Urban Forest Management Plan

Stevens Point, Wisconsin

November, 2010

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RESOURCE GROUP
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Acknowledgement

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This project could not have been nearly as successful without the dedication and hard work of Todd Ernster of the City of Stevens Point, and Don Kissinger of the Wisconsin Department of Natural Resources.

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Executive Summary

The City of Stevens Point is a thriving municipality that combines beautiful neighborhoods, parks, and recreational opportunities to create an attractive community in which to live, work, and play. The economic health of Stevens Point, as with many communities, is closely related to the ability of its municipal government to supply its citizens and visitors with efficient services, safe public spaces, and properly maintained infrastructure. Trees are an integral component of the urban environment. Their shade and beauty contribute to the community's quality of life and soften the hard appearance of concrete structures, parking lots, and streets. Trees help stabilize soils by controlling wind and water erosion and also help reduce noise levels; cleanse pollutants from the air; produce oxygen and absorb carbon dioxide; and provide habitat for wildlife.

The City of Stevens Point has commissioned a study of its public street tree inventory and current forestry program to evaluate the current condition of its public street trees to establish an effective planning and management program for this valuable resource. This document will review current conditions and explore future management options.

Resource Structure

Based on Stevens Point's street tree inventory, the City's public street tree inventory contains:

- A total of 7,229 trees, 7 stumps, and 2,718 vacant planting sites.
- Stevens Point's street trees are valued at approximately **$4,856,426.**
- Stevens Point's average size street tree is 8 inches with an approximate value of $87 per inch.
- Stevens Point has 2,219 (31.89%) maples (*Acer*), 1,076 (15.19%) ash (*Fraxinus*), 503 (7.00%) apple (*Malus*), 444 (6.18%) linden (*Tilia*), 442 (6.15%) pine (*Pinus*), 357 (4.97%) elm (*Ulmus*), 335 (4.66%) honeylocust (*Gleditsia*), and 327 (4.55%) lilac (*Syringa*).
- The relative age distribution of Stevens Point's street trees is made up of 3,980 (55.83%) young trees that are less than 6 inches in diameter at breast height (DBH); 1,729 (24.07%) established trees (6- to 12-inch DBH); 1,266 (17.63%) maturing trees (12- to 24-inch DBH); and 207 (2.88%) mature trees (>24-inch DBH).
- Of Stevens Point's inventoried tree population, 73 (1.02%) are rated in Excellent condition, 6,283 (87.48%) are rated in Good condition, 791 (11.01%) are rated in Fair condition, and 29 (1.63%) are rated in Poor condition. There is 1 (0.01%) rated as Dead and 5 (0.07%) rated as Open Site. Overall, Stevens Point's street trees are in good condition and the City should be commended for having so few poor and dead condition trees.
- The total maintenance requirements indicate that 15 (0.15%) trees are recommended for Removal, 73 (0.73%) trees are recommended for High Priority Prune, 6 (0.06%) trees are recommended for Immediate Prune, 3,246 (32.53%) trees are recommended for Routine Prune, and 3,855 (38.63%) trees are recommended for Training Prune. Seven (0.07%) stumps require a Stump Removal; there are 2,718 (27.24%) sites designated as Plant; and 58 (0.58%) sites that do not have a recorded maintenance.

Resource Function and Value

The cumulative value provided by Stevens Point's street trees is averaged to be $44 per tree annually, for a gross total of $317,600 annually. The City's trees conserve and reduce energy, reduce carbon dioxide levels, improve air quality, mitigate stormwater runoff, and provide other benefits associated with aesthetics, increased property values, and quality of life. Stevens Point's street trees are providing the community substantial annual benefits such as:

- Stevens Point's street trees intercept 5.4 million gallons of stormwater annually. The total value of this benefit to the City is $16,205 per year, for an average value of $2.25 per inventoried tree.
- Inventoried street trees reduce energy and natural gas use in Stevens Point, from shading and climate effects equal to 676 MWh and 92,190 therms annually, for a total savings valued at approximately $163,638, with a citywide average of $22.47 per street tree.
- Street trees in Stevens Point reduce atmospheric CO_2 by a net of 1,242 tons per year, valued at $18,486, for an average net benefit per tree of $2.58.
- The net air quality improvement from the removal and avoidance of air pollutants is valued at $22,226 per year, with an average net benefit per tree of $3.07.
- The estimated total annual benefit associated with increased property values, aesthetics, and other less tangible improvements is $97,648 per year, for an average of $13.61 per inventoried tree.
- When the City's annual tree-related expenditures are considered, which are reported to be approximately $183,000 per year, the net annual benefit (benefits minus costs) to the City is $134,600. The average net benefit for an individual street tree in Stevens Point is $12.99 per year. **The City of Stevens Point receives $1.74 in benefits for every $1 spent on its municipal forestry program.**

Resource Management

Stevens Point's street tree resource is rich in the benefits it provides the community. Maintaining this resource requires constant attention and commitment to achieve sustainability. Urban stressors, such as compacted soils, pollution, limited growing space, and insufficient nutrients, lead to an increased need for an aggressive, proactive management program. To maximize the benefits of Stevens Point's resource and ensure sustainability, the following management practices should be implemented:

- Sustain the existing street tree resource through comprehensive tree maintenance, including new tree establishment and cyclical pruning. Develop a replacement plan for the City's most mature trees (and top benefit producers) to gradually replace them with trees of similar mature stature before they must be removed.
- Inventory vacant planting sites in newly annexed areas of the City.
- Increase tree planting by 185 trees per year to expand the extent of the resource and to be fully stocked in 10 years. Focus on large-stature trees where growing conditions permit and good-performing species to maximize benefits.
- Implement tree planting with street reconstruction projects, during development, and other related activities.
- Reduce dependence on maple and ash through careful species selection to achieve greater diversity and guard against catastrophic losses. Currently, maple and ash comprise approximately 47% of Stevens Point's inventoried street trees.
- Strengthen the City's network of partners and urban forest managers to work together towards the common goal of an improved, more functional, and sustainable street tree resource.
- Increase the forestry budget by an average of an additional $58,000 per year for the next five years.

Emerald Ash Borer Recommendations

Emerald ash borer (EAB) is a highly significant threat to all ash trees in the City. Approximately 1,076 ash trees exist along city streets. When EAB is detected in Stevens Point, all untreated ash trees in the City will likely die within 3-5 years. This insect has already killed more than 20 million ash trees in the Midwest and has been confirmed in several locations in Wisconsin. While EAB has not been confirmed in Stevens Point, it is known to be not more than 200 miles away, in Milwaukee, Wisconsin. Because the cost impacts of EAB infestation can be catastrophic, Davey recommends that the City immediately begin reducing the number of ash trees within the community and work to diversify the City tree population. Davey makes the following EAB recommendations:

- Immediately begin an Ash Reduction Program to lessen the impact when EAB arrives in Stevens Point.
- Begin removing the 543 ash trees that are less than 6 inches in diameter and/or rated in Fair or Poor Condition to be completed within 3 years. This will save the City money in the long term, as the larger these trees get, the higher the removal costs.
- Davey recommends that Stevens Point limit ash pruning to only those ash trees >6 inches in diameter, and only such pruning as is necessary for safety and clearance. All other tree species should continue to receive routine structural pruning.
- Remove all ash trees during street reconstruction projects and under utility lines.
- Begin an annual inspection program of all City-owned ash trees.
- Implement a comprehensive public relations program, and education and outreach campaign to communicate the City's EAB response.
- Replant all ash tree removals as soon as possible.

Introduction

The street trees growing on the rights-of-way along the public streets constitute a valuable community resource. They provide tangible and intangible benefits for diverse services, such as: pollution control; energy reduction; stormwater management; property values; wildlife habitat; education; and aesthetics.

Photograph 1. Trees contribute to the community's quality of life and soften the hard appearance of man-made structures and streets, moderating harsh urban conditions. Trees also provide significant economic benefits, including increased real estate values and improved settings for business activities.

Previously, the services and benefits trees provide in the urban and suburban setting were considered to be unquantifiable. However, by using extensive scientific studies and practical research, these benefits can now be confidently calculated using tree inventory information. The results of applying a proven, defensible model and method that determines tree benefit values for the City of Stevens Point's current tree inventory data are summarized in this report using i-Tree's Streets application (formerly known as STRATUM). Since Stevens Point has conducted a tree inventory, an accurate insight can be drawn in regards to the overall health of the City's public trees and the benefits they provide the community.

The science behind this model and type of analysis is sound and has been published in peer-reviewed journals. The challenge now is to apply the science to enhance the quality of life in the City of Stevens Point by improving the condition and extent of the urban forest.

Statement of Purpose

The purpose of this *Urban Forest Management Plan* is to provide a summary of benefits provided by Stevens Point's inventoried tree population, to analyze the current structure of the population, and to develop a five-year plan of action for maintaining these inventoried street trees. The City commissioned this study to identify the current condition of its urban forest and to quantify the benefits provided by the inventoried tree population in tangible units of measurement. This management plan focuses on existing conditions that require immediate attention, while developing long-term management guidelines that will help protect and preserve City-managed trees in a cost-effective and efficient manner.

Goals

This management plan intends to achieve the following goals:

- To gain an overall understanding of the inventoried tree population composition.
- Provide a summary and analysis of the benefits provided by the inventoried population.
- To analyze the individual and overall health (condition) of the inventoried tree population.
- To maintain a five-year pruning cycle.
- Maintain the established young tree training program and stump removal program.
- Establish strategies to manage emerald ash borer (EAB), *Agrilus planipennis* Fairmaire, or any other exotic pests.
- Tree planting to achieve 100% stocking level and optimum canopy cover on public right-of-ways and other properties.
- Establish oak wilt planning strategies.
- Establish administrative activities to support proactive and efficient maintenance, including staffing, equipment, and wood waste utilization needs.
- Identify educational and training needs for City staff and residents.

Evaluating and Updating This Plan

This management plan provides urban forestry guidelines for the next five years. In order to measure the effectiveness of the implementation of the program in achieving the stated goals, a method for evaluation should be followed. Specific accomplishments can be measured in comparison to the Plan's goals and recommendations. These include:

- The completion of all identified removals and priority pruning in Year 1 of the program.
- In Year 1 of the program, evaluate the number of trees pruned annually in the *Routine Pruning Program* to match the goal of the five-year maintenance cycle.
- Annually compare the number of trees planted to the desired number of plantings and the number of removals per year.
- Beginning in Year 1, continue the *Young Tree Train* program and evaluate the number of trees pruned annually to match the goal of the one-year maintenance cycle.
- At the end of each year, compare the City's annual urban forestry budget to that projected in this Plan.
- The City Forester should be responsible for keeping this Plan and the inventory as up-to-date as possible.

Chapter 1: City of Stevens Point's Tree Population

The urban forest in Stevens Point is a complex system of trees, site conditions, and maintenance needs. Understanding this system is important for proper decision-making regarding species selection and tree care practices. This chapter provides insight into the current composition and condition of Stevens Point's inventoried tree population. By accumulating and using this information, urban forest managers can forecast trends, anticipate maintenance needs, facilitate budgeting for tree-related expenditures, and develop a basis for long-range planning.

Davey Resource Group did not perform the street tree inventory for Stevens Point, but did perform an analysis of the inventory data provided by the City. An arborist from Davey did conducted an on-site visit to meet with the City forestry department and other City staff members. This site visit enabled Davey to get a better understanding of the condition of Stevens Point's urban forest, and to gain more knowledge of the forestry department's operations.

Stevens Point's Municipal Tree Resource

Tree Population Characteristics

The characteristics of the urban forest include species, DBH, condition, and other related tree and site factors. By identifying the species, DBH, and condition of trees in the urban forest, much can be learned about the forest's composition, size distribution, relative age, and health. Species composition data are essential since the types of trees present in a community greatly affect the amount of benefits produced, tree maintenance activities, and budgets.

Species Composition and Diversity

Table 1. Significant Species Composition of Stevens Point Inventoried Tree Population

Scientific Name	Common Name	Number	Percentage of Street Trees
Acer rubrum	red maple	874	12.17
Fraxinus pennsylvanica	green ash	814	11.33
Acer platanoides	Norway maple	633	8.81
Malus spp.	flowering crabapple	506	7.05
Syringa reticulata	Japanese tree lilac	371	5.16
Gleditsia triacanthos	honeylocust	366	5.10
Acer saccharinum	silver maple	322	4.48
Tilia cordata	littleleaf linden	301	4.19
Fraxinus americana	white ash	260	3.62
Celtis occidentalis	common hackberry	256	3.56
Totals		**4,703**	**65.47**

Inventoried Tree Population

Stevens Point's inventoried population of street trees is composed of 7,229 trees distributed among 47 species. Table 1 shows that the top ten species comprise approximately 65% of the inventoried tree population.

In Stevens Point, three of the top ten occurring species are from the genus *Acer* (maple). These three maple species include: red maple (12.17%); Norway maple (8.81%); and silver maple (4.48%). Overall, 31% of the trees occurring in Stevens Point are from the maple genus (Figure 1). Davey recommends that no single species and genus represents more than 10% of the total population. *Fraxinus* (ash) exceeds the guideline set for genera representation as well. A variety of species types can decrease the impact of species-specific pests and diseases by limiting the number of trees that are susceptible. Additionally, a wide variety of tree species may help to limit the impacts from a number of physical events, such as strong storms, wind, flooding, drought, etc.

The inventory illustrates that tree planting practices in Stevens Point have resulted in an uneven species distribution pattern. Davey recommends that Stevens Point continue to plant a wider range of species by including both native and non-native, urban-tolerant, and/or drought-resistant species (see Appendix A for suggested species). Planting a large number of trees of the same species (monoculture) can lead to catastrophic results in the event of species-specific epidemics, such as Dutch elm disease or emerald ash borer (EAB).

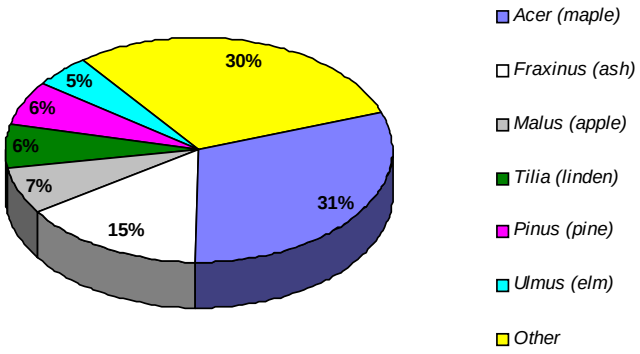


Figure 1. Stevens Point's Distribution of Trees by Genus

Species Importance

i-Tree Streets calculates the importance of any given species in a street tree inventory by assigning each species an Importance Value (IV). Importance Values offer valuable information about a community's reliance on one species for providing environmental benefits. Importance Values can be taken a step further to forecast the loss of benefits should a catastrophic event eliminate a single species.

The top five street tree species in Stevens Point have the following Importance Values: red maple, 19.1; green ash, 10.5; Norway maple, 7.5; flowering crabapple, 2.7; and Japanese tree lilac, 1.8. Stevens Point relies heaviest on the functional capacity of red maple and green ash, which have a higher IV than other species due to their maturity, greater size, broader leaf area, and prevalence among the City's street trees. Appendix B provides IVs for the 14 most prevalent species in Stevens Point. This means that over 19% of Stevens Point's environmental services are coming from one species (red maple).

In Stevens Point, red maple is providing 19.1% and green ash is providing 10.5% of the environmental benefits of the total inventoried tree population. If Stevens Point were to experience a loss of the entire City's public red maple and ash trees, the City would not only deal with the monetary expense of removing and replanting, but also experience a loss of environmental benefits on an annual basis until the replanted trees reached maturity.

As Stevens Point works to diversify its street tree resource, it is recommended that the City utilize trees that have a high per tree benefit and a low IV. Elm and basswood are good examples of trees that have a low IV, 4.6 and 2.3 respectively, but have a high per tree benefit. These trees will grow large and return more environmental benefits over a longer period of time while helping Stevens Point to achieve a more diverse street tree population.

Relative Age Distribution

The distribution of ages within a tree population influences present and future costs as well as the flow of benefits. An uneven-aged population allows managers to allocate annual maintenance costs uniformly over many years and assures continuity in overall tree canopy cover.

The Stevens Point urban forest displays an uneven-aged population as reflected by size class distribution (Figure 2). An ideal street tree population has an imbalanced age distribution, with higher percentages of young trees than mature trees to minimize fluctuations in functional benefits over time. As trees mature and begin to decline, a tree population skewed towards young trees will ensure that a flow of benefits continues to exist.

Relative age should also be considered between species. Red maple, which has the highest Importance Value (19.1) of any street tree in Stevens Point, is represented in the population as 52% mature (>24-inch DBH) or maturing (12- to 24-inch DBH), with 27% established (6- to 12-inch DBH) and 21% young (<6-inch DBH). If young trees of similar size and structure are not planted to improve the age distribution of this species, the return of valuable benefits may be disrupted for future generations. Appendix C displays the relative age distribution for the ten most inventoried street trees in Stevens Point.

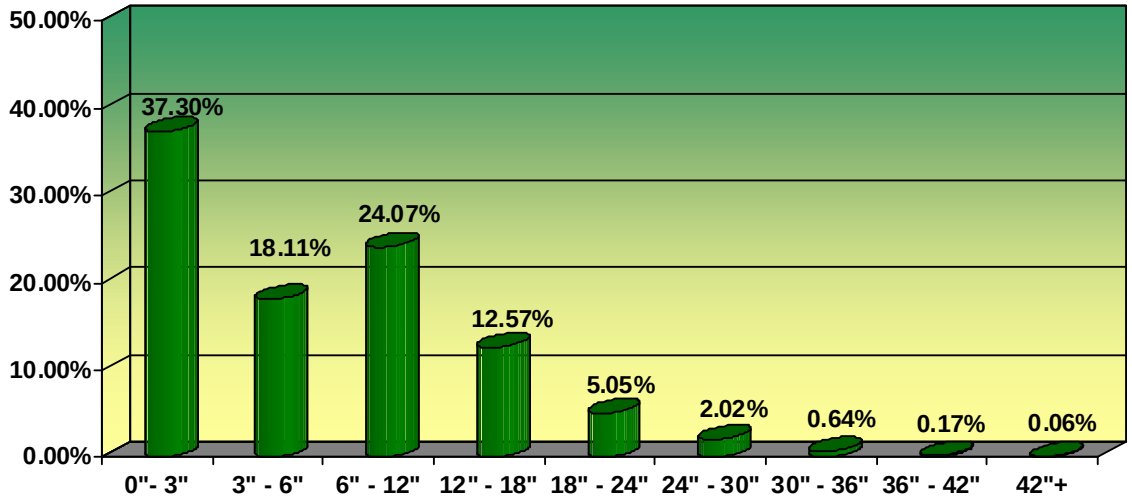


Figure 2. Diameter Size Class Distribution of Stevens Point's Total Inventoried Tree Population

As illustrated in Figure 2, small trees which are 0 to 6 inches in DBH represent approximately 55% of the total inventoried tree population in Stevens Point. Newly planted trees would fall under the small tree size class; however, it must be understood that "small tree" does not mean that all trees in this class are of small growth-habit. For example, the red maples in this group are simply young, immature trees. These trees, under normal conditions, will mature to large-sized trees from 45 to 90 feet in height. Alternatively, flowering crabapples have growth-habits in which they mature at heights from 10 to 30 feet. These trees have a relatively short lifespan in the urban environment compared to longer-lived oaks, for instance.

Large trees, which are 24 inches and greater in diameter at breast height, comprise approximately 3% of Stevens Point's inventoried tree population. Silver maples dominate this size class.

An ideal size class distribution should be more heavily weighted on small tree frequencies gradually declining in numbers towards the large trees. Stevens Point's has done an excellent job at achieving this goal. As trees grow, they generally shift in size class to change the overall dynamics of a population. Young trees are not equal to small-growing species. Maximum benefits are achieved over time by planting young, large-growing species whenever sites permit.

When planting, the City should try to replace large-growing trees with similar large-growing species to ensure that environmental benefits will be maximized. For example, when the City has to remove a pin oak or hackberry, every effort should be made to replace these trees with trees that will grow to be a large shade tree and provide more canopy cover.

General Health and Condition

Tree condition indicates how well trees are managed and how well they perform given site-specific conditions. Currently, the majority of Stevens Point's street trees are in good condition (87%) (Figure 3). When trees are performing at their peak, as are the 87% of trees classified as Good, the benefits they provide will be maximized.

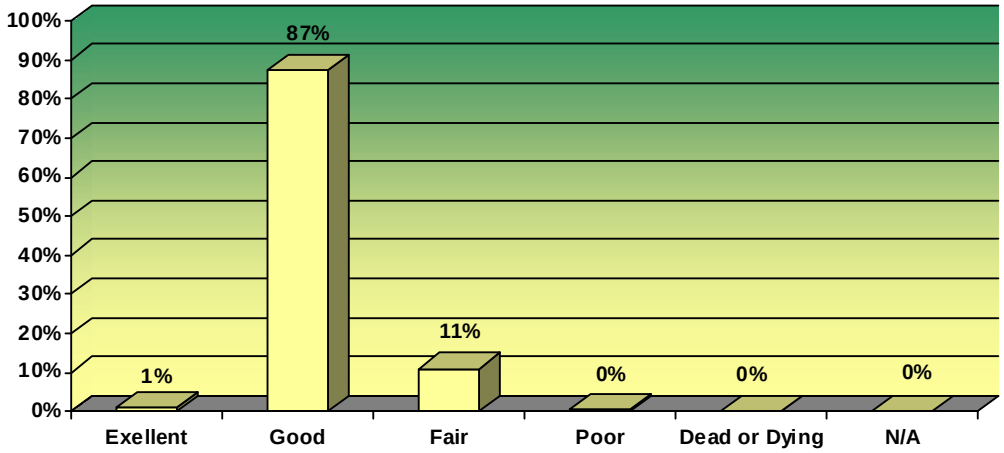


Figure 3. Condition Rating of Inventoried Street Trees

As can be seen in Figure 3, the significant tree population of Stevens Point is in a mostly good to fair state of health. It appears that this is due, in large part, to the fact that public tree care has been a priority in Stevens Point. Dead trees and trees in poor condition only account for approximately less than 1% of the total inventoried population. The goal for dead and dying trees should be zero.

Photograph 2. Overall, the majority of Stevens Point's trees are in Good condition.

Stevens Point should continue to monitor and update these condition ratings. Trees condition is a dynamic assessment and can be affected by many factors. An ongoing assessment will ensure that the City is receiving the maximum benefit from the street tree resource.

Tree Appraisal

Stevens Point's street trees are valued at approximately **$4,856,426.** Stevens Point's average size street tree is 8 inches with an approximate value of $87 per inch. This value was calculated using the Trunk Formula Method outlined in the *Guide for Plant Appraisal (*10th edition), published by the International Society of Arboriculture.

The Trunk Formula Method considers several variables when calculating the value of a landscape tree, including the species of the tree, its size, the condition of the tree, and the location of the tree. The DBH of the trees is used to calculate the cross-sectional area of the trunk. The cross-sectional area is then multiplied by a dollar value that reflects the current market value of nursery stock. This determines the base value of the tree. The base value is then reduced by the percent figures for location, condition, and species.

Tree value = basic tree cost x species rating x condition rating x location factor

Tree Maintenance Recommendations

One important objective of the tree inventory was to determine the current appropriate maintenance recommendations for the tree population. The highest risk maintenance recommendations identified concern protecting public safety first and foremost. Table 2 summarizes the maintenance requirements for Stevens Point's inventoried tree population.

Chapter 3 discusses in detail the specific prioritization of maintenance work and provides a detailed five-year estimated budget for the maintenance of Stevens Point's street tree population.

Table 2. Stevens Point's Tree Maintenance Requirements

Maintenance Required	Number of Sites	Percentage of Maintenance
Removal	15	0.15
Immediate Prune	6	0.06
High Priority Prune	73	0.73
Routine Prune	3,246	32.53
Training Prune	3,855	38.63
Plant	2,718	27.24
Stump	7	0.07
No Maintenance	58	0.58
Total	**9,978**	**100**

Tree Removals

Tree removals are an inevitable and an integral component of every urban forest program. The goal of a removal program is to minimize risk and be efficient. Currently, Stevens Point has 15 trees recommended for removal. Stevens Point should prioritize these trees based on size and condition and remove the largest poorest quality trees as soon as possible. Furthermore, on average, an urban forest can expect an annual mortality rate of 1%. Based on this estimate, Stevens Point should expect to remove an additional 73 trees annually.

It is critical that Stevens Point continue to monitor street trees on an annual basis in order to identify potentially high-risk trees and remove these as soon as possible. Davey recommends that Stevens Point adopt an official methodology for evaluating the risk of a tree. A possible methodology is ISA's and can be found in *A Photographic Guide to the Evaluation of Hazard Trees in Urban Areas* written by Nelda Matheny and James Clark. This book and others can be found on ISA's website, www.isa-arbor.com.

Routine Tree Pruning

One of the most beneficial improvements that any city can do to improve their urban forest is to perform routine preventative pruning. This activity works to structurally prune trees on an established schedule to try and prevent "fire fighting" pruning and minimize potential tree and/or limb failures. Stevens Point currently has 3,325 trees recommended for some form of routine pruning. Of these 3,325 trees, 79 have been identified as having a high level of risk and should be pruned immediately. These trees have a large amount of dead branches, large dead limbs, a high probability of failure, and an immediate target present. A more detailed explanation with management recommendations is included in Chapter 3.

Training Pruning

If the proper trees have been selected for each site, pruning young trees to improve branch structure is the most effective method of reducing maintenance costs as trees mature. Currently, Stevens Point has 3,855 trees recommended for Training Pruning. At the time of planting, the only pruning that should be done is the removal of broken or dead branches. In the second growing season, minor pruning can be performed to remove branches with poor attachments, but it is still best to wait until the third growing season to perform the first young tree training. In subsequent years, selective pruning should be performed to achieve the proper spacing of branches.

Plant Tree

Currently, there are 2,718 (27.24%) vacant planting sites identified in Stevens Point (not including annexed areas since 1996). Furthermore, the City should also consider replanting the 15 trees that are recommended for removal, plan to include projected natural mortality of 1% (73 trees annually), and the recommended removal of ash trees (543 trees) due to EAB. Currently, Stevens Point plants an average of 150 trees per year. At the current level of planting, it will take Stevens Point approximately 22 years to reach 100% stocking of street trees. Davey recommends that Stevens Point consider planting an additional 185 trees per year for a total of 335 trees annually to achieve a fully stocked forest in 10 years.

Photograph 3. There are a number of tree lawns throughout Stevens Point that are too small for planting trees. If a tree was planted in this tree lawn, it would cause clearance issues for vehicles on the road, as well as pedestrians on the sidewalk. The width of the tree lawn is also smaller then what is recommended for even a small-growing tree.

Currently, the City prioritizes planting based off citizen requests and neighboring available sites. Davey recommends that the City continue this practice to prioritize these planting sites. Stevens Point should also base planting priority on growspace size, site location, and presence of overhead utility wires. Large growspace sites in high value locations without overhead wires should be the highest priority for planting. These planting sites should be evenly distributed throughout the entire City. There are approximately 235 sites that are identified as replanting with a large species that are not under wires.

Davey recommends that large-growing trees have a minimum growspace of 8', medium trees have a minimum of 6', and small trees have a minimum of 4'. Only small-growing trees should be planted under overhead utility lines. Every effort should be made to plant the largest growing tree possible in each available planting site, *i.e.*, honeylocust, elms, and oaks should be planted in large growspaces and not crabapples, redbuds, lilacs, or other small-growing trees.

Tree Species Selection

Stevens Point, Wisconsin is located in Zone 4 of the USDA Hardiness Zone Map, which identifies a climatic region where the average annual minimum temperature is between -30º and -20º F. Tree species selected for planting in the City should be appropriate for this zone.

In addition to considering site characteristics, such as availability of space, soil pH, and irrigation, species-specific features must also be scrutinized. Stevens Point has mostly sandy soils, which does not hold water well and often leads to drought-like conditions. There are also many growing spaces within the City's rights-of-way (ROW) that are too small to support trees. These two issues are probably the most limiting factors for tree survivability in Stevens Point, and should greatly be considered when selecting tree species to plant.

Seasonal color should also be considered when planning tree plantings. Flowering varieties are particularly welcome in the spring, and deciduous trees that display bright colors in autumn can add a great deal of interest to surrounding landscapes.

Above all else, tree species should be selected for their durability and low-maintenance characteristics. These attributes are highly dependent on site characteristics as well as species characteristics. Invasive insects and diseases should be greatly considered when selecting species. Matching a species to its favored climatic and soil conditions is the most important task when planning for a low-maintenance landscape. Plants that are well matched to their environmental and site conditions are much more likely to resist pathogens and insect pests and will, therefore, require less maintenance overall. Refer to Appendix A for additional tree species and cultivars suitable for planting in Stevens Point.

Native trees to northern Wisconsin will be more adaptable to weather conditions and other environmental forces but may be more susceptible to exotic pests. Green ash is a perfect example of a tree that is native to Stevens Point but very susceptible to EAB. Davey recommends that the City consider planting non-native trees that are capable of growing in Stevens Point conditions.

The Tree Planting Process

As trees are purchased through local nurseries, the most important consideration should be species selection. This will aid in increasing species diversity throughout Stevens Point. Once the appropriate trees have been selected for planting, the most important detail to ensure success is the preparation of the planting sites. Appendix D explains the proper method of excavating a planting hole. In general, the tree-planting holes should be relatively shallow (typically slightly less deep than the height of the root ball) and quite wide (three times the diameter of the root ball). Care should be taken so that the root collars of the new trees are at the same level or slightly higher than the surrounding soil grade. In most situations, it is not recommended to add soil amendments to the planting holes, as this can lead to severe differences between texture and structure of soils inside the planting holes and the surrounding soil. Such differences can lead to either water being wicked away from or accumulating in planting holes.

Tree staking hardware should only be installed when necessary to keep trees from leaning (windy sites) or to prevent damage from pedestrians and/or vandals. Stakes should only be attached to trees with a loose, flexible material, and all staking material must be removed within one growing season (Appendix D).

Photograph 4. It is recommended to utilize a tree spade for planting when possible.

Tree Mulching

Mulch should be applied to the soil surface around newly planted trees. Mulch should never be piled up around the root collar (so-called mulch "volcanoes"), but rather should be pulled away from the root collar. Mulch that buries the root collar provides shelter for insects, fungi, and small mammals that could damage the tree. Mulch should be applied to an area three times the diameter of the root ball to a depth of two to four inches. Mulch not only suppresses competition from grass and weeds, but also provides a zone where turf maintenance is not needed, thereby keeping lawn mowers and string trimmers safely away and thus preventing mechanical damage. Mulch also helps to hold moisture in the surface of the soil where most of the feeder roots are to be established. Stevens Point currently does a great job of mulching newly planted trees for multiple years after planting for water management purposes.

Tree Pruning

If the proper trees have been selected for each site, pruning young trees to improve branch structure is the most effective method of reducing maintenance costs as trees mature. At the time of planting, the only pruning that should be done is the removal of broken or dead branches. In the second growing season, minor pruning can be performed to remove branches with poor attachments, but it is still best to wait until the third growing season to perform the first young tree training. In subsequent years, selective pruning should be performed to achieve the proper spacing of branches. See Appendix D for more information concerning proper pruning techniques.

Tree Purchases

Tree prices, of course, vary based on the species selected, but many nurseries offer trees of 1.5- to 2.5-inch caliper for $100 to $150. As the City works at planting more trees annually, obtaining a good price for quality trees will become more important and nursery guaranteed stock is crucial. Saving money on the cost per tree will allow a greater number of trees to be purchased.

Historically, Stevens Point has planted mostly balled-and-burlapped (B&B) trees, but in the last few years, the forestry department has been experimenting with bare-root and containerized plantings. Stevens Point should continue to experiment with different species and nursery stock. The City will find that some species may have a better success rate if planted as B&B compared to bare-root, or vice-versa.

Davey believes that a good working relationship with a local nursery is very beneficial, but it is equally important that good prices and wide species availability be considered. It is recommended that Stevens Point continue to explore local and regional sources for trees, discuss pricing with the current nursery source, and search for nurseries that can provide a variety of planting stock. Due to the requirement to work towards species diversity, it may be necessary to use several nurseries as sources for trees.

Chapter 2: Cost-Benefit Analysis of Stevens Point's Street Trees

i-Tree Streets Benefit Model Overview

The method used to determine the overall and net values and benefits is the U.S. Forest Service's i-Tree Streets (Street Tree Resource Analysis Tool for Urban Forest Managers) model, version 3.0. i-Tree Streets is a component of i-Tree, a suite of free software tools recently released by the U.S. Forest Service that can be used to assess and manage community forests. With these tools, cities and urban forest managers can accurately quantify the benefits of urban forests, understand and balance the costs of managing an urban forest, and become better prepared for severe weather emergencies.

Specifically, i-Tree Streets is a tool that quantifies the benefits of street trees and compares them directly with the costs of urban forestry programs to produce accurate net-benefit values. It is a statistically valid, financially sound, and defensible cost-benefit analysis tool for urban forestry that may be used with existing inventories or with a sampling of streets in a community. Appendix E lists additional sources for further information.

i-Tree Streets Benefit Categories

Inventory data from the City of Stevens Point's inventory database was entered into the i-Tree Streets model provided to Davey by the City to assess and quantify the beneficial functions of the public tree resource and to place a dollar value on the annual environmental benefits they provide. The analysis was performed to determine and quantify these benefits:

Photograph 5. Street trees in Stevens Point provide many benefits to the City and its residents. These benefits were calculated using the cost-benefit model, i-Tree Streets.

- Energy Consumption Savings–The energy savings that trees provide can be attributed to shading, the cooling effect of transpiration, and wind reduction. These key factors reduce the amount of radiant energy absorbed in buildings and other hardscapes, cooling the air around buildings in the summer, and helping retain heat during cold winter months. The energy savings is realized by lower cooling and heating costs for any type of building measured in megawatt-hours (MWh).
- Carbon Sequestering–Carbon dioxide (CO_2) is used during a tree's photosynthesis process to produce the natural building blocks necessary for tree growth. This process takes carbon dioxide from the atmosphere and holds it as woody and foliar biomass. This is referred to as carbon sequestration.

- Air Quality–The air quality of Stevens Point's urban environment greatly benefits from the presence of street and other public trees. Trees absorb gaseous pollutants in the form of ozone (O_3) and nitrogen dioxide (NO_2). Reduction in ozone can also be attributed to the tree shading effect on hardscape surfaces and the transpiration process. Trees intercept volatile organic compounds (VOCs), sulfuric dioxide (SO_2), and small particulate matter (PM_{10}), such as dust, ash, dirt, pollen, and smoke, from the air. Trees also emit biogenic, volatile organic compounds (BVOCs), an air pollutant that contributes to the formation of ozone, a process which the i-Tree Streets model takes into account.

- Stormwater Mitigation–The City of Stevens Point's public tree population reduces the volume of stormwater runoff in their neighborhoods and ultimately city-wide. This function and benefit is especially important in developed settings with increased quantities of impervious surfaces (roads, driveways, homes, parking areas) and in areas in close proximity to surface waters. A tree's surface area, especially the leaf surfaces, intercepts and stores rainfall. The root systems of trees increase soil infiltration, thereby decreasing runoff. Trees also reduce stormwater runoff by intercepting raindrops before they hit the ground, reducing soil compaction rates and improving soil absorptive properties. In addition, trees intercept suburban contaminants, such as oils, solvents, pesticides, and fertilizers, which are often part of stormwater runoff, reducing pollutant discharges into the City's vital waterways.

- Aesthetics and Other Public Values–It may seem difficult to place a dollar value on the benefit Stevens Point's public trees provide to the overall ambiance of the City and the well-being of neighborhood residents and visitors. But, trees provide beauty to the landscape, privacy to homeowners, and refuge for urban wildlife, and this can be quantified.

Costs of Managing Stevens Point's Street Trees

Investing time and money in Stevens Point's street trees is well worth the cost. The City's trees provide numerous economic, environmental, psychological, and social benefits to the community. Stevens Point's total related expenditures for street trees were approximately $183,000. Overall, considering Stevens Point's tree population, the City is spending less than other cities of comparable size.

Tree Planting and Establishment

Ensuring that the benefits of Stevens Point's street trees are available for future generations requires quality nursery stock, proper planting techniques, and adequate follow-up care. The City of Stevens Point allocates approximately $20,000 toward planting new trees. Of Stevens Point's total expenditures for tree services, approximately 10.27% of the costs can be attributed to tree planting. According to American Public Works Association best management practices, the national average for tree planting costs is approximately 14% of the urban forestry budget. Using the national average, Stevens Point could justify spending an additional $7,450 for tree planting.

According to inventory data, Stevens Point has an estimated 2,718 vacant planting spaces to be filled. This number does not take into account newly annexed areas of the City. With this in mind, it seems that the City has a high need for planting and should make an effort to plant more trees. Furthermore, the City should expect to remove approximately 73 trees annually from natural mortality (1% of tree population), and it is recommended to remove an additional 543 ash trees. Davey recommends that the City increase annual planting and plan to replant all removals on at least a 1:1 ratio.

Davey conservatively estimates the cost of purchasing and planting a new tree at $210 per tree, Stevens Point could expect to spend $703,290 to reach a stocking level of 100% in the inventoried area. Based on the City's current planting budget of $20,000 and the level of planting at 150 trees per year, the City is only spending approximately $133 per tree. This is great and the forestry department is doing an excellent job at maximizing its resources.

Maintenance

Planting, pruning, removals, disposal, and litter clean-up accounted for 51.87% of Stevens Point's total street tree-related expenditures. Removals accounted for approximately 19.70% of total expenditures, while pruning accounted for 14.94%. Approximately 6.96% of total expenditures are attributed to litter and storm clean-up. Ideally, Davey would recommend that more money be spent on cyclic pruning than on removals. Davey understands that this is not always possible given the current tree population and need to mitigate risk in an urban environment. Stevens Point should continue to work towards a more systematic pruning cycle and try to reduce expenses from removals. Davey recommends that Stevens Point work towards spending 20% of the forestry budget on pruning and less than 15% on removals.

Trees that are properly maintained function at a higher level and, therefore, provide more environmental benefits. Trees that receive routine preventative pruning will save the City money in the long run by reducing the costs of expensive "fire-fighting", high-risk pruning and/or removals. By providing more environmental benefits, the City will benefit from reduced stormwater runoff, higher real estate rates, cleaner air, and less energy use.

Administration

Approximately 11% of total expenditures for managing street trees can be attributed to administration costs. These costs include forestry personnel salaries, clerical staff, summer help, forestry equipment, supplies, training, inspection, and membership fees. Overall, the City seems to be maximizing the amount of work done by administration and 11% is a great goal to try and maintain.

Benefits of Stevens Point's Municipal Trees

Street trees provide a host of benefits to the City of Stevens Point. Street trees conserve energy, reduce carbon dioxide levels, improve air quality, and mitigate stormwater runoff. In addition, trees provide numerous economical, psychological, and social benefits. However, the intent of this study is to determine whether the benefits of street trees outweigh the cost of maintaining them.

This study uses tree inventory data collected in Stevens Point and i-Tree Streets model to assess and quantify the beneficial functions of the City's street tree resource and to place a dollar value on the annual benefits they provide. Table 3 illustrates the total annual benefits for Stevens Point, while Table 4 presents total annual benefits per species for the 15 most prevalent street trees.

Table 3. i-Tree Streets Analysis Results for Total Annual Benefits in the City of Stevens Point

Benefit Category	Energy Savings	Avoided and Sequestered Carbon Dioxide	Air Quality Benefits	Stormwater Runoff Reduction	Aesthetic and Other Benefits	Total ($)
Annual Amount	$163,638	$18,486	$22,226	$16,205	$97,648	$317,600

Table 4. i-Tree Streets Analysis Results for Total Annual Benefits per Species in the City of Stevens Point

Benefits Per Species	Energy Savings	Avoided and Sequestered Carbon Dioxide	Air Quality Benefits	Stormwater Runoff Reduction	Aesthetic and Other Benefits	Total Per Tree	Total ($)
red maple	$36,733	$4,209	$5,604	$3,397	$24,068	$82.10	$74,051
green ash	$18,874	$2,230	$2,553	$1,573	$12,285	$45.42	$37,514
Norway maple	$15,335	$1,627	$2,054	$1,080	$7,747	$42.38	$27,844
apple	$2,129	$194	$254	$74	$352	$6.24	$3,003
Japanese tree lilac	$992	$93	$118	$33	$141	$3.93	$1,376
silver maple	$19,667	$3,074	$2,957	$2,981	$14,247	$129.68	$42,925
honeylocust	$3,908	$367	$503	$249	$2,472	$23.03	$7,508
littleleaf linden	$5,210	$677	$672	$363	$4,271	$35.88	$11,193
white ash	$5,589	$667	$785	$508	$4,174	$41.72	$11,722
red pine	$4,486	$380	$460	$696	$3,029	$34.60	$9,412
northern hackberry	$3,262	$219	$404	$193	$1,668	$22.98	$5,746
elm	$7,061	$852	$1,038	$855	$3,864	$59.69	$13,670
amur maple	$786	$73	$93	$26	$123	$4.89	$1,100
spruce	$2,250	$172	$198	$324	$1,452	$25.71	$4,396
basswood	$3,364	$403	$488	$379	$1,916	$45.18	$6,551
Other street trees	$32,805	$3,394	$4,005	$3,510	$16,597	$38.30	$59,904
Citywide Total	**$163,638**	**$18,486**	**$22,226**	**$16,205**	**$97,648**	**$44.22**	**$317,600**

Electricity and Natural Gas Results

Stevens Point's inventoried street trees provide a savings of 675.8 MWh ($72,105) and 92,190 therms ($90,346) in shading and climate effects per year (Appendix F). The average savings per inventoried tree in the City is $22.47, while Stevens Point saves a total of $163,638 per year over the whole inventory. Red maple produces the largest electricity and natural gas savings at $36,773, 23% of all energy savings.

Avoided and Sequestered Carbon Dioxide

Stevens Point's street tree resource reduces a net 1,242 tons of CO_2 per year valued at $18,486, with the average savings per inventoried tree at $2.58. Red maple accounts for 23% of these savings while constituting 12% of the total tree inventory. On the other hand, pin oaks make up 1% of the total population yet generate more savings per tree at $6.42. Stevens Point may want to consider planting more oaks, where applicable, to take advantage of these benefits, while at the same time increasing species and genus diversity. Planting new trees and maintaining existing ones is the best approach to sustaining these benefits. Appendix F presents benefits associated with carbon sequestration for species and zone.

Deposition and Interception

Each year, Stevens Point's inventoried street trees provide a savings of $4,058 by intercepting or avoiding O_3, NO_2, PM_{10}, and SO_2. Red maple, green ash, and silver maple contribute the most benefits towards air quality due to their representation in the street tree population and size at maturity. The combined savings of these three species, 25% of the inventoried street trees, is $2,353 annually.

Avoided Pollutants

Trees indirectly reduce pollutant emissions, such as NO_2, PM_{10}, VOCs, and SO_2, by lowering dependence on energy consumption. Red maple, green ash, and silver maple trees have the greatest impact on reducing energy needs, returning a combined savings of $20,076.

BVOC Emissions

Trees emit BVOCs that negatively affect air quality. Larger trees, such as red maple, silver maple, honeylocust, and pin oak, tend to have higher BVOC emissions. In Stevens Point, BVOC emissions offset total air quality benefits by $1,948.

Net Air Quality Improvement

Stevens Point experiences a net air quality improvement of $22,226 per year, averaging $3.07 per tree. Red maples may be high BVOC emitters, but they provide the highest number of benefits at an average of $6.21 per tree. Silver maple produces the most air quality benefits per tree with an average of $8.93. Although, silver maples produce the most air quality benefits per tree, it only represents 4.46% of the total inventory. Appendix F displays annual and net benefit values for species on matters of air quality improvement.

Stormwater Runoff Reductions

Street trees in Stevens Point intercept 5.41 million gallons of stormwater annually, for a savings of $16,205 (Appendix F). The average benefit per inventoried street tree is valued at $2.25. Pin oak, eastern white pine, and red maple intercept the greatest amounts of stormwater per tree. Pin oaks, which are first in stormwater benefits, only represent 1% of the inventoried population.

Aesthetic, Property Value, Social, Economic, and Other Benefits

Aesthetic and other related benefits in Stevens Point provide an estimate of $97,648 annually to the City, for an average of $13.61 per inventoried tree. While red maples represent 12% of the inventoried population with average benefits of $26.68 per tree annually, silver maples (4.5%) return the most benefits at $43.04 per tree (Appendix F).

Net Benefits and Benefit-Cost Ratio (BCR)

Stevens Point receives substantial benefits from its street trees. However, the City must also consider the cost of maintaining this resource. Applying a benefit-cost ratio (BCR) is a useful way to evaluate the public investment in public trees. A BCR is an indicator used to summarize the overall value compared to the costs of a given project. Specifically in this analysis, BCR is the ratio of the cumulative benefits provided by the City's public trees, expressed in monetary terms, compared to the costs associated with their management, also expressed in monetary terms.

Not all of the benefits attributed to public trees are easily quantified; therefore, some intangible benefits are not included in this study. For example, benefits linked with human needs, such as increased public safety, are difficult to measure. Furthermore, variances within species and between sites often occur to make estimates less precise.

Stevens Point's street trees provide significant benefits to the community and environment alike. Energy savings are the largest producers (51%) of quantifiable benefits to the City annually, with aesthetic and other non-tangible benefits not far behind at 31%. Air quality improvements account for 7% of annual benefits, carbon dioxide reduction accounts for 6% of annual benefits, and stormwater interception accounts for 5% of annual benefits. As determined throughout this analysis, larger-growing trees, such as red maple, green ash, and silver maple, consistently supply the most benefits.

The sum of estimated benefits for the City of Stevens Point (Table 5) is $317,600 annually at an average of $44 per inventoried street tree and $13 per capita. When Stevens Point annual expenditures are considered ($183,000), the net annual benefit (benefits minus costs) returned by street trees to the City is $134,600. The average net annual benefit for an individual street tree in Stevens Point is $18.56, nearly $4 per capita.

Based on the inventory count of 7,253 street trees, Stevens Point receives $1.74 in benefits for every $1 that is spent on its municipal forestry program (Appendix G).

Table 5. i-Tree Streets Analysis Results for Annual Benefits, Net Benefits, and Cost for Street Trees

	Total ($)	$/Tree	$/Capita
Total Benefits	$317,600	$44.22	$12.57
Total Costs	$183,000	$25.48	$8.85
Net Benefits	$134,600	$18.56	$3.71
Benefit-Cost Ratio	1.74		

Management Implications

When cared for properly, Stevens Point's street trees are worth the investment. Citizens of Stevens Point can take comfort in knowing that the benefits produced by maintaining their urban forest outweigh the costs. Based on this study, every $1 spent on street tree management returns an average net value of $1.74 in benefits back to the community each year. Unfortunately, street trees can become a burden to any municipality if neglected. As trees grow larger and mature, those that are not adequately maintained become increasingly more costly to manage and may create liability issues. Meanwhile, valuable benefits that are not fully achieved lessen opportunities to encourage a safe, healthy, and more enjoyable environment in which to live.

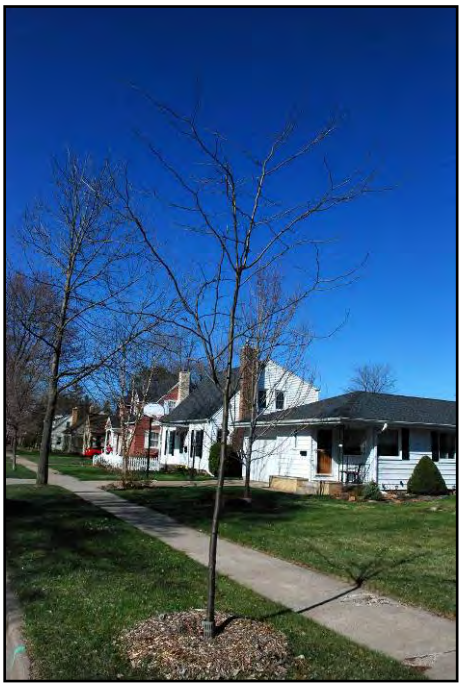
Continuing the comprehensive tree management program, including new tree establishment and cyclical pruning, is the first step to ensure that benefits produced by the City's street trees surpass the cost of managing them. Currently, 88% of Stevens Point's inventoried street trees are considered to be in good condition. Trees in fair condition account for 11% of the population, with 0.4% of street trees recorded as poor, .01% inventoried as dead or dying, and 1% of the street trees as excellent. While these figures indicate a strong commitment to street tree management, Stevens Point should strive to eliminate all dead and dying trees, replace poor performers, and maintain strong-performing and large-growing species that provide the most benefits. Replacing overutilized species, such as maples (comprise 31% of the total population), should be considered to improve overall species diversity and reduce the impact of species-specific pests or disease.

Photograph 6. Stevens Point's trees have a Benefit-Cost ratio of $1.74.

Cost-Benefit Conclusions

Stevens Point's trees provide a net annual benefit of $134,600 to the City each year at an average of $13 per tree and $4 per capita. Citizens of Stevens Point see $1.74 is returned for every $1 spent on management (Table 5 and Appendix G). **As a result, this i-Tree Streets analysis suggests that there is justification for more attention and funding for urban forestry planning, design, management, and maintenance in Stevens Point.** Planning for a greener and healthier City can begin by including urban forestry in all project discussions and considering creative ways to ensure the private and public tree canopy is kept healthy, well maintained, and safe, and is also enhanced by well-planned planting projects.

Planning to enhance Stevens Point's Urban Forest will take careful consideration of budget and time figures. Long-term goals must be kept in mind and routine maintenance must be performed on a cyclical basis to ensure the good health and condition of Stevens Point's public trees as they age and mature. Chapter 3 is designed to assist Stevens Point's managers with maintaining the City's public trees and abating/mitigating elevated-risk levels associated with these trees.



Photograph 7. Stevens Point has mostly young age class trees. If these trees are properly maintained, they will eventually become large mature trees and produce the greatest amounts of benefits to the City.

Benefit Maximization and Cost Reduction

To maximize tree-related benefits, mature and significant trees must be preserved as they are the primary benefit providers.

Monitoring the condition of significant trees and making efforts to maintain their health is essential. When maintaining public trees, the potential for loss is an important factor in prioritizing treatments and making effective use of available funds. The loss of trees over time is an inevitable natural process; however, controlling the decline, removal, and replacement of trees in a timely and cost-effective manner is the ultimate goal of the management process and benefits maximization.

Preservation of Mature Trees. Stevens Point currently does not have many large, mature street trees, but does have 1,692 street trees considered medium to large in diameter. Most of the large shade trees in the City are located on private property and in parks and other public areas. Preserving these trees can be a difficult task within a developing urban area. By using preservation guidelines, or implementing a tree preservation ordinance, Stevens Point will ensure its stately, mature trees will remain protected and healthy (Appendix H).

Create a strong public educational program that promotes the value of quality trees and quality tree care. Through years of experience and research, Davey has found that public education is the true key to reaching the goals of a community urban forestry program Through Arbor Day ceremonies, articles in City newsletters and local newspapers, and training seminars, the City can engage the citizens to support the City's forestry program as well as properly manage their own trees.

Photograph 8. The City should continue to promote Tree City USA and to conduct Arbor Day celebrations. This is an excellent way to educate the future generations about trees.

Davey highly commends the City for the highly successful *Tree-Mendous* campaign that was conducted in 2007.

Photograph 9. The *Tree-Mendous Benefit* campaign was an excellent idea and was very effective at informing the public on the benefits of trees.

Chapter 3: Five-Year Urban Forest Management Program

Summary

This chapter details the activities that will constitute the *Five-Year Urban Forest Management Program* for Stevens Point. Headings in this chapter include:

- High-Risk Tree Maintenance Recommendations
- Routine Pruning Program
- Young Tree Train Program
- Public Relations and Education
- Five-Year Urban Forestry Program and Budget
- Sources of Funding
- Management Recommendations for Updating Inventory

The five-year program was developed with most of the high-risk maintenance activities scheduled during the first year. Year 1 also marks the start of routine low-risk pruning on a ten-year maintenance cycle. Estimated costs for each activity throughout the five-year period are provided in Table 10.

Management Recommendations for Street Trees

- Perform all High-Risk maintenance recommendations. This program is designed to alleviate all potential High-Risk trees identified in the tree inventory during Year 1 (funds permitting) of the Five-Year Program.
- Beginning in Year 1 of the Five-Year Program, implement a continuing routine pruning maintenance cycle for the entire tree population to ensure their pruning every five years. This will involve the pruning of approximately 665 trees annually (Table 7).
- Beginning in Year 1, implement a one-year cyclical *Young Tree Training Pruning Program* for the small, undeveloped trees. This will involve the pruning of 3,855 trees annually (Table 8).
- A plan for after-care of new tree plantings should be implemented in order to maximize the cumulative survival rate. This includes pruning, mulching, watering, and fertilizing (when applicable).
- Implement a Public Relations Program designed to educate the residents of Stevens Point and to generate greater support for the City's urban forestry program.
- Develop a plan of action for invasive species, such as emerald ash borer.
- Develop strategies to manage drought damage.

A five-year budget for each of the above activities has been developed and presented in this chapter (Table 11). Additional sources of funding and recommendations for budgeting the urban forestry program are presented at the end of this chapter.

Risk Tree Maintenance Recommendations

The following tree maintenance recommendations are based on the analysis of the inventoried portion of Stevens Point's tree population. These recommendations should be followed and used in the development of appropriate and realistic management goals. Implementation of these recommendations will allow Stevens Point to first address the highest risk maintenance recommendations related to public safety.

Currently, Stevens Point does an annual "windshield" survey of all the street tree to prioritize needed risk mitigation, trees infected by Dutch elm disease and other needed activities. While this is a good method for determining short-term action, it is not an ideal method for properly planning future needed work. Davey recommends that the City either create a formal risk evaluation methodology or adopt an already created and accepted methodology. While there are several examples of existing risk rating systems, Davey recommends either ISA or the Forest Service methodologies. Both systems work on the same fundamental methodology but differ in the scoring.

ISA Methodology

The ISA methodology is based off the book, *A Photographic Guide to the Evaluation of Hazard Trees in Urban Areas,* by Matheny and Clark. The risk rating system consists of a numerical rating from 3–12 for each tree, with 12 being the highest level of risk and 3 being the lowest. Each tree is rated based on:

- Failure potential: 1 – low; 2 – medium; 3 – high; 4 – severe
- Size of part: 1 – <6"; 2 – 6-18"; 3 – 18-30"; 4 – >30"
- Target rating: 1 – occasional use; 2 – intermittent use; 3 – frequent use; 4 – constant use

Forest Service Methodology

The Forest Service methodology is very similar to the ISA and is based off *Urban Tree Risk Management: A Community Guide to Program Design and Implementation*. This risk rating system consists of a numerical rating from 3–10 for each tree, with 10 being the highest level of risk. Each tree is rated based on:

- Probability of failure: 1 – low; 2 – moderate; 3 – high; 4 – extremely high
- Size of defect: 1 – <4"; 2 – 4-20"; 3 – >20"
- Probability of target impact: 1 – occasional use; 2 – intermediate use; 3 – frequent use
- Other: 0-2 based on professional judgment if there is a need to increase the risk rating.

High-Risk Tree Maintenance Recommendations

The following High-Risk tree maintenance recommendations are based on the collected tree inventory data. Where numerous High-Risk removal and/or pruning treatment recommendations exist in the same area of Stevens Point, the work should be performed at the same time in order to reduce travel time and costs and increase efficiency.

Although large, short-term expenditures are required for trees with removal recommendations, they should be performed within the first year of the Management Plan's implementation.

Based on the tree inventory's results, Table 6 provides a summary of Removal recommendations for Stevens Point's trees. Following completion of these tasks, routine pruning work should then be addressed.

Davey strongly encourages the City to schedule all High-Risk maintenance recommendations to occur as soon as possible in order to abate/mitigate potential risks. By doing so, the City will greatly decrease the potential of injury to residents, damage to property, and possible liability litigation. Although it is impossible to expect the City to perform all needed maintenance activities immediately due to budgetary concerns, an organized and systematic program will achieve the needed results in a timely manner and will demonstrate the City's "good faith" effort to keep all streets and parks/public spaces safe for its residents.

In addition to these immediate concerns, a natural mortality rate of 1% of the total tree population per year is usually expected (national averages show an annual mortality rate of about 1% for tree populations in municipalities). The mortality rate for Stevens Point's trees may represent approximately 73 trees per year. It is important to keep in mind that as the current tree population increases in size and trees mature, costs for maintaining it will also increase. These anticipated tree removal costs are factored into the budget projection for the Five-Year Management Program; however, the City should allocate funds in anticipation of these removals.

Table 6. Removal Recommendations by Size Class

Tree Diameter Size Class (Inches)	Removal
1 – 3	2
4 – 6	3
7 – 12	6
13 – 18	0
19 – 24	2
25 – 30	1
31 – 36	0
37 – 42	1
43+	0
Totals	**15**

Routine Pruning Program

Routine pruning is an activity that should take place on a cyclical basis for the entire tree population. This activity is extremely beneficial for the overall health and longevity of trees. By routinely pruning on a cyclical basis, most potentially serious problems can be avoided since the trees can be closely inspected during pruning. Proper decisions can be made about declining trees and any trees that are becoming potential elevated-risks can be managed appropriately before any serious incidents occur. Note that trees included in this program will not include young or newly planted trees. These trees will be included in the *Young Tree Training Pruning Program* explained later. As young trees in this group grow larger, they will also become part of the *Routine Pruning Program.*

Photograph 10. A routine maintenance program will help to keep trees healthy and reduce potential risk to the community. These trees have been pruned and provide ample clearance to vehicles traveling along the street.

The five-year budget in this chapter provides average yearly estimates for this pruning program based on diameter classes and the number of trees in each diameter class. Table 7 details the average number of trees in each diameter class that would be pruned annually during the five-year cyclical *Routine Pruning Program*. Table 8 details the number of trees in each diameter class that would be pruned annually during the one-year cyclical *Young Tree Training Pruning Program*.

Five-Year Cycle

Results from the tree inventory indicate that 3,325 (46.29%) trees would be included in a cyclical pruning operation.

It is suggested that with the current number of forestry staff and equipment that is available to Stevens Point, a five-year cycle be implemented so that approximately 665 trees per year are routinely pruned per year. A five-year budget has been provided for all inventoried trees. It is intended for these five-year budgets to illustrate estimated costs for each activity and facilitate plans for short-term management recommendations. As happens all too often in many cities, tree pruning consists of trimming by resident request or only if personnel become aware of an elevated-risk situation. Stevens Point has done an excellent job of establishing a cyclical pruning operation. This Management Plan provides the City with exact numbers concerning Routine Pruning which serve as a guideline for accomplishing such a program.

Routine Pruning includes those trees requiring pruning on a cyclical basis to maintain tree form, tree health, and public safety. A proposed breakdown of five Management Zones has been included in Appendix J. These zones are based off the total number of trees within each defined geographic area that need Routine Pruning. Centralized pruning should be carried out, meaning that all trees on one City property or within a management area are trimmed at one time. A certain number of City properties should be designated for each year's work in order to meet the annual routine pruning goal. In the proposed five-year budget (Table 10), it is recommended that the *Routine Pruning Program* begin in Year 1 after the removals are complete, and it should be continued on a five-year cycle thereafter.

Table 7. Routine Pruning Program for Street Trees by Size Class

Diameter Size Class (Inches)	Routine Prune (Total Trees)	Routine Prune (Approximate Trees/Year)
1 – 3	355	71
4 – 6	212	42
7-12	1,307	262
13 – 18	885	177
19 – 24	361	72
25 – 30	144	29
31 – 36	46	9
37 – 42	11	2
43+	4	1
Totals	**3,325**	**665**

Ash Tree Risk Reduction Pruning and Removals

With the inevitable infestation of EAB into Stevens Point, it is advisable to refocus budgeted funds and personnel to higher priority tasks. Davey recommends that Stevens Point only perform safety related activities on ash trees. This activity will end up saving the City money and increasing productivity. However, it is only recommended due to EAB and the eventual removal of infested ash trees. It is estimated that by only performing risk related pruning on ash trees, Stevens Point could save approximately $5,200 annually.

Davey also recommends that Stevens Point proactively remove ash trees during road reconstruction projects and other public works associated activities. By proactively removing ash trees during construction, the cost and impacts should be lower.

In the event that the City of Stevens Point decides to proactively remove ash trees, it is recommended that the removals be done on a three-year timeframe. This will help defer costs and minimize the loss of benefits. Davey recommends that Stevens Point remove all ash trees under 7 inches and trees that are rated as Dead, Poor, or Critical condition first. These trees are providing little benefit to the community and the cost for removals should not be significant. The projected costs for proactively removing Stevens Point's ash trees less than 7" would be a total of approximately $33,000.

Young Tree Training Pruning Program

Young Tree Training Pruning consists of the removal of dead, dying, diseased, broken, interfering, conflicting, and/or weak branches, as well as selective trimming to direct future branch growth. Trees that have been assigned this maintenance type are generally young or newly planted trees with a canopy height under 20-25 feet tall. For these trees, Young Tree Training Pruning is used to develop a strong structural architecture of branches so that future growth will lead to a healthy, structurally sound tree. Many young trees may have branch structure that can lead to potential problems as they grow, such as codominant leaders, many limbs attaching at the same point on the trunk, or crossing/interfering limbs. If these problems are not corrected, they can become elevated-risks as they grow larger, and may create potential liability for Stevens Point in the near future.

Photograph 11. Young, newly planted trees need to be pruned more frequently due to vigorous growth rates. Training Pruning helps to develop good structure, and greatly reduces any future maintenance issues.

All newly planted trees should receive their first Young Tree Training Pruning three years following planting. Pruning should not be performed immediately after a tree is planted since it is already under stress from transplanting. Only dead or broken branches should be removed at the time of planting. Generally trees that are 6 inches in diameter and less are recommended for Young Tree Training Pruning. There are instances where trees below 6 inches in diameter do not need Training Pruning and instances where trees above 6 inches need Training Pruning.

One-Year Cycle Versus Three-Year Cycle

Similar to the *Routine Pruning Program*, the *Young Tree Training Pruning Program* would also be accomplished on a cyclical basis, but the work would be scheduled during a one-year cycle, rather than the five-year cycle for the Routine Pruning of larger established trees, due to the faster growth rates (on average) of younger trees. As mentioned above, newly planted trees should receive their first Young Tree Training Pruning three years after planting. This work can be accomplished throughout the year. Particularly, since no bucket truck is required, City employees can perform this work at any time. This type of work is also highly suitable for properly trained summer interns, part-time employees, and/or volunteers.

Currently, Stevens Point has established a one-year pruning cycle for the young tree training pruning program. This ensures that every young tree will be pruned once every year. It is excellent that Stevens Point has the ability to train prune young trees once per year. This will nearly guarantee that as the younger trees mature in the City, there will be very few, if any, structural issues for trees in the future.

While it is great that the City is able to currently perform this level of pruning, Davey recommends that the City consider a three-year cycle pruning for newly planted trees. As young trees mature and as the City plants more trees, a one-year training prune cycle may not be feasible. As the tree population grows, the City should evaluate their ability to maintain a one-year training prune cycle. If it becomes a struggle to maintain a one-year cycle, the City should consider a three-year cycle; general industry recommendations are to maintain a three-year training prune cycle.

Furthermore, with the impending infestation of EAB, Davey recommends that Stevens Point no longer provide training pruning to ash trees. These ash trees probably aren't worth investing in and the City should consider removing and replacing them while they are still small and the costs are less expensive.

Work Estimates

A one-year pruning cycle would require the Young Tree Training Pruning of approximately 3,855 trees per year while a three-year cycle would require the pruning of only 1,285 trees per year. Davey also recommends that the City stop training pruning ash trees under 6", this would remove a total of 516 trees from the cycle pruning. Table 8 provides the total number of trees that should be trained and an annual average breakdown by diameter size class. The proposed five-year budget (Table 10) recommends that the *Young Tree Training Pruning Program* be implemented in the first year of the budget. It has been Davey's experience that, based on the generally small size of the trees in this category, a crew of two properly trained personnel would be capable of accomplishing all the work.

Table 8. Annual Young Tree Training Pruning Program by Size Class

Size Class (Inches)	Young Tree Training Pruning (Total Trees)	Current Young Tree Training Pruning (1-Year Cycle)	Davey Recommended Young Tree Training (3-Year Cycle)	Young Tree Training Without Ash Trees (3-Year Cycle)
1 – 3	2,333	2,333	778	687
4 – 6	1,088	1,088	363	281
>7	434	434	145	145
Totals	**3,855**	**3,855**	**1,285**	**1,113**

Training of Personnel

Proper training about how to perform young tree structural pruning would be required for all tree crew personnel. Additionally, these workers would require an understanding of the growth-habits of the various species being planted, as well as an understanding of tree anatomy and physiology. This training can be received through local urban forestry consultants, such as the Wisconsin Department of Natural Resources and/or International Society of Arboriculture Certified Arborists. The tremendous aesthetic and financial benefits to be gained in the years to come from the proper structural pruning of young trees are a strong incentive for educating tree crew personnel concerning proper pruning techniques. Additionally, the added knowledge gained by the individuals could help improve the sense of professionalism in their jobs.

Five-Year Urban Forestry Program and Budget

Stevens Point's Forestry Department is responsible for a variety of duties, including guiding the City's tree maintenance programs. The following section consists of a five-year program projection for all pertinent urban forestry activities and is intended to provide an example of the relative costs that could be incurred by the recommended activities. In presenting this budget, Davey's consultants are aware that the portion of Stevens Point's budget allocated to public space tree-related functions might currently be stretched beyond its limits. However, Stevens Point must understand that the budgeting recommendations below are only estimates and are based on the application of sound urban forestry management principles to municipal forestry operations.

The five-year program is designed to address the removals first. This is intended to reduce potential elevated-risk situations for the public and all associated liabilities. The City may find it in its best interest to begin this work in Year 1 of the management program or change the recommended pruning cycle to distribute the annual budget funds more evenly.

Tree pruning and removal costs for trees in this Management Plan are based on quotes from a large number of reputable North American tree care companies and are averages extracted from bids received by communities in the Eastern United States during the past few years. The figures are equivalent to average costs for the same activities by municipal in-house crews. These costs are an average and are used to estimate the Severe-, High-, and Moderate-Risk maintenance recommendations, *Routine Pruning Program*, and *Young Tree Training Pruning Program* budget projections in this Management Plan. Table 9 lists the estimated costs for tree removals, pruning, stump removals, fertilization, and mulching.

Table 9. Cost Estimates Per Tree for Removals, Pruning, Stump Removals, Fertilization, and Mulching

Diameter Size Class (Inches)	Estimated Removal Cost/Tree	Estimated Pruning Cost/Tree	Estimated Stump Removal Cost/Stump	Estimated Fertilization Cost/Tree	Estimated Mulching Cost/Tree
1 – 3	$25	$20	$25	$5	$11
4 – 6	$105	$30	$25	$18	$11
7 – 12	$220	$75	$25	$22	$14
13 – 18	$355	$120	$40	$30	$14
19 – 24	$525	$170	$60	$50	$20
25 – 30	$845	$225	$85	$60	$20
31 – 36	$1,140	$305	$110	$90	$28
37 – 42	$1,470	$380	$130	$120	$28
43+	$1,850	$590	$160	$150	$28

Table 10 has been provided as an estimated budget for the Five-Year Urban Forest Management Program for Stevens Point. This table should be used as a general guideline for implementation of the five-year program, planning future tree care operations, and reviewing on-going City forestry operations. Specific accomplishments should be measured in comparison to the Management Plan's goals and recommendations.

Table 10. Estimated Costs for Stevens Point's Five-Year Urban Forestry Management Program

Estimated Costs for Each Activity			YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		5-Year Total Cost
Activity	Diameter Class	Cost/Tree (dollars)	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Removals (with stumps)	1-3"	$25	2	$50									$50
	4-6"	$105	3	$315									$315
	7-12"	$220	6	$1,320									$1,320
	13-18"	$355	0	$0									$0
	19-24"	$525	2	$1,050									$1,050
	25-30"	$845	1	$845									$845
	31-36"	$1,140	0	$0									$0
	37-42"	$1,470	1	$1,470									$1,470
	43"+	$1,850	0	$0									$0
Activity Total(s)			**15**	**$5,050**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$5,050**
Ash Removals 3-Year Cycle (with stumps)	1-3"	$25	90	$2,250	90	$2,250	90	$2,250					$6,750
	4-6"	$105	82	$8,610	82	$8,610	82	$8,610					$25,830
	7-12"	$220	5	$1,100	5	$1,100	5	$1,100					$1,100
	13-18"	$355	3	$1,065	3	$1,065	3	$1,065					$1,065
	19-24"	$525	1	$525	1	$525	1	$525					$525
	25-30"	$845	1	$845	1	$845	1	$845					$845
	31-36"	$1,140	1	$1,140	1	$1,140	1	$1,140					$1,140
	37-42"	$1,470	0	$0	0	$0	0	$0					$0
	43"+	$1,850	0	$0	0	$0	0	$0					$0
Activity Total(s)			**183**	**$15,535**	**183**	**$15,535**	**183**	**$15,535**					**$37,255**
1% Projected Removals Natural Mortality [2]	Removals	$260	73	$18,980	73	$18,980	73	$18,980	73	$18,980	73	$18,980	$94,900
Activity Total(s)			**73**	**$18,980**	**73**	**$18,980**	**73**	**$18,980**	**73**	**$18,980**	**73**	**$18,980**	**$94,900**
Projected Removal Costs				$39,565		$34,515		$34,515		$18,980		$18,980	$137,205
Current Removal Budget				$21,800		$21,800		$21,800		$21,800		$21,800	$109,000
Additional Needed Budget				**$17,765**		**$12,715**		**$12,715**		**-$2,820**		**-$2,820**	**$37,555**
Stumps	Stumps	$50	7	$350									$350
Activity Total(s)			**7**	**$350**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$350**
High Risk Pruning	1-3"	$20	0	$0									$0
	4-6"	$30	0	$0									$0
	7-12"	$75	14	$1,050									$1,050
	13-18"	$120	30	$3,600									$3,600
	19-24"	$170	23	$3,910									$3,910
	25-30"	$225	8	$1,800									$1,800
	31-36"	$305	2	$610									$610
	37-42"	$380	2	$760									$760
	43"+	$590	0	$0									$0
Activity Total(s)			**79**	**$11,730**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$11,730**
Routine Pruning 5-Year Cycle[1]	1-3"	$20	71	$1,420	71	$1,420	71	$1,420	71	$1,420	71	$1,420	$7,100
	4-6"	$30	42	$1,260	42	$1,260	42	$1,260	42	$1,260	42	$1,260	$6,300
	7-12"	$75	170	$12,750	170	$12,750	170	$12,750	170	$12,750	170	$12,750	$63,750
	13-18"	$120	116	$13,920	116	$13,920	116	$13,920	116	$13,920	116	$13,920	$69,600
	19-24"	$170	47	$7,990	47	$7,990	47	$7,990	47	$7,990	47	$7,990	$39,950
	25-30"	$225	20	$4,500	20	$4,500	20	$4,500	20	$4,500	20	$4,500	$22,500
	31-36"	$305	6	$1,830	6	$1,830	6	$1,830	6	$1,830	6	$1,830	$9,150
	37-42"	$380	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$590	1	$590	1	$590	1	$590	1	$590	1	$590	$2,950
Activity Total(s)			**473**	**$44,260**	**473**	**$44,260**	**473**	**$44,260**	**473**	**$44,260**	**473**	**$44,260**	**$221,300**
Ash Safety Pruning 5-Year Cycle	1-3"	$10	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$15	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$38	75	$2,850	75	$2,850	75	$2,850	75	$2,850	75	$2,850	$14,250
	13-18"	$60	29	$1,740	29	$1,740	29	$1,740	29	$1,740	29	$1,740	$8,700
	19-24"	$80	2	$160	2	$160	2	$160	2	$160	2	$160	$800
	25-30"	$115	1	$115	1	$115	1	$115	1	$115	1	$115	$575
	31-36"	$150	1	$150	1	$150	1	$150	1	$150	1	$150	$750
	37-42"	$190	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	43"+	$300	0	$0	0	$0	0	$0	0	$0	0	$0	$0
Activity Total(s)			**108**	**$5,015**	**108**	**$5,015**	**108**	**$5,015**	**108**	**$5,015**	**108**	**$5,015**	**$25,075**
Young Tree Training 3-Year Cycle[1, 3]	1-3"	$20	687	$13,740	687	$13,740	687	$13,740	837	$16,740	837	$16,740	$74,700
	4-6"	$30	281	$8,430	281	$8,430	281	$8,430	281	$8,430	281	$8,430	$42,150
	>7"	$75	145	$10,875	145	$10,875	145	$10,875	145	$10,875	145	$10,875	$54,375
Activity Total(s)			**1113**	**$33,045**	**1113**	**$33,045**	**1,113**	**$33,045**	**1,263**	**$36,045**	**1,263**	**$36,045**	**$171,225**
Projected Pruning Costs				$94,050		$82,320		$82,320		$85,320		$85,320	**$429,330**
Current Pruning Budget				$40,315		$40,315		$40,315		$40,315		$40,315	**$201,575**
Additional Needed Budget				**$53,735**		**$42,005**		**$42,005**		**$45,005**		**$45,005**	**$227,755**
Current Tree Planting 22-Year Full Stocking	Purchasing	$67	150	$10,050	150	$10,050	150	$10,050	150	$10,050	150	$10,050	$50,250
	Planting	$67	150	$10,050	150	$10,050	150	$10,050	150	$10,050	150	$10,050	$50,250
Activity Total(s)			**150**	**$20,100**	**150**	**$20,100**	**150**	**$20,100**	**150**	**$20,100**	**150**	**$20,100**	**$100,500**
Recommended Additional Tree Planting 10-Year Full Stocking	Purchasing	$67	185	$12,395	185	$12,395	185	$12,395	185	$12,395	185	$12,395	$61,975
	Planting	$67	185	$12,395	185	$12,395	185	$12,395	185	$12,395	185	$12,395	$61,975
Additional Planting Needs			**185**	**$24,790**	**185**	**$24,790**	**185**	**$24,790**	**185**	**$24,790**	**185**	**$24,790**	**$123,950**
Current Other Costs [4]				**$101,000**		**$101,000**		**$101,000**		**$101,000**		**$101,000**	**$505,000**
Projected Budget				**$259,405**		**$242,625**		**$242,625**		**$230,090**		**$230,090**	**$1,204,835**
Current Budget				**$183,000**		**$183,000**		**$183,000**		**$183,000**		**$183,000**	**$915,000**
Additional Recommended Budget				**$76,405**		**$59,625**		**$59,625**		**$47,090**		**$47,090**	**$289,835**

[1] Does not include Ash trees

[2] Projected removal cost is based on the average removal cost and includes stump grinding

3 An additional 150 trees have been added to year 4 & 5 to account for newly planted trees

4 Current Other Costs include pest management, irrigation, administration, litter clean-up, infrastructure repairs, and liability claims

Table 11. Arboricultural Planning Chart for Tree Management Activities

ACTIVITY/ TREATMENT	YEAR*	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
REMOVALS													
Severe and High Risk (Inventory)	1	X	X	X							X	X	X
Moderate Risk (Inventory)	1	X	X	X							X	X	X
Removals (Anticipated)	2A	X	X	X							X	X	X
Stump Removal	1A	X	X	X							X	X	X
PRUNING													
High Risk	1	X	X	X							X	X	X
Moderate Risk	1	X	X	X							X	X	X
Routine Pruning (Five-Year Rotation)	2A	X	X	X							X	X	X
Young Tree Training Pruning (Three-Year Rotation)	2A	X	X	X							X	X	X
FERTILIZATION													
Macronutrient (N-P-K; Fair and Poor Condition Trees)	1A			X	X						X	X	
Macronutrient (N-P-K; Excellent and Good Condition Trees)	2			X	X						X	X	
Micronutrient (Fe/Mn Trunk Injection)	N					X	X	X	X				
Micronutrient (Fe/Mn Soil Treatment)	N												
PEST MANAGEMENT													
Scouting	1A				X	X	X	X	X	X			
Pesticide Treatments	N				X	X	X	X	X	X			
Pest Pruning	N												
TREE PLANTING													
Site Assessment	1A												
Ball & Burlap Container	1A			X	X	X				X	X	X	
Bare Root	1A			X	X	X							
Watering (New Trees)	1A			X	X	X	X	X	X	X	X	X	
Cabling and Bracing	N	X	X	X								X	X
Mulching	1A												
Weed Control	1A			X	X	X							
Watering (Older Trees)	1A							X	X	X	X		
INVENTORY													
Update Field Inventory	5-10	X	X								X	X	X
Update Computer Database	1A												

Notes:
Shaded areas indicate months where tasks can be completed operationally
*** = Year task is recommended to be initiated/completed**
A = Continue on an annual basis after task is initiated
N = Implement on an as-needed basis
X = Optimal biological time (or for cost-efficiency)

Table 11 has been provided in order to help Stevens Point better organize the tree maintenance program that has been described in this chapter. The success of most tree maintenance tasks, such as planting, pruning, or fertilizing, is dependent upon seasonal temperature and weather conditions. The maintenance tasks described in this Management Plan should be scheduled for, and performed during, optimal biological periods to sustain vigorous health and to ensure the best chance for survival of the City's trees.

Management Recommendations for Updating the Inventory

An up-to-date inventory is the best way for the City to monitor the progress of its tree care operations. The major benefit of an accurate tree inventory is that the City can budget, plan, and anticipate tree-related problems and situations in the most cost-effective manner possible. Stevens Point needs to evaluate their methods used for updating their inventory. Currently, the trees are reinspected sometime after pruning takes place; all updates are recorded on a paper form, and then updated in the database back in the office. If there are any errors in the data collection, someone must go back in the field to fix the errors. With this method, each tree has the potential to be visited three times each time the inventory is updated, once for pruning, a second time to update the inventory, and potentially a third time to fix any errors, plus the time in the office spent updating the database. One easy improvement would be to have one person on a pruning crew do the inventory update while doing blockside pruning. The most efficient way to update the inventory would be for the pruning crew to have a laptop or other computer in the field to update the inventory database while in the field. This could be a goal for the City to strive for in the future.

Drought Planning Strategies

Dry soil conditions can significantly reduce the lifespan of valuable landscape trees. Because trees are both difficult and expensive to replace, they need attention both during and after a period of drought. The practices that have improved drought-stressed trees for years are still valid today: watering whenever the soil is dry; fertilizing to enlarge root systems; mulching to conserve moisture; using pest management to control insects and diseases; and pruning to remove dead and dying branches. The Technical Bulletins have more information on how to deal with drought- damaged trees.

Photograph 12. Stevens Point does a good job of preparing trees for drought conditions. Mulch is applied around the base of the tree to help retain moisture in the soil, and to reduce competition with turfgrass for water.

A strategy for managing trees during drought conditions is to take a “triage approach”. That is, group trees in three prioritized categories when allocating staff, equipment, and budget resources to drought response.

The first category of trees to consider providing supplemental watering to are those that will be most vulnerable and affected by the dry conditions. This includes: newly planted and young trees that are not yet established and have an undeveloped root system; trees growing with a restricted root system; and trees that have recently received root injury due to construction.

The next trees to consider for drought mitigation strategies are the "special" trees, such as historic trees, trees at community entranceways, focal point trees in parks and on public properties, rare tree species, and trees in critical areas providing shade and protection, such as near bus stops, near park facilities, and wherever people congregate.

The last group of trees to consider for drought mitigation strategies are the trees that are generally better equipped to withstand drought conditions. In continued dry conditions, even older trees will start to show symptoms of drought stress and will need supplemental water, but may require it less frequently than younger trees. Established, drought-tolerant species may also need supplemental watering with continued drought but could be deferred until higher priority trees are watered. Lastly, trees growing in relatively undisturbed, natural areas may not need supplemental watering at all.

Stevens Point has an excellent watering program for their young and newly planted trees, and should continue to maintain this program. Since the soils in Stevens Point are very sandy, the current watering protocol may not be sufficient in severe drought conditions. Some suggestions for reducing the damage caused by drought stress are:

- Experiment with planting more drought-tolerant species.
- Do not water in the middle of the day; water in early morning or evening to reduce the amount of water evaporation.
- Apply higher volumes of water less frequently to promote deeper root growth and drought tolerance. Frequently watering trees with small amounts of water promotes shallow root growth, and leads to more drought damage.

Table 12. Trees By Drought-Tolerance Attributes

	Botanical Name	Common Name
Drought-Tolerant Trees	*Acer rubrum*	red maple
	Carya spp.	hickories
	Celtis occidentalis	hackberry
	Cercis canadensis	Eastern redbud
	Ginkgo biloba	ginkgo
	Gymnocladis dioicus	Kentucky coffeetree
	Gleditsia triacanthos	honeylocust
	Koelreutaria paniculata	goldenraintree
	Nyssa spp.	blackgum
	Quercus spp.	oaks
Not Drought-Tolerant	*Prunus serotina*	black cherry
	Cornus florida	dogwood
	Liriodendron tulipifera	tuliptree
	Tilia americana	basswood
	Betula spp.	birch
	Platanus spp.	sycamore

Infrastructure and Construction Projects

In Stevens Point, frequent municipal infrastructure improvement activities are street and curb reconstruction projects, underground and overhead utility repair or maintenance, and other construction projects. Also frequently, public trees are located within the project limits. Preferably, before any construction project begins, all of the trees within the project area should be inspected to determine the size and condition of the trees and how the planned construction project may or may not affect the trees. If valuable, healthy trees exist, a tree preservation plan should be created and incorporated into the overall project. For those trees determined to be protected, strategies should be developed to protect the roots, canopy, and soil in the critical root zone. After the construction is complete, the trees should be re-inspected to determine if current or future mitigation is needed, such as corrective pruning, fertilization, core aeration, watering, and mulching. More information about protecting trees during construction can be found in Appendix H.

Photograph 13. This green ash is growing in about a 4- or 5-foot sidewalk cut-out. Green ash is considered a large-growing species, and this space size is considered to be too small for this tree.

When doing new construction, or complete redevelopment, where new trees will be planted, the space size for a planting bed or tree lawn should be considered during the planning phase of any project. If the goal of the project is to have large shade-growing trees, the growing space for the roots is going to have to be much larger than if a small ornamental tree is going to be planted.

- For a large-growing tree, the minimum soil space should be at least 600 cubic feet, and the smallest dimension should be 7 feet wide.
- For a medium-growing tree. the minimum soil space should be at least 400 cubic feet, and the smallest dimension should be 5 feet wide.
- For a small-growing tree, the minimum soil space should be at least 200 cubic feet, and the smallest dimension should be 4 feet.
- Overall, a soil volume of 2 to 3 cubic feet per 1 square foot of crown spread is recommended.

If trees are planted in spaces smaller then what is listed above, the trees will have a lower chance of surviving. If the trees do survive, there is a greater chance the tree will cause hardscape damage, such as lifting or cracking sidewalks.

Administrative Support

Urban Forestry Program Staffing and Equipment

Trees are unique from other assets that municipal departments manage in that they are living, growing organisms that have potentially very long service lives, provide multiple benefits, and have public safety implications. The care and management of this natural resource requires specialized equipment, professional expertise with a unique set of work skills, and a volunteer workforce to assist with special projects and program needs.

Professional Staff

The current staff of the urban forestry program consists of the city forester, one full-time arborist, one full-time custodian whose time is split with other duties, two fall/spring seasonal staff, and five summer seasonal staff. The parks department, which has eight full-time employees, assists the forestry department when needed. The staff assists in tree planting, pruning, removals, mulching, watering, and various other tree and landscaping related tasks.

Generally, an urban forestry program has both supervision and operational employees who are supported by administrative and other management employees within the municipal department. **As reported by the U.S Forest Service and the International Society of Arboriculture, on average, municipalities of the size of Stevens Point have four full-time employees in their municipal tree management programs.** This complement would include a supervisor, an assistant, and two field staff. With routine responsibilities of tree planting, maintenance, citizen request response, public education, and the added responsibilities of plan and site review for new developments, this number of staff is recommended for Stevens Point's urban forestry program.

An adequate complement of professionals who, individually or collectively, understand the technical, operational, and administrative factors in urban forest management is needed to prescribe and monitor the City's urban forestry activities, enforce policies and regulations, apply technical standards and practices, perform tree planting and maintenance, and review plans that affect the forest resource. Without this professional component in sufficient numbers, urban forest management decisions and actions often default to inadequately prepared decision-makers, which can have long-term, negative consequences for the forest resource.

Stevens Point does an excellent job of educating the forestry staff. The Forester and Arborist are provided the opportunity to obtain certification and attend trainings to maintain their certifications. The City should continue to provide these resources for the forestry staff.

If the City continues to utilize existing park department staff for forestry related activities, it is crucial that these employees receive the needed training. Urban forestry is a skilled trade and the necessary training is needed for not only employee safety but to ensure that irreparable damage is not done to a tree. By cross-training and further developing these employees, the City will be better able to utilize them during storm events, EAB removals and even more advanced structural pruning activities.

Volunteers are another great asset that Stevens Point should try to utilize more. Oftentimes, volunteers can save a community money by giving them something productive to do. When properly trained, supervised volunteers can help with planting, mulching, training pruning, and other small jobs. A great way to try and engage the City's current tree board or new members is to send them to "school" at the Tree Board University. www.treeboardu.org. This is a great way to get them more engaged and to better inform them as to their role within the community.

The City has been able to contract out some of its work to local tree care companies that sometimes offer a cheaper price then if the City would do the work themselves. The majority of the work that is contracted out is stump grinding, large tree pruning, and large tree removals. Stevens Point has found it to be more efficient to contract out the large tree work.

Currently, the City Forester is responsible for inspecting private residents' trees. This is a great practice and Davey highly commends the City for helping the citizens. However, if budget and time become an issue, this service is not common among other communities and could be abandoned. Many homeowners understand that their property is their responsibility and there are enough Certified Arborists in the region that could help homeowners with their tree-related questions/problems.

Equipment Resources

Currently, the forestry department has one bucket truck, a chip truck, one chipper, and a watering truck. The forestry department also has access to other equipment through other City departments as needed. The current equipment levels are appropriate for the size of Stevens Point's forestry operations.

Photographs 14 and 15. Stevens Point has a variety of well-maintained equipment which helps the City's arborists be more productive in their daily job duties.

When purchasing new equipment for the forestry department, the staff who will be using the equipment the most should have an input as to what to purchase. The staff will be using the equipment on a regular basis, and should know what will work best for them.

Volunteer Resources

Volunteers are the backbone of any community initiative. The management, protection, and enhancement of Stevens Point's urban forest can be advanced with the inclusion of volunteers in many aspects of the program. Many benefits and efficiencies can be realized by effectively using volunteers. This includes creating community partnerships for funding and action; increasing the awareness and understanding of urban forestry challenges and issues; delivering important messages and advancing public outreach and education; providing valuable resources to fill gaps in skills, experiences, and staffing needs; and giving the urban forestry program the credibility, support, and human resources that are essential in order to advance the program's goals.

The reason volunteers can be so valuable is that they are a part of, live in, and are concerned with the urban forestry issues that affect them and the City. Stevens Point's urban forestry program could benefit from using volunteers to accomplish tasks such as landscape tree planting and reforestation projects, tree mulching, young tree care, monitoring and controlling invasive plants, fund-raising, and performing public education efforts.

Chapter 4: Managing for Exotic Insects and Diseases

Throughout the United States, urban and community forests are under increased pressure from exotic and invasive insects and diseases. Usually these exotic pests arrive from overseas, our native trees and shrubs do not have appropriate defense mechanisms to fight them off, and their natural predators usually do not exist. Mortality can range from two weeks, with oak wilt [OW] (*Ceratocystis fagacearum*), to seven years, with emerald ash borer [EAB] (*Agrilus planipennis*). Five exotic pests have been discovered to be a threat to Stevens Point's trees. These exotic pests are emerald ash borer, Asian longhorned beetle [ALB] (*Anoplophora glabripennis*), gypsy moth [GM] (*Lymantria dispar*), Dutch elm disease [DED] (*Ophiostoma ulmi*), and oak wilt.

An integral part of tree management is being aware of invasive insects and diseases in the area and how to best manage them. Depending on the amount of tree diversity that exists in Stevens Point's urban forest, an invasive insect or disease has the potential to negatively impact the tree population (EAB, for example, could eliminate all ash species from the City).

This chapter will deal with these dangerous insects and diseases. Included for each invasive is a section on how to identify each pest or disease, as well as a section on how to effectively monitor and manage them within the City.

Emerald Ash Borer

EAB is an exotic Asian insect pest whose presence has been confirmed in Illinois, Indiana, Maryland, West Virginia, Pennsylvania, Michigan, Minnesota, Ohio, and Wisconsin. Infested trees have been found in urban areas, woodlots, and nursery stock. This borer has killed millions of trees, from small, young trees to established, mature specimens. In the United States, this pest has been detected only on ash tree species, including white ash (*Fraxinus americana*), black ash (*F. nigra*), green ash (*F. pennsylvanica*), and blue ash (*F. quadrangulata*).

EAB has been identified to the west of Stevens Point in Minnesota, to the south near Milwaukee and Chicago, and to the north in the Upper Peninsula of Michigan. Stevens Point is somewhat surrounded by infestation sites and, unfortunately, it is most likely only a matter of time before EAB is found within Stevens Point.

Photograph 16. EAB adults grow to 5/8-inch in length (photo credit Michigan State University).

Photograph 17. EAB larvae (stock photo).

Identification

Photograph 18. Example of bark splitting caused by EAB in an infested tree (stock photo).

The adult beetle is elongate, metallic green, and 3⁄8- to 5⁄8-inch long. Adults emerge from late May until early August, feeding on a small amount of foliage (this causes jagged leaf edges). Females lay eggs deep into bark crevices on lower main branches. After eggs hatch, the larvae tunnel through the bark and feed on the phloem and outer sapwood for several months. The mature larvae are cream colored and 1- to 1-1⁄4 inch long. Fully grown larvae overwinter under the bark, or sometimes in pupal cells made of outer sapwood. There is one generation per year, but some larvae can remain in the tree for two years.

Initial symptoms include yellowing and/or thinning of the foliage and longitudinal bark splitting. The entire canopy may die back, or symptoms may be restricted to certain branches. Declining trees may sprout epicormic shoots at the tree base or on branches. Removal of bark reveals tissue callusing and frass filled serpentine tunneling. The S-shaped larval feeding tunnels are about 1⁄4 inch in diameter. Tunneling may occur from upper branches to the trunk and root flare. Adults exit from the trunk and branches in a characteristic D-shaped exit hole that is about 1⁄8 inch in diameter. The intense tunneling disrupts water and nutrient flow, causing trees to lose between 30% and 50% of their canopies during the first year of infestation. Trees often die within two years following infestation.

Monitoring and Management

If an ash tree is believed to be infested, it is recommended that the City contact the Wisconsin Department of Agriculture Trade and Consumer Protection (WI-DATCP) for proper identification. Removal of infested trees is recommended, and their stumps should be ground out.

Currently, the street tree population of Stevens Point consists of 1,076 (15.19%) ash trees. If EAB were to be discovered in Stevens Point today, the City could potentially lose 15% of its street tree population. Furthermore, the City will lose an estimated $49,200 in annual benefits if all the ash trees are removed. The City should do what it can to replace its ash population before EAB makes its way into the City. One potential option for reducing the ash population would be to remove ash during street reconstruction projects, work with the utility company to remove any ash growing under utility lines instead of performing line clearance pruning, or remove any trees that are in poor or declining condition.

Stevens Point's current ash population was entered into the Purdue University EAB cost calculator to determine the costs of different management options. Table 13 shows the annual cost for seven different management options for EAB.

Table 13. Projected Costs for EAB Management

Management Option	Annual Cost
Remove All	$188,580
Replace All	$426,400
Treat All ($4/inch)	$41,304
Remove >12	$70,200
Replace >12	$108,700
Replace <12	$317,700
Replace <6	$146,100

It is highly recommended that Stevens Point makes every effort to replace and replant any ash tree that is removed. Since ash make up nearly 15% of the total tree population, a large amount of the benefits of the urban forests stated in Chapter 2 will be lost if ash are removed from the population. The public will also be more accepting of tree removals if they are being replaced with new trees.

Pre-Infestation

The City has started to prepare for the arrival of EAB by treating ash trees in the high visibility areas of the City, such as downtown, along Main Street, and along Clark Street. This is great and the City should continue these types of preventative actions. As can be seen in the Table above, the estimated costs for treating all of Stevens Point's ash trees is less than $42,000 per year. By treating a few high-quality ash trees, Stevens Point can hope to save these trees and even postpone the probable removing of these trees.

Davey recommends that the City conduct a windshield survey of all the identified ash trees to determine the condition and location. This survey will enable the City to better understand what the current threat of EAB is to the urban forest. With this data, the City will be in a better position to properly respond to an EAB infestation.

One thing that Stevens Point needs to work on is what to do with large amount of wood waste that will be produced when EAB makes its way to the area. The current brush drop-off site for residents of Stevens Point is pretty small, with little room to expand. There is also another city property, the Jellich property, that can be utilized as a brush drop-off site, which has ample room for size of Stevens Point. The City should also explore other opportunities throughout Portage County and neighboring communities for wood waste utilization and other EAB issues that may arise. A neighboring community may have a piece of equipment that could be useful to Stevens Point, and Stevens Point may have forestry resources other communities could use.

One thing that Stevens Point should avoid is to put all of its forestry resources into EAB management and mitigation once it is found within the City. When Dutch elm disease was at its peak in the Midwest, the only tree work occurring in communities was the removal of infected elm trees; all other trees were not being maintained. Now, current forestry programs are dealing with many trees that are 30-40 years old that have very poor structure because they were not maintained as young trees when Dutch elm disease was at its peak. To avoid this problem, the City should maintain the pruning cycle as well as manage any EAB infestations.

Post-infestation Recommendations

With the inevitable infestation of EAB on the horizon, it is crucial that Stevens Point be prepared with an action plan once EAB has been detected. One of the most important questions to answer will be; "How many ash do we have, where are they, and what should we do?" In order to answer this question, Stevens Point needs to maintain an up-to-date inventory and know what resources are available and what the City's priorities are. Davey recommends that the City create a custom EAB Readiness Plan with specific action steps.

Based on the current street tree inventory, there are 1,076 ash trees ranging in size from 1-36 inches. Most of these trees are under 12" and rated in Good condition. Below is a Table that illustrates Stevens Point's current ash tree population based on DBH size class and condition.

Table 14. Sample EAB Protocol

Condition	Diameter Class (inches) 1-3	4-6	7-12	13-18	19-24	25-30	31-36	TOTAL
Excellent	0	3	1	0	0	0	0	4
Good	240	197	373	147	9	3	0	969
Fair	26	47	14	6	2	2	1	98
Poor	3	0	2	0	0	0	0	5
Total	269	247	390	153	11	5	1	1,076

543 Trees To Be Removed
533 Trees for Possible Chemical Treatment

Based on these numbers, Davey makes the following recommendations:

Trees To Be Removed and Replaced

1. Remove and replace all 5 trees that are in Poor condition.
2. Remove and replace all 440 trees under 7" DBH.
3. Remove and replace all 98 trees rated in Fair condition.

Trees For Possible Chemical Treatment

1. All 533 trees in this category should be re-inspected annually to verify suitability for treatment or removal.
2. Candidates for chemical treatment should be in Good condition or better and be greater than 7" DBH.
3. Candidate trees should show no more than 20% dieback and be located in a proper location (*i.e.*, not under overhead utilities, too close to stop lights, etc.).

Davey's preferred method for chemical treatment is to apply 1.8 grams/inch dbh of imidacloprid as a soil injection treatment or as a low-volume basal soil injection treatment or as a soil drench treatment in the fall or early spring. If the trees are larger than 15 inches in diameter, research has shown that using a higher rate of imidacloprid gives added protection. Soil applications can begin in fall, but need to be completed by April 15. Imidacloprid can also be trunk injected during spring until May 7. This treatment protocol should last one full year.

Asian Longhorned Beetle

ALB is an invasive insect originally from China that has become a serious problem to trees in certain parts of the United States, such as New York City and Chicago. This beetle's larvae create tunnels by girdling stems and branches on trees. Repeated attacks can result in crown dieback and in severe cases can lead to death. The insect has been reported to have entered the United States via wood packing materials originating from China according to the Animal and Plant Health Inspection Service (APHIS) branch of the USDA.

Although ALB seems to prefer maple species (*Acer* spp.), such as boxelder (*Acer negundo),* Norway maple (*A. platanoides),* red maple (*A. rubrum*), silver maple (*A. saccharinum*), and sugar maple *(A. saccharum*) in the United States, this pest has also been found in horsechestnut/buckeye species (*Aesculus* spp.), alder species (*Alnus* spp.), birch species (*Betula* spp.), poplar species (*Populus* spp.), willow species (*Salix* spp.), and elm species (*Ulmus* spp) [APHIS]. This "list" is not conclusive, however, since a complete list of host trees in the United States has not been determined yet.

The adult beetles are persistent from July to October, but can be found later in the fall if temperatures remain warm. After the adults emerge from their larvae tunnels, they bore another tunnel through wood, creating a round exit hole in the tree bark. Adults generally remain on or around the trees they originated from, only traveling short distances to feed and reproduce.

Identification

The adult form of ALB is 3/4 to 1-3/4 inches in length, with long antennae that are 1-1/2 to 2-1/2 times their body length with distinctive alternating black and white bands. The body is a jet black color with mottled white spots on the back and the feet have a bluish tinge to them.

Photograph 19. An ALB adult (Photo credit: USDA).

Photograph 20. Oval to round ALB egg pits in the bark of an infested tree. (Photo credit: USDA).

There are a few signs that one can use to help identify ALB on trees. Infected trees will often have oval to round pits in the bark (Photograph 15). These pits are from the female beetle chewing out parts of the bark to deposit an egg in each created depression.

Another sign of ALB in the summertime is oozing sap. Sap can sometimes flow from the egg niches as the larvae feed on the trees and this is especially true of maple trees.

As mentioned earlier, the adult beetle emerges from the tree via a round exit hole roughly 3/8 inch in diameter or larger, which occurs on the trunk and branches. This is, however, post-infestation, as the round holes are caused by the adult beetles.

Finally, an infected tree will sometimes have mounds of coarse *frass* (debris or excrement created by insects) around its base, where branches meet the trunk and other branches. These piles are created by the beetle larvae as they bore into the trunk and its branches (Photograph 17).

Photograph 21. Exit hole from an adult ALB (photo credit: USDA).

Photograph 22. Piles of coarse frass (yellow arrow) from the boring activities of ALB larvae in an infested tree (photo credit: USDA).

Monitoring and Management

As of today, the only safe method of effectively eliminating ALB is to remove the infested trees and destroy them by chipping or burning. In an effort to prevent any further spread of the beetle, quarantines have been established to prohibit the export of any infested trees and branches from the area. In addition, an emphasis has been placed on earlier detection of infestations and faster treatment response, both of which are essential to successfully eradicate the insect.

In 2007, the USDA declared that ALB had been totally eradicated in Chicago and lifted the quarantine. Although it is believed ALB is no longer an immediate threat to the Midwest, it would be prudent for Stevens Point to report any possible infestations to the DNR or the USDA.

Gypsy Moth

GM is one of North America's most devastating forest pests. The species originally evolved in Europe and Asia and has existed there for thousands of years. In 1868, GM was accidentally introduced in Medford, Massachusetts. Since then, it has continued to spread west into the Appalachian Mountains, the Ozark Mountains, and into the northern Great Lakes region. It is inevitable that GM will continue to expand its range in the future.

GM is known to feed on the foliage of hundreds of species of plants in North America, but its most common and favored hosts are oak species (*Quercus* spp.). Several successive years of defoliation, in conjunction with contributions by other biotic and abiotic stress factors, may ultimately result in tree mortality. In most northeastern forests of the United States, less than 20% of the total tree population will die in forests, but occasionally tree mortality may be very heavy.

Identification

Trees may be partially or completely defoliated by large numbers of dark, hairy caterpillars. The caterpillars hatch from beige-colored egg masses in early April to late May and begin feeding on new tree leaves that are emerging at the same time. When the population is high, the caterpillars are a nuisance in residential areas and parks as they crawl on buildings, outdoor furniture, cars, and lawns. Their excrement seemingly "rains" out of trees, and sounds of their feeding can be heard clearly as they rapidly devour leaves.

Monitoring and Management

Young caterpillars spin down from treetops on silken threads and are easily spread by the wind. Fully grown caterpillars can be identified from other caterpillar species by the five pairs of blue spots followed by six pairs of red spots on their back. It is estimated that a single caterpillar consumes about 10.8 square feet of foliage during its development. A tree weakened by GM feeding is more susceptible to injury from other insects and diseases.

Photograph 23. Fifth instar GM larva. This is the stage when gypsy moth is the most destructive to trees (photo credit: USDA Forest Service).

Photograph 24. Female GM with egg mass (stock photo).

A female moth lays from 75 to 100 eggs which can be found on trees, rocks, walls, firewood, and even the undersides of vehicles. Accidental transportation of egg masses has accounted for the spread of GM from state to state.

Due to long hatch periods, two or three foliar treatments may be necessary to control GM caterpillars. B.t. (*Bacillus thuringiensis*), a common bacterial pathogen, will control GM, but it is only most effective while the larvae are young.

GM is present in Stevens Point, but the population has been in decline the last few years. The City should continue to monitor the population levels from year to year, and if the population starts to increase, treatment may be necessary.

Dutch Elm Disease

DED is one of the most destructive shade tree diseases in the United States and Canada, and has killed millions of elm trees since its introduction from Europe in 1930. Despite this loss, many elms still remain as street trees or specimen shade trees providing grace and beauty to our landscapes.

The disease is caused by the fungus *Ophiostoma ulmi*. Both the smaller European elm bark beetle (*Scolytus multistriatus*) and native elm bark beetle (*Hylurgopinus rufipes*) can transfer fungal spores from infected elms to healthy elms, thus causing the infection in healthy elms. The fungus is transmitted to healthy trees when beetles carry fungal spores after feeding in stem crotches of diseased elms.

Direct transmission of the disease occurs when diseased trees and healthy trees in proximity to each other have made contact through connecting root grafts. Elms within 40 feet of each other have a good chance of having root grafts.

Identification

Elm trees infected with DED display wilted (flagging) leaves on one or a few branches in the crown of the tree. The wilted leaves may turn yellow, curl, and/or turn brown. Leaves can remain attached to the stem or prematurely fall off. Stems exhibiting flagging typically die back.

Photograph 25. Elm trees with spots of yellow, brown, or curled leaves on one or a few branches should be checked thoroughly for DED (photo credit: USDA).

Photograph 26. Elm trees infected with DED often display wilted leaves on one or a few branches in the crown of the tree (stock photo).

If bark is peeled away from stems exhibiting yellow, brown, or wilted leaves, dark blackish-brown streaking may be visible in the sapwood just under the bark. Sometimes, streaking is embedded deeper in the wood, which indicates that the infection occurred in previous years.

Monitoring and Management

There are a few things that Stevens Point can do to help manage its elm trees and stop the spread of this disease. All infected elms and dead or dying branches on healthy elms should be removed and destroyed immediately to prevent build-up of beetle and fungal populations. Prompt removal of diseased branches can help stop the spread of the disease in a tree if it has not progressed within 10 feet of the main trunk.

Dutch elm disease can also be transmitted from infected to healthy elms by root grafts between the trees. This can be prevented by having the root grafts of suspected trees severed by trenching or soil fumigation.

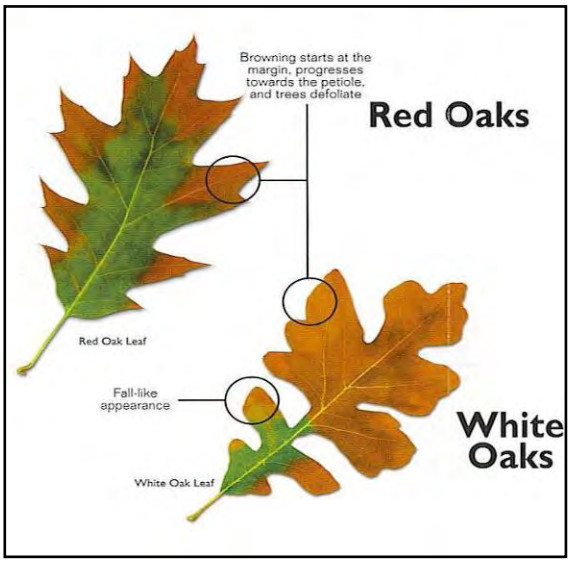
Another solution would be to inject systemic fungicides into the trunks of the trees. This process can be a preventive and therapeutic treatment. Trees receiving therapeutic fungicide treatments have the best response if the crown has 5% or less infection. Research indicates that attempts to manage the bark beetle with insecticides may not be effective. The feeding sites of beetles (stem crotches) must be protected with an insecticide, which is difficult with current equipment, pesticides, and technology. The alternate option is the protection of susceptible trees with preventive trunk injections of recommended fungicides. Finally, trees maintained with good cultural practices, such as fertilization, watering, mulching, and selective pruning, will have the best health and vitality.

With the seasonal inspections and current ordinances for DED, Stevens Point is doing a good job of managing the disease. The current program should be maintained in order to stay on top of DED.

Oak Wilt

The disease known as oak wilt is caused by the fungi *Ceratocystis fagacearum*, which attacks the water-conducting (vascular) system of trees. A tree responds by blocking its vascular system to contain the disease and, in doing so, cuts off the water supply to its leaves.

Oak wilt can be spread by insects that carry the pathogen on their bodies from an infected tree to an uninfected tree. It also spreads via the vascular system of grafted roots of adjacent trees.



Photograph 27. Oak wilt only affects *Quercus* spp. (oak species), and its first symptom is browning of the leaf margin with progression towards the petiole.

Identification

The first sign of OW occurs when leaves in the upper crown turn a dull green, bronze, or tan beginning at the leaf margin. Soon after, the leaves will drop off with various degrees of discoloration. Brown streaks develop in the new sapwood. Trees in the red oak group—scarlet oak (*Quercus coccinea*), pin oak (*Q. palustris),* northern red oak (*Q. rubra*), and black oak (*Q. velutina*)—are not known to recover once infected. The white oak group—(*Q. alba*) and bur oak (*Q. macrocarpa*)—varies in species resistance to oak wilt, but they usually die slowly over a period of several years.

Monitoring and Management

The main strategy for managing OW is to prevent its spread to healthy oaks. This can be an extensive project involving the prompt removal of infected trees and the disruption of root grafts. Without these measures, the disease will almost assuredly spread and kill more trees. If there is a healthy oak within 40 feet of a diseased one, fumigation or trenching should be done to prevent root graft transmission of the fungus at least 10-15 days prior to the removal of the diseased tree.

Root grafts are the most common way for OW to spread from infected to healthy trees. A good strategy to prevent the spread of OW from an infected tree to a healthy oak is to install a root graft barrier. A root graft barrier disrupts the common root systems between oak trees and doesn't allow the fungus to spread via root grafts. It is important that this be done regardless of how the neighboring oak trees appear, oftentimes neighboring trees may appear to be healthy but they could still become infected if nothing is done. Appendix I has more information about oak will management.

Red oak species are much more susceptible to OW and will usually die within a couple of weeks, while white oak species seem to have the ability to defend themselves for a couple of years before death. Preventive fungicide treatments can be effective for preventing the spread of OW into healthy trees as long as there are no root grafts.

OW is present within Stevens Point, and is causing a lot of fatalities to the oaks in the City. The current OW management program maintained by the City is very similar to that of DED. The management program will not stop the spread of OW, which is extremely difficult in any case, but it defiantly slows the spread of OW and makes it more manageable.

There are a few instances where OW is present directly on the city boundary, and the bordering city does not have any ordinances that enforce OW. A question arises whether to enforce Stevens Point's OW ordinance along the city boundary, or to make an exception in these rare instances. Davey recommends enforcing the city ordinance in all cases; if an exception is allowed in one instance, it opens the door for other residents to seek out their own exception. As with EAB, it is recommended to work with or try and form a partnership with the neighboring communities with OW. The neighboring communities may not have the resources or expertise to enforce an OW ordinance, which Stevens Point has. But, the neighboring community may have a large wood waste disposal site, tub grinder, or other pieces of equipment that could be useful to Stevens Point.

Chapter 5: Funding Sources

Urban forest management is a recognized function of the City of Stevens Point and receives annual funding. The urban forestry program functions at a level that allows for some strategic initiatives, but primarily is still reactive in nature. With greater funding levels, the City could move toward a more proactive management approach, provide greater services, and increase tree canopy coverage.

There are various funding mechanisms and sources the City can consider to support increasing staff levels, public education efforts, tree protection, preventive maintenance, new tree care programs, planting activities, and other components of a truly progressive, comprehensive urban forest management program. The following recommendations are made for the City to obtain additional urban forestry funding.

- Establish a Stevens Point "Friends of the Urban Forest" 501(c) (3) Organization.
- Many municipalities have the support of a non-profit group who raises and holds funds for the benefit of the urban forest. These non-profit groups are usually designated by the Internal Revenue Services as a 501(c) (3) organization which is exempt from income and (sometimes) property tax, and able to receive tax-deductible charitable contributions.
- All 501(c) (3) organizations must have a unique name, mission statement, a Board of Directors, Articles of Incorporation, and by-laws.

Establish a Stevens Point Tree Fund

A special account should be created to deposit funds from various sources, which are restricted for use by the urban forestry program. The funds in this account are managed by the City, subject to the annual budget process, and expenditures follow normal purchasing policies and procedures.

This innovative funding mechanism does not rely on City general funds but, instead, on the collection and deposit of monies from various sources. Suggested sources included, but are not limited to, the following:

Damage Compensation. This source may not generate a great deal of funding, but it is a legitimate and often under-pursued source of funds. When an automobile damages a public tree or when construction equipment destroys a group of public trees, the City should seek compensation for the landscape value of that tree(s). The City can rightly seek compensation for the total damages, including: the value of the tree(s); the cost of repair or clean-up; and the cost of the administrative time used during the resolution of the situation. The receipt of $500 from a minor car accident to $5,000 for a major damage claim can add up over time. Generally, the compensation is collected from the insurance company of the person responsible for the damage or directly from the business that caused the damage to public trees. The compensation funds can be used to remedy the specific damage, plant new trees, or be used for other legitimate urban forestry functions throughout the City.

Permit and Plan Review and Inspection Fees. It is not uncommon for municipalities to require private developers and businesses to support the administrative time needed for proper and professional plan review and site inspection tasks. In light of the City's goal to protect and enhance the urban forest, charging specifically for the time and arboricultural expertise needed to approve permit applications, review plans, and make site inspections might be a viable option to help support the salary and benefits of additional full- or part-time urban forestry positions. The City may need to perform a job analysis to determine the time spent performing review and inspection tasks, and could investigate what other cities in the region, or of a similar size, are charging for such tasks.

Developers Fees. In lieu of, or in addition to, tree-related plan and inspection fees, developers could be required to pay a set amount to support Stevens Point's overall urban forestry program. In effect, it would be a cost of doing business within the City limits. The fee could be a percentage of the total project cost, based on the number of housing units built, or based on the area of land being developed. The City's Planning Department may have better information upon which to base this fee. It is suggested that this fee would be paid and deposited in the Tree Bank before the project is approved.

Utility Company Fees. Non-municipal utility companies perform new construction, maintenance, and repair work on an annual basis in the City. This work may affect the aboveground and belowground portions of public trees. It is prudent and reasonable to assess a fee to such utility companies when their work affects municipal trees. Utility companies with aerial facilities might be required to provide the City an anticipated annual work plan and maps with an appropriate fee attached to provide for inspection and monitoring. Any compensation for documented damage to public trees during utility work would be collected separately on a case-by-case basis, and the utility company should be responsible for the costs for any remediation necessary (*e.g.*, pruning, fertilization, or temporary irrigation) above and beyond the fees and compensatory payment. The same conditions would apply for companies installing or maintaining underground utilities.

Private Donations/Corporate Sponsorships. Stevens Point could solicit citizens for private donations to support tree planting, tree care, and public education activities. A major source of donations could be from businesses and corporations who wish to sponsor non-profit, environmental activities. All potential contributors should be reminded that any donations might be tax-deductible when they file their federal income tax return if their financial situation allows.

Fund-Raising Activities. With the support of volunteers, the City can hold various fund-raising events throughout the year. Popular large events include competitive and social runs and walks. Volunteers can staff food and drink booths at local fairs and festivals. Tree and Stevens Point-related merchandise could be commissioned and sold. Restaurants can have special Tree Nights where a small percentage of the patron's bill is donated back to the City for tree planting. Even small efforts, such as school and church bake sales and yard sales and soliciting donations at Arbor Day and tree give-away events, can be encouraged to raise funds for trees in the community.

Firewood/Mulch/Wood Sales. Wood waste from tree maintenance and storm damage repairs can be a source of funds for the Tree Bank. Other cities have been successful in selling split and un-split firewood, hardwood timber, and rough wood chips to the general public and commercial businesses. Rather than pay for proper removal and disposal, cities sell these excess wood products. A new trend is when a significant or historic public tree must be removed, the logs and useable wood are given to local craftsmen who then create furniture, sculpture, and other collectibles from the wood. These are sold and all or portions of the proceeds are returned to the City.

Memorial and Honor Trees. Stevens Point's tree planting program can be partially funded and enhanced by creating and advertising a Memorial and Honor Tree Planting Program. Citizens at times of loss and at times of celebration often choose to plant a tree to remember special people and mark a special achievement. Cities across the country successfully use this funding technique not only for program support but also for generating good public relations for the urban forestry program.

A prudent approach to implementing such a program is to set a level of funding that will not only purchase and plant a tree of a certain size, but that will also collect funds to pay for maintenance for three years.

Utility Bill Donations. These municipal invoices could be a source for needed funds for the urban forestry program. A small fixed amount from $0.25 to $1.00 could be automatically added to each bill; the property owner would then have the option to voluntarily include it with their utility payment. Another option is to ask the bill payers to round the invoice amount up to a higher figure of their choice with all payment overages going to support the urban forestry program. Using this voluntary and "painless" funding mechanism can potentially raise thousands of dollars.

Other Funding Tools

Increase the General Fund Allocation to the Urban Forestry Program. During future budgeting cycles, the City should consider increasing the financial resources available for urban forestry staff and functions.

Obtain Grants. As a municipality and a non-profit with existing support structures and staff, Stevens Point is in a good position to apply for and receive grants to support urban forestry activities. The City has previously received grants for urban forestry projects, such as the grant funding this Management Plan, but with the investment in time and a person skilled in grant writing, there are likely multitudes of grant opportunities for Stevens Point. These opportunities can be found with the State and Federal governments, non-profit organizations, large corporate and private business foundations, and private charitable foundations. If Stevens Point establishes a Tree Bank, there will be a ready source of matching funds to leverage even more grant dollars.

Promote the Federal Tax Incentive to Citizens. As a non-profit, the City is in a unique position to encourage citizens to directly pay for desired tree planting and tree maintenance on public property. The City should inform property owners abutting the public rights-of-way, parks, or other City properties that if they pay for City-approved, proper public tree planting or tree maintenance, then that effort and any related expenditures may qualify as a charitable deduction on their federal income tax return. Until the City urban forestry program is fully staffed, equipped, and funded, this mechanism is a good public relations tool as well as a way to accomplish needed work.

Chapter 6: Summary and Conclusions

Stevens Point is on the right path to a sustainable urban forest. The results of this analysis can be used to improve the City's public tree management strategy, promoting a valuable asset with invaluable qualities. By strengthening its network with partners and urban forest managers, Stevens Point will help to develop the relationships and resources it needs to achieve its urban forestry goals.

Stevens Point has a tree population in relatively good condition that adds to the beauty and livability of the City. Stevens Point should be proud that the majority of their trees are in good condition, and should continue maintenance on the trees to keep them in good condition. As trees get older, they become increasingly inefficient in withstanding the inherent stresses of an urban environment and are subject to decline without professional and regular management. Keeping that in mind, Stevens Point should strive to achieve the goals of this Management Plan.

Generally stated, Stevens Point's goals include:

1. **Understand the inventoried street tree population in terms of species and genus.** Currently, the genus maple (*Acer*) comprises approximately 31% of the tree population. The City must begin planting different species to increase its overall diversity in the future. Species diversity will help avoid potential catastrophic tree losses due to disease outbreaks and/or insect infestations. Additionally, different tree species can add to the City's aesthetic appeal. Every effort must be made to budget enough money each year for new tree plantings, and these new plantings should include many different species of trees suited to the local climate.

2. **Understand the inventoried street tree population in terms of benefits provided.** Stevens Point currently sees $1.74 in benefits provided for every $1.00 invested. Although red maple provides the greatest amount of benefits (23%), alternate species should be researched in Stevens Point to increase species diversity. A high level of benefit production is also the result of the high frequency of mature trees found within the red maple sub-population. Stevens Point should vigorously manage size class distribution to ensure that mature trees are replaced by other maturing trees as they decline due to senescence.

3. **Evaluate the condition of the inventoried tree population.** Site conditions and local climate will influence the general health and longevity of the tree population. Stresses due to improper species selection make trees more prone to pest and disease problems. Although the street tree population is in relatively good condition, approximately 1% of the inventoried trees are in poor condition or dead. Trees in good health and proper site location generally produce more benefits and can withstand the onset of pest and disease problems. Tree benefits can be maximized in the long term by selecting suitable sites and using the best management practices. Controlling the decline, removal, and replacement of trees in a timely and cost-effective manner is the ultimate goal of a sustainable urban forestry management process.

4. **Initiate, establish, and continue tree pruning and removal programs that abate and mitigate potential Severe- and High-Risk conditions without delay.** Situations where injury or property damage has occurred from falling trees are not isolated and are well documented in the media on a regular basis. Along with the potential for personal injury or property damage comes the probability of the responsible parties being held liable for any injuries or damages. Such lawsuits can and have resulted in costly judgments against the defendants. One of the primary concerns in Stevens Point must be public safety. Tree removals and pruning are a vital part of risk mitigation. The tree population along the public

streets is mostly in good condition; however, there are large trees with varying degrees of decay existing in the scaffold limbs, trunks, and roots. Consideration must always be made of area usage and the threat of falling limbs or trees to persons and property when putting a pruning and removal plan into action.

5. **Maintain a *Routine Pruning Program* for all established trees.** The City should refine and prioritize the current cycle to maximize productivity and the health of the urban forest. Stevens Point should cease Routine Pruning of ash trees and only conduct hazard pruning on these trees. Davey recommends that the City establish management zones based on tree density and size to enable a systematic approach to ensure a 5-year cycle is obtained. This cycle will allow for maintenance of all trees in the urban forest, thus decreasing the occurrence of structural problems and potential risks in the City's tree population.

6. **Maintain the *Young Tree Training Pruning Program* for all newly planted and immature trees.** Many young trees may have branch structure that can lead to potential problems as they grow, but these problems can be remedied easily and inexpensively through Young Tree Training Pruning. The training of all immature trees is accomplished in a one-year cyclical basis, and all newly planted trees should receive their first Young Tree Training Pruning three years after planting. Based on the generally small size of the trees in this category, a crew of two properly trained personnel would be capable of accomplishing the work throughout the year. Training young trees would help decrease the occurrence of structural problems and potential risks in the City's total tree population inexpensively as it matures in the future. The City should regularly evaluate the number of trees needing a training prune versus a routine cyclical prune to determine if a one-year training prune cycle is manageable.

7. **Establish a plan to manage the ash population and EAB.** Stevens Point's urban forest consists of approximately 15% ash trees. In the past year, the City has treated some of the ash trees in the high visibility areas of the City with pesticides to protect them from EAB. The City needs to prepare itself for the potential of losing all of their ash trees to EAB. If Stevens Point decides to remove ash trees in preparation of EAB, they should make every effort to replace those trees with new trees. Stevens Point should also look to neighboring cities for partnerships in managing EAB in and around the Stevens Point area.

The management of trees in a municipality is challenging, to say the least. Balancing the recommendations of experts; the wishes of council members and other elected officials; the needs of residents; the pressures of local economics; the concerns for liability issues; the physical aspects of trees; the forces of nature and severe weather events; and the desires for all of these factors to be met simultaneously is quite a daunting task. **Stevens Point's managers must carefully consider each specific issue and balance these pressures with a knowledgeable understanding of trees and their needs**. If balance is achieved, the City's beauty will flourish and the health and safety of its trees and citizens will be maintained.

Appendix A
Suggested Tree Species

Alternative to Ash Trees: Commercially Available Species and Cultivars

Dr. Laura G. Jull
Dept. of Horticulture, University of Wisconsin-Madison

Santamour (1990) established guidelines for tree planting within a city:
Plant no more than 30% of a family: i.e. Aceraceae
Plant no more than 20% of a genus: i.e. *Acer* × *freemanii*, *Acer rubrum*, *Acer platanoides*, *Acer saccharum*, etc.
Plant no more than 10% of a species: i.e. *Acer platanoides*

Large to medium-sized Street/Urban Trees

Acer* × *freemanii: Freeman maple, Zone 3b-4 (depends on cultivar), native hybrid of red and silver maple, oval to rounded form, ascending branches, 40-60' tall, 35-40' wide, moderate to fast growth rate, yellow, orange to red fall color, smooth, light gray bark when young, red samaras in spring, not fall, adaptable to most soils and pH, some cultivars can get chlorotic at very high pH, tolerant to wet soils, drought and urban conditions, moderate salt tolerance, can get verticillium wilt and leaf hoppers, some cultivars prone to included bark formation and narrow branch crotch angles, dioecious (separate male and female flowers produced on separate plants)

- 'Armstrong': narrow, fastigiate form, 45' tall, 15' wide, yellow fall color, female, produces seeds
- 'Celzam' ('Celebration®'): upright to oval form, 45' tall, 25-30' wide, better branch angles and straight central leader, yellow fall color, fast grower, male, seedless, drought tolerant
- 'DTR 102' ('Autumn Fantasy®'): broadly oval form, upright branches, 50' tall, 40' wide, bright to dark red fall color, female, produces seeds
- 'Indian Summer' or 'Morgan': broadly oval to rounded form, 45' tall, 40' wide, early, bright rosy-red fall color, vigorous, female, produces seeds, very sensitive to flooded soils
- 'Jeffersred' ('Autumn Blaze®'): broadly oval form with upright branches, 50' tall, 40' wide, bright orange-red to red fall color that is longer lasting, male, seedless, drought tolerant, tends to develop narrow crotch angles, included bark, and multiple leaders
- 'Marmo': upright, oval form, 55' tall, 45' wide, early, fair, mottled blend of deep red and green fall color starts at leaf tips and gradually works its way down leaf, good branching with straight central leader, male, seedless, slower grower
- 'Scarsen' ('Scarlet Sentinel®'): upright form becoming oval, 40' tall, 20' wide, yellow-orange to orange-red fall color, fast grower, male, seedless
- 'Sienna' ('Sienna Glen®'): pyramidal form, 50' tall, 35' wide, rusty orange to burgundy fall color, male, seedless, wider branch angles, from northern seed source, less susceptible to frost crack, hardy to zone 3

Acer miyabei: Miyabei maple, Zone 4a, native to Japan

- 'Morton' ('State Street®'), 40' tall, 25' wide, upright, oval form, dark green foliage, late, yellow fall color, corky-looking bark, faster grower, grafted higher up than straight species for street tree clearance, very adaptable to soils and pH, urban tolerant, moderate salt tolerance, not invasive, no pests

Acer nigrum: black maple, Zone 4, used to be considered a subspecies of sugar maple, native to central U.S.

- 'Greencolumn': upright, narrow form, 50' tall, 20' wide, straight central leader, light green, thick, leathery leaves leaves, yellow orange fall color, slow grower, more heat and drought tolerant than sugar maple

Acer platanoides: Norway maple, Zone 4b, native to Europe, wide-spreading, rounded, dense form, 40-50' tall, 35-40' wide, dark green, large leaves, late, yellow fall color, adaptable to most soils and pH, easy to transplant, will not tolerate wet soils, salt and urban tolerant, susceptible to verticillium wilt, girdling roots, basal rot, leaf scorch, frost crack, very invasive, do not use near any natural area, shallow roots

'Cleveland': upright, oval, dense form, fast grower, 40' tall, 30' wide, older cultivar
'Columnarbroad' (Parkway®): oval form with straight central leader, broader and faster growing than 'Columnare', 40' tall, 25' wide
'Columnare': upright, narrow-columnar form, ascending branches, 40' tall, 15' wide
'Conzam' (Conquest™): narrow oval form, 40' tall, 20' wide, maroon-red leaves in spring turn bronzish
'Crimson King': older cultivar, oval becoming rounded, dark purple leaves all season, 40' tall, 35' wide, slower growing, hardy only to zone 5a
'Crimson Sentry': but sport off of 'Crimson King', dense, compact, pyramidal to oval form, deep purple leaves all season, 35' tall, 15' wide
'Deborah': common, broadly oval to rounded, reddish-purple leaves in spring turn dark green, 40-60' tall, 40' wide, straight leader
'Drummondii': variegated leaves with white margins, reverts readily to all green leaves, rounded to broadly oval form, 30-40' tall, 25' wide, slow grower, tends to scorch in hot sun and drought
'Ezestre' (Easy Street™): pyramidal to narrow oval form, 40' tall, 20' wide, faster grower
'Fairview': narrow, upright-oval form, reddish purple leaves in spring turn bronzish, 45' tall, 35' wide
'Globosum': dense, globular form, 15-20' tall, 18' wide, slow grower, formal looking
'Jade Glen': broad, rounded, open form, 45' tall, 40' wide, faster growing, says it is verticillium wilt resistant but it is not
'McGill No. 42' (Emerald Queen®): dense, oval to rounded form with upright, spreading branches, deep green, glossy leaves, 50' tall, 40' wide, good branch pattern, straight trunk
'National 2000' (Champtree™): upright spreading to broadly oval form, 50-60' tall, 40' wide
'Pond' (Emerald Lustre®): upright, spreading to rounded form, 45' tall, 40' wide, faster grower, good branching
'Princeton Gold': oval form, bright yellow leaves in spring that turn bright green, bright yellow fall color, 35' tall, 30' wide
'Royal Red': more cold hardy version of 'Crimson King', deep maroon leaves during growing season, oval to rounded form, 40' tall, 30' wide
'Schwedleri': bronzy-purple leaves in spring fade to dark green, broad-rounded form, 40' tall, 30' wide, older cultivar, not recommended, has multiple leaders and twisted look to trunk, prone to frost crack
'Summershade': broad, rounded form, lighter green leaves, 40-50' tall, 40' wide, fast grower, heat tolerant, leathery leaves are scorch resistant
'Superform': broadly oval to rounded form, 45' tall, 40' wide, fast grower, uniform habit

Acer rubrum: red maple (in acidic soils (pH below 7) only or else very chlorotic), hardy to zone 3b-5b (depends on cultivar), native to eastern and central U.S., Canada, and Wisconsin, oval to rounded to irregular form, 40-60' tall, 25-35' wide, moderate to fast grower, yellow, orange to bright red fall color, smooth, light gray bark when young, reddish flowers in early spring, red samaras in spring, not fall, dioecious (separate male and female flowers produced on separate plants), adaptable to most soils, requires acid pH or else develops serious chlorosis due to lack of manganese, not iron, easy to transplant, tolerant to wet soils (some cultivars), sensitive to salt and air pollution, susceptible to verticillium wilt, leaf hoppers, frost crack, girdling roots, prone to included bark formation and narrow, branch crotch angles, shallow roots

Autumn Flame®: dense, rounded with spreading branches, 40' tall, 35' wide, early, bright red fall color, male, seedless, slower grower
Autumn Radiance®: rounded, open, symmetrical form, 60' tall, 40' wide, early red-orange fall color
'Autumn Spire': narrow to oval form, 40-50' tall, 30' wide, bright red fall color, male, seedless, from a northern seed source, newer cultivar, Zone 3
'Bailcraig' (Scarlet Jewell™): upright form, 60' tall, 30' wide, early, deep crimson-red fall color, from a northern seed source, Zone 3, new cultivar
'Bowhall': upright, very narrow form, 40-50' tall, 15' wide, yellowish-orange to reddish fall color, female, produces seed, prone to included bark formation
'Brandywine': oval form 40' tall, 30' wide, deep red fall color for a longer period, male, seedless, newer cultivar
Fairview Flame™: good branching, 45' tall, fast growing, later, orange-red fall color
'Frank Jr.' (Redpointe™): broadly pyramidal form, 45' tall, 30' wide, bright red fall color, faster growing, straight central leader, better branch crotch angles, new cultivar
'Franksred' (Red Sunset®): upright, dense, oval form, symmetrical form, bright red to orange fall color, fast grower, 45-50' tall, 35' wide, female, produces seeds, dark green, glossy leaves, older cultivar

Karpick®: narrow, oval, dense form, 40' tall, 20' wide, yellow to orange fall color, male, seedless, prone to included bark formation

'Magnificient Magenta' (Burgundy Belle®): oval to rounded form, 45' tall, 40' wide, bright red fall color that changes to burgundy, symmetrical form, heat tolerant, prone to leafhoppers and witches' broom

'New World': upright, narrow-oval form, 40' tall, 20' wide, orange-yellow to orange-red fall color, male, seedless

'Northwood': symmetrical, broadly oval to rounded form, ascending branches, 40' tall, 35' wide, early orange to reddish fall color, male, seedless, from a northern seed source, Zone 3

'Olson' (Northfire®): oval form, 50' tall, 35' wide, early, bright red fall color, northern seed source, Zone 3

'PNI 0268' (October Glory®): not hardy, zone 5b-6a, broadly oval to rounded form, 40' tall, 35' wide, red fall color for a longer period, female, produces seeds, old cultivar

'Polara' (Ruby Frost™): upright, dense, broad oval form, 45' tall, 40' wide, ruby-red fall color, selected in NW Wisconsin, Zone 3

'Red Rocket': narrow, columnar form, 35' tall, 8' wide, red fall color, northern seed source, tolerant to leaf hopper

'Schlesinger': broadly vase-shaped to rounded, 45' tall, 35' wide, very early orange to purplish-red fall color, female, produced seed

'Somerset': broadly oval to rounded form, 45' tall, 35' wide, red fall color, leaf hopper resistant newer cultivar

Summer Red®: dense, broad oval form, 20' tall, 10' wide, burgundy red new leaves that turn purplish-green, yellow to orange to purple fall color, leaf hopper resistant, Zone 5

'Sun Valley': oval, symmetrical form, densely branched, 40' tall, 35' wide, bright red fall color

Acer saccharum: sugar maple, hardy to zone 3a-5 (depends on cultivar), native to eastern U.S., Canada, and Wisconsin (our state tree), upright, oval to rounded form, 60-75' tall, 35-50' wide, showy, bright yellow to orange-red fall color, prefers a fertile, moist, well-drained soil, will not tolerate heavy clay, poorly drained, or dry soils, sensitive to drought, salt and air pollution, susceptible to leaf tatter and leaf scorch, verticillium wilt, basal rot, girdling roots, leaf hoppers

'Astis' (Steeple®): narrow oval form, 45' tall, 20' wide, yellow-orange fall color

'Autumn Splendor': broadly oval to rounded form, 45' tall, 40' wide, glossy leaves, orange-red fall color, resistant to heat drought and leaf tatter, Zone 5, newer cultivar

'Bailsta' (Fall Fiesta®): broadly ovate to rounded form, 50' tall, 40' wide, glossy, leathery leaves, yellow-orange to red fall color, leaf tatter and leaf hopper resistant, faster grower, newer cultivar

'Barrett Cole' (Apollo®): symmetrical, narrow, columnar form, 35' tall, 10' wide, yellow-orange to red fall color

Bonfire™: broadly oval form, 50' tall, 40' wide, orange to red fall color, more heat tolerant, fast grower

Commemoration®: oval to rounded, dense form, 50' tall, 35' wide, thick, glossy, dark green leaves, yellow-orange to red fall color, vigorous, faster grower, resistant to leaf tatter

'Endowment': broad columnar form, 50' tall, 20' wide, bright yellow fall color, no leaf scorch

'Heartland' (Autumn Faith™): oval to vase-shape, dense form, 35' tall, 20' wide, new leaves are bronze opening to dark green, bronze fall color, slow grower

'Flax Mill' (Majesty®): broadly oval, symmetrical form, 50' tall, 40' wide, thicker leaves, orange to reddish fall color

'Jefcan' (Unity®): upright, oval form, 50' tall, 30' wide, yellow to orange-red fall color, selected for harsh prairie climate, from Canada, slower grower, resistant to frost crack, newer cultivar, zone 3

Legacy®: oval to rounded, dense form, 50' tall, 35' wide, glossy, thick, dark green leaves, later reddish-orange to red fall color or none, leaf scorch and leaf tatter resistant, faster grower, heat tolerant,

'Morton' (Cresendo™): broadly oval form, 45' tall, 40' wide, orange-red to red fall color, heat tolerant

'PNI 0285' (Green Mountain®): broadly oval form, 45-50' tall, 35' wide, reddish-orange to red fall color, leathery leaves less subject to leaf scorch, faster growing, more heat tolerant

'Wright Brothers': oval form, 50' tall, 35' wide, yellow-orange to red fall color, resistant to leaf scorch and frost crack, faster growing

***Acer* 'Keithsform'**: Norwegian Sunset®: not reliably hardy in zone 5, hybrid of Norway and Shantung maples, may not develop any fall color

***Acer* 'Warrenred'**: Pacific Sunset®: zone 4b, hybrid of Norway and Shantung maples, upright, oval to spreading form, good branching, 30-40' tall, 20-25' wide, glossy leaves, late yellow to bright orange-red fall color, heat, drought, and urban tolerant

Celtis occidentalis: common hackberry, zone 3b, native to eastern and central U.S., Canada, and Wisconsin, vase-shaped when young becoming rounded with drooping branches, moderate to fast growth rate, 50-70' tall, 40-60' wide, corky, warty looking bark, small, pea-sized, purplish-black fruit in fall, adaptable to most soils and pH, tolerates dry, sandy, rocky, and compact, heavy clay soils, slow to establish, plant in spring, drought, urban, wind, and wet soils tolerant, but sensitive to salt, susceptible to hackberry nipple gall on leaves, witches' brooming of twigs, resistant to DED, sensitive to Dicamba herbicides used near tree, branches tend to break in storms, prone to included bark formation, need to train to develop good branch structure

- 'Chicagoland': broad pyramidal form with upright branches, 55' tall, 40' wide, forms a straight central leader, rich green leaves, yellow fall color, warty bark
- 'Windy City': upright, spreading form, straight, central leader, fast grower

Corylus colurna: Turkish filbert, hardy to zone 4b, native to southeastern Europe and western Asia, broad, pyramidal form, formal looking even with age, dense, coarse texture, 40-50' tall, 20-25' wide, no fall color, scaly to corky, gray-brown bark, long, pendulous catkins in early spring are showy, may produce nuts, difficult to transplant, heat, urban, and drought tolerant, once established, sensitive to salt

Ginkgo biloba: ginkgo, maidenhair tree, hardy to zone 4b, native to eastern China, living fossil, found in fossil records dating back 150 million years ago, deciduous gymnosperm, pyramidal when young, becoming wide-spreading with age to upright, slow grower, 50-80' tall, 30-60' wide, very interesting, fan-shaped leaves, golden-yellow fall color, dioecious (separate male and female flowers produced on separate plants), female trees produce smelly, messy fruit, but not until 20 years old, so plant male cultivars only, tolerant to most soils and pH, prefers a sandy, deep soil, difficult to transplant, plant in spring, heat, salt, urban, and drought tolerant, no pests

- 'Autumn Gold': broadly pyramidal, symmetrical form, 45' tall, 35' wide, golden yellow fall color, male, no fruit, good, uniform branching
- 'Fairmount': dense, upright, pyramidal form, straight central leader, male, no fruit
- 'Halka': broadly pyramidal becoming oval, 45' tall, 40' wide, bright yellow fall color, male, no fruit
- 'Golden Globe™': broad, rounded form, 60' tall, 40' wide, slightly faster growth rate, male, no fruit, dense form, golden yellow fall color, Zone 5
- 'Magyar': upright form, 50' tall, 30' wide, bright yellow fall color, male, no fruit
- 'PNI 22720' (Princeton Sentry®): narrow pyramidal, upright form, 50' tall, 20-30' wide, bright yellow fall color, male, no fruit
- 'Saratoga': compact, dense, rounded form, with straight central leader, 20-30' tall, 15-20' wide, pendulous leaves, soft yellow fall color, slower and smaller than other ginkgos, male, no fruit
- Shangri-La®: moderately pyramidal form, 45' tall, 25' wide, slightly faster growth rate, bright yellow fall color, male, no fruit
- 'Windover Gold®: upright, oval form, 40-60' tall, 30-40' wide, golden yellow fall color, strong grower, male, no fruit
- 'Woodstock' (Emperor™): uniform, oval form, strong, central leader, good branching, male, no fruit

Gleditsia triacanthos* var. *inermis: thornless honeylocust, hardy to zone 4a, native to central U.S. and southern Wisconsin (thorny type native, not var. *inermis*), fine texture, fast growing, vase-shaped form becoming flat-topped, spreading branches, open, 50-70' tall, 40-50' wide, early, bright golden-yellow fall color, no thorns, dioecious (separate male and female flowers produced on separate plants), female plants produce long, twisted, black pods that make a slippery, litter mess, tolerant to most soils and pH, tolerant to compacted, heavy clay soil, drought, salt, and urban tolerant, tolerant to periodic flooding, susceptible to leaf hoppers, plant bug, cankers, sunscald on trunk, high maintenance pruning, tends to develop co-dominate branches, can break in storms

- 'Christie' (Halka™): broad, oval to rounded form, 40' tall, 40' wide, horizontal branches, some pods, fast growing, yellowish fall color

'Emerald Kascade': irregular, weeping form with pendulous branches, grafted, 16' tall, male, no pods
'Harve' (Northern Acclaim®): symmetrical, upright, spreading form, 45' tall, 35' wide, yellow fall color, male, no pods, developed in North Dakota, hardy to zone 3b
'Impcole' (Imperial®): rounded form, symmetrical, wide-spreading, with good branching, 35' tall, 35' wide, seedless but can throw a few pods, susceptible to leaf hoppers and plant bug
'Moraine': uniform, rounded crown with vase-shaped branching, male, no pods, older cultivar
'PNI 2835' (Shademaster®): vase-shaped to rounded, irregular form, 45' tall, 35' wide, uniform, ascending branches, occasionally, some trees may produce pods
'Skycole' (Skyline®): broadly pyramidal form, ascending branches with wider crotch angles, 45' tall, 35' wide, develops a strong, central leader better than any other cultivar, male, no pods, bright golden yellow fall color
'Suncole' (Sunburst®): irregular, oval form, 40' tall, 35' wide, 8" of new leaves are bright yellow then fades to green, yellowish fall color, susceptible to leaf hoppers, plant bug, and canker, male, no pods
True Shade®: broadly oval form, 40' tall, 35' wide, wider branch angles, yellow fall color, faster grower, male, no pods
'Wandell' (Perfection™): develops a good crown at a younger age, 35' tall, 30' wide, dark green leaves, male, no pods

Gymnocladus dioica: Kentucky coffeetree, hardy to zone 4a, native to central U.S., southern Ontario, and Wisconsin (scattered distribution), vase-shaped form with upright branches becoming irregular and open, 50-75' tall, 40-50' wide, slow to moderate grower, coarse texture in winter with sparse branching when young, lacy texture when in leaf, yellow fall color, large, bluish-green leaves, ashy-gray, deeply furrowed bark with exfoliating plates, dioecious (separate male and female flowers produced on separate plants), females produce thick, sausage-like, pendulous pods, that can be a litter problem along with the leaf rachis in fall, adaptable to most soils and pH, slow to establish, tolerates compacted, heavy clay soil, salt, drought, periodic flooding, and urban conditions, no pests, can look a bit "gauntly" when young due to sparse branching

'Espresso': oval to vase-shaped form with arching branches, 50' tall, 35' wide, large, blue-green leaves, yellowish fall color, male, no pods, newer cultivar
'J.C. McDaniel' (Prairie Titan™): oval to vase-shaped form, 50' tall, 35' wide, large, blue-green leaves, yellowish fall color, male, no pods, newer cultivar

***Phellodendron amurense* 'Macho'**: Macho Amur corktree, hardy to zone 3b, native to northern China and Japan, broadly vase-shape, upright form, 40' tall, 30' wide, ascending branches, thick, dark green leaves, yellowish-green fall color, male, no fruit, corky bark when older, adaptable to most soils and pH, slow to establish, urban tolerant, moderate salt tolerance, no pests, shallow roots, low branching, avoid female trees as they produce invasive seeds

***Phellodendron lavallei* 'Longenecker'**: Eyestopper™ Lavalle corktree, hardy to zone 4b, native to Japan, upright, wide spreading form, 40' tall, 35' wide, bright yellow fall color, male, no fruit, corky bark when older, same culture as Amur corktree

***Phellodendron sachalinense* 'His Majesty'**: His Majesty Sakhalin corktree, hardy to zone 3b, native to Korea, northern Japan, and western China, broadly vase-shaped to rounded, open form, 35-40' tall, 35' wide, yellow fall color, male, no fruit, same culture as Amur corktree

***Sweating**: Most bare root oaks require sweating before planting to break bud. This involves dormant tree liners laid down and covered with wet packing material such as straw, shingle tow, and covered with a sheet of plastic. This should be done indoors, if possible, or in the shade. Temperatures should be between 45-70°F with high humidity (under plastic). Once the buds have begun to swell, usually within a few days, but usually not more than a week, the trees are ready to be lined out. The key to success is after the sweating process. Delay planting of oaks until the weather is warmer and humid (May) for better success after the sweating process. This is critical for success of sweated oak liners. Oaks are best transplanted in spring, rather than fall. It is best to move oaks at 2-2 1/2" caliper or lower, rather than bigger caliper as transplant shock reduces chances for survival. Other species that benefit from the sweating process include: birch, especially river birch, hawthorns, hackberry, ironwood (*Ostrya*), and redbud

Quercus bicolor: swamp white oak, hardy to zone 4a, native to eastern U.S. and Wisconsin, pyramidal when young, becoming broad, rounded, wide-spreading with age, 50-60' tall, 50-60' wide, slow to moderate growth rate, easier to transplant than bur oak, prefers acidic to neutral pH, but will tolerate a bit higher, but at very high pH, it will get chlorotic, adaptable to most soils including heavy clay, tolerant to wet soil, drought, and urban conditions

***Quercus* × *bimundorum* 'Crimschmidt'**: Crimson Spire™ oak, hardy to zone 4b, hybrid of *Q*. *alba* × *Q*. *robur*, columnar to tightly fastigiate form, 45' tall, 15' wide, dark green to blue green leaves, rusty-reddish fall color, supposed to be mildew resistant, zone 5

Quercus macrocarpa: bur oak, hardy to zone 3a, native to eastern and midwestern U.S. and Wisconsin, pyramidal when young, becoming very wide-spreading, rounded, 70-80' tall, 60-80' wide, slow growing, coarse texture, deeply furrowed bark, no fall color, adaptable to most soils and pH, drought and urban tolerant, difficult to transplant

***Quercus* × *macdenielli* 'Clemon's'**: Heritage® oak, hardy to zone 4, hybrid of *Q*. *robur* × *Q*. *macrocarpa*, broadly pyramidal becoming oval form, 60-80' tall, 40-50' wide, dark green, glossy leaves, no fall color, mildew resistant, vigorous, zone 4

Quercus muehlenbergii: chinkapin oak, hardy to zone 4b, native to eastern and midwestern U.S. and Wisconsin, wide-spreading, rounded, open form, 40-60' tall, 50-60' wide, yellow to orangish-brown fall color, ashy-gray, flaky bark, adaptable to most soils and pH, difficult to transplant, drought and urban tolerant

Quercus robur: English oak, hardy to zone 5a, native to Europe, northern Africa, and western Asia, oval to rounded form, short trunk, slow to moderate growth rate, 40-60' tall, 40-50' wide, no fall color, smaller leaves than other oaks, deeply furrowed bark, adaptable to most soils and pH, does not like compacted soils, urban tolerant, susceptible to powdery mildew, especially fastigiate forms, two-lined chestnut borer, scale, basal canker

'Fastigiata' (Skyrocket®): narrow, fastigiate form, 45' tall, 15' wide, tight branching, susceptible to mildew
'Pyramich' (Skymaster®): hardy to zone 5, narrow when young becoming pyramidal, 50' tall, 25' wide, straight central leader, good branch crotch angles, fast grower, may be a hybrid as it is vigorous
'Wandell' (Attention®): narrow, pyramidal to columnar form, 50' tall, 15' wide, resistant to powdery mildew, smaller leaves

***Quercus* Rosehill®**: Rosehill oak, hybrid of *Q*. *robur* x *Q*. *bicolor* 'Asjes', fastigiate to narrow-oval form, 40' tall, 20' wide, mildew resistant, zone 4b

Quercus* × *schuettei: swamp bur oak, hybrid of *Q*. *bicolor* × *Q*. *macrocarpa*, broad, rounded form, 75' tall, 70' wide, faster growing, better tolerance to high pH and easier to transplant, may be susceptible to leaf/twig galls, zone 3b

***Quercus* × *warei* 'Long'**: Regal Prince® oak, broad columnar becoming upright oval form, 40-60' tall, 20-25' wide, hybrid of *Q*. *robur* 'Fastigiata' × *Q*. *bicolor*, dark green leaves with silvery undersides, holds leaves late, no fall color or mildew, zone 4b

Taxodium distichum: baldcypress, northern provenance is critical, hardy to zone 4b, pyramidal form with straight terminal leader, 50-70' tall, 25-35' wide, fine texture, native to southeastern and southcentral U.S. into southern IL, mainly in swamps, needs training in nursery or it grows like a large bush, deciduous gymnosperm, feathery, soft, bright green leaves, with rusty-brown to orangish-bronze fall color, reddish-brown to grayish, fibrous, shreddy bark, does not form "knees" in urban conditions, only if grown near water, adaptable to most soils, prefers slightly acidic to neutral soils, can get chlorotic at very high pH, easy to transplant, heat, drought, salt, wet soil, and urban tolerant, few, if any pests

'Mickelson' (Shawnee Brave®): narrowly pyramidal form, 55' tall, 20' wide, richer green leaves, more upright form

Tilia americana: American linden, basswood, hardy to zone 3a, native to northeast and central U.S., Canada, and Wisconsin, pyramidal when young becoming upright-oval with age, 60-80' tall, 40-50' wide, fragrant, pale yellow flowers in early summer, small nutlet fruit attached to bract, large, heart-shaped leaves, prefers a deep, fertile soil, pH adaptable, easy to transplant, tolerant to wetter soils, sensitive to salt and air pollution, susceptible to Japanese beetle, linden borer, gypsy moth, basal and stem rots, sunscald on bark, tends to sucker at base, can break in storms, prone to included bark formation and narrow, branch crotch angles, girdling roots

'Bailyard' (Front Yard®): broadly pyramidal when young becoming rounded and dense, symmetrical form, 60-75' tall, 40' wide
'Boulevard': narrowly pyramidal form, 50' tall, 25' wide, ascending branches, yellow fall color
'DTR 123' (Legend®): broadly pyramidal form, 40' tall, 30' wide, well-spaced branches, thicker leaves, single leader, yellow fall color
'Lincoln': pyramidal, compact, dense form, 40' tall, 25' wide, upright branches, dark green leaves, yellow fall color
'Mcksentry' (American Sentry™): symmetrical, pyramidal form with straight central leader, 45' tall, 30' wide, better branch angles, lighter gray bark, yellow fall color

Tilia cordata: littleleaf linden, hardy to zone 3b, native to Europe, pyramidal when young becoming oval to round with age, formal, dense habit, 50-70' tall, 35-50' wide, fragrant, pale yellow flowers in early summer, small nutlet fruit attached to bract, small, heart-shaped leaves, prefers a fertile soil, but is adaptable, pH adaptable, easy to transplant, sensitive to poorly-drained, compacted soils and road salt, urban and air pollution tolerant, same pests as American linden

'Baileyi' (Shamrock®): symmetrical, pyramidal form, 40' tall, 30' wide, stouter branches, more open canopy, uniform branching no fall color
'Chancole' (Chancellor®): upright, narrow, pyramidal form, 40' tall, 20' wide, good branching, faster growing, wider branch crotch angles, yellowish fall color
'Corzam' (Corinthian®): narrowly pyramidal form, 45' tall, 15' wide, dense branching, evenly spaced branches, thick, glossy leaves, yellowish fall color
'Halka' (Summer Sprite®): dense, narrow, pyramidal form, dwarf, 16' tall, 8' wide, yellowish fall color
'Norbert' (Prestige®): broad, pyramidal form, good branching, wider branch crotch angles, shiny leaves, fewer seeds produced, harder to find, but much better form than 'Greenspire'
'PNI 6025' (Greenspire®): pyramidal, symmetrical form becomes rounded with age, 40' tall, 30' wide, yellowish fall color, very prone to narrow crotch angles and included bark formation, tight branching, needs a lot of training pruning, old cultivar
'Ronald' (Norlin™): broad, pyramidal form, 40-45' tall, 30' wide, faster grower, resistant to sunscald, more cold hardy

Tilia* × *euchlora: Crimean linden, hardy to zone 4b, hybrid of *T*. *cordata* × *T*. *dasystyla*, broadly pyramidal form to oval, 40-60' tall, 35' wide, can sucker from base of tree, yellowish fall color

***Tilia* × *flavescens* 'Glenleven'**: Glenleven linden, hardy to zone 4, hybrid of *T*. *americana* × *T*. *cordata*, pyramidal form, 50' tall, 30' wide, yellowish fall color, better branching, more open, larger leaves, faster growing, straight trunk and leader

***Tilia* 'Harvest Gold'**: Harvest Gold linden, hardy to zone 3, hybrid of *T*. *cordata* × *T*. *mongolica*, more cold hardy, upright, oval form, 30-40' tall, 20-25' wide, leaves are deeply lobed, resistant to sunscald, exfoliating bark, golden buds and fall color

***Tilia* 'Redmond'**: Redmond linden, hardy to zone 4, hybrid of *T*. *americana* × *T*. × *euchlora*, pyramidal to oval form, upright branches with terminal leader above the foliage, reddish stems and buds, can sucker at base, 50-70' tall, 30-40' wide, fragrant, pale yellow flowers in early summer, small nutlet fruit attached to bract, large, heart-shaped leaves

Tilia tomentosa: silver linden, hardy to zone 4b, native to southeastern Europe and western Asia, broad-pyramidal form becoming upright-oval, formal looking, dark green leaves with silvery-white undersides, pale yellow flowers in summer, small nutlet fruit attached to a bract, no fall color, prefers a deep, fertile soil, but is

adaptable, pH adaptable, easy to transplant, more heat, drought, and urban tolerant than other lindens, does not tolerate poorly-drained, compacted soils, same pests as American linden

'PNI 6051' ('Green Mountain®'): broadly pyramidal to oval form, 50' tall, 35' wide, dark green leaves with silvery undersides, yellowish fall color, prone to included bark formation

'Wandell' ('Sterling®'): broadly pyramidal form, 45' tall, 35' wide, green leaves with silvery undersides, yellowish fall color, prone to included bark formation

Ulmus americana: American elm (DED resistant cultivars), hardy to zone 3a, native to eastern and central U.S., Canada and Wisconsin, all have vase-shaped form with pendulous branches, 70-80' tall, 60-70' wide, yellow fall color, adaptable to most soils and pH, tolerant to compacted, heavy clay soils, easy to transplant, tolerant to periodic flooding, salt, urban, air pollution, and drought tolerant, pest prone

'New Harmony' (from U.S. National Arboretum): broad, vase-shaped form, arching branches, good form, easier to grow

'Princeton': (from Princeton Nursery) large, leathery leaves, vase-shaped form, more resistant to elm leaf beetle

'Valley Forge' (from U.S. National Arboretum): broad, vase-shaped form with arching branches, 70' tall, 70' wide, wild looking form and branching, vigorous, needs training

***Ulmus* hybrids**: hybrid elms, most are hardy to zone 4-5, all Dutch elm disease resistant, needs pruning in nursery to develop good form, adaptable to most soils and pH, tolerant to compacted, heavy clay soils, moderate salt tolerance, drought, urban, and air pollution tolerant

'Cathedral' (UW-Madison intro): hybrid of *U. japonica* × *U. pumila*, broadly vase-shaped, spreading form, 40-50' tall, 40-60' wide, prone to elm leaf beetle, zone 4

'Frontier' (from U.S. National Arboretum): hybrid of *U. carpinifolia* × *U. parvifolia*, broadly oval form, 35' tall, 25' wide, ascending branches, glossy, small, dark green, glossy leaves, late, burgundy fall color, can get elm leaf beetle, Zone 5

'Homestead' (from U.S. National Arboretum): hybrid of *U. pumila* × (*U.* × *hollandica* × *U. carpinifolia*), upright, narrow to oval form, 55' tall, 35' wide, upright, arching branches, prone to elm leaf beetle, fast growing, Zone 4b

'Morton' ('Accolade®') (from Morton Arboretum): hybrid of *U. japonica* × *U. wilsoniana*, vase-shaped form with arching branches, 70' tall, 60' wide, resistant to elm leaf beetle, vigorous, resistant to elm leaf beetle, dark green, glossy leaves, zone 4

'Morton Glossy' ('Triumph™') (from Morton Arboretum): hybrid of *U.* 'Morton Plainsman' × *U.* 'Morton', upright oval to vase-shape, 55' tall, 45' wide, very glossy, dark green leaves, good form, some elm leaf beetle, excellent drought tolerance, zone 4

'Morton Plainsman' ('Vanguard™') (from Morton Arboretum): hybrid of *U. japonica* × *U. pumila*, rounded, vase-shaped form, 45' tall, 40' wide, glossy, dark green leaves, prone to elm leaf beetle, zone 4

'Morton Red Tip' ('Danada Charm™') (from Morton Arboretum): complex hybrid of (*U. japonica* × *U. wilsoniana*) × *U. pumila* vase-shape form with arching branches, 70' tall, 60' wide, reddish new leaves, new leaves, prone to elm leaf beetle, zone 4

'Morton Stalwart' ('Commendation™') (from Morton Arboretum): complex hybrid of *U.* 'Morton' × (*U. pumila* × *U. carpinifolia*), upright, oval form, 60' tall, 50' wide, zone 5

'New Horizon' (UW-Madison intro): hybrid of *U. japonica* × *U. pumila*, upright, compact form, 50' tall, 25' wide, dark green leaves, wide crotch angles, susceptible to verticillium wilt, zone 3b

'Patriot' (from U.S. National Arboretum): complex hybrid of *U. wilsoniana* × *U. pumila* × *U. carpinifolia* × *U. glabra*, stiffly upright branches, narrow, vase-shape form, 50' tall, 40' wide, dark green leaves, straight central leader, zone 5

'Pioneer' (from U.S. National Arboretum): hybrid of *U. glabra* × *U. carpinifolia*, rounded form, 50' tall, 50' wide, dark green, glossy leaves, prone to elm leaf beetle, zone 5

'Regal' (UW-Madison intro): complex hybrid of *U. carpinifolia* × (*U. pumila* × *U.* × *hollandica*), upright, pyramidal form, 50-60' tall, 30' wide, prone to double leaders and narrow crotches, stiff branches, zone 4

***Ulmus japonica* 'Discovery'**: Discovery Japanese elm, hardy to zone 3, native to Japan and Asia, upright, vase-shape, compact form, 35-40' tall, 35-40' wide, resistant to DED and elm leaf beetle, yellow fall color

Ulmus parvifolia: lacebark elm, Zone 5b, native to China, Korea, and Japan, semi-exfoliating bark with mottled colors of gray, green, orange, and brown inner bark and orange lenticels, adaptable to most soils and pH, easy to transplant, tolerant to compacted, clay soils, urban, air pollution, tolerant, DED resistant

'Dynasty' (from U.S. National Arboretum), more cold hardy, zone 5a, upright, vase-shaped to rounded form, 40-45' tall, 40' wide, orange-yellow to red fall color, bark not as exfoliating as other cultivars

***Ulmus wilsoniana* 'Prospector'** Prospector elm (from U.S. National Arboretum): hardy to zone 4, dense, broad, vase-shaped form, slightly pendulous branches, 40' tall, 30' wide, resistant to elm leaf beetle, DED, and phloem necrosis, deep green, glossy leaves, yellow fall color

Small Urban Area or Street Trees

Acer tataricum: Tatarian maple, Zone 3a, native to southeastern Europe and central Asia, invasive, do not plant near any natural areas, single or multi-stemmed, upright form, 25' tall, 20' wide, yellow to reddish-brown fall color, pinkish-red samaras in summer changing to brown in fall, adaptable to most soils and pH, easy to transplant, drought, salt, and urban tolerant, very susceptible to verticillium wilt

'GarAnn' (Hot Wings™): upright, spreading form, 20-25' tall, 15-20' wide, bright red samaras, yellow to red fall color, drought tolerant
'Patdell' (Pattern Perfect™): upright form, 20' tall, 15-20' wide, bright red samaras, red stems, red-orange fall color
'Summer Splendor™: upright, spreading form, 15-20' tall, 15' wide, bright red fruit in summer

Acer tataricum* subsp. *ginnala: Amur maple, Zone 3a, native to China, Manchuria, and Japan, very invasive, do not plant near any natural areas, multi-stemmed, rounded form, low branches, 15-18' tall and wide (smaller cultivars are available), dagger-shaped leaves, orange to bright red fall color, red samaras in summer turn brown in fall, adaptable to most soils and pH, easy to transplant, drought, salt, and urban tolerant, very susceptible to verticillium wilt

'Compactum' or 'Bailey Compact': dense, compact, rounded, shrubby form, 6-8' tall, 6-8' wide, slower grower, orange to scarlet fall color
'Embers': rounded form, 15-20' tall, 15' wide, bright red samaras, scarlet fall color
'Emerald Elf': compact, rounded, dense, shrubby form, 5-6' tall and wide, scarlet to purple fall color
'Flame': multi-stemmed, spreading, irregular form, 15-20' tall, 20-25' wide, bright orange-red to deep red fall color
'JFS-UGA' (Red November™): multi-stemmed, low, rounded form, 18' tall, 24' wide, later, bright red fall color, heat tolerant, Zone 5

Acer truncatum: Shantung maple, Zone 3b, use a northern provenance (seed source), native to northern China, Russia, Korea, and Japan, broad-rounded, dense, symmetrical form, 20-30' tall, 20-30' wide, yellowish-orange to purple fall color, star-shaped leaves, adaptable to most soils and pH, drought, salt, heat and urban tolerant, no pest problems, harder to find, but worth trying

Amelanchier* × *grandiflora: apple serviceberry, hardy to zone 3a, native hybrid of downy and Allegheny serviceberry, multi or single-stemmed tree to large shrub, upright to irregular form, no suckers, 15-30' tall, 15-25' wide, produces bronze to purplish-red, fuzzy leaves in spring that turn smooth and green, white flowers in early spring, edible fruit in June, smooth, gray bark, yellowish-orange to red fall color, can develop chlorosis at high pH, prefers loamy soil, does poorly in poorly drained soils, difficult to transplant, plant in spring

'Autumn Brilliance': upright, spreading form, 20-25' tall, 15' wide, orange-red fall color, leaf spot resistant, multi-stemmed
'Cole's Select': upright, spreading form, 15-20' tall, 15' wide, multi-stemmed, orange-red fall color, leaf spot resistant, thicker, glossier leaf
'Forest Prince': oval form, 20' tall, 15' wide, red-orange fall color
'Princess Diana': wide spreading form, 15-20' tall, 15' wide, multi-stemmed, red-orange fall color, leaf spot resistant
'Robin Hill': upright, open form, 20-30' tall, 15-20' wide, flowers pink in bud open to pale pink fading to white, red fall color, single-stemmed

Amelanchier laevis: Allegheny serviceberry, hardy to zone 4a, native to eastern and central U.S., Canada, and Wisconsin, upright form, single or multi-stemmed tree, 15-25' tall, 15-20' wide, can sucker, produces white flowers in early spring, bronze to purplish-red new leaves in spring that turn green, edible fruit in June, orange to reddish-bronze fall color, prefers moist, loamy soils, does poorly in poorly drained soils, difficult to transplant, plant in spring

Cumulus®: upright, open form, 20-30' tall, 15' wide, orange-red fall color, minimal suckering, single-stemmed

'JFS-Arb' (Spring Flurry®): upright, oval form, 30-35' tall, 20' wide, orange fall color, single-stemmed, straight central leader, newer cultivar
'Rogers' (Lustre®): upright, open form, 20-30' tall, 15-20' wide, orange-red fall color, minimal suckering, single-stemmed
'Snowcloud': upright, oval form, 25' tall, 15' wide, scarlet fall color, single-stemmed

Cornus mas: Corneliancherry dogwood (more of a boulevard tree), hardy to zone 4b, native to Europe and western Asia, bright yellow flowers in early spring, long lasting, fruit is in summer and is bright red changing to dark purple and becoming edible, but tart, adaptable to most soils, but prefers rich soils, pH adaptable, easy to transplant, tolerates partial shade, straight species is sensitive to drought, but cultivars are more tolerant, sensitive to salt, no pest problems, hardy to zone 4b

'Golden Glory': narrow, upright form, 20-25' tall, 10' wide, much better form and darker green, glossy, thicker leaves, more flowers and fruit, good substitute to invasive tallhedge buckthorn!
'Pyramidalis': upright, pyramidal to upright form, 20' tall, 10-15' wide, dark green leaves

Crataegus crus-galli* var. *inermis: thornless cockspur hawthorn, hardy to zone 4a, native to eastern and central U.S., Canada, and Wisconsin, multi-stemmed tree, broad, spreading, horizontal, low branches, flat-topped crown, 20-30' tall, 20-35' wide, adaptable to most soils and pH, difficult to transplant, plant in spring, drought, salt, and urban tolerant, susceptible to cedar quince rust (on fruit) or cedar hawthorn rust (leaves), this variety has no thorns, white flowers in late spring, deep red fruit in early to mid fall that drops creating a litter problem, bronzish-orange to reddish fall color, dark green, leathery, spoon-shaped leaves

'Cruzam' (Crusader®): rounded form, 15' tall, 15' wide, thornless, bright red fruit, orange fall color

Crataegus phaenopyrum: Washington hawthorn, hardy to zone 4b, native to eastern U.S. and Canada, multi-stemmed tree, vase-shaped to broadly oval form, horizontal, low branches, 20-30' tall, 20-25' wide, adaptable to most soils and pH, difficult to transplant, plant in spring, tolerant to poor, sandy soils, drought and urban tolerant, moderate salt tolerance, susceptible to cedar quince rust (on fruit) or cedar hawthorn rust (leaves), has long, sharp thorns, white flowers in late spring to early summer, showy, persistent, glossy, bright-orange-red fruit fall to winter

'Westwood I' (Washington Lustre®): rounded, upright form, 20-25' tall, 20-25' wide, has fewer thorns than species, vigorous

***Crataegus viridis* 'Winter King'**: Winter King hawthorn, hardy to 4b, native to eastern U.S., vase-shaped to rounded, wide-spreading form, horizontal, low branches, adaptable to most soils and pH, difficult to transplant, plant in spring, drought and urban tolerant, moderate salt tolerance, less susceptible to cedar hawthorn rust but can get cedar quince rust on fruit, white flowers in late spring, very showy, bright orange-red, persistent fruit from mid fall to winter, silvery-gray bark that exfoliates on the trunk revealing orange inner bark, has few if any thorns, yellowish-purple fall color

Maackia amurensis: Amur maackia, hardy to zone 4a, native to Manchuria, vase-shaped to rounded form, upright, arching branches, 20-30' tall, 20-30' wide, slow grower, silvery and fuzzy leaves in spring turn olive-green and smooth, coppery-green to bronzish-brown, slightly exfoliating bark, off-white flowers in summer, small pods in fall, tolerant to most soils and pH, roots fix atmospheric N, tolerant to poor, infertile soils, urban and salt tolerant, prone to included bark formation, needs pruning when young, no pests, not invasive

'Starburst': upright, vase-shaped form with rounded crown, 25-30' tall, 20' wide, dark green leaves
Summertime®: upright, rounded form, 18-20' tall, 12-15' wide, white flowers in summer

***Malus* spp.**: flowering crabapple, most are hardy to zone 4a and are hybrids with parents originating from Asia, Europe and U.S., size and form are quite variable, adaptable to most soils and pH, prefers low nitrogen to decrease disease susceptibility, drought and urban tolerant, apple scab resistant species and cultivars listed below and have smaller fruit, some cultivars prone to suckering and watersprouts on branches

White Flowers/Red Fruit

'Adirondack': narrow, upright form, 18' tall, 10' wide, persistent fruit
'Guinzam' ('Guinevere®): rounded form, 8-10' tall, 10' wide, persistent fruit
'Jewelcole' ('Red Jewel®): upright, pyramidal form, 15' tall, 12' wide, persistent fruit, can get fireblight
'Kinarzam' ('King Arthur®): upright, rounded form, 12' tall, 10' wide, can sucker from base
'Sutyzam' ('Sugar Tyme®): upright, spreading, oval form, 18' tall, 15' wide, persistent fruit
Malus baccata 'Jackii': Jackii crabapple, hardy to zone 3, rounded form, 20' tall, 20' wide, glossy leaves, zone 3
Malus sargentii: Sargent crabapple, low, spreading form, 8' tall, 12' wide, alternate bearing, persistent fruit
    'Select A' ('Firebird®): rounded, spreading form, 7' tall, 9' wide, persistent fruit, bears annually, persistent fruit
    'Tina': small, rounded, dwarf form, 5' tall, 6' wide, slow growing
Malus × *zumi* var. *calocarpa*: redbud crabapple, rounded, spreading form, 20' tall, 24' wide, persistent fruit

White Flowers/Yellow Fruit
'Bob White': dense, rounded form, 20' tall, 20' wide, persistent fruit, but is a watersprouter
'Cinzam' ('Cinderella®): dwarf, rounded to upright form, 8' tall, 5' wide, persistent fruit
'Excazam' ('Excalibur™): upright form, 10' tall, 8-10' wide, good form
'Hargozam' ('Harvest Gold®): upright, oval form, 22' tall, 18' wide, persistent fruit, may get some scab
'Lanzam' ('Lancelot®): compact, upright, dense form, 8-10' tall, 8' wide, persistent fruit
'Ormiston Roy': broad, rounded form, 20-25' tall, 25' wide, furrowed, orangish bark, yellow fruit with a rosy blush turn orange-brown after a hard frost

Pink or Reddish Flowers/Red to Purplish-Red Fruit
'Camzam' ('Camelot™): rounded form, 10' tall, 8' wide, pinkish-white flowers, burgundy-green leaves, persistent fruit
Malus sargentii 'Candymint': low, spreading, horizontal form, 10' tall, 15' wide, purple tinted foliage becoming bronze-green
'Canterzam' ('Canterbury™): rounded, compact form 10' tall, 8-10' wide, light, pinkish-white flowers
'Cardinal': irregular, spreading form, 16' tall, 22' wide, dark purplish-red, glossy leaves
'JFS-KW5' ('Royal Raindrops®): upright, spreading form, 20' tall, 15' wide, cutleaf, purple leaves, orange-red fall color, persistent fruit
'Orange Crush': spreading form, 12-15' tall, 12-15' wide, bronze to purplish-green leaves
'Parrsi' ('Pink Princess®): low, spreading form, 8' tall, 12' wide, purple leaves become bronze-green
'Prairifire': upright, spreading to rounded form, 20' tall, 20' wide, slower growing, purple leaves become reddish-green
'Prairie Maid': rounded to spreading form, 20' tall, 25' wide, burgundy tinged leaves in spring, but is a watersprouter
'Purple Prince': rounded form, 20' tall, 20' wide, purple leaves become bronzish-green, persistent fruit

Weeping Form
'Coral Cascade': semi-weeping form, 15' tall, 20' wide, white flowers, coral fruit, persistent fruit
'Louisa': graceful weeper, 15' tall, 15' wide, pink flowers, fruit are yellow turning orange-brown, not showy or persistent
'Luwick': graceful, low weeper, 7' tall, 14' wide, deep pink buds open to light pink to whitish flowers, bright red fruit
'Manbeck Weeper' ('Anne E.®): wide spreading, horizontal weeper, 10-12' tall, 10-12' wide, white flowers, cherry-red fruit, persistent fruit, is difficult to find, but is one of the nicest crabs
'Molazam' ('Molten Lava®): broadly weeping form, 14' tall, 20' wide, white flowers, bright red fruit

Prunus sargentii: Sargent cherry, hardy to zone 4b, native to Japan, oval to vase-shaped form, 25-35' tall, 20-30' wide, showy, single, pink flowers in clusters in early spring, small, purplish-black fruit in summer, bronze to orange-red fall color, reddish-gray to chestnut-brown, polished bark, adaptable to most soils and pH, does not tolerate compacted, heavy-clay soils, plant in spring, likes roots kept cool, must have good drainage, resistant to black knot, may form included bark

'Columnaris': narrow, columnar to narrow, vase-shape form, 25-35' tall, 15' wide, orange to orange-red fall color
'JFS-KW58' (Pink Flair®): upright, narrow, vase-shape form, 25' tall, 15' wide, orange-red fall color

***Prunus* 'Accolade'**: Accolade cherry (hybrid with *P. sargentii* and *P. subhirtella*), hardy to zone 4b, 20-25' tall, 20-25' wide, horizontal branching with vase-shaped form, semi-double, early, pink flowers in drooping clusters before the leaves in early spring, no fruit, golden to orange fall color

Pyrus calleryana: callery pear, hardy to zone 4b, native to China and Korea, upright, pyramidal to oval form, 25-35' tall, 20-30' wide, adaptable to most soils and pH, drought, urban, and salt tolerant, can get fireblight, fast grower, dark green, glossy, leathery leaves, late, reddish-orange to purple fall color, white flowers in mid spring, small, brown, rounded fruit

Aristocrat®: pyramidal form with open branching, 35' tall, 25' wide, yellow to red fall color but is inconsistent for fall color, wider branch crotch angles
'Autumn Blaze': rounded form, 30' tall, 25' wide, earlier, bright red to purplish fall color, wide crotch angles, less prone to included bark formation
'Cambridge': upright, narrowly pyramidal form, 35' tall, 15' wide, bright orange fall color
'Capital': narrow, columnar form, 30' tall, 12' wide, reddish-purple fall color, susceptible to limb breakage in storms, susceptible to fireblight, zone 5
'Cleveland Select' or 'Glenn's Form' (Chanticleer®): formal, upright, narrowly pyramidal form, 25-30' tall, 15' wide, late orangish to reddish fall color, not as good as other cultivars for fall color, rarely produces fruit
'Redspire': pyramidal, dense, symmetrical form, 35' tall, 25' wide, yellow to reddish fall color or none at all, susceptible to fireblight, slower grower
'XP-005' (Trinity®): broadly oval to rounded form, 30' tall, 25' wide, glossy, lighter green leaves, orange-red fall color

***Pyrus* 'Edgedell'**: Edgewood® pear, hardy to zone 5, hybrid of *P. calleryana* x *P. betulifolia*, rounded, open form, 30' tall, 25' wide, silvery leaf undersides, white flowers, good branch crotch angles, reddish-purple fall color

Syringa pekinensis: Peking lilac, Pekin lilac, hardy to zone 4a, native to northern China, loose, rounded form, 20-25' tall, 15-20' wide, moderate to fast grower, no fall color, reddish-brown, shiny bark, creamy-white, large flowers in early summer that do not smell like lilacs but rather like a privet, tends to flower heavily every other year, adaptable to most soils and pH, easy to transplant, salt and urban tolerant, susceptible to bacterial blight and verticillium wilt, resistant to mildew

'DTR 124' (Summer Charm®): upright, spreading, better form, 20' tall, 15' wide, single-stemmed
'Morton' (China Snow®): upright, spreading, wild form, big crown, 25' tall, 20' wide, vigorous, showy, showy, exfoliating, coppery to orangish-brown bark, single-stemmed
'Zhang Zhimming' (Beijing Gold™): upright, rounded form, 25' tall, 20' wide, vigorous, single or multi-stemmed, yellow flowers instead of white

Syringa reticulata: Japanese tree lilac, hardy to zone 3a, native to Japan and Manchuria, upright with a rounded to oval form, 20-25' tall, 15-20' wide, no fall color to yellowish, reddish-brown, shiny bark, creamy-white, large flowers in early summer that do not smell like lilacs but rather like a privet, tends to flower heavily every other year, adaptable to most soils and pH, easy to transplant, salt and urban tolerant, susceptible to bacterial blight and verticillium wilt, resistant to mildew

'Elliott' (Snowcap™): upright, more compact form, 15-20' tall 10-12' wide, uniform branching, thick, dark green leaves, good form
'Golden Eclipse': upright, compact form, 18-24' tall, 8-14' wide, new leaves in spring emerge green with a darker center, the edge of the leaf gradually turns bright gold with the dark green center remaining
'Ivory Silk': over used, upright, spreading becoming oval to rounded, 20' tall, 15' wide, susceptible to bacterial blight
'Summer Snow': broad, rounded, compact form, 20' tall, 15' wide, good form, glossy, dark green leaves
'Williamette' (Ivory Pillar™): upright, pyramidal, narrower form, 20-25' tall, 10-15' wide

Wholesale nursery sources used in this guide (does not imply endorsement by me of nurseries named, nor criticism of similar nurseries not mentioned)

Bailey Nurseries: St. Paul, Minnesota, www.baileynurseries.com, (800) 829-8898
Beaver Creek Nursery: Poplar Grove, Illinois, www.beavercreeknursery.com, (815) 737-8758
Carlton Plants: Dayton, Oregon, www.carltonplants.com, (800) 398-8733
Femrite Nursery: Aurora, Oregon, www.femrite.com (800) 547-2161
Heritage Seedlings: Salem, Oregon, www.heritageseedlings.com (503) 371-9688
J. Frank Schmidt and Son: Boring, Oregon, www.jfschmidt.com, (800) 825-8202
Johnson's Nursery: Menomonee Falls, Wisconsin, www.johnsonsnursery.com, (262) 252-4980
Mariani Nurseries: Kenosha, Wisconsin, (866) 627-4264
McKay Nursery: Waterloo, Wisconsin, www.mckaynursery.com, (920) 478-2121
Meadow Lake Nursery, McMinnville, Oregon, www.meadow-lake.com (503) 435-2000
Silver Creek Nurseries: Manitowoc, Wisconsin, (920) 684-6267

U.S.D.A. Cold Hardiness Zones

Zone 3a (cold hardy to –35 to –40ºF): northwestern Wisconsin
Zone 3b (cold hardy to –30 to –35ºF): most of northern Wisconsin

Zone 4a (cold hardy to –25 to –30ºF): northern central and extreme northwestern Wisconsin
Zone 4b (cold hardy to –20 to –25ºF): southwestern and central Wisconsin and along shore of Lake Superior

Zone 5a (cold hardy to –15 to –20ºF): southeastern and eastern Wisconsin up to Door County and Madison near the lakes
Zone 5b (cold hardy to –10 to –15ºF): Milwaukee, Racine, and Kenosha areas near Lake Michigan

Suggested Tree Species

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant community personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in the majority of soil and climate conditions found throughout the Wisconsin.

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Aesculus hippocastanum	horsechestnut	
Catalpa speciosa	Northern catalpa	
Celtis occidentalis	common hackberry	'Prairie Pride'
*Fagus grandifolia**	American beech	
*Fagus sylvatica**	European beech	(numerous exist)
Ginkgo biloba	ginkgo	(male trees only)
Gleditsia triacanthos inermis	thornless honeylocust	'Imperial', 'Shademaster', 'Skyline', 'Sunburst'
Gymnocladus dioica	Kentucky coffeetree	
*Larix decidua**	European larch	
Larix kaempferi	Japanese larch	
Liriodendron tulipifera	tuliptree	
Metasequoia glyptostroboides	dawn redwood	
Platanus x *acerifolia*	London planetree	
*Platanus occidentalis**	American sycamore	
Prunus serotina	black cherry	
Quercus alba	white oak	
Quercus bicolor	swamp white oak	
Quercus macrocarpa	bur oak	
Quercus palustris	pin oak	
Quercus robur	English oak	
Quercus rubra	northern red oak	
Taxodium distichum	common baldcypress	
Tilia americana	American linden	'Redmond'
Tilia cordata	littleleaf linden	'Chancellor', 'Greenspire'
Tilia tomentosa	silver linden	
Ulmus x	hybrid elm	'New Horizon', 'Regal'

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Aesculus x *carnea*	red horsechestnut	'Briotii'
Aesculus glabra	Ohio buckeye	
*Alnus glutinosa**	common alder	
Betula nigra	river birch	'Heritage'
Betula papyrifera	paper birch	
Betula pendula	European birch	'Gracilis'
Betula platyphylla var. *japonica*	whitespire birch	'Whitespire'
Cercidiphyllum japonicum	katsuratree	
Cladrastis lutea	American yellowwood	
Magnolia acuminata	cucumbertree	
Nyssa sylvatica	black tupelo	
Ostrya virginiana	eastern hophornbeam	
Phellodendron amurense	amur corktree	'Macho'
Prunus maackii	amur chokecherry	
Prunus sargentii	Sargent cherry	
Salix x sepulcralis	golden weeping willow	'Tristis'
Ulmus parvifolia	lacebark elm	

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Amelanchier arborea	downy serviceberry	(numerous exist)
Amelanchier x grandiflora	apple serviceberry	'Autumn Brilliance', 'Cole's Select', 'Princess Diana', 'Strata'
Amelanchier laevis	Allegheny serviceberry	'Cumulus'
Carpinus caroliniana	American hornbeam	
Cercis canadensis	eastern redbud	
Cornus alternifolia	pagoda dogwood	
Crataegus crus-galli inermus	cockspur hawthorn	
Craategus mollis	downy hawthorn	
Crataegus phaenopyrum	Washington hawthorn	
Crataegus punctata	dotted hawthorn	
Crataegus viridis	green hawthorn	'Winter King'
Magnolia x *loebneri*	loebner magnolia	'Leonard Messel', 'Merrill'
Magnolia x *soulangiana*	saucer magnolia	
Malus spp.	flowering crabapple	(disease resistant only)
Ostrya virginiana	hophornbeam	
Prunus Americana	American plum	
Prunus x 'Newport'	Newport plum	
Prunus virginiana	common chokecherry	'Canada Red', 'Schubert'
Pyrus calleryana	callery pear	'Autumn Blaze', 'Chanticleer'
Salix matsudana	corckscrew willow	'Tortuosa'
Salix pentandra	laurel willow	
Sorbus alnifolia	Korean mountainash	
Sorbus aucuparia	European mountainash	
Sorbus decora	Showy mountainash	
Syringa reticulata	Japanese tree lilac	'Ivory Silk'

Note: * denotes species not recommended for use as street trees.

Coniferous and Evergreen Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Abies concolor	white fir	
Juniperus virginiana	Eastern redceader	'Burkii', 'Canaertii', 'Glauca', 'Hillii'
Picea abies	Norway spruce	
Picea glauca	white spruce	'Black Hills Spruce'
Picea omorika	Serbian spruce	
Picea glauca var. *densata*	Colorado blue spruce	
Pinus cembra	swiss stone pine	
Pinus nigra	Austrian pine	
Pinus resinosa	red pine	
Pinus strobus	eastern white pine	
Pinus sylvestris	Scotch pine	
Psedotsuga menziesii	Douglasfir	
Taxus cuspidata		
Tsuga canadensis	eastern hemlock	

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Juniperus virginiana	eastern redcedar	
Thuja occidentalis	eastern arborvitae	(numerous exist)

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Juniperus chinensis	Chinese juniper	'Iowa', 'Mountbatten'
Taxus cuspidate	Japanese yew	

Note: * denotes species recommended for use as street trees.

This suggested species list was compiled using the excellent references *Dirr's Hardy Trees and Shrubs* (Dirr, 2003) and *Manual of Woody Landscape Plants* (5th Edition) (Dirr, 1998). Cultivar selections are only recommendations and are based on Davey Resource Group's experience and tree availability in the nursery trade.

Appendix B
Importance Value for Most Abundant Trees

Stevens Point

Importance Values for Most Abundant Public Trees

4/21/2010

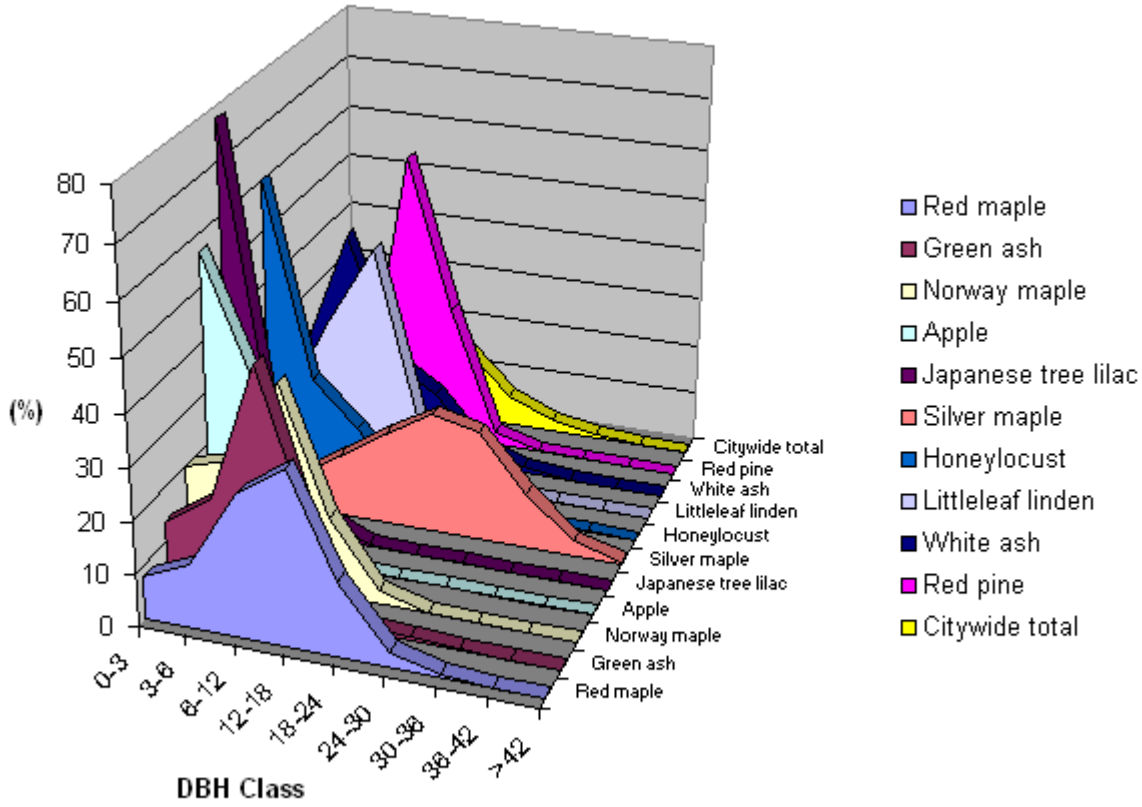
Species	Number of Trees	% of Total Trees	Leaf Area (ft²)	% of Total Leaf Area	Canopy Cover (ft²)	% of Total Canopy Cover	Importance Value
Red maple	902	12.5	1,654,623	21.5	660,958	23.2	19.1
Green ash	826	11.4	709,326	9.2	305,961	10.7	10.5
Norway maple	657	9.1	420,419	5.5	229,924	8.1	7.5
Apple	481	6.7	15,675	0.2	32,040	1.1	2.7
Japanese tree lilac	350	4.8	6,656	0.1	14,445	0.5	1.8
Silver maple	331	4.6	1,445,000	18.8	432,913	15.2	12.8
Honeylocust	326	4.5	101,316	1.3	67,494	2.4	2.7
Littleleaf linden	312	4.3	143,402	1.9	74,415	2.6	2.9
White ash	281	3.9	231,638	3.0	98,115	3.4	3.4
Red pine	272	3.8	320,303	4.2	75,467	2.6	3.5
Northern hackberry	250	3.5	68,419	0.9	50,019	1.8	2.0
Broadleaf Decidious sma	235	3.3	11,169	0.1	23,106	0.8	1.4
Elm	229	3.2	458,977	6.0	135,081	4.7	4.6
Amur maple	225	3.1	5,081	0.1	11,681	0.4	1.2
Spruce	171	2.4	154,922	2.0	35,159	1.2	1.9
Basswood	145	2.0	198,615	2.6	61,780	2.2	2.3
Eastern white pine	130	1.8	313,331	4.1	44,564	1.6	2.5
Siberian elm	128	1.8	211,815	2.8	84,542	3.0	2.5
Blue spruce	113	1.6	95,306	1.2	25,138	0.9	1.2
Northern red oak	97	1.3	121,815	1.6	49,557	1.7	1.6
Pin oak	96	1.3	222,029	2.9	84,123	2.9	2.4
Sugar maple	83	1.1	150,334	2.0	51,938	1.8	1.6
Other trees	589	8.1	627,574	8.2	206,129	7.2	7.8
Total	7,229	100.0	7,687,745	100.0	2,854,550	100.0	100.0

Appendix C
Relative Age Distribution

Stevens Point

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

4/21/2010



	DBH class (in)								
Species	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	>42
Red maple	8.20	12.42	27.27	33.81	14.41	2.88	0.78	0.11	0.11
Green ash	13.68	19.98	46.73	18.16	0.85	0.48	0.12	0.00	0.00
Norway maple	20.24	22.83	39.27	15.07	2.44	0.15	0.00	0.00	0.00
Apple	56.76	34.93	8.11	0.21	0.00	0.00	0.00	0.00	0.00
Japanese tree lilac	77.71	17.71	4.29	0.29	0.00	0.00	0.00	0.00	0.00
Silver maple	4.23	6.04	12.08	18.13	23.56	21.45	10.88	3.02	0.60
Honeylocust	59.82	21.78	13.19	3.07	1.53	0.31	0.00	0.31	0.00
Littleleaf linden	13.14	29.81	45.51	11.22	0.32	0.00	0.00	0.00	0.00
White ash	18.86	43.42	19.22	13.52	3.91	1.07	0.00	0.00	0.00
Red pine	5.51	7.72	56.99	27.21	2.57	0.00	0.00	0.00	0.00
Citywide total	26.45	22.23	26.77	14.70	6.08	2.59	0.90	0.22	0.07

Appendix D
Davey® Planting Guidelines and Davey® Pruning Guidelines

Planting Guidelines

The following guidelines to tree planting will help reduce transplanting shock and ensure that trees adapt to the new site. Keep in mind that spring and fall are the best times of the year to plant trees, but some trees do better when transplanted in spring rather than fall, and vice versa. Check with your nursery when planning tree-planting operations.

Site Conditions

A frequent cause of new tree failure is poor acclimation to site conditions. This includes not only the planting site, but also the climate conditions at the nursery and the similarity in the new tree location. For example, a tree raised in a nursery farther south than the planting site may have more difficulty in adapting than a tree grown in more similar climate conditions. Furthermore, the soil conditions of the site (pH, moisture, oxygen, and nutrient availability) should be sufficient to meet the specific requirements of the tree. It is more cost-effective to choose the right tree for a site than to modify the site after the tree has been planted or to have high maintenance costs because a poorly established tree is unhealthy.

Tree Selection

In addition to selecting trees that are tolerant of existing site conditions, select trees that show normal growth and are free of serious insect and disease problems. The trees should exhibit good vitality, appearing undamaged with a healthy root mass. Trees should have good leaf color, annual twig growth, and bud appearance. Careful nursery selection is essential.

Single-stemmed trees should not have the appearance of clumped foliage arising from the same point on the stem. Such a condition, while providing an initial tree form, will ultimately cause branching problems, such as weak crotches, and should be avoided. Trees with good potential for lower maintenance when mature will have a scaffold or ladder appearance with branch angles greater than forty-five degrees. Some trees have this form naturally, while others need to be pruned when young to encourage such form.

Stock Type

Trees are delivered from the nursery in one of three states of preparation: balled-and-burlapped trees, with soil surrounding the root system; bare-root trees, without soil; and containerized trees, generally grown in the container in which they are delivered.

Bare-root is the least expensive and allows roots to be in contact with the native soil. However, care must be taken to keep the roots protected and moist before planting, as the fine roots can dry rapidly.

Balled-and-burlapped tree roots are slower to dry out than bare-root trees, as the roots are inside a soil ball. However, the burlap may cover dead or poorly pruned roots and should be inspected before planting. The type of soil surrounding the roots should not be too different from the soil on the site or the tree roots may not extend sufficiently into the surrounding soil from the root ball. In such a case, the backfill soil should be amended to provide a transition between the two types of soil.

Container-grown trees have an undisturbed root system and can be planted with the intact root system. If the tree has been in the container for too long; however, the tree may be pot-bound with the roots encircling the inside perimeter of the pot. The roots should be sliced or partially separated in order to improve the ability of the tree to extend the roots into the surrounding soil.

Tree Planting

The tree should be planted to the same depth or slightly higher than it was growing at the nursery. A high mound should be avoided as the soil can dry out quickly in the summer and freeze in the winter.

The hole should be dug shallow and wide. It should not be any deeper than the root ball but should be a wide hole, allowing for amendments, if necessary, or for loosening heavy clay soil to allow for improved oxygen availability and root penetration.

The backfill soil should be added gradually and watered carefully to settle the soil but not to saturate it. Balled-and-burlapped trees should have any untreated burlap pulled away from the top of the root ball and cut away—not buried—so that none of the burlap is exposed at the soil surface. Otherwise, the burlap can wick moisture away from the roots of the freshly planted tree.

Tree Staking

Stakes should only be used to support trees on windy sites or for smaller trees with weak trunks. The stakes should be placed before the backfill is added to avoid damaging any large roots. A stake is meant to provide a temporary support and should be removed within a year to allow the tree to develop trunk strength and to limit the potential for physical damage from the stakes and support ties.

Wooden stakes, metal pipe, fence stakes, and metal reinforcing bars may all be used for support. Anything used for a tie should have a flat, smooth surface and be somewhat elastic to allow for slight movement for the tree. Suitable materials include rubber strips or webbing and belting. Wire covered with hose or tubing **should not** be used.

Tree Irrigation

Because a newly transplanted tree may have lost much of its root system, watering is critical for successful establishment. Initial watering at planting should be followed with weekly watering, particularly during dry periods. A newly planted tree will benefit from at least an inch of water a week.

Mulching

Newly planted trees respond well to mulch placed around the tree. This reduces initial root competition with turf and limits the possibility of physical damage by mowers. These factors contribute to the health of the trees and increase the likelihood of survival.

The mulch should **not** be piled (mulch 'volcanoes') around the tree and should not actually touch the tree trunk. No more than a 2- to 3-inch depth of mulch should be added, with it being no more than ½ inch deep closest to the tree.

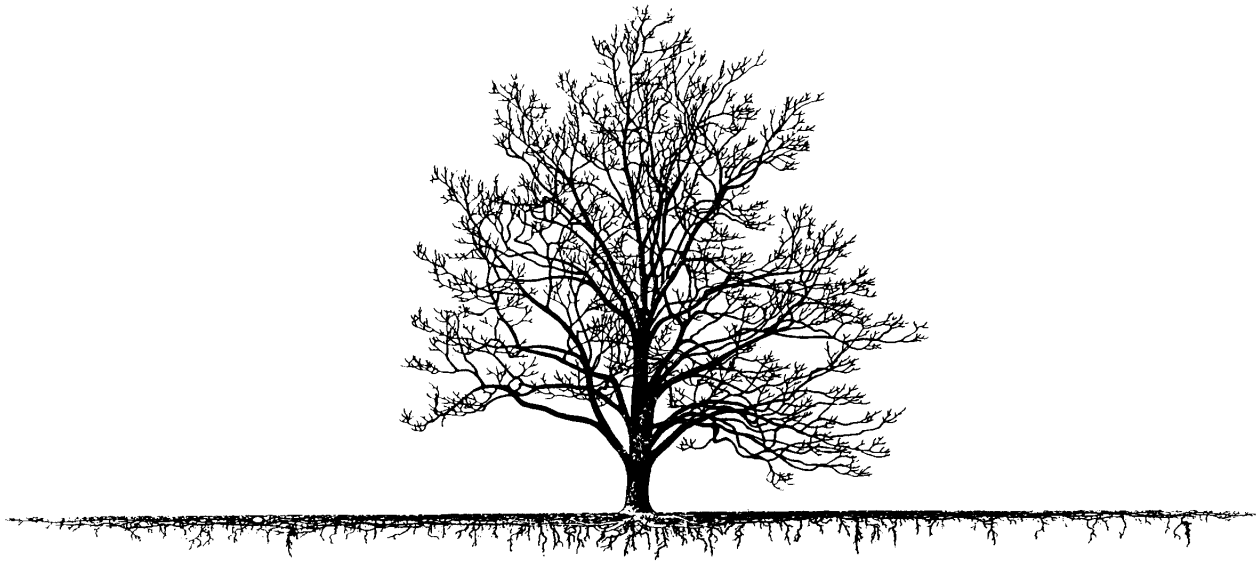
Pruning

When planting a tree, only dead or broken branches should be removed. All living branches should be left on the tree to help promote tree establishment. Once the tree has been established on the site, training pruning can be done to promote good branching patterns, but no more than 1/4 of the branches should be removed at any one time.

Fertilizing

Fertilizer is not generally necessary at the time of planting and, indeed, if placed improperly in the planting hole can injure roots. The addition of nitrogen, in a slow-release form, however, can benefit a newly planted tree, and it may be efficient to apply at the time of planting.

Tree Pruning Guidelines



DAVEY®

Introduction

Pruning consists of *selectively* removing branches (living and dead) from woody plants, ranging from pinching off a bud at the end of a twig to removing large limbs.

Proper pruning benefits trees, shrubs, and vines, and the associates of woody plants (including humans). Pruning branches can be one of the most beneficial or the most damaging practices arborists do to trees.

A basic principle of pruning is that the removal of any live stems, branches, twigs, and buds affects growth of the plant. Proper pruning prevents and corrects defective form that could result in branch or stem failure. Thus, knowledge of plant biology is essential for the correct methods of Davey pruning.

Most tree species evolved in competitive forest communities. Consequently, trees developed efficient branching systems to capture the energy of available light for photosynthesis.

Woody plants also evolved the ability to get rid of inefficient energy resources by *shedding* shaded branches (cladaptosis). A branch is naturally shed from its base. As natural shedding occurs, the wood tissue around the branch core within the stem protects against decay. Davey's limb removal cuts imitate natural branch shedding (natural target pruning).

Many people equate woody plant pruning to amputation, but there should be no fear of wise and careful use of pruning equipment. A properly pruned tree, shrub, or vine is a combination of art, science, and skill.

Davey Tree surgeons adhere to Davey and industry pruning standards. In the arboriculture industry, the current standard approved by the ISA and the NAA is *The American National Standards Institute* (ANSI) A300 issued in 1995. Davey Residential Operations adheres to the National Arborist Association (NAA) *Pruning Standards for Shade Trees* (revised 1988) where four classes of pruning are defined. The NAA classes appear in a condensed version on the back of the Davey Plant Health Care quote/work order forms printed before 1996.

Reasons for Pruning

The first rule in pruning is **do not cut without a reason**. Too often arborists tend to over prune to meet client expectations. Proper pruning is an effort to *direct* new growth rather than 'control' growth.

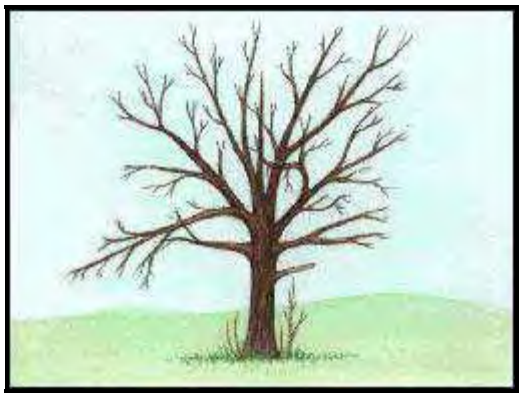
Most pruning cuts are of a *preventive* or a *corrective* nature to be beneficial to woody plant health.

Health

- *Sanitation* by removing dead, broken, decayed, diseased or insect-infested wood (crown cleaning).
- *Thinning* to improve penetration of light and air, and to reduce wind resistance and potential storm damage.
- Reduction of the number of poorly attached *epicormic branches.*
- *Girdling root* removal.
- Correct and/or redirect *structural growth* that may cause future problems (weak crotches, branches growing out of proportion, etc.).

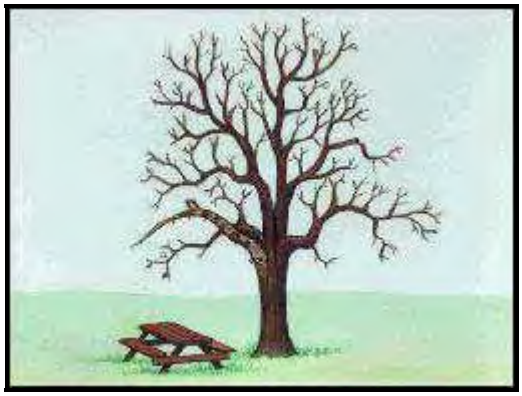
Appearance

- Shape for aesthetic purpose, natural forms, growth habit (training).
- Influence flowering, fruiting, promotion of shoots, canes, bark color.
- Direct new growth and/or correct improper prior pruning (crown restoration).



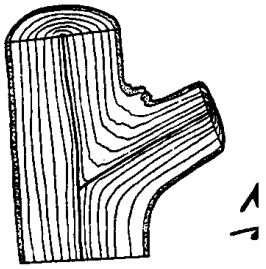
Convenience or Safety of Property and People

- Correct or modify storm-damaged, neglected, or poorly pruned woody plants.
- Identify and remove potential hazard limbs, stems, and deadwood (hazard reduction pruning).
- Line clearance (directional pruning).
- Raise or lower obstructive canopies over or near roads, sidewalks, playgrounds, buildings, pools, satellite dishes, etc. by removing interfering limbs (crown reduction and/or crown raising).
- Provide access to more light for understory plants and turf (crown thinning).
- Vista pruning (alter crowns to allow views of something beyond tree screens).



Pruning Methods and Techniques

Branch Attachment to Stems



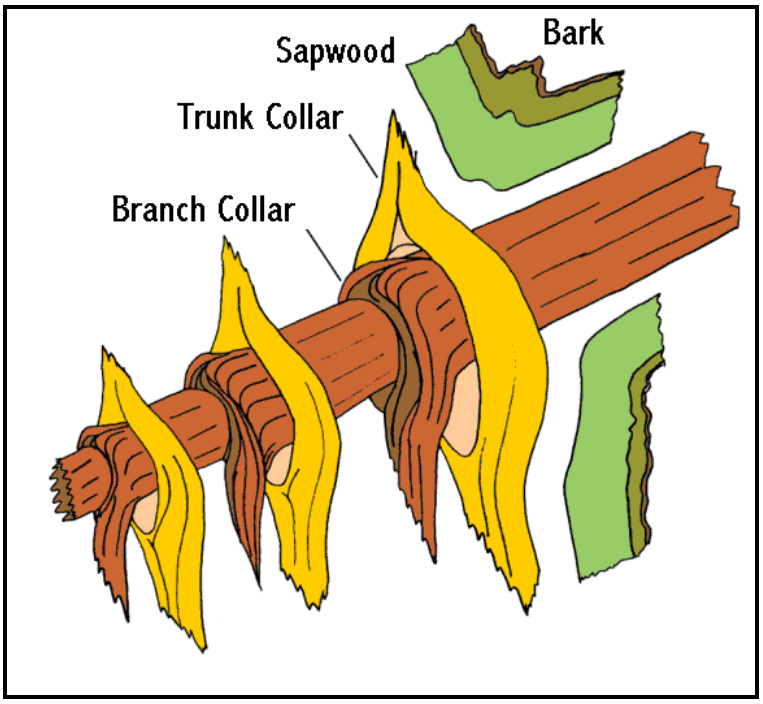
New branch tissues generated by the vascular cambium usually start growth before trunk tissues. As current-year branch tissue develops from branch ends toward the trunk, it turns abruptly downward at the branch base to form a *collar.*

Trunk branch tissues grow later and form a trunk collar over the branch collar (trunk collars and branch collars are collectively called the *branch collar*).

The collar is where wood and bark of the branch and the trunk come together, like an overlapping tissue 'switching zone'. All true branches on woody plants have branch collars.

The *branch bark ridge* (BBR) is raised bark developing in the branch crotch and shows the angle of the branch core in the tree.

If a branch dies or is removed, the trunk collar continues to grow over the thin belt of branch tissue below the collar junction. The wood core of the branch is walled off (compartmentalized) in the trunk.



Proper Pruning Cuts (Natural Target Pruning)

Location of *branch bark ridges* and *branch collars* determines the location of a pruning cut. Cuts must be made *outside* of the branch bark ridge, angling away from the trunk outward as close as possible to the collar.

- There is no set or standard angle for a proper collar cut.
- The proper angle depends on the shape of the collar.
- Conifers often have flat collars where a straight cut close to the collar is correct.
- Sometimes the angle of the cut will necessitate an *upstroke* cut with a handsaw or chainsaw.

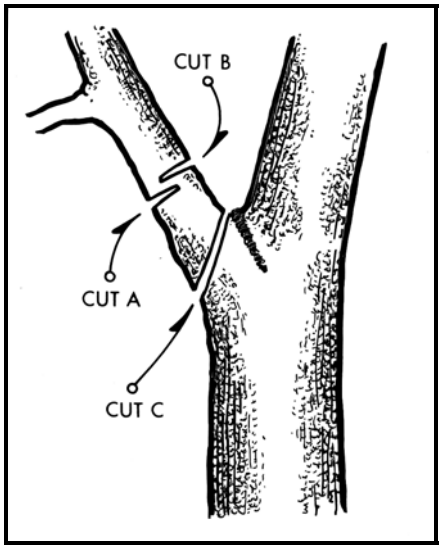
Do not cut into the collar to stimulate callus production and rapid closure. Although closure is desirable for appearance, such a cut promotes decay and future hazards. Never put a pruning tool behind the branch bark ridge.

Whether a branch collar is obvious or not, the position of the final or finish cut should:

- Minimize the branch stub that is an entryway for decay fungi.
- Retain the natural decay protection present in the branch core. The intact branch collar is the first line of defense in preventing decay within the trunk.
- Minimize the overall size of the pruning wound and direct damage to the stem.

Always **stub cut** the branch first. Limbs that cannot be controlled must be removed using at least **three** cuts. Roping of limbs may be necessary to prevent damage to other parts of the tree if they cannot be controlled by hand.

1. The first cut (Cut A) **undercuts** the limb one or two feet out from the parent branch or trunk. A properly made undercut will eliminate the chance of the branch 'peeling' or tearing bark as it is removed.
2. The second cut (Cut B) is the **top cut** which is usually made slightly further out on the limb than the undercut. This allows the limb to drop smoothly when the weight is released.
3. The third cut (Cut C) or **finish cut** is to remove the stub.



Each finish cut should be made carefully, outside of the branch bark ridge and the evident collar, leaving a smooth surface with no jagged edges or torn bark.

There are some situations where the cambium dies back beneath a branch collar after a correct cut:

- The trunk collar did not join the branch collar directly below the branch. Sunken spots under branches are a sign of this condition.
- Winter cuts may result in undercollar dieback.
- Problem tends to increase with size of branches removed.

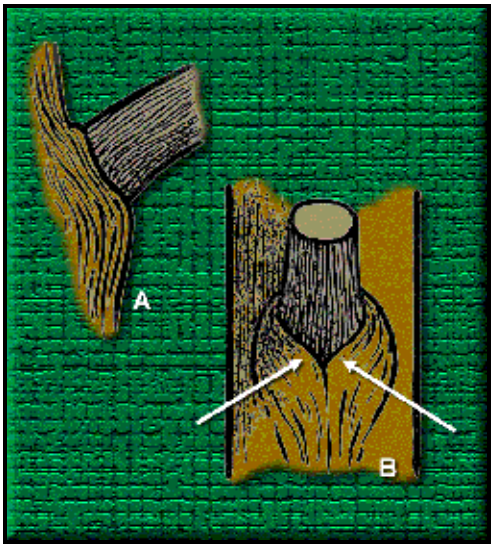
Callus and Woundwood

Callus is undifferentiated meristematic tissue that forms at wound margins from the cambium.

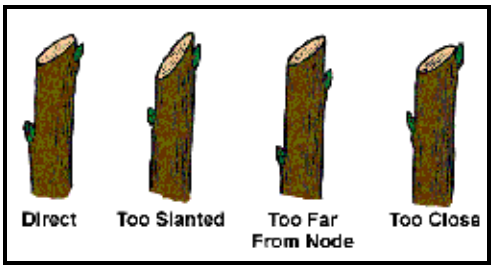
Callus differentiates into *woundwood* over time. Woundwood is 'new wood' and has the different cell components of periderm, cambium, phloem, and xylem.

A *complete* ring of callus and subsequent woundwood will develop around and eventually over proper cuts. Woundwood forms only to the sides of improper cuts (flush cuts), which means the collar and branch protection zone is damaged and the trunk is wounded.

A proper pruning cut results in a smaller wound area, and more rapid callus and woundwood movement over the wound. Cuts on dead limbs that have trunk collars moving up the dead branch wood must also be made just outside of the evident collar.



- Appropriate only for small woody plants or one- to two-year-old branches (twigs, branchlets) on trees.
- Cut back to a bud (lateral bud) or lateral branchlet, slanting at a 45° angle above the bud *node* on alternately arranged branches and stems.
- Two or more buds at a node (opposite, whorled) require a *transverse* cut just above the bud tips or a 45° angle cut, removing one of the buds and leaving the other(s) to elongate in a desired direction.
- Cut 1/8" higher above the bud tips when pruning in cold weather to prevent winter injury to the bud (tissue around a winter cut is more vulnerable to desiccation).



- Leaving a majority of *inward* facing buds produces growth towards center.

- Leaving a majority of *outward* facing buds results in more open growth.

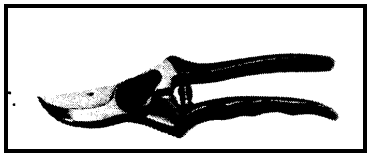
Pruning Tools

Use **well-sharpened** tools for both your safety and to help reduce tearing of wood and cambial tissues. Wear specified protective equipment.

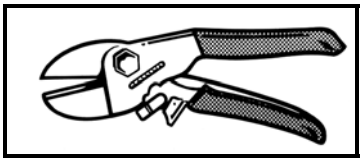
Pruning Shears

Hand shears, secateurs, hand pruners, one-hand shears:

- Remove branches, stems up to 1/2" diameter.
- By-pass (hook and blade, scissors, drop-forge, curve blade): make closer cuts than anvil-type.



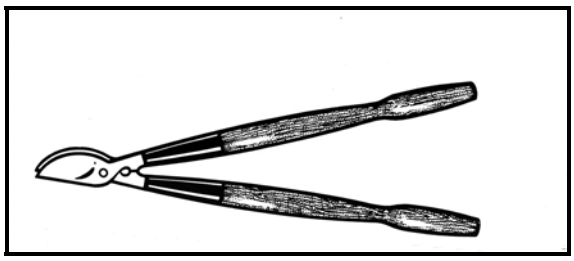
- Anvil (straight-blade): good for only soft-tissued wood; will crush harder wood (inappropriate per A300 standards).



Lopping shears

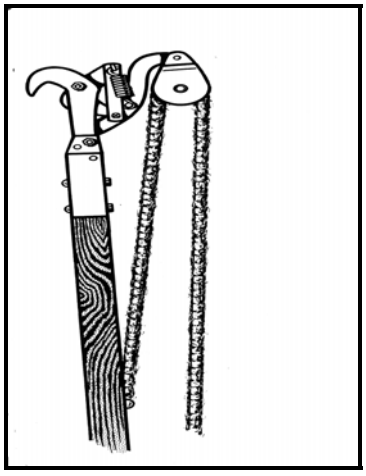
Two-hand shears:

- Remove branches, stems up to 1-3/4" diameter.
- Most useful in rejuvenation.
- By-pass, hook and blade, etc.
- Anvil, straight-blade.
- Ratcheting.



Pole Pruners

- Wood and insulated poles (round and squared).
- Cut like by-pass shears.
- Important to keep blade side in toward the cut.



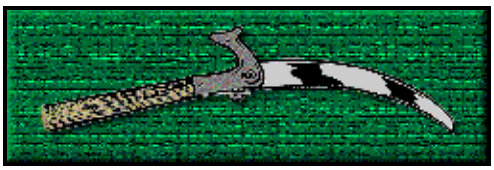
Cut at the outer side of the branch bark ridge at a slightly outward angle so as not to injure or remove the branch collar. Hook the pruner head around the limb to be cut with the blade side against the lateral branch or stem to remain. The arborist must be in a safe working position and the pruner handle positioned so the blade will not jam in the wood. You should not cut off a limb directly above yourself if there is any chance that it could fall and hit you.

Change your working position before completing the cut; place the hook so you have a straight pull on the rope and the lever arm can move far enough to complete the cut. An experienced tree surgeon can give a limb a flip with the side of the pruner head, just as the cut is completed, so that the limb will fall in the desired direction.

Saws

Pole saws:

- Hook cast onto pole-head.
- Wood poles (round and squared).
- Insulated poles (foam core).
- Difficult to make clean, accurate cuts.



Fine-tooth saw blades (more points per inch):

- On folding, rigid, and grip handles.
- *Needlepoint* teeth.
- Razor-tooth, Japanese, or *tri-edge*-style teeth (*Fanno*™ 1311, *Felco*™, *Corona*™); narrow, curved blades facilitate getting into tight spots.

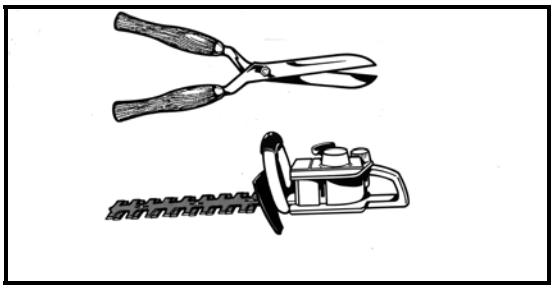
Arborist saws cut on the *pull* stroke:

- Davey-issue speed saw.
- Raker and gullet saws.
- Needle-tooth saws Fanno™ series.
- Scabbards, blade lengths.
- Pole saw blades now available with tri-edge teeth.

Hedge Shears

Clippers/trimmers:

- Manual (sometimes called 'pruning' shears)



- Powered (electric, gasoline)
- Cut off growth ‘in line’ with no regard for node locations or branch bark ridges.
- Provide time and labor savings at expense of overall plant health.
- Dull blades compound problems and make you work harder!

Crown Thinning and Cleaning

A proper thinning cut removes a branch at its point of attachment, or back to a lateral branch large enough to assume a terminal role.

Learn to foresee the need for removing live branches while they are small. Avoid large cuts. Direction can be influenced by removal of short portions of growth or even by removal of individual buds.

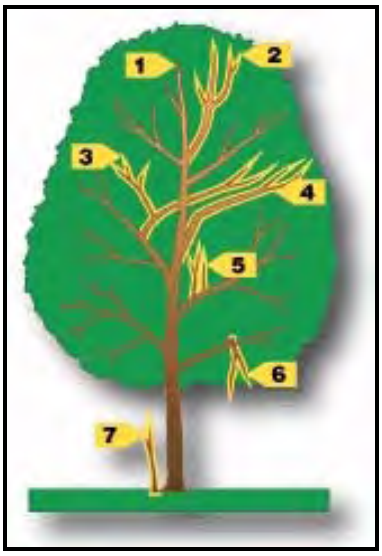
Thinning of lower branches can ‘raise’ a limb. If, after crown raising, the remaining leaf material is insufficient for limb size, consider complete removal. The client's opinion is important.

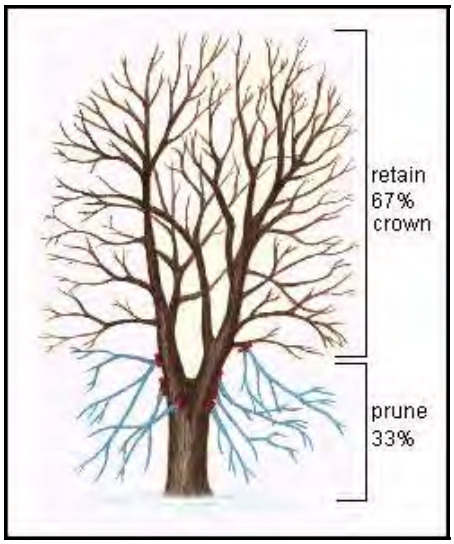
Never perform excessive thinning, which is stressful, especially on thin-barked or young trees prone to sunscald.

Avoid removing more than 1/4 of the live branches on a tree. Older or overmature trees should have an absolute minimum of living branches removed.

Always avoid ‘skinning’ or ‘hollowing' out the center of a tree's canopy. The majority of thinning cuts should be made along the outer crown. Proper thinning requires a good deal of limb-walking and deft use of a pole-pruner when and where aerial lifts are not used.

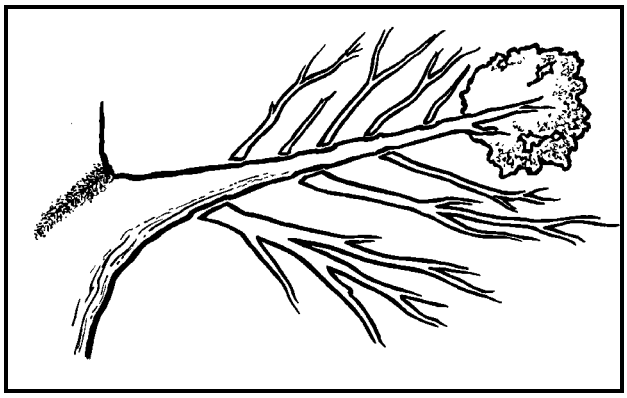
When thinning laterals from a limb, maintain well-spaced inner branches to achieve more distribution of foliage along the branch.





Caution must be taken to avoid creating an effect known as *lion-tailing*:

- Caused by removing all of the inner laterals and foliage.
- Displaces foliar weight to the ends of the branches.
- May result in sunburned bark tissue, renewed and excessive epicormic branches, weakened branch structure and breakage.
- Wind whippage.



Lion-tailing

Removal of Diseased or Insect-Infested Branches

Sanitation or 'eradicative' pruning (crown cleaning):

- Cut out diseased limbs back to collars, appropriate lateral branches, or a scaffold branch at least one foot below infected portion.
- Disinfect tools *during or after* pruning diseased branches with bleach solution (1 part bleach to 10 parts water) or Lysol.
- Do not use any form of alcohol to sterilize pruning tools *during* the work. Use alcohol to disinfect auger-bits, injection tees, or pruning tools *after* the job, especially plants with wetwood or fireblight bacterial infections.

Removal of Weak, Rubbing, or Competing Stems

Remove, if possible, but avoid large holes in the canopy.

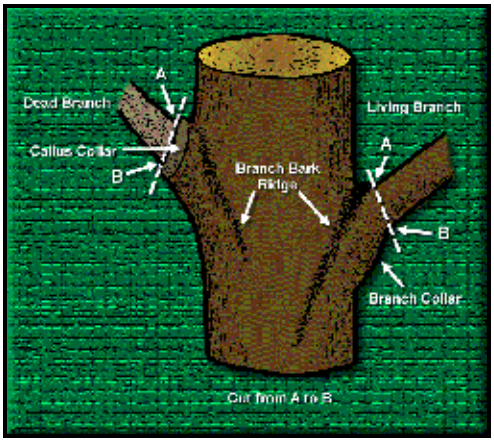
The life of large limbs, weakened by decay or cracks, can often be extended by "shortening" or weight removal using highly selective thinning cuts. Cabling and/or rigid bracing may be required to secure limbs or codominant stems if removal is not possible.

Deadwood Removal

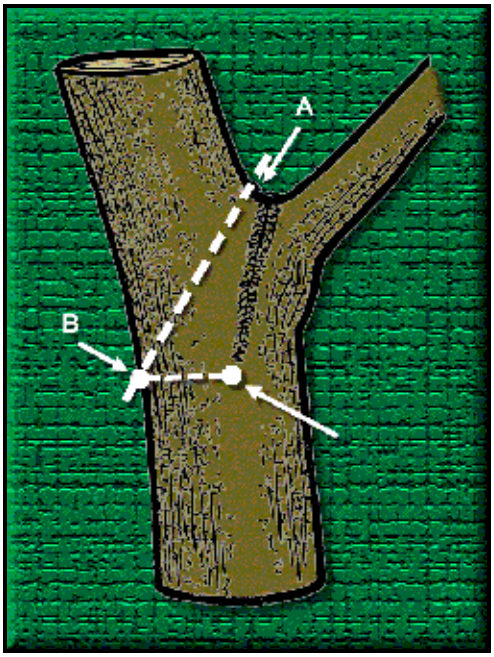
Sanitation and hazard reduction pruning:

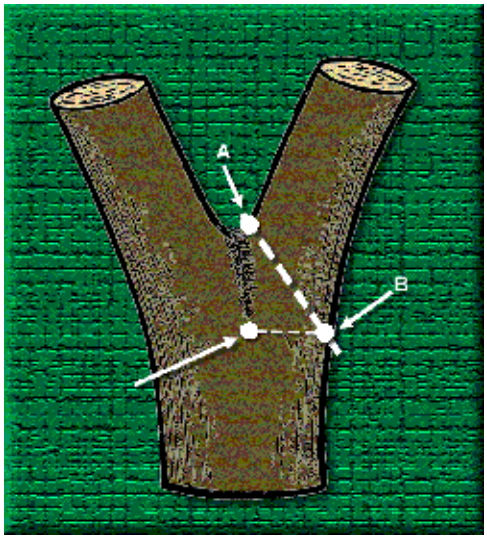
- Dead branches and stubs are an energy source (cellulose, glucose).
- Decay fungi.
- Boring insects.

Again, do not remove the branch collar around dead branches. Cut as close as possible to the collar of good wood surrounding the branch base.



Locate Target Points





Codominant Stem or Branch Removal

Always *stub cut* the stem to be removed, and then make the *finish* cut with care.

Some defect (discoloration) will develop in the remnant stem 'core' in the main stem:

- Usually not attached like a true branch with protective collar.
- Barrier zone should develop and confine defect if correct cut is performed.

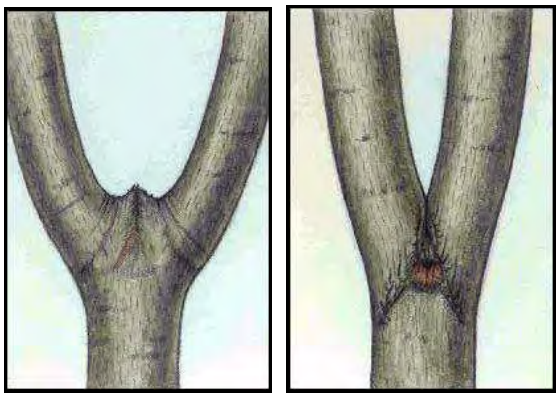
Never remove both stems!

When the bark plates on the stem bark ridge turn upward, the union of the stems is usually *strong.*

When the bark between the stems turns inward, the union of the stems is *weak.*

It is the *union* of the stems or upright branches more than the *angle* that determines whether attachment is weak or strong.

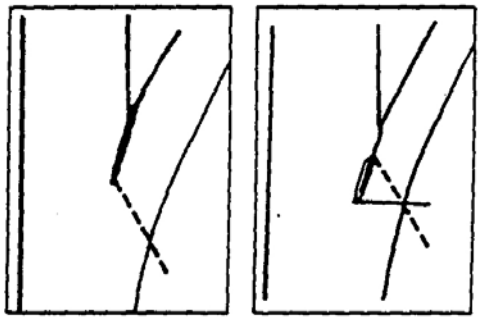
The stems have *included bark* squeezed or embedded *between* them.



Remedies:

To *remove*, stub cut the stem first and then cut where the dotted line is with care; avoid cutting into the remaining stem.

If the saw cannot complete this cut, tap a small wedge into the kerf and cut the remainder of the wood with a flat chisel and mallet.



To *strengthen* stem on older trees, a cable can be attached; place at a point approximately two-thirds of the distance from the crotch to the ends of the stems.

When a cable is used to strengthen stems, the cable and hardware must be checked regularly. When the risk of stem fracture becomes high, the weaker stem should be removed.

Davey Residential Operations employs four general classes of pruning. Classes 1, 2, and 3 are classified as maintenance pruning, which is recommended when the primary objective is to maintain or improve tree health and structure, including hazard reduction pruning:

- Class #1 - *Fine Pruning*: consists of the removal of dead, dying, diseased, interfering, objectionable, and weak branches (crown cleaning), as well as selective thinning to lessen wind resistance. Some deadwood up to ½ inch in diameter may remain within the main leaf area where it is not practical to remove such. Girdling roots will be monitored and removed where possible.

- Class #2 - *Medium Pruning*: consists of the removal of dead, dying, diseased, interfering, objectionable, and weak branches (crown cleaning). Some deadwood up to one inch in diameter may remain within the leaf canopy.
- Class #3 - *Hazard reduction*: pruning is recommended when the primary objective is to reduce the danger to a specific target, caused by visibly defined hazards in a tree, by removing dead, diseased, or obviously weak branches two inches in diameter or greater.
- Class #4 - *Crown Reduction Pruning*: consists of reducing canopy tops, sides, under branches, or individual limbs at appropriate lateral limbs and stems for purposes of clearance of storm damage repair. Some crown reduction pruning incorporates hazard reduction pruning.

Epicormic Branches

Epicormic branches may be needed to fill in the canopy where trees have been excessively thinned or storm damage has occurred (crown restoration).

Epicormic branches (shoots, watersprouts, suckers) arise from two types of "buds":

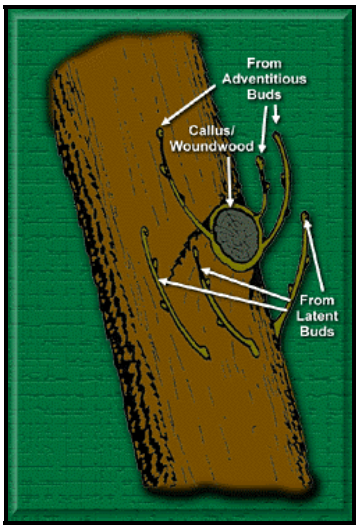
- Adventitious buds.
- Latent (dormant) buds or meristematic points.

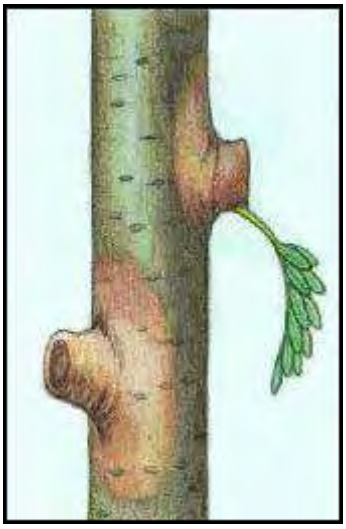
Adventitious epicormics come from meristematic tissue generated anew by the cambium. Most adventitious buds develop from callus tissues moving over a wound, or from root tissue.

Latent (dormant) buds or *meristematic points* are formed at an earlier time in the life of a woody plant but do not 'release' or grow. Latent buds are 'carried along' in rays in the cambial zone year after year, as the tree increases girth, and are usually released upon injury or stress. Epicormic sprouts from latent meristematic points are often found in the vicinity of pruning cuts, usually below the wound.

Epicormic branches are *stimulated* on a much larger scale by winter or early spring pruning rather than by late spring-summer pruning (desirable in shrub renewal or rejuvenation).

A *watersprout* is an epicormic branch growing from branch and stem parts, or above a graft union.





A *sucker* is an epicormic branch growing from root tissue or <u>below</u> a graft union.

Apical Dominance and Control

Woody plant natural shapes, forms, or habits are governed by species' inherent (genetic) determination of:

- Leaf and flower bud locations.
- Bud-break patterns along stems.
- Branching angles.
- How buds and branches elongate.

Apical dominance = terminal bud(s) suppress lateral buds along an elongating shoot

Excurrent and *decurrent* branching patterns:

- Decurrent woody plants have overall weak apical control, but strong apical dominance while shoots are elongating.
- Random-branching excurrent plants have weak apical dominance and overall strong apical control.
- Whorl-branching excurrent trees have both strong apical dominance and control.

Excurrent

Decurrent

Plant growth regulators are substances that enhance or alter the growth and development process of a plant. In most cases, these chemicals either increase or decrease normal growth, flowering, and/or fruiting of plants.

Selective growth control and/or branch release by natural growth regulators:

- Auxins
- Abscisic acid (ABA)
- Cytokinins
- Gibberellins (gibberellic acid = GA)
- Ethylene

Branch terminals – auxin source
Roots – cytokinin source

Low auxin = axillary bud release,
High cytokinin energy storage drain

High auxin = bud suppression,
Low cytokinin initiate new roots

Plant growth regulators are substances that enhance or alter the growth and development process of a plant. In most cases, these chemicals either increase or decrease normal growth, flowering, and/or fruiting of plants.

Utility arborists use synthetic growth regulators to *control* the growth of trees and other vegetation beneath utility lines. Growth *inhibitors* can be:

- Sprayed on the foliage.
- Painted on pruning wounds.
- Banded on the bark.
- Soil applied.
- Injected into trees.

Antigibberellins are growth regulators that counter the effects of naturally occurring *cell-elongation* hormones (gibberellin). Ideal formulations are being sought that would minimize phytotoxicity while reducing utilities' pruning expenses.

Another use of growth inhibitors is to suppress epicormic branch production on trees:

- Not yet widely used by arborists.
- Must be applied annually.
- Client concern over the use of chemicals.
- Applicator safety concerns.
- Epicormic branch growth can be minimized with proper cuts.
- Retarded woundwood development.

Painting of Cuts

Proper cuts negate the "need" for wound dressings. Wound dressings will not *prevent* decay; wound dressings have been evaluated to often *promote* wood decay or cause cambium damage.

Cuts or wounds in certain species during the growing season may attract insects that carry diseases or allow fungus invasion. Native oaks or elms and European elms should be pruned during dormant periods in regions where wilt disease conditions are known to exist.

If pruned in summer, pruning wounds on wilt-susceptible oaks and elms should be treated with the current wound dressing recommended by The Davey Institute.

Pruning Phenology

The ideal or optimal times to prune most woody plants are:

- Late in the dormant season.
- After leaves are fully formed and expanded.

Client concerns with excessive *sap flow* (birches, maples):

- Avoid pruning during height of sap flow (just before growing season) if possible.
- Sap flow may be unsightly but does not cause definite injury.
- Prune immediately after leaves are fully expanded if client cannot be convinced.

Avoid pruning birches after leaf expansion, as the wounds may be attractive to boring insects.

Dead, broken, or weak limbs may be removed at any time with little effect, except in wilt-susceptible oaks and elms.

Pruning before the spring leaf bud-break period can enhance stimulated growth and rapid wound closure. Pruning during the period after leaf expansion will result in suppressed growth and maximum ‘dwarfing’.

Avoid pruning those woody plants undergoing bud break and early leaf expansion, especially in the period where bark ‘slips’ (cambial development of unlignified wood).

Flowering can be reduced or enhanced by pruning at the appropriate time of the year. Woody plants that bloom on current season's growth (‘summer-flowering’ such as crapemyrtle or butterfly-bush) are best pruned to enhance flowering:

- During the dormant season.
- Just prior to or immediately after leaf expansion.
- In late summer (post-bloom).

Plants that bloom on last season's wood ('spring-flowering') should be pruned *just after bloom.*

- Fruit trees are often pruned during the dormant season to enhance structure and distribute fruiting wood, and after bloom to thin fruit-load.

Pruning Selection

Ideal pruning technique begins with planting the right tree in the right place (PHC selection).

Maintaining tree size or allowing for limited crown growth is possible with a regular pruning schedule begun early in the tree's life.

- Consider the extent of mature branches and crown.
- Select good stock with proper growth form.
- Imagine how form will continue to develop; there is no way to turn a large tree back into a small tree.
- Don't expect to improve form with future prunings.

Avoid obtaining saplings with included bark; the stem union becomes weaker rather than stronger as the plant grows. Failure of one or both stems of the fork frequently occurs when the tree is mature, especially during snow and ice storms (loading events).

Structural Pruning

Structural pruning principles are used when training young woody plants or working with a tree that has not been pruned in many years. Properly trained shrubs and young trees will develop into structurally strong plants that should require little corrective pruning as they mature.

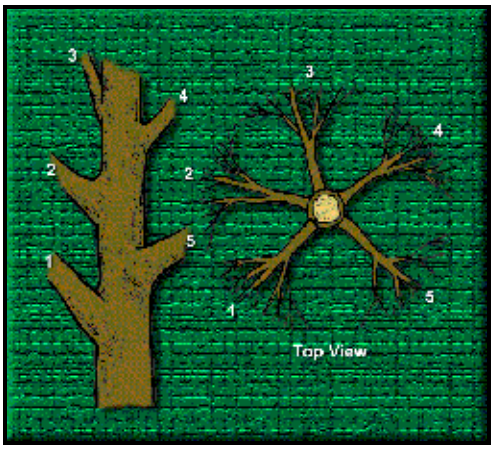
Trees that will be large at maturity should have a sturdy, tapered trunk, with well-spaced branches smaller in diameter than the trunk.

If two branches develop from apical buds at the tip of the same stem, they will form *codominant* branches or, eventually, codominant stems. Each codominant branch is a direct extension of the stem. It is best if one is removed when the tree is young.

Branches with narrow angles of attachment and codominant branches may tend to break if there is *included bark* that gets enclosed inside the crotch as the two branches develop girth and length.

The relative *size* of a branch in relation to the trunk is usually more important for strength of branch attachment than is the *angle* of attachment. Scaffold branches' diameters should not be more than 1/2 the stem or trunk diameter.

Select main branches to give *radial distribution*. Discourage branches growing directly over another unless spaced well apart.



On large-growing trees, except whorl-branching conifers, branches that are more than 1/3 the diameter of the trunk in size should be well spaced along the trunk (at least 18 inches apart).

Maintain one-half the foliage on branches arising in the lower 2/3 of younger trees.

- Increases trunk taper.
- More uniformly distributes weight and wind stress along the trunk.

This rule of thumb also holds true for an individual limb:

- Leave lower and inside branches along the limb.
- Limb can develop taper and strength.
- Stress and weight can be evenly distributed along the length.

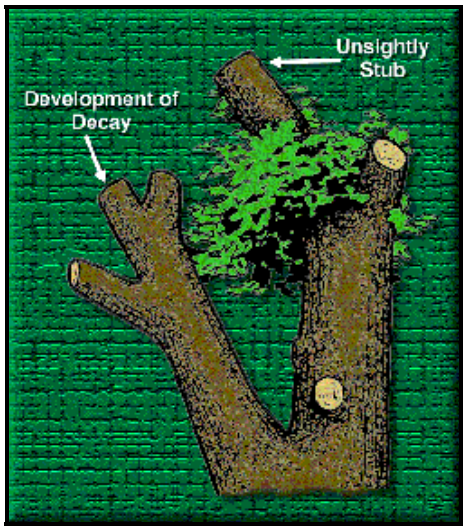
The height of the lowest scaffold branch will depend on the intended function of the tree: screen an unsightly view, provide a windbreak, shade a patio, installed as a walkway or street tree.

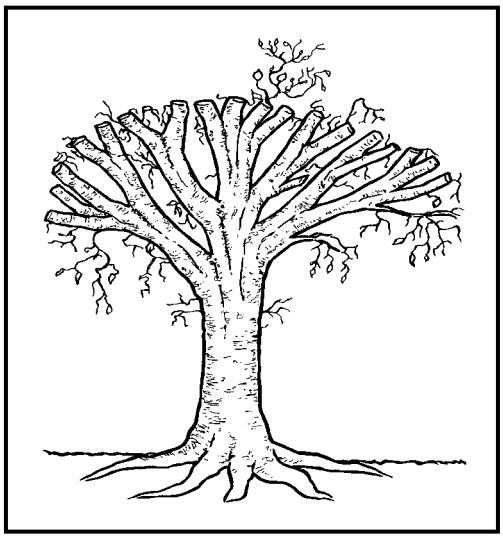
Pruning at Planting

For years, the conventional wisdom was that trees should be severely pruned at time of transplant to compensate for root loss and to "balance" the crown with the root system (especially bareroot trees). This practice has since been discovered to prolong *transplant shock.*

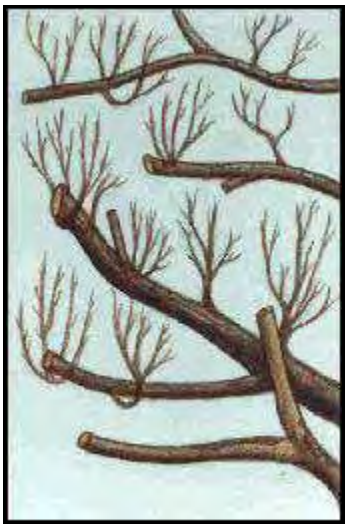
- Transplant pruning should be limited to removal of dead, broken, diseased, or interfering branches.
- Leave small shoots along the trunk for later removal.
- Protect the trunk from ‘sunburn’.
- Aid in development of proper trunk taper.
- Leave as many terminal buds as possible.
- Stimulate root growth triggered by hormones in these buds.

Topping, Tipping, and Roundover

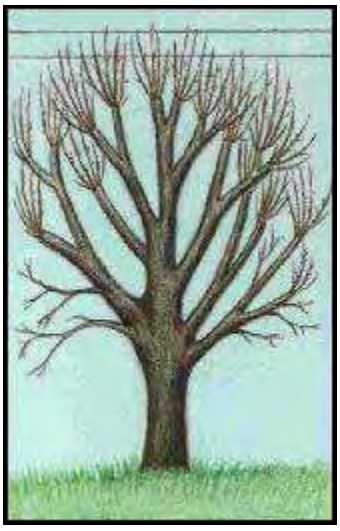




Topping: cutting vertical branches and stems back to inadequate nodes (heading) or to internodes (stubbing).



Tipping: heading side or horizontal branches to stubs or weak laterals.



Roundover: topping + tipping.

Many people have the misconception that cutting or heading the main branches of a tree back to stubs to 'reduce the height' is the proper way to prune.

Apparently, a short tree is thought to be safer and healthier than a tall tree regardless of how the result is attained. Heading back to stubs or inadequate laterals permanently disfigures and weakens a tree. Topping is one of the worst things humans do to trees.

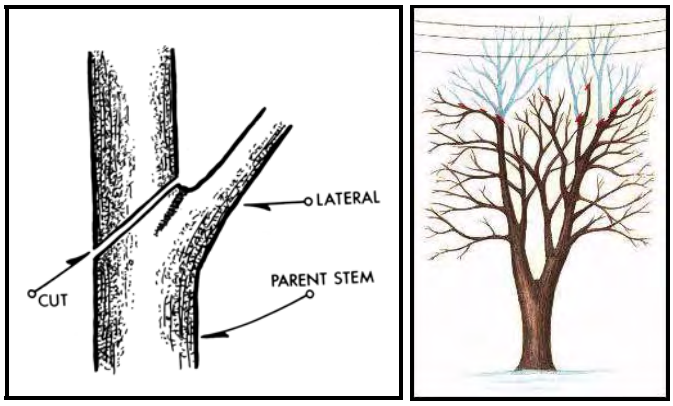
The International Society of Arboriculture (ISA) and the National Arborist Association (NAA) consider heading-back to stubs an unacceptable arboricultural practice. Modern pruning standards do not include heading-back as any sort of a recommended technique.

- Topping removes a major portion of a tree's leaves that are necessary for the production of carbohydrates.
- Stimulation of epicormic branches at or just below an internodal stub cut causes a topped tree to grow back to its original height faster and denser than a properly pruned tree. The sprouts are weakly attached and easily broken off in storms.
- Bark within the canopy can become scalded by sudden exposure to direct sunlight.
- Stubs attract wood-boring insects and sustain wood decay organisms.
- Topping, tipping, and roundover cuts permanently disfigure a tree.

Crown Reduction, Restoration, and Raising

If the height or width of a tree has to be reduced because of storm damage or interference with structures or utility lines, it is performed correctly by a method called *crown reduction* or *drop-crotch* pruning (NAA Class IV Crown Reduction). This procedure involves the removal of a main leader, scaffold, or branch at its point of attachment with a lateral branch large enough to assume a terminal or leader role.

The final cut should begin or end somewhat *parallel* to the remaining lateral branch and offset slightly above the branch bark ridge (without cutting into the bark ridge). The remaining lateral branch must be at least one-half to one-third the diameter of the branch or leader that is being removed.



If a tree has been topped previously and now has epicormic sprouts, *crown restoration* can improve its structure and appearance. Decayed, rotting stubs and tipped branches are cut back to appropriate laterals or entirely removed. One to three sprouts on main branch stubs are retained to become permanent branches and reform a more natural appearing crown. Selected epicormic branches may need to be thinned to a lateral to control length and ensure adequate attachment for the size of the sprout. Restoration usually requires several prunings over a number of years.

Trees in urban and landscape settings may need to have lower limbs removed. *Crown raising* or elevating removes the lower branches of a tree in order to provide clearance for buildings, vehicles, pedestrians, and vistas. Excessive removal of lower limbs should be avoided so that the development of trunk taper is not affected and structural stability is maintained.

Definitions of Arboricultural Terms

Anvil-Type Pruning Tool – Pruning tool that has a straight sharp blade that cuts against a flat metal cutting surface (see *hook and blade-type pruning tool*).

Arborist – A professional who possesses the technical competence through experience and related training to provide for or supervise the management of trees and other woody plants in the residential, commercial, and public landscape.

Boundary Reaction Zone – A separating boundary between wood present at the time of wounding and wood that continues to form after wounding.

Branch – A secondary shoot or stem arising from one of the main axes (i.e. trunk or leader) of a tree or woody plant.

Branch Collar – Trunk tissue that forms around the base of a branch between the main stem and the branch or a branch and a lateral. As a branch decreases in vigor or begins to die, the branch collar becomes more pronounced.

Branch Bark Ridge – Raised area of bark in the branch crotch that marks where the branch wood and trunk wood meet.

Callus – Undifferentiated tissue formed by the cambium layer around a wound.

Cambium – Dividing layer of cells that forms sapwood (xylem) to the inside and bark (phloem) to the outside.

Climbing Spurs – Sharp, pointed devices affixed to the climber's leg used to assist in climbing trees (also known as *gaffs, hooks, spurs, spikes, climbers).*

Closure – The process of woundwood covering a cut or other tree injury.

Crotch – The angle formed at the attachment between a branch and another branch, leader, or trunk of a woody plant.

Crown – The leaves and branches of a tree or shrub; the upper portion of a tree from the lowest branch on the trunk to the top.

Crown Cleaning – The removal of dead, dying, diseased, crowded, weakly attached, low-vigor branches, and watersprouts from a tree's crown.

Crown Raising – The removal of the lower branches of a tree in order to provide clearance.

Crown Reduction – The reduction of the top, sides, or individual limbs by the means of removal of the leader or longest portion of a limb to a lateral no less than one-third of the total diameter of the original limb removing no more than one-quarter of the leaf surface.

Crown Thinning – The selective removal of branches to increase light penetration and air movement, and to reduce weight.

Cut – The exposed wood area resulting from the removal of a branch or portion thereof.

Decay – Degradation of woody tissue caused by biological organisms.

Espalier Pruning – A combination of cutting and training branches that are oriented in one plane, formally or informally arranged, and usually supported on a wall, fence, or trellis. The patterns can be simple or complex, but the cutting and training is precise. Ties should be replaced every few years to prevent girdling the branches at the attachment site.

Facility – Equipment or structure used to deliver or provide protection for the delivery of an essential service such as electricity.

Girdling Roots – Roots located above or below ground whose circular growth around the base of the trunk or over individual roots applies pressure to the bark area, ultimately restricting sap flow and trunk/root growth. Frequently results in reduced vitality or stability of the plant.

Heading – Cutting a currently growing or one-year-old shoot back to a bud, or cutting an older branch or stem back to a stub or lateral branch not sufficiently large enough to assume the terminal role. Heading should rarely be used on mature trees.

Heartwood – The inactive xylem (wood) toward the center of a stem or root that provides structural support.

Hook and Blade Pruning Tool – A hand pruner that has a curved, sharpened blade that overlaps a supporting hook (in contrast to *an anvil-type pruning tool*).

Horizontal Plane (palms) – An imaginary level line that begins at the base of live frond petioles.

Lateral – A branch or twig growing from a parent branch or stem.

Leader – A dominant upright stem, usually the main trunk. There can be several leaders in one tree.

Limb – Same as *Branch,* but larger and more prominent.

Lopping – See *Heading.*

Mycellum – Growth mass of fungus tissue found under bark or in rotted wood.

Obstructing – To hinder, block, close off, or be in the way of; to hinder or retard a desired effect or shape.

Parent Branch or Stem – The tree trunk or a large limb from which lateral branches grow.

Petiole – The stalk of a leaf.

Phloem – Inner bark tissue through which primarily carbohydrates and other organic compounds move from regions of high concentration to low.

Pollarding – Pollarding is a training system used on some large-growing deciduous trees that are severely headed annually or every few years to hold them to modest size or to give them and the landscape a formal appearance. Pollarding is not synonymous with topping, lopping, or stubbing. Pollarding is severely heading some and removing other vigorous water sprouts back to a definite head or knob of latent buds at the branch ends.

Precut or Precutting – The two-step process to remove a branch before the finished cut is made so as to prevent splitting or bark tearing into the parent stem. The branch is first undercut, and then cut from the top before the final cut.

Pruning – Removal of plant parts.

Qualified Line Clearance Tree Trimmer – A tree worker who, through related training and on-the-job experience, is familiar with the techniques in line clearance and has demonstrated his/her ability in the performance of the special techniques involved. This qualified person may or may not be currently employed by a line clearance contractor.

Qualified Line Clearance Tree Trimmer Trainee – Any worker undergoing line-clearance tree trimming training, who, in the course of such training, is familiar with the techniques in line clearance and has demonstrated his/her ability in the performance of the special techniques involved. Such trainees shall be under the direct supervision of qualified personnel.

Qualified Person or Personnel – Workers who, through related training or on-the-job experience, or both, are familiar with the techniques and hazards of arboriculture work including training, trimming, maintaining, repairing, or removing trees, and the equipment used in such operations.

Qualified Tree Worker, Person, or Personnel – A person who, through related training and on-the-job experience, is familiar with the hazards of pruning, trimming, repairing, maintaining, or removing trees and with the equipment used in such operations and has demonstrated ability in the performance of the special techniques involved.

Qualified Tree Worker Trainee – Any worker undergoing on-the-job training who, in the course of such training, is familiar with the hazards of pruning, trimming, repairing, maintaining, or removing trees, with the equipment used in such operations and has demonstrated ability in the performance of the special techniques involved. Such trainees shall be under the direct supervision of qualified personnel.

Remote/Rural – Areas associated with very little human activity, land improvement, or development.

Sapwood – The active xylem (wood) that stores water and carbohydrates, and transports water and nutrients; a wood layer of variable thickness found immediately inside the cambium, comprised of water-conducting vessels or tracheids and living plant cells.

Shall – As used in this standard, denotes a mandatory requirement.

Should – As used in this standard, denotes an advisory recommendation.

Stub – An undesirable short length of a branch remaining after a break or incorrect pruning cut is made.

Stubbing – See *Heading.*

Target – A person, structure, or object that could sustain damage from the failure of a tree or portion of a tree.

Terminal Role – Branch that assumes the dominant vertical position on the top of a tree.

Thinning – The removal of a lateral branch at its point of origin or the shortening of a branch or stem by cutting to a lateral large enough to assume the terminal role.

Throwline – A small, lightweight line with a weighted end used to position a climber's rope in a tree.

Topping – See *Heading.*

Tracing – Shaping a wound by removing loose bark from in and around a wound.

Urban/Residential – Locations normally associated with human activity such as populated areas including public and private property.

Utility – An entity that delivers a public service such as electricity or communication.

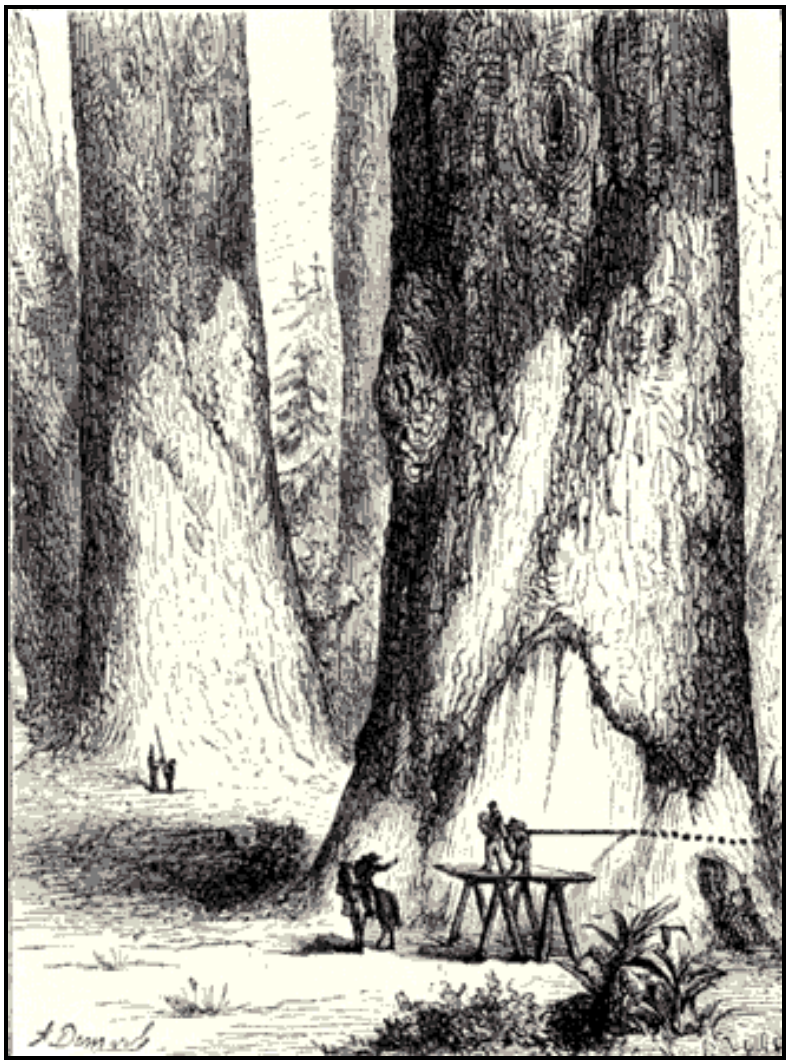
Utility Space – The physical area occupied by the utility's facilities and the additional space required ensuring its operation.

Wound – An opening that is created any time the tree's protective bark covering is penetrated, cut, or removed, injuring or destroying living tissue. Pruning a live branch creates a wound, even when the cut is properly made.

Woundwood – Differentiated woody tissue that forms after the initial callus has formed around the margins of a wound. Wounds are closed primarily by woundwood.

Xylem – Wood tissue; active xylem is called *sapwood* and inactive xylem is called *heartwood.*

Young Tree – A tree young in age or a newly installed tree.



Appendix E
Further Information

Further Information

www.itreetools.org

City of Minneapolis, Minnesota Municipal Tree Resource Analysis
McPherson, E.G., Simpson, J. R., Peper, P. J., Maco, S. E., Gardner, S. L., Cozad, S. K., Xiao, Q (2005).

Midwest Community Tree Guide
Benefits, Costs, and Strategic Planning
McPherson, E.G., Simpson, J. R., Peper, P. J., Gardner, S. L., Vargas, K. E., Maco, S.E., Xiao, Q (2006).

Appendix F
Annual Benefits (by Species)

Stevens Point

Annual Air Quality Benefits of Public Trees by Species

4/21/2010

Species	Deposition (lb) O_3	NO_2	PM_{10}	SO_2	Total Depos. ($)	Avoided (lb) NO_2	PM_{10}	VOC	SO_2	Total Avoided ($)	BVOC Emissions (lb)	BVOC Emissions ($)	Total (lb)	Total ($)	Standard Error	% of Total Trees	Avg. $/tree
Red maple	242.0	41.2	116.2	10.7	1,298	738.8	108.3	103.4	710.4	4,626	-85.3	-320	1,985.7	5,604	(N/A)	12.5	6.21
Green ash	30.8	4.9	21.1	1.4	182	378.6	55.5	53.0	363.9	2,370	0.0	0	909.2	2,553	(N/A)	11.4	3.09
Norway maple	45.8	7.9	26.8	2.0	260	298.3	43.0	40.9	277.9	1,845	-13.3	-50	729.5	2,054	(N/A)	9.1	3.13
Apple	2.7	0.4	1.9	0.1	16	39.2	5.5	5.2	34.9	238	0.0	0	90.1	254	(N/A)	6.7	0.53
Japanese tree lilac	1.2	0.2	0.8	0.1	7	18.3	2.6	2.4	16.2	111	0.0	0	41.7	118	(N/A)	4.8	0.34
Silver maple	145.8	24.7	74.8	6.5	795	393.9	57.7	55.1	378.3	2,465	-80.9	-304	1,055.8	2,957	(N/A)	4.6	8.93
Honeylocust	10.8	1.8	6.0	0.5	60	75.8	10.9	10.4	70.8	469	-6.9	-26	180.1	503	(N/A)	4.5	1.54
Littleleaf linden	11.3	2.0	7.3	0.5	66	102.0	14.8	14.1	95.7	632	-7.0	-26	240.5	672	(N/A)	4.3	2.15
White ash	12.3	2.0	7.7	0.6	71	113.6	16.7	16.0	110.5	715	0.0	0	279.3	785	(N/A)	3.9	2.79
Red pine	23.0	4.6	21.4	2.8	159	95.1	13.8	13.2	89.8	591	-77.3	-290	186.4	460	(N/A)	3.8	1.69
Northern hackberry	3.7	0.6	3.1	0.2	24	62.0	8.9	8.4	56.7	381	0.0	0	143.6	404	(N/A)	3.5	1.62
Broadleaf Decidious small	1.8	0.3	1.3	0.1	11	27.8	3.9	3.7	24.8	169	0.0	0	63.8	180	(N/A)	3.3	0.77
Elm	30.7	4.9	15.5	1.4	166	140.1	20.4	19.5	133.1	873	0.0	0	365.4	1,038	(N/A)	3.2	4.53
Amur maple	0.8	0.1	0.6	0.0	5	14.4	2.0	1.9	12.8	88	0.0	0	32.8	93	(N/A)	3.1	0.41
Spruce	10.2	2.0	9.7	1.3	71	43.4	6.2	5.9	40.3	268	-37.4	-140	81.6	198	(N/A)	2.4	1.16
Basswood	12.7	2.0	6.6	0.6	69	67.1	9.8	9.3	64.0	419	0.0	0	172.1	488	(N/A)	2.0	3.37
Eastern white pine	19.2	3.8	16.4	2.4	128	54.0	7.9	7.5	51.5	337	-75.6	-283	87.0	182	(N/A)	1.8	1.40
Siberian elm	15.9	2.7	9.0	0.7	89	89.0	13.0	12.4	84.8	555	0.0	0	227.4	644	(N/A)	1.8	5.03
Blue spruce	7.3	1.4	6.9	0.9	51	30.6	4.4	4.2	28.4	189	-23.7	-89	60.5	151	(N/A)	1.6	1.33
Northern red oak	16.1	2.8	8.3	0.7	88	57.6	8.4	8.0	55.0	360	-22.6	-85	134.3	363	(N/A)	1.3	3.74
Pin oak	19.9	3.5	11.2	0.9	112	87.0	12.7	12.1	83.0	543	-40.0	-150	190.4	505	(N/A)	1.3	5.26
Sugar maple	10.0	1.7	5.6	0.4	56	58.4	8.6	8.2	56.4	366	-8.4	-31	140.9	391	(N/A)	1.1	4.71
Other street trees	47.3	8.1	29.5	3.0	275	235.7	34.3	32.7	223.0	1,466	-40.9	-153	572.7	1,588	(N/A)	8.1	2.70
Citywide total	721.2	123.7	407.9	37.6	4,058	3,220.5	469.3	447.5	3,062.3	20,076	-519.4	-1,948	7,970.6	22,186	(N/A)	100.0	3.07

Stevens Point

Annual Aesthetic/Other Benefits of Public Trees by Species

4/21/2010

Species	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Red maple	24,068	(N/A)	12.5	24.5	26.68
Green ash	12,285	(N/A)	11.4	12.5	14.87
Norway maple	7,747	(N/A)	9.1	7.9	11.79
Apple	352	(N/A)	6.7	0.4	0.73
Japanese tree lilac	141	(N/A)	4.8	0.1	0.40
Silver maple	14,247	(N/A)	4.6	14.5	43.04
Honeylocust	2,472	(N/A)	4.5	2.5	7.58
Littleleaf linden	4,271	(N/A)	4.3	4.3	13.69
White ash	4,174	(N/A)	3.9	4.2	14.85
Red pine	3,030	(N/A)	3.8	3.1	11.14
Northern hackberry	1,668	(N/A)	3.5	1.7	6.67
Broadleaf Decidious small	274	(N/A)	3.3	0.3	1.17
Elm	3,864	(N/A)	3.2	3.9	16.87
Amur maple	123	(N/A)	3.1	0.1	0.55
Spruce	1,452	(N/A)	2.4	1.5	8.49
Basswood	1,916	(N/A)	2.0	2.0	13.21
Eastern white pine	1,723	(N/A)	1.8	1.8	13.26
Siberian elm	1,919	(N/A)	1.8	2.0	15.00
Blue spruce	1,096	(N/A)	1.6	1.1	9.70
Northern red oak	871	(N/A)	1.3	0.9	8.98
Pin oak	2,851	(N/A)	1.3	2.9	29.70
Sugar maple	1,400	(N/A)	1.2	1.4	16.86
Other street trees	6,463	(N/A)	8.2	6.6	10.97
Citywide total	98,406	(N/A)	100.0	100.0	13.61

Stevens Point

Annual CO_2 Benefits of Public Trees by Species

4/21/2010

Species	Sequestered (lb)	Sequestered ($)	Decomposition Release (lb)	Maintenance Release (lb)	Total Released ($)	Avoided (lb)	Avoided ($)	Net Total (lb)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Red maple	312,613	2,345	-13,026	-1,413	-108	263,022	1,973	561,196	4,209	(N/A)	12.5	22.6	4.67
Green ash	168,933	1,267	-5,430	-900	-47	134,679	1,010	297,283	2,230	(N/A)	11.4	12.0	2.70
Norway maple	118,939	892	-4,044	-656	-35	102,690	770	216,929	1,627	(N/A)	9.1	8.7	2.48
Apple	13,453	101	-358	-199	-4	12,931	97	25,827	194	(N/A)	6.7	1.0	0.40
Japanese tree lilac	6,690	50	-163	-109	-2	6,003	45	12,422	93	(N/A)	4.8	0.5	0.27
Silver maple	285,553	2,142	-15,080	-856	-120	140,201	1,052	409,817	3,074	(N/A)	4.6	16.5	9.29
Honeylocust	24,834	186	-735	-168	-7	26,198	196	50,129	376	(N/A)	4.5	2.0	1.15
Littleleaf linden	56,781	426	-1,485	-300	-13	35,335	265	90,332	677	(N/A)	4.3	3.6	2.17
White ash	50,113	376	-1,798	-260	-15	40,903	307	88,958	667	(N/A)	3.9	3.6	2.37
Red pine	18,450	138	-723	-360	-8	33,264	249	50,631	380	(N/A)	3.8	2.0	1.40
Northern hackberry	8,601	65	-262	-149	-3	20,950	157	29,140	219	(N/A)	3.5	1.2	0.87
Broadleaf Decidious sm	9,219	69	-249	-131	-3	9,195	69	18,034	135	(N/A)	3.3	0.7	0.58
Elm	69,393	520	-4,798	-324	-38	49,263	369	113,535	852	(N/A)	3.2	4.6	3.72
Amur maple	5,129	38	-123	-82	-2	4,746	36	9,671	73	(N/A)	3.1	0.4	0.32
Spruce	8,481	64	-346	-176	-4	14,913	112	22,872	172	(N/A)	2.4	0.9	1.00
Basswood	32,240	242	-1,981	-154	-16	23,685	178	53,791	403	(N/A)	2.0	2.2	2.78
Eastern white pine	11,850	89	-836	-209	-8	19,065	143	29,871	224	(N/A)	1.8	1.2	1.72
Siberian elm	32,563	244	-1,991	-203	-16	31,391	235	61,760	463	(N/A)	1.8	2.5	3.62
Blue spruce	3,913	29	-169	-113	-2	10,541	79	14,172	106	(N/A)	1.6	0.6	0.94
Northern red oak	16,968	127	-1,485	-143	-12	20,378	153	35,717	268	(N/A)	1.3	1.4	2.76
Pin oak	54,048	405	-2,388	-183	-19	30,733	230	82,210	617	(N/A)	1.3	3.3	6.42
Sugar maple	21,133	159	-1,403	-125	-11	20,878	157	40,483	304	(N/A)	1.2	1.6	3.66
Other street trees	92,588	694	-5,098	-643	-43	82,553	619	169,400	1,271	(N/A)	8.2	6.8	2.16
Citywide total	1,422,485	10,669	-63,969	-7,854	-539	1,133,517	8,501	2,484,178	18,631	(N/A)	100.0	100.0	2.58

Stevens Point

Annual Energy Benefits of Public Trees By Species

4/21/2010

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Red maple	156.8	16,731	20,451.1	20,042	36,773	(N/A)	12.5	22.6	40.77
Green ash	80.3	8,567	10,517.2	10,307	18,874	(N/A)	11.4	11.6	22.85
Norway maple	61.2	6,532	8,981.9	8,802	15,335	(N/A)	9.1	9.4	23.34
Apple	7.7	823	1,333.4	1,307	2,129	(N/A)	6.7	1.3	4.43
Japanese tree lilac	3.6	382	622.4	610	992	(N/A)	4.8	0.6	2.83
Silver maple	83.6	8,918	10,967.7	10,748	19,667	(N/A)	4.6	12.1	59.42
Honeylocust	15.6	1,667	2,286.9	2,241	3,908	(N/A)	4.5	2.4	11.99
Littleleaf linden	21.1	2,248	3,022.6	2,962	5,210	(N/A)	4.3	3.2	16.70
White ash	24.4	2,602	3,047.7	2,987	5,589	(N/A)	3.9	3.4	19.89
Red pine	19.8	2,116	2,786.2	2,730	4,846	(N/A)	3.8	3.0	17.82
Northern hackberry	12.5	1,333	1,969.0	1,930	3,262	(N/A)	3.5	2.0	13.05
Broadleaf Decidious smal	5.5	585	937.8	919	1,504	(N/A)	3.3	0.9	6.40
Elm	29.4	3,134	4,007.0	3,927	7,061	(N/A)	3.2	4.4	30.83
Amur maple	2.8	302	493.7	484	786	(N/A)	3.1	0.5	3.49
Spruce	8.9	949	1,328.3	1,302	2,250	(N/A)	2.4	1.4	13.16
Basswood	14.1	1,507	1,895.4	1,857	3,364	(N/A)	2.0	2.1	23.20
Eastern white pine	11.4	1,213	1,541.0	1,510	2,723	(N/A)	1.8	1.7	20.95
Siberian elm	18.7	1,997	2,535.9	2,485	4,482	(N/A)	1.8	2.8	35.02
Blue spruce	6.3	671	935.9	917	1,588	(N/A)	1.6	1.0	14.05
Northern red oak	12.1	1,296	1,625.9	1,593	2,890	(N/A)	1.3	1.8	29.79
Pin oak	18.3	1,955	2,471.3	2,422	4,377	(N/A)	1.3	2.7	45.59
Sugar maple	12.4	1,328	1,595.7	1,564	2,892	(N/A)	1.2	1.8	34.84
Other street trees	49.2	5,251	6,836.1	6,699	11,951	(N/A)	8.2	7.4	20.29
Citywide total	675.8	72,105	92,190.0	90,346	162,451	(N/A)	100.0	100.0	22.47

Stevens Point

Annual Stormwater Benefits of Public Trees by Species

4/21/2010

Species	Total rainfall interception (Gal)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Red maple	1,132,214	3,397	(N/A)	12.5	20.9	3.77
Green ash	524,168	1,573	(N/A)	11.4	9.7	1.90
Norway maple	360,115	1,080	(N/A)	9.1	6.7	1.64
Apple	24,548	74	(N/A)	6.7	0.5	0.15
Japanese tree lilac	10,916	33	(N/A)	4.8	0.2	0.09
Silver maple	993,490	2,981	(N/A)	4.6	18.4	9.01
Honeylocust	83,053	249	(N/A)	4.5	1.5	0.76
Littleleaf linden	120,841	363	(N/A)	4.3	2.2	1.16
White ash	169,166	508	(N/A)	3.9	3.1	1.81
Red pine	232,131	696	(N/A)	3.8	4.3	2.56
Northern hackberry	64,308	193	(N/A)	3.5	1.2	0.77
Broadleaf Decidious small	17,661	53	(N/A)	3.3	0.3	0.23
Elm	284,902	855	(N/A)	3.2	5.3	3.73
Amur maple	8,726	26	(N/A)	3.1	0.2	0.12
Spruce	107,992	324	(N/A)	2.4	2.0	1.89
Basswood	126,426	379	(N/A)	2.0	2.3	2.62
Eastern white pine	175,006	525	(N/A)	1.8	3.2	4.04
Siberian elm	148,931	447	(N/A)	1.8	2.8	3.49
Blue spruce	73,281	220	(N/A)	1.6	1.4	1.95
Northern red oak	88,177	265	(N/A)	1.3	1.6	2.73
Pin oak	145,192	436	(N/A)	1.3	2.7	4.54
Sugar maple	92,395	277	(N/A)	1.2	1.7	3.34
Other street trees	429,518	1,289	(N/A)	8.2	7.9	2.19
Citywide total	5,413,157	16,241	(N/A)	100.0	100.0	2.25

Appendix G
Annual Benefits, Net Benefits, and Cost Summary

Stevens Point

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

11/22/2010

Benefits	Total ($)	Standard Error	$/tree	Standard Error	$/capita	Standard Error
Energy	162,451	(N/A)	22.47	(N/A)	6.42	(N/A)
CO2	18,631	(N/A)	2.58	(N/A)	0.74	(N/A)
Air Quality	22,186	(N/A)	3.07	(N/A)	0.88	(N/A)
Stormwater	16,241	(N/A)	2.25	(N/A)	0.64	(N/A)
Aesthetic/Other	98,406	(N/A)	13.61	(N/A)	3.89	(N/A)
Total Benefits	317,915	(N/A)	43.98	(N/A)	12.57	(N/A)
Costs						
Planting	20,000		2.77		0.79	
Contract Pruning	26,000		3.60		1.03	
Pest Management	21,400		2.96		0.85	
Irrigation	17,000		2.35		0.67	
Removal	21,800		3.02		0.86	
Administration	16,000		2.21		0.63	
Inspection/Service	14,314		1.98		0.57	
Infrastructure Repairs	20,000		2.77		0.79	
Litter Clean-up	15,600		2.16		0.62	
Liability/Claims	3,000		0.41		0.12	
Other Costs	8,000		1.11		0.32	
Total Costs	183,114		25.33		7.24	
Net Benefits	134,801	(N/A)	18.65	(N/A)	5.33	(N/A)
Benefit-cost ratio	1.74	(N/A)				

Appendix H
Construction Damage and Tree Preservation

Construction Damage and Tree Preservation

Trees are valuable assets. They clean the air, provide shade and wind protection, add aesthetic benefits, decrease cooling and heating costs, provide pollution control, provide stormwater management benefits, and increase property value.

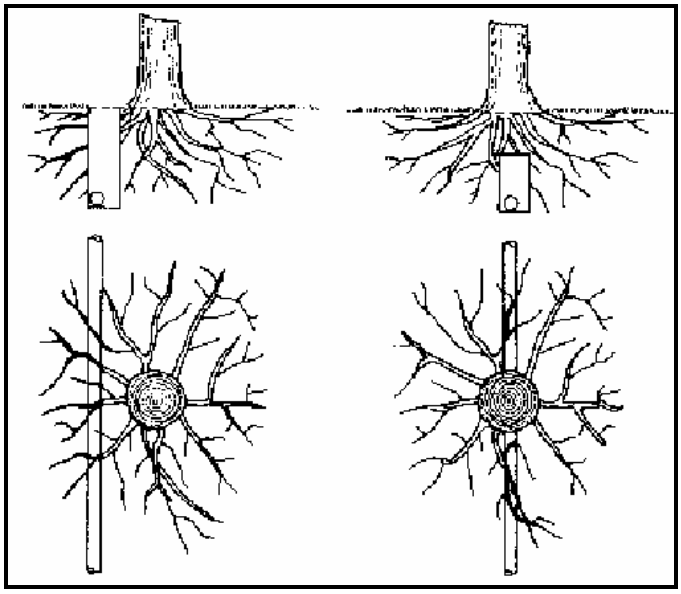
Unfortunately, when expansion occurs in the name of progress, trees are often compromised in the process. Attempts to save trees during the construction process are often doomed unless protective measures are carefully implemented prior to and strictly enforced during construction.

Scientists and arborists agree that the greatest percentage of tree roots are in the upper 12 to 18 inches of soil and extend well beyond the spread of the canopy. Trees are adversely affected both above and below ground by construction activities. To preserve trees during construction activities, every possible preservation technique must be implemented to minimize damage.

The following activities damage trees during construction:

1. **<u>Trenching</u>:** Construction equipment can injure a tree by tearing or breaking limbs and/or roots and by damaging the bark and wounding the trunk. Wounds created from these actions are permanent and can be fatal if extensive.

Whenever possible, trenching should be restricted to areas that will disturb the least amount of root systems. Where this cannot be achieved because of other site restrictions, tunneling or directional boring should be considered. These practices minimize tree damage by keeping root injury to a minimum.



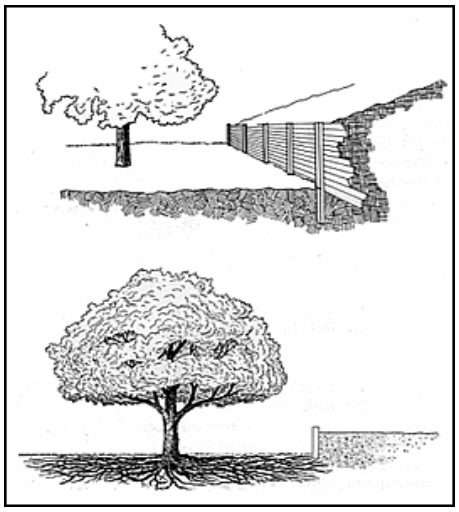
2. **<u>Soil Compaction</u>:** The most damaging effect of construction activity is soil compaction. Species tolerance to compaction varies, but most trees will suffer when the surrounding soil is compacted extensively.

Soil compaction during construction is usually due to equipment and vehicles continually driving over the root zone and from construction supplies and materials being stored for long periods of time near trees. Compaction happens very quickly and is difficult, if not impossible, to correct. Only seven passes of a small tractor over the same area is enough to change a porous soil consistency to one similar to concrete.

To remedy this, fencing and 'off-limits' areas should be established. If this cannot be accomplished, then a thick layer of unrefined (coarse) wood chips (12 to 18 inches deep) or sturdy geotextile materials can be temporarily laid over the driving area to reduce compaction.

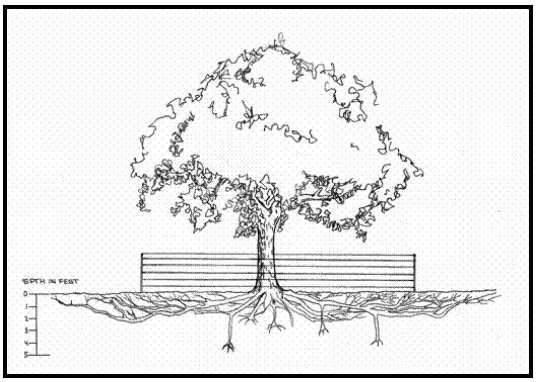
3. **<u>Soil Clearing and Grading</u>:**

Mechanical damage, soil compaction, and stripping of soil nutrients can all be avoided by preserving a tree's root zone. Restricting construction activity in and near the root zone by erecting metal, plastic, or wood fencing is the most effective means of avoiding damage to roots, trunks, and crowns.



Also, site design solutions are available to achieve required grade changes and to retain trees. The project architect and/or engineer, working in conjunction with a qualified arborist, can help develop innovative solutions to construction activities and tree preservation.

Branches directly interfering with construction work should be properly pruned back. If a tree is severely injured, it should be removed.



Ultimately, a *Tree Preservation Plan* should be developed specifically for all construction projects in the City that will affect trees. A preservation plan must note that protective tree fencing shall be installed prior to any site work and that it be placed at or outside of the dripline to ensure survivability of existing trees. It must also state that no site disturbing activities (cut, fill, parking, or material storage) shall take place inside the fenced area. It is also a very good idea to post signs on the fencing that display all pertinent information such as potential penalties, City forester's name and phone, etc.

Trees that are only slightly damaged may be restored to a healthy condition by pruning, watering, fertilizing, core aeration, and/or radial trenching.

While trees that have been disrupted by construction activities may not be showing signs of damage or stress now, they may show signs of decline in the near future. Trees in construction zones can be damaged or killed by root severance, soil compaction, soil grading, and/or construction materials (toxic leaks and spills).

Tables 1 and 2 list symptoms of construction damage and methods to minimize damage to trees. More information about construction damage and protecting trees during construction is included in Appendix O.

Table 1. Symptoms and Signs of Construction Activity Damage

Tree Part	Symptoms and Signs of Damage
Crown	Slow growth rate, staghorns, and/or dieback
Leaves	Wilted, scorched, sparse, undersized, distorted, chlorotic, browning margins, premature autumn color, and/or premature drop
Trunk	Wounds, absent bark, crown rot, absence of buttress (root) flares, adventitious sprouting, suckering, and/or severe insect damage and disease
Branches	Dieback, slow growth rate, wounds, adventitious sprouting, and/or suckering
Fruits and flowers	Abnormally large crop, absence of fruit, and/or flowering out of season

Table 2. Major Construction Impacts and Methods to Minimize Damage

Impact to Tree	Construction Activity	Methods/Treatments to Minimize Damage
Root Loss	Stripping site of organic surface soil during mass grading	Restrict stripping of topsoil around trees. Any woody vegetation (slated for removal and adjacent to preserved trees) should be cut at ground level and not pulled out by equipment. This will prevent tree root injury.
	Lowering grade; scarifying; preparing subgrade for fills and/or structures	Use retaining walls with discontinuous footings to maintain natural grade as far as possible from trees. Excavate to finish grade by hand and cut exposed roots with a saw to avoid root wrenching and shattering by equipment, or cut with root pruning equipment. Spoil beyond cut face can be removed by equipment sitting outside the dripline of the tree.
	Subgrade preparation for pavement	Use paving materials requiring a minimum amount of excavation (e.g., reinforced concrete instead of asphalt). Design traffic patterns to avoid heavy loads adjacent to trees (heavy load bearing pavement requires thicker base material and subgrade compaction). Specify minimum subgrade compaction under pavement within dripline (extra reinforcement in concrete or geotextile under asphalt may be needed).
	Excavation for footings, walls, and/or foundations	Design walls/structures with discontinuous footings/pier foundations. Excavate by hand. Avoid slab foundations/post and beam footings.
	Trenching for utilities and/or drainage	Coordinate utility trench locations with installation contractors. Consolidate utility trenches. Excavate trenches by hand in areas with roots larger than 2 in. in diameter. Tunnel under woody roots rather than cutting them.
Wounding Top of Tree	Injury from equipment	Fence trees to enclose low branches and protect trunk. Report all damage promptly so arborists can treat appropriately.
	Pruning for vertical clearance for buildings, traffic, and/or construction equipment	Prune to minimum height required prior to construction. Consider minimum height requirements of construction equipment and emergency vehicles over roads. An arborist, not construction personnel, should perform all pruning.
Unfavorable Conditions for Root Growth; Chronic Stress from Reduced Root Systems	Compacted soils	Fence-off trees to keep traffic and storage out of root area. In areas of engineered fills, specify minimum compaction (usually 85%) if fill will not support a structure. Provide a storage yard and traffic areas for construction activity well away from trees. Protect soil surface from traffic compaction with thick mulch. Following construction, vertical mulch compacted areas. Install aeration vents.

Table 2. Major Construction Impacts and Methods to Minimize Damage (Continued)

Impact to Tree	Construction Activity	Methods/Treatments to Minimize Damage
Unfavorable Conditions for Root Growth; Chronic Stress from Reduced Root Systems (Continued)	Spills and/or waste disposal (e.g., paint, oil, fuel)	Post notices on fences prohibiting dumping and disposal of waste around trees. Require immediate cleanup of accidental spills.
	Soil sterilants (herbicides) applied under pavement	Use herbicides safe for use around existing vegetation and follow label directions.
	Impervious pavement over soil surface	Utilize pervious paving materials (e.g., interlocking blocks set on sand). Install aeration vents in impervious paving.
Inadequate Soil Moisture	Rechannelization of stream flow, redirecting runoff, lowering water table, and/or lowering grade	In some cases, it may be possible to design systems to allow low flows through normal stream alignments and provide bypass into storm drains for peak flow conditions. (Usually flood control and engineering specifications are not flexible where the possibility of flooding occurs). Provide supplemental irrigation in similar volumes and seasonal distribution as would normally occur.
Excess Soil Moisture	Underground flow backup; raising water table	Fills placed across drainage courses must have culverts placed at the bottom of the low flow so that water is not backed up before rising to the elevation of the culvert. Study the geotechnical report for groundwater characteristics to see that walls and fills will not intercept underground flow.
	Lack of surface drainage away from tree	Where surface grades are to be modified, make sure that water will flow away from the trunk; i.e., that the trunk is not at the lowest point. If the tree is placed in a well, drainage must be provided from the bottom of the well.
	Compacted soils; irrigation of exotic landscapes	Compacted soils have few macropores and many micropores. Core vent to improve drainage. Some species cannot tolerate frequent irrigation required to maintain lawns, flowers, and other shallow-rooted plants. Avoid landscaping under those trees, or utilize plants that do not require irrigation.
Increased Exposure	Thinning stands; removal of undergrowth	Preserve species that perform poorly in single stands as groups or clusters of trees. Maintain the natural undergrowth.
	Reflected heat from surrounding hard surfaces	Minimize use of hard surfaces around trees. Monitor soil moisture needs where water use is expected to increase.
	Pruning	Avoid severe pruning where previously shaded bark would be exposed to sun. Where pruning is unavoidable, provide protection to bark from sun.

Appendix I
Invasive Species Technical Bulletins

TECHNICAL BULLETIN

DAVEY

Prepared by The Davey Institute

DUTCH ELM DISEASE

Ophiostoma ulmi (syn. Ceratocystis ulmi)

Dutch elm disease is one of the most destructive shade tree diseases in the United States and Canada, and has killed millions of elm trees since its introduction from Europe in 1930. Despite this loss, many elms still remain as street trees or specimen shade trees providing grace and beauty to our landscapes.

SYMPTOMS: Infected elm trees display wilted leaves on one or a few branches in the crown of the tree – called flagging. The wilted leaves may turn yellow, curl, and/or turn brown. Leaves can remain attached to the stem or prematurely fall off. Stems exhibiting flagging typically die back.

If bark is peeled away from stems exhibiting yellow, brown or wilted leaves, brown streaking may be visible in the sapwood just under the bark. Sometimes streaking is embedded deeper in the wood, which indicates that the infection occurred in previous years.

CAUSE: The disease is caused by the fungus *Ophiostoma ulmi*. Both the smaller European elm bark beetle and native elm bark beetle can transfer fungal spores of the disease from infected elms to healthy elms. The fungus is transmitted to healthy trees when beetles carry fungal spores after feeding in stem crotches of diseased elms.

Direct transmission of the disease occurs when diseased trees and healthy trees in proximity to each other have connecting root grafts. Elms that are within 40 feet of each other have a good chance of having root grafts.

SOLUTIONS:

1. All infected elms and dead or dying branches on healthy elms should be promptly removed and destroyed to prevent build-up of beetle and fungal populations. Prompt removal of diseased branches can help stop the spread of the disease in a tree if it has not progressed within 10 feet of the main trunk.
2. To prevent root graft transmission of the disease from infected to healthy elm trees, trees suspected of having root grafts should have them severed by trenching or soil fumigation.
3. Systemic fungicides can be trunk injected for preventive and therapeutic treatment. Trees receiving therapeutic fungicide treatments have the best response if the crown has 5% or less infection.
4. Research indicates that attempts to manage the bark beetle with insecticides may not be effective. The feeding sites of beetles (stem crotches) must be protected with insecticides, which is difficult with current equipment, pesticides and technology. The alternate option is the protection of susceptible trees with preventative trunk injections of recommended fungicides.
5. Trees maintained with good cultural practices such as fertilization, watering, mulching and selective pruning will have the best health and vitality.

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T15064 – 8/2002

TECHNICAL BULLETIN

DAVEY

Prepared by The Davey Institute

EMERALD ASH BORER

(Agrilus planipennis)

The emerald ash borer is an exotic Asian insect pest whose presence has been confirmed in Michigan, Ohio, Maryland and Ontario, Canada. Infested trees have been found in urban areas, woodlots and nursery stock. This borer has killed millions of trees, from small, young specimens to established, mature specimens.

Figure 1. Adult borers grow to ⅝" in length.

HOSTS: In the United States, the borer has been detected only on ash tree species, including black ash (*Fraxinus nigra*), blue ash (*F. quadrangulata*), green ash (*F. pennsylvanica*) and white ash (*F. americana*).

IDENTIFICATION AND LIFE CYCLE: The adult beetle is elongate, metallic green and ⅜ to ⅝ inches long (Figure 1). In Michigan and Ohio, adults emerge from early to mid-June until early August, feeding on a small amount of foliage (this causes jagged leaf edges). Females lay one to two eggs deep into bark crevices and lower main branches. After eggs hatch, the larvae tunnel through the bark and feed on the phloem and outer sapwood for several months. The mature larvae are cream colored and 1 to 1¼ inches long (Figure 2). Fully-grown larvae overwinter under the bark or sometimes in pupal cells made of outer sapwood. There is one generation per year.

Figure 2. Larva (Photo credit: Michigan State University).

SYMPTOMS AND SIGNS: Initial symptoms include yellowing and/or thinning of the foliage and longitudinal bark splitting (Figure 3). The entire canopy may die back, or symptoms may be restricted to certain branches. Declining trees may sprout epicormic shoots at the tree base or on branches. Removal of bark reveals tissue callusing and frass-filled, serpentine tunneling. The S-shaped larval feeding tunnels are about ¼ inch in diameter. Tunneling may occur from upper branches to the trunk and root flare. Adults exit from the trunk and branches in a characteristic D-shaped exit hole about ⅛ inch in diameter. The intense tunneling disrupts water and nutrient flow, causing trees to lose between 30 and 50 percent of their canopies during the first year of infestation. Trees often die within two years following infestation.

Figure 3. Bark splitting.

MANAGEMENT: Removal and chipping or incineration of infested wood is recommended. Stumps should be ground out. Quarantines have been set up to prevent movement of untreated ash lumber, firewood or nursery stock from the affected areas. Those who are concerned about protecting valuable trees should contact a Davey arborist.

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G3590

Lake States Woodlands

Oak wilt management—what are the options?

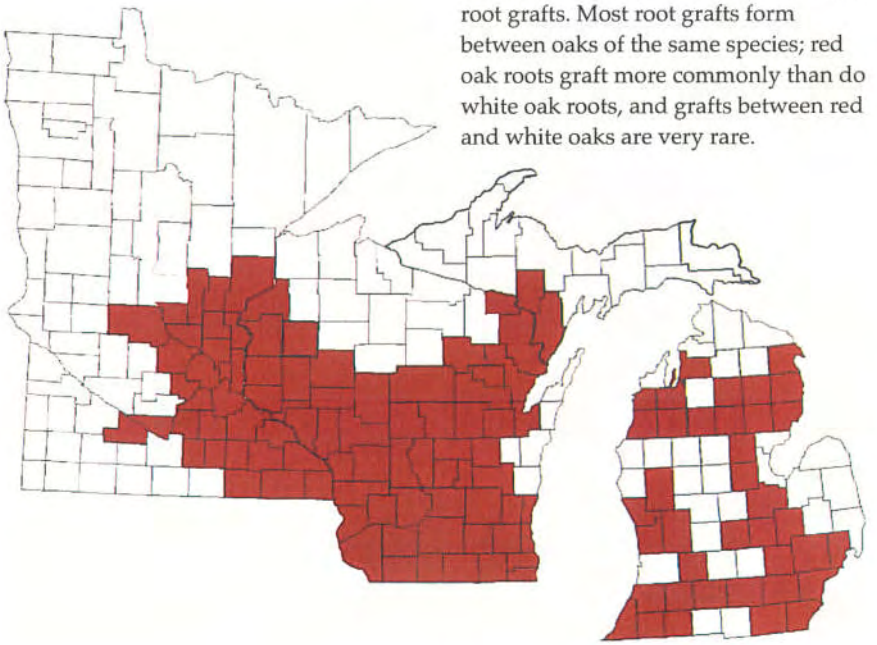
Jane Cummings Carlson, A. Jeff Martin and Kyoko Scanlon

Trees at risk

Thousands of oaks in woodland and urban settings die from oak wilt every year. Widespread in Wisconsin, Minnesota and Michigan, the disease is caused by the fungus *Ceratocystis fagacearum*. Figure 1 shows the extent of oak wilt in Michigan, Minnesota and Wisconsin.

Trees from the white and red oak groups, both found commonly in the Lake States, are susceptible to oak wilt. Because trees in the red oak group fall prey to the disease most often, this publication focuses on the red oak group.

Figure 1. This map shows the county distribution of oak wilt in Michigan, Minnesota and Wisconsin in 2010. Map produced by the USDA Forest Service, Northeastern Area–Forest Health Monitoring GIS Group.



Biology and spread of oak wilt

Mats of fungus, known as "pressure pads," develop under the bark of trees that have died from oak wilt (example 1a). Mats form most often in spring, approximately 9-10 months after a tree dies from oak wilt. These mats force the bark to crack open. The fungus produces a sweet odor that attracts sap-feeding beetles such as Nitidulids (example 1b). The beetles pick up fungal spores by crawling on the mats. Then they fly to healthy oaks to feed on sap flowing from fresh wounds, thus infecting new trees.

As fungus invades a tree's water conducting system, the leaves turn dull green, bronze or tan, and wilt from the top of the tree downward (example 1c). Leaves fall rapidly after wilting. Infected trees are bare in 4-6 weeks.

Underground spread of oak wilt from infected to healthy trees occurs through root grafts. Most root grafts form between oaks of the same species; red oak roots graft more commonly than do white oak roots, and grafts between red and white oaks are very rare.

Example 1a. In April, May and June, fungal mats ("pressure pads") grow under the bark of trees that wilted the previous summer. Mats are sometimes present in late summer or fall.

Example 1b. Fungal mats force the bark to crack open. The mats' odor attracts sap-feeding beetles which spread the disease to healthy trees.

Example 1c. The fungus invades the tree's water-carrying system, causing leaves to wilt and fall. Wilting occurs most often in July and August, and occasionally in spring or fall.

Prevention, sampling and management

Prevention

You can take two precautions to lessen the chances of oak wilt invading your yards and woodlands.

1. **Do not harvest, prune or otherwise wound oak trees from bud swell up to two or three weeks past full leaf development.** During this time, fungal mats are most abundant and oak trees most vulnerable to oak wilt. In the urban setting, remember not to prune oak trees from April through July. If the spring comes early with unusually warm temperatures, pruning may need to stop before the beginning of April in some years. Infection is less common later in the summer but can occur after July. If you decide to take a very cautious approach—limit any cutting activities from April 1 to October 1. If wounding does occur, apply a tree wound paint immediately. These products normally inhibit proper wound closure so limit your use of tree paint to these situations.

   In the forest setting, the Wisconsin Department of Natural Resources developed new oak harvesting guidelines. The guidelines are site-specific, and based on factors that affect the risk level of introduction and spread of this disease. For more information about oak harvesting guidelines in the forest setting, please visit http://dnr.wi.gov/forestry/fh/oakWilt/guidelines.asp

2. **Do not move infected trees with the bark still attached (as firewood or logs) into your woodlands.** Pressure pads may form on the transported wood, attracting insects that spread oak wilt.

   Note: The research on the transmission of oak wilt through tools is minimal. Transmission of the pathogen was observed via selected tools through artificial inoculation; however no evidence of natural spread through a variety of tools has been confirmed. At this time, it does not appear necessary to disinfect the tools.

Example 2a. Don't confuse oak wilt with the two-lined chestnut borer. Galleries, or feeding tunnels of the two-lined chestnut borer are visible in this photo. The insect causes symptoms resembling that of oak wilt with one notable difference—trees infested with the chestnut borer usually keep their dead leaves, while trees with oak wilt lose them.

Sampling

You may need a laboratory analysis to confirm the presence of oak wilt. To obtain an analysis, collect three twigs (about ½ in. diameter and 4 in. long) from three different branches with wilting leaves. You must send samples which still have live tissue. Scratch the sample branch with your fingernail. If the wood under the bark is a light color (white to green), the sample is fresh. If the wood is brown or dark, it is too old to be useful. Wrap the samples in wax paper and keep them cool until you mail them.

In Wisconsin, mail your samples to:
Plant Disease Diagnostic Clinic
Dept. of Plant Pathology
University of Wisconsin-Madison
1630 Linden Drive
Madison, WI 53706
(608) 262-2863
www.plantpath.wisc.edu/PDDC

In Minnesota, send them to:
Minnesota Dept. of Agriculture
Plant Protection Laboratory
90 West Plato
St. Paul, MN 55108
(651) 296-4749
www.mda.state.mn.us

In Michigan, mail to:
State Pathologist
Michigan Dept. of Agriculture
Laboratory Division
1615 Harrison Rd.
East Lansing, MI 48823
(517) 337-5091

Example 2b. This aerial view shows the characteristic pocket of dead trees, a hallmark of oak wilt.

A fee may be charged for testing. Call the appropriate lab to determine charges.

If sampling results are negative

If your samples test negative for oak wilt, check for the presence of the two-lined chestnut borer which harms trees by tunneling between the bark and wood (example 2a). This insect causes leaves to wilt and turn brown in mid-summer when larvae feed between the bark and wood of infested trees. Dead leaves generally remain on the tree. A few branches or the whole crown may be affected. (Oak wilt always affects the entire crown in red oaks.)

If sampling results are positive

There are two management strategies from which you can choose.

Passive management. If you allow the disease to progress, it will spread to healthy oaks through the roots of diseased trees. In the Lake States, oak trees may grow in pure or relatively homogeneous stands. You may also find them mixed with species such as white pine, sugar maple, basswood and white birch (common in the northern hardwood forest type), or hickory, elm, ash, aspen, and black cherry (species common in the oak-hickory forest type).

In pure oak stands, the disease moves outward from the original infected trees through root grafts, killing more trees each year. This creates the pocket of dead trees that characterizes oak wilt. In mixed stands, where oaks are scattered among other species, root grafts may occur less often than in pure oak stands; thus, spread may be slower or less conspicuous. New pockets can appear in your woodlands from overland spread by Nitidulid beetles feeding on fresh wounds (example 2b).

If you allow the disease to progress, you should consider the impact on the health of neighboring trees. Even if root-graft spread to your neighbor's trees is unlikely, overland spread to a neighbor's yard or woodlot is a real possibility. Proper removal and utilization of infected trees reduces the hazard of overland spread. You can find guidelines for removing and using dead and infected trees in the section on active management.

As oaks die, the open spaces and dead trees can provide valuable feeding and nesting sites for wildlife. When overstory trees die, the site often becomes brushy for about ten years. Warblers, grosbeaks, cuckoos, cardinals, grouse, rabbits, deer and shrews will be attracted to the brushy area. Brown creepers may nest under the sloughing bark on dead trees. Dead trees will furnish insects for birds, and larger specimens may provide perches for raptors.

Example 3b. Oak wilt trenching.

Example 3c. Crown wilt indicates the presence of oak wilt.

Example 3a. The vibratory plow is a tracked or rubber-tired vehicle with a vibrating head attached at the rear. A knife-like plow blade with a slight hook at the bottom is attached to the vibrating head. The blade is pulled horizontally through the soil, slicing the root connections.

Activema nagement. Since oak wilt spreads both underground and above ground, you must combat it with a two-pronged approach. To contain the disease:

1. **install a root graft barrier; and**
2. **remove and properly use trees inside the barrier.**

Installing a root graft barrier. Root graft barriers break the root connections between infected and healthy trees. A barrier should be at least four, and preferably five feet deep. Trenchers and vibratory plows are the tools most commonly used for this job (example 3a, 3b, 3d).

Locating the root graft barrier. Properly locating the root graft barrier is critical to stopping the underground spread of oak wilt. Incorrectly placing the barrier may cancel out your efforts to halt the disease (figure 2).

A forest pest specialist, forester or arborist trained in oak wilt management should work with you to plan the barrier location. Choose a location for the barrier in early August, after most of the year's infected trees have wilted. Barrier installation should take place before the soil freezes.

To determine where to place the barrier, measure the diameters at 4½ feet above the ground (or diameter at breast height, DBH) of an infected tree (example 3c) and a nearby apparently healthy tree; add these figures to calculate the combined diameter. A sprout clump is represented as the sum of the diameters of all its stems. Measure the distance between the same two trees. Consult table 1 to determine the minimum inter-tree distance listed for the combined diameters.

If the two trees are closer than the distance listed in the table, the barrier should be placed outside the apparently healthy tree. If the two trees are farther than the distance listed in the table, the barrier should be placed inside the apparently healthy tree.

Research shows that three factors significantly determine the likelihood of two trees grafting:

1) diameter;
2) distance between the trees; and
3) soil and drainage characteristics.

In general, root grafts spread oak wilt farther in shallower than in deeper soils, and in sandier than in loamier soils. The exact underground location of the oak wilt pathogen is unknown.

Table 1. Distances for loamy sand and sandy soils were based on 95% confidence level model of Bruhn et al. (1992); Distances for sandy loam and loam soils were extrapolated from sandy loam model at 80% confidence level.

Combined DBH (inches)	Inter-tree distance sandy	loamy sand	sandy loam/loam
2	3.9	3.1	2.2
4	7.8	6.2	4.5
6	11.6	9.3	6.7
8	15.5	12.4	8.9
10	19.4	15.4	11.2
12	23.3	18.5	13.4
14	27.2	21.6	15.6
16	31.0	24.7	17.9
18	34.9	27.8	20.1
20	38.8	30.9	22.3
22	42.7	34.0	24.6
24	46.6	37.1	26.8
26	50.4	40.2	29.1
28	54.3	43.2	31.3
30	58.2	46.3	33.5
32	62.1	49.4	35.8
34	66.0	52.5	38.0
36	69.8	55.6	40.2
38	73.7	58.7	42.5
40	77.6	61.8	44.7
42	81.5	64.9	46.9
44	85.4	68.0	49.2
46	89.3	71.1	51.4
48	93.1	74.1	53.6

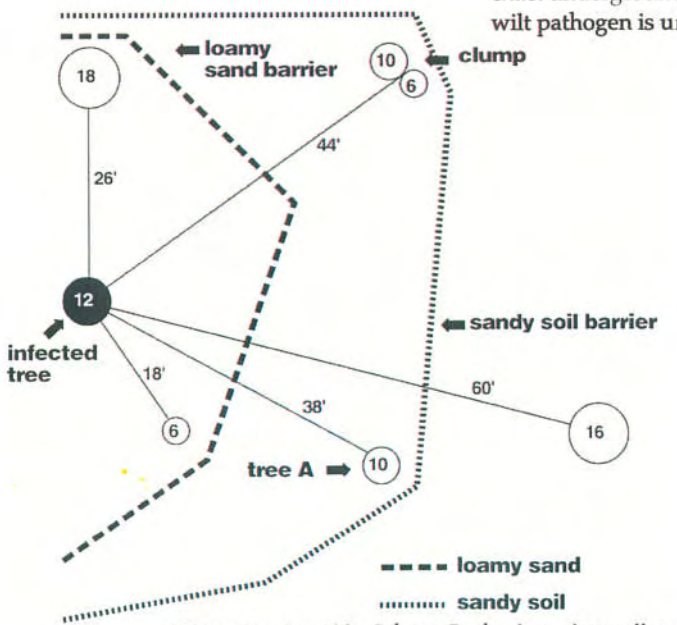


Figure 2. Based on table 1, tree A must be at least 34 feet away from the infected tree on loamy sand, and 42.7 feet away on sandy soil, to assume that it has not been infected through root graft. Table 1 forecasts with 95% accuracy.

Since tree A is farther than the recommended guidelines for loamy sand, a barrier can be placed between the healthy and diseased tree. On sandy soil, tree A is less than the recommended safe distance, so you can conclude with 95% certainty that the tree has been infected and that a barrier must be placed outside it.

Model developed by Johann Bruhn from data colleted in Menominee County, MI.
Bruhn, J.N., and Heyd, R.L., 1992, Biology and Control of Oak Wilt in Michigan Red Oak Stands, *Northern Journal of Applied Forestry* 9(2): 47-51.

The method shown in figure 2 attempts to include, inside the root graft barrier, all apparently healthy oaks with a 5% or greater chance of being infected in the first year after installation of the root graft barriers. Additional lines closer to diseased trees can be installed in an effort to save more trees, but such attempts often fail. This model was developed for sites with sand and loamy sand soils. Use of the model for root graft barrier placement on sites with sandy loam and heavier textured soil will predict longer root grafting distances than what actually occurs. Thus, if this model is used on sandy loam or loamy sites, the number of healthy trees removed to the line increases. The inter-tree distances to use for such sites were extrapolated accordingly based on a recent study in Minnesota (Arboriculture and Urban Forestry, in press), and are provided in table 1 when such sacrifices are unacceptable to the landowner.

Removing and using infected trees

You must install root barriers before trees in the pocket of wilting trees are removed. Water tension released when live wilting trees are felled permits fluids to move rapidly to grafted healthy trees beyond the intended barrier. **Remove all dead trees with the bark attached and all apparently healthy trees from inside the barrier** (all trees over 3 in. in diameter should be removed). Apply an herbicide registered for treating cut oak stumps to prevent sprouting and minimize the chance of roots regrafting across the barrier. If you do not use an herbicide, sprouts may continue to keep the disease active in the pocket, posing a risk to trees outside the barrier. Remove trees and treat stumps after placing the barrier and before the following April (when fungal mats may form). You do not need to remove trees with loose bark since they can no longer produce fungal mats.

Example 3d. A trencher is a rubber-tired vehicle with a digging chain attached to the back. The chain moves along a boom, digging a trench and breaking root grafts as it is pulled through the soil.

WHITE OAKS

- **Types:** White oak, bur oak, swamp white oak
- Oaks in the white oak group have greater resistance to oak wilt. They often remain healthy after surrounding black and red oaks succumb to the disease.
- **Symptoms:** Wilted and bronzed leaves appear on scattered branches; leaf fall is usually light. More branches may die each year until the tree dies—or the tree may survive.

white oak

bur oak

RED OAKS

- **Types:** northern red oak, northern pin oak, black oak
- Oaks in the red oak group are most susceptible to oak wilt. Trees die rapidly after leaves wilt.
- **Symptoms:** Leaves wilt from the top of the tree downward. Leaf fall is usually heavy and occurs during and shortly after leaves wilt. Wilting takes place most often in July and August.

red oak

black oak

Firewood. Dead trees with the bark attached should be debarked, chipped, or cut and split to hasten drying. Stack the cut pieces and place them in the sun; tarp the stack with 4 mil plastic. Placing the tarped pile in the sun will hasten bark deterioration and loosen the bark quicker. Seal the plastic around the base to be as airtight as possible to prevent insects from reaching the fungal mats. If the wood is not burned over the winter, leave the tarp on until the end of the following summer (approximately one year after cutting).

Moving infected firewood without careful attention to tarping can contribute to overland spread of oak wilt. Wood from dead trees with loose bark, and from apparently healthy trees with no wilting symptoms, does not pose a danger and does not require tarping.

Wisconsin has developed a number of requirements pertaining to the movement of firewood coming into the state and the movement of firewood within the state's borders. This is to limit the spread or introduction of invasive insects and diseases that are easily transported on firewood. For more information about firewood restrictions, please visit the Wisconsin Department of Agriculture, Trade and Consumer Protection website at http://datcp.state.wi.us/arm/environment/insects/firewood_restrictions/

Other wood products. Wood from infected trees may be sold to a sawmill or chipping facility—preferably one which is several miles away from the nearest red oak. Advise the purchaser that the infected trees with attached bark must be used over the coming winter.

Regenerating oak in the pocket. Though information on the likelihood of oak wilt transferring to regenerated growth is sparse, it is clear that thorough tree removal and stump treatment minimize the risk. Planting oak seedlings or encouraging natural oak seeding in the pocket can be tried after you remove the infected trees and treat the stumps. You may need to apply herbicides to sprouts for two to three years after cutting if sprouts continue to form inside the barrier.

Chemical treatment. Fungicides have recently been developed and may be added to the management toolbox. Currently available products contain the active ingredient propiconazol. This product may be effective in preventing oak wilt when injected into living oak trees without disease symptoms. If you are considering using chemical treatment, contact an arborist specializing in oak wilt management. The cost and intensity of this level of management is typically reserved for high-value urban oaks.

Herbicides as a tool to stop root graft transmission of oak wilt

Several studies have been conducted to test the effectiveness of various herbicides in stopping the transmission of oak wilt by root grafts in the Lake States. Three different combinations of herbicides were tested. Products tested included various formulations and combinations of Garlon 3A, Garlon 4, Arsenal AC, Stalker and Tordon RTU.

The results showed that some products were effective in killing the aboveground portions of the trees; some were not. None of the products killed roots completely in a timely manner. This lack of complete root death indicates herbicides may not be effective in stopping root graft transmission of oak wilt. There is a similar study in progress in Wisconsin and the test sites are being monitored.

Herbicides continue to be an important tool for killing or at least weakening trees and sprouts inside a trenched area. However, at this printing, herbicides should not be presented as a proven means of creating effective root graft barriers.

UW Extension
Cooperative Extension

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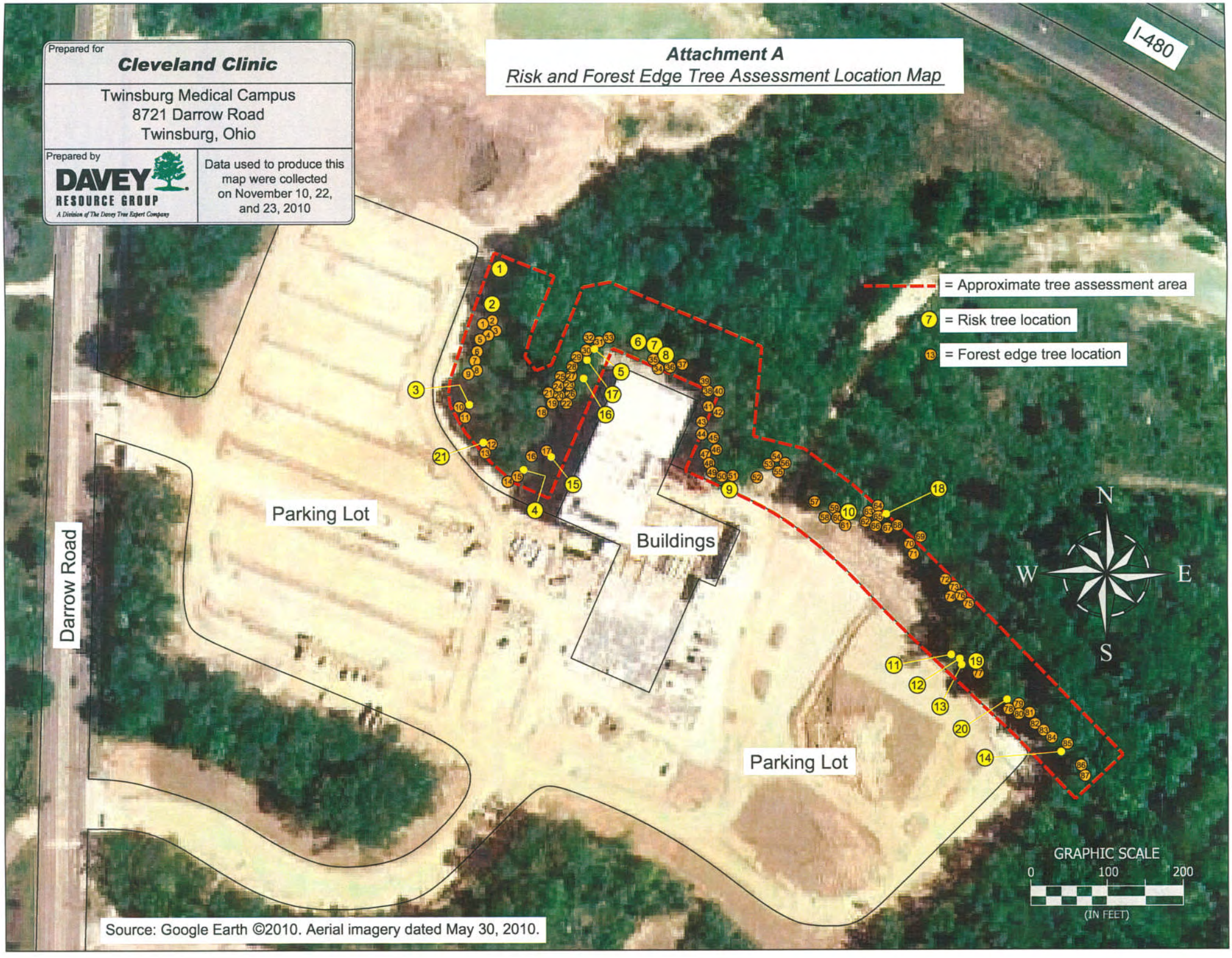
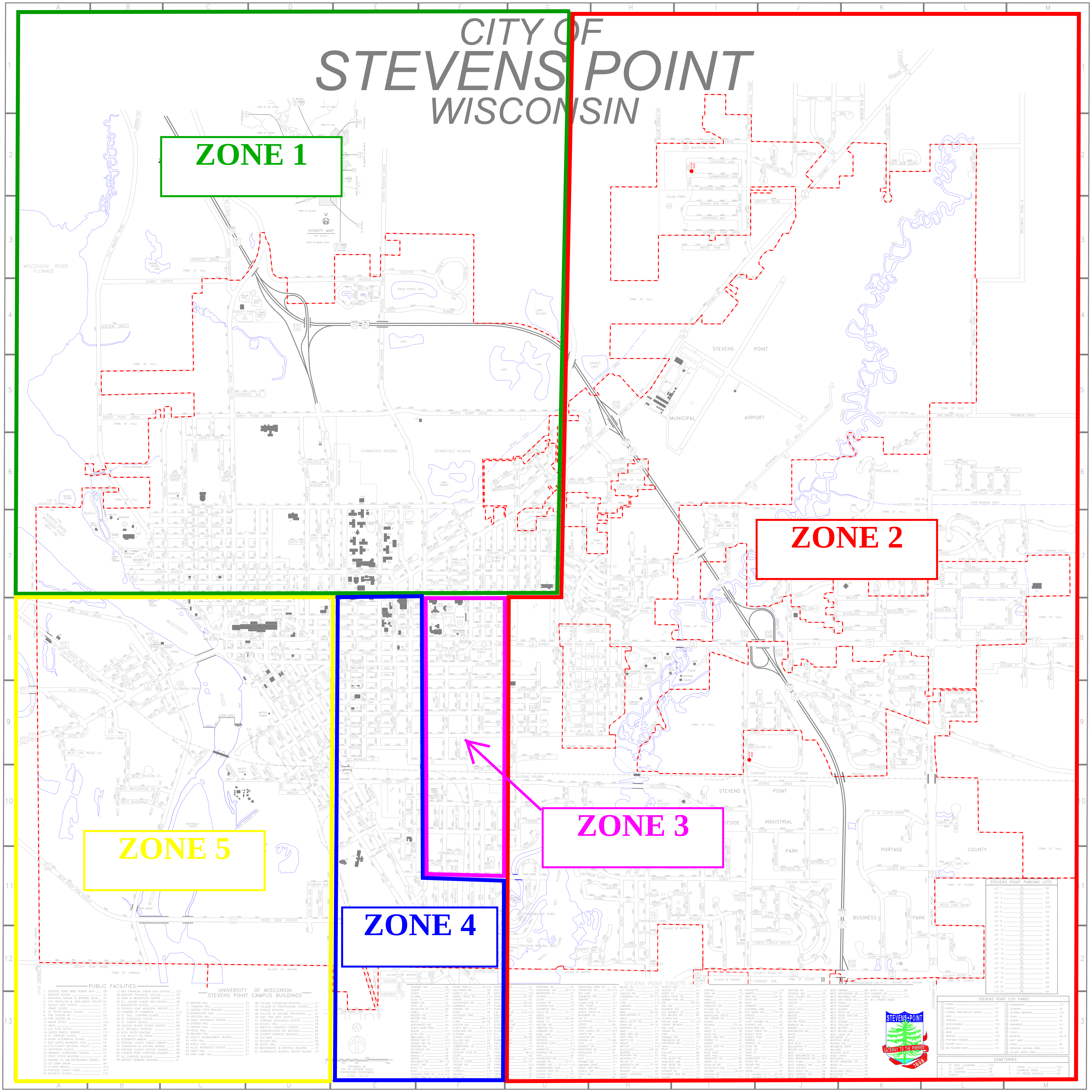

Prepared for
Cleveland Clinic
Twinsburg Medical Campus
8721 Darrow Road
Twinsburg, Ohio
Prepared by
DAVEY RESOURCE GROUP
A Division of The Davey Tree Expert Company
Data used to produce this map were collected on November 10, 22, and 23, 2010
Attachment A
Risk and Forest Edge Tree Assessment Location Map
I-480
= Approximate tree assessment area
= Risk tree location
= Forest edge tree location
Parking Lot
Buildings
Parking Lot
Darrow Road
N
W
E
S
GRAPHIC SCALE
0
100
200
(IN FEET)
Source: Google Earth ©2010. Aerial imagery dated May 30, 2010.

Appendix J
Recommended Management Zones


CITY OF
STEVENS POINT
WISCONSIN
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5