# Campus Tree Management Plan and Campus Environmental Asset Review

University of Windsor
Windsor, Ontario

**July 2011**

DAVEY RESOURCE GROUP

*A Division of The Davey Tree Expert Company*

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## *Acknowledgement*

*Thank you to:*

*To the dedicated Staff of Facility Services, Environmental Services for their vision and dedicated work toward enhancing and sustaining the University of Windsor campus landscape for the benefit of future generations.*

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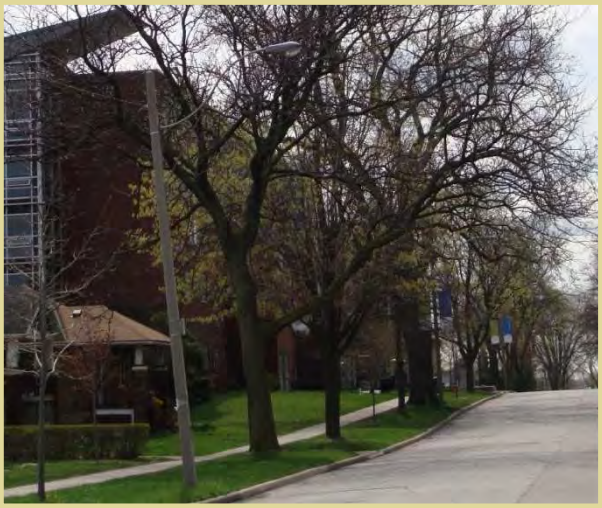
# Executive Summary

The campus at the University of Windsor is a vibrant and bustling community used frequently by students, faculty, staff, and visitors. Trees are an integral component of this campus landscape. They provide shade and beauty, and enhance the appearance of buildings, parking lots, common areas and streets. Trees help reduce noise levels, cleanse pollutants from the air, produce oxygen and absorb carbon dioxide, deflect stormwater, and provide habitat for wildlife. The campus forest improves the quality of life for all, and provides significant economic benefits to the University.

The campus forest is a prominent asset of the University that, with proper care, will actually continue to increase in value with each passing year. Trees, when properly maintained, can return ecological and economic benefits to the campus far in excess of the time and money invested in them for planting, pruning, protection, and removal. The commissioning of this Campus Environmental Asset Review is testament to the interest of the University in keeping this forest resource alive and well, while seeking to understand quantitatively its unique contribution to the University of Windsor experience.

Managing natural resources in a campus environment is challenging. For many campuses like the University of Windsor, finding suitable space for trees among roads, buildings, and sidewalks is difficult. As the campus forest performs services to the University, quantified in this plan, it can be understood that trees comprise part of the institution's infrastructure as well, and merit consideration as a functional asset of the campus community.



***Photograph 1.*** *A diverse, healthy, and sustainable urban forest is a valuable asset that positively contributes to quality of life now and in the future.*

Precisely because the University is a hub of activity in the community, it is important that the University maintain public safety and manage its tree risk related to persons and property. To improve proactive tree management, the University of Windsor commissioned an environmental asset review of its campus trees to evaluate their current condition and benefit contribution. A Campus Tree Management Program was developed based on the results of the review and suggests establishing a long-term tree care program as part of the overall Campus Tree Management Plan.

A successful urban forestry program requires a combination of organized leadership, comprehensive information about the tree population, dedicated personnel, and effective campus relations. This Plan was developed to help University of Windsor face the challenge of managing their campus trees.

# Environmental Asset Structure

University of Windsor's tree inventory includes 1,634 trees, and 35 stumps for a total of 1,669 sites. In order to gain an understanding of the benefits these trees provide the community and the management needs involved, an analysis of University of Windsor's campus tree resource has been performed. Species richness, relative age distribution, overall condition, and canopy coverage can be used to characterize University of Windsor's resource as follows:

- University of Windsor's tree population is comprised of 46 genera and 71 species. The predominant tree species are Austrian pine (*Pinus nigra*, 13.7%), Norway maple (*Acer platanoides*, 12.3%), silver maple (*Acer saccharinum*, 8.6%), thornless honeylocust (*Gleditsia triacanthos 'inermis'*, 8.3%), and Colorado spruce (*Picea pungens*, 6.3%). The genus *Acer* (maple) comprises 26.5% of the tree population.
- The age structure is approaching an ideal distribution. The campus tree age distribution is 39:38:20:3 (percentages of young: established: maturing: mature trees). An ideal population has a stair-stepped distribution, a greater percentage of young trees with decreasing percentages of established, maturing, and mature populations.
- The majority of campus trees are in Fair condition (48.4%). Trees classified in Good condition make up 41.8% of the population, while trees in Poor condition make up 8.9% of the population, and trees that are Dead or Dying make up 0.9% of the population.
- i-Tree Streets estimates the inventoried campus tree canopy cover to be 7 hectares, which is 13.7% of the University's total land area (51 hectares).
- The total maintenance requirements (1,669 sites) indicate that 76 (4.6%) trees are recommended for Removal, 1,021 (61.2%) trees are recommended for Large Tree Clean, 102 (6.1%) trees are recommended for Small Tree Clean, 435 (26.0%) trees are recommended for Young Tree Train, and 35 (2.1%) stumps require Stump Removal.
- Of the 1,634 inventoried trees, 830 (50.8%) trees have a Low level of risk (Risk Rating of 3 or 4), 712 (43.6%) have a Moderate level of risk (Risk Rating of 5 or 6), 77 (4.7%) have a High level of risk (Risk Rating of 7 or 8), and 15 (0.9%) have a Severe level of risk (Risk Rating of 9 or 10).

# Environmental Asset Function and Value

The University of Windsor's campus trees conserve and reduce energy consumption, reduce carbon dioxide levels, improve air quality, mitigate stormwater runoff, and provide other benefits associated with aesthetics, increased property values, and quality of life. The University's campus trees are providing the community substantial benefits such as:

- Increased property values, aesthetics, and other less tangible improvements are valued at $32,178 per year, for an average of $19.69 per tree.
- Reduction of energy and natural gas use due to shading and climate effects equal to 77.7 Megawatt-hours and 29,709.0 Therms valued at $22,834 per year, for an average benefit of $13.97 per tree.
- The interception of 5,562 cubic meters of stormwater is valued at $11,313 per year, for an average benefit of $6.92 per tree.
- Net air quality improvements from the removal and avoidance of 771.2 kilograms of air pollutants are valued at $8,727 per year, for an average benefit of $5.34 per tree.

- Reduction of atmospheric carbon dioxide ($CO_2$) by a net of 68,772 kilograms is valued at $1,083 per year, for an average benefit of $0.66 per tree.
- The total annual benefit received from the University's campus trees is $76,135. The average benefit per tree is $46.59 per year and per student benefit is $4.76 per year.
- When the University's annual tree-related expenditures of $12,000 per year are considered, the net benefit (benefits minus costs) returned to the University is $64,135 annually.
- The University of Windsor receives $6.34 in benefits for every $1 spent on its campus forestry program.

## Environmental Asset Management

Based on the structural data analysis, this report recommends best management practices and provides long-term planning strategies that will improve maintenance efficiency, public safety, tree health and population stability. A *Campus Tree Management Program* is explained and outlined in Chapter 3 and includes estimated budgets for each recommended activity. The following recommendations will enhance the management of the University of Windsor's campus trees:

- Perform all recommended Severe- and High-Risk Removals, Crown Cleans, and other high priority concerns as soon as possible beginning in 2011 and have completed by 2012.
- Implement a five-year cyclical Routine Pruning Program for all established, maturing, and mature trees beginning no later than 2013.
- Implement a three-year cyclical Young Tree Training Program for all young trees beginning no later than 2012.
- Implement a well-planned Tree Planting Program that focuses on species diversity and population sustainability. Replace all recommended removals by 2016.
- Inventory all planting sites on Campus and revisit trees with omitted inventory data. Continuously update the inventory as tree maintenances are completed, and perform a complete re-inventory of Campus spaces in 2021.
- Implement an expanded public relations campaign to gain increased community interest and University support for the campus forestry program.
- Create a University Tree Preservation or Tree Stewardship policy that ensures trees are made a priority in campus operations and for external service providers.
- Create educational programs to highlight the findings of this Management Plan, to ensure that the community and existing/potential donors are made aware of the University's tree-related programs, activities and commitments.
- Continue exploring ways to fund the campus forestry program. Consider developing a Tree Fund to help fund tree maintenances and plantings.

# Introduction

Campus trees are a significant component of the University of Windsor's urban forest and an integral part of the University's infrastructure, no less so than its buildings, sidewalks, streets, and other utilities. However, unlike other infrastructure components, a properly maintained tree population will appreciate over time because trees are alive, growing, and respond well to maintenance. Unfortunately, without proper planning and maintenance, trees can become a costly liability. Improper selection of tree species can lead to high maintenance costs for insect and disease control, excessive litter clean-up from cones or fruit on the ground, or frequent pruning to improve structure. Trees can also pose potential risks to people if branches or entire trees fail and fall. A well-planned tree management program based on proper species selection, plant health care practices, and proactive maintenance will maximize the benefits offered by trees while minimizing costs and liabilities.

Trees are assets and provide tangible and intangible services and benefits to the University and its community well worth the cost of tree-related maintenances. Such tangible and intangible services and benefits include: pollution control, energy reduction, stormwater management, increased property values, wildlife habitat, enhanced education and research, and improved aesthetics. Until recently, these services and benefits urban trees provide were considered unquantifiable. i-Tree Streets is an urban forestry tool developed to assess and quantify the beneficial functions of an inventoried population and to place a dollar value on the annual benefits those trees provide. i-Tree Streets is useful because it provides conclusive data and rationales for the University of Windsor's Environmental Services to promote its "green infrastructure" management program to the Board of Governance, Facility Services Managers, other Department Managers, allied organizations, and the community the program serves—the University's students, facility, and staff. The challenge now is to apply the science to enhance the quality of life at the University of Windsor by improving the condition and extent of the campus forest.

***Photograph 2.*** *Trees contribute to the community's quality of life and soften the hard appearance of man-made structures and streets, moderating harsh urban conditions.*

To maintain the University of Windsor's campus forest effectively, an understanding of its campus trees – as individuals and as a group – must exist. Species composition, relative age, general condition, and maintenance recommendations all provide information about the trees, both as individuals and as a group. This information is used to identify trends about the general characteristics of the campus tree population. These population trends will be used to develop a tree management program and plan that improves the structure and composition of the University of Windsor's campus forest for the long-term.

# Statement of Purpose

The purpose of this *Campus Tree Management Plan* is to analyze the current structure of the population, summarize benefits provided by the inventoried tree population, and to develop a multi-year plan of action for maintaining these inventoried campus trees. The University commissioned this study to identify the current condition of its community 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 University-managed trees in a cost-effective and efficient manner.

# Goals

This Management Plan intends to achieve the following goals:

- Gain an overall understanding of the species composition, relative age distribution, condition, and maintenance needs of the inventoried tree population.
- Provide a summary and analysis of the environmental and economic benefits provided by the inventoried population.
- Identify and take immediate remedial action for trees with structural or other defects that cause them to be a severe- or high-risk to students, faculty, staff, vehicles, and property.
- Establish a Routine Pruning Program designed to mitigate potential risk by cyclically pruning approximately 20% of the population designated in the inventory as Small and Large Tree Clean every year.
- Establish a Young Tree Training Program designed to develop strong structured trees and mitigate potential risks as they mature by cyclically pruning approximately 146 of the population designated in the inventory as Young Tree Train every year.
- Establish a Tree Planting Program designed to install trees where needed, improving aesthetics and providing environmental services, and replace trees when removed from the population.

# Implementation

The recommendations made in this Plan are intended to be considered and implemented over a period of seven years. However, the results of the Plan's implementation, in relation to the overarching goal and final measurable result of achieving a sustainable campus tree population through a proactive urban forestry program, may take twenty years or more.

Trees are long-lived organisms and managing them appropriately in the urban environment can be difficult. However, routinely caring for and planting trees today will provide environmental and economic benefits for future generations of students, faculty, and staff. By having systematic tree maintenance and planting programs, and by having adequate funding, regulations, and public education resources, the future campus tree population and overall urban forest will be expanded and sustainable.

# Chapter 1: University of Windsor's Tree Population

The urban forest at the University of Windsor is a complex system of trees, site conditions, and maintenance recommendations. 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 University of Windsor's inventoried tree population. By accumulating and using this information, Facility Services managers can forecast trends, anticipate maintenance needs, facilitate budgeting for tree-related expenditures, and develop a basis for long-range planning. Analytical information like this is essential since the types, sizes, and conditions of trees present greatly affect the extent of benefits produced, tree maintenance needed, and budgets required. Davey Resource Group Inventory Arborists collected tree data for the University of Windsor as described in **Appendix A**.

## Species Richness and Composition

University of Windsor's inventoried tree population is composed of 1,634 trees distributed among 46 genera and 71 species. The majority of the campus tree population is comprised of large-statured broadleaf deciduous trees. There are 791 (48.4%) large broadleaf deciduous trees, 387 (23.7%) large coniferous evergreen trees, 218 (13.3%) medium broadleaf deciduous trees, 193 (11.8%) small broadleaf deciduous trees, 44 (23.7%) medium coniferous evergreen trees, and 1 (23.7%) medium broadleaf evergreen tree. Broadleaf trees usually have larger canopies than coniferous trees, and because most of the benefits provided by trees are related to leaf surface area, large-stature trees usually provide the highest level of benefits. For a complete listing of tree type classification frequencies and population composition refer to **Appendix B**.

***Table 1. Top Ten Significant Species Composition of University of Windsor's Campus Trees***

| Scientific Name | Common Name | Number | % of Campus Trees |
|---|---|---|---|
| *Pinus nigra* | Austrian pine | 223 | 13.6 |
| *Acer platanoides* | Norway maple | 201 | 12.3 |
| *Acer saccharinum* | silver maple | 141 | 8.6 |
| *Gleditsia triacanthos 'inermis'* | thornless honeylocust | 135 | 8.3 |
| *Picea pungens* | Colorado spruce | 103 | 6.3 |
| *Tilia cordata* | littleleaf linden | 88 | 5.4 |
| *Acer rubrum* | red maple | 63 | 3.9 |
| *Malus species* | apple spp. | 63 | 3.9 |
| *Platanus x acerifolia* | London planetree | 51 | 3.1 |
| *Celtis occidentalis* | northern hackberry | 46 | 2.8 |
| **Totals** | | **1,114** | **68.2** |

**Table 1** shows that the species *Pinus nigra* (Austrian pine) represents 13.6% of the campus tree population and *Acer platanoides* (Norway maple) represents 12.3% of the campus tree population. Furthermore, **Figure 1** shows the genera *Acer* (maple) and *Pinus* (pine) represent 25.7% and 24.1% of the overall population, respectively. Davey Resource Group recommends that no single species should represent more than 10% of the total population and no single genus should represent more than 20% of the total population. Austrian pine and Norway maple both exceed this population management guideline for species, while maples collectively exceed the guideline set for genera distribution.

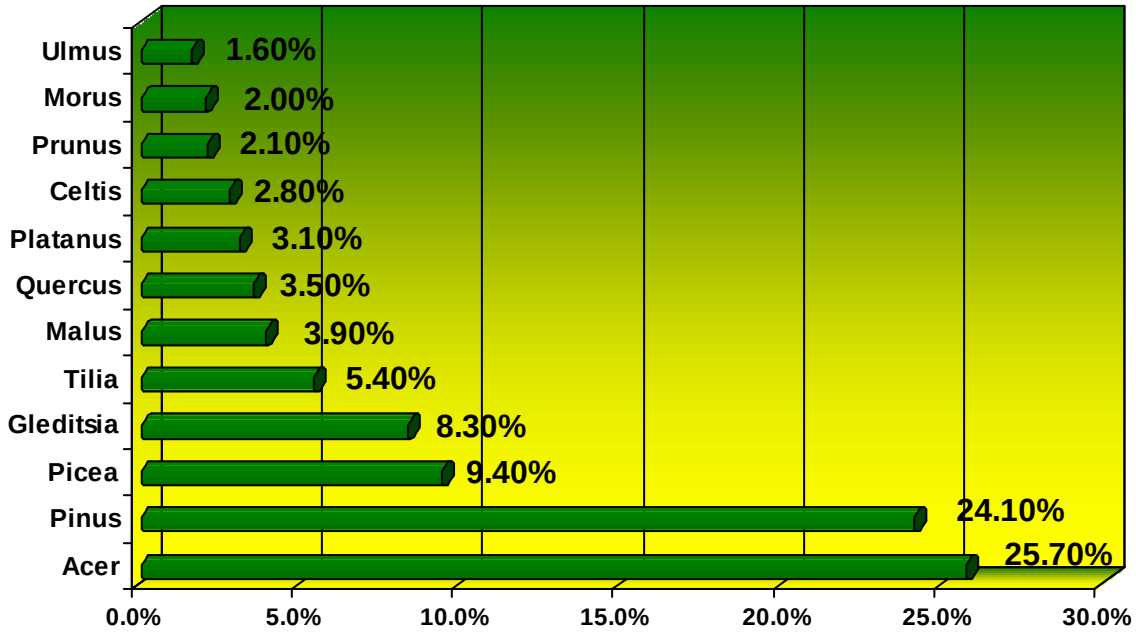



***Figure 1. University of Windsor's Distribution of Campus Trees by Genus***

Davey Resource Group recommends that the University of Windsor plant a wider range of species by including both native and non-native, urban-tolerant species. Planting a large number of trees of the same species, also known as a monoculture, can lead to catastrophic results in the event of invasive species-specific epidemics, such as Dutch elm disease (DED), Asian Longhorned beetle (ALB), or emerald ash borer (EAB). The University of Windsor should minimize the use of maples and pines around campus and increase the use of other beneficial species in the genera *Quercus* (oaks), *Ulmus* (elms), and *Tilia* (lindens). See **Appendix C** for a list of suggested species to plant on the University of Windsor's campus.

## Species Importance

To quantify the significance of any one particular species found in the campus tree population, an Importance Value (IV) is assigned to each species in the tree inventory. Importance Values are particularly meaningful to urban forest managers because they indicate a community's reliance on the functional capacity of particular species. i-Tree Streets calculates IV based on each species population's percentage of total population, percentage of total leaf area, and percentage of total canopy cover. Importance Value goes beyond tree numbers alone to suggest reliance on different species based on the benefits they provide.

Importance Value can range from zero, which implies no reliance, to 100, which suggests total reliance. Because IV goes beyond population numbers alone, it can help managers better understand the loss of benefits from a catastrophic loss of one species. When IVs are evenly dispersed among the 10 to 15 most abundant species, the risk of significant reductions to benefits is less.

At the University of Windsor these five species populations currently present the greatest IVs: silver maple, 16.3; Norway maple, 11.6; *Gleditsia triacanthos 'inermis'* (thornless honeylocust), 11.1; Austrian pine, 10.8; and *Platanus* x *acerifolia* (London planetree), 4.6. The University of Windsor relies most on the functional capacity of silver and Norway maple, which have a higher IV than other species due to their maturity, greater size, broader leaf area, and prevalence on campus. **Appendix D** provides IVs for the 21 most prevalent species on the University of Windsor's campus.

## Relative Age Distribution

The University of Windsor's campus forest approaches an ideal age distribution as reflected by the size class distribution in **Figure 2**. An ideal age distribution has a stair-stepped distribution, with a higher percentage of young (<15 centimeters DBH) trees than established (15- to 30-centimeters DBH), maturing (30- to 61-centimeters DBH), and mature (>61 centimeters DBH) trees. A stair-stepped distribution in a tree population is understood as a population having at least four young trees for every one mature tree. As trees mature and begin to decline, a tree population skewed towards young trees helps to maintain overall tree canopy cover, ensures that a flow of benefits continues to exist, and allows managers to allocate annual maintenance costs uniformly over many years. **Appendix D** displays relative age distributions in the campus tree inventory at the University of Windsor.

As time progresses and trees grow, they generally shift in size class which changes the overall dynamics of a population. Newly planted small-, medium-, and large-statured trees are generally recorded under the young size class. For example, *Quercus rubra* (northern red oak) in the 0- to 15-centimeter DBH class are simply young trees and through the years young northern red oaks will progress into the established, mature, and maturing size classes as they reach their mature height of 18- to 23-meters. Alternatively, *Pyrus calleryana* (callery pear) are medium-statured trees and mature at heights from 3- to 10-meters. Callery pear will progress up to the maturing size class because they generally do not grow larger than 60 centimeters DBH. The University of Windsor's young size class is a mix of small-, medium-, and large-statured trees.

**Figure 2** illustrates that the University of Windsor's size class distribution shows a high frequency of young and established trees. Small- and medium-statured trees have relatively short lifespans compared to large-statured trees and because large-statured species generally provide greater benefits due to amount of leaf area and canopy cover they should be planted whenever sites permit. The University of Windsor should make a concerted effort to adjust its size class distribution by continuing to plant a mix of large-, medium-, and small-statured trees on campus and routinely maintain the health of established, maturing, and mature trees to even the steps along the distribution, thus, maximizing the population's potential benefit.

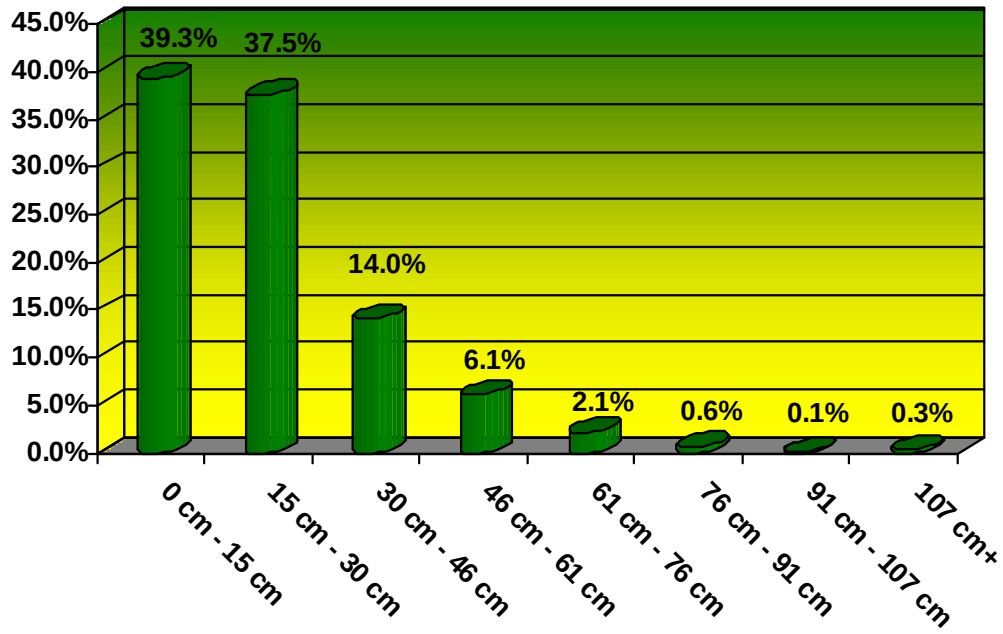



***Figure 2. Diameter Size Class Distribution of University of Windsor's Campus Tree Population***

# 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 University of Windsor's campus trees are in Fair (48.4%) or Good condition (41.8%). Trees in Good condition are performing at their peak and the benefits they provide are maximized.

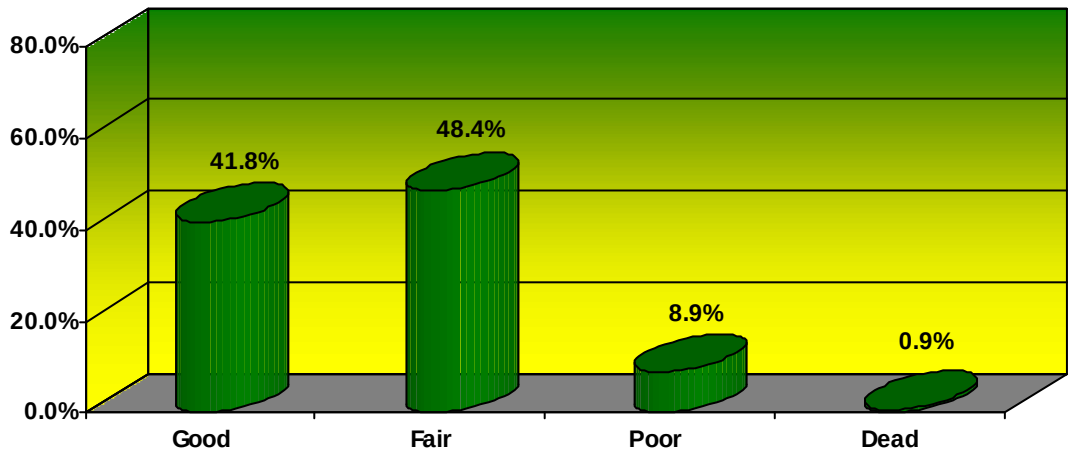



***Figure 3. University of Windsor's Campus Tree Conditions***

**Figure 3** shows a small percentage of trees are found in Poor or Dead conditions. This indicates that the University of Windsor has done a good job addressing tree condition through necessary maintenance, either pruning or removal. Dead trees and trees in Poor condition account for 9.8% of the total inventoried population. Norway maple, silver maple, and white mulberry have the highest numbers of trees listed in poor or dead condition classes (see **Appendix D**). The University should work to improve its campus tree population's overall condition by mitigating all poor performing trees and replacing all dead or dying trees.

# Canopy Cover

Canopy cover directly correlates with the benefits of public trees. i-Tree Streets defines canopy cover as the amount and distribution of leaf surface area. The greater the leaf surface area exhibited by a tree, the greater its canopy cover; and, as a result, the greater the benefits that particular tree is likely to provide the community. In other words, trees with large leaves and spreading canopies tend to produce the most benefits.

i-Tree Streets estimates University of Windsor's inventoried campus tree canopy cover to be approximately 7 hectares of the total land area of 51 hectares, or 13.7% of the campus (see Importance Values, **Appendix D**). **Figure 4** shows that the total inventoried tree population's canopy cover varies greatly between species. Silver maple is illustrated as having the largest canopy cover (13,247.9 square meters). The difference in canopy cover is simply due to species maturity, tree size, leaf area, and prevalence among the University's campus trees. These characteristics are the building blocks of a campus tree population and influence the potential for the University's population to provide benefits to the community.

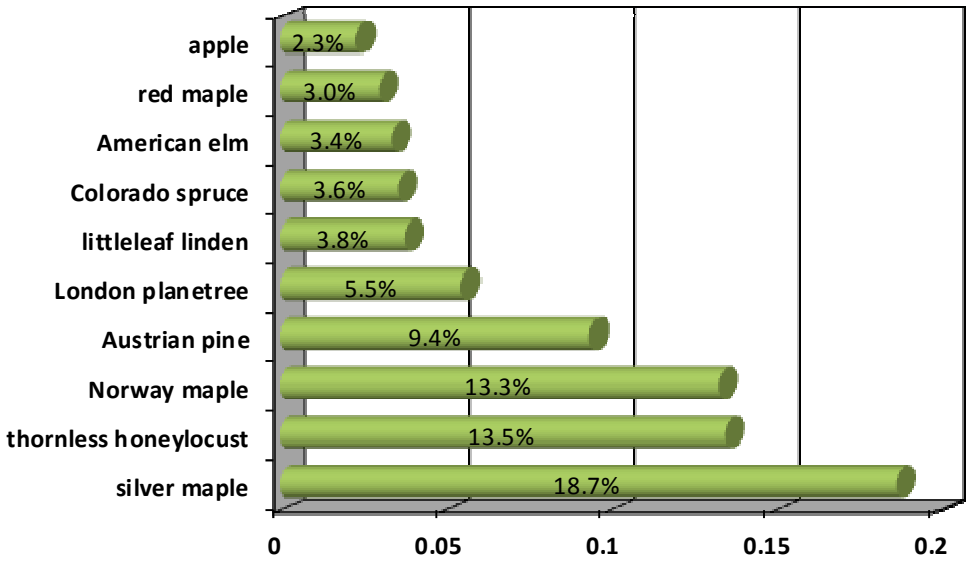



***Figure 4. Distribution of the University of Windsor's Public Tree Canopy Cover***

## Relative Performance Index

One way to analyze the performance of individual urban trees utilizes a Relative Performance Index (RPI). RPI gives urban forest managers an interesting look at how each species' performance compares to that of other species. The calculation of RPI is relatively simple: take the percentage of each species with a condition rating recorded as Good and divide it by the percentage of the total population recorded as Good. A value of 1.0 or more indicates that the species is performing well since its percentage of Good is at least equal to or greater than that of the entire population. RPI values less than 1.0 indicate that the species is not performing well compared to the rest of the population.

**Table 2** shows the values for species in the University of Windsor's campus tree population that represent over 1% of the entire population. Species that are performing well (RPI >1) should be considered for more frequent planting throughout the University. An interesting correlation to consider is that honeylocust is performing above average (RPI 1.1) and also has a high IV (11.1). This species should be considered for further planting. The RPI can be used by urban forest managers to make important management decisions. For example, if a community has been planting two new species in its urban forest, the RPI can be utilized to compare the two. If the RPI indicates that one is performing relatively poorly, a community can reduce, or even cease, planting that species and subsequently save money on planting stock and replacement costs. The RPI enables urban forest managers to look at the performance of long-standing species as well. Species planted for many years that have a RPI of 1.0 or better have performed well compared to the population as a whole. These good performers should be maintained as a significant portion of the urban forest.

***Photograph 3.*** *The second most frequent tree inventoried at the University of Windsor is silver maple (Acer saccharinum). The Relative Performance Index shows that silver maple performs just below average in comparison to other species in the campus tree population.*

Poor performing species (RPI <1) should be re-evaluated as planting choices since they may indicate a species is not well adapted to local conditions. As such, they may present increased safety and maintenance issues. However, before making decisions concerning good and poor performers, urban forest managers must take into account the age range of the species. A species that has a RPI of less than 1.0, but has a significant number of trees in larger DBH classes, may just be exhibiting signs of a population that is naturally senescing. The individuals of this species have produced a number of benefits over the years, which must be taken into account when making species selection decisions. For example, silver maple has a 0.9 RPI, a 16.3 IV, and 11.4% of its population is greater than 61 centimeters DBH. Even though the performance of this species is just below average, its proportional benefit is greatest in the University's campus tree population. Silver maple should be included in a cyclical maintenance schedule and future plantings should continue.

***Table 2. Relative Performance Index for University of Windsor's Campus Tree Population***

| Scientific Name | Common Name | RPI |
|---|---|---|
| *Cercis canadensis* | eastern redbud | 1.2 |
| *Syringa reticulata* | Japanese tree lilac | 1.2 |
| *Platanus x acerifolia* | London planetree | 1.2 |
| *Pyrus calleryana* | Callery pear | 1.2 |
| *Pinus nigra* | Austrian pine | 1.1 |
| *Quercus rubra* | northern red oak | 1.1 |
| *Picea pungens* | Colorado spruce | 1.1 |
| *Gleditsia triacanthos inermis* | thornless honeylocust | 1.1 |
| *Prunus species* | plum spp. | 1.1 |
| *Zelkova serrata* | Japanese zelkova | 1.0 |
| *Tilia cordata* | littleleaf linden | 1.0 |
| *Acer rubrum* | red maple | 1.0 |
| *Celtis occidentalis* | northern hackberry | 1.0 |
| *Acer platanoides* | Norway maple | 1.0 |
| *Ulmus americana* | American elm | 0.9 |
| *Acer saccharinum* | silver maple | 0.9 |
| *Malus species* | apple spp. | 0.9 |
| *Picea abies* | Norway spruce | 0.9 |
| *Thuja occidentalis* | northern white cedar | 0.9 |
| *Morus alba* | white mulberry | 0.7 |
| *Ailanthus altissima* | tree of heaven | 0.7 |

# Tree Maintenance Recommendations

One important objective of the tree inventory was to determine the current appropriate maintenance recommendations for the tree population. All primary and secondary maintenance recommendations are based on the American National Standards Institute (ANSI) A300 standard specifications and were made by Davey Resource Group urban foresters. Recommendations were based on the existence of potential safety risks to the general public at the University of Windsor and/or University property at the time of the inventory. **Table 3** summarizes the Primary Maintenance recommendations for University of Windsor's campus tree population and **Table 4** summarizes the Secondary Maintenance recommendations for University of Windsor's campus tree population. Maintenance recommendations are directed at improving the overall health, stability, and aesthetics of the urban forest, as well as the cost-effectiveness of the Campus Tree Management Program. **Chapter 3** discusses in detail the specific prioritization of maintenance work and provides a detailed seven-year estimated budget for the maintenance of University of Windsor's campus tree population.

***Table 3. University of Windsor's Primary Maintenance Recommendations***

| Maintenance Required | Number of Sites | % of Maintenance |
|---|---|---|
| Removal | 76 | 4.6 |
| Large Tree Clean | 1,021 | 61.2 |
| Small Tree Clean | 102 | 6.1 |
| Young Tree Train | 435 | 26.0 |
| Stump Removal | 35 | 2.1 |
| **Total** | **1,669** | **100.0** |

***Table 4. University of Windsor's Secondary Maintenance Recommendations***

| Maintenance Required | Number of Sites | % of Maintenance |
|---|---|---|
| None | 1,406 | 84.2 |
| Raise | 182 | 10.9 |
| Reduce | 73 | 4.4 |
| Thin | 5 | 0.3 |
| Restoration | 3 | 0.2 |
| **Total** | **1,669** | **100.0** |

# Risk Rating Analysis

A major objective of this inventory was to quantify the potential risk of each tree, in addition to the overall risk of the tree population as a whole. Risk rating values were assigned to each tree using an assessment protocol based on the USDA Forest Service Community Tree Risk Rating System. This system analyzes risk in four separate categories (probability of failure, size of defective part, probability of target impact, and other risk factors) and then uses a point system to calculate a risk rating value from 3–10, with 10 being the most severe. The risk rating number assigned to each tree is an important tool that can be used to prioritize work in University of Windsor's urban forest. All risk rating determinations were made by Davey Resource Group urban foresters. This section discusses overall risk patterns. The use of the risk rating system as it relates to tree maintenance is discussed in **Chapter 3**.

Seen in **Figure 5**, the majority of University of Windsor's campus tree population is classified as Low- to Moderate-Risk. There are 830 trees in the Low-Risk category (3-4), 712 trees in the Moderate-Risk category (5-6), 77 trees in the High-Risk category (7-8), and 15 trees in the Severe-Risk category (9-10).

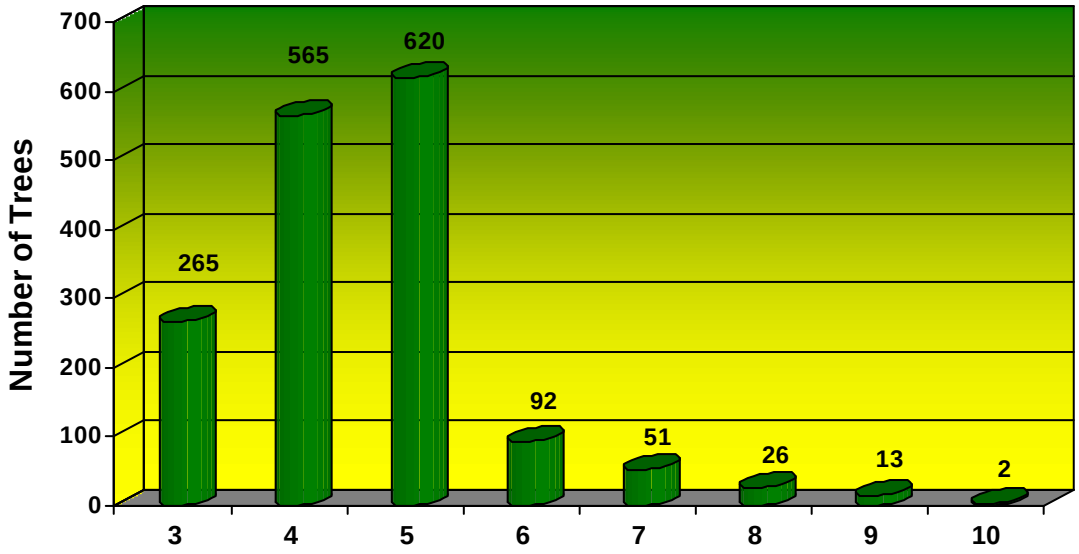



***Figure 5. Risk Rating Distribution of University of Windsor's Campus Tree Population***

It is impossible to maintain an urban forest that is 100% free of risk. Trees fail from natural causes, such as disease, insects, and weather conditions, and from physical injury due to vehicles, vandalism, poisoning, and root disturbances, among others. The goal of a risk rating system is to increase public safety by identifying structural defects before trees fail and cause damage. Trees that present an unacceptable amount of risk should be pruned or removed immediately, thus, reducing the overall risk of the urban forest and increasing safety within the community. Additionally, all trees with Severe-, High-, and Moderate-Risk ratings should be examined closely during pruning operations for severe internal and external decay and/or dieback. If, upon closer inspection, these trees are found to be severely decayed, they should be removed. The following subsections provide a summary of Primary Maintenance by Risk Rating.

## Severe-Risk Trees

A Severe-Risk tree is categorized by a Risk Rating of 9 or 10. These trees pose the greatest level of risk on campus. In the University of Windsor's campus tree population there are:

- 10 (0.6%) Severe-Risk Removals
- 4 (0.2%) Severe-Risk Large Tree Cleans
- 1 (0.1%) Severe-Risk Small Tree Clean

## High-Risk Tree

A High-Risk tree is categorized by a Risk Rating of 7 or 8. This risk class usually encapsulates larger trees in poor condition or with major limbs in danger of failure. In the University of Windsor's campus tree population there are:

- 16 (1.0%) High-Risk Removals
- 59 (3.6%) High-Risk Large Tree Cleans
- 2 (0.1%) High-Risk Small Tree Cleans

## Moderate-Risk Tree

A Moderate-Risk tree is categorized by a Risk Rating of 5 or 6. Trees in this category still pose some risk to the community; however, smaller defect size and/or less potential for target impact have resulted in a Moderate-Risk rating. In the University of Windsor's campus tree population there are:

- 33 (2.0%) Moderate-Risk Removals
- 529 (32.4%) Moderate-Risk Large Tree Cleans
- 38 (2.3%) Moderate-Risk Small Tree Cleans
- 107 (6.5%) Moderate-Risk Young Tree Trains

## Low-Risk Tree

A Low-Risk tree is characterized by a Risk Rating of 3 or 4. Many of these trees will be younger trees with smaller diameter size and, therefore, less associated risk. In the University of Windsor's campus tree population there are:

- 17 (1.0%) Low-Risk Removals
- 429 (26.3%) Low-Risk Large Tree Cleans
- 153 (9.4%) Low-Risk Small Tree Cleans
- 328 (20.1%) Low-Risk Young Tree Trains

Making removal and maintenance decisions based on risk enables Facility Services managers to use available funds more efficiently. The use of these funds can be focused on the highest risk situations first, effectively contributing the highest gain in overall safety of the campus. Maintenance and risk assessment data should be used as a basis for prioritizing activity needs. This information will allow the University of Windsor to develop cost-effective strategies by assisting University officials in prioritizing tree maintenance needs according to risk. The seven-year budget table in **Chapter 3** will help Facility Services managers decide what maintenance activities the budget may permit on a year-to-year basis.

# Other Data Fields

## Further Inspection Required

There are 13 (0.7%) trees maintained by the University recommended for Further Inspection. These trees are in Fair or Poor condition and have been noted as having a cavity or decay to an undetermined extent, or poor structure. A Certified Arborist should perform an additional inspection with assistance of mechanical equipment, such as a resistograph or an aerial lift. If it is determined these trees exceed the University's threshold for acceptable risk during further inspection, the defective part of the tree should be mitigated. This may require complete removal.

## Utilities

Of the 1,634 trees that were collected in the inventory, 150 (9.2%) are identified as having utilities above or immediately adjacent to them. Noting the presence of utility lines is necessary when planning pruning activities and can be used to identify which sites are more suitable for small-structured species that will not interfere with utility lines when they mature. During planning of tree planting location a focus on the concept "right tree, right location" will aid in the reduction of unnecessary maintenance costs.

## Observations

Of the 1,634 trees included in the inventory:

- 62 (3.8%) have a Cavity or Decay
- 54 (3.3%) have Mechanical Damage
- 23 (1.4%) are designated a Memorial Tree
- 13 (0.8%) have a Pest Problem
- 12 (0.7%) are in a Poor Location
- 11 (0.7%) have Poor Structure
- 9 (0.6%) are Improperly Pruned
- 6 (0.4%) have a Remove Hardware designation

***Photograph 4.*** *These tree wells are located in the street right-of-way on campus. Here is an example of overhead utilities.*

## Clearance Requirements

Of the 1,634 trees included in the inventory:

- 100 (6.1%) require clearance for Pedestrians
- 81 (5.0%) require clearance for a Building
- 79 (4.8%) require clearance for Vehicles
- 12 (0.7%) require clearance for a Light

When trees are recorded with a clearance category, there are usually multiple safety issues involved. Davey Resource Group recorded the clearance issue of most concern. University of Windsor should incorporate the pruning technique of crown raising (elevating of tree limbs) and reducing (removing strategic sections of tree crown) into its routine pruning program to help eliminate future safety issues involved with clearance issues.

## Grow Space Type

Of the 1,634 trees included in the inventory:

- 1,465 (89.7%) are located in open or unrestricted areas
- 124 (7.6%) are located in a tree lawn or parkway
- 28 (1.7%) are located in a well or pit
- 17 (1.0%) are located in an island

When evaluating future growing spaces and planting locations, the University must carefully select suitable species for each site's specific growing conditions, keeping in mind ultimate mature size.

# Chapter 2: University of Windsor's Benefit-Cost Analysis

Campus trees provide the University of Windsor a multitude of environmental and economic benefits, in excess of what the community pays to manage their urban forest. Trees are environmental assets: they mitigate stormwater runoff, conserve energy, improve air quality, and reduce carbon dioxide levels. They also provide other aesthetic benefits such as economic, social, psychological, and wildlife enhancements. This chapter uses the University's campus tree inventory and the i-Tree Streets model to assess and quantify the beneficial functions of the campus tree resource and to place a dollar value on the annual benefits they provide. Considering this in a Campus Environmental Asset Review framework, these annual benefits are a "snapshot" of environmental and economic benefits produced by trees during one year. i-Tree Streets generally accounts for the benefits produced by the University's campus trees – an accounting that is based on the best available science, with an accepted degree of uncertainty that can nonetheless provide a platform from which real management decisions can be made. A discussion concerning the methodology used to quantify and price these benefits can be found in **Appendix E**.

## Benefits Provided by University of Windsor's Campus Trees

The i-Tree Streets model is considered a high level of data analysis upon which to base a management plan, and the information generated has become an integral part of the comprehensive Campus Tree Management Program. Beyond statistical calculations of public tree inventory data, i-Tree Streets provides conclusive data and rationales for University of Windsor's Facility Services to promote its "green infrastructure" management program to Board of Governance, Facility Services Managers, other Department Managers, allied organizations, and the community the program serves – the University's students, faculty, and staff. The i-Tree Streets analysis was performed to quantify stormwater mitigation, energy consumption savings, air quality improvement, carbon sequestration, and aesthetics and other public values. **Table 5** presents the total annual benefits per species for the 10 most prevalent tree species at the University and the University-wide total annual benefits. All benefit analysis reports are included in **Appendix F**.

### Aesthetic Value and Other Benefits

It may seem difficult to place a dollar value on the benefit of trees provide to the overall ambiance of a community and the well-being of neighborhood residents and visitors. However, trees provide beauty to the landscape, privacy to residents, and refuge for urban wildlife, and this can be quantified. Studies show that differences in property values reflect the willingness of buyers to pay for the benefits and costs associated with trees.

Aesthetic benefits, property value, social benefits, economic benefits, among other non-tangible related benefits provide the University of Windsor an estimate of $32,178 annually, for an average of $19.69 per tree. The population of American elms provides the greatest single tree benefit ($52.40).

### Energy Consumption Savings

The energy savings that trees provide can be attributed to climate changes, shading, and wind reduction. Ambient air is cooled when leaves use solar energy during transpiration and air movement in an urban setting is influenced by tree spacing, crown spread, and vertical distribution leaf area. These key factors also reduce the amount of radiant energy absorbed in buildings and other hardscapes, cool the air in buildings during hot summer months, and help retain heat during cold winter months. The energy savings is realized by lower cooling and heating costs.

***Photograph 5.*** *Silver maples (Acer saccharinum) provide an average of $29.70 in annual energy savings for the University.*

Campus trees provide annual electric and natural gas savings equal to 77.7 Megawatt-hours ($5,674) and 29,709.0 Therms ($17,160), respectively. The University of Windsor saves a total of $22,834 per year and has an average annual savings of $13.97 per tree. The population of silver maple currently provides the greatest total benefit accounting for 18.3% ($4,188) of all energy savings. Silver maple also provides the greatest single tree benefit ($29.70).

### Stormwater Runoff Reductions

Trees reduce the volume of stormwater runoff in neighborhoods and ultimately community-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, particularly leaf and trunk surfaces, intercept and store rainfall. The tree's root system increases soil infiltration, thereby decreasing runoff. Trees also reduce stormwater runoff by intercepting raindrops before they hit the ground, thus, reducing soil compaction rates and improving soil absorptive properties. Additionally, trees intercept suburban contaminants such as oils, solvents, pesticides, and fertilizers which are often part of stormwater runoff, reducing pollutant discharges into vital waterways.

University of Windsor campus tree resource intercepts 5,562 cubic meters of stormwater annually, for a savings of $11,313 or $6.92 per tree. The population of silver maple currently provides the greatest total benefit accounting for 19.8% ($2,245) of the stormwater management savings. American elm provides the greatest single tree benefit ($21.50).

### Air Quality Improvement

Urban environments greatly benefit from the presence of street and other public trees. Trees release oxygen through photosynthesis and absorb gaseous pollutants in the form of ozone ($O_3$) and nitrogen dioxide ($NO_2$). Ozone reduction can also be attributed to the trees' shading effect on hardscape surfaces, their cooling effect on ambient air from the transpiration process, and their contribution to reduced emissions from power generation. 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 an air pollutant called biogenic volatile organic compounds (BVOCs) that contribute to the formation of ozone. The i-Tree Streets model takes this whole process into account.

University of Windsor's campus tree resource removes 771.2 kilograms of air pollutants annually. The University experiences net air quality improvement benefits equal to $8,727 per year, averaging $5.34 per tree. The population of silver maple currently provides the greatest total air quality benefits accounting for 19.0% ($1,654 annually) of all enhancements. American elm provides the great single tree benefit ($15.75).

### Carbon Dioxide Reduction

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.

University of Windsor's campus tree resource reduces a net 68,772 kilograms of $CO_2$ per year valued at $1,083, with the average savings per tree at $0.66. The population of silver maple currently provides the most avoided and sequestered $CO_2$ benefit accounting for 18.7% ($203.00) of the total annual savings. Silver maple also provides the greatest single tree benefit ($1.44).

## Summary of Total Annual Benefits

University of Windsor's campus trees provide $76,135 of annual benefits to the community and its environment. **Figure 6** shows environmental services from campus trees provide the largest benefit accounting for 57.7% of the total annual benefits. Environmental benefits include energy savings which account for 30.0% of the total annual benefits, stormwater mitigation which accounts for 14.9%, air quality improvements which account for 11.5%, and carbon dioxide reduction which contributes 1.4% of total annual benefits. Aesthetics, or annual increases in property value, contribute the remaining 42.3% of quantifiable benefits to the University per year. Leaf surface area, population, and canopy cover determine an urban forest's ability to produce benefits. The more canopy cover one community has the more benefits it will yield.

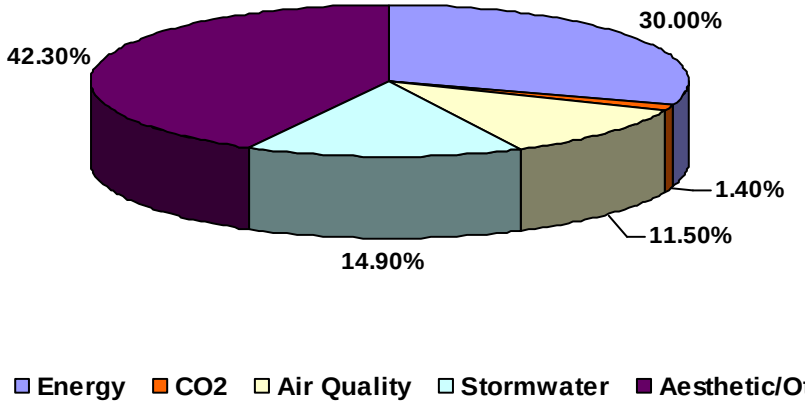



***Figure 6. University of Windsor's Distribution of Annual Benefits***

Large-growing trees consistently supply the most benefits per tree. They intercept large volumes of water, provide great amounts of shade, and absorb massive amounts of air pollution. **Table 5** shows individual species' total annual benefit and their average annual per tree. Silver maple provides the greatest benefit overall and benefit on a per tree basis.

***Table 5. University of Windsor's Total Annual Benefits per Species***

| Species | Aesthetic/ Other | Energy | Stormwater | Air Quality | $CO_2$ | Total | Average Benefits Per Tree |
|---|---|---|---|---|---|---|---|
| Austrian pine | $3,021 | $2,106 | $1,406 | $825 | $87 | $7,444 | $33.38 |
| Norway maple | $3,690 | $3,285 | $1,217 | $1,236 | $179 | $9,608 | $47.80 |
| silver maple | $3,475 | $4,188 | $2,245 | $1,654 | $203 | $11,765 | $83.44 |
| thornless honeylocust | $4,361 | $2,885 | $1,222 | $1,086 | $124 | $9,678 | $71.69 |
| Colorado spruce | $1,371 | $812 | $546 | $315 | $34 | $3,079 | $29.89 |
| littleleaf linden | $1,764 | $944 | $400 | $341 | $47 | $3,497 | $39.73 |
| red maple | $1,594 | $687 | $391 | $260 | $31 | $2,963 | $47.04 |
| apple spp. | $543 | $643 | $226 | $234 | $26 | $1,672 | $26.55 |
| London planetree | $1,257 | $1,151 | $565 | $424 | $55 | $3,451 | $67.66 |
| northern hackberry | $1,328 | $188 | $88 | $67 | $9 | $1,680 | $36.52 |
| **University-wide** | **$32,178** | **$22,834** | **$11,313** | **$8,727** | **$1,083** | **$76,135** | **$44.43** |

# Costs for Managing University of Windsor's Campus Trees

The costs of managing University of Windsor's campus trees are an investment back into the community on campus. In 2010, the University's total related expenditures for campus trees were approximately $12,000, less than 0.1% of the University's total institutional budget. Approximately $7.34 per tree is spent on average during one year. Approximately 16,000 students are enrolled at the University and $0.75 is spent per student on tree maintenance.

# Net Benefits and Benefit-Cost Ratio Discussion

According to the benefits presented in this chapter, having trees makes good sense, but are the collective benefits worth the costs of management? In other words, are trees a good investment for the University of Windsor? To answer that question, we must compare the benefit campus trees provide to the cost of their management.

The sum of environmental and economic benefits provided to the University of Windsor is $76,135 annually at an average of $46.59 per campus tree and $4.76 per enrolled student (**Table 6**). When the University of Windsor's annual expenditures of $12,000 are considered, the net annual benefit (benefits minus costs) returned by campus trees to the University is $64,135. The average net annual benefit for an individual campus tree is $39.25, which also translates to $4.01 per student.

Applying a benefit-cost ratio (BCR) is a useful way to evaluate the University's investment in its 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 University's campus trees, expressed in monetary terms, compared to the costs associated with their management, also expressed in monetary terms. The University of Windsor receives $6.34 in benefits for every $1.00 that is spent in its forestry program (**Table 6**). **Appendix F** provides a summary of the University of Windsor's total annual benefits, annual costs for managing their campus tree population, and net annual benefits.

***Table 6. University of Windsor's Net Benefits and Benefit-Cost Ratio***

| Benefit/Cost | Total ($) | $/Tree | $/Student |
|---|---|---|---|
| Total Benefits | 76,135 | 46.59 | 4.76 |
| Total Costs | 12,000 | 7.34 | 0.75 |
| Net Benefits | 64,135 | 39.25 | 4.01 |
| **Benefit Cost Ratio** | **6.34** | **-** | **-** |

## Management Implications

As a result, this i-Tree Streets analysis suggests that there is justification for more attention and increased funding for urban forestry planning, design, management, and maintenance at the University of Windsor. Planning for a greener and healthier campus can begin by including urban forestry in all Campus improvement project discussions and considering creative ways to ensure that campus trees are kept healthy, well maintained, safe, and expanded for the betterment of campus life.

Implementing a comprehensive tree management program, including cyclical pruning and new tree establishment, is the first step to ensure that benefits produced by the University's campus trees surpass the cost of managing them. Currently, 48.4% of the University of Windsor's inventoried trees are considered to be in fair condition and trees in good condition account for 41.8% of the population. While these figures indicate a strong commitment to campus tree management, University of Windsor should strive to eliminate all dead and dying (15 trees), replace poor performers (146 trees), cyclically maintain the remaining population (particularly large-statured species that provide the most benefits), and plant underutilized species to improve species diversity and reduce the impact of species-specific pests or diseases.

Planning to enhance University of Windsor's campus trees will require careful consideration of budget and time figures. Short- and long-term goals must be kept in mind and routine maintenance must be performed on a cyclical basis to ensure good health and condition of trees as they mature. Chapter 3 is designed to assist University of Windsor's Facility and Environmental Services managers with maintaining campus trees and abating/mitigating elevated levels of risk.


***Photograph 6.*** *Trees provide significant economic benefits, including increased real estate values and improved settings for community activities.*

# Chapter 3: Campus Tree Management Program

This chapter details the activities that will constitute the Campus Tree Management Program for the University of Windsor. Headings in this chapter include:

- Campus Tree Management Program and Budget
- Priority Risk Tree Maintenance Recommendations
- Routine Pruning Program
- Young Tree Training Pruning Program
- Tree Planting Program
- Management Recommendations for Updating the Inventory
- Program Support

## Campus Tree Management Program and Budget

University of Windsor's Facility Services is responsible for a variety of duties, including guiding the University's tree maintenance programs. This section consists of a seven-year program projection for all pertinent campus forestry activities and is intended to provide an example of the relative costs that could be incurred by the recommended activities. While accounting for current budgetary limitations, University of Windsor must understand that the budgeting recommendations below are only estimates and are based on the application of sound urban forestry management principles to urban forestry operations. The sections to follow will provide a detailed description of the work needed to accomplish the projected seven-year Campus Tree Management Program.

**Table 7** has been provided as an estimated budget for the University of Windsor's seven-year Campus Tree Management Program. The Management Program is designed to address the highest-risk removal and pruning recommendations first. This is intended to reduce potential elevated-risk situations for the public and all associated liabilities. The University may find it in its best interest to begin projected work in 2011 of the Management Program or change the recommended amount of work to fit within annual budget funds. For this purpose, Table 7 has been included on the CD-ROM as an Excel spreadsheet.

**Table 7** should be used as a general guideline for: implementation of the seven-year program, planning of future tree care operations, and reviewing on-going University forestry operations. Short-term accomplishments should be measured in comparison to the Management Program's goals and recommendations, and long-term goals should be measured in comparison to the Management Plan's goals and recommendations. The process to do so will be discussed in Management Recommendations for Updating the Inventory section.

*Table 7. Estimated Costs for University of Windsor's Campus Tree Management Program*

| Estimated Costs for Each Activity | | | YEAR 1: 2011-2012 | | YEAR 2: 2012-2013 | | YEAR 3: 2013-2014 | | YEAR 4: 2014-2015 | | YEAR 5: 2015-2016 | | YEAR 6: 2016-2017 | | YEAR 7: 2017-2018 | | Seven-Year Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Activity | Diameter Class (cm) | Cost/Tree (dollars) | # of Trees | Total Cost | # of Trees | Total Cost | # of Trees | Total Cost | # of Trees | Total Cost | # of Trees | Total Cost | # of Trees | Total Cost | # of Trees | Total Cost | |
| Severe Risk Removal | 1-8 | $25 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 9-15 | $105 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 16-30 | $220 | 2 | $440 | | | | | | | | | | | | | $440 |
| | 31-46 | $355 | 2 | $710 | | | | | | | | | | | | | $710 |
| | 47-61 | $525 | 1 | $525 | | | | | | | | | | | | | $525 |
| | 62-76 | $845 | 4 | $3,380 | | | | | | | | | | | | | $3,380 |
| | 77-91 | $1,140 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 92-107 | $1,470 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 108+ | $1,850 | 1 | $1,850 | | | | | | | | | | | | | $1,850 |
| **Activity Total(s)** | | | **10** | **$6,905** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **$6,905** |
| High Risk Removal | 1-8 | $25 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 9-15 | $105 | 1 | $105 | | | | | | | | | | | | | $105 |
| | 16-30 | $220 | 4 | $880 | | | | | | | | | | | | | $880 |
| | 31-46 | $355 | 6 | $2,130 | | | | | | | | | | | | | $2,130 |
| | 47-61 | $525 | 3 | $1,575 | | | | | | | | | | | | | $1,575 |
| | 62-76 | $845 | 1 | $845 | | | | | | | | | | | | | $845 |
| | 77-91 | $1,140 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 92-107 | $1,470 | 1 | $1,470 | | | | | | | | | | | | | $1,470 |
| | 108+ | $1,850 | 0 | $0 | | | | | | | | | | | | | $0 |
| **Activity Total(s)** | | | **16** | **$7,005** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **$7,005** |
| Moderate Risk Removal | 1-8 | $25 | | | 10 | $250 | | | | | | | | | | | $250 |
| | 9-15 | $105 | | | 4 | $420 | | | | | | | | | | | $420 |
| | 16-30 | $220 | | | 14 | $3,080 | | | | | | | | | | | $3,080 |
| | 31-46 | $355 | | | 3 | $1,065 | | | | | | | | | | | $1,065 |
| | 47-61 | $525 | | | 2 | $1,050 | | | | | | | | | | | $1,050 |
| | 62-76 | $845 | | | 0 | $0 | | | | | | | | | | | $0 |
| | 77-91 | $1,140 | | | 0 | $0 | | | | | | | | | | | $0 |
| | 92-107 | $1,470 | | | 0 | $0 | | | | | | | | | | | $0 |
| | 108+ | $1,850 | | | 0 | $0 | | | | | | | | | | | $0 |
| **Activity Total(s)** | | | **0** | **$0** | **33** | **$5,865** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **$5,865** |
| Low Risk Removal | 1-8 | $25 | | | 9 | $225 | | | | | | | | | | | $225 |
| | 9-15 | $105 | | | 3 | $315 | | | | | | | | | | | $315 |
| | 16-30 | $220 | | | 3 | $660 | | | | | | | | | | | $660 |
| | 31-46 | $355 | | | 2 | $710 | | | | | | | | | | | $710 |
| | 47-61 | $525 | | | 0 | $0 | | | | | | | | | | | $0 |
| | 62-76 | $845 | | | 0 | $0 | | | | | | | | | | | $0 |
| | 77-91 | $1,140 | | | 0 | $0 | | | | | | | | | | | $0 |
| | 92-107 | $1,470 | | | 0 | $0 | | | | | | | | | | | $0 |
| | 108+ | $1,850 | | | 0 | $0 | | | | | | | | | | | $0 |
| **Activity Total(s)** | | | **0** | **$0** | **17** | **$1,910** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **$1,910** |
| Severe Risk Prune | 1-8 | $20 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 9-15 | $30 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 16-30 | $75 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 31-46 | $120 | 3 | $360 | | | | | | | | | | | | | $360 |
| | 47-61 | $170 | 1 | $170 | | | | | | | | | | | | | $170 |
| | 62-76 | $225 | 1 | $225 | | | | | | | | | | | | | $225 |
| | 77-91 | $305 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 92-107 | $380 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 108+ | $590 | 0 | $0 | | | | | | | | | | | | | $0 |
| **Activity Total(s)** | | | **5** | **$755** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **$755** |
| High Risk Prune | 1-8 | $20 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 9-15 | $30 | 3 | $90 | | | | | | | | | | | | | $90 |
| | 16-30 | $75 | 13 | $975 | | | | | | | | | | | | | $975 |
| | 31-46 | $120 | 20 | $2,400 | | | | | | | | | | | | | $2,400 |
| | 47-61 | $170 | 13 | $2,210 | | | | | | | | | | | | | $2,210 |
| | 62-76 | $225 | 8 | $1,800 | | | | | | | | | | | | | $1,800 |
| | 77-91 | $305 | 2 | $610 | | | | | | | | | | | | | $610 |
| | 92-107 | $380 | 0 | $0 | | | | | | | | | | | | | $0 |
| | 108+ | $590 | 2 | $1,180 | | | | | | | | | | | | | $1,180 |
| **Activity Total(s)** | | | **61** | **$9,265** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **$9,265** |
| Stump Removal | 1-8 | $25 | | | 20 | $500 | | | | | | | | | | | $500 |
| | 9-15 | $25 | | | 11 | $275 | | | | | | | | | | | $275 |
| | 16-30 | $30 | | | 42 | $1,260 | | | | | | | | | | | $1,260 |
| | 31-46 | $45 | | | 22 | $990 | | | | | | | | | | | $990 |
| | 47-61 | $75 | | | 8 | $600 | | | | | | | | | | | $600 |
| | 62-76 | $105 | | | 5 | $525 | | | | | | | | | | | $525 |
| | 77-91 | $140 | | | 1 | $140 | | | | | | | | | | | $140 |
| | 92-107 | $165 | | | 1 | $165 | | | | | | | | | | | $165 |
| | 108+ | $200 | | | 1 | $200 | | | | | | | | | | | $200 |
| **Activity Total(s)** | | | **35** | **$0** | **111** | **$4,655** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **0** | **$0** | **$4,655** |
| Routine Pruning Program | 1-8 | $20 | | | | | 13 | $260 | 13 | $260 | 13 | $260 | 13 | $260 | 13 | $260 | $1,300 |
| | 9-15 | $30 | | | | | 23 | $690 | 23 | $690 | 23 | $690 | 23 | $690 | 23 | $690 | $3,450 |
| | 16-30 | $75 | | | | | 116 | $8,700 | 116 | $8,700 | 116 | $8,700 | 116 | $8,700 | 116 | $8,700 | $43,500 |
| | 31-46 | $120 | | | | | 39 | $4,680 | 39 | $4,680 | 39 | $4,680 | 39 | $4,680 | 39 | $4,680 | $23,400 |
| | 47-61 | $170 | | | | | 16 | $2,720 | 16 | $2,720 | 16 | $2,720 | 16 | $2,720 | 16 | $2,720 | $13,600 |
| | 62-76 | $225 | | | | | 5 | $1,125 | 5 | $1,125 | 5 | $1,125 | 5 | $1,125 | 5 | $1,125 | $5,625 |
| | 77-91 | $305 | | | | | 2 | $610 | 2 | $610 | 2 | $610 | 2 | $610 | 2 | $610 | $3,050 |
| | 92-107 | $380 | | | | | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | 0 | $0 | $0 |
| | 108+ | $590 | | | | | 1 | $590 | 1 | $590 | 1 | $590 | 1 | $590 | 1 | $590 | $2,950 |
| **Activity Total(s)** | | | **0** | **$0** | **0** | **$0** | **215** | **$19,375** | **215** | **$19,375** | **215** | **$19,375** | **215** | **$19,375** | **215** | **$19,375** | **$96,875** |
| **Cost Sub Total** | | | | **$23,930** | | **$12,430** | | **$19,375** | | **$19,375** | | **$19,375** | | **$19,375** | | **$19,375** | **$133,235** |

| Estimated Costs for Each Activity | | | YEAR 1: 2011-2012 | | YEAR 2: 2012-2013 | | YEAR 3: 2013-2014 | | YEAR 4: 2014-2015 | | YEAR 5: 2015-2016 | | YEAR 6: 2016-2017 | | YEAR 7: 2017-2018 | | Seven-Year 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 | # of Trees | Total Cost | # of Trees | Total Cost | |
| Young Tree Training Pruning Program | 1-8 | $20 | | | 117 | $2,340 | 117 | $2,340 | 117 | $2,340 | 117 | $2,340 | 117 | $2,340 | 117 | $2,340 | $14,040 |
| | 9-15 | $30 | | | 28 | $840 | 28 | $840 | 28 | $840 | 28 | $840 | 28 | $840 | 28 | $840 | $5,040 |
| | 16-30 | $75 | | | 1 | $75 | 1 | $75 | 1 | $75 | 1 | $75 | 1 | $75 | 1 | $75 | $450 |
| **Activity Total(s)** | | | **0** | **$0** | **146** | **$3,255** | **146** | **$3,255** | **146** | **$3,255** | **146** | **$3,255** | **146** | **$3,255** | **146** | **$3,255** | **$19,530** |

| Estimated Costs for Each Activity | | | YEAR 1: 2011-2012 | | YEAR 2: 2012-2013 | | YEAR 3: 2013-2014 | | YEAR 4: 2014-2015 | | YEAR 5: 2015-2016 | | YEAR 6: 2016-2017 | | YEAR 7: 2017-2018 | | Seven-Year Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Activity | Item | Cost/Tree (dollars) | # of Trees | Total Cost | # of Trees | Total Cost | # of Trees | Total Cost | # of Trees | Total Cost | # of Trees | Total Cost | # of Trees | Total Cost | # of Trees | Total Cost | |
| Tree Planting | Purchasing | $200 | | | 20 | $4,000 | 20 | $4,000 | 20 | $4,000 | 20 | $4,000 | 20 | $4,000 | 20 | $4,000 | $24,000 |
| | Planting | $110 | | | 20 | $2,200 | 20 | $2,200 | 20 | $2,200 | 20 | $2,200 | 20 | $2,200 | 20 | $2,200 | $8,800 |
| **Activity Total(s)** | | | **0** | **$0** | **40** | **$6,200** | **40** | **$6,200** | **40** | **$6,200** | **40** | **$6,200** | **40** | **$6,200** | **40** | **$6,200** | **$37,200** |
| **Activity Grand Total** | | | **143** | | **347** | | **401** | | **401** | | **401** | | **401** | | **401** | | **1,693** |
| **Cost Grand Total** | | | | **$23,930** | | **$21,885** | | **$28,830** | | **$28,830** | | **$28,830** | | **$28,830** | | **$28,830** | **$189,965** |

**Table 8** has been provided in order to help University of Windsor's Facility Services better organize specific activities throughout a year of the tree management program further 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 University's campus trees.

***Table 8. 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 | X | X | X | X | X | X |
| Moderate-Risk (Inventory) | 2 | X | X | X | X | X | X | X | X | X | X | X | X |
| Low-Risk (Inventory) | 2A | X | X | X | X | X | X | X | X | X | X | X | X |
| Stump Removal (Inventory) | 2A | X | X | X | X | X | X | X | X | X | X | X | X |
| **PRUNING** | | | | | | | | | | | | | |
| Severe-Risk(Inventory) | 1 | X | X | X | | | | | | | X | X | X |
| High-Risk (Inventory) | 1 | X | X | X | | | | | | | X | X | X |
| Routine Pruning (Five-Year Rotation) | 3A | X | X | X | | | | | | | X | X | X |
| Young Tree 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 | | | X | X | X | | | | | | | |
| **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 | 2A | | | | | | | | | | | | |
| Ball & Burlap Container | 2A | | | X | X | X | X | X | X | X | X | X | |
| Bare Root | 2A | | | X | X | X | | | | | | | |
| Watering (New Trees) | 2A | | | X | X | X | X | X | X | X | X | X | |
| Cabling and Bracing | N | X | X | X | | | | | | | | X | X |
| Mulching | 2A | | | | | | | | | | | | |
| Weed Control | 2A | | | X | X | X | X | X | X | X | | | |
| Watering (Older Trees) | 2A | | | | | | | X | X | X | X | | |
| **INVENTORY** | | | | | | | | | | | | | |
| Update Field Inventory | 8-10 | 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 9** lists the estimated costs for tree removals, pruning, stump removals, fertilization, and mulching. Local pricing may vary from these figures. 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. These dollar amounts have been modified to reflect Canadian pricing and confirmed with Canadian contractors. These costs are an average and are used to estimate the priority maintenance recommendations, *Routine Pruning Program*, and *Young Tree Training Pruning Program* budget projections described in this Management Plan.

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

| Diameter Size Class (cm) | Estimated Removal Cost/Tree | Estimated Pruning Cost/Tree | Estimated Stump Removal Cost/Stump | Estimated Fertilization Cost/Tree | Estimated Mulching Cost/Tree |
|---|---|---|---|---|---|
| 1-8 | $25 | $20 | $25 | $5 | $11 |
| 9-15 | $105 | $30 | $25 | $18 | $11 |
| 16-30 | $220 | $75 | $30 | $22 | $14 |
| 31-46 | $355 | $120 | $45 | $30 | $14 |
| 47-61 | $525 | $170 | $75 | $50 | $20 |
| 62-76 | $845 | $225 | $105 | $60 | $20 |
| 77-91 | $1,140 | $305 | $140 | $90 | $28 |
| 92-107 | $1,470 | $380 | $165 | $120 | $28 |
| 108+ | $1,850 | $590 | $200 | $150 | $28 |

# Priority Risk Tree Maintenance Recommendations

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

The overall maintenance priorities, in order of how they should be abated/mitigated, are:

- Removals—Severe- and High-Risk
- Pruning—Severe- and High-Risk
- Removals—Moderate- and Low-Risk

Based on tree inventory results, **Table 10** provides a summary of Severe- and High-Risk Removals and Severe- and High-Risk Pruning recommended in Year 1 of the Management Program. In Year 2, the Davey Resource Group recommends the removal of all Moderate- and Low-Risk trees. In addition, it is recommended that all existing stump removals, including the stumps created as a product of removals in Years 1 and 2, be completed in Year 2.

Davey Resource Group strongly encourages the University to schedule all Severe- and High-Risk maintenance recommendations to occur in Year 1 – as soon as possible in order to abate/mitigate potential risks. By doing so, the University will greatly decrease the potential of injury to the public, damage to property, and possible liability litigation. Where numerous Severe- and High-Risk removal and/or pruning treatment recommendations exist in the same area of the University, the work should be performed at the same time in order to capture efficiencies like reduced travel time and costs.

In addition to these immediate concerns, a natural mortality rate of 1% of the total tree population per year is expected. National averages in the United States show annual mortality rates of about 1%. The mortality rate for the University of Windsor's trees may represent approximately 16 trees per year. These anticipated tree removal costs are not factored into the Campus Tree Management Program budget projection; however, the University should allocate funds in anticipation of these removals.

Also, 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. The University must establish procedures for keeping the tree inventory information current. Keeping accurate records of work completed on specific trees and tracking removals and installations will help accomplish this. Inventory update recommendations are discussed in a later section of this chapter.

The recommended budget does suggest increased spending on campus forestry. Though the University may not have the resources to perform all needed maintenance activities immediately due to budgetary restrictions, an organized and systematic program to achieve the needed results in a timely manner, will demonstrate the University's "good faith" effort to keep the University spaces safe for its residents, students, faculty, staff, and visitors.

See **Appendix G** for an example of work specifications for pruning and removals.

***Photograph 7.*** *This split trunk on University property presents a Severe-Risk to the community and should be removed as soon as possible.*

***Table 10. Risk Tree Maintenance Recommendations by Type and Size Class***

| Tree Diameter Size Class (centimeters) | Severe Risk Removal | High Risk Removal | Moderate Risk Removal | Low Risk Removal | Severe Risk Prune | High Risk Prune |
|---|---|---|---|---|---|---|
| 1-8 | 0 | 0 | 10 | 9 | 0 | 0 |
| 9-15 | 0 | 1 | 4 | 3 | 0 | 3 |
| 16-30 | 2 | 4 | 14 | 3 | 0 | 13 |
| 31-46 | 2 | 6 | 3 | 2 | 3 | 20 |
| 47-61 | 1 | 3 | 2 | 0 | 1 | 13 |
| 62-76 | 4 | 1 | 0 | 0 | 1 | 8 |
| 77-91 | 0 | 0 | 0 | 0 | 0 | 2 |
| 92-107 | 0 | 1 | 0 | 0 | 0 | 0 |
| 108+ | 1 | 0 | 0 | 0 | 0 | 2 |
| **Totals** | **10** | **16** | **33** | **17** | **5** | **61** |

# Routine Pruning Program

Routine pruning is an activity that should take place on a cyclical basis for the entire tree population once all trees with Severe- and High-Risk Ratings have been managed. This activity is extremely beneficial for the overall health and longevity of campus trees and can prevent future problems requiring costly intervention. 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 concerning declining trees and any trees that are becoming potential elevated-risks can be managed appropriately before any serious incidents occur. Davey Resource Group recommends quickly treating, pruning, or removing any trees infested by insects or disease to eliminate potential breeding sites.

Note that young or newly planted trees are not included in this program. These trees will be included in the Young Tree Training Pruning Program explained later. However, as young trees in the Young Tree Training Pruning Program grow larger, they will become part of the Routine Pruning Program.

## Five-Year Cycle

Results from the tree inventory indicate that 1,057 trees would be included in a cyclical pruning operation. This includes all trees designated with a Primary Maintenance of Large Tree Clean or Small Tree Clean with a Moderate- or Low-Risk Rating. It is suggested that a five-year cycle be implemented so that approximately 215 trees are routinely pruned every year. A seven-year budget has been provided for all inventoried trees. In the proposed Management Program (**Table 7**), it is recommended that the Routine Pruning Program begin in Year 3, and should be continued on a five-year cycle thereafter. **Table 11** details the average number of trees in each diameter class that would be pruned annually during the five-year cyclical Routine Pruning Program. It is intended for this seven-year budget to illustrate estimated costs for each activity and facilitate plans for short-term management recommendations. This Management Plan provides the University with exact numbers concerning Routine Pruning and it serves as a guideline for accomplishing such a program.

As part of the proposed Management Program, 66 (4.0%) trees were recommended for Severe- or High-Risk Pruning. Once the Severe- and High-Risk pruning recommendations of these trees are met, they will also fall into the maintenance category of Routine Pruning. This will eventually increase the total number of mature trees requiring Routine Pruning to approximately 1,123. Davey Resource Group suggests that once the Routine Pruning Program is established and implemented in Year 3 of the Campus Tree Management Program that the Routine Pruning Program continues uninterrupted. In Year 7 of the Management Program University of Windsor's Facility Services will need to re-evaluate the number of trees needing cyclical maintenance. The trees pruned in Year 1 as a result of Severe- and High-Risk Prunes, and those pruned in Year 3 as a part of the Routine Pruning Program, will need to be pruned again. Approximately 20% of the tree population will require pruning each year. It is important that staff continue to update the tree inventory as pruning, removals or plantings are undertaken, to ensure an excellent record for due diligence purposes. See **Appendix G** for details on proper pruning guidelines.

Centralized pruning should be carried out, meaning that all trees on a single University property or within a management area are trimmed at the same time. An example of a convenient schedule is to divide the five grounds-keeping zones throughout the five-year cycle to allow for one zone to be pruned each year. Each inventoried tree was assigned to a grounds-keeping zone determined by its location on campus ground and designated by University of Windsor's Environmental Services.

*Table 11 Routine Pruning Program by Size Class*

| Tree Diameter Size Class (centimeters) | Trees for Routine Prune (Large and Small Tree Clean Moderate- and Low-Risk) | Approximate Number of Trees Pruned per Year (5-Year Cycle) |
|---|---|---|
| 1-8 | 65 | 13 |
| 9-15 | 112 | 23 |
| 16-30 | 576 | 116 |
| 31-46 | 193 | 39 |
| 47-61 | 80 | 16 |
| 62-76 | 21 | 5 |
| 77-91 | 8 | 2 |
| 92-107 | 0 | 0 |
| 108+ | 2 | 1 |
| **Totals** | **1,057** | **215** |

## Useful Life

The useful life of a campus tree is ended when the cost of maintenance is greater than the value added by the tree to the community. This can be due to either the decline of the tree's condition and increasing maintenance activities or to the costs of repairing damage caused by the tree's presence.

Decline generally starts when the tree has reached a point where it cannot withstand the stresses imposed by its environment. Restrictive growing space, disease, insects, mechanical injury, pollution, and vandalism, among others, can cause stress. Although some species are more resistant to these urban stresses, all trees in urban settings will eventually decline, whether due to overmaturity, stress, or senescence.

The pattern of decline generally begins with persistent limiting site factors that place the tree in a state of chronic stress. This weakens the tree's natural defenses, leaving it more susceptible to injury from pests or unusual weather, such as a single insect-induced defoliation or a late frost. Because the tree is now stressed, it has difficulty withstanding or combating the circumstance or recovering from such stress. As a result, the tree can become even more vulnerable to insects and diseases that continue to reduce its vitality. Often, the first signs of a problem appear at this point.

The age at which a tree reaches the end of its useful life differs by genus and also for certain species within a genus. Slow-growing trees, such as northern red oak, are most valuable when they attain maturity. Faster-growing species, such as silver maple, are most valuable as juvenile trees because they provide benefits quickly and become brittle as they reach maturity.

The end of a tree's useful life can also be reached while the tree is still healthy if it is growing in a "limited" site. Useful life, in this instance, is the point at which the cost of related maintenance, such as the repair of hardscape damage, exceeds the value added by the tree. For example, a large, fast-growing tree used in a smaller tree lawn will cause hardscape damage at an early age and periodically throughout its lifetime. The useful life of this tree will be reached before it begins to decline. A smaller tree, on the other hand, would probably not exceed grow space dimensions at any point in its life. The end of its useful life would probably be reached only when it started to decline due to senescence. A smaller tree, as a result, would make better use of this example tree site.

***Photograph 8.*** *University of Windsor has created a beautiful learning environment, due in part to its commitment to campus forestry management. From past to present, the unique campus setting has attracted students from many places. As the University continues to develop, all trees should be properly cared for so that future generations will experience the benefits of diverse, healthy, and mature campus trees.*

# Best Management Practices for Maturing Trees

## Tree Crew Training

Proper training about how to properly prune trees should be required for all tree crew personnel. All crews need an understanding of the growth-habits of the various species being planted, as well as an understanding of basic tree anatomy and physiology. It is imperative to emphasize proper arboricultural and horticultural techniques and practices. The tremendous aesthetic and financial benefits to be gained in the years to come from the proper pruning of large- and small-stature trees and training of young trees is a strong incentive for educating tree crews concerning proper pruning techniques. DRG recommends that existing staff's training be enhanced with additional hands-on training, and/or classroom training. Training could be provided by qualified, respected tree care contractors, through Landscape Ontario sessions, or by partnering with the City of Windsor's Forestry department.

## Insect and Disease Control

Generally, trees do not have significant insect and disease problems if they are healthy and well cared for. However, some degree of insect infestation and disease incidence will always be present, as this is the norm for the natural world. It is only when particularly damaging insects are detected and the levels of insect populations are extremely high (such as Emerald Ash Borer or Asian Longhorned Beetle) or when particularly virulent diseases are diagnosed (such as oak wilt) that action must be taken. The type and extent of action depends on the type and extent of the insect or disease problem. See **Appendix H** for more information on pests and diseases.

The array of insects and diseases that can threaten the health of forest and urban trees and their treatments are too numerous to completely encompass within the scope of this document. However, a basic discussion on the fundamentals of an Integrated Pest Management program, and specifically monitoring, is covered in this section.

Fundamentals of an Integrated Pest Management program are:

1. **Identification:** The proper identification of trees and their existing and potentially harmful pests is necessary to successfully manage a pest outbreak or occurrence. Additionally, understanding each pest's life cycle is important for a positive diagnosis. Knowledge of beneficial and incidental (non-threatening) organisms also plays an important role in the identification and diagnostic process.

2. **Monitoring:** Proactive, regular monitoring for potential threats is perhaps the most important part of an Integrated Pest Management program. Monitoring for pest activity can be done using a variety of techniques, including visual inspection, and, in some cases, use of specialized traps. Regular contact with provincial and local plant health care officials can help to focus monitoring efforts and increase awareness of emerging threats. The Canadian Food Inspection Agency (CFIA) or the Ontario Ministry of Natural Resources (OMNR) can provide support for suspicions of potential pest infestations.

3. **Understanding the Economic Threshold Level:** The economic threshold is the level in which the costs involved in managing a pest infestation overshadow the value that a tree or plant is providing. In an urban situation, the economic value of a tree can be tied to the benefits that a tree provides. These benefits include, but are not limited to, aesthetic, environmental, and cultural benefits. This concept, on a general level, amounts to determining whether or not a tree is worth the costs of mitigating against a pest problem compared to its value to the community.

4. **Selecting the Correct Treatment:** Once a pest problem has been properly diagnosed and the decision has been made to treat the problem, selection of the correct treatment is the next step. Selecting treatment is a decision that requires a solid understanding of all the options, chemical or otherwise, for pest management material.

5. **Proper Timing of Management Strategies:** Once an appropriate treatment has been selected, it is important to carefully plan the timing and implementation to maximize effectiveness.

6. **Recordkeeping:** To facilitate future pest management decisions, accurate records should be kept concerning information on pests, treatments, locations, timing, weather conditions, and any other useful information.

7. **Evaluation:** A successful Integrated Pest Management program must be evaluated based on experience, successes, and failures in order to focus efforts and resources for the future.

## Fertilization

Mature trees need not be placed on a scheduled fertilization program without a documented need. If soil analyses show a distinct and serious nutrient deficiency, or if the tree's root system or growing area has been damaged or contaminated, then the time and expense of fertilization may be worthwhile to save the tree. See **Appendix I** for an example of work specifications for Fertilization.

## Irrigation

All trees need supplemental watering when there are drought conditions. This supplemental irrigation can be accomplished with a water truck and hose and/or deep root watering lance, or with watering aids, such as the widely used Treegator® Drip Irrigation Bags. The University is encouraged to water trees frequently during the summer, even when there are no drought conditions.

## Cabling and Bracing

Rather than removing or severely pruning a mature tree if a structural defect is discovered, the use of structural support can reduce safety risks. Cabling and bracing are the two most common forms of structural support for trees. Other, less common forms of structural support are guying and propping. Structural support is infrequently recommended, but trees with special or historic significance can be spared from removal by using such techniques as cabling and bracing. Generally, this involves installing flexible cables or rigid rods to reduce the chances of failure of defective unions.

If the decision is made that a tree needs structural support, there are a few basic considerations. First, only use a Certified Arborist who is knowledgeable and experienced in this area. Ask about the important technical aspects of correct cabling and bracing: the strength and material of the hardware; the arrangement of the cables (*e.g.*, simple, triangle, or box) or rods (*e.g.*, single or multiple); and the location, type and size of the entries made into the tree. Be sure to specify in writing "all work and materials shall be in accordance with ANSI, A300 Tree Care Standards (Part 3), 2005".

# 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 6- to 8-meters tall. For these trees, 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, multiple 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 University of Windsor in the future.

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. Young tree training is a relatively simple task that requires a low investment in equipment, training and time. It also can be performed from the ground, using hand secateurs or loppers. It is recommended that existing staff be provided with training on basic pruning practices and tasked with training young trees, to promote care of, and pride in their tree infrastructure. Staff that are responsible for care of young trees also provide value in preventing tree injuries such as mechanical damage caused by mowing, and other preventable tree injuries.

## Three-Year Cycle for Young Tree Training

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 three-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.

A three-year pruning cycle would require the training pruning of approximately 146 trees per year. In the proposed seven-year Management Program (**Table 7**), it is recommended that the Young Tree Training Pruning Program begin in Year 2, and should be continued on a three-year cycle thereafter. **Table 12** details the average number of trees in each diameter class that would be pruned annually during the three-year cyclical Young Tree Training Pruning Program. In Year 5, the Young Tree Training Pruning Program must be re-evaluated to account for a new generation of trees planted and trees that have matured out of the Young Tree class.

This work can be accomplished throughout the year, but is generally done at university campuses during summer or winter seasons, as spring and fall present peak challenges with student activity. Particularly, since no aerial lift truck is required, University employees can perform this work at any time. It has been Davey Resource Group'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 young tree training. This type of work is also suitable for properly trained summer interns, part-time employees, and/or volunteers.

*Table 12. Young Tree Training Pruning Program by Size Class*

| Size Class (centimeters) | Number of Trees for Young Tree Training Pruning (Young Tree Train, Moderate- and Low-Risk) | Approximate Number of Trees Pruned per Year (3-Year Cycle) |
|---|---|---|
| 1-8 | 351 | 117 |
| 9-15 | 83 | 28 |
| 16-30 | 1 | 1 |
| **Totals** | **435** | **146** |

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).

## Tree Establishment

To establish themselves in a new environment all trees need to be watered periodically. Irrigation can be accomplished with a water truck and hose and/or deep root watering lance, or with watering aids, such as the widely used Treegator® Drip Irrigation Bags.

Noted during the campus tree inventory was frequent mechanical damage to young trees on campus. Higher than necessary mortality rates in young trees may be mitigated through increased attention to detail in lawn maintenance activities. It is common that urban trees are girdled from lawnmower activity or use of weed trimmers around the base of trees. It is important to utilize mulching techniques to remove the proximity of mechanical equipment to young trees (see the Tree Planting Program section of this chapter).

# Tree Planting Program

During the University of Windsor's campus tree inventory, potential planting sites were not mapped or recorded. Currently, the University plants an estimated 20 trees per year. Davey Resource Group recommends that the University, at a minimum, replace trees removed with new plantings. The University should plant as many trees as their budget will allow, taking into consideration post-planting costs. **Table 7** presents the proposed budget for the University of Windsor and includes an estimated planting of 20 trees per year.

Since the removal of 76 Severe-, High-, Moderate-, and Low-Risk trees were recommended to occur in the first year of the maintenance program, Davey Resource Group recommends the University of Windsor replace those trees within four years starting in 2012. It is important to develop an overall planting strategy, initially concentrating on areas with the greatest need for improvement. When planting trees, species selection and planting location are significant considerations due to the long-term impact of these decisions. Additionally, it is very important to make sure that the new trees are properly installed and the species characteristics of the planted tree are right for the location and site restrictions. Matching a species to its favored climate, soil, and site conditions are essential when planning for a low-maintenance landscape.

## Best Management Practices for Tree Planting

It is important to develop an overall planting strategy, initially concentrating on specific areas of the campus, including around buildings, streets, parking lots, and athletic fields with the greatest need for improvement. Tree planting priorities should focus on the core campus first. The success of a continuing tree planting program will be judged by the health of the trees post-planting and the amount of money spent on planting and maintaining the new trees. With a small amount of planning, healthy trees with greater life expectancies can be established with minimal up-front investment and minor maintenance costs.

The key elements for a successful tree-planting program are covered in this chapter and are primarily based on the exceptional reference, Principles and Practice of Planting Trees and Shrubs (Watson and Himelick, 1997). Also see **Appendix I** for an example of work specifications for tree planting.

## Species Diversity

Tree plantings add greatly to the aesthetic appeal of campuses. However, species diversity in new plantings should be of major importance. Maples account for 25.7% of University of Windsor's total tree population. The dangers of planting monocultures have proven to be devastating throughout Southern Ontario, and the United States. The goal should be to increase species diversity throughout the Campus, such that no one species represents 10% and that no one genus comprises more than 20% of the total campus tree population. Whenever possible, consideration should be given to large trees that provide shade and are aesthetically pleasing. Consideration should also be given to planting native trees for both educational and sustainability purposes.

***Photograph 9.*** *This tree has developed girdling roots. Proper planting techniques can help mitigate girdling roots.*

## Tree Species and Site Selection

Windsor is located in Plant Hardiness Zone 6b, which identifies a climatic region where the average annual minimum temperature is -21℃. Tree species selected for pla nting on University grounds should be appropriate for this zone.

The relationship between species mature growth-habit and site restrictions should be carefully considered before planting. The size of each site is of great importance, including maximum desired height due to overhead utilities, and proximity to buildings and infrastructure. Proper site selection can maximize benefits and minimize long-term costs, ensuring the most productive use of University resources. In addition to considering site characteristics such as availability of space, soil pH, and irrigation, species-specific features must also be scrutinized.

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. University campuses have a high volume of visitors during spring and fall, so choice of colourful species during these periods should be considered.

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. Matching a species to its favoured climatic and soil conditions is the most important task when planning for a low-maintenance landscape. Plants that are well-matched to their environmental site conditions are much more likely to resist pathogens and insect pests and will, therefore, require less maintenance overall. Refer to **Appendix C** for additional tree species and cultivars suitable for planting in Windsor.

## Tree Purchasing

As the University 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.

Davey Resource Group 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 University of Windsor explore local and regional sources for trees and discuss pricing with the current nursery source. Due to the requirement to work towards species diversity, it may be necessary to use several nurseries as sources for trees. It is recommended that the University consult with the City of Windsor for recommendations on preferred pricing for large volume plantings.

## Tree Planting Process

Many trees that appear on campus exist within street rights-of-way of the City of Windsor. A relationship should exist between the University and the City such that future tree planting in proximity to Campus property consider recommendations of the University's Campus Tree Management Plan.

Once the appropriate trees have been selected for planting in the appropriate location, the most important detail to ensure success is the preparation of the planting sites. Since the University of Windsor's Environmental Services does the majority of the tree planting on Campus, all staff charged with the task of planting should be well versed in proper planting techniques. Any contractors that plant trees on Campus should also be properly trained in this procedure. Their work should be inspected and any tree not installed properly should be required to be replanted by the contractor at fault. 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. **Appendix I** explains the proper method of excavating a planting hole.

Tree size is an important consideration. Davey Resource Group recommends a minimum 50mm caliper size for campus plantings, as trees of this size are more resistant to vandalism than smaller girth trees.

Tree staking hardware should 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 should be removed after one growing season. In areas of high vandalism, stakes can be retained for an additional year, but must be removed after two years to allow the tree to develop strength.

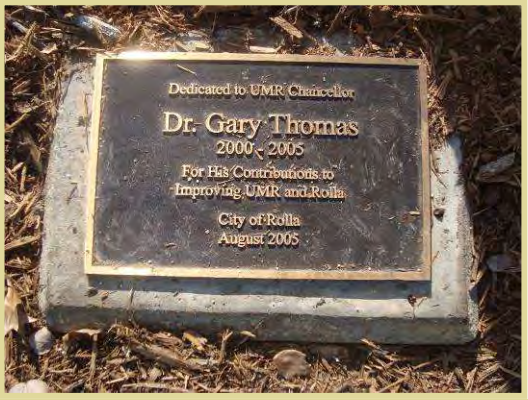
## Tree Mulching

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.

## Memorial Tree Program

The University of Windsor's tree planting program can be partially funded and enhanced by creating and advertising a Memorial and Honour Tree Planting Program. Community members 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.

The form of a memorial, such as a plaque at the tree or a listing in a campus register, will need to be decided prior to initiating the program. This will ensure a uniform sense of overall continuity to the marking of all memorial trees found on Campus. Before deciding the form and function of the memorial tree markers, it will be necessary to include grounds maintenance personnel in the discussion to weigh in on the maintenance




***Photograph 10.*** *Example of a memorial tree marker.*

and overall upkeep of the markers. Choosing a style and construction that will be durable, as well as practical, will ensure the markers will be both long-lasting and well-cared for in the years to come. Simple low-profile markers made of steel or stone and set adjacent to the trees and moved as the trees grow would be ideal. Staked memorial markers often provide cost effective options for a memorial tree planting program. Such markers might be set within the mulched area around a tree and anchored to the ground, but still remain movable based on the growth of that individual tree.

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. It is important to set a donation price per tree that includes the cost of purchasing and planting, as well as any recognition given to the donors. Consideration should be given to the initial maintenance and care needed for the establishment of the newly planted memorial trees. Young tree pruning, watering, and mulching are critical practices during the first years of newly planted trees (**Appendix I**). These practices will ensure the tree becomes well established, and can be enjoyed by the donor and student body for years to come. A variety of donor programs exist at universities, including programs that plaque existing trees, and programs that plant new trees. Replacement guarantees may or may not be included as part of the program, should the memorial tree die.

An overall timeframe for the project is important in order to set short- and long-term goals, set new benchmarks for success, and periodic review of the program to gauge effectives and make necessary improvements. Once the Memorial Tree Program is established, the University should take steps to promote the program through a kick-off ceremony, brochure, campus announcement, press release, and other avenues of communication within the general campus, as well as Alumni and the Windsor community.

## Management Recommendations for Updating the Inventory

Monitoring trees conditions and making efforts to maintain their health is essential. When maintaining campus 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. It is recommended that the University conduct yearly inspections of all campus trees and record any necessary changes in tree condition, maintenance, and risk. Any tree requiring removal should be scheduled and budgeted for accordingly. Any tree presenting severe- or high-risk of limb failure should also be scheduled and budgeted for accordingly. In these two cases, work should be done immediately or following the year work is recorded as required. It is also recommended that the University conduct inspections after severe storm events and record changes in tree conditions, maintenances, and risks of the inventoried tree population.

An up-to-date inventory is the best way for the University to monitor the progress of its tree care operations. The major benefit of an accurate tree inventory is that the University can budget, plan, and anticipate tree-related problems and situations in the most cost-effective manner possible. Only if the inventory database is updated is it a useful management tool for work planning. Completion of recommended tree work, newly performed tree inspections, and resulting new tree work must be updated in the inventory database/Asset Manager software system to reflect changes in maintenance requirement, tree condition, and potential risk changes. At a minimum, tree work should be updated monthly.

In order to measure the seven-year Campus Tree Management Program effectiveness, a method for evaluation should be followed. Specific accomplishments can be measured in comparison to the Program's goals and recommendations. These include:

- Compare the actual number of completed Severe- and High-Risk Removals to the recommended number listed in Year 1.
- Compare the actual number of completed Severe- and High-Risk Prunes to the recommended number listed in Year 1.
- In Years 3 through 7, compare the number of trees pruned annually in the Routine Pruning Program to the annual goals of the five-year maintenance cycle.

- Count the number of trees pruned annually in the Young Tree Training Pruning Program and compare it to the recommended number in the three-year maintenance cycle.
- Compare the actual number of plantings to the recommended number in the Management Program.
- Compare the University's annual campus forestry expenses to the budget projected in this Management Program. Modify the planned work or increase budget requests to accomplish campus forestry goals and objectives.
- Conduct a complete re-inventory of campus after Year 7.

# Program Support

## Tree Preservation/Stewardship Policy

University of Windsor is endowed with mature trees that give the campus a unique and beautiful look. Preserving these trees can be a difficult task within a campus environment. By using preservation guidelines, or implementing a tree stewardship policy, the University of Windsor will ensure their stately, mature trees will remain protected and healthy.

One of the most common causes of tree death throughout the country is the lack of proper protection measures during construction activities. This involves street and sidewalk repair and construction, utility work, building construction, trenching, soil grading, and any other activities that require digging in the root zone of existing trees. Tree preservation and protection on campus grounds should be governed by tree protection rules. Without tree protection rules, contractors, whether they be construction workers, electrical contractors, concrete contractors, utility workers, etc., may not place a priority on protecting trees from undue damage. In general, contractors do not have enough knowledge about tree biology and understanding of the impact of their actions, to take action to properly protect trees.

Davey Resource Group has concerns that protection mechanisms are not formalized on campus. By formalizing protection and preservation regulations in writing, understanding and adherence by builders and contractors is more likely. Tree preservation and protection guidelines could be made part of a new tree stewardship policy or placed in another appropriate legislative area. Many campuses have such policies, and the University of Windsor should consider all aspects and conditions of these types of policies and ordinances to develop one suited to the Campus' needs. See **Appendix J** for a Sample Tree Preservation Ordinance and a document concerning Construction Damage and Tree Preservation.

## Education and Outreach

The University of Windsor now has important data that can be used to promote and publicize the importance of the urban forest. Davey Resource Group recommends the implementation of a Public Relations Program designed to educate students, faculty and staff of University of Windsor and to generate greater support for the University's urban forestry program.

The University should:

- Use i-Tree Streets results to demonstrate the environmental and economic impact and value of University trees.
- Advertise species planting lists to control species diversity and limit invasive species, also encouraging varying sizes of trees to be planted to impact the age distribution of the campus forest.
- Explain that removing hazard trees and tree parts increases public safety, but also, in the case of a removal, increases tree planting opportunities.
- Educate the community about the negative impact invasive flora and fauna have on the urban forest and community ecosystem as a whole.
- Educate contractors, utility workers and other service providers that work on campus grounds regarding tree stewardship related policies.

## Sources of Funding

A special account could be created to deposit funds from various sources, which are restricted for use by the forestry program. The funds in this account are managed by the University's Environmental Services and expenditures follow normal purchasing policies and procedures. This innovative funding mechanism does not rely on University general funds but, instead, on the collection and deposit of monies from various sources. The University should establish a Campus Tree Fund. Suggested sources included, but are not limited to, the following:


***Photograph 11.*** *A community in Missouri educates trail goers about benefits this tree provides.*

**Damage Compensation.** This source may not generate a great deal of money, but it is a legitimate and often under-pursued source of funds. When an automobile damages a campus tree or when construction equipment destroys a group of campus trees, the University should seek compensation for the landscape value of the tree(s). The University 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, or be used for other legitimate forestry functions throughout the University.

**Utility Company Fees.** Non-municipal utility companies perform new construction, maintenance, and repair work on an annual basis at the University. This work may affect the aboveground and belowground portions of campus trees. It is prudent and reasonable to assess a fee to such utility companies when their work affects University trees. Utility companies with aerial facilities might be required to provide the University an anticipated annual work plan and maps with an appropriate fee attached to provide for inspection and monitoring. Any compensation for documented damage to campus 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.** The University of Windsor could promote private donations to support tree planting, tree care, and public educational activities. A major source of donations could be from businesses and corporations who wish to sponsor 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. These types of programs usually require signage and recognition throughout the partnership, but are oftentimes more sustainable.

**Fund-Raising Activities.** With the support of volunteers, the University 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-related merchandise could be commissioned and sold. Arbour week events could be held. Restaurants can have special Tree Nights where a small percentage of the patrons' bills are donated back to the University for tree maintenance and planting. Even small efforts, such as bake sales and yard sales, can be encouraged to raise funds for trees in the community.

**Firewood.** Wood waste from tree maintenance and storm damage repairs can be a source of funds for the Tree Fund. One strategy with which cities have had success that may also work for a university, is the sale of 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. Also, a new trend has begun for removals of significant or historic trees; the logs and useable wood are given to local craftsmen who then create furniture, sculpture, and other collectibles from the wood. Alumni groups may be particularly interested. As an example, a piece of a historic elm tree at McMaster University that was cut down years prior was made into a treasured retirement gift for the University President. These are sold and all or portions of the proceeds could be returned to the University.

**Student Enrollment Donations.** The University charges students directly for their tuition fees. These fees could be a source of needed funds for the campus forestry program. A small fixed amount, such as $1 or $2 could be added to each student's tuition. In some cases, students are asked whether they would be willing to donate this small gift, and if they agree it is added to their student fees. A funding strategy such as this will likely require inter-departmental cooperation and policy changes. Other key components may be approval from the Board of Governors and the University of Windsor Students' Alliance.

**Obtain Grants.** As a municipality and a non-profit with existing support structures and staff, the University of Windsor is in a good position to apply for and receive grants to support urban forestry activities. The University may have previously received grants for campus forestry projects, but with the investment in time and a person skilled in grant writing, there may be many other grant opportunities available. These opportunities may be found with the Provincial and Federal governments, non-profit organizations, large corporate and private business foundations, and private charitable foundations. If the University establishes a Tree Fund, there will be a ready source of matching funds to leverage even more grant dollars. The University should also explore the possibility of grants with organizations such as TD Canada Trust, Friends of the Environment.

# Summary of Recommendations

The University of Windsor's tree population adds to the beauty and livability of the campus. The campus tree population is relatively healthy and young trees outnumber maturing and mature trees. 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. With that in mind, the University of Windsor should strive to achieve the goals of this Campus Tree Management Plan.

Generally stated, the University of Windsor's goals and implementation actions include:

## Achieve Population Sustainability

- Construct planting projects so that each year all plantings meet the 10% species and 20% genus rule. Maples should be restricted to small numbers for future plantings and other suitable species should become the focus of future plantings.
- Manage the tree population so there are at least four young trees for every one mature tree.
- Work to minimize the number of poor and worse condition trees and replace all dead or dying trees.
- Implement a routine pruning program where all trees are maintained on a cyclical basis to improve tree health, aesthetics and increase safety. Eliminate breeding sites for insects and diseases by quickly treating, pruning, or removing infested trees.
- Apply best management practices for tree maintenance including tree crew training, insect and disease control programs, fertilization, irrigation, and cabling and bracing.
- Schedule maintenance activities for and perform them during optimal biological periods to sustain vigorous tree health and to ensure the best chance for survival of the University's trees.
- Consistently budget and plant approximately 20 trees per year, adhering to the principle of planting the "right tree for the right place" to minimize future conflicts with surrounding infrastructure and improve overall campus tree health.
- Consider species that need less maintenance and are desired for characteristics such as spring flowers and fall color.
- Apply best management practices for planting including tree fertilization, tree mulching, tree planting designs, tree planting program assistance, tree planting process, tree pruning, tree purchasing, tree species diversity, and tree species selection.

## Increase Environmental Asset Benefits

- Plant large-growing species wherever possible to maximize the tree population's potential benefit. Utilize a wider range of species to reforest the community by including both native and non-native, urban-tolerant species.
- Apply the concept "right tree for the right place" to help minimize maintenance costs in the future and potentially provide a greater net benefit value and benefit-cost ratio.
- Replace the 76 trees recommended for removal within four years starting in 2012.

- Professionally manage and protect campus trees to preserve them now for all community members and to expand them for future students, faculty, staff and members of the public.
- Conduct a thorough inventory every ten years or more frequently if rapid changes in the campus forest occur, such as severe storms, serious insect and disease problems, or a dramatic increase in new tree planting occurs.
- Conduct an i-Tree Streets analysis every five to ten years to see the return of benefits produced by managing the University's campus trees through the Campus Tree Management Program.

## Proactive Maintenance Among the Population

- Use the Arboricultural Planning Chart as a general guideline for implementation of the seven-year Campus Tree Management Program.
- Complete all identified Severe and High-Risk Removals by 2012.
- Complete all identified Severe and High-Risk Crown Cleans by 2012.
- Begin the Routine Pruning Program in 2013 by pruning approximately 215 trees per year. Monitor trees for pest and disease signs and symptoms.
- Develop an organized and documented approach to ensure cyclical tree maintenance. This may include pruning one management zone each year in order to meet the annual routine pruning goal.
- Perform all needed crown cleaning, crown reduction, and crown thinning at the same time to reduce travel time and costs.
- Begin the Young Tree Training Program in 2012 and training prune approximately 146 young trees per year.
- Prune young trees for the first time three years following planting. Only dead or broken branches should be removed at the time of planting.
- Compare the University's annual campus forestry expenditures and number of tasks completed at the end of each year to that projected at the beginning of each year.
- Update the inventory database on a daily, weekly, or monthly basis to reflect changes made through tree maintenance and observation.

## Notice of Disclaimer

- Inventory data provided by Davey Resource Group are based on visual recording at the time of inspection. Visual records do not include individual testing or analysis and do not include aerial or subterranean inspection. Davey Resource Group is not responsible for discovery or identification of hidden or otherwise non-observable risks. Records may not remain accurate after inspection due to variable deterioration of inventoried material. Davey Resource Group provides no warranty with respect to the fitness of the urban forest for any use or purpose whatsoever.

- Arborists are tree specialists who use their education, knowledge, training, and experience to examine trees, assess their condition, and recommend measures to enhance the beauty and health of trees, while attempting to reduce risk. Clients may choose to accept or disregard the recommendations of the arborist, or to seek additional advice.

- Arborists cannot detect every condition that could possibly lead to the failure of a tree. Trees are living organisms that fail in ways that cannot always be predicted. Conditions are often hidden within trees and below ground, and can develop quickly after an inspection. Arborists cannot guarantee that a tree will be healthy or safe under all circumstances, or for a specified period of time. Likewise, remedial treatments cannot be guaranteed.

- Important: Know and understand that this basic visual assessment is confined to the designated subject tree(s), and that this consultation was performed in the interest of facts of the tree(s) without prejudice to or for any other service or any interested party.

# Appendix A
# Inventory Methodology

# ***University of Windsor Campus Tree Management Plan***

## *Methodology*

The following lists the types of data that were collected during the tree inventory at the University of Windsor.

- **Mapping coordinate.** X and Y coordinate locations.
- **Area.** Tree locations will be identified by subdivision, management area, park name, or other discrete location/property name as determined by Davey Resource Group and the Client.
- **Location.** The tree's physical location in relation to public ROW and/or public space will be recorded.
- **Species.** Trees will be identified by genus and species, with the exception of genera such as *Crataegus* or *Malus*, where field identification of species is often not practical.
- **Diameter.** Diameter is measured in centimeters at 1.4 metres above the ground, or diameter-breast-height (DBH).
- **Stems.** The number of stems a tree has will be recorded.
- **Location Value.** The location value involves an assessment of the site where the tree is planted, the tree's functional and aesthetic contributions to the site, and the placement of the tree within that site. Location Value is collected for its use in the Trunk Formula Method of landscape plant appraisal along with species, size, and condition. The Trunk Formula Method is adapted from the *Guide for Plant Appraisal* (9th edition), published by the International Society of Arboriculture and generically applied to the entire inventory population for informational purposes only and is not a substitute for a detailed, individual plant appraisal.

    1. Excellent. The quality of the location, the environment and aesthetic contributions, and the placement of the tree relative to adjacent structures and landscaping, are all exceptional.
    2. Good. The location, contribution, and placement of the tree are all favorable. In a good site, a tree should thrive and provide benefits to the surrounding environment.
    3. Fair. A fair tree location has no evident limitations that would seriously impede growth, but relative placement, location quality, or environmental and aesthetic contributions of the tree do not enhance potential benefits of this specific plant.
    4. Poor. Some characteristics of the site or the tree make this location unfavorable, or the tree exhibits an undesirable trait, such as shading solar panels.

- **Condition.** In general, the health and structure of each tree will be recorded in one of the following categories based on visible root, trunk, scaffold branch, twig, and foliage conditions at the time of the inventory and adapted from the rating system

established by the International Society of Arboriculture and based on visible root, trunk, scaffold branch, twig, and foliage conditions at the time of the inventory:

1. Excellent. 100% condition rating.
2. Very Good. 90% condition rating.
3. Good. 80% condition rating.
4. Fair. 60% condition rating.
5. Poor. 40% condition rating.
6. Critical. 20% condition rating.
7. Dead. 0% condition rating.

- **Primary Maintenance Need.** The following primary maintenance needs will be determined based on ANSI A300 standard specifications:

1. Removal. Trees designated for removal have defects that cannot be cost-effectively or practically treated. The majority of the trees in this category have a large percentage of dead crown. All trees with safety risks that could be seen as potential threats to persons or property and seen as potential liabilities to the client would be in this category. This category includes large, dead and dying trees that are high-liability risks as well as those that pose minimal liability to persons or property (such as trees in poor locations or undesirable species).
2. Large Tree Clean. These trees require selective removal of dead, dying, broken, and/or diseased wood to minimize potential risk. Priority of work should be dependent upon the *Risk* associated with the individual trees. Trees in this category may be large enough to require bucket truck access or manual climbing.
3. Small Tree Clean. These trees require selective removal of dead, dying, broken, and/or diseased wood to minimize potential risk. Priority of work should be dependent upon the *Risk* associated with the individual trees. These trees are small-growing, mature trees that can be evaluated and pruned from the ground.
4. Young Tree Train. These are young trees that must be pruned to correct or eliminate weak, interfering, or objectionable branches in order to minimize future maintenance requirements. Generally, these trees may be up to 6 meters in height and can be worked with a pole pruner by a person standing on the ground.
5. Stump Removal. This category indicates a stump that should be removed. Lacking specific information on stump removal required by local code requirements per the client.

- **Secondary Maintenance Need.** The following secondary maintenance needs will be determined based on ANSI A300 standard specifications:

1. Raise. Trees requiring pruning to remove low branches that interfere with sight and/or traffic. Lacking specific information on clearance required by local code per the client, 2.5 meters over sidewalk for *Pedestrian* clearance, 4.3 meters over roads for *Vehicle* clearance, and 2.1 meters in public/park areas to allow for grounds maintenance, will be used.

2. Reduce. Selective pruning to decrease height and/or spread of the crown in order to provide clearance for electric utilities and lighting.

3. Thin. The selective removal of water sprouts, epicormic branches, and live branches to reduce density.

4. Restoration. Selective pruning to improve the structure, form, and appearance of trees that have been severely headed, vandalized, or damaged.

5. None. No secondary maintenance is recommended for the tree. This will be used as the default value when *Primary Maintenance* equals Removal, Stump Removal, or Plant Tree.

- **Observations.** Significant observations affecting a tree's health, structure, and location will be made.
- **Further Inspection.** This field will be used to indicate that a particular tree will require further or periodic inspection due to particular conditions with the tree that could cause it to be a safety risk and, therefore, potentially hazardous to the public.
- **Clearance Required.** Trees which are causing or may cause visibility or clearance difficulties for pedestrians or vehicles will be identified, as well as those trees blocking clear visibility of signs or traffic signals, street lights, traffic signals, or other safety devices.
- **Hardscape Damage.** Damage to sidewalks and curbs by tree roots is noted.
- **Overhead Utilities.** The inventory indicates whether overhead conductors or other utilities are present at the tree site that could result in conflicts with the tree.
- **Growing Space Type—**Growing space locations are categorized as:

  1. Island
  2. Median
  3. Open/Unrestricted
  4. Raised Planter
  5. Tree Lawn/Parkway
  6. Unmaintained Area
  7. Well/Pit

- **Space Size.** The minimum width of the growing space for root development is recorded.
- **Risk Assessment.** A risk rating will be assigned using an assessment protocol based on the USDA Forest Service Community Tree Risk Rating System.

  1. Probability of Failure (1–4 points). Identifies the most likely failure and rates the likelihood that the structural defect(s) will result in failure based on observed, current conditions.

     (1) Low: some minor defects present.
     - minor branch/crown dieback
     - minor defects or wounds

     (2) Moderate: several moderate defects present

- stem decay or cavity within safe shell limits: shell thickness >2.5 centimeters of sound wood for each 15 centimeters of stem diameter
- crack(s) without extensive decay
- defect(s) affecting 30–40% of the tree's circumference
- crown damage/breakage: hardwoods up to 50%; pines up to 30%
- weak branch union: major branch or codominant stem has included bark
- stem girdling roots: <40% tree's circumference with compressed wood
- root damage: <40% of roots damaged within the critical root radius

(3) High: multiple of significant defects present:

- stem decay or cavity at or exceeding shell safety limits: minimum shell thickness = 2.5 centimeters of sound wood for each 15 centimeters of stem diameter
- cracks, particularly those in contact with the soil or associated with other defects
- defect(s) affecting >40% of the tree's circumference
- crown damage/breakage: hardwoods >50%; pines >30%
- weak branch union with crack or decay
- girdling roots with >40% of tree's circumference with compressed wood
- root damage: >40% of roots damaged within the critical root radius
- leaning tree with recent root breakage or soil mounding, crack or extensive decay
- dead tree: standing dead without other significant defects

(4) Extremely High: multiple and significant defects present; visual obstruction of traffic signs/lights or intersections:

- stem decay or cavity exceeding shell safety limits and severe crack
- cracks: when a stem or branch is split in half or has cracks on opposite sides
- defect(s) affecting >40% of tree's circumference or critical root radius and extensive decay or crack(s)
- weak branch union with crack and decay
- leaning tree with recent root breakage or soil mounding and crack or extensive decay
- dead branches: broken (hangers) or with a crack
- dead trees: standing dead with other defects, such as cracks, hangers, extensive decay, or major root damage
- visual obstruction of traffic signs/lights or intersections
- physical obstruction of pedestrian or vehicle traffic

2. Size of Defective Part (1–3 points). Rates the size of the part most likely to fail. If the trunk is the part most likely to fail, tree will be recommended for removal and the DBH value will be used for the size of the defective part.

   (1) Parts less than 10 centimeters in diameter

   (2) Parts from 10 to 51 centimeters in diameter

   (3) Parts greater than 51 centimeters in diameter

3. Probability of Target Impact (1–3 points). Rates the use and occupancy of the area that would be struck by defective part.

   (1) Occasional Use: low-use roads and park trails; parking lots adjacent to low-use areas; natural areas such as woods or riparian zones; transition areas with limited public use; industrial areas.

   (2) Intermediate Use: moderate- to low-use school playgrounds, parks, and picnic areas; parking lots adjacent to moderate-use areas; secondary roads (neighborhoods) and park trails within moderate- to high-use areas; and dispersed campgrounds.

(3) Frequent Use: emergency access routes, medical and emergency facilities and shelters, and handicap access areas; high-use school playgrounds, parks, and picnic areas; bus stops; visitor centers, shelters, and park administrative buildings and residences; main thoroughfares and congested intersections in high-use areas; parking lots adjacent to high-use areas; interpretive signs, kiosks; scenic vistas; and campsites (particularly drive-in).

4. Other Risk Factors (0–2 points). This optional subjective risk rating is used if professional judgment suggests the need to increase the total risk rating and invoke immediate corrective action. For example, trees with a numeric risk rating of 9 or 10 would be identified as high-priority trees to receive corrective treatments first. An inspector may wish to increase a tree's risk rating from 8 to 9 as a means of ensuring the tree will receive immediate corrective treatment. The total risk rating should not exceed 10 points.

- **Risk Rating.** Generally, trees with the highest numeric risk ratings should receive corrective treatment first. The overall risk rating of the tree will be indicated, based on the sum of the above risk assessment field values. See the formula below:

**Risk Rating (3–10 points) = probability of failure (1–4 points) + size of defective part (1–3 points) + probability of target impact (1–3 points) + optional subjective risk rating (0–2 points)**

Trees assessed as lower risk may fail before trees assessed as higher risk. There are many uncontrollable conditions, such as weather, pests, and human involvement, that can contribute to tree failure. Davey's assigned risk is meant only to be used as a guideline to make safety-driven maintenance decisions and to direct normal tree maintenance programs efficiently. All risk ratings are based on observable defects at the time of assessment. All observations are made from the ground. The following risk ratings will be assigned:

1. None. Numeric *Risk Rating* equals 0. Used for planting and stump sites only.

2. Low. Numeric *Risk Rating* equals 3 or 4. Trees designated as presenting a Low risk have minor visible structural defects or wounds in areas with moderate to low public access. At the current time, the observable defects—using visual inspection—do not meet the threshold of failure. No corrective action is required.

3. Moderate. Numeric *Risk Rating* equals 5 or 6. Trees designated as presenting a Moderate risk have defects that may be cost-effectively or practically treated. The majority of trees in this category exhibit several moderate defects affecting <40% of a tree's trunk, crown, or critical root zone. This category may also include young or newly planted trees in frequent public use areas, such as downtown business districts or popular parks. At the current time, the observable defects—using visual inspection—do not meet the threshold of failure. The defects may or may not result in eventual tree failure. These trees can be recommended for pruning or removal and should be addressed after all *Severe*- and *High-Risk* tree maintenance.

4. High. Numeric *Risk Rating* equals 7 or 8. Trees designated as presenting a *High Risk* have defects that cannot be cost-effectively or practically treated. The majority of the trees in this category have multiple or significant defects affecting >40% of the trunk, crown, or critical root zone. Defective trees and/or tree parts are most likely between 10-51 centimeters in diameter and can be found in areas of frequent occupation, such as a main thoroughfare, congested streets, and/or near schools. Currently, these defects indicate that the tree is failing, is in immediate danger of failing, or has already partially failed. These trees can be recommended for pruning or removal and should be addressed immediately after all *Severe-Risk* removals.

5. Severe. Numeric *Risk Rating* equals 9 or 10. Trees designated as presenting a *Severe Risk* have defects that cannot be cost-effectively or practically treated. The majority of the trees in this category have multiple and significant defects present in the trunk, crown, or critical root zone. Defective trees and/or tree parts are most likely larger than 51 centimeters in diameter and can be found in areas of frequent occupation, such as a main thoroughfare, congested streets, and/or near schools. Currently, these defects indicate that the tree is failing, is in immediate danger of failing, or has already partially failed. Large, dead and dying trees that are high-liability risks are included in this category. This category is reserved for the highest priority removals only and corrective action should be taken as soon as possible.

- **Notes.** Additional information regarding disease, insect, mechanical damage, etc. can be included in this field.

# Appendix B
# Population Composition and Frequency Report

# Ontario

# Complete Population of All Trees

7/19/2011

| Species | DBH Class (cm) 0-8 | 8-15 | 15-30 | 30-46 | 46-61 | 61-76 | 76-91 | 91-107 | >107 | Total | Standard Error |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Broadleaf Deciduous Large (BDL)** | | | | | | | | | | | |
| maple, Norway | 0 | 25 | 127 | 35 | 14 | 0 | 0 | 0 | 0 | 201 | |
| maple, silver | 0 | 4 | 36 | 54 | 31 | 13 | 3 | 0 | 0 | 141 | |
| honeylocust, Thornless | 33 | 12 | 51 | 22 | 17 | 0 | 0 | 0 | 0 | 135 | |
| planetree, London | 8 | 14 | 1 | 15 | 7 | 5 | 1 | 0 | 0 | 51 | |
| hackberry, Northern | 38 | 4 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 46 | |
| oak, northern red | 12 | 18 | 8 | 1 | 0 | 0 | 0 | 0 | 0 | 39 | |
| Tree of heaven | 1 | 4 | 10 | 2 | 3 | 0 | 0 | 1 | 0 | 21 | |
| elm, American | 1 | 3 | 2 | 2 | 4 | 1 | 3 | 0 | 1 | 17 | |
| zelkova, Japanese | 10 | 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 17 | |
| oak, English | 0 | 8 | 2 | 4 | 2 | 0 | 0 | 0 | 0 | 16 | |
| Tulip tree | 8 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | |
| catalpa, Northern | 0 | 1 | 8 | 1 | 0 | 1 | 0 | 0 | 1 | 12 | |
| Horsechestnut | 1 | 1 | 1 | 5 | 3 | 0 | 0 | 0 | 0 | 11 | |
| cottonwood, Eastern | 0 | 0 | 1 | 1 | 1 | 3 | 1 | 0 | 2 | 9 | |
| beech, American | 0 | 0 | 3 | 2 | 2 | 1 | 0 | 0 | 0 | 8 | |
| ash, green | 2 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | |
| Sweetgum | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | |
| Ginkgo | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | |
| coffeetree, Kentucky | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | |
| elm, Siberian | 0 | 2 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 6 | |
| maple, Sugar | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | |
| maple, Freeman | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | |
| Japanese pagoda tree | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 3 | |
| walnut, black | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| locust, black | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| baldcypress | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| walnut, English | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | |
| oak, white | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| oak, Bur | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | |
| locust, clammy | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | |
| elm, hybrid | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| **Total** | **123** | **132** | **257** | **149** | **88** | **29** | **8** | **1** | **4** | **791 (±NaN)** | |
| **Broadleaf Deciduous Medium (BDM)** | | | | | | | | | | | |
| linden, littleleaf | 26 | 21 | 12 | 25 | 4 | 0 | 0 | 0 | 0 | 88 | |
| maple, red | 10 | 38 | 4 | 3 | 2 | 5 | 1 | 0 | 0 | 63 | |
| mulberry, white | 3 | 10 | 11 | 4 | 2 | 0 | 1 | 0 | 1 | 32 | |
| Boxelder | 0 | 3 | 3 | 8 | 2 | 0 | 0 | 0 | 0 | 16 | |
| hornbeam, American | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | |
| Goldenrain tree | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | |
| tupelo, black | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | |
| unknown tree | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| birch, European white | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| Sassafras | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| willow, Corkscrew | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| elm, slippery | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | |
| **Total** | **48** | **76** | **35** | **41** | **10** | **5** | **2** | **0** | **1** | **218 (±NaN)** | |
| **Broadleaf Deciduous Small (BDS)** | | | | | | | | | | | |
| Apple | 1 | 26 | 25 | 10 | 1 | 0 | 0 | 0 | 0 | 63 | |
| Plum | 14 | 15 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 34 | |
| pear, callery | 8 | 11 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 23 | |
| redbud, Eastern | 16 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | |
| lilac, Japanese tree | 13 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | |
| maple, Japanese | 1 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | |
| Hawthorn | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | |
| Chinese magnolia; Saucer m | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | |
| Serviceberry | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | |
| dogwood, pagoda | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | |

# Ontario

## Complete Population of All Trees

7/19/2011

| Species | DBH Class (cm) 0-8 | 8-15 | 15-30 | 30-46 | 46-61 | 61-76 | 76-91 | 91-107 | >107 | Total | Standard Error |
|---|---|---|---|---|---|---|---|---|---|---|---|
| dogwood, Kousa | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | |
| serviceberry, Eastern | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| dogwood, flowering | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| mountainash, showy | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| maple, Amur | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| smoketree, common | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| magnolia, star | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| **Total** | **69** | **72** | **39** | **12** | **1** | **0** | **0** | **0** | **0** | **193** | **(±NaN)** |
| **Broadleaf Evergreen Large (BEL)** | | | | | | | | | | | |
| **Total** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **(±NaN)** |
| **Broadleaf Evergreen Medium (BEM)** | | | | | | | | | | | |
| magnolia, southern | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| **Total** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** | **(±NaN)** |
| **Broadleaf Evergreen Small (BES)** | | | | | | | | | | | |
| **Total** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **(±NaN)** |
| **Conifer Evergreen Large (CEL)** | | | | | | | | | | | |
| pine, Austrian | 0 | 24 | 191 | 8 | 0 | 0 | 0 | 0 | 0 | 223 | |
| spruce, Colorado | 3 | 42 | 48 | 10 | 0 | 0 | 0 | 0 | 0 | 103 | |
| spruce, Norway | 3 | 6 | 27 | 6 | 1 | 0 | 0 | 0 | 0 | 43 | |
| spruce, white | 0 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | |
| pine, red | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | |
| pine, eastern white | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | |
| fir, Balsam | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| cypress, Leyland | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| elm, rock | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | |
| **Total** | **10** | **81** | **267** | **27** | **1** | **1** | **0** | **0** | **0** | **387** | **(±NaN)** |
| **Conifer Evergreen Medium (CEM)** | | | | | | | | | | | |
| cedar, Northern white | 19 | 6 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 38 | |
| Juniper spp. | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | |
| cedar, Eastern red | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | |
| arborvitae spp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| **Total** | **21** | **8** | **15** | **0** | **0** | **0** | **0** | **0** | **0** | **44** | **(±NaN)** |
| **Conifer Evergreen Small (CES)** | | | | | | | | | | | |
| **Total** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **(±NaN)** |
| **Palm Evergreen Large (PEL)** | | | | | | | | | | | |
| **Total** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **(±NaN)** |
| **Palm Evergreen Medium (PEM)** | | | | | | | | | | | |
| **Total** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **(±NaN)** |
| **Palm Evergreen Small (PES)** | | | | | | | | | | | |
| **Total** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **(±NaN)** |
| **Grand Total** | **272** | **369** | **613** | **229** | **100** | **35** | **10** | **1** | **5** | **1,634** | **(±0)** |

# Appendix C
# Suggested Tree Species

# 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 campus 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 in the Midwestern United States. Most of these species are commonly planted in Southern Ontario.

## Deciduous Trees

***Large Trees: Greater than 45 Feet in Height at Maturity***

| Scientific Name | Common Name | Cultivar |
|---|---|---|
| *Acer rubrum* | red maple | Red Sunset® |
| *Acer nigrum* | black maple | |
| *Acer saccharum* | sugar maple | 'Legacy' |
| *Aesculus flava** | yellow buckeye | |
| *Betula nigra* | river birch | Heritage® |
| *Carpinus betulus* | European hornbeam | 'Franz Fontaine' |
| *Castanea mollissima** | Chinese chestnut | |
| *Celtis occidentalis* | common hackberry | 'Prairie Pride' |
| *Cercidiphyllum japonicum* | katsuratree | 'Aureum' |
| *Diospyros virginiana** | common persimmon | |
| *Fagus grandifolia** | American beech | |
| *Fagus sylvatica** | European beech | (numerous exist) |
| *Ginkgo biloba* | ginkgo | (male trees only) |
| *Gleditsia triacanthos inermis* | thornless honeylocust | 'Shademaster' |
| *Gymnocladus dioica* | Kentucky coffeetree | Prairie Titan® |
| *Juglans regia** | English walnut | 'Hansen' |
| *Larix decidua** | European larch | |
| *Liquidambar styraciflua* | American sweetgum | Cherokee™ |
| *Liriodendron tulipifera* | tuliptree | 'Fastigiatum' |
| *Maclura pomifera* | osage-orange | 'White Shield','Witchita' |
| *Magnolia acuminata** | cucumbertree magnolia | (numerous exist) |
| *Magnolia macrophylla** | bigleaf magnolia | |
| *Metasequoia glyptostroboides* | dawn redwood | 'Emerald Feathers' |
| *Nyssa sylvatica* | black tupelo | |
| *Platanus* x *acerifolia* | London planetree | 'Yarwood' |
| *Platanus occidentalis** | American sycamore | |
| *Quercus alba* | white oak | |
| *Quercus coccinea* | scarlet oak | |
| *Quercus ellipsoidalis* | northern pin oak | |

## *Large Trees: Greater than 45 Feet in Height at Maturity (continued)*

| Scientific Name | Common Name | Cultivar |
|---|---|---|
| *Quercus frainetto* | Hungarian oak | |
| *Quercus imbricaria* | shingle oak | |
| *Quercus lyrata* | overcup oak | |
| *Quercus macrocarpa* | bur oak | |
| *Quercus montana* | chestnut oak | |
| *Quercus muehlenbergii* | chinkapin oak | |
| *Quercus robur* | English oak | Heritage® |
| *Quercus rubra* | northern red oak | 'Splendens' |
| *Quercus shumardii* | Shumard oak | |
| *Quercus texana* | Texas oak | |
| *Styphnolobium japonicum* | Japanese pagodatree | 'Regent' |
| *Taxodium distichum* | common baldcypress | 'Shawnee Brave' |
| *Tilia americana* | American linden | 'Redmond' |
| *Tilia cordata* | littleleaf linden | 'Greenspire' |
| *Tilia tomentosa* | silver linden | 'Sterling' |
| *Ulmus parvifolia* | Chinese elm | Allée® |
| *Zelkova serrata* | Japanese zelkova | 'Green Vase' |

## *Medium Trees: 31 to 45 Feet in Height at Maturity*

| Scientific Name | Common Name | Cultivar |
|---|---|---|
| *Alnus glutinosa** | common alder | 'Pyramidalis' |
| *Cladrastis kentukea* | American yellowwood | 'Rosea' |
| *Eucommia ulmoides* | hardy rubbertree | |
| *Koelreuteria paniculata* | goldenraintree | |
| *Ostrya virginiana* | eastern hophornbeam | |
| *Parrotia persica* | Persian parrotia | 'Vanessa' |
| *Phellodendron amurense* | amur corktree | 'Macho' |
| *Prunus maackii* | amur chokecherry | 'Amber Beauty' |
| *Prunus sargentii* | Sargent cherry | |
| *Pyrus calleryana* | callery pear | 'Earlyred' |
| *Quercus acutissima* | sawtooth oak | |
| *Quercus cerris* | European turkey oak | |
| *Sorbus alnifolia* | Korean mountainash | 'Redbird' |

## *Small Trees: 15 to 30 Feet in Height at Maturity*

| Scientific Name | Common Name | Cultivar |
|---|---|---|
| *Acer buergerianum* | trident maple | Streetwise® |
| *Acer campestre* | hedge maple | Queen Elizabeth™ |
| *Acer cappadocicum* | coliseum maple | 'Aureum' |
| *Acer ginnala* | amur maple | Red Rhapsody™ |
| *Acer griseum* | paperbark maple | |
| *Acer pensylvanicum** | striped maple | |
| *Acer truncatum* | Shantung maple | |
| *Aesculus pavia** | red buckeye | |
| *Amelanchier arborea* | downy serviceberry | (numerous exist) |
| *Amelanchier laevis* | Allegheny serviceberry | |
| *Carpinus caroliniana* | American hornbeam | |
| *Cercis canadensis* | eastern redbud | 'Forest Pansy' |
| *Chionanthus virginicus* | white fringetree | |
| *Cornus kousa* | Kousa dogwood | (numerous exist) |
| *Cornus mas** | corneliancherry dogwood | 'Spring Sun' |
| *Corylus avellana* | European filbert | 'Contorta' |
| *Cotinus coggygria** | common smoketree | 'Flame' |
| *Cotinus obovata** | American smoketree | |
| *Crataegus phaenopyrum* | Washington hawthorn | Princeton Sentry™ |
| *Crataegus viridis* | green hawthorn | 'Winter King' |
| *Franklinia alatamaha** | Franklinia | |
| *Halesia tetraptera* | Carolina silverbell | 'Arnold Pink' |
| *Magnolia* x *soulangiana** | saucer magnolia | 'Alexandrina' |
| *Magnolia stellata** | star magnolia | 'Centennial' |
| *Magnolia tripetala** | umbrella magnolia | |
| *Magnolia virginiana** | sweetbay magnolia | Moonglow® |
| *Malus* spp. | flowering crabapple | (disease resistant only) |
| *Oxydendrum arboreum* | sourwood | 'Mt. Charm' |
| *Prunus subhirtella* | Higan cherry | pendula |
| *Prunus virginiana* | common chokecherry | 'Schubert' |
| *Styrax japonicus* | Japanese snowbell | 'Emerald Pagoda' |
| *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 balsamea* | balsam fir | |
| *Abies concolor* | white fir | 'Violacea' |
| *Chamaecyparis nootkatensis* | Nootka falsecypress | 'Pendula' |
| *Cryptomeria japonica* | Japanese cryptomeria | 'Sekkan-sugi' |
| *Ilex opaca** | American holly | |
| *Picea omorika* | Serbian spruce | |
| *Picea orientalis* | Oriental spruce | |
| *Pinus densiflora* | Japanese red pine | |
| *Pinus strobus* | eastern white pine | |
| *Pinus sylvestris* | Scotch pine | |
| *Psedotsuga menziesii* | Douglasfir | |
| *Thuja plicata* | western arborvitae | (numerous exist) |
| *Tsuga canadensis* | eastern hemlock | |

### *Medium Trees: 31 to 45 Feet in Height at Maturity*

| Scientific Name | Common Name | Cultivar |
|---|---|---|
| *Chamaecyparis thyoides* | Atlantic whitecedar | (numerous exist) |
| *Juniperus virginiana* | eastern redcedar | |
| *Pinus bungeana* | lacebark pine | |
| *Pinus flexilis* | limber pine | |
| *Thuja occidentalis* | eastern arborvitae | (numerous exist) |

### *Small Trees: 15 to 30 Feet in Height at Maturity*

| Scientific Name | Common Name | Cultivar |
|---|---|---|
| *Ilex* x *attenuata** | Foster's holly | |
| *Pinus aristata* | bristlecone pine | |
| *Pinus mugo mugo* | mugo pine | |

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 D
# Importance Values, Relative Age Distribution, Tree Condition

**Ontario**

# Importance Values for All Most Abundant Trees

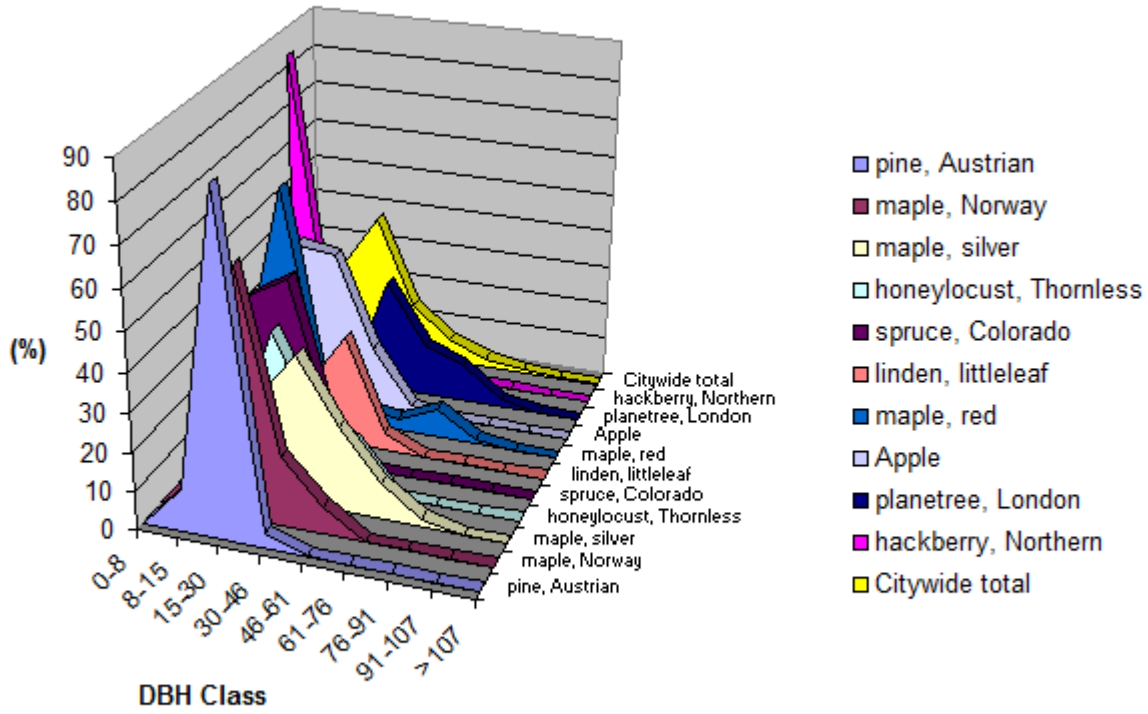
7/19/2011

| Species | Number of Trees | % of Total Trees | Leaf Area (m) | % of Total Leaf Area | Canopy Cover (m) | % of Total Canopy Cover | Importance Value |
|---|---|---|---|---|---|---|---|
| pine, Austrian | 223 | 13.6 | 18,477 | 9.4 | 6,646 | 9.4 | 10.8 |
| maple, Norway | 201 | 12.3 | 17,802 | 9.1 | 9,423 | 13.3 | 11.6 |
| maple, silver | 141 | 8.6 | 42,467 | 21.6 | 13,248 | 18.7 | 16.3 |
| honeylocust, Thornless | 135 | 8.3 | 22,799 | 11.6 | 9,531 | 13.5 | 11.1 |
| spruce, Colorado | 103 | 6.3 | 7,314 | 3.7 | 2,531 | 3.6 | 4.5 |
| linden, littleleaf | 88 | 5.4 | 7,351 | 3.7 | 2,684 | 3.8 | 4.3 |
| maple, red | 63 | 3.9 | 8,096 | 4.1 | 2,131 | 3.0 | 3.7 |
| Apple | 63 | 3.9 | 3,575 | 1.8 | 1,642 | 2.3 | 2.7 |
| planetree, London | 51 | 3.1 | 10,119 | 5.2 | 3,855 | 5.4 | 4.6 |
| hackberry, Northern | 46 | 2.8 | 2,172 | 1.1 | 504 | 0.7 | 1.5 |
| spruce, Norway | 43 | 2.6 | 3,739 | 1.9 | 1,395 | 2.0 | 2.2 |
| oak, northern red | 39 | 2.4 | 2,496 | 1.3 | 853 | 1.2 | 1.6 |
| cedar, Northern white | 38 | 2.3 | 448 | 0.2 | 350 | 0.5 | 1.0 |
| Plum | 34 | 2.1 | 658 | 0.3 | 421 | 0.6 | 1.0 |
| mulberry, white | 32 | 2.0 | 5,460 | 2.8 | 1,516 | 2.1 | 2.3 |
| pear, callery | 23 | 1.4 | 788 | 0.4 | 290 | 0.4 | 0.7 |
| Tree of heaven | 21 | 1.3 | 4,208 | 2.1 | 1,462 | 2.1 | 1.8 |
| redbud, Eastern | 19 | 1.2 | 169 | 0.1 | 106 | 0.1 | 0.5 |
| lilac, Japanese tree | 19 | 1.2 | 265 | 0.1 | 83 | 0.1 | 0.5 |
| elm, American | 17 | 1.0 | 7,779 | 4.0 | 2,416 | 3.4 | 2.8 |
| zelkova, Japanese | 17 | 1.0 | 740 | 0.4 | 223 | 0.3 | 0.6 |
| OTHER TREES | 218 | 13.3 | 29,351 | 15.0 | 9,456 | 13.4 | 13.9 |
| Total | 1,634 | 100.0 | 196,274 | 100.0 | 70,766 | 100.0 | 100.0 |

**Ontario**

# Relative Age Distribution of Top 10 All Tree Species (%)

7/19/2011




| | DBH class (cm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | 0-8 | 8-15 | 15-30 | 30-46 | 46-61 | 61-76 | 76-91 | 91-107 | >107 |
| pine, Austrian | 0.00 | 10.76 | 85.65 | 3.59 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| maple, Norway | 0.00 | 12.44 | 63.18 | 17.41 | 6.97 | 0.00 | 0.00 | 0.00 | 0.00 |
| maple, silver | 0.00 | 2.84 | 25.53 | 38.30 | 21.99 | 9.22 | 2.13 | 0.00 | 0.00 |
| honeylocust, Thornless | 24.44 | 8.89 | 37.78 | 16.30 | 12.59 | 0.00 | 0.00 | 0.00 | 0.00 |
| spruce, Colorado | 2.91 | 40.78 | 46.60 | 9.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| linden, littleleaf | 29.55 | 23.86 | 13.64 | 28.41 | 4.55 | 0.00 | 0.00 | 0.00 | 0.00 |
| maple, red | 15.87 | 60.32 | 6.35 | 4.76 | 3.17 | 7.94 | 1.59 | 0.00 | 0.00 |
| Apple | 1.59 | 41.27 | 39.68 | 15.87 | 1.59 | 0.00 | 0.00 | 0.00 | 0.00 |
| planetree, London | 15.69 | 27.45 | 1.96 | 29.41 | 13.73 | 9.80 | 1.96 | 0.00 | 0.00 |
| hackberry, Northern | 82.61 | 8.70 | 2.17 | 6.52 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Citywide total | 16.65 | 22.58 | 37.52 | 14.01 | 6.12 | 2.14 | 0.61 | 0.06 | 0.31 |

# Ontario

# Structural (Woody) Condition of All Trees by Species

7/19/2011

| Species | Condition | Tree Count | Standard Error | % of Species | % of All Trees |
|---|---|---|---|---|---|
| **Apple** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 7 | (N/A) | 11.11 | 0.43 |
| | Fair | 44 | (N/A) | 69.84 | 2.69 |
| | Good | 12 | (N/A) | 19.05 | 0.73 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 63 | (N/A) | 100.00 | 3.86 |
| **arborvitae spp.** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 100.00 | 0.06 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **ash, green** | Dead or Dying | 1 | (N/A) | 14.29 | 0.06 |
| | Poor | 3 | (N/A) | 42.86 | 0.18 |
| | Fair | 3 | (N/A) | 42.86 | 0.18 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 7 | (N/A) | 100.00 | 0.43 |
| **baldcypress** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 50.00 | 0.06 |
| | Good | 1 | (N/A) | 50.00 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 2 | (N/A) | 100.00 | 0.12 |
| **beech, American** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 12.50 | 0.06 |
| | Fair | 4 | (N/A) | 50.00 | 0.24 |
| | Good | 3 | (N/A) | 37.50 | 0.18 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 8 | (N/A) | 100.00 | 0.49 |
| **birch, European white** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 1 | (N/A) | 100.00 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **Boxelder** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 10 | (N/A) | 62.50 | 0.61 |
| | Fair | 6 | (N/A) | 37.50 | 0.37 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 16 | (N/A) | 100.00 | 0.98 |
| **catalpa, Northern** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 8 | (N/A) | 66.67 | 0.49 |
| | Fair | 3 | (N/A) | 25.00 | 0.18 |
| | Good | 1 | (N/A) | 8.33 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 12 | (N/A) | 100.00 | 0.73 |
| **cedar, Eastern red** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 50.00 | 0.06 |
| | Good | 1 | (N/A) | 50.00 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 2 | (N/A) | 100.00 | 0.12 |

# Ontario

## Structural (Woody) Condition of All Trees by Species

7/19/2011

| Species | Condition | Tree Count | Standard Error | % of Species | % of All Trees |
|---|---|---|---|---|---|
| **cedar, Northern white** | Dead or Dying | 2 | (N/A) | 5.26 | 0.12 |
| | Poor | 4 | (N/A) | 10.53 | 0.24 |
| | Fair | 26 | (N/A) | 68.42 | 1.59 |
| | Good | 6 | (N/A) | 15.79 | 0.37 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 38 | (N/A) | 100.00 | 2.33 |
| **Chinese magnolia; Saucer magnolia** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 25.00 | 0.06 |
| | Good | 3 | (N/A) | 75.00 | 0.18 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 4 | (N/A) | 100.00 | 0.24 |
| **coffeetree, Kentucky** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 6 | (N/A) | 100.00 | 0.37 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 6 | (N/A) | 100.00 | 0.37 |
| **cottonwood, Eastern** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 5 | (N/A) | 55.56 | 0.31 |
| | Fair | 1 | (N/A) | 11.11 | 0.06 |
| | Good | 3 | (N/A) | 33.33 | 0.18 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 9 | (N/A) | 100.00 | 0.55 |
| **cypress, Leyland** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 1 | (N/A) | 100.00 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **dogwood, flowering** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 2 | (N/A) | 100.00 | 0.12 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 2 | (N/A) | 100.00 | 0.12 |
| **dogwood, Kousa** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 33.33 | 0.06 |
| | Fair | 1 | (N/A) | 33.33 | 0.06 |
| | Good | 1 | (N/A) | 33.33 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 3 | (N/A) | 100.00 | 0.18 |
| **dogwood, pagoda** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 3 | (N/A) | 100.00 | 0.18 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 3 | (N/A) | 100.00 | 0.18 |
| **elm, American** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 5.88 | 0.06 |
| | Fair | 13 | (N/A) | 76.47 | 0.80 |
| | Good | 3 | (N/A) | 17.65 | 0.18 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 17 | (N/A) | 100.00 | 1.04 |

# Ontario

## Structural (Woody) Condition of All Trees by Species

7/19/2011

| Species | Condition | Tree Count | Standard Error | % of Species | % of All Trees |
|---|---|---|---|---|---|
| **elm, hybrid** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 1 | (N/A) | 100.00 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **elm, rock** | Dead or Dying | 1 | (N/A) | 100.00 | 0.06 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **elm, Siberian** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 16.67 | 0.06 |
| | Fair | 5 | (N/A) | 83.33 | 0.31 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 6 | (N/A) | 100.00 | 0.37 |
| **elm, slippery** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 100.00 | 0.06 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **fir, Balsam** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 50.00 | 0.06 |
| | Good | 1 | (N/A) | 50.00 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 2 | (N/A) | 100.00 | 0.12 |
| **Ginkgo** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 3 | (N/A) | 50.00 | 0.18 |
| | Good | 3 | (N/A) | 50.00 | 0.18 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 6 | (N/A) | 100.00 | 0.37 |
| **Goldenrain tree** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 2 | (N/A) | 50.00 | 0.12 |
| | Good | 2 | (N/A) | 50.00 | 0.12 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 4 | (N/A) | 100.00 | 0.24 |
| **hackberry, Northern** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 8 | (N/A) | 17.39 | 0.49 |
| | Fair | 18 | (N/A) | 39.13 | 1.10 |
| | Good | 20 | (N/A) | 43.48 | 1.22 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 46 | (N/A) | 100.00 | 2.82 |
| **Hawthorn** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 16.67 | 0.06 |
| | Fair | 5 | (N/A) | 83.33 | 0.31 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 6 | (N/A) | 100.00 | 0.37 |

# Structural (Woody) Condition of All Trees by Species

7/19/2011

| Species | Condition | Tree Count | Standard Error | % of Species | % of All Trees |
|---|---|---|---|---|---|
| **honeylocust, Thornless** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 3 | (N/A) | 2.22 | 0.18 |
| | Fair | 57 | (N/A) | 42.22 | 3.49 |
| | Good | 75 | (N/A) | 55.56 | 4.59 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 135 | (N/A) | 100.00 | 8.26 |
| **hornbeam, American** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 5 | (N/A) | 100.00 | 0.31 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 5 | (N/A) | 100.00 | 0.31 |
| **Horsechestnut** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 10 | (N/A) | 90.91 | 0.61 |
| | Good | 1 | (N/A) | 9.09 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 11 | (N/A) | 100.00 | 0.67 |
| **Japanese pagoda tree** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 2 | (N/A) | 66.67 | 0.12 |
| | Good | 1 | (N/A) | 33.33 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 3 | (N/A) | 100.00 | 0.18 |
| **Juniper spp.** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 2 | (N/A) | 66.67 | 0.12 |
| | Good | 1 | (N/A) | 33.33 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 3 | (N/A) | 100.00 | 0.18 |
| **lilac, Japanese tree** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 2 | (N/A) | 10.53 | 0.12 |
| | Good | 17 | (N/A) | 89.47 | 1.04 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 19 | (N/A) | 100.00 | 1.16 |
| **linden, littleleaf** | Dead or Dying | 1 | (N/A) | 1.14 | 0.06 |
| | Poor | 2 | (N/A) | 2.27 | 0.12 |
| | Fair | 47 | (N/A) | 53.41 | 2.88 |
| | Good | 38 | (N/A) | 43.18 | 2.33 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 88 | (N/A) | 100.00 | 5.39 |
| **locust, black** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 2 | (N/A) | 100.00 | 0.12 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 2 | (N/A) | 100.00 | 0.12 |
| **locust, clammy** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 100.00 | 0.06 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |

# Structural (Woody) Condition of All Trees by Species

7/19/2011

| Species | Condition | Tree Count | Standard Error | % of Species | % of All Trees |
|---|---|---|---|---|---|
| **magnolia, southern** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 100.00 | 0.06 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **magnolia, star** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 100.00 | 0.06 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **maple, Amur** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 1 | (N/A) | 100.00 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **maple, Freeman** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 3 | (N/A) | 100.00 | 0.18 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 3 | (N/A) | 100.00 | 0.18 |
| **maple, Japanese** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 4 | (N/A) | 57.14 | 0.24 |
| | Good | 3 | (N/A) | 42.86 | 0.18 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 7 | (N/A) | 100.00 | 0.43 |
| **maple, Norway** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 16 | (N/A) | 7.96 | 0.98 |
| | Fair | 127 | (N/A) | 63.18 | 7.77 |
| | Good | 58 | (N/A) | 28.86 | 3.55 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 201 | (N/A) | 100.00 | 12.30 |
| **maple, red** | Dead or Dying | 1 | (N/A) | 1.59 | 0.06 |
| | Poor | 7 | (N/A) | 11.11 | 0.43 |
| | Fair | 27 | (N/A) | 42.86 | 1.65 |
| | Good | 28 | (N/A) | 44.44 | 1.71 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 63 | (N/A) | 100.00 | 3.86 |
| **maple, silver** | Dead or Dying | 2 | (N/A) | 1.42 | 0.12 |
| | Poor | 13 | (N/A) | 9.22 | 0.80 |
| | Fair | 95 | (N/A) | 67.38 | 5.81 |
| | Good | 31 | (N/A) | 21.99 | 1.90 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 141 | (N/A) | 100.00 | 8.63 |
| **maple, Sugar** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 3 | (N/A) | 75.00 | 0.18 |
| | Fair | 1 | (N/A) | 25.00 | 0.06 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 4 | (N/A) | 100.00 | 0.24 |

# Ontario

## Structural (Woody) Condition of All Trees by Species

7/19/2011

| Species | Condition | Tree Count | Standard Error | % of Species | % of All Trees |
|---|---|---|---|---|---|
| **mountainash, showy** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 2 | (N/A) | 100.00 | 0.12 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 2 | (N/A) | 100.00 | 0.12 |
| **mulberry, white** | Dead or Dying | 1 | (N/A) | 3.13 | 0.06 |
| | Poor | 12 | (N/A) | 37.50 | 0.73 |
| | Fair | 19 | (N/A) | 59.38 | 1.16 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 32 | (N/A) | 100.00 | 1.96 |
| **oak, Bur** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 100.00 | 0.06 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **oak, English** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 7 | (N/A) | 43.75 | 0.43 |
| | Fair | 7 | (N/A) | 43.75 | 0.43 |
| | Good | 2 | (N/A) | 12.50 | 0.12 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 16 | (N/A) | 100.00 | 0.98 |
| **oak, northern red** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 2 | (N/A) | 5.13 | 0.12 |
| | Fair | 12 | (N/A) | 30.77 | 0.73 |
| | Good | 25 | (N/A) | 64.10 | 1.53 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 39 | (N/A) | 100.00 | 2.39 |
| **oak, white** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 1 | (N/A) | 100.00 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **pear, callery** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 5 | (N/A) | 21.74 | 0.31 |
| | Good | 18 | (N/A) | 78.26 | 1.10 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 23 | (N/A) | 100.00 | 1.41 |
| **pine, Austrian** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 2 | (N/A) | 0.90 | 0.12 |
| | Fair | 86 | (N/A) | 38.57 | 5.26 |
| | Good | 135 | (N/A) | 60.54 | 8.26 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 223 | (N/A) | 100.00 | 13.65 |
| **pine, eastern white** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 2 | (N/A) | 66.67 | 0.12 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 1 | (N/A) | 33.33 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 3 | (N/A) | 100.00 | 0.18 |

# Ontario

## Structural (Woody) Condition of All Trees by Species

7/19/2011

| Species | Condition | Tree Count | Standard Error | % of Species | % of All Trees |
|---|---|---|---|---|---|
| **pine, red** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 33.33 | 0.06 |
| | Fair | 2 | (N/A) | 66.67 | 0.12 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 3 | (N/A) | 100.00 | 0.18 |
| **planetree, London** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 11 | (N/A) | 21.57 | 0.67 |
| | Good | 40 | (N/A) | 78.43 | 2.45 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 51 | (N/A) | 100.00 | 3.12 |
| **Plum** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 2 | (N/A) | 5.88 | 0.12 |
| | Fair | 12 | (N/A) | 35.29 | 0.73 |
| | Good | 20 | (N/A) | 58.82 | 1.22 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 34 | (N/A) | 100.00 | 2.08 |
| **redbud, Eastern** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 2 | (N/A) | 10.53 | 0.12 |
| | Good | 17 | (N/A) | 89.47 | 1.04 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 19 | (N/A) | 100.00 | 1.16 |
| **Sassafras** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 100.00 | 0.06 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **Serviceberry** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 33.33 | 0.06 |
| | Good | 2 | (N/A) | 66.67 | 0.12 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 3 | (N/A) | 100.00 | 0.18 |
| **serviceberry, Eastern** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 2 | (N/A) | 100.00 | 0.12 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 2 | (N/A) | 100.00 | 0.12 |
| **smoketree, common** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 100.00 | 0.06 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **spruce, Colorado** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 3 | (N/A) | 2.91 | 0.18 |
| | Fair | 37 | (N/A) | 35.92 | 2.26 |
| | Good | 63 | (N/A) | 61.17 | 3.86 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 103 | (N/A) | 100.00 | 6.30 |

# Structural (Woody) Condition of All Trees by Species

7/19/2011

| Species | Condition | Tree Count | Standard Error | % of Species | % of All Trees |
|---|---|---|---|---|---|
| **spruce, Norway** | Dead or Dying | 3 | (N/A) | 6.98 | 0.18 |
| | Poor | 3 | (N/A) | 6.98 | 0.18 |
| | Fair | 25 | (N/A) | 58.14 | 1.53 |
| | Good | 12 | (N/A) | 27.91 | 0.73 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 43 | (N/A) | 100.00 | 2.63 |
| **spruce, white** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 12.50 | 0.06 |
| | Fair | 6 | (N/A) | 75.00 | 0.37 |
| | Good | 1 | (N/A) | 12.50 | 0.06 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 8 | (N/A) | 100.00 | 0.49 |
| **Sweetgum** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 2 | (N/A) | 28.57 | 0.12 |
| | Good | 5 | (N/A) | 71.43 | 0.31 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 7 | (N/A) | 100.00 | 0.43 |
| **Tree of heaven** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 10 | (N/A) | 47.62 | 0.61 |
| | Fair | 11 | (N/A) | 52.38 | 0.67 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 21 | (N/A) | 100.00 | 1.29 |
| **Tulip tree** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 2 | (N/A) | 14.29 | 0.12 |
| | Fair | 3 | (N/A) | 21.43 | 0.18 |
| | Good | 9 | (N/A) | 64.29 | 0.55 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 14 | (N/A) | 100.00 | 0.86 |
| **tupelo, black** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 25.00 | 0.06 |
| | Fair | 3 | (N/A) | 75.00 | 0.18 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 4 | (N/A) | 100.00 | 0.24 |
| **unknown tree** | Dead or Dying | 2 | (N/A) | 100.00 | 0.12 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 2 | (N/A) | 100.00 | 0.12 |
| **walnut, black** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 2 | (N/A) | 100.00 | 0.12 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 2 | (N/A) | 100.00 | 0.12 |
| **walnut, English** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 100.00 | 0.06 |
| | Fair | 0 | (N/A) | 0.00 | 0.00 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |

# Ontario

## Structural (Woody) Condition of All Trees by Species

7/19/2011

| Species | Condition | Tree Count | Standard Error | % of Species | % of All Trees |
|---|---|---|---|---|---|
| **willow, Corkscrew** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 0 | (N/A) | 0.00 | 0.00 |
| | Fair | 1 | (N/A) | 100.00 | 0.06 |
| | Good | 0 | (N/A) | 0.00 | 0.00 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 1 | (N/A) | 100.00 | 0.06 |
| **zelkova, Japanese** | Dead or Dying | 0 | (N/A) | 0.00 | 0.00 |
| | Poor | 1 | (N/A) | 5.88 | 0.06 |
| | Fair | 8 | (N/A) | 47.06 | 0.49 |
| | Good | 8 | (N/A) | 47.06 | 0.49 |
| | N/A | 0 | (N/A) | 0.00 | 0.00 |
| | Total | 17 | (N/A) | 100.00 | 1.04 |

# Appendix E
# i-Tree Streets Methodology and Climate Zone Map

# i-Tree Streets

The method used to determine environmental and economic benefit values is the United States Department of Agriculture (USDA) Forest Service's i-Tree Streets software. 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, communities and urban forest managers can accurately quantify the benefits of urban forests to better understand and balance the costs of urban forest management.

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 annual benefit values. It is a statistically valid, financially sound, and defensible cost-benefit analysis tool for urban forest managers that may be used with complete or sample inventories.

i-Tree Streets was originally designed to quantify the environmental and economic functional benefit and corresponding value of street trees. Since some of the University of Windsor's campus trees are not growing near buildings or pavement, some of the environmental and economic values reported here may not be definitive. However, this program is still relevant to assessing the environmental and economic benefits and values of campus landscaped trees.

i-Tree Streets assesses tree population structure and the function of those trees, such as their role in building energy use, air pollution removal, stormwater interception, carbon dioxide removal, and property value increases. In order to analyze the economic benefits of the University of Windsor's inventoried trees, i-Tree Streets assigns a dollar value to the annual resource functionality and compares that to annual program expenditures. This analysis combines the results of the University's tree inventory with benefit-cost modeling data to produce information regarding resource structure, resource function, and resource value to make informed resource management decisions. For a detailed accounting of how i-Tree Streets handles tree sampling, tree growth modeling, replacement value, and the calculations of annual benefits, refer to the *City of New York, York Municipal Forest Resource Analysis*.

i-Tree Streets regionalizes the calculations of its output by incorporating detailed reference city project information for 16 climate zones across the United States. The University of Windsor falls within the Northeast zone (see map). Sample inventory data from Queen's, New York, represent the basis for the Northeast Reference City Project for the Northeast Community Tree Guidelines. The basis for the benefit modeling in this study compares the inventory data from the University of Windsor to the results of Northeast Reference City Project to obtain an estimation of the annual benefits provided by the University's managed resource.

Growth rate modeling information was used to perform computer-simulated growth of the existing tree population for one year and account for the associated annual benefits. This "snapshot" analysis assumed that no trees were added to, or removed from, the existing population during the year. Calculations of carbon dioxide ($CO_2$) released due to decompositions of wood from removed trees did consider average annual mortality. This approach directly connects benefits with tree-size variables such as diameter at breast height (DBH) and leaf-surface area. Many benefits of trees are related to processes that involve interactions between leaves and the atmosphere (*e.g.*, interception, transpiration, and photosynthesis); therefore, benefits increase as tree canopy cover and leaf surface area increase.

For each of the modeled benefits, an annual resource unit was determined on a per-tree basis. Resource units are measured as Megawatt-hours (MWh) of electricity saved per tree; one hundred thousand British thermal units (Therm) of natural gas conserved per tree; kilograms of atmospheric $CO_2$ reduced per tree; kilograms of nitrogen dioxide ($NO_2$), particulate matter ($PM_{10}$), and volatile organic compounds (VOCs) reduced per tree; cubic meters of stormwater runoff reduced per tree; and square meters of leaf area added per tree to increase property values.

Prices were assigned to each resource unit using economic indicators of society's willingness to pay for the environmental benefits trees provide. Estimates of benefits are initial approximations as some benefits are difficult to quantify (*e.g.*, impacts on psychological health, crime, and violence). In addition, limited knowledge about the physical processes at work and their interactions makes estimates imprecise (*e.g.*, fate of air pollutants trapped by trees and then washed to the ground by rainfall). Therefore, this method of quantification provides first-order approximations. It is meant to be a general accounting of the benefits produced by urban trees—an accounting with an accepted degree of uncertainty that can, nonetheless, provide science-based platform for decision-making.

For a detailed description of how the default benefit prices are derived, refer to the *City of New York, York Municipal Forest Resource Analysis* (Peper, P.J., et al., 2007) and the *Northeast Community Tree Guide* (McPherson, Gregory E., et al., 2007). In order to further refine the estimation of benefits to the University of Windsor, certain benefit prices have been obtained specific for the University of Windsor (see table).

***University of Windsor's Benefit Prices Used in this Analysis (CDN $)***

| Benefits | Price | Unit | Source |
|---|---|---|---|
| Electricity | $0.073 | $/ Kilowatt-hour | Energyshop |
| Natural Gas | $0.5776 | $/Therm | Energyshop |
| $CO_2$ | $0.0032 | $/pound | i-Tree Streets default- Northeast |
| $PM_{10}$ | $8.03 | $/ pound | i-Tree Streets default- Northeast |
| $NO_2$ | $4.44 | $/ pound | i-Tree Streets default- Northeast |
| $SO_2$ | $3.36 | $/ pound | i-Tree Streets default- Northeast |
| VOC | $2.23 | $/ pound | i-Tree Streets default- Northeast |
| Stormwater Interception | $0.0077 | $/ gallon | i-Tree Streets default- Northeast |
| Average Home Resale Value | $160,000 | $ | Windsor-Essex County Real Estate Board |

The local benefit price for electricity ($0.073/Kwh) was obtained from the Energyshop website in July 2011. This electricity benefit price is the rate as of July 1,2011, for the Windsor area. The local benefit price for natural gas ($0.5776/Therm) was obtained from the Energyshop website in July 2011. This natural gas benefit price is the rate as of July 12, 2011, for the Windsor area. The local benefit price for average home resale value ($160,000) was obtained from Windsor-Essex County Real Estate Board website in July 2011, for the month of June, 2011. i-Tree Street's default values from the Northeast Climate Zone were used for all additional benefit values (air quality and stormwater). These values were converted from US dollars to Canadian dollars (exchange rate on July 12, 2011). Using these

prices, the magnitude of the benefits provided by the street tree resource was calculated using i-Tree Streets. For a detailed description of how the magnitudes of benefit prices are calculated, refer to the *New York City, New York Municipal Forest Resource Analysis.*

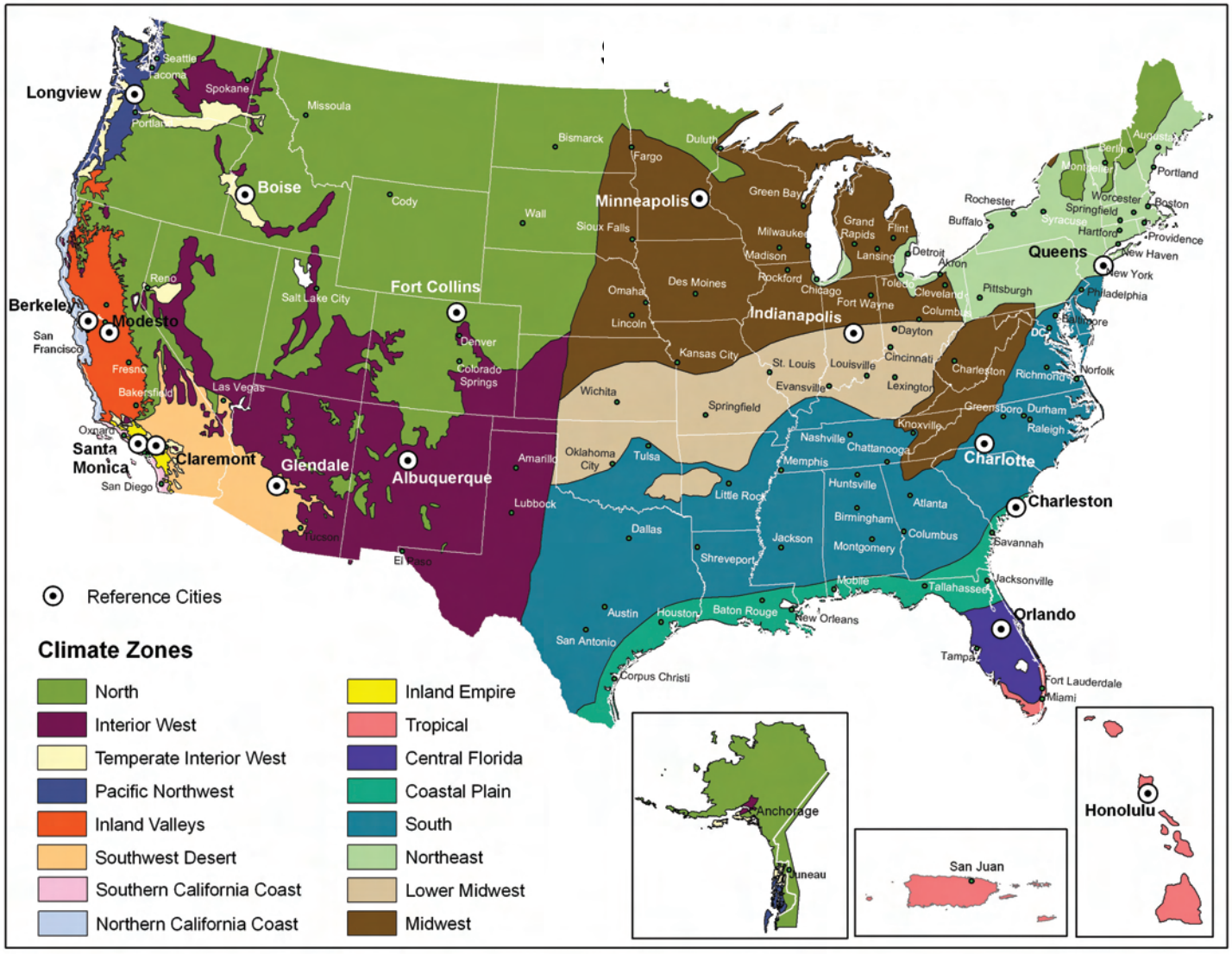



Fig. 1. Streets climate zones.

# Appendix F
# Benefit Reports and Summaries

**Ontario**

# Annual Aesthetic/Other Benefits of All Trees by Species

13/07/2011

| Species | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|
| pine, Austrian | 3,021 | (N/A) | 13.7 | 9.4 | 13.55 |
| maple, Norway | 3,690 | (N/A) | 12.3 | 11.5 | 18.36 |
| maple, silver | 3,475 | (N/A) | 8.6 | 10.8 | 24.64 |
| honeylocust, Thornless | 4,361 | (N/A) | 8.3 | 13.6 | 32.31 |
| spruce, Colorado | 1,371 | (N/A) | 6.3 | 4.3 | 13.31 |
| linden, littleleaf | 1,764 | (N/A) | 5.4 | 5.5 | 20.05 |
| maple, red | 1,594 | (N/A) | 3.9 | 5.0 | 25.30 |
| Apple | 543 | (N/A) | 3.9 | 1.7 | 8.63 |
| planetree, London | 1,257 | (N/A) | 3.1 | 3.9 | 24.64 |
| hackberry, Northern | 1,328 | (N/A) | 2.8 | 4.1 | 28.87 |
| spruce, Norway | 573 | (N/A) | 2.6 | 1.8 | 13.32 |
| oak, northern red | 705 | (N/A) | 2.4 | 2.2 | 18.08 |
| cedar, Northern white | 237 | (N/A) | 2.3 | 0.7 | 6.23 |
| Plum | 179 | (N/A) | 2.1 | 0.6 | 5.27 |
| mulberry, white | 784 | (N/A) | 2.0 | 2.4 | 24.49 |
| pear, callery | 555 | (N/A) | 1.4 | 1.7 | 24.12 |
| Tree of heaven | 526 | (N/A) | 1.3 | 1.6 | 25.06 |
| redbud, Eastern | 87 | (N/A) | 1.2 | 0.3 | 4.57 |
| lilac, Japanese tree | 309 | (N/A) | 1.2 | 1.0 | 16.24 |
| elm, American | 891 | (N/A) | 1.0 | 2.8 | 52.40 |
| zelkova, Japanese | 488 | (N/A) | 1.0 | 1.5 | 28.70 |
| OTHER STREET TREES | 4,442 | (N/A) | 13.3 | 13.8 | 20.37 |
| Citywide total | 32,178 | (N/A) | 100.0 | 100.0 | 19.69 |

## Ontario

# Annual Energy Benefits of All Trees By Species

7/19/2011

| Species | Total Electricity (MWh) | Electricity ($) | Total Natural Gas (Therms) | Natural Gas ($) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|
| pine, Austrian | 7.2 | 526 | 2,734.2 | 1,579 | 2,106 | (N/A) | 13.7 | 9.2 | 9.44 |
| maple, Norway | 10.6 | 775 | 4,345.6 | 2,510 | 3,285 | (N/A) | 12.3 | 14.4 | 16.34 |
| maple, silver | 14.5 | 1,061 | 5,413.4 | 3,127 | 4,188 | (N/A) | 8.6 | 18.3 | 29.70 |
| honeylocust, Thornless | 10.0 | 729 | 3,732.0 | 2,156 | 2,885 | (N/A) | 8.3 | 12.6 | 21.37 |
| spruce, Colorado | 2.9 | 210 | 1,043.0 | 602 | 812 | (N/A) | 6.3 | 3.6 | 7.89 |
| linden, littleleaf | 3.4 | 247 | 1,205.4 | 696 | 944 | (N/A) | 5.4 | 4.1 | 10.72 |
| maple, red | 2.2 | 164 | 905.5 | 523 | 687 | (N/A) | 3.9 | 3.0 | 10.91 |
| Apple | 1.9 | 138 | 872.9 | 504 | 643 | (N/A) | 3.9 | 2.8 | 10.20 |
| planetree, London | 4.1 | 302 | 1,470.3 | 849 | 1,151 | (N/A) | 3.1 | 5.0 | 22.57 |
| hackberry, Northern | 0.6 | 47 | 244.3 | 141 | 188 | (N/A) | 2.8 | 0.8 | 4.09 |
| spruce, Norway | 1.6 | 115 | 564.7 | 326 | 441 | (N/A) | 2.6 | 1.9 | 10.27 |
| oak, northern red | 1.0 | 71 | 418.9 | 242 | 313 | (N/A) | 2.4 | 1.4 | 8.03 |
| cedar, Northern white | 0.4 | 28 | 161.2 | 93 | 121 | (N/A) | 2.3 | 0.5 | 3.18 |
| Plum | 0.5 | 35 | 232.8 | 134 | 169 | (N/A) | 2.1 | 0.7 | 4.98 |
| mulberry, white | 1.6 | 120 | 653.7 | 378 | 498 | (N/A) | 2.0 | 2.2 | 15.56 |
| pear, callery | 0.3 | 23 | 128.2 | 74 | 97 | (N/A) | 1.4 | 0.4 | 4.21 |
| Tree of heaven | 1.5 | 111 | 593.9 | 343 | 454 | (N/A) | 1.3 | 2.0 | 21.64 |
| redbud, Eastern | 0.1 | 9 | 63.6 | 37 | 45 | (N/A) | 1.2 | 0.2 | 2.39 |
| lilac, Japanese tree | 0.1 | 7 | 40.9 | 24 | 30 | (N/A) | 1.2 | 0.1 | 1.59 |
| elm, American | 2.3 | 166 | 754.0 | 436 | 602 | (N/A) | 1.0 | 2.6 | 35.39 |
| zelkova, Japanese | 0.5 | 38 | 233.0 | 135 | 172 | (N/A) | 1.0 | 0.8 | 10.14 |
| OTHER STREET TREES | 10.3 | 751 | 3,897.5 | 2,251 | 3,002 | (N/A) | 13.3 | 13.2 | 13.77 |
| Citywide total | 77.7 | 5,674 | 29,709.0 | 17,160 | 22,834 | (N/A) | 100.0 | 100.0 | 13.97 |

## Ontario

# Annual Stormwater Benefits of All Trees by Species

7/18/2011

| Species | Total rainfall interception (cu.m.) | Total ($) | Standard Error | % of Total Trees | % of Total $ | Avg. $/tree |
|---|---|---|---|---|---|---|
| pine, Austrian | 691 | 1,406 | (N/A) | 13.7 | 12.4 | 6.30 |
| maple, Norway | 598 | 1,217 | (N/A) | 12.3 | 10.8 | 6.06 |
| maple, silver | 1,104 | 2,245 | (N/A) | 8.6 | 19.8 | 15.92 |
| honeylocust, Thornless | 601 | 1,222 | (N/A) | 8.3 | 10.8 | 9.05 |
| spruce, Colorado | 269 | 546 | (N/A) | 6.3 | 4.8 | 5.30 |
| linden, littleleaf | 197 | 400 | (N/A) | 5.4 | 3.5 | 4.55 |
| maple, red | 192 | 391 | (N/A) | 3.9 | 3.5 | 6.21 |
| Apple | 111 | 226 | (N/A) | 3.9 | 2.0 | 3.59 |
| planetree, London | 278 | 565 | (N/A) | 3.1 | 5.0 | 11.07 |
| hackberry, Northern | 43 | 88 | (N/A) | 2.8 | 0.8 | 1.91 |
| spruce, Norway | 142 | 289 | (N/A) | 2.6 | 2.6 | 6.71 |
| oak, northern red | 67 | 136 | (N/A) | 2.4 | 1.2 | 3.48 |
| cedar, Northern white | 24 | 48 | (N/A) | 2.3 | 0.4 | 1.27 |
| Plum | 24 | 49 | (N/A) | 2.1 | 0.4 | 1.44 |
| mulberry, white | 134 | 272 | (N/A) | 2.0 | 2.4 | 8.49 |
| pear, callery | 23 | 47 | (N/A) | 1.4 | 0.4 | 2.05 |
| Tree of heaven | 109 | 222 | (N/A) | 1.3 | 2.0 | 10.56 |
| redbud, Eastern | 6 | 12 | (N/A) | 1.2 | 0.1 | 0.65 |
| lilac, Japanese tree | 7 | 15 | (N/A) | 1.2 | 0.1 | 0.77 |
| elm, American | 180 | 366 | (N/A) | 1.0 | 3.2 | 21.50 |
| zelkova, Japanese | 18 | 36 | (N/A) | 1.0 | 0.3 | 2.11 |
| OTHER STREET TREES | 746 | 1,518 | (N/A) | 13.3 | 13.4 | 6.96 |
| Citywide total | 5,562 | 11,313 | (N/A) | 100.0 | 100.0 | 6.92 |

## Ontario

# Annual Air Quality Benefits of All Trees by Species

13/07/2011

| Species | Deposition (kg) $O_3$ | $NO_2$ | $PM_{10}$ | $SO_2$ | Total Depos. ($) | Avoided (kg) $NO_2$ | $PM_{10}$ | VOC | $SO_2$ | Total Avoided ($) | BVOC Emissions (kg) | BVOC Emissions ($) | Total Emissions | Total ($) | Standard Error | % of Total Trees | Avg. $/tree |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pine, Austrian | 24.6 | 11.8 | 15.6 | 6.7 | 682 | 28.4 | 1.8 | 1.1 | 14.4 | 423 | -56.9 | -280 | 47.5 | 825 | (N/A) | 13.6 | 3.70 |
| maple, Norway | 25.6 | 11.1 | 12.6 | 4.2 | 613 | 43.3 | 2.8 | 1.7 | 21.1 | 639 | -3.2 | -16 | 119.3 | 1,236 | (N/A) | 12.3 | 6.15 |
| maple, silver | 36.0 | 15.6 | 17.7 | 5.9 | 862 | 56.8 | 3.7 | 2.2 | 28.9 | 847 | -11.0 | -54 | 155.8 | 1,654 | (N/A) | 8.6 | 11.73 |
| honeylocust, Thornless | 23.7 | 9.6 | 11.3 | 3.6 | 553 | 39.1 | 2.5 | 1.5 | 19.9 | 583 | -10.2 | -50 | 101.2 | 1,086 | (N/A) | 8.3 | 8.04 |
| spruce, Colorado | 9.4 | 4.5 | 5.9 | 2.5 | 260 | 11.1 | 0.7 | 0.4 | 5.7 | 166 | -22.5 | -111 | 17.8 | 315 | (N/A) | 6.3 | 3.06 |
| linden, littleleaf | 7.0 | 3.0 | 3.4 | 1.1 | 166 | 13.0 | 0.8 | 0.5 | 6.7 | 195 | -3.9 | -19 | 31.7 | 341 | (N/A) | 5.4 | 3.88 |
| maple, red | 5.6 | 2.4 | 2.8 | 0.9 | 134 | 9.1 | 0.6 | 0.4 | 4.5 | 135 | -1.7 | -8 | 24.5 | 260 | (N/A) | 3.9 | 4.13 |
| Apple | 4.8 | 2.1 | 2.4 | 0.8 | 115 | 8.2 | 0.5 | 0.3 | 3.8 | 119 | 0.0 | 0 | 22.9 | 234 | (N/A) | 3.9 | 3.72 |
| planetree, London | 10.1 | 4.3 | 4.9 | 1.6 | 238 | 15.8 | 1.0 | 0.6 | 8.2 | 237 | -10.6 | -52 | 35.9 | 424 | (N/A) | 3.1 | 8.30 |
| hackberry, Northern | 1.3 | 0.5 | 0.6 | 0.2 | 29 | 2.5 | 0.2 | 0.1 | 1.3 | 38 | 0.0 | 0 | 6.6 | 67 | (N/A) | 2.8 | 1.46 |
| spruce, Norway | 5.2 | 2.5 | 3.3 | 1.4 | 143 | 6.1 | 0.4 | 0.2 | 3.1 | 91 | -11.5 | -57 | 10.6 | 177 | (N/A) | 2.6 | 4.13 |
| oak, northern red | 2.2 | 1.0 | 1.1 | 0.4 | 54 | 4.1 | 0.3 | 0.2 | 1.9 | 60 | -2.2 | -11 | 8.9 | 103 | (N/A) | 2.4 | 2.63 |
| cedar, Northern white | 1.3 | 0.6 | 0.8 | 0.4 | 36 | 1.6 | 0.1 | 0.1 | 0.8 | 23 | -0.2 | -1 | 5.4 | 58 | (N/A) | 2.3 | 1.53 |
| Plum | 1.1 | 0.5 | 0.6 | 0.2 | 27 | 2.1 | 0.1 | 0.1 | 1.0 | 31 | 0.0 | 0 | 5.7 | 58 | (N/A) | 2.1 | 1.71 |
| mulberry, white | 4.0 | 1.7 | 2.0 | 0.7 | 95 | 6.6 | 0.4 | 0.3 | 3.3 | 98 | -1.1 | -6 | 17.8 | 188 | (N/A) | 2.0 | 5.87 |
| pear, callery | 0.8 | 0.4 | 0.4 | 0.1 | 20 | 1.3 | 0.1 | 0.0 | 0.6 | 19 | 0.0 | 0 | 3.8 | 39 | (N/A) | 1.4 | 1.70 |
| Tree of heaven | 3.8 | 1.6 | 1.8 | 0.6 | 90 | 6.1 | 0.4 | 0.2 | 3.0 | 90 | 0.0 | 0 | 17.6 | 181 | (N/A) | 1.3 | 8.61 |
| redbud, Eastern | 0.3 | 0.1 | 0.1 | 0.0 | 7 | 0.6 | 0.0 | 0.0 | 0.2 | 8 | 0.0 | 0 | 1.5 | 15 | (N/A) | 1.2 | 0.78 |
| lilac, Japanese tree | 0.2 | 0.1 | 0.1 | 0.0 | 6 | 0.4 | 0.0 | 0.0 | 0.2 | 6 | 0.0 | 0 | 1.1 | 12 | (N/A) | 1.2 | 0.61 |
| elm, American | 6.0 | 2.4 | 2.9 | 0.9 | 140 | 8.5 | 0.5 | 0.3 | 4.5 | 128 | 0.0 | 0 | 26.1 | 268 | (N/A) | 1.0 | 15.75 |
| zelkova, Japanese | 0.6 | 0.2 | 0.3 | 0.1 | 14 | 2.2 | 0.1 | 0.1 | 1.0 | 32 | 0.0 | 0 | 4.7 | 46 | (N/A) | 1.0 | 2.71 |
| OTHER STREET TREES | 25.0 | 10.6 | 12.4 | 4.1 | 598 | 40.5 | 2.6 | 1.6 | 20.5 | 603 | -12.7 | -62 | 104.7 | 1,139 | (N/A) | 13.3 | 5.22 |
| Citywide total | 198.8 | 86.5 | 102.9 | 36.5 | 4,884 | 307.6 | 20.0 | 11.9 | 154.8 | 4,569 | -147.7 | -726 | 771.2 | 8,727 | (N/A) | 100.0 | 5.34 |

**Ontario**

# Annual CO $_2$ Benefits of All Trees by Species

13/07/2011

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pine, Austrian | 8,802 | 28 | -1,819 | -1,482 | -11 | 21,723 | 70 | 27,225 | 87 | (N/A) | 13.7 | 8.0 | 0.39 |
| maple, Norway | 32,282 | 103 | -6,600 | -1,579 | -26 | 31,975 | 102 | 56,079 | 179 | (N/A) | 12.3 | 16.6 | 0.89 |
| maple, silver | 28,974 | 93 | -7,573 | -1,716 | -30 | 43,770 | 140 | 63,455 | 203 | (N/A) | 8.6 | 18.7 | 1.44 |
| honeylocust, Thornless | 14,755 | 47 | -5,158 | -951 | -20 | 30,088 | 96 | 38,735 | 124 | (N/A) | 8.3 | 11.4 | 0.92 |
| spruce, Colorado | 3,355 | 11 | -752 | -590 | -4 | 8,656 | 28 | 10,668 | 34 | (N/A) | 6.3 | 3.2 | 0.33 |
| linden, littleleaf | 7,341 | 23 | -2,242 | -533 | -9 | 10,212 | 33 | 14,777 | 47 | (N/A) | 5.4 | 4.4 | 0.54 |
| maple, red | 4,142 | 13 | -865 | -363 | -4 | 6,771 | 22 | 9,685 | 31 | (N/A) | 3.9 | 2.9 | 0.49 |
| Apple | 3,512 | 11 | -781 | -391 | -4 | 5,708 | 18 | 8,048 | 26 | (N/A) | 3.9 | 2.4 | 0.41 |
| planetree, London | 6,271 | 20 | -1,102 | -475 | -5 | 12,449 | 40 | 17,143 | 55 | (N/A) | 3.1 | 5.1 | 1.08 |
| hackberry, Northern | 1,336 | 4 | -221 | -98 | -1 | 1,934 | 6 | 2,951 | 9 | (N/A) | 2.8 | 0.9 | 0.21 |
| spruce, Norway | 1,745 | 6 | -430 | -293 | -2 | 4,757 | 15 | 5,779 | 18 | (N/A) | 2.6 | 1.7 | 0.43 |
| oak, northern red | 1,770 | 6 | -342 | -141 | -2 | 2,941 | 9 | 4,227 | 14 | (N/A) | 2.4 | 1.3 | 0.35 |
| cedar, Northern white | 1,304 | 4 | -150 | -131 | -1 | 1,149 | 4 | 2,173 | 7 | (N/A) | 2.3 | 0.6 | 0.18 |
| Plum | 1,434 | 5 | -316 | -111 | -1 | 1,444 | 5 | 2,451 | 8 | (N/A) | 2.1 | 0.7 | 0.23 |
| mulberry, white | 2,535 | 8 | -795 | -248 | -3 | 4,965 | 16 | 6,458 | 21 | (N/A) | 2.0 | 1.9 | 0.65 |
| pear, callery | 1,358 | 4 | -26 | -26 | 0 | 936 | 3 | 2,242 | 7 | (N/A) | 1.4 | 0.7 | 0.31 |
| Tree of heaven | 2,336 | 7 | -381 | -184 | -2 | 4,599 | 15 | 6,371 | 20 | (N/A) | 1.3 | 1.9 | 0.97 |
| redbud, Eastern | 275 | 1 | -35 | -32 | 0 | 359 | 1 | 567 | 2 | (N/A) | 1.2 | 0.2 | 0.10 |
| lilac, Japanese tree | 452 | 1 | -6 | -22 | 0 | 275 | 1 | 699 | 2 | (N/A) | 1.2 | 0.2 | 0.12 |
| elm, American | 6,569 | 21 | -1,411 | -240 | -5 | 6,851 | 22 | 11,770 | 38 | (N/A) | 1.0 | 3.5 | 2.22 |
| zelkova, Japanese | 471 | 2 | -60 | -43 | 0 | 1,559 | 5 | 1,927 | 6 | (N/A) | 1.0 | 0.6 | 0.36 |
| OTHER STREET TREES | 20,597 | 66 | -5,020 | -1,435 | -21 | 30,973 | 99 | 45,115 | 144 | (N/A) | 13.3 | 13.3 | 0.66 |
| Citywide total | 151,616 | 485 | -36,082 | -11,085 | -151 | 234,095 | 749 | 338,543 | 1,083 | (N/A) | 100.0 | 100.0 | 0.66 |

**Ontario**

# Total Annual Benefits of All Trees by Species ($)

7/19/2011

| Species | Energy | $CO_2$ | Air Quality | Stormwater | Aesthetic/Other | Total ($) | Standard Error | % of Total $ |
|---|---|---|---|---|---|---|---|---|
| pine, Austrian | 2,106 | 87 | 825 | 1,406 | 3,021 | 7,444 | (±0) | 9.8 |
| maple, Norway | 3,285 | 179 | 1,236 | 1,217 | 3,690 | 9,608 | (±0) | 12.6 |
| maple, silver | 4,188 | 203 | 1,654 | 2,245 | 3,475 | 11,765 | (±0) | 15.5 |
| honeylocust, Thornless | 2,885 | 124 | 1,086 | 1,222 | 4,361 | 9,678 | (±0) | 12.7 |
| spruce, Colorado | 812 | 34 | 315 | 546 | 1,371 | 3,079 | (±0) | 4.0 |
| linden, littleleaf | 944 | 47 | 341 | 400 | 1,764 | 3,497 | (±0) | 4.6 |
| maple, red | 687 | 31 | 260 | 391 | 1,594 | 2,963 | (±0) | 3.9 |
| Apple | 643 | 26 | 234 | 226 | 543 | 1,672 | (±0) | 2.2 |
| planetree, London | 1,151 | 55 | 424 | 565 | 1,257 | 3,451 | (±0) | 4.5 |
| hackberry, Northern | 188 | 9 | 67 | 88 | 1,328 | 1,680 | (±0) | 2.2 |
| spruce, Norway | 441 | 18 | 177 | 288 | 573 | 1,499 | (±0) | 2.0 |
| oak, northern red | 313 | 14 | 103 | 136 | 705 | 1,270 | (±0) | 1.7 |
| cedar, Northern white | 121 | 7 | 58 | 48 | 237 | 471 | (±0) | 0.6 |
| Plum | 169 | 8 | 58 | 49 | 179 | 464 | (±0) | 0.6 |
| mulberry, white | 498 | 21 | 188 | 272 | 784 | 1,762 | (±0) | 2.3 |
| pear, callery | 97 | 7 | 39 | 47 | 555 | 745 | (±0) | 1.0 |
| Tree of heaven | 454 | 20 | 181 | 222 | 526 | 1,404 | (±0) | 1.8 |
| redbud, Eastern | 45 | 2 | 15 | 12 | 87 | 161 | (±0) | 0.2 |
| lilac, Japanese tree | 30 | 2 | 12 | 15 | 309 | 367 | (±0) | 0.5 |
| elm, American | 602 | 38 | 268 | 366 | 891 | 2,163 | (±0) | 2.8 |
| zelkova, Japanese | 172 | 6 | 46 | 36 | 488 | 748 | (±0) | 1.0 |
| OTHER STREET TREI | 3,002 | 144 | 1,139 | 1,518 | 4,442 | 10,244 | (±0) | 13.5 |
| Citywide Total | 22,834 | 1,083 | 8,727 | 11,313 | 32,178 | 76,135 | (±0) | 100.0 |

**Ontario**

# Annual Benefits of All Trees by Species ($/tree)

7/19/2011

| Species | Energy | $CO_2$ | Air Quality | Stormwater | Aesthetic/Other | Total ($) | Standard Error |
|---|---|---|---|---|---|---|---|
| pine, Austrian | 9.44 | 0.39 | 3.70 | 6.30 | 13.55 | 33.38 | (N/A) |
| maple, Norway | 16.34 | 0.89 | 6.15 | 6.06 | 18.36 | 47.80 | (N/A) |
| maple, silver | 29.70 | 1.44 | 11.73 | 15.92 | 24.64 | 83.44 | (N/A) |
| honeylocust, Thornless | 21.37 | 0.92 | 8.04 | 9.05 | 32.31 | 71.69 | (N/A) |
| spruce, Colorado | 7.89 | 0.33 | 3.06 | 5.30 | 13.31 | 29.89 | (N/A) |
| linden, littleleaf | 10.72 | 0.54 | 3.88 | 4.55 | 20.05 | 39.73 | (N/A) |
| maple, red | 10.91 | 0.49 | 4.13 | 6.21 | 25.30 | 47.04 | (N/A) |
| Apple | 10.20 | 0.41 | 3.72 | 3.59 | 8.63 | 26.55 | (N/A) |
| planetree, London | 22.57 | 1.08 | 8.30 | 11.07 | 24.64 | 67.66 | (N/A) |
| hackberry, Northern | 4.09 | 0.21 | 1.46 | 1.91 | 28.87 | 36.52 | (N/A) |
| spruce, Norway | 10.27 | 0.43 | 4.13 | 6.71 | 13.32 | 34.85 | (N/A) |
| oak, northern red | 8.03 | 0.35 | 2.63 | 3.48 | 18.08 | 32.57 | (N/A) |
| cedar, Northern white | 3.18 | 0.18 | 1.53 | 1.27 | 6.23 | 12.40 | (N/A) |
| Plum | 4.98 | 0.23 | 1.71 | 1.44 | 5.27 | 13.64 | (N/A) |
| mulberry, white | 15.56 | 0.65 | 5.87 | 8.49 | 24.49 | 55.06 | (N/A) |
| pear, callery | 4.21 | 0.31 | 1.70 | 2.05 | 24.12 | 32.39 | (N/A) |
| Tree of heaven | 21.64 | 0.97 | 8.61 | 10.56 | 25.06 | 66.84 | (N/A) |
| redbud, Eastern | 2.39 | 0.10 | 0.78 | 0.65 | 4.57 | 8.49 | (N/A) |
| lilac, Japanese tree | 1.59 | 0.12 | 0.61 | 0.77 | 16.24 | 19.33 | (N/A) |
| elm, American | 35.39 | 2.22 | 15.75 | 21.50 | 52.40 | 127.25 | (N/A) |
| zelkova, Japanese | 10.14 | 0.36 | 2.71 | 2.11 | 28.70 | 44.02 | (N/A) |
| OTHER STREET TRI | 13.77 | 0.66 | 5.22 | 6.96 | 20.37 | 46.99 | (N/A) |

## Ontario

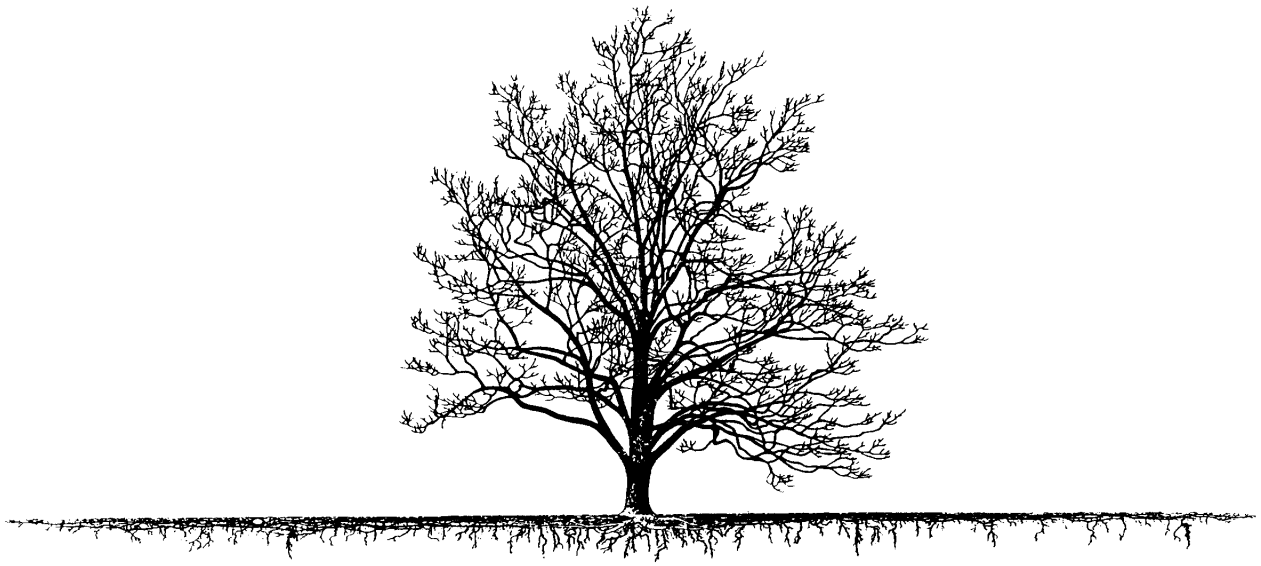
# Total Annual Benefits, Net Benefits, and Costs for All Trees

7/19/2011

| Benefits | Total ($) | Standard Error | $/tree | Standard Error | $/capita | Standard Error |
|---|---|---|---|---|---|---|
| Energy | 22,834 | (N/A) | 13.97 | (N/A) | 1.43 | (N/A) |
| CO2 | 1,083 | (N/A) | 0.66 | (N/A) | 0.07 | (N/A) |
| Air Quality | 8,727 | (N/A) | 5.34 | (N/A) | 0.55 | (N/A) |
| Stormwater | 11,313 | (N/A) | 6.92 | (N/A) | 0.71 | (N/A) |
| Aesthetic/Other | 32,178 | (N/A) | 19.69 | (N/A) | 2.01 | (N/A) |
| Total Benefits | 76,135 | (N/A) | 46.59 | (N/A) | 4.76 | (N/A) |
| Costs | | | | | | |
| Planting | 0 | | 0.00 | | 0.00 | |
| Contract Pruning | 0 | | 0.00 | | 0.00 | |
| Pest Management | 0 | | 0.00 | | 0.00 | |
| Irrigation | 0 | | 0.00 | | 0.00 | |
| Removal | 0 | | 0.00 | | 0.00 | |
| Administration | 0 | | 0.00 | | 0.00 | |
| Inspection/Service | 0 | | 0.00 | | 0.00 | |
| Infrastructure Repairs | 0 | | 0.00 | | 0.00 | |
| Litter Clean-up | 0 | | 0.00 | | 0.00 | |
| Liability/Claims | 0 | | 0.00 | | 0.00 | |
| Other Costs | 12,000 | | 7.34 | | 0.75 | |
| Total Costs | 12,000 | | 7.34 | | 0.75 | |
| Net Benefits | 64,135 | (N/A) | 39.25 | (N/A) | 4.01 | (N/A) |
| Benefit-cost ratio | 6.34 | (N/A) | | | | |

# Appendix G
# Davey® Pruning Guidelines

# Tree Pruning Guidelines



DAVEY RESOURCE GROUP
*A Division of The Davey Tree Expert Company*

# 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 adhere 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 *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

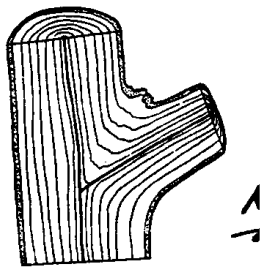
- Shape for aesthetic purpose, natural forms, growth habit (training).
- Influence flowering, fruiting, promotion of shoots, canes, bark color.
- Direct new growth and/or correct improper prior pruning (crown restoration).

## 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



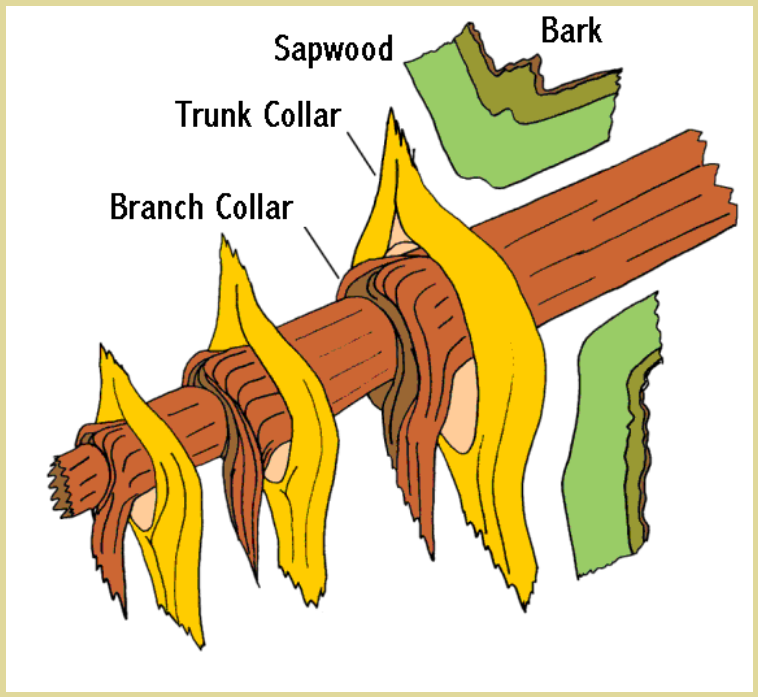
New branch tissues generated by the vascular cambium usually start growth before trunk tissues. As current-year branch tissue develops from branch ends toward the trunk, it turns abruptly downward at the branch base to form a *collar*.

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.

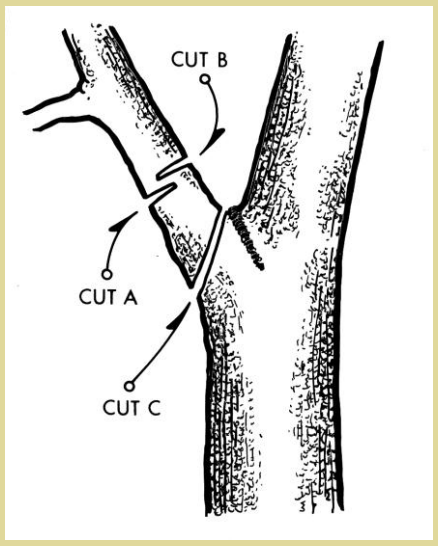
Do not cut into the collar to stimulate callus production and rapid closure. Although closure is desirable for appearance, such a cut promotes decay and future hazards. Never put a pruning tool behind the branch bark ridge.

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.

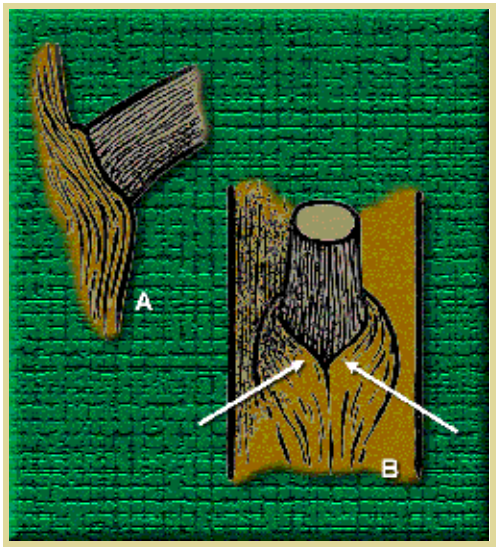
## Callus and Woundwood

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

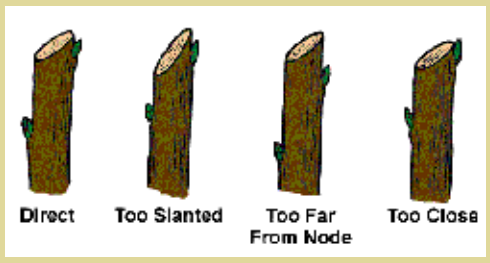
Callus differentiates into *woundwood* over time. Woundwood is 'new wood' and has the different cell components of periderm, cambium, phloem, and xylem.

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 0.3 centimeters 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

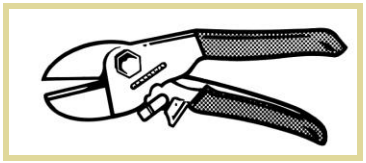
Use **well-sharpened** tools for both your safety and to help reduce tearing of wood and cambial tissues. Wear specified protective equipment.

## Pruning Shears

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

- Remove branches, stems up to 1.25 centimeters diameter.
- By-pass (hook and blade, scissors, drop-forge, curve blade): make closer cuts than anvil-type.

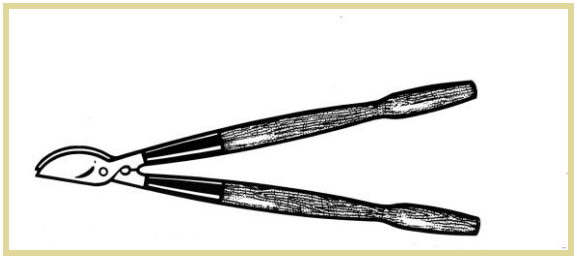
- Anvil (straight-blade): good for only soft-tissued wood; will crush harder wood (inappropriate per A300 standards).



## Lopping Shears

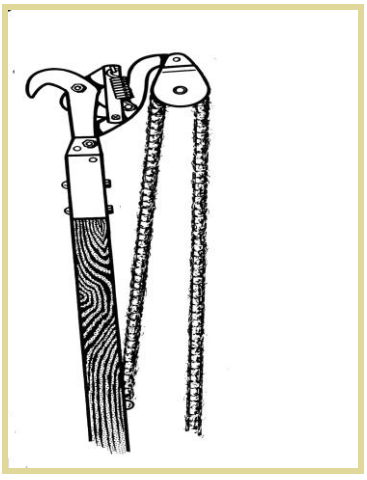
Two-hand shears:

- Remove branches, stems up to 4.5 centimeters 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.



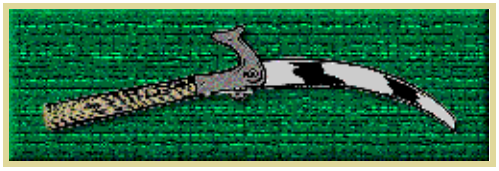
Cut at the outer side of the branch bark ridge at a slightly outward angle so as not to injure or remove the branch collar. Hook the pruner head around the limb to be cut with the blade side against the lateral branch or stem to remain. The arborist must be in a safe working position and the pruner handle 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 centimeter):

- 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.

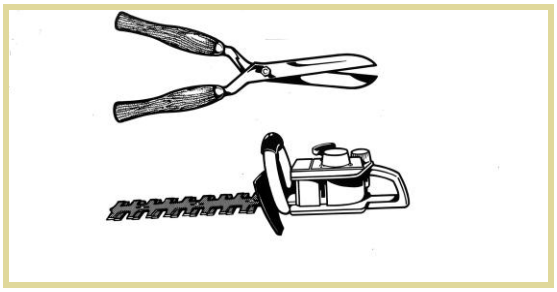
Arborist saws cut on the *pull* stroke:

- 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.

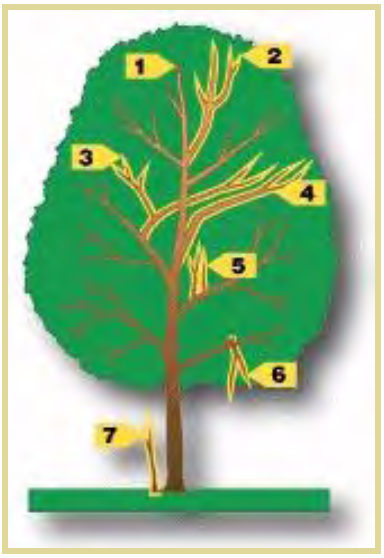
Thinning of lower branches can ‘raise’ a limb. If, after crown raising, the remaining leaf material is insufficient for limb size, consider complete removal. The client's opinion is important.

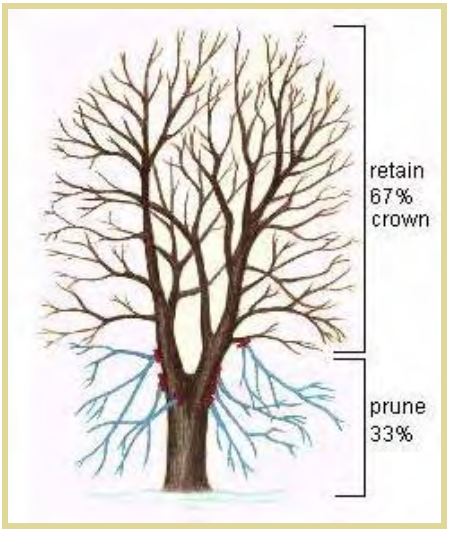
Never perform excessive thinning, which is stressful, especially on thin-barked or young trees prone to sunscald.

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 33 centimeters 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.

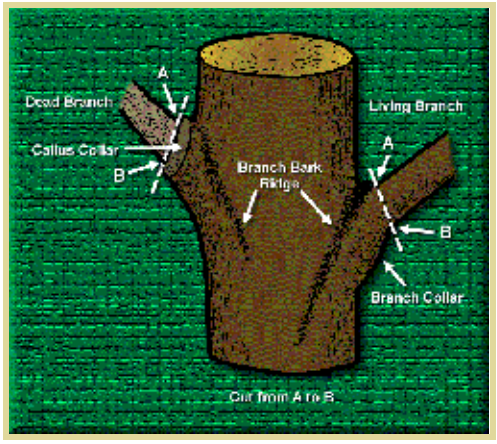
The life of large limbs, weakened by decay or cracks, can often be extended by "shortening" or weight removal using highly selective thinning cuts. Cabling and/or rigid bracing may be required to secure limbs or codominant stems if removal is not possible.

## Deadwood Removal

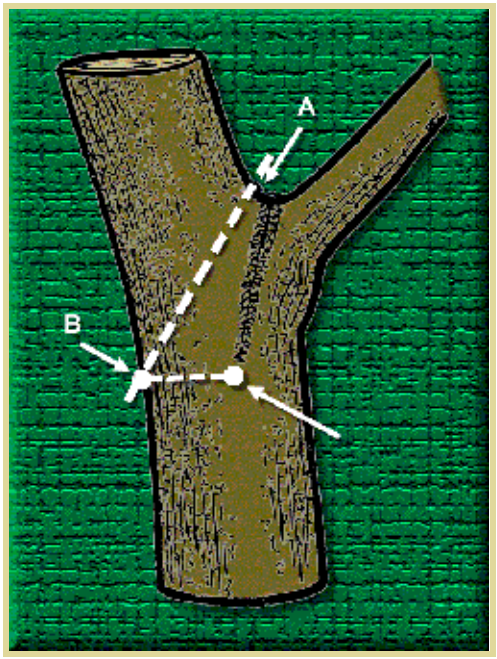
Sanitation and hazard reduction pruning:

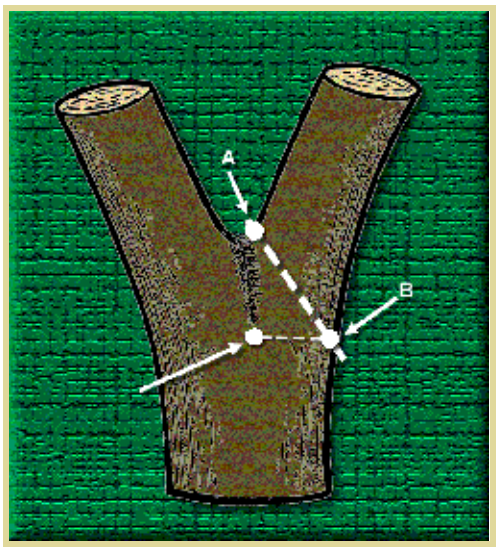
- Dead branches and stubs are an energy source (cellulose, glucose).
- Decay fungi.
- Boring insects.

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.

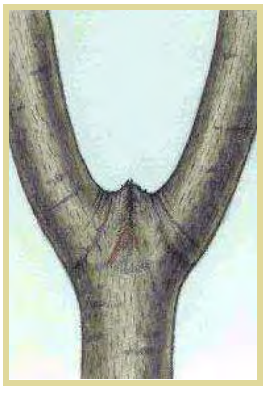
Never remove both stems!

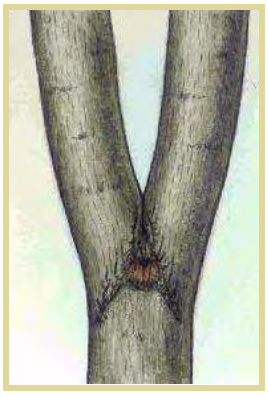
When the bark plates on the stem bark ridge turn upward, the union of the stems is usually *strong*.

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.

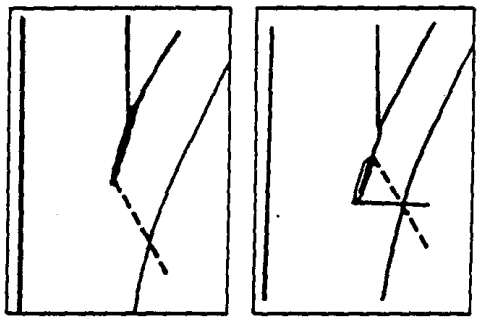




## Remedies

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* stems 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 1.25 centimeters 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 2.5 centimeters 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 five centimeters 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":

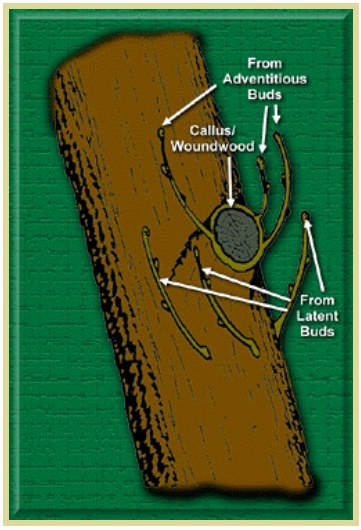
- Adventitious buds.
- Latent (dormant) buds or meristematic points.

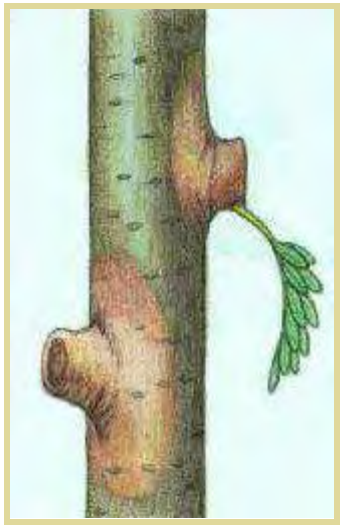
*Adventitious* epicormics come from meristematic tissue generated anew by the cambium. Most adventitious buds develop from callus tissues moving over a wound, or from root tissue.

*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 below 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.
- Budbreak 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 budbreak 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 budbreak 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.

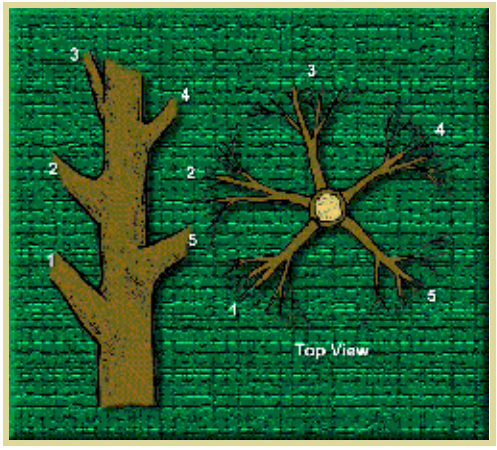
Trees that will be large at maturity should have a sturdy, tapered trunk, with well-spaced branches smaller in diameter than the trunk.

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 45 centimeters 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.

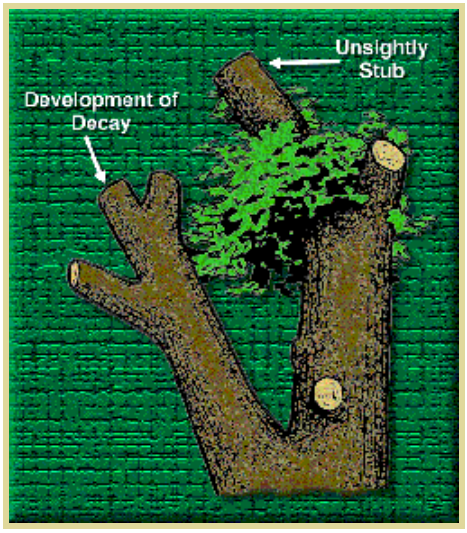
The height of the lowest scaffold branch will depend on the intended function of the tree: screen an unsightly view, provide a windbreak, shade a patio, installed as a walkway or street tree.

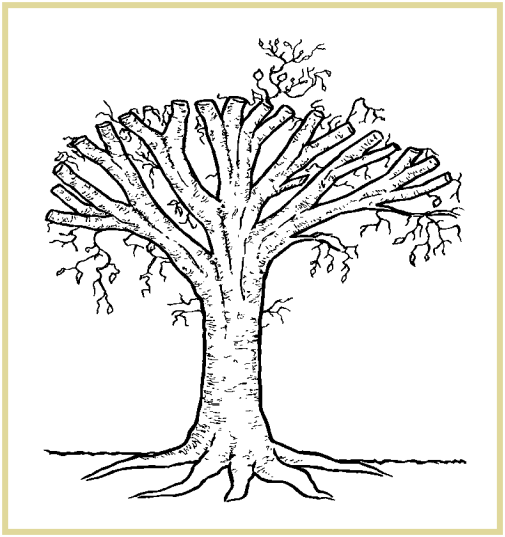
## Pruning at Planting

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 bare-root 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.

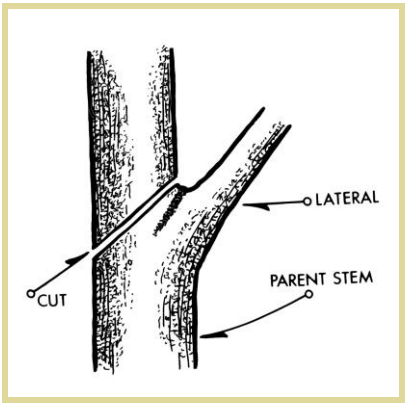
The International Society of Arboriculture (ISA) and the National Arborist Association (NAA) consider heading-back to stubs an unacceptable arboricultural practice. Modern pruning standards do not include heading-back as any sort of a recommended technique.

- Topping removes a major portion of a tree's leaves that is 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 Rais**ing – 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.

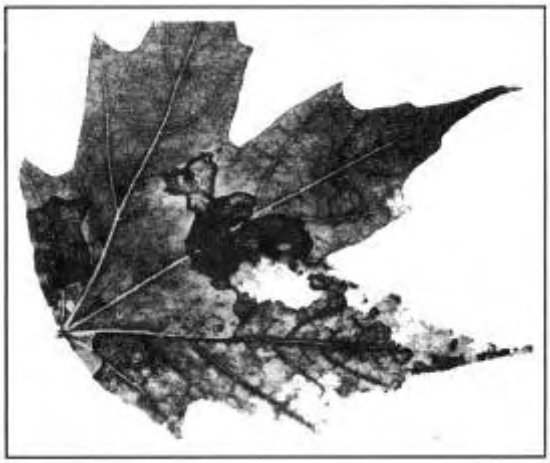
# Appendix H
# Insect and Disease Literature

TECHNICAL BULLETIN
Prepared by The Davey Institute

# Anthracnose

*Gnomonia plantani*

Anthracnose is one of the most common and destructive foliar diseases of shade trees caused by fungi. Leaf tissue will be killed and defoliation may occur, thus reducing the aesthetic value and vitality of the affected trees.



*Anthracnose on sugar maple leaf.*

The disease affects many different kinds of trees. It is more common and serious on American sycamore and white oak than on sugar and Norway maple or ash. Although the disease can occur throughout the United States, it is most prevalent in the north central and northeastern states.

***SYMPTOMS:*** Leaf symptoms vary somewhat, depending upon the tree affected.

**SYCAMORE** *(Platanus)* - *Areas* along the major veins turn brown. Gradually more and more of the leaf will be killed as the fungus spreads. Infected buds may not open in the spring or, if they do, the leaves will be killed before they reach full size. Twigs and branches may show discoloration around infected buds or exhibit dead sunken areas in the bark (cankers).

*Large sycamore tree mostly defoliated by anthracnose.*

**OAK** *(Quercus)* - *The* affected area shows light tan blotches or spots with distinct borders. Leaves may be twisted or distorted.

**MAPLE** *(Acer)* - *The* disease is severe on sugar and silver. maples. Norway maple leaves turn purple along the major veins, while large irregular tan-to-brown blotches are produced in sugar maples.

**ASH** *(Fraxinus)* - Brown areas with irregular shapes occur, especially along the leaf margin. Leaf distortion and premature leaf drop may occur.

***CAUSE:*** The fungus generally overwinters in infected, dead leaves on the ground. In sycamore it also overwinters in infected buds or in cankers formed at the base of an infected leaf or twig.

During cool and wet springs, minute blister-like swellings in the infected tissues release thousands of spores. These get blown around, land on newly developed leaves, and cause infection and death of the tissue resulting in the tan-to-brown areas.

Varying amounts of leaf drop take place, depending upon the severity of the disease that season. Conditions are then ready to repeat the cycle the following year.

***SOLUTIONS:*** Current recommendations for preventing or correcting anthracnose in shade trees include the following:

1. Fertilize trees that have become infected and water during dry periods. This will help the tree overcome the stress brought on by the disease and the resulting defoliation.
2. Rake up and destroy infected leaves and prune off cankered branches. This will reduce the potential for infection.
3. Fungicidal treatments during leaf development will aid in preventing leaf infection and defoliation. Trunk injections of Arbotech can also be used to manage Sycamore Anthracnose.

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TECHNICAL BULLETIN

DAVEY

Prepared by The Davey Institute

# Bagworms

***Bagworms*** *(Thyridopteryx ephemeraeformis) are native to North America and are serious pests of shrubs and woody ornamentals. Since their spindle-shaped, protective bags are made of silk, debris and portions of foliage, they're camouflaged and often go unnoticed until serious plant damage has occurred.*

**LIFE CYCLE AND HABITS:** Bagworms overwinter as eggs within the bag of the adult female (Figure 1). Eggs hatch in mid to late April (may vary by location), and the larvae begin to look for food. Larvae disperse by first producing silk strands that are attached to branches. They then swing down and are caught in wind currents (ballooning). Once on a host plant, larvae feed and begin construction of tiny, cone-shaped bags around themselves. By adding plant material and silk, growing larvae increase their bag size and are protected from predators through pupation. In early August, adult males emerge as black moths with fuzzy bodies, while adult females remain wingless and never leave the bag. Mated females may produce up to 1,000 eggs, and bagworms have one generation per year.

Figure 1. *Adult female bagworms.*

**HOSTS:** Bagworms attack more than 120 species of both deciduous and evergreen trees and shrubs. Some of these hosts include juniper, arborvitae, cedar, spruce, honeylocust, linden, willow, maple, oak, birch, elm and poplar.

**SYMPTOMS:** Bagworm caterpillars consume foliage, and heavy infestations may lead to defoliation (Figure 2). In evergreens, no re-growth occurs and attacked branches often die.

Figure 2. *Defoliation caused by bagworm infestation.*

## Management

**CULTURAL:** Management of bagworms by homeowners may involve hand picking. Make sure that all bags are removed and destroyed, since even one bag left behind could lead to re-infestation.

**BIOLOGICAL/CHEMICAL:** When hand picking is not practical, foliar applications of Bt (*Bacillus thuringiensis*), or any insecticide recommended by Davey Tree, should be made when young larvae are first observed. While spraying, thorough coverage of the foliage is critical. Two applications, two weeks apart, may be necessary for heavy infestations.

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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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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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T 15243 – 02/04

# Appendix I
# Davey® Planting Guidelines and Sample Service Specifications

# 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 45 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 2.5 centimeters 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 5 to 7.5 centimeters depth of mulch should be added, with it being no more than 1.25 centimeters 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.

# UNIVERSITY-WIDE TREE PLANTING SPECIFICATIONS

# University of Windsor

## I. Scope of Work

To provide all supervision, material, labor, equipment, service operations, and expertise required to deliver, locate, plant, and guarantee for one year, trees at the University of Windsor as specified herein. Contractor has responsibility to:

A) Furnish, transport, and plant trees;

B) Reserve workspace along streets;

C) Excavate in-place soil, plant, and backfill with topsoil approved by University Administrator;

D) Furnish and place mulch;

E) Remove excess material and clean up site;

F) Guarantee trees for one year and make appropriate replacement planting;

G) Keep work site safe at all times; and

H) Any work incidental to above.

## II. Definitions

A) Reference is any other specifications or standards means the latest revision in effect on date of invitation to bid. This set of specifications governs when disagreement with a reference specification occurs.

B) Specified means specified in the invitation to bid and/or order or contract.

C) ANSI Z60.1-Standards are American Standard for Nursery Stock.

D) University Administrator is the University's representative who will administer the technical aspects of this tree planting contract. The University Administrator for this contract is: _____.

E) Contractor is a company that earns the majority of its annual revenue from planting or maintaining trees and/or shrubbery. Contractor must possess an ISA Certified Arborist License or Certified Landscapers License or Certificate.

## III. Materials Specifications

Mention of any product name neither constitutes an endorsement of that product nor excludes the use of similar products meeting specifications.

A) Nursery Stock - All trees healthy, vigorous, and well-grown, showing evidence of proper root and top pruning, single-trunked, high-branched specimens suitable for use along streets. All trees 4.4 centimeter caliper unless otherwise noted. All trees will be grown at least one year in a currently active nursery having same climatic conditions as the University of Windsor. All trees meet ANSI Z60.1-standards for top grade. Label attached to each tree at nursery indicating botanical name and common name. University Administrator will mark trees in the nursery and has final approval of species or variety used and nursery from which trees are obtained.

B) Root balls and burlap - All trees balled and burlapped with ball shape and size conforming to ANSI Z60.1 standards. Root flare will be easily visible on root balls. Only rottable burlap and rottable rope permitted. Root balls adequately protected at all times from sun, heat, freezing, and drying. University Administrator will reject any cracked or manufactured root balls.

C) Mulch - Year-old rough wood chips created by local tree service companies during brush chipping operations.

# IV. Work Procedures

A) Source of supply - Contractor submits to University Administrator, within ten (10) days after receipt of notice of award of contract, complete and detailed information concerning the source of supply for each item of plant material specified in the planting list.

B) Tree location - All planting sites will be identified and marked by the University Administrator before planting begins. The appropriate utilities services will be notified of planting site locations by Contractor immediately after contract has been awarded. Contractor will also be responsible for notifying the appropriate utility authority prior to digging. Contractor will be responsible for any damage to utilities during the planting process. Sites will be marked by a white flag in the grass area and also with a white mark painted on the curb. All trees will be centered between curb and sidewalk, at least 0.6 meters from curb line unless otherwise specified by the University Administrator.

C) Delivery - Trees shall be transported and handled with adequate protection. Trees shall be covered with burlap or tarpaulin during transit or transported in a closed truck to prevent drying out of the tree. Trees in leaf shall be sprayed before shipping with "Wiltpruf" or other anti-desiccant approved by the University Administrator.

D) Temporary storage - Root balls of trees not immediately planted after delivery must be adequately protected by mulch or heeling-in and watering until planting occurs. Contractor assumes all risk and expense of temporary storage.

E) Planting holes - Holes may be dug by hand, backhoe, tree spade, or other approved equipment at specified location. An auger is not considered approved equipment. Walls of the planting hole shall be dug so that they are properly sloped and sufficiently loosened to remove the glazing effects of the digging. The planting hole shall be elliptical in shape with the top diameter two times that of the ball. The bottom of the hole shall be rough, flat, and deep enough to have the plant at its original planting depth or slightly higher. Holes shall be ground only on the day the tree is planted. Contractor is responsible to ensure all holes are safe until planted and covered with mulch.

F) Precautions during digging - When underground utilities are encountered, Contractor immediately calls the controlling agency or company and the University of Windsor. The Contractor, at his expense, restores to original condition all structures, facilities, and other property damaged by his company's work.

G) Surplus excavation - Removed and disposed of by Contractor at his/her own expense.

H) Planting - Allowed only between the dates of _____ and _____. Planting is only allowed when the soil is not frozen. Balled and burlapped trees are set on tamped backfill, placing tree at same depth as in nursery or up to five (5) centimeters higher than that level. Planting height may be adjusted if unusual site situations are encountered after approval by University Administrator. Burlap should be pulled back one-third the depth of the root ball and rope or twine should be cut from trunk. Trees with forked, top oriented with forked limbs shall be pointed parallel to street and not toward street. Planting is not allowed on days when temperatures fall below 0° C.

I) Root pruning - Ends of broken or damaged roots more than 0.75 centimeters in diameter should be pruned with a clean cut, removing only injured portion.

J) Backfilling - Planting holes shall be backfilled with approved topsoil. Mix soil amendments in mixture prior to filling the hole to prevent stratification. Incorporate a transplant inoculant that contains water-absorbing material such as polymers, root stimulants, and endo- and ecto-mycorrhizal fungi into the backfill. Backfill sides of the tree hole halfway with soil mixture and tamp as the hole is being filled. Cut and remove all rope, twine, burlap, and wires from the top half of the soil ball. Wire baskets should be cut and removed to a five-centimeter depth below the soil line. Burlap should be pulled back with one-half of the soil ball exposed after plants are properly placed in the planting hole. Shape backfill and mulch in a water ring to facilitate watering.

K) Top pruning and wound treatment - Pruning to make trees shapely and typical of species shall be done according to recognized horticultural standards and instructions of the University Administrator. Accidental damage during planting not great enough to warrant branch removal or tree replacement should be promptly traced according to recognized horticultural practices. Pruning paint is not necessary.

L) Mulching - Place rough wood chips loosely around trees within 24 hours after planting to uniform depth of no more than ten (10) centimeters and to a diameter of one (1) meter where possible.

M) Extra holes - Excess or improperly located planting holes are to be immediately backfilled and seeded with Kentucky bluegrass, and covered with five (5) centimeters of straw, at Contractor's expense.

N) Watering - Thoroughly water to settle backfill when one-half of backfill is in place and again after all backfill is placed. It is highly recommended that watering continue through the first growing season to increase chances of survival after planting.

O) Wrapping - Trees are not wrapped unless specified by the University Administrator. If wrapping is required, trunk and wrapping shall be treated with a 20 percent Lindane and water spray. Wrapping is crinkle-draft tree wrapping paper tied with rottable twine.

P) Productivity - Production schedule beginning and ending dates will be agreed upon in writing between the Contractor and the University Administrator.

Q) Supervision - Contractor is required to consult with the University Administrator concerning details and scheduling of all work. Contractor shall have a competent person in charge of work at all times to whom the University Administrator may issue directions and who is authorized to accept and act upon such directives. Supervisor calls the University Administrator before each day's work begins to provide work locations by street.

R) Public relations - An information sheet shall be supplied by the University Administrator to Contractor for distribution to property owner.

## V. Substitutions

If a species or variety is used as a substitute with the approval of the University Administrator, the per tree price paid by the University is the lowest of:

A) The per tree price of the species or variety originally bid on; or

B) The lowest bid price for the substitute species or variety if it is specified elsewhere in this contract.

## VI. Inspections

A) Nursery inspection - The University Administrator, at its discretion, will inspect and mark nursery stock purchased under this contract before digging.

B) Agency inspection - Federal, Provincial, and other authorities inspect all trees before removal from nursery, as required by local law. Required certificates declaring trees free of all diseases and insects shall accompany each order or shipment of trees.

C) Planting inspection - The University Administrator, at its discretion, inspects progress of planting or temporarily stored trees to review the progress of the work and condition of trees.

D) Guarantee period inspection - The University Administrator inspects planting work to verify completion and begin guarantee period. Contractor requests this inspection in writing at least ten (10) days before its scheduled date. After inspection, the University Administrator notifies Contractor in writing of date of beginning of guarantee period or of deficiencies to correct before guarantee period begins.

E) Correction inspection - Two months before end of guarantee period, the University Administrator inspects work and notifies Contractor of replacement and other corrections required to make work acceptable.

F) Final inspection - At end of guarantee period, University Administrator inspects trees to determine final acceptance. Contractor requests this inspection in writing at least ten (10) days before the scheduled date.

G) Stock inspections - The University Administrator reserves right to inspect trees before they are removed from delivery truck at work site. Delivery truck driver or other agent or Contractor should call the University Administrator's office before leaving for work site each day to facilitate these on-truck inspections.

H) Other inspections - University Administrator reserves right to inspect on-site work at any time without notice. Contractor calls University Administrator on morning of each working day to provide work location.

## VII. Guarantee

Contractor guarantees that all trees remain alive and healthy until the end of a one- (1) year guarantee period. Contractor replaces, as specified, and at his expense, any dead trees and any trees, that in the opinion of the University Administrator, have become unhealthy or unsightly or have lost their natural shape due to dead branches, improper pruning or maintenance, or any other cause due to the Contractor's negligence, or weather conditions. Contractor straightens any leaning trees, bearing the entire cost.

## VIII. Rejection

Contractor disposes of any tree rejected by the University Administrator at the Contractor's expense.

## IX. Items

Each entry (street name, estimated number of trees and species) within each section is considered a separate item. The University Administrator reserves the right to delete any item or items because of an inability to obtain specified trees or other reasonable cause.

# TREE REMOVAL AND PRUNING SPECIFICATIONS UNIVERSITY OF WINDSOR

## I. Scope of Work

To provide all labor, supervision, equipment, services, and expertise necessary to perform urban forestry maintenance work in the University of Windsor as specified herein. Since this work is of a potentially dangerous nature, and requires special expertise, it is to be performed by a contractor that derives a majority of its annual income from arboricultural work and whose employees are highly trained and skilled in all phases of tree service work. Contractors must have been in business for at least five years. The University will require proof of Contractor's involvement in tree service work. The contractor has the responsibility to:

A. Remove or prune designated trees.

B. Reserve work space along streets.

C. Grind out stump when tree is to be removed.

D. Remove excess material and clean up site.

E. Guarantee that specifications be met.

F. Keep work site safe at all times.

## II. Definitions

A. **Reference:** Reference to any other specifications or standards means the latest revision in effect on date of invitation to bid. This set of specifications governs when disagreement with a reference specification occurs.

B. **Specified:** Means specified in the invitation to bid.

C. **ANSI Z-133:** American Standard of Tree Worker Safety.

D. **ANSI A300:** Standard Practices for Trees, Shrubs, and Other Woody Plant Maintenance.

E. **University Administrator:** The University's representative who will administer the technical aspects of this tree pruning and removal contract. The University administrator for this contract is: _____.

F. **Contractor:** A company that earns the majority of its annual revenue for pruning, removing, or maintaining trees and/or shrubbery. Contractor must possess an ISA Certified Arborist License.

# III. Work Procedures

A. **Equipment:** All bidders must have in their possession or available to them by formal agreement at the time of bidding: trucks, devices, chippers, hand tools, aerial, and other equipment and supplies which are necessary to perform the work as outlined in these specifications. The University may inspect such equipment or agreements prior to the awarding of a contract.

B. **Tree Location:** Work limited to trees located on all public rights-of-way and University-owned property. All work under this contract shall be assigned by supplying the Contractor with a list of trees that have been marked with blue paint for priority pruning or red paint if tree is to be removed. All other trees on list are to be pruned for vehicular and pedestrian traffic. The University reserves the right to change, add, or delete areas or quantities to be pruned or removed as it deems to be in its best interest. Pruning and removal operations will commence no later than thirty (30) days after the contract has been awarded and will be completed no later than 90 days after work has begun. The Contractor will be responsible for notifying the appropriate utility authority before removing trees growing in the utility wires. Contractor will be responsible for any damage to utilities during the removal or pruning process.

C. **Public Relations:** An information sheet will be sent by the University Administrator to the property owners.

D. **Supervision:** Contractor consults with the University concerning details of scheduling of all work. Contractor has a competent person in charge of his work at all times to whom the University may issue directives and who shall accept and act upon such directives, and who reads, speaks, and writes English competently. Failure for the supervisor to act on said directives shall be sufficient cause to give notice that the Contractor is in default of contract unless such directives would create potential personal injury of safety hazards. The University requires a Certified Arborist on the job site, and requires the arborist's certification number in this bid.

E. **Inspections:** The University is called at phone number: (_____) _____ before 8:30 a.m. on mornings of each working day and told exact location of that day's work. The University inspects work at its discretion and is requested by letter, five days in advance of the completion of this contract, to provide a final inspection.

F. **Tree Damage:** Climbing irons, spurs, or spikes are not used on trees to be pruned. Any tree damage caused by contractor is repaired immediately at no additional expense to the satisfaction of the University Administrator. Trees damaged beyond repair, as judged by the University Administrator, are removed at no expense to the University and replaced by a tree of size and species designated by the University Administrator at no additional expense to the University or the dollar value of such damaged trees, as determined by the University Administrator, is deducted from the monies owed the Contractor.

G: **Pruning Specifications:** Conforms to latest revision of standards of National Arborist Association, ANSI A300. All cuts shall be made as close as possible to the trunk or parent limb, without cutting into the branch collar or leaving a protruding stub. Bark at the edge of all pruning cuts should remain firmly attached. All branches too large to support with one hand shall be precut to avoid splitting or tearing of the bark. Where necessary, ropes or other equipment should be used to lower large branches or stubs to the ground. Treatment of cuts and wounds with wound dressing or paints has not been shown to be effective in preventing or reducing decay and is not generally recommended for this reason. Wound dressing over infected wood may stimulate the decay process. If wounds are painted for cosmetic or other reasons, then material non-toxic to the cambium layer of meristematic tissue must be used.

Care must be taken to apply a thin coating of material only to exposed wood.

Old injuries are to be inspected. Those not closing properly and where the callus growth is not already completely established should be bark traced if the bark appears loose or damaged. Such tracing shall not penetrate the xylem (sapwood), and margins shall be kept rounded.

Equipment that will damage the bark and cambium layer should not be used on or in the trees. For example, the use of climbing spurs (hooks or irons) is not an acceptable work practice for pruning operations on live trees. Sharp tools shall be used so that clean cuts will be made at all times.

All cut limbs shall be removed from the crown upon completion of the pruning. Clean-up of branches, logs, or any other debris resulting from any tree pruning shall be promptly and properly accomplished. The work area shall be kept safe at all times until the clean-up operation is completed. Under no condition shall the accumulation of brush, branches, logs, or other debris be allowed upon a public property in such a manner as to result in a public hazard.

Trees impeding vehicle or pedestrian traffic should be raised up at least 4.3 meters over streets and 2.7 meters over sidewalks. Trees obstructing control devices (stop signs, yield signs, and traffic lights) should be trimmed to allow for adequate visibility.

H. **Removal Specifications:** Removals will include topping and other operations necessary to safely remove the assigned trees. No trees or trunks are felled onto pavement. Work includes removal of basal sprout and brush and weeds within one meter of the trunk. The tree stump will be ground out to a depth of fifteen (15) centimeters below the normal surface level including all surface roots. Immediately after grinding each stump, the grindings must be removed from the work area. Adjacent sidewalks, lawns, streets, and gutters will be cleaned. Backfill consisting of clean earthen soil should be used to fill the cavity, free of debris, to normal ground level and seeded with an approved seeding mix. Do not backfill with wood chips. All labor, supervision, equipment, materials, and supplies necessary for the execution of this work must be provided for by the contractor at no additional cost to the University. All debris disposal must be provided by the contractor at no additional cost to the University. The chosen contractor will be required to follow the ANSI Z-133 Standards for tree worker safety. If a contractor is not aware of these standards, copies can be provided by the University of Windsor.

I. **Traffic Control:** Is total responsibility of Contractor and is coordinated with the proper department of the University of Windsor.

The contractor shall be solely responsible for pedestrian and vehicular safety and control within the work site and shall provide the necessary warning devices, barricades, and personnel needed to give safety, protection, and warning to persons and vehicular traffic within the area.

Blocking of public streets shall not be permitted unless prior arrangements have been made with the University and is coordinated with the appropriate departments. Traffic control is the responsibility of the Contractor and shall be accomplished in conformance with Provincial, County, and Local highway construction codes.

J. **Utility Agencies:** Are contacted by Contractor any time assistance is needed to work safely around overhead or underground installations. The University provides a list of principal contacts and telephone numbers for public and private utility organizations.

Tree trimming and removal operations may be conducted in areas where overhead electric, telephone, and cable television facilities exist. The Contractor shall protect all utilities from damage, shall immediately contact the appropriate utility if damage should occur, and shall be responsible for all claims for damage due to his operations.

The Contractor shall make arrangements with the utility for removal of all necessary limbs and branches that may conflict with or create a personal injury hazard in conducting the operations of this contract. If the Contractor has properly contacted the utility in sufficient time to arrange for the required work by the utility, delays encountered by the Contractor in waiting for the utility to complete its work will not be the responsibility of the Contractor.

K. **Safety:** Work conforms to the latest revision of American National Standards Institute Standard Z-133.1 (Safety Requirement for Pruning, Trimming, Repairing, Maintaining, Removing Trees, and for Cutting Brush).

At the time a contract is entered into, the Contractor shall certify in writing to the University that all Contractor's employees working on this job are either 'Qualified Line Clearance Tree Trimmers' or 'Qualified Line Clearance Tree Trimmer Trainees', as defined in the above ANSI Z-133.1 Standards.

L. **Clean-Up:** Clean-up procedures are completed within two hours after debris have been placed around the site of each tree requiring pruning or removal. The work site is left equal to or cleaner than pre-work conditions. Tree parts dropped or lowered from trees are kept off private property.

It shall be the responsibility of the Contractor to remove and dispose in a proper and acceptable manner all logs, brush, and debris resulting from the tree maintenance operations. Wood may be left for residents, but that not taken must be disposed.

M. **Damages:** Done by the Contractor to any person or property, public or private, are the total responsibility of the Contractor and are repaired or compensated for by the Contractor to the satisfaction of both injured party and the University at no cost to the University.

N. **Insurance:** Contractor shall be fully insured as specified and shall be completely covered by Provincial Workers' Compensation during the life of this contract. The Contractor shall have liability insurance in the amount of $1,000,000.00 for each occurrence and shall name the University as an additional insured on its policy for the work being performed in the University of Windsor.

O. **Payments:** Partial billings are acceptable, but not more frequently than every two weeks. Payment is made according to actual number of stumps removed. Ten percent (10%) of each invoice is withheld until Contractor's work is completed to the satisfaction of the University. Billing for work along any street may not be made until Contractor completes all work on that street. At the discretion of the University, one-half of the ten percent (10%) retainer may be held until spring if enough snow is on the ground that a proper inspection of sites cannot be conducted. When an inspection is done and the Contractor, as directed by the University, corrects any problem that may occur, the remainder of the retainer will be paid.

P. **Working Hours:** The Contractor will schedule work between the hours of 7:00 a.m. and 6:00 p.m. Monday through Friday unless authorized by the University to do otherwise.

Q. **Subcontracts:** The Contractor will not be allowed to subcontract work under this contract unless written approval is granted by the University. The Subcontractor, as approved, shall be bound by the conditions of the contract between the University and the Contractor. The authorization of a Subcontractor is to perform in accordance with all terms of the contract and specifications. All directions given to the Subcontractor in the field shall bind the Contractors as if the notice had been given directly to the Contractor.

R. **Execution of Contract:** The successful Bidder shall, within five (5) calendar days of the mailing of written notice of selection as the successful bidder, enter into contract with the University on forms included within the bidding documents for the performance of work awarded him and shall simultaneously provide the appropriate bonds, indemnities, and insurance required hereunder.

The contract, when executed, shall be deemed to include the entire agreement between the parties; the Contractor shall not base any claim for modification of the contract upon any prior representation or promises made by representatives of the University, or other persons.

S. **Discontinuance of Work:** Any practice obviously hazardous as determined by the University shall be immediately discontinued by the Contractor upon receipt of either written or oral notice to discontinue such practice.

T. **Observance of Laws, Ordinances, and Regulations:** The Contractor, at all times during the term of this contract, shall observe and abide by all Federal, Provincial, and Local laws which in any way affect the conduct of the work and shall comply with all decrees and orders of courts and competent jurisdiction. The Contractor shall comply fully and completely with any and all applicable Provincial and Federal Statutes, rules, and regulations as they relate to hiring, wages, and other applicable conditions of employment.

U. **Supervision:** This contract will be under the direct supervision of the University or its authorized representatives. Any alteration or modifications of the work performed under this contract shall be made only in written agreement between the Contractor and the University-authorized representative and shall be made prior to commencement of the altered or modified work. No claims for extra work or materials shall be allowed unless covered by written agreement.

V. **Bidding Specification and Contractual Terms:** Tree maintenance work done under the direction of this contract shall be bid on forms as provided by the University.

W. **References:** Municipal tree pruning and removal experience is required. The bidder will provide a list of municipal governments that it has serviced in the past five years with a contact person listed.

X. **Award:** For a bid to be considered, prices must be quoted for the entire pruning and removal project.

Y. **Contract Termination:** The University shall have the right to terminate a contract or a part thereof before the work is completed in the event:

i. Previous unknown circumstances arise making it desirable in the public interest to void the contract;

ii. The Contractor is not adequately complying with the specifications;

iii. Proper arboricultural techniques are not being followed after warning notification by the University or its authorized representatives;

iv. The Contractor refuses, neglects, or fails to supply properly trained or skilled supervisory personnel and/or workers or proper equipment of the specified quality and quantity;

v. The Contractor in the judgment of the University is unnecessarily or willfully delaying the performance and completion of the work;

vi. The Contractor refuses to proceed with work when as directed by the University; or

vii. The Contractor abandons the work.

Z. **Indemnification:** I, the Contractor, agree to indemnify, hold harmless, and defend the University from and against any and all loss, damage, or expense which the University may suffer or for which the University may be liable by reason of any injury (including death) or damage to any property arising out of negligence on the part of the Contractor in the execution of the work to be performed hereunder.

This indemnity provision shall not apply in cases where the Contractor has not been provided with timely notice, nor shall the Contractor be liable to the University for any settlement of any complaint affected without the prior written consent of the Contractor. This indemnity provision also specifically does not apply to loss, damage, or expense arising out of contact with the University's trees by persons (other than employees of the Contractor engaged in the work contemplated by this agreement) who are around such trees.

# STUMP REMOVAL SPECIFICATIONS FOR DEPARTMENT OF PUBLIC SERVICE UNIVERSITY OF WINDSOR

## Scope of Work

To provide all labor, supervision, equipment, services, and expertise necessary for grinding of stumps, disposal of grindings and debris, and backfilling of stump holes in the University of Windsor as specified herein. Since the work is potentially dangerous, and requires special expertise, it is to be performed by a Contractor that derives a majority of its annual income from arboricultural work and whose employees are highly trained and skilled in all phases of tree service work. Contractors must have been in business for at least five years. The University may require proof of the Contractor's involvement in tree service work.

The Contractor has the responsibility to:

A. Reserve work space along streets;

B. Grind out designated stumps;

C. Remove excess material and clean up the work site;

D. Guarantee the specifications will be met; and

E. Keep work site safe at all times.

All bidders must have in their possession or available to them by formal agreement at the time of bidding: trucks, stump grinders, hand tools, and other equipment and supplies that are necessary to perform the work as outlined in these specifications.

## Location

Work is limited to stumps located on all public rights-of-way and University-owned property. All work under this contract shall be assigned by supplying the Contractor with a list of stumps that have been marked with the diameter of the stump.

The University reserves the right to change, add, or delete areas or quantities of stumps to be removed as it deems necessary. Stumping operations will commence no later than five (5) days after the contract has been awarded and will be completed no later than _____.

## Supervision

Contractor consults with the University concerning details of scheduling of all work. Contractor has a competent person in charge of his work at all times to whom the University may issue directives and who shall accept and act upon such directives, and who reads, speaks, and writes English competently.

Failure for the supervisor to act on said directives shall be sufficient cause to give notice that the Contractor is in default of contract unless such directives would create potential personal injury of safety hazards. The University requires a Certified Arborist on the job site, and requires the arborist's certification number in this bid.

# I. Inspections

The University is called at phone number: (_____) _____ before 8:30 a.m. on mornings of each working day and told exact location of that day's work. The University inspects work at its discretion and is requested by letter, five days in advance of the completion of this contract, to provide a final inspection.

# II. Stump Grinding

The tree stumps will be ground out to a depth of fifteen (15) centimeters below the normal surface level including all surface roots. Immediately after grinding each stump, the grindings must be removed from the work area. Adjacent sidewalks, lawns, streets, and gutters will be cleaned. Holes are not to be left open overnight. Backfill consisting of clean earthen soil should be used to fill in the cavity, free of debris, to ten (10) centimeters above the existing lawn grade surrounding the stump site (to allow for settling) and seeded with an approved seeding mix. Do not backfill with wood chips.

All labor, supervision, equipment, material, and supplies necessary for the execution of the work must be provided for by the Contractor at no additional cost to the University. All debris disposal must be provided by the Contractor at no additional cost to the University.

The chosen Contractor will be required to follow the ANSI Z-133 Standards for tree worker safety. If a Contractor is not aware of these standards, copies can be provided by the University of Windsor.

# III. Traffic Control

Is total responsibility of Contractor and is coordinated with the proper department of the University of Windsor.

The Contractor shall be solely responsible for pedestrian and vehicular safety and control within the work site and shall provide the necessary warning devices, barricades, and personnel needed to give safety, protection, and warning to persons and vehicular traffic within the area.

Blocking of public streets shall not be permitted unless prior arrangements have been made with the University and is coordinated with the appropriate departments. Traffic control is the responsibility of the Contractor and shall be accomplished in conformance with Provincial, County, and Local highway construction codes.

# IV. Utility Agencies

Are contacted by Contractor any time assistance is needed to work safely around overhead or underground installations. The University provides list of principal contacts and telephone numbers for public and private utility organizations.

The Contractor shall protect all utilities from damage, shall immediately contact the appropriate utility if damage should occur, and shall be responsible for all claims for damage due to his operations. It is left to the Contractor's discretion to notify the appropriate utility authority before stump removal begins. If the Contractor has properly contacted the utility in sufficient time to arrange for the required work by the utility, delays encountered by the Contractor in waiting for the utility to complete its work will not be the responsibility of the Contractor.

# V. Damages

Done by the Contractor to any person or property, public or private, are the total responsibility of the Contractor and are repaired or compensated for by the Contractor to the satisfaction of both injured party and the University at no cost to the University.

## VI. Insurance

Contractor shall be fully insured as specified and shall be completely covered by Provincial Workers' Compensation during the life of this contract. The Contractor shall have liability insurance in the amount of $_____ for each occurrence and shall name the University as an additional insured on its policy for the work being performed in the University of Windsor.

## VII. Payments

Partial billings are acceptable, not more frequently than every two weeks. Payment is made according to actual number of stumps removed. Ten percent (10%) of each invoice is withheld until Contractor's work is completed to the satisfaction of the University. Billing for work along any street may not be made until Contractor completes all work on that street. At the discretion of the University, one-half of the ten percent (10%) retainer may be held until spring if enough snow is on the ground that a proper inspection of sites cannot be conducted. When an inspection is done and the Contractor, as directed by the University, corrects any problem that may occur, the remainder of the retainer will be paid.

## VIII. Working Hours

The Contractor will schedule work between the hours of 7:00 a.m. and 6:00 p.m. Monday through Friday unless authorized by the University to do otherwise.

## IX. Subcontracts

The Contractor will not be allowed to subcontract work under this contract unless written approval is granted by the University. The Subcontractor, as approved, shall be bound by the conditions of the contract between the University and the Contractor. The authorization of a Subcontractor is to perform in accordance with all terms of the contract and specifications. All directions given to the Subcontractor in the field shall bind the Contractors as if the notice had been given directly to the Contractor.

## X. Execution of Contract

The successful Bidder shall, within five (5) calendar days of the mailing of written notice of selection as the successful bidder, enter into contract with the University on forms included within the bidding documents for the performance of work awarded him and shall simultaneously provide the appropriate bonds, indemnities, and insurance required hereunder. The contract, when executed, shall be deemed to include the entire agreement between the parties; the Contractor shall not base any claim for modification of the contract upon any prior representation or promises made by representatives of the University, or other persons.

## XI. Discontinuance of Work

Any practice obviously hazardous as determined by the University shall be immediately discontinued by the Contractor upon receipt of either written or oral notice to discontinue such practice.

## XII. Observance of Laws, Ordinances, and Regulations

The Contractor, at all times during the term of this contract, shall observe and abide by all Federal, Provincial, and Local laws which in any way affect the conduct of the work and shall comply with all decrees and orders of courts and competent jurisdiction. The Contractor shall comply fully and completely with any and all applicable Provincial and Federal Statutes, rules, and regulations as they relate to hiring, wages, and other applicable conditions of employment.

## XIII. Supervision

This contract will be under the direct supervision of the University or its authorized representatives. Any alteration or modifications of the work performed under this contract shall be made only in written agreement between the Contractor and the University-authorized representative and shall be made prior to commencement of the altered or modified work. No claims for extra work or materials shall be allowed unless covered by written agreement.

## XIV. Bidding Specification and Contractual Terms

Stump work done under the direction of this contract shall be bid on forms as provided by the University.

## XV. Award

For a bid to be considered, prices must be quoted for the entire stump removal project.

## XVI. Contract Termination

The University shall have the right to terminate a contract or a part thereof before the work is completed in the event:

A. Previous unknown circumstances arise making it desirable in the public interest to void the contract;

B. The Contractor is not adequately complying with the specifications;

C. Proper arboricultural techniques are not being followed after warning notification by the University or its authorized representatives;

D. The Contractor refuses, neglects, or fails to supply properly trained or skilled supervisory personnel and/or workers or proper equipment of the specified quality and quantity;

E. The Contractor in the judgment of the University is unnecessarily or willfully delaying the performance and completion of the work;

F. The Contractor refuses to proceed with work when as directed by the University; or

G. The Contractor abandons the work.

## XVII. Indemnification

I, the Contractor, agree to indemnify, hold harmless, and defend the University from and against any and all loss, damage, or expense which the University may suffer or for which the University may be liable by reason of any injury (including death) or damage to any property arising out of negligence on the part of the Contractor in the execution of the work to be performed hereunder.

This indemnity provision shall not apply in cases where the Contractor has not been provided with timely notice, nor shall the Contractor be liable to the University for any settlement of any complaint affected without the prior written consent of the Contractor. This indemnity provision also specifically does not apply to loss, damage, or expense arising out of contact with the University's stumps by persons (other than employees of the Contractor engaged in the work contemplated by this agreement) who are around such stumps.

# UNIVERSITY WIDE STREET TREE FERTILIZATION SPECIFICATIONS

# UNIVERSITY OF WINDSOR

## I. Scope of Work

To provide all supervision, material, labor, equipment, service operations, and expertise required to fertilize street trees in the University of Windsor as specified herein. Contractor has responsibility to:

A) Furnish, transport, and apply water-soluble fertilizer;

B) Reserve work space along streets;

C) Use hydraulic sprayer and soil probe or lance at 100-200 PSI;

D) Remove excess material and clean up site;

E) Keep work site safe at all times; and

F) Any work incidental to above.

## II. Material Specifications

**Section A: Types of Fertilizer to be Used**

1. Inorganic Fertilizer (Chemical) - Is that derived from chemical sources. These nutrients are readily available in the soil and are rapidly soluble, with a short residual period.
2. Soluble Fertilizer - Is mixed with water and applied in liquid form. Soluble fertilizers may be applied via the deep root feeding method. Soluble fertilizers are usually inorganic and readily available. Materials with a limited solubility that dissolve slowly are often listed on fertilizer labels as water-insoluble nitrogen (WIN).

**Section B: Fertilizer Analysis**

1. Established Plantings - use fertilizers with N-P-K ratios of 3-1-2 or 3-1-1 for best response. These formulations may have slight variations.
2. Inorganic (water-soluble) nitrogen should be supplemented with synthetic or organic nitrogen (WIN) for the slow availability characteristics of the insoluble form of the material.

**Section C: Rates of Application**

1. For optimum plant growth, apply 2-3 kilograms of actual nitrogen per 93 square meters every two years.
2. Diameter at Breast Height (DBH) - Measure the trunk diameter at 1.5 meters above grade. Generally for optimum growth, apply 100 grams actual nitrogen per 2.5 centimeters DBH to trees under 15 centimeters in diameter. The rate can be increased to 200 grams. N per 2.5 centimeters DBH for most trees of 15 centimeters DBH. The majority of the trees to be fertilized in this project will be 5- to 10 centimeters DBH. Using a 7.5 centimeters DBH tree and fertilizing with 100 grams actual N per 2.5 centimeters DBH would require 2 kilograms of an 18-5-11 complete fertilizer:

   8 centimeters (dia) x 100 grams/2.5 centimeters (rate) = 0.34 kilograms (amount of N).

   0.34 kilograms (amount of N) / 0.18 (%N in 18-5-11) = 1.89 kilograms of 18-5-11.

3. Liquid application - Diluted fertilizer solutions should be applied at the rate recommended by the manufacturer according to operating pressure and flow rate of the equipment to be used. Apply sufficient liquid mixture to supply the required rate of fertilizer as determined by the surface area of DBH method. It is suggested that one apply 568 liters to each 186 square meters of surface area. Inject approximately 1.89 liters of fertilizer solution per injection at 0.8 meter spacings.

## Section D: Timing of Fertilizer Applications

Early spring before budbreak is the recommended time for fertilizing. Fertilizing should not be done after leaves have fully expanded.

## Section E: Method of Fertilizer Application

Liquid Injection - Injections using a soil probe or lance should be 0.8 meters apart, and 15-31 centimeters deep for trees. Begin lance injection 0.6-1.0 meters from the tree trunk and work out about 2.7 meters beyond the trunk or to the sidewalk or other hardscape obstacle, whichever is farthest. Use a hydraulic sprayer at 100-200 pounds.pressure and soil lance designed for liquid fertilizer with a manual shut-off valve and three or four horizontal discharge holes at 90 degrees in its point. Inject 1.89 liters of fertilizer solution into each hole. The addition of water to dry soil as occurs during the liquid injection process is an excellent side-benefit.

## Section F: Additional Guidelines

1. Undesirable tree species that could be found on tree lawns or on public rights-of-way should not be fertilized. These are: silver maple, boxelder, alder, birch, catalpa, redbud, Russian-olive, osage-orange, apple, mulberry, poplar, cottonwood, cherry plum, black cherry, black locust, sassafras, willow, and elm.
2. Be aware that overfertilizing small trees such as flowering crabapple can result in excessive succulent growth. Succulent growth is more prone to fireblight symptoms on susceptible plants such as pear, crabapple, and mountain ash.
3. Fertilize in moist soils - Fertilizer should always be applied in moist soils to enhance fertilizer uptake and reduce fertilizer injury to plants and aid in soil injection treatment. If soils are not moist, irrigation should precede fertilization to moisten the plant root zone area. The liquid injection method of fertilizing trees will help moisten the soil in the root zone while applying desired nutrients.
4. Fertilizing Excessively Wet Soils - Avoid fertilizing trees growing in soil that is excessively wet. The roots in wet soil are often damaged from lack of oxygen caused by the accumulation of toxic gases. Adding fertilizer in any form may contribute to root injury.
5. Read the Label - Read the entire label of any fertilizer product before application and apply per label recommendations.

# Appendix J
# Tree Preservation Guidelines and Sample Tree Ordinance

# SAMPLE TREE PRESERVATION ORDINANCE



## 1.0 Intent

The City of _____ finds that:

- _____ has an abundance of trees that have benefited its citizens for many years, providing protection, cool shade, food, and rest;
- _____'s trees have played an important role in the quality of life and the economic value of homes and property in the City;
- _____'s trees have acted as purifying systems for the air, and their roots have held the soil to minimize erosion and flooding;
- _____'s trees have been an invaluable physical and psychological counter-balance to the urban setting, making life more comfortable by providing shade and cooling the air, reducing noise level and glare, and providing an essential counter-point to man's impact on the land;
- As the population of the City has expanded, so have the needs for housing and services. To meet those needs, development has occurred, but sometimes those needs have been met at very great expense to the City's natural environment;
- The City's trees, which have been so invaluable, are easily damaged and destroyed during the activities associated with development, even when these trees are not in the direct way of said development;
- While homeowners commonly preserve, plant, and replace their trees, the process of development itself has often resulted in the clearing or inadvertent damage to trees and shrubs on large tracts of land, that results in a net loss of trees to the City;
- The intent of this ordinance is to ensure the protection of the maximum number of City trees possible and to preserve and perpetuate these natural assets for future generations.

## 1.1 Purpose

City of _____ finds that the interests of the public health, safety, and welfare of its citizens require the establishment of standards limiting the destruction of and ensuring the survival of as many trees as possible in the City and the replacement of trees sufficient to promote the value of property and the quality of life of its citizens; to safeguard the ecosystem necessary to ensure the stabilization of soil by the prevention of erosion and sedimentation; to reduce stormwater run-off and the costs associated therewith; to replenish groundwater supplies; to prevent the destruction of carbon dioxide and to replenish oxygen in the atmosphere; and to provide greenbelts and buffers to screen against noise pollution, artificial light, and glare.

Toward those ends, and for the benefit of all of the citizens of _____, it is intended that this ordinance will prohibit the unnecessary clearing of trees and to provide for the reforestation of cleared land so as to achieve no net loss of trees and to preserve, as much as possible, the existing tree composition.

## 2.0 Definitions

1. Basal area (BA) is the cross-sectional area at breast height (4.5 feet), usually expressed in square inches or square feet of all of the trees in the stand.
2. Diameter breast height (dbh) is the diameter of any tree, 4.5 feet above the natural ground line. Wherever the word diameter is used in this ordinance, it shall be taken to mean dbh, unless otherwise specified. The related term, circumference, is the diameter multiplied by 3.1416 (π), and is also a measurement around the tree at the 4.5 feet standard.
3. Dripline is the outside diameter of a tree crown.
4. Historic Tree is a tree which has been found by the City to be of notable historic interest to the City based on its age, species, size, or historic association with the City.
5. Official Master Tree Protection Map is a map identifying tree protection areas, specimen trees, and historic trees, and shall mean those official maps on file with the City.
6. Person is any public or private individual, group, company, firm, corporation, partnership, association, society, or other combination of human beings whether legal or natural.
7. Protected Tree is any tree growing within tree protection areas.
8. Shrub is any woody plant of low height with several stems.
9. Specimen Tree is a tree determined by the City to be of high value to the community because of its type, size, age, or other significant tree characteristic.
10. Urban Forester(s) is the individual, or individuals, responsible for administering and enforcing this ordinance.
11. City Tree Board is the board responsible for overseeing this ordinance.
12. Tree is a woody plant having at least one well-defined stem and a more or less definitely formed crown, usually attaining a height of at least eight feet.
13. Tree Destruction Permit is the permit which must be obtained before any tree may be removed, as specified in this ordinance.
14. Tree Protection Area is any undeveloped area which contains a significant number of trees, and which should have an on-site inspection by the Urban Forester before any tree destruction permit is issued for that area, notwithstanding any exemptions which otherwise apply. Such areas are identified on the Official Master Tree Protection Map.

## 3.0 Tree Destruction Permit

It shall be unlawful to cut or remove or otherwise cause the death of any tree having a dbh of over eight (8) inches, except as otherwise provided by the City Tree Board, pursuant to Section _____, in _____, as covered in this ordinance, without first having obtained a permit, except as otherwise herein provided. It shall be unlawful to remove any tree from a Tree Protection Area without having first obtained a Tree Destruction Permit. Certain trees, designated as specimen or historic trees, because of their size, age, rarity, historic, or ecological value, shall be protected from cutting or destruction regardless of their location within the City.

## 3.1 Exceptions

The requirement of a permit in the above section is modified in the following situations:

3.1.1 Homeowners shall not be required to obtain a permit to cut a tree from the parcel of land upon which they reside, unless that parcel exceeds 100,000 square feet or unless the tree is identified as a specimen or historic tree pursuant to the terms of this ordinance.

3.1.2 This ordinance is not intended to regulate commercial nurseries, Christmas tree farms, orchards, horticultural operations, or the destruction of dead trees or the destruction of a tree that has become, or threatens to become, an immediate danger to human life or property. This exception shall not be construed to include the harvesting of lumber.

3.1.3 Cutting down, killing, or otherwise destroying trees by state or county agencies, public service companies, and natural gas companies performing normal construction and maintenance pursuant to applicable state or federal safety construction laws and regulations, do not fall within the purview of this ordinance.

## 4.0 Enforcement Authority

The City Forester shall have the responsibility to identify and designate tree protection areas, specimen and historic trees, issue tree destruction permits, and supervise all work performed under any permit issued pursuant to this ordinance.

4.1 Any person residing in the City may request that the City Forester examine any tree to determine if that tree should be protected as a specimen or historic tree.

4.2 The City Forester shall survey the City for specimen, historic, and other important trees. Upon identifying a specimen or historic tree, the City Forester shall place a notice in the land records of property upon which any such tree is located, stating that such tree is protected by the provisions of this ordinance. Such notice shall also be added to the City official Tree Protection Map. When a tree destruction permit application is received, the Forester shall make an on-site inspection, if necessary, to ascertain the presence or absence of such protected trees.

4.3 The City Forester shall consult with the applicant for a tree destruction permit so as to ensure the survival of any trees not removed from the site.

4.4 The City Forester may make reasonable entry upon any lands within the City for the purpose of making any investigation, survey, or study contemplated by this ordinance.

4.5 The City Forester shall make all approvals or denials of tree destruction permits and all designations of specimen or historic tree status in writing.

4.6 The City Forester shall prepare the Official Master Tree Protection Map.

4.7 The City Forester shall coordinate with the entities identified in 3.1.3 of this ordinance so as to meet the purposes of this ordinance.

## 5.0 City Tree Board

There is hereby created a City Tree Board, consisting of no less than five individuals, to oversee the activities of this ordinance and to serve in an advisory role to the City Forester in setting policy guidelines for enforcement of this ordinance. They shall be residents of the City, no less than 18 years of age, and shall be individuals who are actively interested in the improvement of the natural environment of _____. Their terms shall be for ____ years, following usual procedures for new boards.

5.1 The City Tree Board shall have the authority to change the minimum size requirement for a tree destruction permit for some species of trees, when appropriate.

## 6.0 Application for Tree Destruction Permits

A tree destruction permit shall be obtained for the destruction of any tree protected by this ordinance by submitting a written application to the City Forester, together with such filing fee as shall be set by the Board of Trustees. The application shall be a sworn statement which shall include the applicant's name and address; the consent of the owner of the land upon which the trees are located; the location of the property upon which the trees to be removed are located; and tree size, age, and species, if known, of the trees to be removed.

6.1 If the application for tree destruction involves more than three trees, or if the property whereon the trees are located has been the subject of three previous tree destructions during the year preceding the current application, or if the tree to be removed is in a tree protection area, the application shall additionally contain the following information: a diagram of the 100-foot radius surrounding each tree to be removed, or a diagram to the property line, whichever is closer, that indicates the location of trees to be removed; and the locations of surrounding trees within that radius, together with their diameter and a tree restoration plan that meets the requirements of Section 9.0.

6.2 In addition to the previous permit requirements, if the proposed destruction is pursuant to construction or on-site improvements such as roads or utilities, in order to provide the City Forester enough information to evaluate the applicant’s proposed restoration plan, and to also allow the City Forester to make recommendations that would facilitate the preservation of on-site trees, the applicant must also provide: the location of all diseased or damaged trees; the location of any trees interfering with any roadway, pavement, or utility line; any proposed grade changes; all trees to be removed identified on the site for the Forester's inspection; and a plan showing location of future buildings and improvements.

## 7.0 Approval of the Tree Destruction Permit

Upon receipt of an application for the destruction of more than three trees, or upon the receipt of an application for any tree destruction in a Tree Protection Area, the City Forester shall visit and inspect the site and shall approve the destruction permit for those trees that meet the following criteria: the destruction of the tree or trees is necessary to allow reasonable use of the property; the destruction of the trees will not adversely affect soil erosion, soil moisture retention, flow of surface waters, and the destruction of the trees is not inconsistent with the master drainage plan of the City; the trees to be removed are not specimen or historic trees as defined in this ordinance; and the applicant's tree restoration plan is adequate, pursuant to the standards described in Section 9.0.

7.1 The City Forester shall review the application for tree destruction to confirm that all the trees that will be destroyed are, in fact, included in the plan.

7.2 For purposes of this ordinance, it shall be presumed that trees within fifteen (15) feet of buildings and improvements will be irreparably damaged.

7.3 No tree destruction permit shall be valid for a period longer than one (1) year.

## 8.0 Appeal Procedures

Any person may appeal in writing, within 14 days, the City Forester's written decision approving or denying a tree destruction permit, or approving or denying specimen or historic tree status to the City Tree Board.

8.1 Any person may appeal any decision of the City Tree Board to the Board of Trustees in writing within 14 days.

## 9.0 Tree Restoration Plan and Mitigation Standards

The restoration plan shall provide for the preservation or the restoration of a minimum of 75% of the original basal area of all of the trees in the stand, except as otherwise allowed in this ordinance's mitigation sections.

9.1 If the tree restoration plan calls for the replacement of trees, the trees should be replaced in kind, if feasible. If not, the replacement trees will be selected from an approved list of preferred trees prepared by the City Forester and posted in a prominent place in the City and also provided to the applicant at the time of original application.

9.2 The applicant may, as mitigation to the restoration plan requirements, deposit with the City Tree Board, a cash payment in lieu of the preservation of some or all of the trees on the site necessary to meet the basal area requirements. Such deposit shall be placed in a fund to be established by the City Tree Board. Such fund shall be used only for tree planting and maintenance projects within the City that have been approved by the City Tree Board. The City Tree Board shall determine the amount of the deposit based upon the value of the trees removed from the applicant’s property, including replacement cost, using procedures established by the International Society of Arboriculture.

9.3 Any of the aforementioned alternatives may be utilized in combination as deemed appropriate by the City Tree Board.

## 10.0 Timeliness

Before a preliminary plat plan, application for a special use permit, grading permit, or a building permit may be approved by the City, the site must be inspected by the City Forester to determine if a tree destruction permit is necessary and to determine if specimen and historic trees are present on the site.

## 11.0 Tree Protection During Development

During any building, renovating, or razing operations on any site which has been the subject of an approved tree restoration plan, the builder must erect and maintain suitable protective barriers around all trees, so as to prevent damage to said trees and so as to prevent a change in grade within the dripline of the tree.

11.1 Protective posts of nominal 2 inches by 4 inches or larger, or equivalent, shall be implanted deep enough in the ground to be stable, with at least 3 feet of post visible above ground, and linked together by approved fencing or other approved material and shall be clearly flagged with bright plastic tape so as to be readily visible.

11.2 The protective barrier described in 11.1 shall be established at a distance from the trunk of the protected tree to be at least 6 inches for each 1 inch of trunk diameter at 4.5 feet above natural grade line, or at minimum of two-thirds (2/3) of the distance to the dripline, whichever is greater.

11.3 The City Forester or the Tree Board may from time to time provide further protective standards or instructions so as to increase the likelihood of protected tree survival after development.

## 12.0 Bonding Procedure and Re-inspection Process

The City Forester has the authority, subject to appeal in writing within 14 days by the applicant to the Township Board of Trustees, to require the applicant to post a bond sufficient to guarantee the survival of specimen and historic trees and the completion of the approved restoration plan. The bond shall not be discharged until the City Forester shall visit and inspect the site to determine compliance. The inspection shall take place one year after planting, thereby allowing the City Forester to confirm the survival of the trees.

## 13.0 Penalties

Any person who violates any of the provisions of this ordinance, or permits any such violation, or who fails to comply with any of the requirements hereof, or who uses any land in violation of any detailed statement or plan submitted by him and approved by the City Forester, shall be subject to punishment as provided by law. Each tree unlawfully removed or otherwise destroyed shall be a separate violation. Each violation shall be punished by a $500 fine, in addition to the value of the tree. The value of such tree(s) shall be determined using procedures established by the International Society of Arboriculture and in accordance with section 9.0 of this ordinance.

13.1 Any violation of this ordinance shall also constitute a public nuisance that may be enjoined and abated as provided by law.

13.2 No building permit, plat plan, grading permit, or special use permit shall be issued for any parcel of land that has been cleared of trees without meeting the requirements of this ordinance for a period of six years after the offense.

## 14.0 Severability

This ordinance is not a substitute for landscaping requirements which may be imposed pursuant to other sections of the City ordinances, although other landscaping requirements may be used to satisfy the requirements of an applicant's restoration plan. Should any part or provision of this ordinance be declared invalid by a court of competent jurisdiction, the same shall not affect the validity of the ordinance as a whole, or any part thereof, other than the part declared to be invalid.

## 15.0 Effective Date

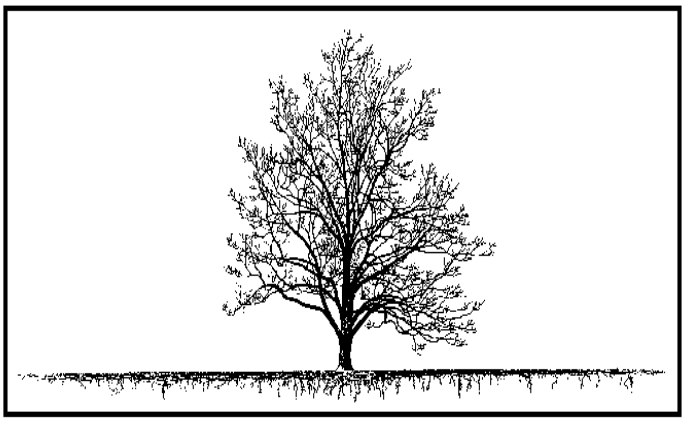
This ordinance is declared to be an emergency ordinance which is immediately necessary for the preservation of the public health, safety and general welfare, and is, therefore, made immediately effective.

# *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.

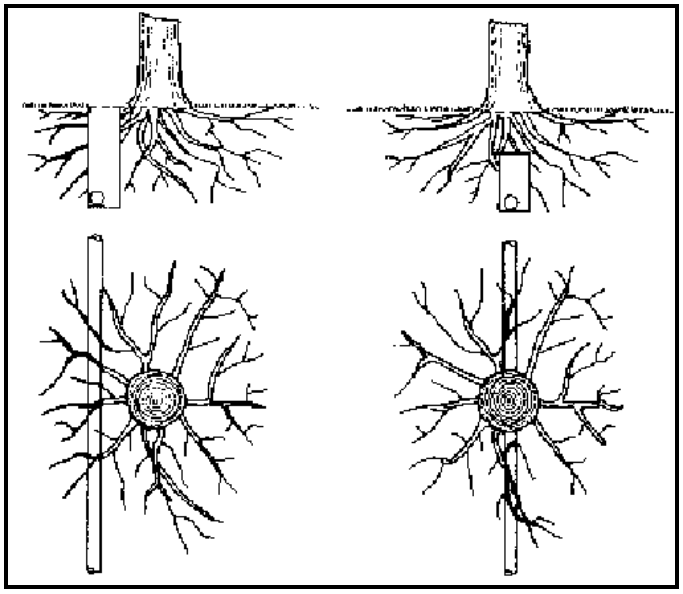
Scientists and arborists agree that the greatest percentage of tree roots are in the upper 31 to 46 centimeters of soil and extend well beyond the spread of the canopy. Trees are adversely affected both above and below ground by construction activities. To preserve trees during construction activities, 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.



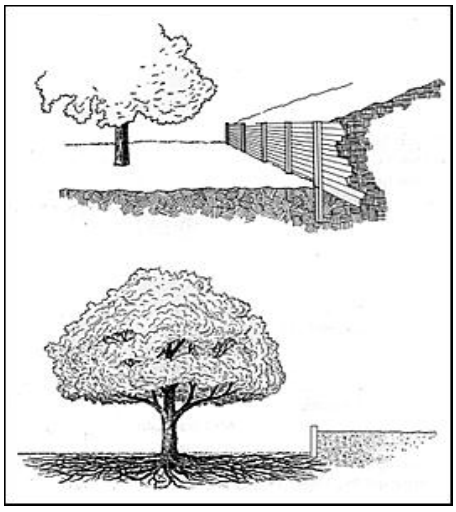
2. **<u>Soil Compaction</u>:** The most damaging effect of construction activity is soil compaction. Species tolerance to compaction varies, but most trees will suffer when the surrounding soil is compacted extensively.

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 (31 to 46 centimeters deep) or sturdy geotextile materials can be temporarily laid over the driving area to reduce compaction.

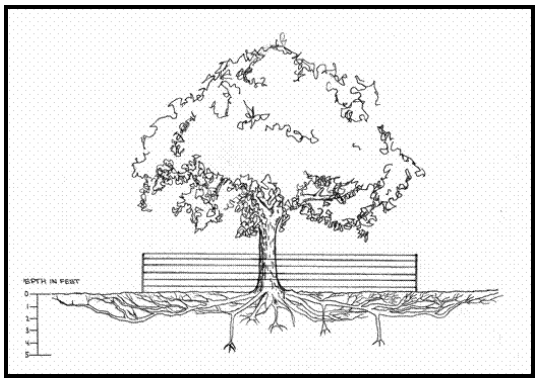
3. **<u>Soil Clearing and Grading</u>:**

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.

***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 5 centimeters 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 K
# Literature Cited

## *Literature Cited*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# Appendix L
# Davey® Technical Bulletins

TECHNICAL BULLETIN

DAVEY

Prepared by The Davey Institute

# GIRDLING ROOTS

The presence of girdling roots is a common landscape occurrence for some tree species, particularly Norway maple. Other species which have a tendency to develop girdling roots are: maples, American beech, elms, oaks, poplars, pines and certain littleleaf linden cultivars.

***SYMPTOMS:*** Indications of girdling roots include: reduced canopy growth, thin crown, leaf scorching, reduced leaf size, early fall coloration, and early defoliation on all or part of the crown. At ground level, the trunk may lack a root flare where it joins the buttress roots or appear strikingly flattened on one side, rather than as a normal cylinder (Figure 1). Girdling roots may be visible at the soil surface. If long established, they may be fused to the main trunk or other roots. A tree afflicted with girdling roots may also be more susceptible to disease, pests and other environmental stresses.

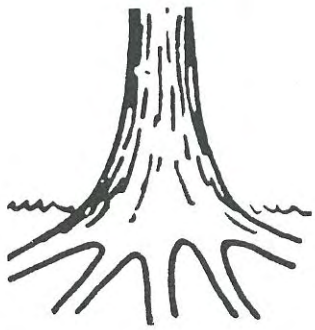

*Figure 1. Normal tree trunk with flare or buttress at soil line.*

***CAUSE:*** Girdling roots are roots which grow around another root or trunk, putting pressure on the root or trunk, thus "choking" and compressing the water and nutrient conductive tissues (Figure 2). Girdling roots generally occur around or against larger roots and around or against the trunk, below, at or slightly above ground level. Because the nutrients flowing downward do not reach the roots, the root system will become stunted. This can result in decline and subsequent death and creates a hazardous situation if there are structures or pedestrians in striking range of the falling tree.

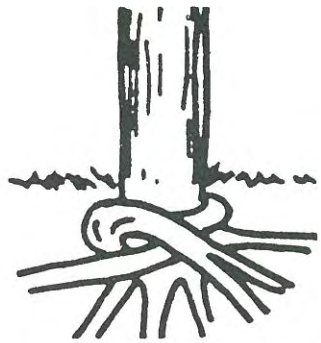

*Figure 2. Girdling root. Trunk may grow straight up.*

Girdling roots sometimes are initiated with container-grown (cans, pots) plants. Incorrect planting of bareroot stock can result in girdling roots or planting in soils where the difference between the soil of the root ball and the soil on-site are drastically different (Figure 3). It seems, however, that Norway maples will develop girdling roots regardless of cultural practices. Some experts believe that the most damaging girdling roots are those closest to the surface, in the first few inches of soil.

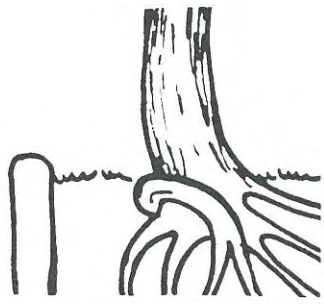

*Figure 3. Girdling root caused by obstruction such as curb, sidewalk, wall or compacted soil.*

***SOLUTION:*** Recommendations vary with respect to the value and practicality of removing girdling roots. The girdling roots may be supplying a significant part of the tree with nutrients and water, and the removal of that root may further stress the tree. If the root is large enough that its removal may affect the structural stability of the tree or the root may be fused to the girdled root or stem, then nothing should be done. If a girdling root can be seen at the surface, it may be considered for removal but should not be more than ¼ of the diameter of the trunk. Removal of girdling roots on young Norway maples was actually found to result in increased girdling roots in later years, indicating that there are limits to what can be done with girdling roots of some tree species. It requires extreme caution in removing roots, as more damage than good can be done. Have a Davey expert examine the tree since there are surgery options that can be suggested. Some situations may require removal of a few roots over a period of several years so that new roots can be regenerated. Crown thinning may be required to reduce wind resistance to compensate for root removal. Deep root fertilizing with a slow release nitrogen source is also recommended.

TECHNICAL BULLETIN DAVEY

Prepared by The Davey Institute

# HAZARDOUS TREES

### *Tree Risk*

No tree is absolutely safe. At times, even healthy trees fail. However, a tree is classified as high risk or potentially hazardous if any of these is true:

- It has a large defective part.
- The likelihood of that part failing is high.
- There is a target in proximity.

A target may be persons, pets or property (automobiles, homes, utility lines or other structures).

### *Tree Defects*

Defective parts include roots, trunks or larger branches (see Figure 1 on the reverse side).

- Defective roots may be the result of construction nearby that has severed the large roots or may be caused by internal decay due to rot fungi. Root rot can result in tree failure, even though little evidence is seen in the above-ground parts of the tree.
- Defective trunks may be due to large internal or external cavities, cracks or seams in the wood, v-shaped or narrow branch crotches, or internal decay due to rot fungi.
- Defective branches may be due to broken or dead branches, large internal or external cavities, insect and disease activity, narrow or v-shaped crotches, or internal decay due to rot fungi.

Risk of tree failure increases when defects are left untreated or if two or more defects occur together, as when v-shaped branch crotches also contain decay. Trees that have been topped and those damaged during home construction are highly prone to decline and become hazardous in time.

### *Other symptoms of tree weakness are:*

- Leaning of the tree, along with buckling and heaving up of the soil at the base of the tree on the side opposite the direction of the lean. This condition is caused by severed or decayed anchoring roots.
- An unbalanced or weak canopy with numerous staghorns (dead branches).
- Animals (birds, bats, bees) nesting in cavities within decayed trunks or branches.

### *Other Factors*

The examples listed in the sketch (Figure 1) are not exhaustive. The species of the tree in question, soil conditions, exposure of the tree to wind, overall tree health and other factors need careful evaluation, along with the tree's defects, to determine how hazardous a tree is.

### *Evaluation and Care*

Not all trees with defects need to be immediately removed. Some defects can be treated to prolong the life of the tree. In addition, not all hazards are visible or obvious. Advanced hazard tree analysis, either through the use of a tool such as the resistograph or through root crown excavation, may be necessary. Once a tree

has been documented as a hazardous tree, the owner of the tree may be responsible for any damage done by the tree. A certified Davey arborist should be consulted to evaluate the tree and determine the proper course of care and action.

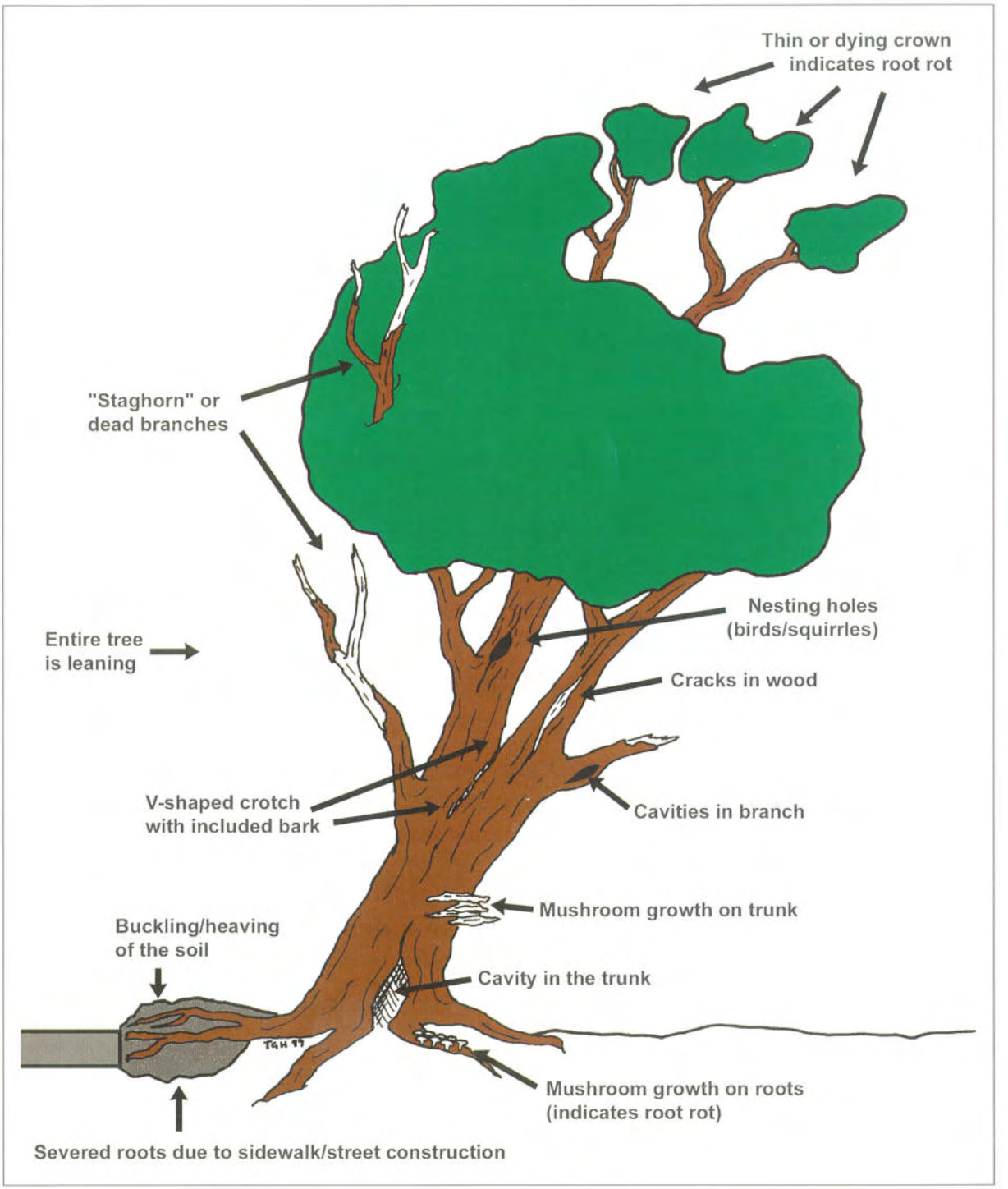


*Figure 1. Any of these defective parts of a tree can make it hazardous.*

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# TECHNICAL BULLETIN

DAVEY

Prepared by The Davey Institute

# HOW TO MINIMIZE STORM DAMAGE TO TREES

*Storm damage due to poor branch structure.*

*Top heavy – entire root system failure.*

Storm damage to trees can be caused by heavy, wet snow, freezing rain, lightning, or high winds. All of these put tremendous mechanical stresses on the leaves, branches, trunks, and root systems of trees on your property.

Proper tree maintenance can reduce the potential hazards that storms can cause to your safety, your property, and your trees. Proper pruning, cabling and bracing, a lightning protection system, proper tree selection, and cavity filling are all methods used by arborists to improve the chances of your trees to survive these storms.

***PROPER PRUNING:*** Thinning the tree canopy allows wind to blow through the crown, instead of against it as though it were a sail. Properly pruned trees offer less resistance to high winds and are less likely to suffer breakage or to blow down. The removal of potentially hazardous dead or weak branches is an important safety practice.

***CABLING AND BRACING:*** Strong metal cables and rods are used to relieve the strain that causes structurally weak trees to split and break in high winds, ice, and snow. Whether used in prevention or repair of structural damage to trees, cabling and bracing provides a support system to reduce the potential for fork splitting and branch breakage. Cabling and bracing your trees, along with thinning the crown, will reduce the chances of costly damage.

***LIGHTNING PROTECTION:*** Lightning strikes trees because they provide better conduction of the electrical charge than the surrounding air. Lightning can severely blow apart a tree or it may only produce a spiraling dead area on the trunk. The installation of a lightning protection system in your valuable trees will prevent this destruction by harmlessly conducting the electrical charge to the ground and bypassing the tree itself.

***TREE SELECTION:*** Certain tree species characteristically have weak wood and should not be considered for landscape situations. Although every tree has its place, quality landscapes should generally avoid weak-wooded trees such as silver maple, Siberian elm, willow, catalpa and poplar.

***CAVITY FILLING:*** An open cavity in a tree's trunk is a weak point in its structural support system. Think of such a tree as a tube with a hole in its wall. This kind of tube can't support as much weight as an intact tube.

A cavity filling does not actually provide structural support, but rather a flat surface for callus tissue to grow over. Eventually, the continuity of the tree trunk is re-established and the trunk is better able to support the weight of its canopy. Fertilization with Davey's Arbor Green® helps promote the callusing process. A tree with strong, healthy wood is more likely to survive a destructive storm.

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