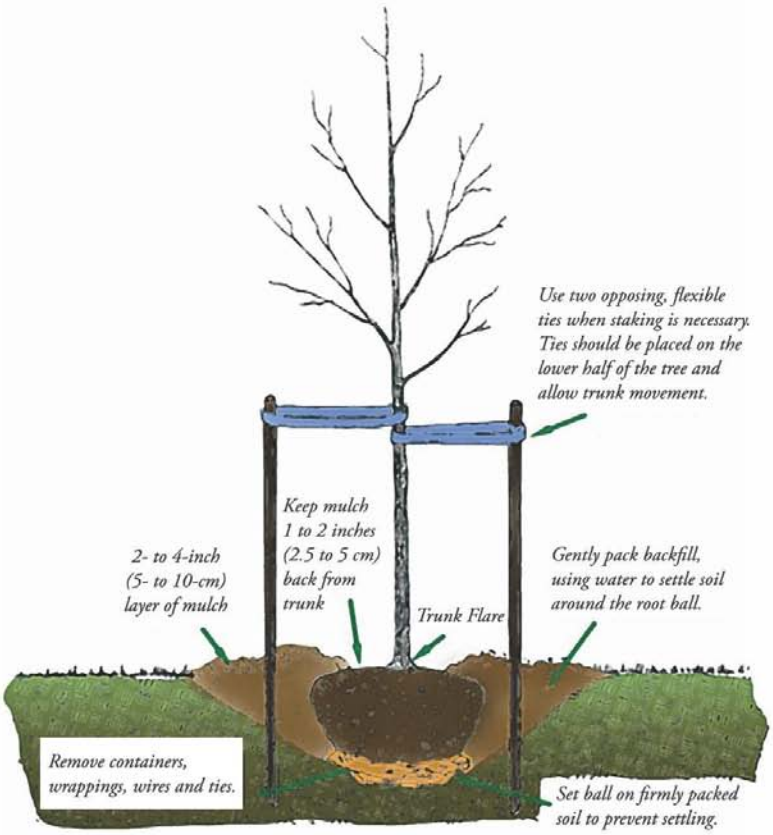
When to Plant

Ideally, trees are planted during the dormant season — in the fall after leaf drop or in early spring before budbreak. Weather conditions are cool and allow plants to establish roots in the new location before spring rains and summer heat stimulate new top growth. Healthy balled and burlapped or container trees, however, can be planted throughout the growing season if given appropriate care. In tropical and subtropical climates where trees grow year round, any time is a good time to plant a tree, provided that sufficient water is available.

Planting Stress

Balled and burlapped trees lose a significant portion of their root system when dug at the nursery. As a result, trees commonly exhibit what is known as "transplant shock." Transplant shock is a state of slowed growth and reduced vitality following transplanting. Container trees may also experience transplant shock, particularly if they have circling or kinked roots that must be cut. Proper site preparation, careful handling to prevent further root damage, and good follow-up care reduces transplant shock and promotes faster recovery.

Carefully follow the nine simple steps below to help your tree establish quickly in its new location. **Note: Before you begin planting your tree, be sure you have located all underground utilities prior to digging.**



1. **Identify the trunk flare.** The trunk flare is where the trunk expands at the base of the tree. This point should be partially visible after the tree has been planted (see diagram). Remove excess soil from the top of the root ball prior to planting if the root flare is not visible.
2. **Dig a shallow, broad planting hole.** Holes should be 2 to 3 times wider than the root ball, but only as deep as the root ball. Digging a broad planting pit breaks up the surrounding soil and provides newly emerging tree roots room to expand.
3. **Remove the containers or cut away the wire basket.** Inspect container tree root balls for circling roots. Straighten, cut, or remove them. Expose the trunk flare, if necessary.
4. **Place the tree at the proper height.** Take care to dig the hole to the proper depth — and no more. The majority of a tree's roots develop in the top 12 inches (30 cm) of soil. If the tree is planted too deep, new roots will have difficulty developing because of a lack of oxygen. In poorly drained or heavily clayed soils, trees can be planted with the base of the trunk flare 2 to 3 inches (5 to 7.5 cm) above grade. When placing the tree in the hole, lift it by the root ball, not the trunk.

5. **Straighten the tree in the hole.** Before backfilling, have someone view the tree from several directions to confirm it is straight. Once planted, it is difficult to reposition the tree.

6. **Fill the hole gently, but firmly.** Pack soil around the base of the root ball to stabilize it. If the root ball is wrapped, carefully cut and remove any fabric, plastic, string, and/or wire from around the trunk and root ball to prevent girdling and to facilitate root growth (see diagram). Fill the remainder of the hole, firmly packing the soil to eliminate air pockets that may dry out roots. Further reduce air pockets by watering periodically while backfilling. Avoid fertilization at the time of planting.

7. **Stake the tree, if necessary.** Studies have shown that trees establish more quickly and develop stronger trunk and root systems if they are not staked at the time of planting. Staking may be required, however, when planting bare root stock or planting on windy sites. Stakes may also offer protection against lawn mower damage and vandalism. One or two stakes used in conjunction with a wide, flexible tie material on the lower half of the tree will hold the tree upright and minimize injury to the trunk (see diagram), yet still allow movement. Remove support staking and ties after the first year of growth.

8. **Mulch the base of the tree.** Mulch is organic matter spread around the base of a tree to hold moisture, moderate soil temperature extremes, and reduce grass and weed competition. Common mulches include leaf litter, pine straw, shredded bark, peat moss, or composted wood chips. A 2- to 4-inch (5- to 10-cm) layer is ideal. More than 4 inches (10 cm) may cause a problem with oxygen and moisture levels. Piling mulch right up against the trunk of a tree may cause decay of the living bark. A mulch-free area, 1 to 2 inches (2.5 to 5 cm) wide at the base of the tree, reduces moist bark conditions and prevents decay.

9. **Provide follow-up care.** Keep the soil moist, but not waterlogged. Water trees at least once a week, barring rain, and more frequently during hot, windy weather. When the soil is dry below the surface of the mulch, it is time to water. Continue until mid-fall, tapering off as lower temperatures require less-frequent watering.

Other follow-up care may include minor pruning of branches damaged during the planting process. Prune sparingly after planting and delay necessary corrective pruning until a full season of growth in the new location has occurred.

Completing these nine simple steps will maximize the likelihood that your new tree will grow and thrive in its new home. When questions arise regarding your tree, be sure to consult your local ISA Certified Arborist or a tree care or garden center professional for assistance.

This brochure is one in a series published by the International Society of Arboriculture as part of its Consumer Information Program. You may have additional interest in the following titles currently in the series:

- Avoiding Tree and Utility Conflicts
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- Benefits of Trees
- Buying High-Quality Trees
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- Mature Tree Care
- New Tree Planting
- Plant Health Care
- Proper Mulching Techniques
- Palms
- Pruning Mature Trees
- Pruning Young Trees
- Recognizing Tree Risk
- Treatment of Trees Damaged by Construction
- Tree Selection and Placement
- Trees and Turf
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Appendix H: Recommended Species for Planting

Suggested Trees for Streetside Planting in Western Wisconsin
USDA Hardiness Zone 4

Trees can successfully be planted streetside *if* matched to the site. Trees vary widely in physical characteristics & site requirements. Street trees should meet the following criteria:

- tolerant of adverse soil conditions such as poor infiltration and drainage, compaction, droughtiness, low fertility, elevated alkalinity and salinity, and surface temperature extremes

  When evaluating soil, keep in mind that undisturbed native soil is very uncommon in the streetside environment. Soil in the rooting zone often includes off-site backfill and construction debris; soil properties can be abruptly different between fill layers and from site to site; topsoil is typically minimal to nonexistent.

- tolerant of reflected heat (off pavement/metal/glass), wind, pollution, deicing salt and other contaminants
- relatively long lived, decay resistant, low maintenance and pest free
- form and branching habit will not block views of stop signs, driveways, etc.
- free of highly objectionable characteristics such as thorns, excessive litter or invasiveness

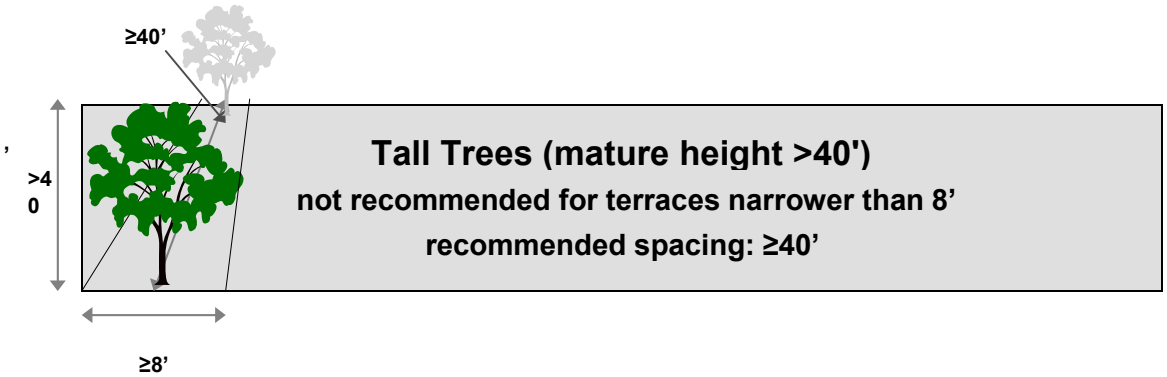
Street tree selection should further be based on anticipated size and shape at maturity. Consider available space above ***and*** below ground, noting restrictions such as overhead & buried utilities, storefront windows/doorways/awnings/signs, adjacent trees & buildings. Plant at least 5' from driveways, 10' from fire hydrants and 25' from street corners, or as otherwise specified by local ordinance. Plant tall-growing trees at least 20' from overhead power lines. Plant all trees at least 2' from sidewalks and curbs. Avoid planting trees on terraces (boulevards) less than 4' wide or less than 5' wide with buried utilities. Tall-growing trees, low-spreading trees and trees with strong surface-rooting tendencies need wide terraces. Trees with inadequate space can damage other infrastructure, require excessive maintenance, and become unattractive, unhealthy or hazardous.

To limit potential catastrophic loss from insects or diseases, strive for a diverse mixture of trees, generally no more than 10–20% of any *genus* (e.g., oak, maple, elm). Avoid trees that are already very common in the local landscape, even if those trees are otherwise suited for streetside use. Try unfamiliar trees in limited numbers until proven.

There is no "perfect" street tree. Trees listed on the following pages meet most or all of the general criteria above and are potentially suitable for streetside use. High-quality nursery stock, proper planting technique, regular watering, proper pruning and protection from damage are also essential to growing healthy, attractive & functional street trees.

notes: In this document, streetside means within 2–6' of the edge of a street &/or sidewalk.

In some cases, hardiness is further differentiated as zone 4a (Eau Claire) or 4b (La Crosse). Suggestions for Hardiness Zone 3 (Barron, Burnett, Polk, Washburn and southern 3/4^{ths} of Douglas County) are listed on the last page.



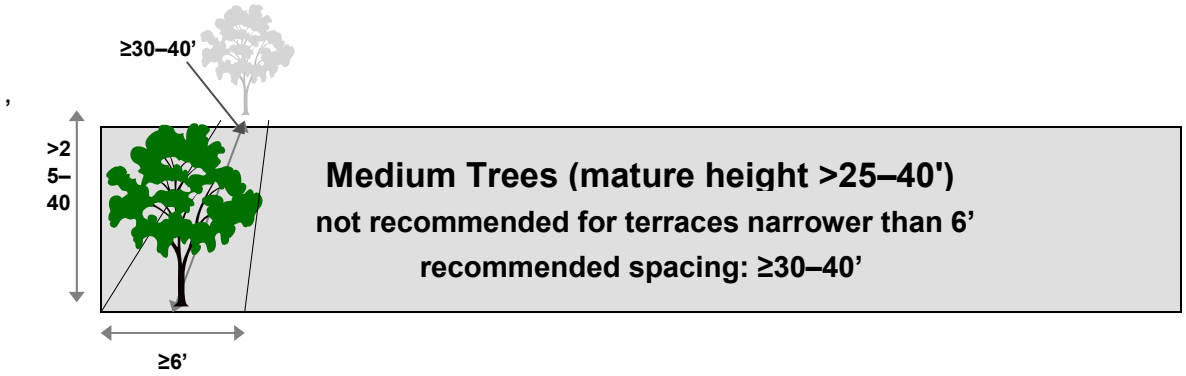
botanic name	common name	cultivars	comments
Acer x *freemanii*	Freeman **maple***	**Autumn Blaze** (‘Jeffersred’); **Celebration** (‘Celzam’); **Marmo**; **Scarlet Sentinel** (‘Scarsen’); **Sienna Glen** (‘Sienna’)	Freeman maple is a hybrid of silver and red maple, with the faster growth and adaptability of silver maple, the better branching and ornamental features of red maple; surface rooting; size, fall color & seed production vary by cultivar; Autumn Blaze needs considerable training pruning for good branch structure; Celebration, Marmo, Scarlet Sentinel & Sienna Glen are essentially seedless; ***see also Trees for Narrow Spaces***
Acer nigrum	black **maple***	**Greencolumn**	black maple is very similar to sugar maple but more heat & drought tolerant; Greencolumn is upright & narrow, with yellow–orange fall color
Acer platanoides	Norway **maple***	**Emerald Queen** (‘McGill No. 42’); **Champtree** (‘National 2000’)	Emerald Queen & Champtree are larger Norway maple cultivars, reaching ~50’; the species is described under ***Medium Trees***; ***see also Short Trees*** and ***Trees for Narrow Spaces***
Aesculus hippocastanum	**horsechestnut**	**Baumann** (‘Baumannii’)	horsechestnut is slow growing; leaf scorch is common & can be severe on dry sites, but is not significant to tree health; moderate tolerance to deicing salt; Baumann has showy, white flowers, no fruit; untested in western WI; should be hardy to zone 4b
Carpinus betulus	European **hornbeam**	**Fastigiata**	columnar when young, becoming rounded with age; formal-looking; heat and drought tolerant but sensitive to deicing salt—avoid high-speed thoroughfares; untested in western WI; should be hardy to zone 4b
Celtis occidentalis	common **hackberry**	see comments	native to WI; potentially a very large tree; nipple gall is a common but harmless leaf problem; bare-root stock must be sweated before planting (see www.plant-materials.nrcs.usda.gov/pubs/ndpmcnl7274.pdf); Prairie Pride is more compact than the species; Windy City is upright & spreading
Corylus colurna	Turkish **filbert** (Turkish hazel)		needs supplemental watering initially, then quite drought tolerant; small nuts can be a litter problem, though squirrels harvest the majority (solitary trees won't produce nuts); City of La Crosse has been using the species with success since ’03
Ginkgo biloba	**ginkgo**	see comments	underused, adaptable, low-maintenance tree; best planted B&B; moderate deicing salt tolerance; use named cultivars (male/fruitless); height, spread & shape vary by cultivar; availability somewhat limited; poor-quality stock (headed back, buried root collar) is common; Rochester, MN, uses various cultivars with excellent success; ***see also Medium Trees*** and ***Trees for Narrow Spaces***
Gymnocladus dioica	Kentucky **coffeetree**	**Stately Manor**; **Espresso**; **Prairie Titan** (‘J.C. McDaniel’)	coffeetree is native to southern Wisconsin; pest free; choose named cultivars (male/fruitless & smaller) for streetside use; Stately Manor is narrow and upright; Espresso is upward-arching; Prairie Titan is oval; young trees look gangly but develop better appearance with age

Maple is **heavily over planted in most Wisconsin communities; choose alternatives if maple comprises >10–20% of the local tree population.*

Tall Trees - continued

*Quercus bicolor**	bicolor **oak** (swamp white oak)		native to Wisconsin; underused; good drought tolerance; better transplant success than many oaks; requires slightly acid soil (pH≤6.7); ***see also*** Rosehill oak
Quercus ellipsoidalis	northern pin **oak**	**Majestic Skies** ('Bailskies')	the species is native to Wisconsin; susceptible to oak wilt—avoid pruning April through July; Majestic Skies is a 2010 introduction from Bailey Nurseries, with improved form and branching; should be thoroughly hardy to zone 4
*Quercus muehlenbergii**	chinkapin **oak**		native to far southern Wisconsin; untested as a street tree in western WI; should be hardy to zone 4b
*Quercus palustris**	pin **oak**		underused; requires slightly acid soil (pH ≤6.7); susceptible to oak wilt—avoid pruning April through July; better form, fall color, growth rate and transplant success than most oaks; lower limbs angle downward, requiring more pruning for clearance over streets & sidewalks; ***see also Trees for Narrow Spaces***
*Quercus robur**	English **oak**	see comments	tolerates higher-pH soils better than other oaks; English oak is hardy only to zone 5, but some hybrids and cultivars should be hardy to zone 4b; hybrids and cultivars have better size and form for streetside use; Attention! (*Q. robur* 'Wandell') is narrow–columnar; English oak hybrids and cultivars have not been thoroughly tested in western WI; ***see also Trees for Narrow Spaces***
Quercus Rosehill	Rosehill **oak**		bicolor x English oak hybrid; zone 4b
Quercus x *bimundorum*	**oak**	**Crimson Spire** ('Crimschmidt')	white x English oak hybrid; spire-like; zone 4b; ***see also Trees for Narrow Spaces***
Quercus x macdanielli	**oak**	**Heritage** ('Clemon's')	bur x English oak hybrid; vigorous & mildew resistant; crown narrower than bur oak; should be hardy throughout zone 4
Quercus x *warei*	**oak**	**Regal Prince** ('Long')	bicolor x English oak hybrid; narrow form; zone 4b
Taxodium distichum	**baldcypress**	**Shawnee Brave** ('Mickelson')	baldcypress is a deciduous conifer; can be limbed up for street/sidewalk clearance; Shawnee Brave is narrower than the species; untested in western WI; should be hardy to zone 4b if from northern seed source
Tilia americana	American **linden** (basswood)	**Frontyard** ('Bailyard'); **Boulevard**; **Amercian Sentry** ('McKSentry')	American linden is native to Wisconsin; larger leaves, better Japanese beetle resistance & better branch attachment than littleleaf lindens, but less salt tolerant; cultivars have better form; Frontyard is larger; Boulevard is narrowly pyramidal, reaching >60' tall x 25–30' wide; American Sentry is slightly shorter; ***see also Medium Trees***
Tilia cordata	littleleaf **linden**	see comments	littleleaf linden needs early pruning for strong branch structure; basal sprouting is common; many cultivars available— most have dense, symmetrical, teardrop-shaped crowns and a formal appearance; leaves susceptible to Japanese beetle damage; Prestige (*T. cordata* 'Norbert') is very cold hardy; Greenspire has inferior branching—other cultivars are preferable; ***see also Medium Trees, Short Trees*** and ***Trees for Narrow Spaces***
Tilia Redmond	Redmond **linden**		American x Crimean linden hybrid; dense, formal, teardrop-shaped crown; some basal sprouting; sensitive to deicing salt—avoid high-speed thoroughfares
Tilia tomentosa	silver **linden**		faster growth and better pest, heat and drought resistance than other lindens; pH adaptable; silvery leaf undersides; more resistant than littleleaf linden to Japanese beetle; needs early pruning for strong branch structure; untested in western WI; should be hardy in zone 4b, marginally hardy in 4a
Tilia x *flavescens*	**linden**	**Glenleven**	American x littleleaf linden hybrid; good branching, fast growing

Ulmus americana	American **elm**	**Prairie Expedition** ('Lewis & Clark'); **Princeton**	Dutch elm disease–resistant/tolerant American elms; Prairie Expedition should be very cold hardy; ***see also comments for elm hybrids below***
Ulmus spp.	**elm** hybrids	see comments	many Dutch elm disease–resistant/tolerant elm hybrids are available; U of MN & City of Minneapolis have an ongoing elm evaluation project (see http://www.forestry.umn.edu/extension/Home/ElmsTwinCities=Guide.pdf); most <2"-caliper elms need several years of training pruning and staking—buy larger stock if possible; try: Accolade, Commendation, Danada Charm, New Horizon, Patriot, Triumph (somewhat susceptible to leaf pests); ***see also Medium Trees***



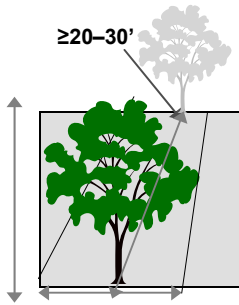
botanic name	common name	cultivars	comments
Acer miyabei	Miyabe **maple***	**State Street** ('Morton')	the species is more heat and drought tolerant than Norway maple; fast growing; ascending branches; adaptable; State Street has performed well in Eau Claire
Acer platanoides	Norway **maple***	see comments	an overused tree; invasive in some southern Wisconsin parks & woodlands—choose alternative species in zone 4b; surface rooting and dense shade make it difficult to grow grass under most Norway maple; very prone to stem-girdling roots and sunscald complex—high-quality stock, proper planting technique and adequate moisture during the establishment period are essential; dozens of cultivars available—several have maroon to purplish leaves & are often mistakenly called "red maple"; avoid Crimson King (not reliably hardy to zone 4) and Schwedler (more prone to frost crack); most cultivars top out at 40–45'; ***see also Tall Trees, Short Trees*** and ***Trees for Narrow Spaces***
Acer triflorum	three-flower **maple***		matures at ~25–30'; untested in western WI; should be hardy to zone 4b if from northern seed source
Acer Warrenred	Pacific Sunset **maple***		Norway x Shantung maple hybrid; star-shaped foliage turns yellow to reddish purple in fall; not thoroughly tested in western WI—should be hardy to zone 4b if from northern seed source; can reach 45'
Betula nigra	river **birch**	**Dura-Heat** ('BNMTF')	river birch is native to WI; needs supplemental watering initially, then fairly drought tolerant; use single stems, not clumps, for streetside planting; Dura-Heat has better heat tolerance and leaf-spot resistance than the species; untested as a street tree in western WI; should be hardy throughout zone 4; can reach 45'
Ginkgo biloba	**ginkgo**	**Autumn Gold**; **Halka**; **Mayfield**; **Saratoga**; **Shangri-La**	shorter, more compact ginkgo cultivars, maturing at about 40–45'; availability may be limited; ***see also Trees for Narrow Spaces; other characteristics as described for ginkgo under Tall Trees***

Gleditsia triacanthos var. *inermis*	thornless **honeylocust**	see comments	honeylocust is native to Wisconsin; plant bugs and leafhoppers are frequent—but usually minor—leaf pests; most cultivars top out at 40–45'; though generally fruit-free, some cultivars bear a few pods; Sunburst is more pest prone; Skyline has a strong central leader & better branching; Imperial tends to lack a central leader & it branches low on the stem, requiring more clearance pruning, however City of Minneapolis has good success with it & plants bare-root, 1¾"– caliper stock
Maackia amurensis	Amur **maackia**	see comments	hardy, uncommon tree; frequent name confusion with Amur chokecherry (*Prunus maackii*) to which it is unrelated; needs training pruning for good branch attachment; somewhat sensitive to deicing salt—avoid high-speed thoroughfares; untested in western WI but should be hardy to zone 3; City of Rochester, MN, has good success with the species; Starburst is a narrower, more upright cultivar; ***see also Small Trees*** and ***Trees for Narrow Spaces***
Malus spp.	**crabapple**	**Spring Snow**	Spring Snow is a larger, white-flowering crab, maturing at about 30'; no fruit; ***other characteristics as described for crabapple under Short Trees***
Phellodendron amurense	Amur **corktree**	**Macho**	Amur corktree is adaptable and pest free; slow to establish; needs pruning for street/sidewalk clearance; Macho is male/fruitless; limited availability; untested in western WI; should be hardy throughout zone 4
Phellodendron lavallei	Lavalle **corktree**	**Eyestopper** ('Longenecker')	upright & broad spreading; very limited availability; untested in western WI; should be hardy to zone 4b
Phellodendron sachalinense	Sakhalin **corktree**	**His Majesty**	slow growing; low branches need pruning for clearance; no fruit; very limited availability; untested in western WI; should be hardy throughout zone 4

Maple is **heavily over planted in most Wisconsin communities; choose alternatives if maple comprises >10–20% of the local tree population.*

Medium Trees - continued

Prunus maackii	Amur **chokecherry**		less susceptible to black knot than other *Prunus* species; hardy to zone 3 if from northern seed source; prone to stemgirdling roots—high-quality stock and proper planting technique are essential; needs early pruning for good branch attachment; avoid excessive heat & deicing salt spray
Pyrus calleryana	callery **pear**	**Aristocrat**; **Autumn Blaze**	most callery pears are not hardy to zone 4; Autumn Blaze is hardy throughout zone 4; it may have a few thorns & is susceptible to fire blight, though less so than in the south; Aristocrat has better branching, is marginally hardy in 4a but does well in 4b
Pyrus ussuriensis	Ussurian **pear**	**Mountain Frost** ('Bailfrost')	Mountain Frost is a smaller, upright Ussurian pear; abundant white flowers in spring; sparse ~¾" fruit (solitary trees won't produce fruit); somewhat susceptible to fire blight; not thoroughly tested in western WI; limited availability; City of Rochester, MN, has very good success with Ussurian pear cultivars; should be hardy to zone 3; ***see also Short Trees***
Tilia americana	American **linden** (basswood)	**Legend** ('DTR 123'); **Lincoln**	Legend & Lincoln are smaller basswood cultivars, topping out at 40'; ***other characteristics as described for basswood under Tall Trees***
Tilia cordata	littleleaf **linden**	**Chancellor** ('Chancole'); **Olympic** & **Shamrock** ('Baileyi')	Chancellor, Olympic & Shamrock are smaller littleleaf lindens, maturing at 35–45'; ***other characteristics as described for littleleaf linden under Tall Trees; see also Short Trees*** and ***Trees for Narrow Spaces***
Tilia x 'Harvest Gold'	Harvest Gold **linden**		a littleleaf x Mongolian linden hybrid; Harvest Gold is slightly smaller than littleleaf linden and is less susceptible to snow-load damage; sunscald resistant; golden fall foliage; untested in western WI; should be hardy to zone 3
Ulmus x 'Cathedral'	Cathedral **elm**		a Japanese x Siberian elm hybrid developed at University of Wisconsin; smaller than most disease-resistant/tolerant elms; ***other characteristics as described for elm hybrids under Tall Trees***



Short Trees (mature height ≤25')

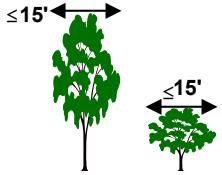
not recommended for terraces narrower than 6'*

recommended spacing: ≥20–30'

botanic name	common name	cultivars	comments
Acer platanoides	Norway **maple***	**Globe** ('Globosum')	Globe is dense, compact, formal-looking; slower growing; ***see also Trees for Narrow Spaces; other characteristics as described for Norway maple under Medium Trees***
Acer tataricum	Tatarian **maple***	**Summer Splendor**; **Pattern Perfect** ('Patdell'); **Hot Wings** ('GarAnn')	Tatarian maple is potentially invasive; do not plant near woodlands, natural areas, uncultivated fields, river corridors or other unmowed areas; choose single-stem plants for streetside planting; Summer Splendor produces less seed than the species; ***see also Trees for Narrow Spaces***
Acer truncatum	Shantung **maple***		uncommon, drought-tolerant; untested in western WI; should be hardy throughout zone 4 if from northern seed source
Amelanchier x *grandiflora*	apple **serviceberry**	**Autumn Brilliance**; **Robin Hill**	apple serviceberry has nice ornamental features and requires little maintenance; somewhat sensitive to drought, heat & deicing salt spray—not for the toughest urban sites; Autumn Brilliance and Robin Hill are commonly available in Tree Form; single-stemmed plants are suitable for streetside use; ***see also Trees for Narrow Spaces***
Crataegus crusgalli var. *inermis*	thornless cockspur **hawthorn**	**Crusader** ('Cruzam')	cockspur hawthorn is native to Wisconsin; the species has thorns & a wide-spreading crown; Crusader is thornless & narrower, with better disease resistance & orange fall color; fruit drop is a potential litter concern; hawthorn flower odor is generally considered unpleasant, but lasts only a week; somewhat sensitive to deicing salt spray–avoid high-speed thoroughfares; ***see also Trees for Narrow Spaces***
Crataegus viridis	green **hawthorn**	**Winter King**	nice ornamental features; low-spreading crown requires wider terrace; essentially thornless; hardy to zone 4b
Maackia amurensis	Amur **maackia**	**Summertime**	Summertime is a smaller Amur maackia, maturing at about 20'; ***other characteristics as described for Amur maackia under Medium Trees; see also Trees for Narrow Spaces***
Malus spp.	**flowering crab** (crabapple)	see comments	dozens of species & cultivars—most mature at ~20' but some are taller; choose ***upright***, ***disease resistant*** cultivars; purple-leaf cultivars are favored by Japanese beetle; basal sprouting is common on many crabs; good white-flowering choices are **Adirondack, Golden Raindrops, Harvest Gold, Red Jewel** and **Sugar Tyme*;*** good pink-flowering choices are **Pink Satin** and **Sentinel**; good red-flowering choices are **Centurion, Kelsey, Prairifire** (wider terrace) and **Red Baron**; ***see also Medium Trees and Trees for Narrow Spaces***
Pyrus ussuriensis	Ussurian **pear**	**Prairie Gem** ('MorDak')	Prairie Gem is a smaller, more rounded Ussurian pear, maturing at about 25'; untested in western WI; ***other characteristics as described for Ussurian pear under Medium Trees***
Syringa pekinensis	Pekin **lilac**	**Summer Charm** ('DTR 124')	Pekin lilac (Peking lilac) is similar to the more common Japanese tree lilac, though slightly less cold hardy; Summer Charm has more upright, predictable form than the species; Pekin lilac has not been thoroughly tested as a street tree in western WI; should be hardy throughout zone 4; ***see also Trees for Narrow Spaces***
Syringa reticulata	Japanese tree **lilac**	several	common beneath power lines; large, white, flower panicles in June; no fall color; grows slowly at first; cultivars have better form for streetside use; ***see also Trees for Narrow Spaces***
Tilia cordata	littleleaf **linden**	**Summer Sprite** ('Halka')	Summer Sprite is a dwarf cultivar, maturing at about 20'; ***other characteristics as described for littleleaf linden under Tall Trees; see also Trees for Narrow Spaces***

*Many short trees reach their maximum crown spread low on the stem and need ≥6'-wide terraces to avoid potential clearance problems. Most do well in properly constructed raised planters with accommodation for irrigation and drainage.

* *Maple is **heavily** over planted in most Wisconsin communities; choose alternatives if maple comprises >10–20% of the local tree population.*



Narrow Trees
(crown spread ≤15')
recommended terrace width varies*

botanic name	common name	spread	comments
Acer x *freemanii* 'Armstrong'	Armstrong maple*	15'	40–50'; produces seed; ***the species is described under Tall Trees***
Acer platanoides 'Columnare'	Columnare Norway maple*	10'	matures at ~40'; ***the species is described under Tall Trees***
Acer tataricum 'Summer Splendor'	Summer Splendor Tatarian maple*	15'	15–20' tall; bright red fruit in summer; somewhat less fruit than most Tatarian maple; ***the species is described under Short Trees***
Amelanchier x *grandiflora* 'Robin Hill'	Robin Hill serviceberry	15'	20–25' tall; ***other characteristics as described under Short Trees***
Crataegus crusgalli 'Cruzam'	Crusader cockspur hawthorn	15'	~15' tall; rounded form; ***other characteristics as described under Short Trees***
Ginkgo biloba 'Mayfield'	Mayfield ginkgo	8–10'	30' tall; habit similar to Lombardy poplar; ***the species is described under Tall Trees***
Maackia amurensis 'Summertime'	Summertime Amur maackia	<15'	a smaller Amur maackia, maturing at about 20' tall; ***the species is described under Medium Trees***; ***see also Short Trees***
Malus spp.	flowering crab (crabapple)	10–15'	most flowering crab cultivars spread to ~15'; narrower and wider cultivars are available; ***the species is described under Short Trees***
Quercus palustris 'Pringreen'	Green Pillar (Emerald Pillar) pin oak	15'	a faster-growing oak, tops out at 50'; begins branching low on the stem; ***the species is described under Tall Trees***
Quercus robur 'Wandell'	Attention! English oak	15'	tall, columnar; formal appearance; ***other characteristics as described under Tall Trees***
Quercus x *bimundorum* 'Crimschmidt'	Crimson Spire oak	15'	tall, columnar; formal appearance; ***other characteristics as described under Tall Trees***
Syringa pekinensis 'DTR 124'	Summer Charm Pekin lilac	15'	somewhat narrower than other Pekin lilac cultivars; ***the species is described under Short Trees***
Syringa reticulata 'Elliot'; 'Ivory Silk'; 'PNI 5723'; 'Willamette'	Snowcap, Ivory Silk, Regent & Ivory Pillar Japanese tree lilac	15'	narrower Japanese tree lilac cultivars; ***the species is described under Short Trees***
Tilia cordata 'Corzam'; 'Halka'	Corinthian & Summer Sprite littleleaf linden	10–15'	Corinthian is columnar, ~45' tall x 15' wide; Summer Sprite is a dwarf form, 15–20' tall x <10' wide; ***other characteristics as described under Tall Trees***

Appendix I – Managing Trees During Construction

Construction and Trees:
Guidelines for Protection

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Trees and machinery can get along. In fact, it is possible to build a new house or install a sidewalk or driveway with little or no damage to surrounding trees. One of the most challenging issues with any construction project is protecting and preserving existing trees on the site. Established and mature trees on a construction site can be preserved if provisions are made to ensure the tree trunk, limbs and root system are not damaged or disturbed.

During the planning process, it's important to understand that not all trees can be saved, nor should they be. Accurate identification is essential. The decision-making process should include a certified arborist or qualified consultant to determine which trees are sustainable. This will help identify the trees suitable for preservation based on species, size, condition and location. In addition, this preconstruction evaluation provides an opportunity to improve the site by pruning or removing trees that are in decline or dying, or will become a hazard. Depending on the size and species of trees in the construction zone, trees could be relocated to more appropriate places. Transplanting desirable trees with a tree spade or other mechanical means is possible with assistance from professionals.

Tree roots usually are considered as "out of sight, out of mind." However, this underground system is one of the most vital and easily damaged parts of the plant, making roots the leading cause of decline and death of injured trees. Any encroachment, disturbance or compaction of the soil around the tree can lead to harm, destroying these fine absorbing roots. Injury caused by activities such as improper cutting,

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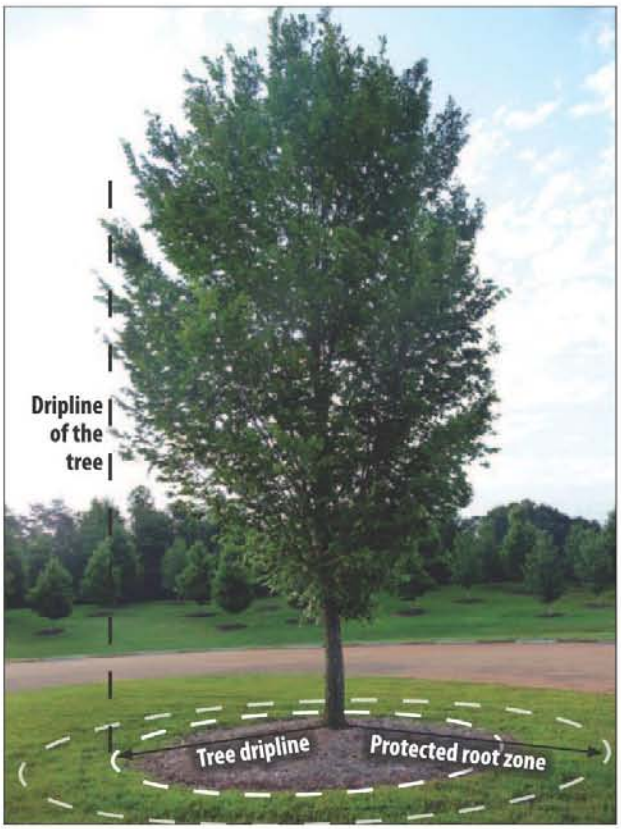
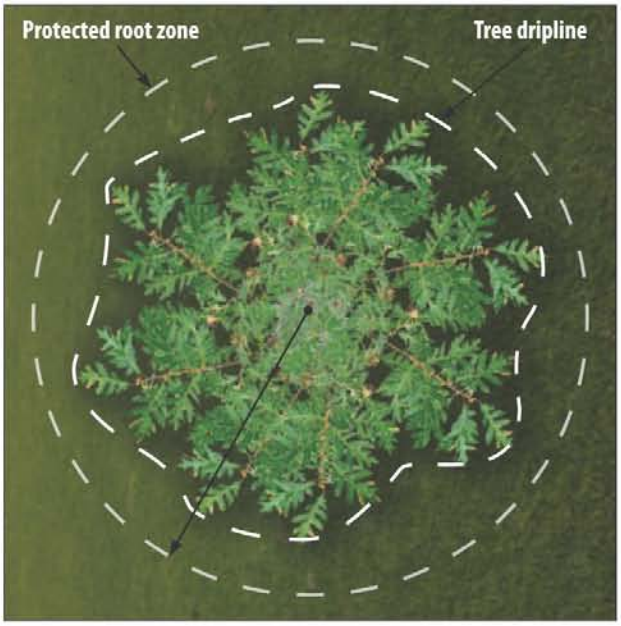


crushing, suffocation or poisoning can result in slow decline, dieback and, eventually, the death of the tree. Trees damaged during construction projects may take years to exhibit symptoms.

The first step in damage prevention is identifying the location of the critical root radius and the protected root zone (PRZ). The dripline area includes the soil and roots that lie directly below the outermost branches. The roots within the dripline are crucial for tree survival. To locate the dripline of the tree, draw a ring just beneath the outermost branches around the entire tree. This is off limits to any project activity. The roots and soil in this area must be protected to ensure tree stability and health. If this area is protected, there likely will not be any major damage to the tree.

Not all trees respond the same to changes in their environment. There are degrees to which certain species tolerate construction activities such as compaction and root cutting. Newly planted or younger trees typically are more resilient in construction zones. Older, mature trees suffering from decline and those growing in wooded areas are more sensitive to changes in their ecosystem. Additional protective measures should be taken for trees determined to be more sensitive because of species characteristics or age. To determine proper distances for tree protection consider location, soil type, size and health during the site survey and inventory.

Safeguarding sensitive trees that have been growing naturally in a wooded area with a more narrow form, or juvenile trees, can be achieved by using the "critical root radius" approach. This method provides an increased area of defense and buffers against nearby construction activity. To determine the critical



root radius, measure the tree diameter in inches at 4½ feet up the trunk, also known as diameter breast height (DBH). Then, multiply that number by 1.5 to get the distance in feet from the trunk where the protected root zone should be established. For example, if the tree is 16 inches in diameter, multiply times 1.5 (equals 24 feet) to determine the distance from the trunk where protective fence or barriers should be established around the tree. The area inside this barrier is considered the PRZ.

On many sites, especially in urban areas, the critical root zone radius – and even the protected root zone area – cannot be achieved because of limited space. Preservation of the soil volume supporting the tree is equally as important as minimizing disturbances. Do not allow more than 25 percent of the roots in the PRZ to be damaged. Don't give up on saving a tree if the recommended allowances cannot be met and disturbances occur. Trees may overcome construction damage to an extent if preconstruction and post-construction measures are taken. A healthy tree always has a better chance to overcome damage.

For a construction project that involves successfully preserved trees, work begins in the planning and construction phases. Good communication between the property owner, arborist, project manager and contractor is vital to saving trees. The list below gives some minimum standards for building sites where vegetation is to be preserved. These guidelines should be incorporated into construction documents and posted on site, and the details made available to all involved who work on the site, especially equipment operators. Tree preservation is site-specific and other guidelines and protective measures also may be appropriate.

1. **Protection barriers**: Install a physical and highly visible obstruction around the tree or trees to be preserved. Use durable fencing material, such as plastic construction fencing, snow fence or chain link. Place the barrier as determined in the preconstruction survey, identifying the critical root zone (CRZ) and protected root zone (PRZ).

2. **Signage**: Place tree protection signs in protection areas and in visible places. All signage should be in both English and Spanish. Place signs approximately every 20 feet on protection fences.

3. **Site access**: Identify and prepare access areas for all construction activities. Limit vehicular traffic to designated paths, which minimizes loads on site soils. Limit crew and project parking to locations off site. Prepare and maintain the access ways with at least 6 inches of hardwood mulch to reduce compaction.

4. **Storage of materials**: Do not allow storage of chemicals, materials or supplies within the area of the protective barriers.

5. **Fuel storage**: Do not allow fuel storage on the site, and specify this in the preservation plan. Petroleum-based products can contaminate the soil and are highly toxic to trees. Require refueling, servicing and maintenance of equipment and machinery in an off-site area.

6. **Debris and waste materials**: Do not allow debris and waste from construction activities within protected areas. Washing down concrete or cement handling equipment, in particular, should be prohibited on site. The ingredients in concrete products are high in pH, which is very caustic and can drastically alter the soil chemistry, damaging plants.

7. **Grade changes**: Have an International Society of Arboriculture Certified Arborist or other qualified experts approve any grade changes before construction begins, and specify measures to reduce serious construction activities. Grade changes can be damaging to trees, with as little as 2 inches of fill soil over the root zone of a tree potentially causing death. Removing soil or lowering the grade can destroy major portions of a root system, causing decline and eventual death.

8. **Root cutting and pruning**: If it becomes necessary to precut or prune roots outside the PRZ during construction, require clean cuts perpendicular to the natural growth direction. Also, backfill within an hour of cutting roots and water the tree within 24 hours. Severing roots can have a significant impact on tree health and survival, as well as tree stability.

9. **Physical damage**: Have an ISA Certified Arborist perform any advance pruning that will reduce physical damage to low limbs, etcetera, especially considering the clearances required by equipment. Careless use of construction equipment can wound the trunk and lower limbs, allowing decay and other pests to enter the tree. Injury to trunks or branches and limbs can damage the long-term health and appearance of the plant. This type of injury also can create a tree hazard on the site. Additionally, the appearance of the tree can be ruined if the branching structure is damaged and cannot be corrected with restorative pruning. Canopy damage should be considered and pruned according to industry guidelines such as ANSI A300 pruning standards.

10. **Administer, monitor and inspect**: Review tree preservation and contractor performance in daily construction meetings. Enforcement, penalties and mitigation regarding breach of the preservation policy should be discussed, understood and captured in construction documents. Place the details of the preservation policy on the project site for reference and reminder. Any tree damage or injuries should be reported to the project arborist as soon as possible. Follow-up by the consulting arborist or forester on the site after construction is critical for success of the preservation plan. It is common to monitor the post-construction site for several years for evaluation of tree health.

Prevention and follow-up

Pre- and post-construction action: Even with the best preservation plan in place, damage can occur, leading to changes in a tree's environment. Response to construction will depend on the degree of site modifications and the health of the tree. To minimize adverse effects, it is important to have a healthy, vigorous tree going into the construction project. Proper watering is essential to the tree's survival. Be sure the tree is well watered in the months prior to the project start. Reducing plant stress will lessen chances of decline. Mulching the PRZ will help insulate soils from major changes in the canopy, exposure and water loss. Fertilization is not necessary or advised, especially on mature trees.

The sooner care begins the better the chance the tree will survive with few problems. Post-construction care includes similar activities as before to maintain good plant health. Minimize stress with supplemental irrigation during dry periods, maintain an adequate layer of mulch and monitor the plant for signs of stress or pest activity.

Trees are a capital asset on the property and protecting this investment by proper management is critical. The best strategy for building with trees is to have a qualified consulting arborist or forester involved from the start of the planning phase. Too often, the tree professional is called too late when the damage has been done and mitigation is unlikely or impossible. Considering the important benefits and values that trees provide, it is wise for the contractor or property owner to employ the services of the tree expert and a well-supported preservation plan. It might seem easier and sometimes more affordable to just clear-cut the site and plant more trees, but mature trees provide considerable real estate and environmental value. Unnecessarily removing trees takes away the many environmental and economic advantages they provide. Large, mature trees provide many life-sustaining benefits, which humans need for survival and quality of life. Preservation is just as important as planting.

To help prevent construction damage, have a certified arborist in place during the planning and site preparation phase of development.

PURDUE AGRICULTURE

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Appendix J – Tree Selection and Placement

Tree Selection and Placement

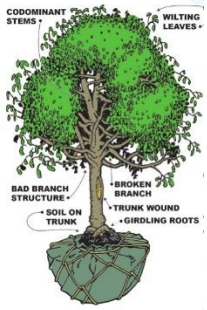
Understand important issues in selecting a tree for planting, such as the tree's intended function, location, common pests, geographic regions and hardiness zones, and considerations for best placement alternatives.

Tree selection and placement are two of the most important decisions a homeowner makes when landscaping a new home or replacing a tree. Many trees have the potential to outlive those who plant them, so the impact of this decision can last a lifetime. Matching the tree to the site benefits both the tree and the homeowner.

One of the most common tree care questions is: "Which kind of tree should I plant?" Before this question can be answered, a number of factors need to be considered:

- Why is the tree being planted? What functions will it serve?
- Is a small, medium, or large tree best suited for the location and available space? Do overhead or belowground utilities preclude planting a large, growing tree — or any tree at all? What clearance is needed for sidewalks, patios, or driveways?
- What are the soil conditions? Is enough soil available of sufficient quality to support mature tree growth?
- How will necessary maintenance be provided? Will someone water, fertilize, and prune the tree as needed after planting?

Answering these and other questions can help you choose the "right tree for the right place."



When selecting a tree, check for signs of structural problems, damage, and poor tree health.

Tree Function

Large, healthy trees increase property values and make outdoor surroundings more pleasant. A deciduous shade tree that loses leaves in fall provides cooling relief from summer's heat while allowing the winter sun to warm a home. An ornamental tree displays beautiful flowers, leaves, bark, or fruit. Evergreens with dense, persistent foliage can provide a windbreak or a screen for privacy. A tree or shrub that produces fruit can provide food for the owner or wildlife. Street trees decrease the glare from pavement, reduce runoff, filter out pollutants, and add oxygen to the air we breathe. Street trees also improve the overall appearance and quality of life in a city or neighborhood.

Form and Size

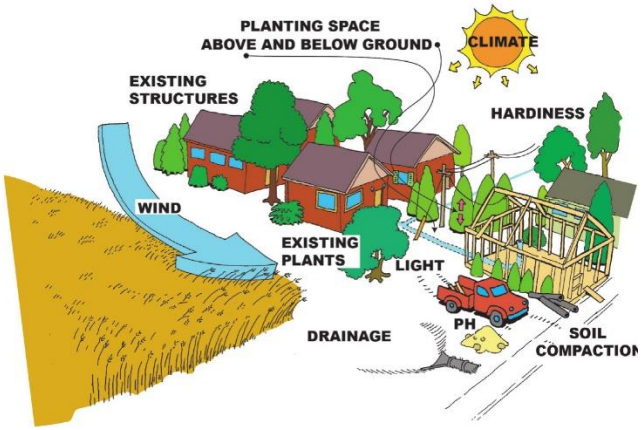
A basic principle of modern architecture is "form follows function." Selecting the right form (shape) to complement the desired function (what you want the tree to do) can significantly reduce maintenance costs and increase the tree's value in the landscape. In addition, mature tree size determines the level of benefits received. Larger trees typically provide the greatest economic and environmental returns.

Depending on site restrictions, you can choose from hundreds of form and size combinations. A low, spreading tree may be planted under overhead utility lines. A narrow, columnar evergreen may provide a screen between two buildings. Large, vase-shaped trees can create an arbor over a driveway or city street.

Site Conditions

Selecting a tree that will thrive in a given set of site conditions is the key to long-term tree survival and reduced maintenance. Consider the following when selecting a tree:

- soil conditions
- exposure (sun and wind)
- drainage
- space constraints
- hardiness zone
- human activity
- insect and disease susceptibility



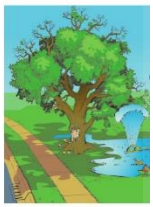
Soil Conditions

In dense urban areas and new subdivisions, soil is often disturbed, shallow, compacted, and subject to drought. Most trees will suffer in these conditions without additional care. An arborist can take soil samples from your yard to test for texture, fertility, salinity, and pH (alkalinity or acidity). These tests can be used to determine which trees are suited for your property and may include recommendations for improving poor soil conditions.

Exposure

The amount of sunlight available will affect tree and shrub species selection for a particular location. Most woody plants require full sunlight for proper growth and flowering. Some do well in, or even prefer, light shade; however, few species perform well in dense shade. Wind exposure is also a consideration. Wind can dry out soils, damage tree crowns, and uproot newly planted trees. Special maintenance, such as staking or more frequent watering, may be necessary to establish young trees on windy sites.

Drainage

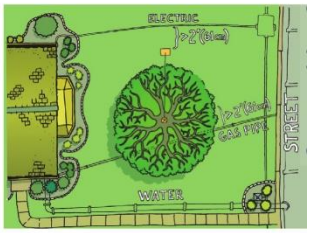


Tree roots require oxygen to develop and thrive. Poor drainage limits oxygen availability to the roots and may ultimately kill the tree. If drainage is an issue on your property, ask a local arborist about what can be done to correct the problem.

Hardiness

Hardiness is the plant's ability to survive in the extreme temperatures of the particular geographic region in which you are planting the tree. Plants can be cold hardy, heat tolerant, or both. Most plant reference books provide a map of hardiness zone ranges. Check with your local garden center for the hardiness information for your region.

Space Constraints



Many different factors can limit the planting space available to the tree: overhead or underground utilities, pavement, buildings, other trees, visibility. The list goes on and on. Make sure there is adequate room for the tree you select to grow to maturity, both above and below ground.

Human Activity

Often an overlooked aspect of tree selection, the reality is that the top five causes of tree death result from things people do. Soil compaction, underwatering, overwatering, vandalism, and the number one cause — planting the wrong tree — account for more tree deaths than all insect- and disease-related tree deaths combined.

Pest Problems

Every plant has its particular pest problems, and the severity varies geographically. These pests may or may not be life threatening to the plant, but selecting trees resistant to pest problems specific to your area is the best choice. Your local ISA Certified Arborist, tree consultant, or extension agent can direct you to information relevant to problem species for your location.

Species Selection

Personal preferences and site constraints play major roles in the selection process. Taking into consideration the factors listed above, you can help ensure the tree you plant grows and functions as desired. Remember, the beautiful, mature specimen trees you see in historic neighborhoods and in landscape photography would never have reached their full potential if planted in improperly matched sites.

This brochure is one in a series published by the International Society of Arboriculture as part of its Consumer Information Program. You may have additional interest in the following titles currently in the series:

- Avoiding Tree and Utility Conflicts
- Avoiding Tree Damage During Construction
- Benefits of Trees
- Buying High-Quality Trees
- Insect and Disease Problems
- Mature Tree Care
- New Tree Planting
- Plant Health Care
- Proper Mulching Techniques
- Palms
- Pruning Mature Trees
- Pruning Young Trees
- Recognizing Tree Risk
- Treatment of Trees Damaged by Construction
- Tree Selection and Placement
- Trees and Turf
- Tree Values
- Why Hire an Arborist
- Why Topping Hurts Trees

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Appendix K – Salt Tolerant Trees

Winter in Wisconsin often means snow and ice. To allow safe travel for pedestrians and motorists, walkways and roads must be kept as ice-free as possible. While snow and ice removal is best done with shovels, snow blowers, and plows, this may not remove all of the snow, and ice can quickly form, leaving slick, hazardous surfaces. Deicing salts are used extensively to melt this ice and snow.

Sodium chloride (NaCl), or rock salt, is the most commonly used deicer due to its effectiveness, availability, and comparatively low cost. However, it also has significant drawbacks. It's highly corrosive, causing significant environmental damage and corroding vehicles and concrete. The national cost of damage to vehicles and infrastructure alone is estimated at $3.5 to $7.0 billion annually.

This publication focuses on recognizing and preventing plant damage caused by deicing salts, evaluates the pros and cons of alternatives to rock salt, and provides an extensive list of salt-tolerant plants.

Types of salt damage

SOIL DAMAGE. When salt accumulates in the soil, excessive sodium (Na) from salt destroys soil structure, raises soil pH, and reduces water infiltration and soil aeration, leading to soil compaction, increased erosion, and water runoff. The soil becomes unsuitable for proper root growth and plant development. Deicing salts are also detrimental to beneficial mycorrhizal fungi in the soil, which form a symbiotic relationship with roots assisting with nutrient uptake.

PLANT DAMAGE. Salt is moved off the pavement and into the environment by one of two mechanisms: it may accumulate in the soil along streets or sidewalks from melted, salt-laden snow or it may become dispersed in an aerosol spray by fast-moving traffic and high winds along wet, salted roads. This dispersed salt causes significant damage to turfgrass as well as landscape and wetland plants growing near or along roadways, highways, driveways, and sidewalks. While salt runoff is typically limited to areas bordering salted roadways, salt spray can travel hundreds and even thousands of feet from the road.

BROWNING ALONG THE EDGES OF THESE MAPLE LEAVES MAY BE INDICATIVE OF SALT INJURY.

Plant roots can take up salt, leading to accumulation in the plant. Plants may also have salt deposits on surfaces, such as twigs, buds, or leaves, causing tissue dehydration. Build-up of deicing salts in the plant can interfere with photosynthesis and other plant processes, like respiration and transpiration. Chloride (Cl) ions in salt can injure plant tissue, reduce water uptake, and cause nutrient imbalances such as magnesium (Mg) and potassium (K) within a plant. Salt applications made in late winter or early spring cause the most damage compared to applications made earlier due to active uptake of water by the root systems as plants are beginning to break their dormancy. In areas where salt concentrations are high, native vegetation is being replaced by salt-tolerant, invasive species such as reed canarygrass (*Phragmites australis*) and/or narrow-leaved cattail (*Typha angustifolia*) leading to landscapes dominated by a single species.

PEOPLE. Well water contaminated with excessive chloride contributes to hypertension and other heart related conditions in humans. The intake of high chloride levels from salt may also be associated with elevated mortality from cancer. Maximum safe level of chloride in drinking water is 250 mg/L (250 ppm) but salt runoff often exceeds these levels.

WATER QUALITY. Water quality can be adversely affected by road salt runoff into lakes, ponds, rivers, and wetlands.

WILDLIFE. Local wildlife lose food and shelter as plants die due to excess salt.

Diagnosing salt injury

Diagnosing salt injury can be difficult because similar symptoms may result from a wide variety of causes. The following problems all cause similar symptoms: drought stress, root damage from construction, girdling roots, winter burn of foliage, air pollution, compacted soil, grade changes, nutrient deficiencies, insects and diseases, natural gas leaks, water-logged soils, and improper planting depth. There are, however, some details to look for that may help:

Indications of salt spray injury

- Salt damage more severe on side of plant facing the road or on outer portions of dense plants
- Severity of damage increases with volume and speed of traffic and amount of salt used
- Plants downwind from road show more damage than upwind
- Most damage occurs within 60 feet of road and decreases with distance from road
- Sensitive plants show symptoms of salt damage at distances as much as 1,000 feet or more from major highways
- Branches covered by snow or sheltered from road show no damage
- Branches growing above spray drift zone show no damage
- Plants that are less cold hardy show more injury

Indications of soil salt injury

- Most damage occurs within 30 feet of road and decreases with distances from road
- Plants are severely injured in poorly drained soils or where runoff from salt-laden snow collects
- Damage increases with amount of salt used
- Plants growing near areas that receive frequent salt applications (walkways, parking lots, entrances) show most damage
- Plants damaged over several years lack vigor and are in decline

If salt injury is suspected, either foliar analysis or soil salt tests are needed to confirm the diagnosis. These tests are available at a soil and plant analysis lab for a nominal fee. Collect soil samples in early spring before rain leaches salts out of the sampling area. Leaf and stem tissue samples can be submitted during the growing season for chloride content. Foliar chloride concentrations that exceed 0.5% dry weight for conifers and 1.0% for deciduous plants are considered harmful. Use clean pruners and wear gloves when handling the samples to avoid contamination of sample, or prune the tissue directly into plastic bags. Contact your county Extension office for specific instructions, location, and costs for this service.

Symptoms of salt injury

Salt spray

Salt spray enters plants through buds, bud and leaf scars, young shoots, as well as the leaves of evergreens species. Salt deposited on plants draws moisture out of the tissues causing desiccation (drying) and burn. Recent research indicates that salt spray injury contributes to winter injury, although it does not normally affect cold hardiness of dormant buds on woody ornamentals. The morphology and physiology of a plant bud appear to work together determining tissue sensitivity to deicing salts and freezing temperatures. For example, species that have naked buds (no scales on buds) appear more susceptible to freezing and to deicing salt than species with multi-scaled (covered) buds. Buds are most susceptible in late winter and early spring as they break dormancy. The degree of bud injury can be influenced by the plant's genetic differences, type of salt exposure (aerial spray or soil salt), intensity of the salt exposure, biotic factors, climate, and seasonal differences.

Salt accumulation and damage of Japanese pachysandra foliage

Symptoms on deciduous plants

- Injury appears in early spring
- Delayed budbreak
- Reduced leaf size and stem growth
- Off-colored foliage
- Outer edges of leaves turn brown
- Plants may fail to flower
- Death of buds and twigs leading to misshapen, unsightly looking plants
- When the tip of a branch dies back, many new shoots sprout just below the dead area, creating a "witches' broom"
- Crown of the tree begins to thin
- Large branches may die if severe injury occurs over several years

Symptoms on evergreens

- Injury evident in late winter to early spring
- Tips of mature needles turn brown or yellow; discoloration moves down the needle, eventually killing entire needle; damaged needles eventually fall off
- Discoloration of needles is often hidden by new growth in spring
- Twigs die back
- Symptoms occur primarily on the side of the plant facing the road

Soil salt

Unlike salt spray injury, soil salt injury is slow to develop and injury progresses over several years. Deicing salts create a wide range of problems for plants. Salt is highly absorbent and binds tightly with water, preventing plant roots from taking up water. Thus, even when soil moisture is plentiful, high salt levels create an artificial, drought-like environment for plants. Compounding the problem, high concentrations of soil salt can actually draw water out of the roots. When roots do absorb salt, high concentrations will eventually kill roots, causing plants to decline over several years. At high concentrations in the soil, sodium (Na) will compete with essential nutrients for uptake by plants. Roots will also absorb toxic levels of chloride (Cl) from deicing salts, which accumulates in buds, leaves and twigs, causing desiccation (drying). Since an affected plant's health is compromised, it become more susceptible to insects, diseases, and drought stress. With regard to soil texture, plants tend to be more salt tolerant in sandy, well-drained soils than in heavy clay soils as the salt is more easily leached through the soil by rainwater.

Symptoms on deciduous plants

- Browning along edges of leaves
- Wilting during hot, dry weather when soil moisture is limited
- Off-colored or discolored foliage
- Nutrient deficiencies, in particular magnesium and potassium
- Stunting and reduced plant vigor
- Plant produces fewer, smaller leaves that are often chlorotic (yellow)
- Premature fall coloration and leaf drop
- Flowers and fruit smaller than normal
- Twig dieback
- Turfgrass and herbaceous perennials may die due to excessive soil salt

Symptoms on evergreens

- Similar to salt spray injury, but both old and new needles are affected
- Eventual plant death

THE TIPS OF THESE EASTERN WHITE PINE NEEDLES ARE TURNING BROWN FROM SALT INJURY. DAMAGE WILL PROGRESS INWARD, EVENTUALLY KILLING THE NEEDLES.

EASTERN WHITE PINE TREES DAMAGED ON SIDE OF TREE FACING THE ROAD. NOTE SALT DAMAGE DID NOT OCCUR ON LOWER FOLIAGE DUE TO SNOW COVER.

Prevention of Salt Injury

There are many ways to prevent or alleviate salt injury. Deicing salt applications should be used primarily in high-risk areas such as highways, intersections, hills, steps, and major walkways; limit applications in non-critical areas. If possible, avoid using pure sodium chloride (NaCl), a common deicing salt. Instead, mix less than 5% of sodium chloride (NaCl) with abrasive materials such as sand, crushed rock, kitty litter, ash or cinders, or use an alternate deicing product (see table 2 for a comparison of available products). These mixtures are particularly useful on roads with low traffic volume and when temperatures fall below 20°F (sodium chloride is ineffective at colder temperatures). For example, 1 pound of deicing salt mixed with 50 pounds of sand makes an effective abrasive compound, particularly on walkways where good foot traction is required. This combination stays loose and unfrozen and is easy to spread; however, there is usually not enough salt to do any appreciable melting. Do not use commercial fertilizers as a deicing salt as these products will burn plant roots.

If using a deicer, wait to apply until after all the snow has been plowed or shoveled. Early applications of small amounts of salt can be very effective in keeping ice from bonding to the pavement, which improves removal of snow and ice after a storm. Remove slush before it has a chance to refreeze. Once ice has bonded to the pavement, it takes more salt to remove the ice than if a lighter application been made earlier. If possible, avoid application of salt in late winter and early spring as the plants are coming out of dormancy.

Prevention Tips

- One of the best preventive techniques is to plant salt-tolerant species in areas that are subject to salt spray or runoff (see table 1). Be aware that a plant's degree of tolerance to soil salts may be different from its aerial salt tolerance.
- In areas where soil salt is a problem, planting trees and shrubs on berms (raised, mounded beds) will prevent salty runoff water from moving into root zones.
- Protect plants from salt spray by placing physical barriers such as plastic, burlap, or snow fencing around or near plants in late fall.
- Avoid shoveling salt-laden snow over the root zones of sensitive plants.
- During a warm spell in winter, rinse off plants to eliminate residual salt before budbreak.
- In early spring, water soil heavily (at least 6 inches) to flush salt out of the plant's root zone.
- Direct salt runoff away from plants using barriers such as gutters or alter drainage patterns away from planting areas. (This method works best on well-drained soils and is not very effective on clay soils and compacted soils where water does not drain readily.)
- Application of gypsum ($CaSO_4$) to heavy clay soils that are high in salt will displace the sodium ion with calcium, improving both aeration and drainage.
- If salt-sensitive plants are to be used, plant them at least 60–100 feet from highways and 30–40 feet from city streets where salt runoff into soil is common.

Use of anti-transpirants and dormant oil sprays are ineffective in prevention of salt spray injury and are not recommended.

ON DECIDUOUS TREES, CLUSTERS OF NEW SHOOTS, KNOWN AS "WITCHES' BROOMS," SPROUT WHERE BRANCH TIPS DIE BACK.

Why some plants are salt tolerant

A variety of physiological characteristics are involved in making plants tolerant or susceptible to salt.

Protection against salt spray. **Some plants have features that physically prevent salt spray from penetrating. Such features include hidden or submerged buds; thick surface wax; numerous, tightly arranged bud scales; fuzzy buds; or sticky resin-coated buds. (None of these structures protect the plant against soil-borne salt, which is taken up through the roots.) In contrast, plants that produce naked buds (no bud scales) are very susceptible to salt spray injury in winter, more so than plants with scaled buds. Examples of plants that have naked buds include wayfaringtree viburnum (*Viburnum lantana*), Koreanspice viburnum (*Viburnum carlesii*), Judd viburnum (*Viburnum* x *juddii*), pawpaw (*Asimina triloba*), witchhazels (*Hamamelis* spp.), fothergillas (*Fothergilla* spp.), and the highly invasive tallhedge buckthorn (*Rhamnus frangula* 'Columnaris').**

Protection against soil salt. **Some plants, such as green ash (*Fraxinus pennsylvanica*), are able to exclude soil salt from entering their cells or they may be able to withstand higher concentrations within the cells.**

Varying degrees of tolerance. **An individual plant's tolerance to salt will vary depending on its state of dormancy, on temperature fluctuations, and on morphological changes. Plants exhibit the greatest resistance to salt damage in early winter (December through early January). In March and April as spring approaches, buds become much more susceptible to salt injury. Newly planted trees and shrubs, which have small root systems and little stored water, are more susceptible to salt injury in winter than established plants. For these plants, extra attention should be given to preventive measures during the first few years after planting to help protect plants from salt damage.**

Products for ice control and alternatives

There are several chemicals commonly used as deicers. They are often blended together or combined with other materials such as sand, cinders, ash, agricultural byproducts, or other proprietary material to improve performance, limit environmental and concrete damage, and reduce cost. There are many commercial blends available in local stores with different percentages of deicing chemicals. Some deicing compounds are sold with anti-corrosive additives. While additives help, they will not eliminate corrosion entirely and their effects on plants and the environment are often unknown.

Performance of a deicing product is influenced by many factors including chemical concentration, air and pavement temperatures, traffic and weather conditions, type of road surface, topography, traffic volume, width of application, duration of the deicing salt melting action, shape of the deicer particles, and the time it takes the deicing salt to form a brine. Consider a balance between safety, cost, and practical storage and application issues when selecting a final product to use.

Always follow label directions when using a deicing product. Never over-apply deicing products as this may cause serious damage to plants and the environment.

TABLE 1. Salt-tolerant landscape plants

SPRAY	SOIL	DECIDUOUS TREES		ZONE
H		*Acer campestre*	Hedge maple	5b
H		*Acer miyabei*	Miyabe maple	4a
H		*Acer platanoides*	Norway maple	4b
H		*Acer pseudoplatanus*	Sycamore maple	5b
M		*Acer tataricum* subsp. *ginnala*	Amur maple	3a
H		*Aesculus* x *carnea*	Red horsechestnut	5a
H	M	*Aesculus hippocastanum*	Common horsechestnut	4b
M		*Amelanchier* x *grandiflora*	Apple serviceberry	3a
M		*Betula nigra*	River birch	4a
H		*Carya ovata*	Shagbark hickory	4b
M	M	*Catalpa speciosa*	Northern catalpa	4a
H	M	*Crataegus crus-galli*	Cockspur hawthorn	4a
H	H	*Fraxinus americana**	White ash	4a
H		*Fraxinus excelsior**	European ash	4b
H	H	*Fraxinus pennsylvanica**	Green ash	2a
M		*Fraxinus quadrangulata**	Blue ash	4a
M	M	*Ginkgo biloba*	Ginkgo	4b
H	H	*Gleditsia triacanthos* var. *inermis*	Thornless honeylocust	4a
H	H	*Gymnocladus dioicus*	Kentucky coffeetree	4a
H		*Juglans nigra*	Black walnut	4b
H		*Larix decidua*	European larch	3a
H		*Larix kaempferi*	Japanese larch	4a
H		*Larix laricina*	American larch, tamarack	2a
H	H	*Liquidambar styraciflua*	Sweet gum	5b
M	M	*Nyssa sylvatica*	Black gum, tupelo, sour-gum	4b
H		*Populus deltoides*	Eastern cottonwood	3a
H		*Populus grandidentata*	Bigtoothed aspen	3a
H		*Populus tremula* 'Erecta'	Upright European aspen	2b
H		*Populus tremuloides*	Quaking aspen	2a
H		*Prunus americana*	American plum	3b
M		*Prunus maackii*	Amur chokecherry	3a
M		*Prunus sargentii*	Sargent cherry	4b
M	M	*Prunus virginiana*	Chokecherry	3a
M		*Pyrus calleryana*	Callery pear	4b
M		*Quercus alba*	White oak	3b
M	M	*Quercus bicolor*	Swamp white oak	4a
M	M	*Quercus ellipsoidalis*	Northern pin oak	4a
M		*Quercus imbricaria*	Shingle oak	4b
M	M	*Quercus macrocarpa*	Bur oak	3a
M		*Quercus robur*	English oak	5a
M	M	*Quercus rubra*	Northern red oak	3b
H		*Robinia pseudoacacia* 'Lace Lady'	Twisty Baby® black locust (fruitless)	4b
H		*Salix matsudana* 'Tortuosa'	Curly willow, contorted willow	4b
H		*Salix* x *sepulcralis* var. *chrysocoma*	Golden weeping willow	4a
H		*Styphnolobium japonicum*	Japanese pagodatree	5b
H	H	*Syringa pekinensis*	Peking lilac or Pekin lilac	4a
H	H	*Syringa reticulata*	Japanese tree lilac	3a
H	M	*Taxodium distichum*	Baldcypress	4b
H		*Ulmus glabra*	Scotch elm	4b
H	M	*Ulmus* hybrids	Hybrid elms	4a-5
		DECIDUOUS SHRUBS		
M		*Amelanchier canadensis*	Juneberry, serviceberry	3b
H	H	*Amorpha fruticosa*	Indigo-bush	4b
M		*Aronia arbutifolia*	Red chokeberry	4b
M		*Aronia melanocarpa*	Black chokeberry	3b
H		*Berberis koreana*	Korean barberry	4a
H		*Berberis thunbergii*	Japanese barberry	4a
	H	*Buddleja davidii*	Butterfly bush (dieback shrub)	5b
H	H	*Caragana arborescens*	Siberian peashrub	2a
M		*Clethra alnifolia*	Summersweet clethra	4b
H		*Comptonia peregrina*	Sweet-fern	3b
M	M	*Cotoneaster apiculatus*	Cranberry cotoneaster	4b
M	M	*Cotoneaster divaricatus*	Spreading cotoneaster	5b
M	M	*Cotoneaster horizontalis*	Rockspray cotoneaster	5a
M	M	*Cotoneaster acutifolius* var. *lucidus*	Hedge cotoneaster	3a
M		*Cotoneaster multiflorus*	Many-flowered cotoneaster	4b
H		*Euonymus alatus*	Winged euonymus, burningbush	4a-b
H	H	*Hippophae rhamnoides* 'Sprite'	Sprite common seabuckthorn	4a

*No longer recommending planting ash (*Fraxinus* spp.) species due to susceptibility to Emerald ash borer

(H = HIGH LEVEL OF TOLERANCE; M = MODERATE LEVEL OF TOLERANCE)

SPRAY	SOIL	DECIDUOUS SHRUBS		ZONE
H		*Hydrangea macrophylla*	Bigleaf hydrangea	5a-6
H		*Hypericum kalmianum*	Kalm's St. Johnswort	4a
M		*Ilex verticillata*	Winterberry, Michigan holly	3b
	H	*Lespedeza bicolor*	Shrub bush-clover (dieback shrub)	5b
M	H	*Morella pennsylvanica* (*Myrica pennsylvanica*)	Northern bayberry	4a
	H	*Perovskia atriplicifolia*	Russian sage (dieback shrub)	5a
M		*Philadelphus coronarius*	Mockorange	4b
H		*Dasiphora fruticosa* (*Potentilla fruticosa*)	Potentilla	3a
H		*Prunus maritima*	Beach plum	3b
H		*Pyracantha coccinea*	Scarlet firethorn	5b
H		*Rhodotypos scandens*	Black jetbead	5a
H	H	*Rhus aromatica*	Fragrant sumac	3b
H	H	*Rhus copallina*	Shining sumac, winged sumac	4b
H	H	*Rhus glabra*	Smooth sumac	3a
H	H	*Rhus typhina*	Staghorn sumac	3b
M	H	*Ribes alpinum*	Alpine currant	3a
H		*Ribes odoratum*	Clove currant	4a
H	H	*Robinia hispida*	Bristly locust (fruitless)	5b
H	H	*Rosa rugosa*	Rugosa rose	2b
H		*Rosa virginiana*	Virginia rose	3b
H		*Salix caprea*	Goat willow	4a
H		*Salix discolor*	Pussy willow	3a
H		*Salix purpurea*	Purpleosier willow, blue arctic willow	3b
H		*Shepherdia argentea*	Silver buffaloberry	3a
M		*Spiraea japonica*	Japanese spirea	3b
M		*Spiraea nipponica* 'Snowmound'	Snowmound spirea	4a
M		*Spiraea* x *vanhouttei*	Vanhoutte spirea	4a
H		*Symphoricarpos albus*	Common snowberry	3b
M	M	*Syringa meyeri* 'Palibin'	Palibin lilac	4a
M	M	*Syringa pubescens* subsp. *patula* 'Miss Kim'	Miss Kim lilac	3b
H		*Tamarix chinensis*	Tamarisk	2b
M		*Viburnum dentatum*	Arrowwood viburnum	4a
M		*Viburnum lentago*	Nannyberry viburnum	3a
M	M	*Viburnum prunifolium*	Blackhaw viburnum	4a
M		*Viburnum opulus* var. *americanum* (*Viburnum trilobum*)	American cranberrybush viburnum	3a
	H	*Vitex agnus-castus*	Chastetree (dieback shrub)	5b
H		*Yucca filamentosa*	Adam's needle yucca	4b
H		*Yucca filifera* 'Golden Sword'	Golden sword yucca	4b
		EVERGREEN TREES & SHRUBS		
M		*Juniperus chinensis*	Chinese juniper	4a
H	H	*Juniperus communis*	Common juniper	3a
H	H	*Juniperus communis* var. *depressa*	Common oldfield juniper	3a
H	H	*Juniperus virginiana*	Eastern red-cedar	3b
H	M	*Picea pungens* var. *glauca*	Colorado blue spruce	3a
H		*Pinus banksiana*	Jack pine	2a
H		*Pinus leucodermis*	Bosnian pine	4b
H	H	*Pinus mugo*	Mugo pine	3a
H		*Pinus nigra*	Austrian pine	4a
H		*Pinus parviflora*	Japanese white pine	5a
H		*Pinus ponderosa*	Ponderosa pine	4a
H		*Pinus sylvestris*	Scots or scotch pine	3a
		GROUNDCOVERS		
H		*Arctostaphylos uva-ursi*	Bearberry	2b
H		*Euonymus fortunei* 'Coloratus'	Purpleleaf wintercreeper	4b
H		*Hedera helix*	English ivy	4b
H	H	*Juniperus horizontalis*	Creeping juniper	3a
H	H	*Juniperus sabina*	Savin juniper	3a
H	H	*Juniperus sargentii*	Sargent juniper	4a
H		*Prunus pumila* var. *depressa*	Eastern sandcherry (deciduous)	4b
H	H	*Rhus aromatica* 'Gro-low'	Gro-Low sumac (deciduous)	3b
		VINES		
H		*Campsis radicans*	Trumpetcreeper	4b
H		*Hedera helix*	English ivy	4b
H		*Parthenocissus inserta*	Woodbine	3b
H		*Parthenocissus quinquefolia*	Virginia creeper	3b

SPRAY	SOIL	ORNAMENTAL GRASSES		ZONE
	H	*Calamagrostis* x *acutiflora* 'Karl Foerster'	Karl Foerster feather reed grass	4b
	H	*Chasmanthium latifolium*	Northern sea oats	4b
	M	*Festuca glauca* 'Elijah Blue'	Elijah Blue fescue	4a
	M	*Helictotrichon sempervirens*	Blue oat grass	4a
	H	*Leymus arenarius* 'Glaucus'	Blue lyme grass	4a
	M	*Miscanthus* spp.	Miscanthus, maiden grass	5a
	H	*Panicum virgatum*	Switch grass	4b
	H	*Pennisetum alopecuroides*	Fountain grass, pennisetum	5a
	M	*Schizachyrium scoparium*	Little bluestem	4a
		HERBACEOUS PLANTS		
	M	*Achillea millefolium* 'Apple Blossom'	Apple Blossom common yarrow	3b
	M	*Achillea* 'Moonshine'	Moonshine yarrow	3b
	H	*Allium christophii*	Stars of Persia	4b
	H	*Allium senescens*	Ornamental onion	3b
	H	*Anthemis punctata* subsp. *cupaniana*	Anthemis	5b
	H	*Armeria maritima* 'Splendens'	Splendens sea thrift	4a
	M	*Artemisia ludoviciana*	White sage	4a
	M	*Artemisia* 'Powis Castle'	Powis Castle artemisia	5b
	M	*Artemisia schmidtiana* 'Nana'	Dwarf silvermound artemisia	3b
	M	*Artemisia stelleriana*	Beach wormwood	4a
	M	*Aster novae-angliae* 'Purple Dome'	Purple Dome New England aster	4a
	M	*Bergenia cordifolia*	Heart-leaf bergenia	3b
	M	*Catananche caerulea*	Cupid's dart	4b
	M	*Centranthus ruber*	Jupiter's beard, red valerian	5a
	H	*Crambe maritima*	Sea kale	5a
	H	*Dianthus* x *allwoodii* 'Helen'	Helen allwood pinks	4a
	M	*Dianthus gratianopolitanus*	Cheddar pinks	4a
	H	*Echinops* spp.	Globe thistle	4a
	H	*Erigeron glaucus*	Seaside aster, beech fleabane	4a
	H	*Eryngium* x *oliverianum*	Sea holly	4a

SPRAY	SOIL	HERBACEOUS PLANTS		ZONE
	H	*Eryngium* x *tripartitum*	Sea holly	5b
	M	*Euphorbia polychroma*	Cushion spurge	4a
	M	*Gaillardia* x *grandiflora* 'Goblin'	Goblin blanket flower	3a
	M	*Goniolimon tataricum*	German statice	4b
	M	*Gypsophila paniculata*	Baby's-breath	4a
	M	*Hemerocallis* spp.	Daylily	3b
	M	*Heuchera micrantha* 'Palace Purple'	Palace Purple coral bells	4a
	M	*Heuchera sanguinea* 'Chatterbox'	Chatterbox coral bells	4a
	M	*Hosta plantaginea*	Fragrant hosta, August lily	4a
	M	*Hosta undulata* 'Medio-variegata'	Variegated hosta, wavy hosta	3b
	M	*Iberis sempervirens*	Evergreen candytuft	5a
	M	*Iris sibirica* 'Caesar's Brother'	Caesar's Brother Siberian iris	3b
	M	*Iris* spp. (Germanica Group)	Bearded iris	3b
	M	*Kniphofia* 'Royal Standard'	Red-hot poker	5b-6
	M	*Leucanthemum* x *superbum* 'Becky'	Becky shasta daisy	4a
	M	*Limonium latifolium*	Purple sea lavender	4a
	M	*Liriope spicata*	Creeping lilyturf	5b
	M	*Nepeta* x *faassenii*	Nepeta, catmint	4a
	M	*Oenothera fruticosa* subsp. *glauca*	Sundrops	4a
	M	*Oenothera macrocarpa*	Silver evening primrose	4a
	M	*Penstemon* spp.	Beardtongue	3b-4a
M	M	*Phlox subulata*	Creeping phlox (evergreen)	4a
	M	*Physostegia virginiana*	Obedient plant	3a
	M	*Saponaria ocymoides*	Rock soapwort	4a
	M	*Sedum* spp.	Stonecrop	3b-4
	M	*Sedum* 'Herbstfreude'	Autumn Joy sedum	3b
	M	*Sempervivum* spp.	Hens and chicks	4a
	M	*Sidalcea malviflora*	Prairie mallow	4b
	M	*Thymus* spp.	Thyme	5b
	M	*Veronica incana*	Woolly speedwell	3b
	M	*Waldsteinia ternata*	Barren strawberry	3b

(H = HIGH LEVEL OF TOLERANCE; M = MODERATE LEVEL OF TOLERANCE)

TABLE 2. Products available for ice control (not including products used only in airports)

PRODUCT	ADVANTAGES	DISADVANTAGES
SODIUM CHLORIDE (NaCl)	• Effective, melts snow, penetrates ice • Low cost • Dissolves easily • Readily available • Easy to remove residue from floors and carpets	• Highly corrosive • Accumulates in soil • Damages soil structure • Injurious to plants • Readily leaches and contaminates groundwater • Increases runoff of heavy metals • Increases soil erosion • Ineffective at temperatures below 20°F
CALCIUM CHLORIDE ($CaCl_2$)	• Effective to –20°F • Works better at lower temperatures than NaCl • Dissolves faster than NaCl at lower temperatures • Releases some heat when dissolved • Won't damage soil structure • Often included in commercial blended products • No visible residue on plants when dry	• Highly corrosive, but anti-corrosive compounds can be added • Costs about 10 times more than NaCl • Injurious to plants • Readily leaches into groundwater • Requires special storage and handling to prevent caking • Tends to keep pavement wet • Leaves greasy stains on carpets and dulls floors from shoes • Causes skin irritation—must wear protective clothing when applying • Damages leather gloves and shoes
MAGNESIUM CHLORIDE ($MgCl_2$)	• Effective to 0°F • Dissolves easily and faster acting than NaCl • Works better at lower temperatures than NaCl • Won't damage soil structure • Available with corrosion inhibitors	• Highly corrosive, but anti-corrosive compounds can be added • Costs about 10 times more than NaCl • Injurious to plants • Readily leaches into groundwater • Requires special storage and handling to prevent caking • Tends to keep pavement wet • Leaves greasy stains on carpets and dulls floors from shoes
POTASSIUM CHLORIDE (KCl)	• Used as a commercial fertilizer • Dissolves easily • Won't damage soil structure • Easy to handle and store • Easy to remove residue from floors and carpets	• Highly corrosive • Costs about 10 times more than NaCl • High salt index and potential to burn foliage and roots • Readily leaches into groundwater • Limited use • Ineffective at temperatures below 25°F
POTASSIUM ACETATE (K-acetate)	• Produced from renewable resources • Effective to –25°F • Biodegradable • Safe for the environment and plants • Non-corrosive • Won't damage soil structure • More desirable than urea or glycol for airport application	• Very expensive • Only available as a liquid; requires liquid application equipment • Not commonly available

TABLE 2. Products available for ice control (not including products used only in airports), *continued*

PRODUCT	ADVANTAGES	DISADVANTAGES
UREA OR NITROGEN SALTS SUCH AS AMMONIUM SULFATE $[(NH_4)_2SO_4]$, or **POTASSIUM NITRATE** (KNO_3)	• Used as a commercial fertilizer • Lower burn potential than KCl • Less damaging to plants than NaCl • Melts snow, but not commonly used • Non-corrosive (if use lower ammonia content)	• May be corrosive if using high ammonia content • Expensive • May cause concrete degradation • Reduced effectiveness below 25°F • High potential for nitrogen runoff to surface water • Runoff promotes weed growth and eutrophication of lakes • Readily leaches into groundwater • Toxic to fish and animals
CALCIUM MAGNESIUM ACETATE (CMA)	• Made from dolomitic limestone and acetic acid • Biodegradable • Does not harm plants • Won't damage soil structure • Can increase soil permeability • Adds calcium and magnesium to soil • Less corrosive than other deicing salts • Less likely to leach into groundwater • Can be used in environmentally sensitive areas • Does not bond to pavement, so snowplow can scrape aside dry snow	• Costs approximately 40 times more than NaCl • Ineffective at temperatures below 20°F, in freezing rain, and on dry snow • Poor at removing existing ice • Can leach into surface water (lakes and ponds), degrading water quality • Leaves a slight greasy film on carpets
AGRICULTURAL BY-PRODUCTS from processing of sugar beets or processed corn or by-products from beer brewing. Product can be used as a pre-wetting liquid for deicing salts, or as a component of a liquid deicing salt brine solution.	• Non-corrosive and reduces corrosiveness when mixed with chloride-containing deicers • Increases equipment life • Reduces deicing salt consumption and labor costs • Less harmful to plants as less deicing salt is needed • Biodegradable (before mixed with deicers) • Adheres well to dry surfaces thereby preventing ice and snow from sticking to pavement • Mixes well with other liquid chemicals • Improves ice melting of chloride-containing deicers when mixed with it • Greater low temperature performance when mixed with deicers • No dust-causing abrasives are needed	• Expensive and adds cost to chemical deicing mixtures • Only available as a liquid • Purity of product and amount of smell varies between agricultural by-products used • May contain high phosphates (depends on product) • Very sticky material that can track under foot and vehicle traffic • Some blends may have high biological oxygen demand* and could remove oxygen from surface waters if not fully biodegraded before entering surface water

*Biological oxygen demand is a measurement of the oxygen consumed by microorganisms decomposing organic matter in water. This would primarily be a concern in ponds and lakes.

TABLE 2. Products available for ice control (not including products used only in airports), *continued*

PRODUCT	ADVANTAGES	DISADVANTAGES
ABRASIVE MATERIALS (sand, crushed aggregate, slag, bottom ash, kitty litter, cinders)	• Low initial cost • Readily available • Does not harm plants • Non-corrosive • Useful at lower temperatures when deicing chemicals become less effective • Improves traction for vehicles and pedestrians • Works immediately upon application	• Does not melt ice or snow • Traffic reduces its effectiveness (blown off, pushed off into snow) • Covered by new snow • Does not work well on hard ice • Not as effective as deicing salts at preventing skids • Requires reapplication, leading to more equipment trips per mile than NaCl • Accumulates and clogs gutters and drains; must be removed • Can chip paint and scar windshields if kicked up by traffic • Some abrasives create dust problems after storms and can contribute to particulate air pollution (ash fines)

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WINTER SALT INJURY AND SALT-TOLERANT LANDSCAPE PLANTS (A3877) I-04-2009