Whittemore Park
Tree Inventory and Management Plan | 2018

Submitted by:
Bartlett Tree Experts

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MAKING THE MOST OF YOUR INVENTORY MANAGEMENT PLAN

Those who operate a large business or institution understand how inventory impacts operations and budgeting. One must know what's there, how much or how many, and where it all is. But the task doesn't end there. To obtain the greatest benefit from inventory, owners or their designees must manage it. Are a company's tools, for example, old and defective, in need of repair, in short supply, or useless and taking up space that could be better occupied? A good management plan will address these issues and keep the inventory current, in good condition, and functioning for the benefit and safety of those involved.

Managing trees on a large property can seem like an overwhelming task, but the same principles of inventory management apply. This inventory and management plan should provide managers the data they need to develop realistic budgets for their tree maintenance needs, and it will help make the Whittemore Park a safer and more beautiful environment.

The following tips will assist you in making the most of this document:

Who's Who

Those who conducted the inventory and prepared this document are members of the Bartlett Inventory Solutions team. They are also employees of Bartlett Tree Experts. The Bartlett Inventory Solutions team is overseen by four technical advisors out of the Bartlett Tree Research Laboratories in Charlotte, North Carolina. The advisors are primarily charged with client support, coordination, quality control, and documentation of inventories and the related data. Extensively trained Regional Inventory Arborists from local Bartlett Tree Experts offices are the primary data collectors and authors of the management plans. Readers may interpret the terms "Bartlett Tree Experts," "Bartlett," "the Inventory Team," "the team," "we," and "our" as the Bartlett company and those who conducted the inventory and prepared this management plan. In addition to the primary author(s) listed on the cover page, Team Member(s) involved in this project included:

Technical Advisor

Nicholas A. Martin, Bartlett Inventory Solutions Assistant Manager
ISA Certified Arborist & Municipal Specialist #SO-6537BM,
ISA Tree Risk Assessment Qualified, Registered Consulting Arborist #552

Data Collection

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Subject Trees

In this document, the term "subject trees" refers (depending on context) to some or all of the 37 trees included in the inventory.

Definitions & Bolded Terms

Some definitions or specifications are detailed within a given section to explain how readers should interpret certain terms or classifications. We have also appended a Glossary for other terms that appear throughout the document. The first reference to each of these terms appears in **bold** for the reader's convenience.

How This Document is Organized

An outline appears below that introduces the order in which the sections of the management plan will appear. The management plan layout is as follows:

- **Table of Contents**
  - Road map for the management plan
- **Making the Most of Your Inventory Management Plan**
  - Explanations for how to efficiently and effectively understand and navigate this management plan document
- **Executive Summary**
  - Synopsis of the major findings and recommendations
- **Introduction**
  - Brief explanation of the inventory and what was included
- **Goals & Objectives**
  - Explanation of the specific goals and objectives for this inventory
- **Data Collection & Tree Inspection Methodology**
  - Lists, explanations, and definitions of all data collected during the inventory
- **Stand Dynamics Results**
  - Summary information for the entire tree population inventoried including risk ratings assigned during the inventory with corresponding table and map displays with figures if applicable
- **Recommendations**
  - Summary of all recommendations made during the inventory including associated table and map displays, explanations and examples, and figures if applicable
- **Defects or Observations**
  - List of all trees observed to have defects in the field in a table view with associated descriptive figures and maps if applicable

- **Entire Inventory**
    - List of all trees collected in a table display
- **Additional Resources**
    - Listing of all appended items for this management plan

EXECUTIVE SUMMARY

In April 2018, the Bartlett Inventory Solutions (BIS) Team from Bartlett Tree Experts conducted an inventory of trees on the Whittemore Park site. We identified 37 trees which included 8 species. The attributes that we collected include tree latitude and longitude, size, age and condition class, and a visual assessment of tree structure, health, and **vigor**.

We conducted the attribute collection using a sub-meter accuracy Global Positioning Satellite Receiver (GPSr) device with an error-in-location potential of not greater than three meters. Our recommendations for the subject trees over the next 3-year period are outlined below. All tree work activities will comply with current American National Standards Institute (ANSI) Z133.1 requirements for safety.

Tree Risk Assessments and Mitigation
Perform the recommended tree risk mitigation activities for the 11 trees (30%) which we found defects or concerns that prompted the need to use the International Society of Arboriculture's (ISA) risk matrices in the field. Risk mitigation activities will comply with current ANSI A300 standard practices. Please see the Tree Risk Assessments, Limitations & Glossary section for more information.

Soil Sampling
Taking soil samples throughout planting beds and actively managed areas. Soil analysis provides information on the presence of soil nutrients, pH, organic matter, and cation exchange capacity.

Bulk Density Sampling
Taking bulk density samples throughout planting beds and actively managed areas to determine the amount of soil compaction.

Root Invigoration™
Perform Bartlett's patented Root Invigoration™ on 4 trees (11%) to improve aeration and promote more efficient root growth, especially for high-value trees in disturbed areas.

Mulching
Wherever possible, apply 2-4 inches of mulch within the root zone to help moderate soil temperatures, reduce soil moisture loss, reduce soil compaction, provide nutrients, improve soil structure, and keep mowers and string trimmers away from tree trunks. The best mulch materials are wood chips, bark nuggets, composted leaves, or pine needles. To avoid potential disease problems, mulch should not be placed directly against the trunk.

Root Collar Excavations
Perform **root collar** excavations to 11 trees (30%) to lower risk of damaging conditions such as **girdling roots**, basal cankers, masking of root decay and lower-stem decay, and predisposing trees to various insect and disease pests.

Plant Health Care (PHC)
At the time of inventory, no pests were observed on the subject trees. However, we recommend implementing Bartlett's PHC program to monitor pests and disease that may not have been visible at the time of inventory. Treatments are therapeutic and preventative, and treatment timing is based on pest life cycle.

Pruning
Prune 25 trees (68%) for safety, health, structure, and appearance. Pruning will comply with current ANSI A300 standard practices for pruning.

Structural Support
There are structural support system recommendations for 2 trees (5%) to reduce risk of branch or whole tree failure. All structural support systems will comply with current ANSI A300 standard practices for supplemental support systems.

Lightning Protection
At the time of inventory, no trees were recommended for lightning protection systems. However, as trees continue to grow and site changes occur, we recommend continual consultation with your local Bartlett Arborist Representative to determine if lightning protection systems are warranted in the future.

Removals
Remove 6 trees (16%) due to condition or because of their location in relation to other trees to try and prevent competition or damage to infrastructure.

Tree Risk *Advanced Assessments (Level 3)*
At the time of inventory, no trees were recommended for *advanced assessments* to evaluate the impact of wood decay in **stems** or **buttress roots**. However, as trees continue to grow and site changes occur, we recommend continual consultation with your local Bartlett Arborist Representative to determine if *advanced assessments* are warranted in the future.

INTRODUCTION

In April 2018, Michelle Crowley Landscape Architecture in Boston, MA retained Bartlett Tree Experts to perform an inventory of trees on the Arlington, MA, Whittemore Park site. Team member Timothy Armstrong visited the site on April 2, 2018 to conduct the inventory.

The inventory included:

- identifying trees and assigning a Tree ID number (Tree ID numbers ranging from 1 to 37);
- identifying the trees' condition, health, and vigor;
- recommending risk evaluations and removals of appropriate trees;
- recommending tree care, soil care and fertilization, structural support, and pest management treatments to promote tree safety, health, appearance, and longevity; and
- mapping the trees using GPSr hardware and Geographic Information System (GIS) software, and Bartlett Tree Experts' ArborScope™ web-based management system

The methods and procedures we used to make the above determinations and recommendations are detailed in the following sections.

GOALS & OBJECTIVES

An effective management plan communicates clear goals and the specific objectives designed to carry out those goals. We intend "goal" to mean the overall aim or result we expect to achieve for the client in producing the inventory and management plan. The objectives are the specific actions taken or recommended to support goal completion. The table below describes each goal and its corresponding objective(s).

GOALS & OBJECTIVES

GOAL	OBJECTIVES TO ACCOMPLISH GOAL
Establish the tree inventory (per numbers agreed) on the Whittemore Park site.	• Using Trimble® Geo GPSr hardware and ArborScope™ Inventory Management Tools, collect data such as tree name, location, size, age class, and condition class. • Assign a Tree ID number to each tree inventoried.
Provide mechanism for managing inventory, recommendations, and related budget planning.	• Provide map or maps of the inventoried trees to assist the client in managing property areas. • Submit a comprehensive management plan that documents and organizes findings and provides other resources to assist the client in efficient use of the information.
Maximize client understanding and implementation of management plan.	• Include in management plan specific explanations and visuals related to plan recommendations. • Provide appended resources that address health, procedures, and standards related to tree care. • Make periodic contact with client to follow up and answer any questions about the management plan's contents.
Maximize immediate and long-term tree health and aesthetics.	Implement recommended plant-health-care program that uses • integrated pest management • soil care and fertilization • maintenance pruning
Manage immediate and long-term risk associated with trees in high-use areas.	Implement recommended risk-management measures that include • risk-reduction pruning • required removals • tree structure evaluations

DATA COLLECTION & TREE INSPECTION METHODOLOGY

In conducting the inventory, we used specialized equipment and software and followed specific procedures to determine tree characteristics, risk evaluations, and recommendations. The following explanation will assist the reader in interpreting the findings of this management plan.

Data Collection Equipment & Attribute Data

The Inventory Team used Trimble® Geo GPSr hardware units, TerraSync® and GPS Pathfinder® Office GIS software, and Bartlett Tree Experts' ArborScope™ web-based management system to inventory the trees. The attribute data we collected on site are listed below.

- botanical name and regional common name according to local ISA Chapter Tree Species List
- tree location based on GPS coordinate system
- tree ID number
- diameter at breast height (**DBH**)
- canopy radius
- age class
- height class
- condition class
- root zone infringement, based on **dripline** and estimated **grayscape** (e.g., sidewalks) impact on root zone
- infrastructure interaction (between trees and grayscape that may cause an undesirable condition
- documented *basic assessment (Level 2)* of tree risk where defects or concerns were observed that prompted the need to use the ISA risk matrices in the field resulting in an *overall risk rating*
- priority of tree and shrub work (based on 3-year management plan)
- pruning
- need for and inspection of existing structural support systems
- need for and inspection of existing lightning protection systems
- need for *advanced assessments (Level 3)*
- tree removals
- soil care and fertilization recommendations
- plant health care recommendations
- noted defects/observations
- observed pests/diseases

Specifications/Definitions

Age Class

New Planting	Tree not yet established
Young	Established tree but not in the landscape for many years
Semi-mature	Established tree but has not yet reached full growth potential
Mature	Tree within its full growth potential
Over-mature	Tree that is declining or beginning to decline due to its age

Height Class

Small	Less than 15 feet
Medium	15 to 40 feet
Large	Greater than 40 feet

Condition Class

Dead

Poor Most of the canopy displays dieback and undesirable leaf color, inappropriate leaf size or inadequate new growth. Tree or parts of tree are in the process of failure.

Fair Parts of canopy display undesirable leaf color, inappropriate leaf size, and inadequate new growth. Parts of the tree are likely to fail.

Good Tree health and condition are acceptable.

Tree and Shrub Care Priority

Priority class recommendations are based on a 3-year management plan that takes into consideration tree species, condition, location, age, and proximity to infrastructure. We intend that this rating system assist decision makers in prioritizing tree pruning, cabling and bracing, and tree lightning protection recommendations. *Trees with a priority of 1 and an Overall Risk Rating of Extreme or High (see definitions in the next section) should be addressed immediately.* Prioritization does not take into account any budgetary or financial considerations.

Recommendations for Priorities 1, 2, and 3 are all based on observations by the inventory arborist. The following additional information clarifies each priority class:

Priority 1 To be addressed in years 1 or 2 of the management cycle. Priority 1 may include trees with large dead wood, structural defects, located in exposed sites, high aesthetic value, and/or parts that are currently negatively interacting with infrastructure, such as branches that touch buildings, interfere with signage or lighting, or obstruct pathways.

Priority 2 To be addressed in years 2 or 3 of the management cycle. Priority 2 may include trees with small dead wood, developing structural defects, located in semi-exposed sites, moderate esthetic value, and/or parts that are anticipated to negatively interact with infrastructure, such as branches that touch buildings, interfere with signage or lighting, or obstruct pathways.

Priority 3 To be addressed in year 3 of the management cycle. Priority 3 may include trees with small dead wood, developing structural defects, located in lesser used sites, and/or parts that are anticipated to negatively interact with infrastructure, such as branches that rub on buildings, interfere with signage or lighting, or obstruct pathways.

Pruning

Each of the following is a selective pruning technique to achieve the pruning goal described:

Clean	Remove one or more of dead, diseased, and/or broken branches
Raise	Provide vertical clearance
Thin	Reduce height or spread, sometimes for a particular branch (overextended or co-dominant)
Reduce	Reduce height or spread
Structural	Select live branches and stems to influence orientation, spacing, growth rate, strength of attachment, and ultimate size of branches and stems; possibly to reduce defects or space main branches on mature trees.
Vista	A combination of thinning and reduction pruning to enhance the view from a vantage point to an area of interest while minimizing negative impacts on tree structure and health.

Tree Risk Assessments, Limitations & Glossary

In accordance with industry standards, tree risk ratings are derived from a combination of three factors: the *likelihood of failure*, the *likelihood of the failed tree part impacting a target*, and the *consequences* of the target being struck. The guidelines used to classify each of these factors are presented in the *ISA's BMP for Tree Risk Assessment* and guidelines developed by the Bartlett Tree Research Laboratories. *These factors are then used to categorize tree risk as Extreme, High, Moderate or Low*. The factors used to define your risk ratings are identified in this report. An explanation of terms used in this report appears in the glossary located in the appendix. The information provided in this report is based on the conditions identified at the time of inspection. Tree conditions do change over time so reassessment is recommended annually and after major storm events.

Limitations of Tree Risk Assessments

It is important for the tree owner or manager to know and understand that all trees pose some degree of risk from failure or other conditions. The information and recommendations within this report have been derived from the level of tree risk assessment identified in this report, using the information and practices outlined in the *International Society of Arboriculture's Best Management Practices for Tree Risk Assessment*, as well as the information available at the time of the inspection. However, the overall risk rating, the mitigation recommendations, or any other conclusions do not preclude the possibility of failure from undetected conditions, weather events, or other acts of man or nature. Trees can unpredictably fail even if no defects or other conditions are present. It is the responsibility of the tree owner or manager to schedule repeat or *advanced assessments*, determine actions, and implement follow up recommendations, monitoring and/or mitigation.

Bartlett Tree Experts can make no warranty or guarantee whatsoever regarding the safety of any tree, trees, or parts of trees, regardless of the level of tree risk assessment provided, the risk rating, or the residual risk rating after mitigation. The information in this report should not be considered as making safety, legal, architectural, engineering, landscape architectural, land surveying advice or other professional advice. This information is solely for the use of the tree owner and manager to assist in the decision making process regarding the management of their tree or trees. Tree risk assessments are simply tools which should be used in conjunction with the owner or tree manager's knowledge, other information and observations related to the specific tree or trees discussed, and sound decision making.

Glossary

Tree risk assessment has a unique set of terms with specific meanings. Definitions of all specific terms may be found in the International Society of Arboriculture's *Best Management Practice for Tree Risk Assessment*. Definitions of some of these terms used in this report are as follows:

The *likelihood of failure* may be categorized as imminent meaning that failure has started or could occur at any time; probable meaning that failure may be expected under normal weather conditions within the next 3 years; possible meaning that failure could occur, but is unlikely under normal weather conditions during that time frame; and improbable meaning that failure is not likely under normal weather conditions, and may not occur in severe weather conditions during that time frame.

The likelihood of the failed tree part impacting a target may be categorized as high meaning that a failed tree or tree part will most likely impact a target; medium meaning that a failed tree or tree part may or may not impact a target with equal likelihood; low meaning that the failed tree or tree part is not likely to impact a target; and very low meaning that the chance of a failed tree or tree part impacting the target is remote.

The *likelihood of failure and impact* is defined by the Likelihood Matrix below.

LIKELIHOOD OF FAILURE AND IMPACT

Likelihood of Failure	Likelihood of Impacting Target			
	Very Low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	Likely	Very Likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

The *consequences* of a known target being struck may be categorized as severe meaning that impact could involve serious personal injury or death, damage to high value property, or disruption to important activities; significant meaning that the impact may involve personal injury, property damage of moderate to high value, or considerable disruption; minor meaning that impact could cause low to moderate property damage, small disruptions to traffic or a communication utility, or minor injury; and negligible meaning that impact may involve low value property damage, disruption that can be replaced or repaired, and do not involve personal injury.

Targets are people, property, or activities that could be injured, damaged or disrupted by a tree failure.

Levels of assessment 1) *Limited visual assessments* are conducted to identify obvious defects. 2) *Basic assessments* are visual inspections done by walking around the tree looking at the site, buttress roots, trunk and branches. It may include the use of simple tools to gain information about the tree or defects. 3) *Advanced assessments* are performed to provide detailed information about specific tree parts, defects, targets of site conditions. Drilling to detect decay is an advanced assessment technique.

Tree Risk Ratings are terms used to communicate the level of risk rating. They are defined in defined in the Risk Matrix below as a combination of Likelihood and Consequences:

ISA RISK MATRIX

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

Overall tree risk rating is the highest individual risk identified for the tree. The *residual risk* is the level of risk the tree should pose after the recommended mitigation.

STAND DYNAMICS RESULTS

STAND DYNAMICS RESULTS

In reviewing the results and recommendations, the reader will find useful the specifications and definitions detailed in the preceding methodology above. We used the following categories to organize the stand dynamics results, which are displayed in tables:

- **Tree Risk Assessment Report and Mitigation**
- **Subject Trees Summarized According to:**
  - Tree Species Identified
  - Condition Class
  - Age Class
  - Tree Size per DBH
  - Tree Asset Value

Where appropriate, we have included explanations, photos, drawings, or other information to illuminate the table contents.

Tree Risk Assessment Report and Mitigation

As part of the inventory process, the Inventory Team conducts a *basic assessment (Level 2)* from the ground. While every tree poses a risk, typically *Low*, the trees in the following table were assigned *likelihood of failure, likelihood of the failed tree part impacting a target, and consequences* ratings in the field. The Inventory Team found conditions with these trees that posed a hazardous situation, prompting the arborists to go through the steps outlined in the Tree Risk Assessments, Limitations, and Glossary section of this plan. *Overall risk ratings* were then assigned to these trees.

The Tree Risk Table below summarizes the inventoried trees that were observed posing a hazardous situation during the course of the inventory. The table is organized first by *Overall Risk Rating* (highest to lowest), then by Tree Care Priority (ascending order), and finally by Tree ID (ascending order)

TREE RISK ASSESSMENT REPORT AND MITIGATION (11 Trees)

Tree ID	Common Name	DBH	Condition	Overall Risk Rating	Primary Target	Tree Care Priority	Pruning	Defect(s) or Observation(s)
23	Tree of Heaven	33	Poor	Moderate	Sidewalk	1	Remove	• Buried root collar • Decay-Root flare • Cavity-stem • Hanger • Dead branches >2
24	Tree of Heaven	36	Poor	Moderate	Bench	1	Remove	• Buried root collar • Broken branch(s) • Lion tailing • Wound-root flare • Cavity-Suspected
26	Tree of Heaven	41	Poor	Moderate	Sidewalk	1	Remove	• Co-dominant leaders • Included bark • Cavity-stem • Dead branches >2 • Lion tailing • Wound-root flare
11	Honeylocust-Thornless Common	25	Good	Low	Parking	1	Clean, Reduce, Thin	• Wound-root • Dead branches >2 • Co-dominant leaders
25	Tree of Heaven	22	Poor	Low	Bench	1	Remove	• Dead branches >2 • Decay-Root flare • Co-dominant leaders • Dieback (severe)
27	Maple-Norway	16	Poor	Low	Sidewalk	1	Remove	• Buried root collar • Girdling roots suspected • Decay-Stem • Dead branches >2

Tree ID	Common Name	DBH	Condition	Overall Risk Rating	Primary Target	Tree Care Priority	Pruning	Defect(s) or Observation(s)
28	Maple-Norway	21	Fair	Low	Sidewalk	1	Clean, Reduce	• Buried root collar • Girdling roots suspected • Uneven crown • Dead branches >2
30	Maple-Norway	18	Fair	Low	Sidewalk	1	Clean	• Dead branches >2 • Uneven crown
31	Maple-Norway	16	Poor	Low	Sidewalk	1	Clean	• Growing against object • Dead branches >2 • Uneven crown
32	Maple-Norway	19	Poor	Low	Sidewalk	1	Clean	• Girdling roots present (severe) • Dead branches >2 • Co-dominant leaders
1	Honeylocust-Thornless Common	26	Good	Low	Parking	2	Clean	• Co-dominant leaders • Dead branches >2 • Wound-root

INVENTORIED TREES ASSIGNED RISK RATINGS AT THE TIME OF DATA COLLECTION

Overall Risk Rating: Low Moderate

Stand Dynamics

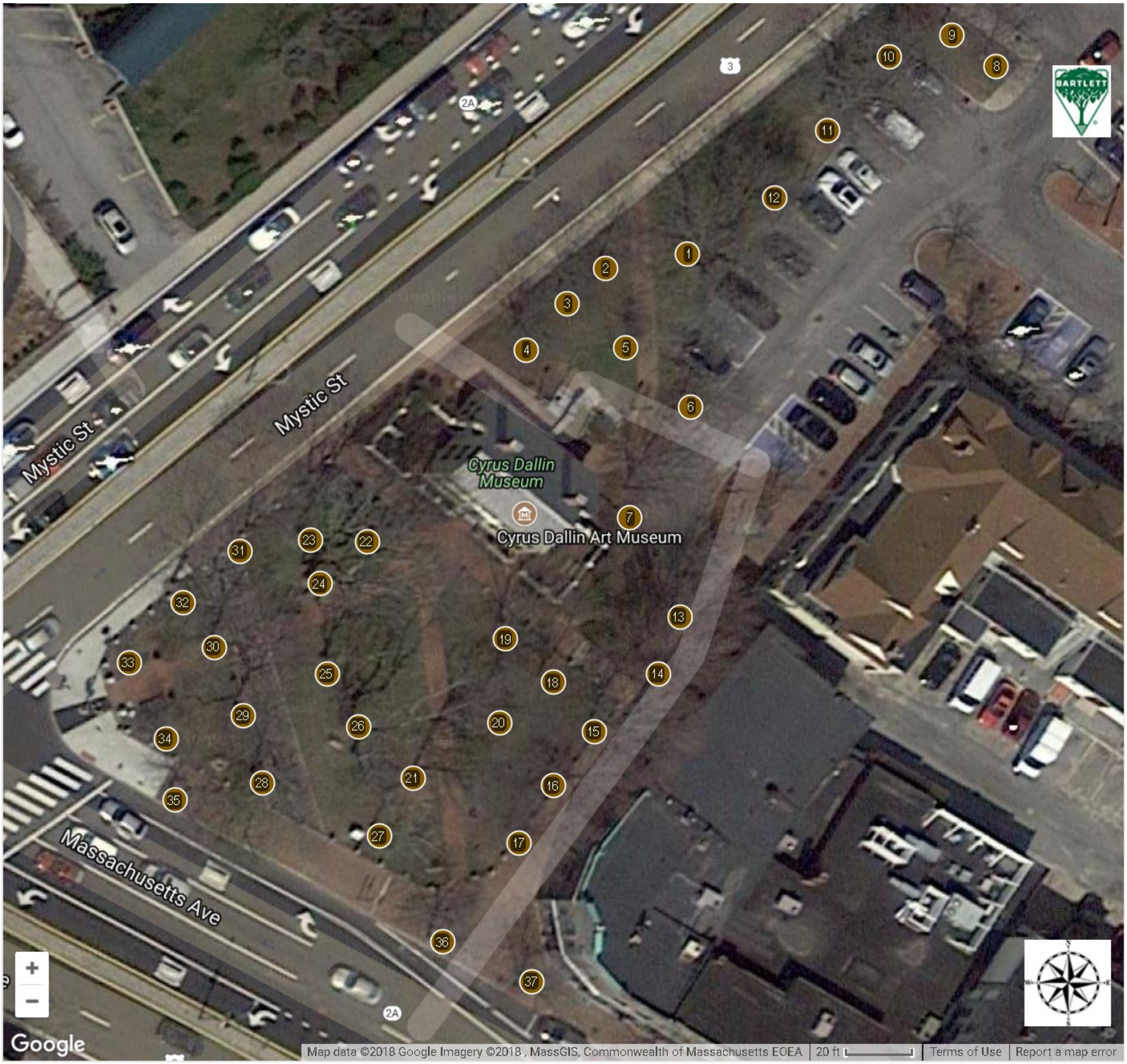
Tree Species Identified

Our inventory revealed 8 species of trees, as detailed in the following table:

TREE SPECIES IDENTIFIED

Genus	Species	Common Name	Count	% Distribution Total
Acer	*platanoides*	Maple-Norway	6	16%
	rubrum	Maple-Red	12	32%
***Acer* Total**			**18**	**49%**
Ailanthus	*altissima*	Tree of Heaven	4	11%
Cladrastis	*kentukea*	Yellowwood	2	5%
Gleditsia	*triacanthos* var. inermis	Honeylocust-Thornless Common	5	14%
Magnolia	sp.	Magnolia	2	5%
Malus	sp.	Crabapple	3	8%
Quercus	*palustris*	Oak-Pin	3	8%
Grand Total			**37**	**100%**

2018 TREE INVENTORY

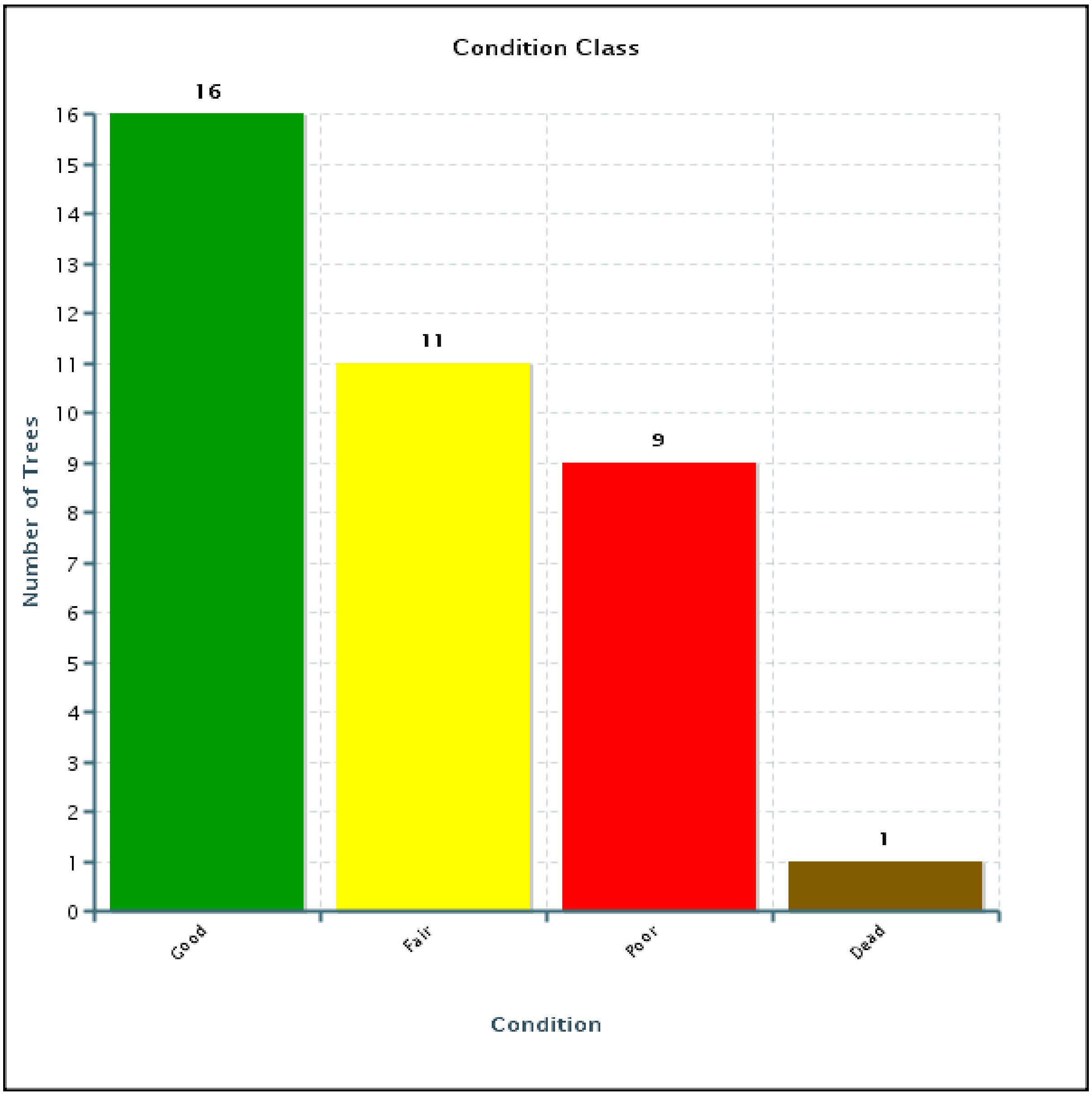


Condition Class

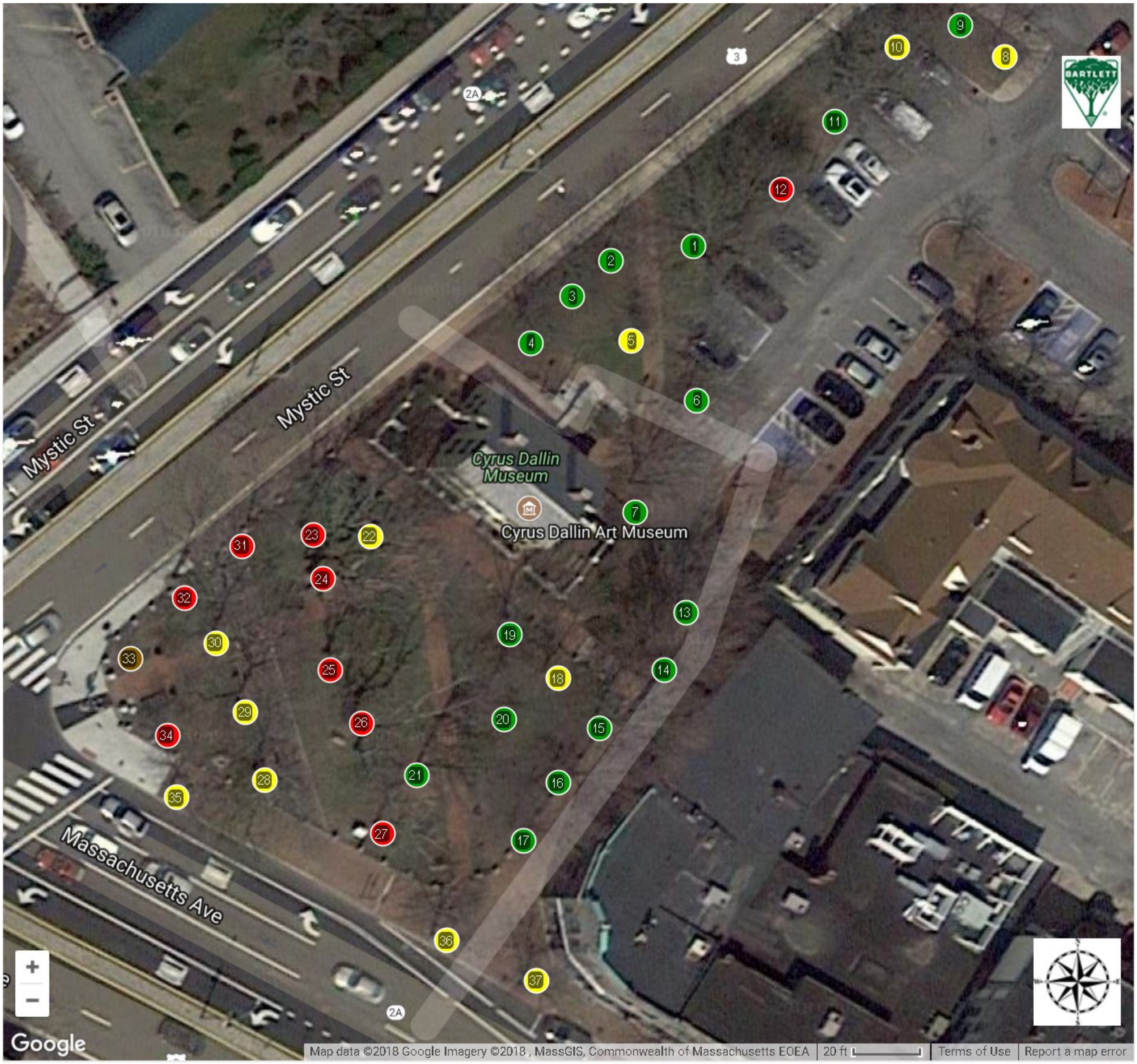
The breakdown of tree condition follows:

CONDITION CLASS BREAKDOWN

Condition Class	Quantity	% of Total
Good	16	43%
Fair	11	30%
Poor	9	24%
Dead	1	3%



INVENTORIED TREES BY CONDITION CLASS



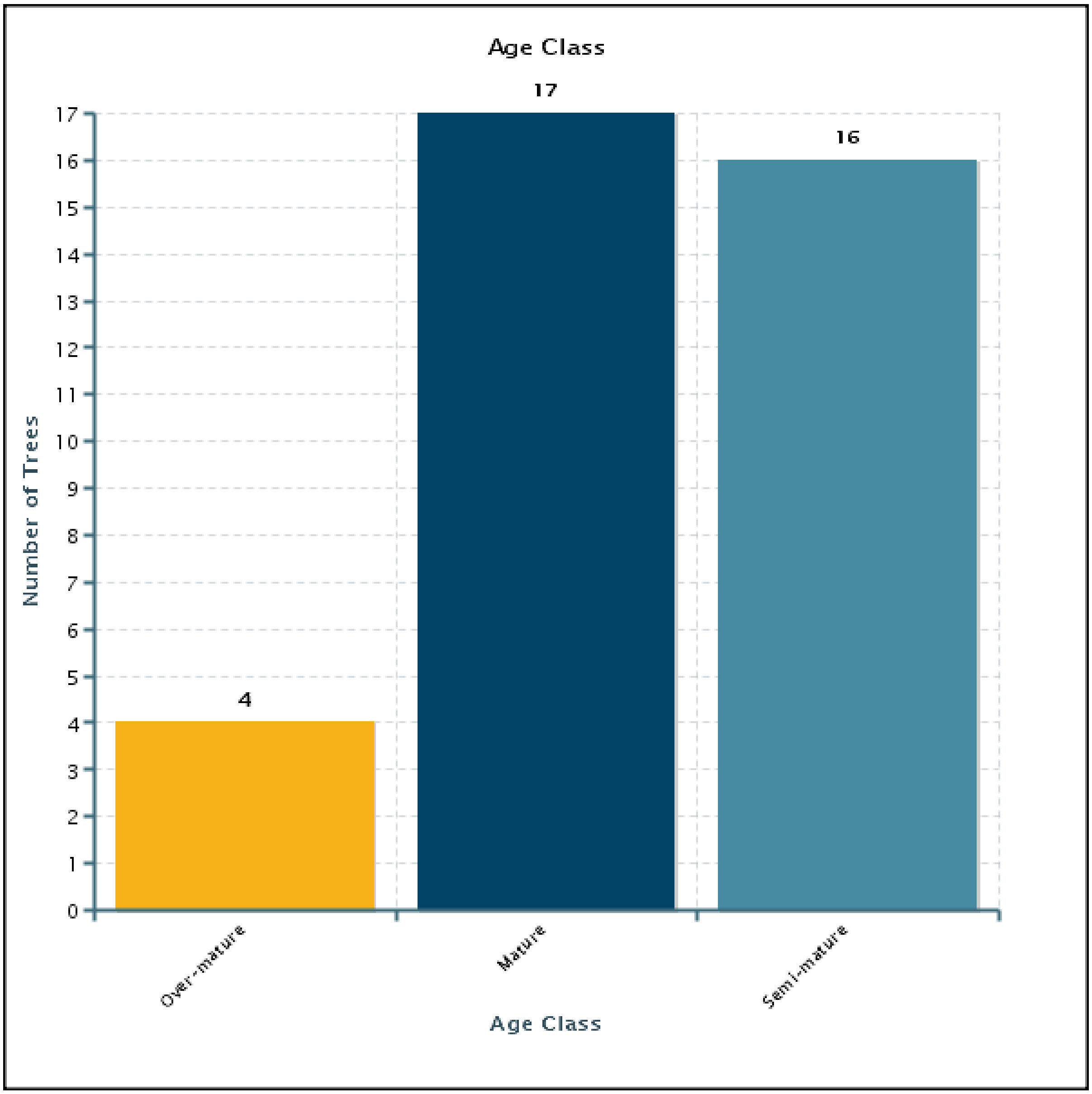
Condition: Good Fair Poor Dead

Age Class

The breakdown of tree age class follows:

AGE CLASS BREAKDOWN

Age Class	Quantity	% of Total
Over-mature	4	11%
Mature	17	46%
Semi-mature	16	43%

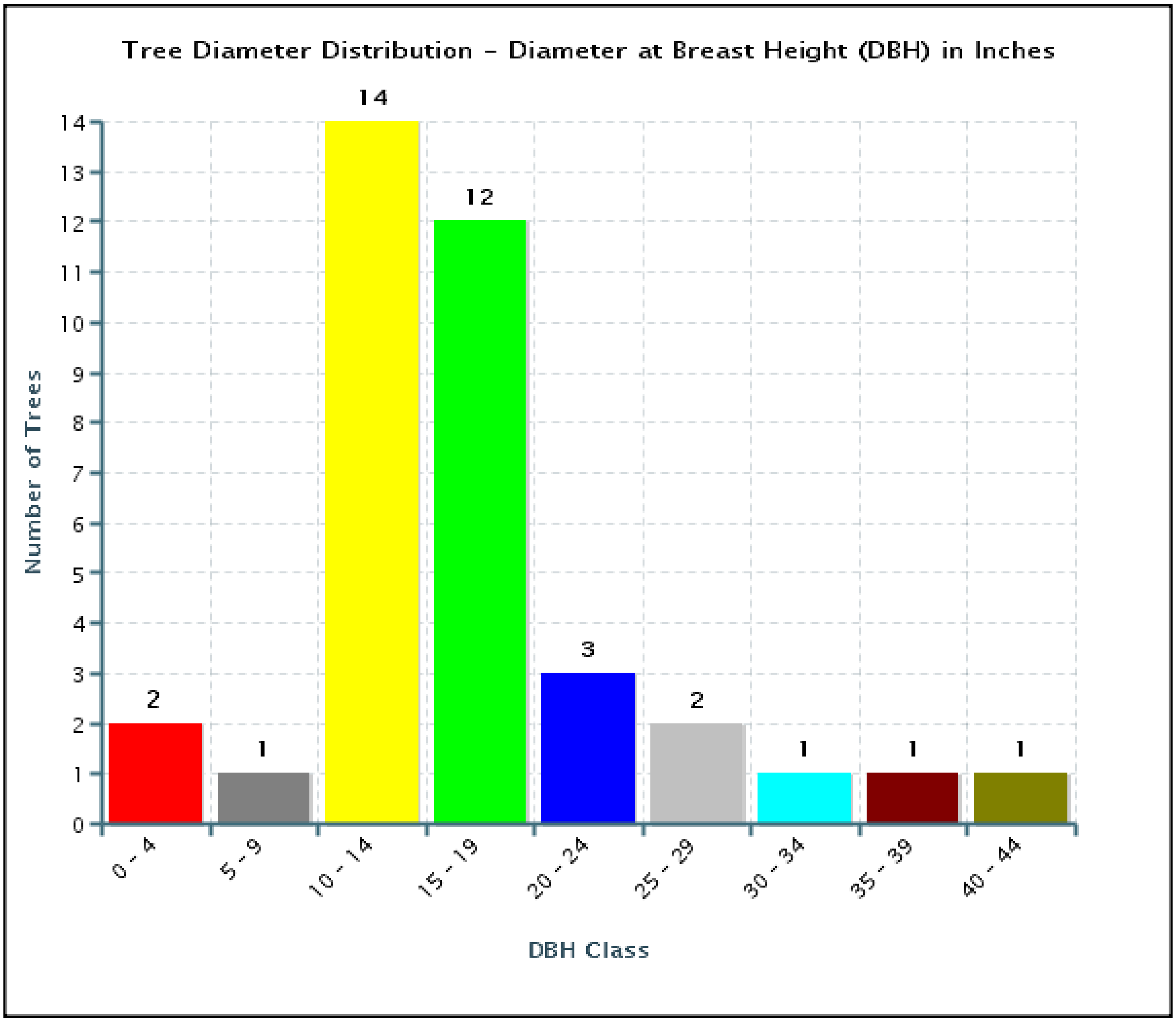


INVENTORIED TREES BY AGE CLASS

Age: Semi-Mature Mature Over-Mature

Tree Size (DBH)

The following chart illustrates numbers of trees according to size per DBH:



Tree Asset Value

As part of the Bartlett inventory process, we have included a Tree Asset Value for each tree and a cumulative total for all trees inventoried. To calculate the Tree Asset Value, we use a modified version* of the Trunk Formula Method published by the Council of Tree and Landscape Appraisers in The Guide for Plant Appraisal, 9th Edition (CTLA, 2000).

The following data fields are used in this formula:

Data Field	Description
Size	Based on tree DBH (4.5 feet above grade)
Species Factor	Relative species desirability based on 100% for the tree in that geographical location. In most cases, species desirability ratings, published by the International Society of Arboriculture, are used for adjustment.
Condition Factor	Rating of the tree's structure and health based on 100%
Location Factor	Average rating for the site and the tree's contribution and placement, based on 100%

Tree Asset Value = Size*Species Factor*Condition Factor*Location Factor

The estimated cumulative total value for all trees inventoried is **$152,835.65**. The following table lists the ten trees with the highest Tree Asset Values:

TOP TEN TREES - HIGHEST TREE ASSET VALUE

Tree ID	Common Name	Genus	Species	DBH	Tree Asset Value
1	Honeylocust-Thornless Common	*Gleditsia*	*triacanthos* var. inermis	26	$14,561.31
11	Honeylocust-Thornless Common	*Gleditsia*	*triacanthos* var. inermis	25	$13,462.75
21	Oak-Pin	*Quercus*	*palustris*	19	$9,442.39
15	Maple-Red	*Acer*	*rubrum*	19	$8,331.52
20	Oak-Pin	*Quercus*	*palustris*	16	$6,695.99
28	Maple-Norway	*Acer*	*platanoides*	21	$6,300.57
29	Maple-Norway	*Acer*	*platanoides*	21	$6,300.57
7	Maple-Red	*Acer*	*rubrum*	16	$5,908.22
16	Maple-Red	*Acer*	*rubrum*	15	$5,192.77
14	Maple-Red	*Acer*	*rubrum*	15	$5,192.77

*This version does not consider cost of purchase and installation of the largest available "like tree."

TOP TEN TREES - HIGHEST TREE ASSET VALUE

Condition: Good Fair

RECOMMENDATIONS

BARTLETT TREE EXPERTS

SCIENTIFIC TREE CARE SINCE 1907

RECOMMENDATIONS

In reviewing the results and recommendations, the reader will find useful the specifications and definitions detailed in the preceding methodology. We used the following categories to organize the results and recommendations, which are displayed in tables:

Recommendations

- Soil Care and Fertilization
- Plant Health Care
- Tree Pruning
- Structural Support Systems
- Lightning Protection Systems
- Tree Removal
- Tree Risk *Advanced Assessments (Level 3)*

Soil Care and Fertilization

Healthy soil is critical to the health and longevity of trees. Soil provides trees with the essential nutrients required for their growth. Many secondary problems such as reduced vigor, inadequate growth, branch dieback, and pest or disease concerns are related to the primary stress of poor soil conditions. Undisturbed, native forest soils generally contain adequate levels of organic matter, soil microbes, and nutrients. Urban, suburban, and landscape soils (as opposed to forest soils) usually lack these qualities, and are often compacted. In many cases, trees in a landscaped environment suffer from inadequate soil fertility, soil compaction, root zone competition with turf grasses, and inadequate total soil volume. Soil care recommendations are intended to correct these concerns and improve or maintain overall plant health.

Bartlett Tree Experts recommends several procedures and treatments that address soil quality. Taking soil samples is perhaps the most important. Proper tree care cannot be initiated unless it is known what type of soil environment the trees are growing in. Soil testing results can help to create a path forward for improved tree health. We address some of these below.

Soil Sampling

Collecting soil samples and having them tested helps determine nutrients that may be lacking, unfavorable soil pH values, and adequacy of soil organic matter. Laboratory tests and analyses can determine the need for soil amendments.

Bulk Density

Compacted soils are regrettably common in the urban setting. A bulk density test, which requires an undisturbed core sample, measures the level of soil compaction. Arborists can use the results to diagnose problems or to determine what size holes to dig for planting. If soil density exceeds a measured threshold for a given soil type and tree species, we recommend Bartlett's Root Invigoration™ program.

Soil Rx®

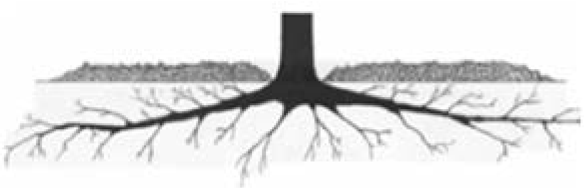
Bartlett's Soil Rx® program, which is a prescription fertilization program, aims to correct nutrient deficiencies and optimize soil conditions for designated trees.

Root Invigoration™

The aim of Bartlett's patented Root Invigoration™ Program is to improve soil conditions by addressing soil compaction and promoting efficient root growth, especially for high-value trees in disturbed areas. The process includes taking soil samples to determine what nutrients are deficient, performing a root collar excavation, "air-tilling" a portion of the root zone to find fine roots, incorporating organic matter, fertilizing (based on soil sample), and applying mulch. The area of the root system treated can vary by tree. For the Root Invigoration™ Program to be successful, proper watering techniques must be employed after the process is complete.

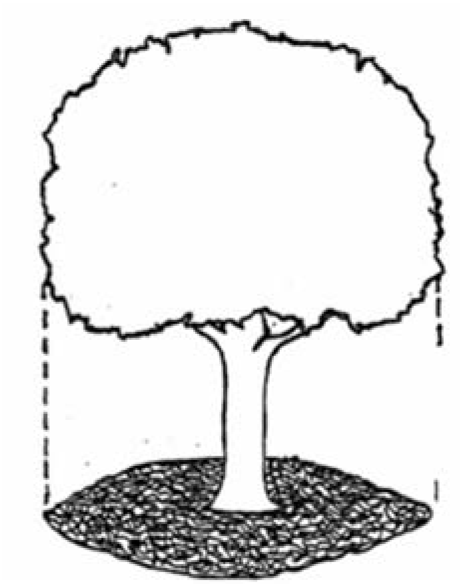
Mulch Application

Proper mulching (top left and bottom left) provides many benefits to trees and shrubs. It moderates soil temperatures, reduces soil moisture loss, reduces soil compaction, provides nutrients, and improves soil structure. This practice results in more root growth and healthier plants. The image on the top right illustrates root growth density under grass versus mulch. Mulch is frequently applied incorrectly (bottom right), so we recommend that readers inspect the technical report on mulch application guidelines that appears in the Appendix.



Example of how mulch should be installed, 2-4 inches thick and not against the trunk.

Example of root density under grass versus mulch.



Example of how mulch should be applied from the trunk to the dripline.

Example of improper mulch application, known as "volcano mulch".

The following inventoried trees are recommended for soil management because of possible nutrient deficiencies, soil compaction, or inadequate soil conditions:

INVENTORIED TREES RECOMMENDED FOR SOIL MANAGEMENT (4 Trees)

Tree ID	Common Name	DBH	Soils Management Type
5	Crabapple	10	Root Invigoration ™
18	Yellowwood	10	Root Invigoration ™
19	Yellowwood	15	Root Invigoration ™
34	Magnolia	3,3,2,2,1,1	Root Invigoration ™

INVENTORIED TREES RECOMMENDED FOR SOIL MANAGEMENT

Soil: ● Root Invigoration ™

Root Collar Excavation

Excavating the root collar is necessary for trees whose buttress roots are covered by excess soil or mulch. Buried root collars can contribute to tree health problems, including girdling roots, basal cankers, and masking root and lower stem decay.

The top image shows a buried root collar and the bottom image shows an exposed root collar.

Example of a buried root collar.

Example of an exposed root collar.

Girdling Roots

Girdling roots (top left and right) restrict water and nutrient movement throughout the tree. If left untreated they can cause the tree to decline, fail (bottom), and eventually die in severe cases. Girdling roots should be removed as soon as possible, unless removal will significantly impact the condition of the tree. In some cases, the presence of significant or severe girdling roots may cause the tree to be recommended for removal.


Examples of girdling roots.

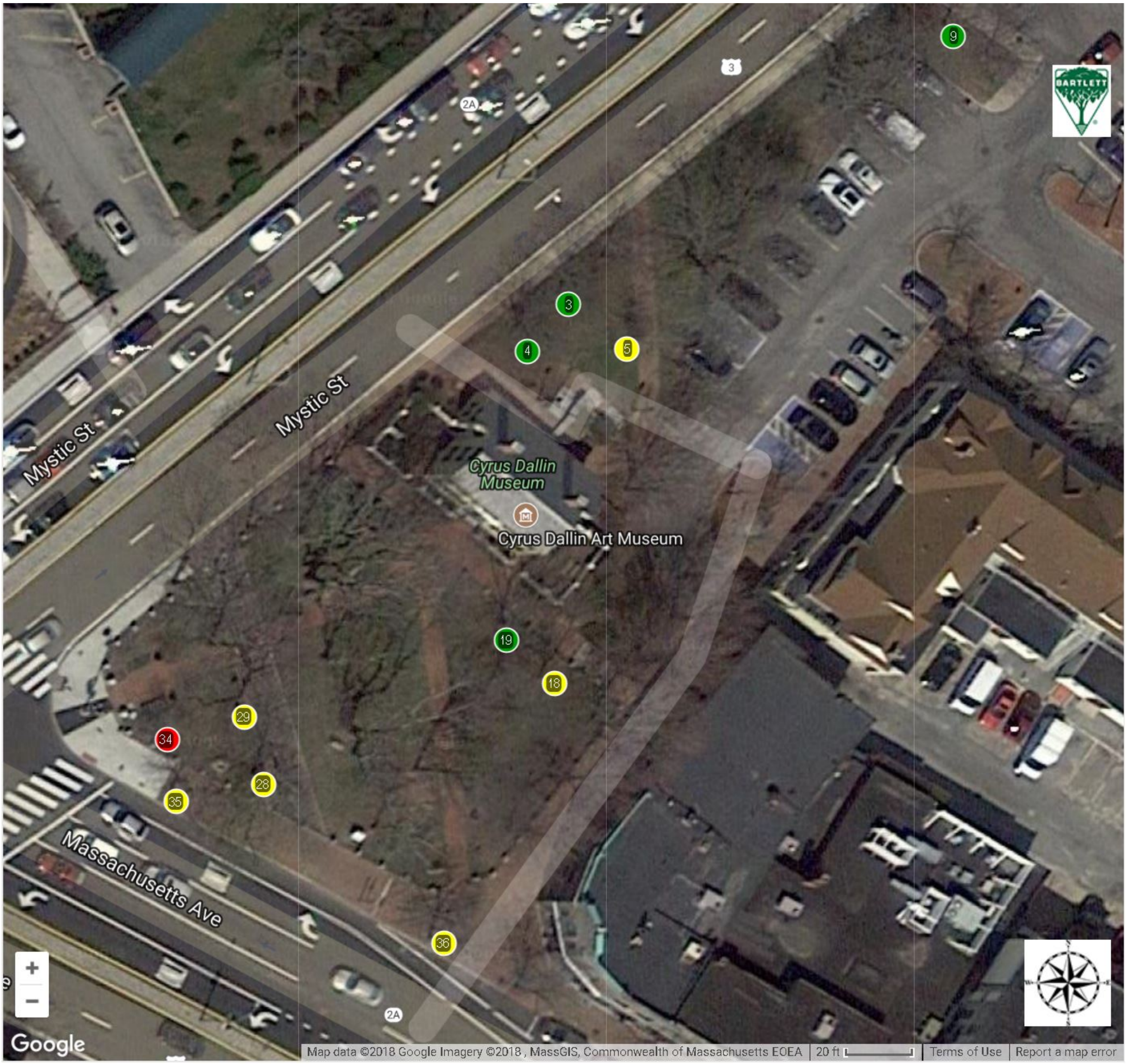
Example of tree failure from girdling roots.

The following trees are recommended for a root collar excavation:

INVENTORIED TREES RECOMMENDED FOR A ROOT COLLAR EXCAVATION (11 Trees)

Tree ID	Common Name	DBH	Girdling Roots
3	Maple-Red	13	Girdling roots present
4	Maple-Red	13	Girdling roots present
5	Crabapple	10	...
9	Maple-Red	11	Girdling roots present
18	Yellowwood	10	Girdling roots present
19	Yellowwood	15	Girdling roots present
28	Maple-Norway	21	Girdling roots suspected
29	Maple-Norway	21	Girdling roots present
34	Magnolia	3,3,2,2,1,1	...
35	Honeylocust-Thornless Common	11	...
36	Honeylocust-Thornless Common	13	...

INVENTORIED TREES RECOMMENDED FOR A ROOT COLLAR EXCAVATION



Condition: Good Fair Poor

Plant Health Care

The Inventory Team also recommends Plant Health Care (PHC) programs for trees in the formal landscape. In addition, an Integrated Pest Management (IPM) program monitors for potentially damaging insects, diseases and cultural problems that are often seasonal and may not have been evident during our inventory visit. These pests and diseases include, but are not limited to, the following:

- Anthracnose - on a variety of species
- Aphids - on a variety of species
- Bacterial Leaf Scorch - on trees within red oak group
- Bagworms - on a variety of tree species
- Boring Insects - on a variety of tree species
- Caterpillar Defoliators - on a variety of tree species, especially oak
- Gall Insects - on a variety of species
- Lacebugs - on a variety of species
- Scab and Rust Fungi - on crabapple and apple species.
- Suspected Phytophthora Root Rot and Canker - on a variety of tree species, especially beech species
- Scale Insects - on a variety of tree species, especially oak
- Spider Mites - on a variety of tree species

At the time of inventory, no pests were observed on the subject trees. However, we recommend implementing Bartlett's PHC program to monitor pests and disease that may not have been visible at the time of inventory. Treatments are therapeutic and preventative, and treatment timing is based on pest life cycle.

Tree Pruning

A commonly offered service among tree companies, pruning trees is one of the most poorly executed practices by tree workers who lack training in the basics of tree biology. "Lion's tailing," topping, and flush cuts are a few examples, and these can lead to hazardous conditions over time.

Because this practice is so misunderstood, and because specific standards exist to perform pruning correctly, the Inventory Team decided to include some explanation in the main body of this management plan.

Tree owners and tree-care practitioners should always keep in mind that any pruning cut is a wound. Informed tree-care professionals have learned to manage that wounding to preserve the health, safety, and integrity of the tree.

Improper Pruning Practices

A few of the most common pruning abuses are

- Lion's Tailing - pruning that removes interior branches along the stem and scaffold branches. This encourages poor branch taper, poor wind load distribution, and risk of branch failure. It also deprives the tree of foliage it needs to produce **photosynthates**. See next page, top left
- Topping - pruning cuts that reduce a tree's size by using heading cuts that shorten branches to a predetermined size. Topping substantially reduces the functional benefits a tree is capable of providing and predisposes trees to structural defects that can contribute to failures in the future. It also reduces the value of the trees substantially and deprives the tree of adequate foliage. See next page, top right.
- Flush Cuts - pruning cut through the **branch collar**, flush against the trunk or parent stem, causing unnecessary injury. See next page, bottom.
- Using Climbing Spikes Inappropriately - Using climbing spikes on a healthy tree, for example, wounds healthy stem tissues and can lead to infection by fungal pathogens.

Example of Lion's tailing.

Examples of topping.

Examples of flush cuts.

Correct Pruning Practices

We have included below some key pruning categories and diagrams to illuminate the goal of each.

Cleaning
Selective pruning to remove one or more of the following parts: dead, diseased, and/or broken branches.

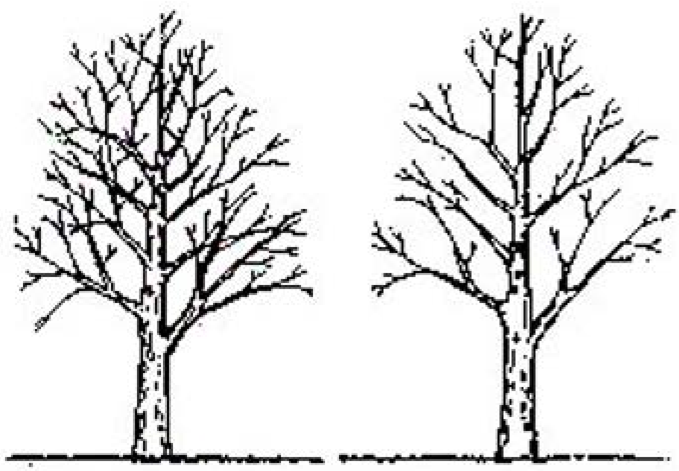


Illustration of crown cleaning.

Raising
Selectively pruning to provide vertical clearance.

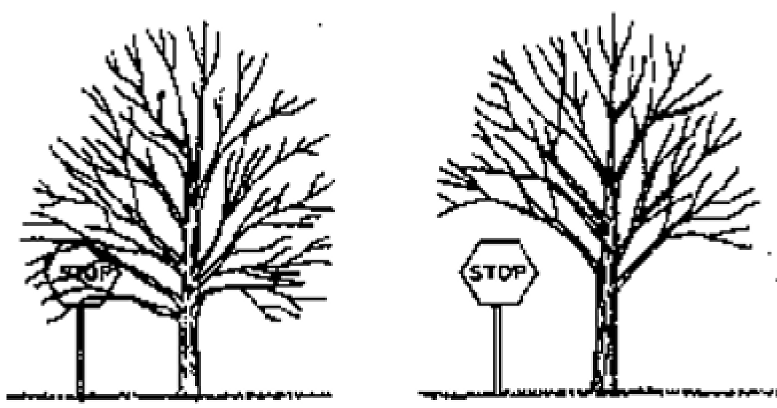


Illustration of crown raising.

Thinning

Selective pruning to reduce density of live branches.

Illustration of thinning.

Reducing (Reduction Pruning)

Selective pruning to reduce height or spread.

Illustration of reduction pruning.

Structural
Selective pruning of live branches and stems to influence orientation, spacing, growth rate, strength of attachment, and ultimate size of branches and stems.

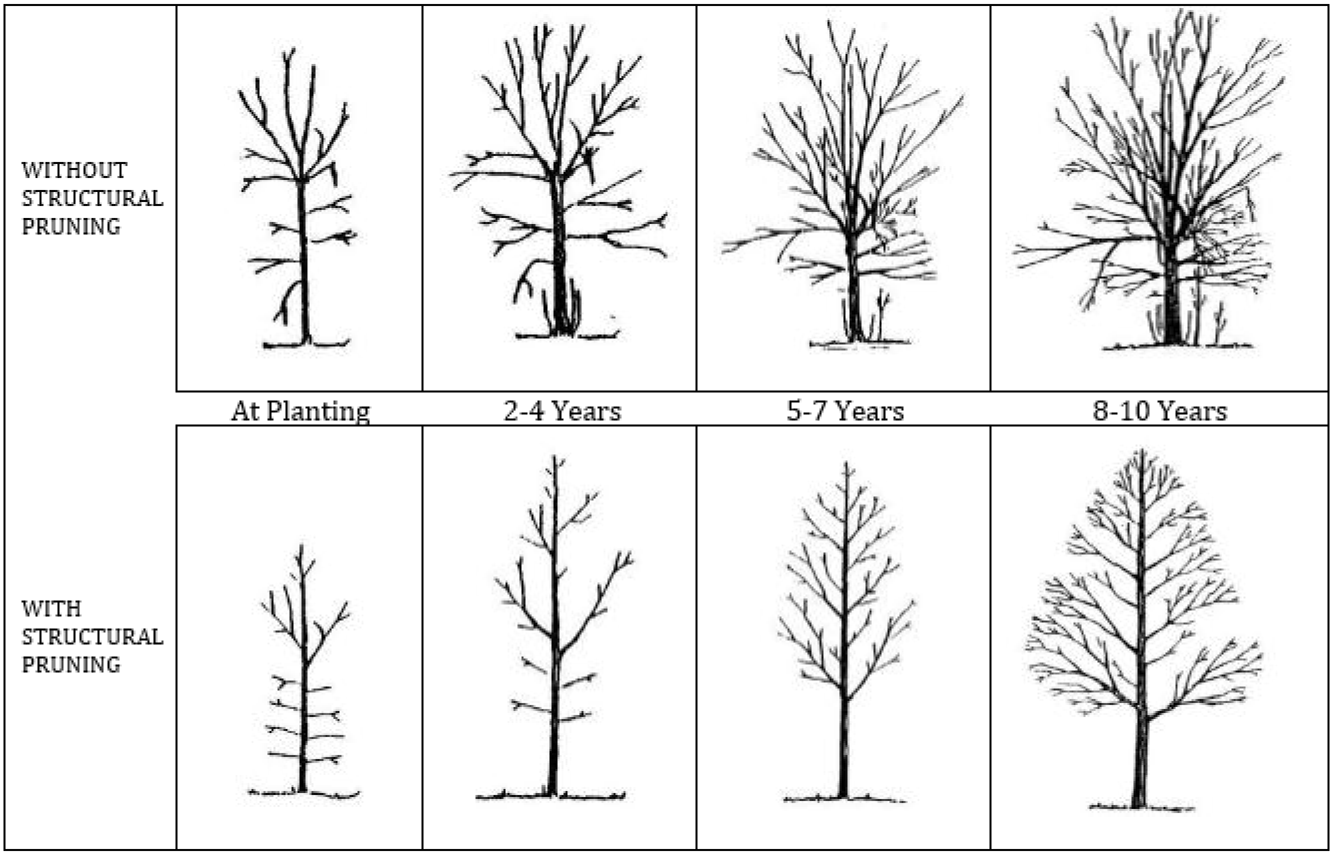


Illustration of structural pruning.

Vista Pruning
Vista pruning is a combination of thinning and reduction pruning to enhance the view from a vantage point to an area of interest while minimizing negative impacts on tree structure and health.

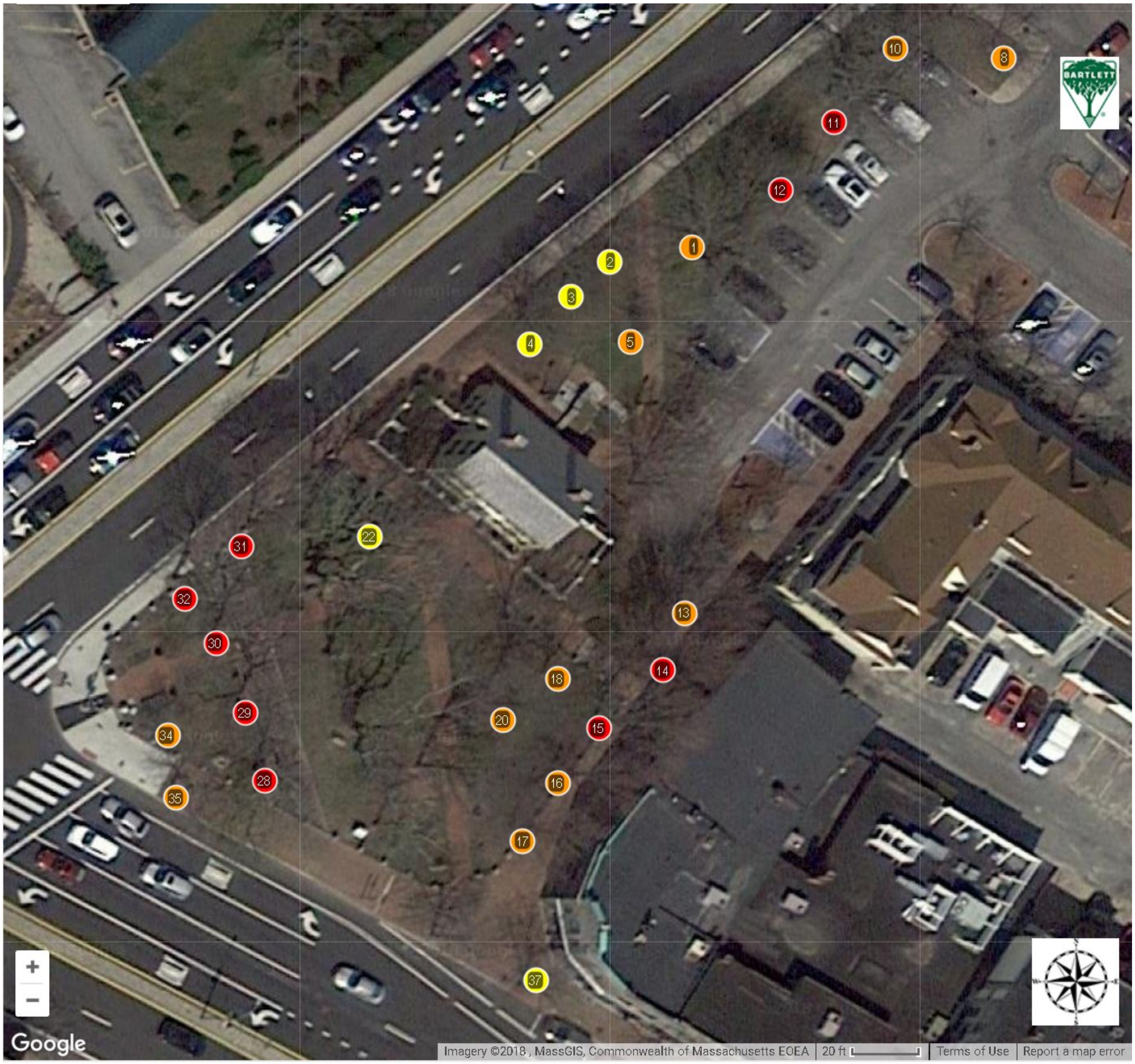
We recommended pruning on the following trees:

INVENTORIED TREES RECOMMENDED FOR PRUNING (25 Trees)

Tree ID	Common Name	DBH	Overall Risk Rating	Tree Care Priority	Pruning Recommended
11	Honeylocust-Thornless Common	25	Low	1	• Clean • Reduce: Lighting • Thin
28	Maple-Norway	21	Low	1	• Clean • Reduce: Branch weight
30	Maple-Norway	18	Low	1	• Clean
31	Maple-Norway	16	Low	1	• Clean
32	Maple-Norway	19	Low	1	• Clean
1	Honeylocust-Thornless Common	26	Low	2	• Clean
12	Crabapple	7,7	...	1	• Clean
14	Maple-Red	15	...	1	• Clean • Reduce: Building • Thin
15	Maple-Red	19	...	1	• Clean • Reduce: Building • Thin
29	Maple-Norway	21	...	1	• Clean • Reduce: Branch weight
5	Crabapple	10	...	2	• Clean • Thin • Structural
8	Maple-Red	10	...	2	• Clean
10	Crabapple	12	...	2	• Clean • Raise: Sidewalk • Structural
13	Maple-Red	14	...	2	• Reduce: Building • Structural
16	Maple-Red	15	...	2	• Clean • Reduce: Building • Structural
17	Maple-Red	14	...	2	• Clean • Reduce: Building • Thin • Structural
18	Yellowwood	10	...	2	• Clean

Tree ID	Common Name	DBH	Overall Risk Rating	Tree Care Priority	Pruning Recommended
20	Oak-Pin	16	...	2	• Clean • Structural
34	Magnolia	3,3,2,2,1,1	...	2	• Clean
35	Honeylocust-Thornless Common	11	...	2	• Clean
2	Maple-Red	13	...	3	• Clean • Raise: Sidewalk
3	Maple-Red	13	...	3	• Raise: Sidewalk
4	Maple-Red	13	...	3	• Clean • Raise: Sidewalk • Structural
22	Oak-Pin	15	...	3	• Reduce: Branch weight
37	Honeylocust-Thornless Common	12	...	3	• Clean • Reduce: Building

INVENTORIED TREES RECOMMENDED FOR PRUNING



Tree Care Priority: 1 2 3

Structural Support Systems

Structural support systems can reduce risk of tree or tree part(s) failure by limiting movement of stems or branches in certain situations. Examples include co-dominant stems or overextended branches with heavy foliage loads.

Cabling

Cabling is the process of connecting two or more upright stems or leaders to one another to add stability and reduce the likelihood of failure. In some instances, a lateral branch may be secured to the central leader using a cabling system to support the weight of the branch.

Bracing

Bracing is the process of securing the union of two codominant leaders or stems using high strength steel rods to alleviate stresses at the union and reduce the likelihood of failure. Bracing may also be used to reinforce trees that have a partial failure and are likely to benefit from bracing.

Guying

Guying is the process of anchoring a tree's stem to the ground or another immovable object to reduce the likelihood of root failure. Guying can be temporary or permanent and is most often used for establishing a tree in the landscape.

Propping

Propping is the process of using rigid structures that are built on or into the ground to help support the trunk or branch(s) that are oriented near the ground in a horizontal position to reduce the likelihood of failure from the weight or defect of the tree part being supported.

Tree #15 recommended for cabling due to co-dominant leaders.

The following table lists all inventoried trees with structural support system recommendations:

INVENTORIED TREES WITH STRUCTURAL SUPPORT SYSTEM RECOMMENDATIONS (2 Trees)

Tree ID	Common Name	DBH	Tree Care Priority	Cable
14	Maple-Red	15	1	New 1
15	Maple-Red	19	1	New 1

INVENTORIED TREES WITH STRUCTURAL SUPPORT SYSTEM RECOMMENDATIONS

Structural Support: ● Cable

Lightning Protection Systems

Lightning strikes kill many people each year and can cause significant damage to objects on the property. Lightning protection systems are designed to provide a preferred path for lightning to the ground in a manner that minimizes tree damage; adjacent tree damage; and also to buildings, property, animals, and people near the tree. Tree species that are naturally more susceptible to lightning strikes, valuable to the landscape, and trees that are within 10 feet of, taller than, or have limbs that are extending over a structure are recommended for lightning protection systems due to the possibility of damage, "sideflashes", and step voltage.

At the time of inventory, no trees were recommended for lightning protection systems. However, as trees continue to grow and site changes occur, we recommend continual consultation with your local Bartlett Arborist Representative to determine if lightning protection systems are warranted in the future.

Tree Removal

In some cases, the inspector may determine need for removal while assessing the tree. Trees may be recommended for removal during the inventory for several reasons:

- The tree is dead;
- The tree is in poor condition and thought to be beyond rehabilitation;
- The tree is over-mature and will continue to decline in condition;
- The tree has significant structural weaknesses that cannot be addressed;
- The tree is already or will interfere with infrastructure (overhead lines for example);
- The location value for the tree is poor or unacceptable (for example, large maturing tree growing directly under overhead lines); and/or,
- The tree species has been declared an invasive for the given area or region.

The tree(s) listed in the table below are recommended for removal:

INVENTORIED TREES RECOMMENDED FOR REMOVAL (6 Trees)

Tree ID	Common Name	DBH	Overall Risk Rating	Condition	Tree Care Priority	Defect(s) or Observation(s)
23	Tree of Heaven	33	Moderate	Poor	1	• Buried root collar • Decay-Root flare • Cavity-stem • Hanger • Dead branches >2
24	Tree of Heaven	36	Moderate	Poor	1	• Buried root collar • Broken branch(s) • Lion tailing • Wound-root flare • Cavity-Suspected
26	Tree of Heaven	41	Moderate	Poor	1	• Co-dominant leaders • Included bark • Cavity-stem • Dead branches >2 • Lion tailing • Wound-root flare
25	Tree of Heaven	22	Low	Poor	1	• Dead branches >2 • Decay-Root flare • Co-dominant leaders • Dieback (severe)

Tree ID	Common Name	DBH	Overall Risk Rating	Condition	Tree Care Priority	Defect(s) or Observation(s)
27	Maple-Norway	16	Low	Poor	1	• Buried root collar • Girdling roots suspected • Decay-Stem • Dead branches >2
33	Magnolia	3	...	Dead	1	• Dead branches >2 • Buried root collar

INVENTORIED TREES RECOMMENDED FOR REMOVAL

Tree Risk *Advanced Assessments (Level 3)*

As part of the inventory process, the Inventory Team conducts a *basic assessment (Level 2)* from the ground. During this assessment the inspector can determine whether some aspect of tree structure or health indicates that a more comprehensive tree structure evaluation *(Level 3) advanced assessment* is needed to more thoroughly evaluate tree condition and risk of failure.

In such cases, we may recommend *(Level 3) advanced assessments* of the roots, stem, or crown. These assessments may include climbing inspections, examination of the root system using a compressed-air tool (that avoids damage to roots and underground utilities), or one or more of the following: resistance drilling; using the resistograph (a precision drilling instrument that provides graphical output); or sonic tomography that produces a visual representation of internal conditions based on how sound moved through the tree. The goal is to use the appropriate method to evaluate impact of wood decay in stems and buttress roots that show potential for failure and to determine presence and condition of the root system.

Once we complete such *(Level 3) advanced assessments*, we can then recommend appropriate measures, such as remediation, maintenance, or removal.

At the time of inventory, no trees were recommended for *advanced assessments*. However, as trees continue to grow and site changes occur, we recommend continual consultation with your local Bartlett Arborist Representative to determine if *advanced assessments* are warranted in the future.

DEFECTS OR OBSERVATIONS

DEFECTS OR OBSERVATIONS

The following table lists inventoried trees for which we noted defects, observations, or other structural issues.

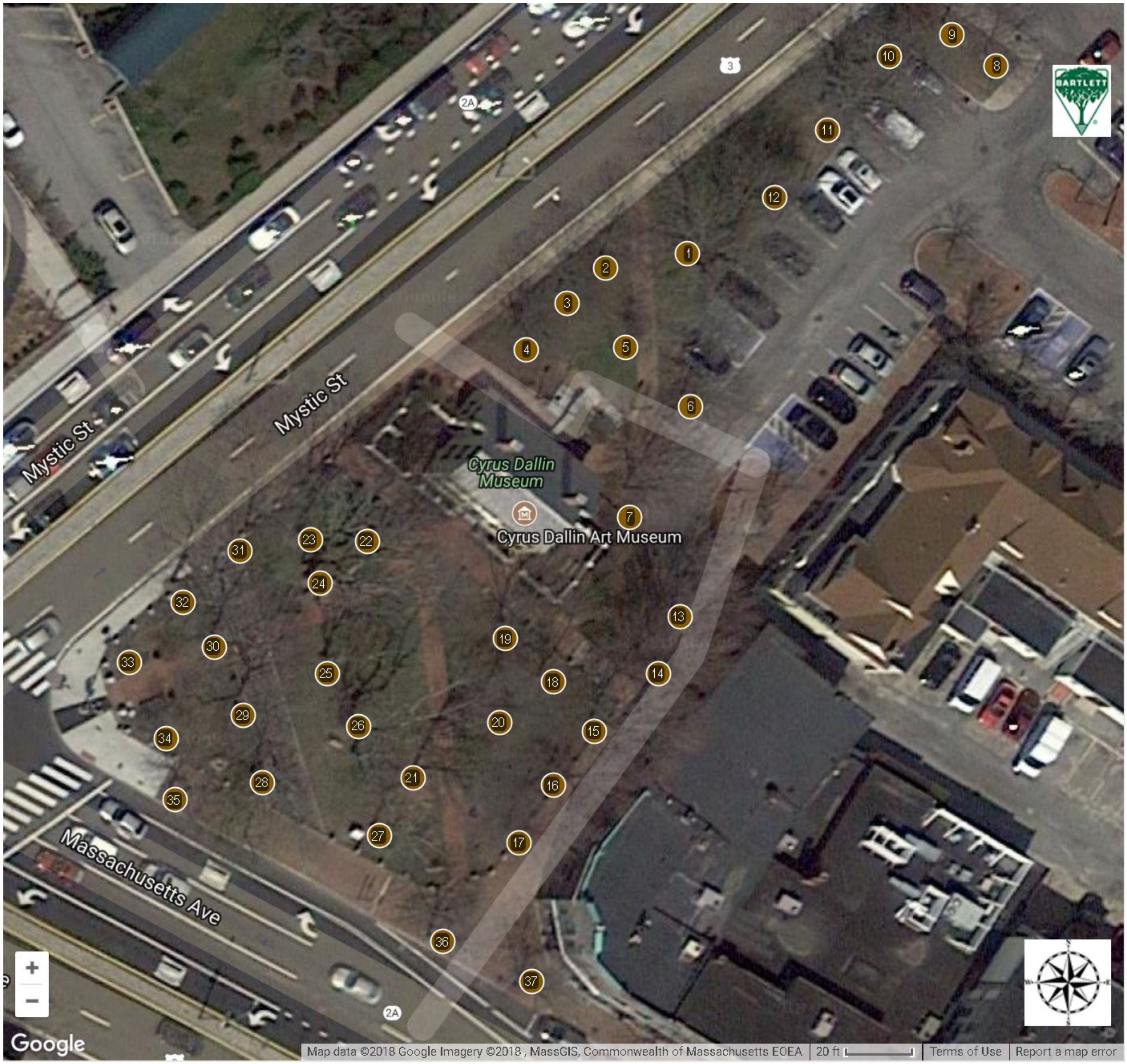
INVENTORIED TREES WITH DEFECTS, OBSERVATIONS, OR OTHER STRUCTURAL ISSUES (37 Trees)

Tree ID	Common Name	DBH	Defect(s) or Observation(s)
1	Honeylocust-Thornless Common	26	• Co-dominant leaders • Dead branches >2 • Wound-root
2	Maple-Red	13	• Dead branches <=2 • Wound-root
3	Maple-Red	13	• Wound-root • Girdling roots present
4	Maple-Red	13	• Girdling roots present • Wound-root • Dead branches <=2 • Poor branch structure
5	Crabapple	10	• Buried root collar • Uneven crown • Dead branches <=2 • Poor branch structure
6	Maple-Red	13	• Dead branches <=2
7	Maple-Red	16	• Dead branches <=2
8	Maple-Red	10	• Dead branches >2 • Uneven crown
9	Maple-Red	11	• Girdling roots present
10	Crabapple	12	• Poor branch structure • Dead branches <=2
11	Honeylocust-Thornless Common	25	• Wound-root • Dead branches >2 • Co-dominant leaders
12	Crabapple	7,7	• Co-dominant leaders • Included bark • Dead branches >2
13	Maple-Red	14	• Co-dominant leaders • Uneven crown • Poor branch structure
14	Maple-Red	15	• Co-dominant leaders • Dead branches <=2
15	Maple-Red	19	• Dead branches <=2 • Co-dominant leaders • Included bark

Tree ID	Common Name	DBH	Defect(s) or Observation(s)
16	Maple-Red	15	• Poor branch structure • Dead branches <=2
17	Maple-Red	14	• Poor branch structure • Dead branches <=2
18	Yellowwood	10	• Girdling roots present • Co-dominant leaders • Dead branches <=2
19	Yellowwood	15	• Dead branches <=2 • Girdling roots present
20	Oak-Pin	16	• Co-dominant leaders • Included bark • Dead branches <=2 • Poor branch structure
21	Oak-Pin	19	• Uneven crown
22	Oak-Pin	15	• Uneven crown
23	Tree of Heaven	33	• Buried root collar • Decay-Root flare • Cavity-stem • Hanger • Dead branches >2
24	Tree of Heaven	36	• Buried root collar • Broken branch(s) • Lion tailing • Wound-root flare • Cavity-Suspected
25	Tree of Heaven	22	• Dead branches >2 • Decay-Root flare • Co-dominant leaders • Dieback (severe)
26	Tree of Heaven	41	• Co-dominant leaders • Included bark • Cavity-stem • Dead branches >2 • Lion tailing • Wound-root flare
27	Maple-Norway	16	• Buried root collar • Girdling roots suspected • Decay-Stem • Dead branches >2
28	Maple-Norway	21	• Buried root collar • Girdling roots suspected • Uneven crown • Dead branches >2
29	Maple-Norway	21	• Girdling roots present • Dead branches >2 • Uneven crown

Tree ID	Common Name	DBH	Defect(s) or Observation(s)
30	Maple-Norway	18	• Dead branches >2 • Uneven crown
31	Maple-Norway	16	• Growing against object • Dead branches >2 • Uneven crown
32	Maple-Norway	19	• Girdling roots present (severe) • Dead branches >2 • Co-dominant leaders
33	Magnolia	3	• Dead branches >2 • Buried root collar
34	Magnolia	3,3,2,2,1,1	• Co-dominant stems • Included bark • Dead branches >2
35	Honeylocust-Thornless Common	11	• Buried root collar • Uneven crown • Dead branches <=2
36	Honeylocust-Thornless Common	13	• Buried root collar • Dead branches <=2
37	Honeylocust-Thornless Common	12	• Co-dominant leaders • Dead branches <=2

INVENTORIED TREES WITH DEFECTS, OBSERVATIONS, OR OTHER STRUCTURAL ISSUES



ENTIRE INVENTORY

ENTIRE INVENTORY (37 Trees)

Tree ID	Common Name	Genus	Species	DBH	Age Class	Condition Class	Tree Care Priority	Tree Asset Value
1	Honeylocust-Thornless Common	*Gleditsia*	*triacanthos* var. inermis	26	Mature	Good	2	$14,561.31
2	Maple-Red	*Acer*	*rubrum*	13	Semi-mature	Good	3	$3,900.35
3	Maple-Red	*Acer*	*rubrum*	13	Semi-mature	Good	3	$3,900.35
4	Maple-Red	*Acer*	*rubrum*	13	Semi-mature	Good	3	$3,900.35
5	Crabapple	*Malus*	sp.	10	Semi-mature	Fair	2	$1,538.60
6	Maple-Red	*Acer*	*rubrum*	13	Semi-mature	Good	...	$3,900.35
7	Maple-Red	*Acer*	*rubrum*	16	Mature	Good	...	$5,908.22
8	Maple-Red	*Acer*	*rubrum*	10	Semi-mature	Fair	2	$1,648.50
9	Maple-Red	*Acer*	*rubrum*	11	Semi-mature	Good	...	$2,792.56
10	Crabapple	*Malus*	sp.	12	Mature	Fair	2	$2,215.58
11	Honeylocust-Thornless Common	*Gleditsia*	*triacanthos* var. inermis	25	Mature	Good	1	$13,462.75
12	Crabapple	*Malus*	sp.	7,7	Mature	Poor	1	$904.70
13	Maple-Red	*Acer*	*rubrum*	14	Semi-mature	Good	2	$4,523.48
14	Maple-Red	*Acer*	*rubrum*	15	Mature	Good	1	$5,192.77
15	Maple-Red	*Acer*	*rubrum*	19	Mature	Good	1	$8,331.52
16	Maple-Red	*Acer*	*rubrum*	15	Semi-mature	Good	2	$5,192.77

Tree ID	Common Name	Genus	Species	DBH	Age Class	Condition Class	Tree Care Priority	Tree Asset Value
17	Maple-Red	*Acer*	*rubrum*	14	Semi-mature	Good	2	$4,523.48
18	Yellowwood	*Cladrastis*	*kentukea*	10	Semi-mature	Fair	2	$1,428.70
19	Yellowwood	*Cladrastis*	*kentukea*	15	Mature	Good	...	$4,500.40
20	Oak-Pin	*Quercus*	*palustris*	16	Mature	Good	2	$6,695.99
21	Oak-Pin	*Quercus*	*palustris*	19	Mature	Good	...	$9,442.39
22	Oak-Pin	*Quercus*	*palustris*	15	Mature	Fair	3	$4,203.67
23	Tree of Heaven	*Ailanthus*	*altissima*	33	Over-mature	Poor	1	$2,104.41
24	Tree of Heaven	*Ailanthus*	*altissima*	36	Over-mature	Poor	1	$2,453.57
25	Tree of Heaven	*Ailanthus*	*altissima*	22	Over-mature	Poor	1	$957.45
26	Tree of Heaven	*Ailanthus*	*altissima*	41	Over-mature	Poor	1	$3,001.74
27	Maple-Norway	*Acer*	*platanoides*	16	Mature	Poor	1	$2,194.48
28	Maple-Norway	*Acer*	*platanoides*	21	Mature	Fair	1	$6,300.57
29	Maple-Norway	*Acer*	*platanoides*	21	Mature	Fair	1	$6,300.57
30	Maple-Norway	*Acer*	*platanoides*	18	Mature	Fair	1	$4,628.99
31	Maple-Norway	*Acer*	*platanoides*	16	Mature	Poor	1	$2,194.48
32	Maple-Norway	*Acer*	*platanoides*	19	Mature	Poor	1	$3,094.56
33	Magnolia	*Magnolia*	sp.	3	Semi-mature	Dead	1	...
34	Magnolia	*Magnolia*	sp.	3,3,2,2,1,1	Semi-mature	Poor	2	$258.48
35	Honeylocust-Thornless Common	*Gleditsia*	*triacanthos* var. inermis	11	Semi-mature	Fair	2	$1,861.71
36	Honeylocust-Thornless Common	*Gleditsia*	*triacanthos* var. inermis	13	Semi-mature	Fair	...	$2,600.23
37	Honeylocust-Thornless Common	*Gleditsia*	*triacanthos* var. inermis	12	Semi-mature	Fair	3	$2,215.58

APPENDIX

BIBLIOGRAPHY

Council of Tree and Landscape Appraisers (CTLA). 2000. *Guide for Plant Appraisal*, 9th Edition. International Society of Arboriculture, Champaign, IL. 143 pp.

ADDITIONAL RESOURCES

Bartlett publishes a variety of tree-resource documents, including technical reports, plant health care recommendations, and service brochures. The following technical reports may be pertinent to your inventory. To access these documents and view the complete Bartlett Resource Library online, please follow this URL:

https://www.bartlett.com/resourcelist.cfm

Girdling Roots

Maintenance Pruning Program

Monitor IPM Program

Mulch Application Guidelines

Tree Risk Assessments

Tree Structure Evaluation

GLOSSARY OF TERMS

air pollution removal: removal of pollutants from the air by plants through natural processes

arborist: 1. An individual engaged in the profession of arboriculture who, through experience, education and related training, possesses the competence to provide for, or supervise the management of, trees and other woody ornamentals. [ANSI A300 (Part 1, 2, 4, 5, 6)] 2. An individual engaged in the profession of arboriculture. [ANSI Z133.1-2000 Safety Requirements for Arboricultural Operations]

bracing: The installation of lag-thread screw or threaded-steel rods in limbs, leaders, or trunks to provide supplemental support. [ANSI A300 (Part 3)-2000 Support Systems]

branch: An outgrowing shoot, stem or twig that grows from the main stem or trunk. [ANSI Z60.1â€"2004 Nursery Stock]

buttress roots: Lateral surface roots that aid in stabilizing the tree.

cable: 1) Zinc coated strand per ASTM A-475 for dead-end grip applications. 2) Wire rope or strand for general applications. 3) Synthetic-fiber rope or synthetic-fiber webbing for general applications. [ANSI A300 (Part 3)-2000 Support Systems]

cabling: The installation of a steel wire rope, steel strand, or synthetic-fiber system within a tree between limbs or leaders to limit movement and provide supplemental support. [ANSI A300 (Part 3)-2000 Support Systems]

canopy: collective branches and foliage of a tree or group of trees' crowns

carbon sequestration: removal of carbon from the air by plants through natural processes

carbon storage: storage of carbon removed from the air in plant tissues

cation exchange capacity(CEC): The ability of soil to absorb nutrients.

cavity: An open wound characterized by the presence of decay and resulting in a hollow.

cleaning: Selective pruning to remove one or more of the following parts: dead, diseased, and/ or broken branches (5.6.1). [ANSI A300 (Part 1)-2001 Pruning]

co-dominant branches: Equal in size and importance, usually associated with either the trunks, stems, or scaffold limbs.

conk: fruiting body or nonfruiting body of a fungus. Often associated with decay. critical root zone(CRZ): area of soil around a tree trunk where roots are located that provide stability and uptake of water and minerals required for tree survival.

crown: 1. The leaves and branches of a tree measured from the lowest branch on the trunk to the top of the tree. [ANSI A300 (Part 1)-2001Pruning] [ANSI A300 (Part 6)-2005 Transplanting] 2. The portion of a tree comprising the branches. [ANSI Z60.1-2004 Nursery Stock]

D.B.H. [diameter at breast height]: Measurement of trunk diameter taken at 4.5 feet (1.4 m) off the ground. [ANSI A300 (Part 6)- 2005 Transplanting]

decay: The degradation of woody tissue caused by microorganisms. [ANSI A300 (Part 1)- 2001 Pruning]

Geographic Information System (GIS): is any system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to earth.

girdling root: A root that may impede proper development of other roots, trunk flare, and/or trunk. [ANSI A300 (Part 6)-2005 Transplanting]

Global Positioning System (GPS): A constellation of at least 24 Medium Earth Orbit satellites that transmit precise microwave signals, the system enables a GPS receiver to determine its location, speed, direction, and time.

Global Positioning System receiver (GPSr): A receiver that receives its input from GPS satellites to determine location, speed, direction, and time.

heading: cutting a shoot back to a bud o cutting branches back to buds, stubs, or lateral branches not large enough to assume apical dominance. Cutting an older branch or stem back to meet a structural objective

integrated pest management (IPM): A pest control strategy that uses an array of complementary methods: mechanical devices, physical devices, genetic, biological, legal, cultural management, and chemical management. These methods are done in three stages of prevention, Observation, and finally Intervention. It is an ecological approach that has its main goal is to significantly reduce or eliminate the use of pesticides.

lateral branch: A shoot or stem growing from a parent branch or stem. [ANSI A300 (Part 1)- 2001 Pruning]

leader: A dominant or co-dominant, upright stem. [ANSI A300 (Part 1)-2001 Pruning]

lean: Departure from vertical of the stem, beginning at or near the base of the trunk.

limb: A large, prominent branch. [ANSI A300 (Part 1)-2001 Pruning] lion's tailing: The removal of an excessive number of inner, lateral branches from parent branches. Lion's tailing is not an acceptable pruning practice (5.5.7). [ANSI A300 (Part 1)- 2001 Pruning]

macronutrient: Nutrient required in relatively large amounts by plants, such as nitrogen (N), phosphorus (P), potassium (K), and sulfur (S). [ANSI A300 (Part 2)-2004 Fertilization]

micronutrient: Nutrient required in relatively small amounts by plants, such as iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), and boron (B). [ANSI A300 (Part 2)-2004 Fertilization]

noise attenuation: reducing sound levels via materials, structures, plants, etc.

nutrient: Element or compound required for growth, reproduction or development of a plant. [ANSI A300 (Part 2)-2004 Fertilization]

organic matter: material derived from the growth (and death) of living organisms. The organic components of soil.

parent branch or stem: A tree trunk, limb, or prominent branch from which shoots or stems grow. [ANSI A300 (Part 1)-2001 Pruning]

pH: unit of measurement that describes the alkalinity or acidity of a solution. Measured on a scale of 0 to 14. Greater than 7 Is alkaline, less than 7 is acid, and 7 is neutral (pure water).

pruning: The selective removal of plant parts to meet specific goals and objectives. [ANSI A300 (Part 1)-2001 Pruning]

qualified arborist: An individual who, by possession of a recognized degree, certification, or professional standing, or through related training and on-the-job experience, is familiar with the equipment and hazards involved in arboricultural operations and who has demonstrated ability in the performance of the special techniques involved. [ANSI Z133.1-2000 Safety Requirements for Arboricultural Operations]

raising: Selective pruning to provide vertical clearance (5.6.3). [ANSI A300 (Part 1)-2001 Pruning]

reduction: Selective pruning to decrease height and/or spread (5.6.4). [ANSI A300 (Part 1)-2001 Pruning]

risk assessment: process of evaluating what unexpected things could happen, how likely it is, and what the likely outcomes are. In tree management, the systematic process to determine the level of risk posed by a tree, tree part, or group of trees.

root collar: 1. The transition zone between the trunk and the root system. [ANSI A300 (Part 6)-2005 Transplanting] 2. See COLLAR. [ANSI Z60.1-2004 Nursery Stock]

root flare or trunk flare: The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk. [ANSI Z60.1-2004 Nursery Stock] [ANSI A300 (Part 6)-2005 Transplanting]

root zone: The volume of soil containing the roots of a plant. [ANSI A300 (Part 5)-2005

secondary nutrient: Nutrient required in moderate amounts by plants, such as calcium (Ca) and magnesium (Mg). [ANSI A300 (Part 2)-2004 Fertilization]

seam: Vertical line that appears where two edges of wound wood or callus ridge meet.

soil amendment: Any material added to soil to alter its composition and structure, such as sand, fertilizer, or organic matter. [ANSI A300 (Part6)-2005 Transplanting]

soil pH: A measure of the acidity or alkalinity of the soil.

stormwater runoff: water (generally from rain or snow melt) that flows over the ground after storm events.

structural support system: hardware installed in tree, may be; cables, braces, or guys, to provide supplemental support.

sweep: Departure from vertical of the stem, beginning above the base of the trunk.

thinning: Selective pruning to reduce density of live branches (5.6.2). [ANSI A300 (Part 1)-2001 Pruning]

tree risk assessment: Closer inspection of visibly damaged, dead, defected, diseased, leaning or dying tree to determine management needs.

topping: The reduction of a tree's size using heading cuts that shorten limbs or branches back to a predetermined crown limit. Topping is not acceptable pruning practice. (5.5.7). [ANSI A300 (Part 1)-2001 Pruning]

tree inventory: A comprehensive list of individual trees providing descriptive information on all or a portion of the project area. [ANSI A300 (Part 5)-2005 Management during site planning, site development, and construction]

tree protection zone: A space above and belowground within which trees are to be retained and protected. [ANSI A300 (Part 5)-2005 Management during site planning, site development, and construction]

trunk: That portion of a stem or stems of a tree before branching occurs. [ANSA Z60.1-2004 Nursery Stock]

vigor : Overall health. Capacity to grow and resist stress. [ISA Municipal Specialist Certification Study Guide 2008]

wound: An opening that is created when the bark of a living branch or stem is penetrated, cut, or removed. [ANSI A300 (Part 1)-2001 Pruning]

ANSI A300 (Part 1)-2008 Pruning
Revision of ANSI A300 (Part 1)-2001

American National Standard

for Tree Care Operations —

Tree, Shrub, and Other Woody Plant Management — Standard Practices (Pruning)

ANSI A300 (Part 1)-2008 Pruning
Revision of ANSI A300 (Part 1)-2001

TCIA®
VOICE OF TREE CARE

Approved American National Standard
ANSI

ANSI®
A300 (Part 1)-2008

for Tree Care Operations —

Tree, Shrub, and Other Woody Plant Management — Standard Practices *(Pruning)*

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Contents

* The term pruning type is replaced with the term pruning method. The purpose of this is to label the processes detailed in section 6 with greater accuracy.

Foreword This foreword is not part of American National Standard A300 (Part 1)-2008 *Pruning*

ANSI A300 Standards are divided into multiple parts, each focusing on a specific aspect of woody plant management (e.g. Pruning, Fertilization, etc).

These standards are used to develop written specifications for work assignments. They are not intended to be used as specifications in and of themselves. Management objectives may differ considerably and therefore must be specifically defined by the user. Specifications are then written to meet the established objectives and must include measurable criteria.

ANSI A300 standards apply to professionals who provide for or supervise the management of trees, shrubs, and other woody landscape plants. Intended users include businesses, government agencies, property owners, property managers, and utilities. The standard does not apply to agriculture, horticultural production, or silviculture, except where explicitly noted otherwise.

This standard has been developed by the Tree Care Industry Association (TCIA), an ANSI-accredited Standards Developing Organization (SDO). TCIA is secretariat of the ANSI A300 standards, and develops standards using procedures accredited by the American National Standards Institute (ANSI).

Consensus for standards writing was developed by the Accredited Standards Committee on Tree, Shrub, and Other Woody Plant Management Operations – Standard Practices, A300 (ASC A300).

Prior to 1991, various industry associations and practitioners developed their own standards and recommendations for tree care practices. Recognizing the need for a standardized, scientific approach, green industry associations, government agencies and tree care companies agreed to develop consensus for an official American National Standard.

The result – ANSI A300 standards – unify and take authoritative precedence over all previously existing tree care industry standards. ANSI requires that approved standards be developed according to accepted principles, and that they be reviewed and, if necessary, revised every five years.

TCIA was accredited as a standards developing organization with ASC A300 as the consensus body on June 28, 1991. ASC A300 meets regularly to write new, and review and revise existing ANSI A300 standards. The committee includes industry representatives with broad knowledge and technical expertise from residential and commercial tree care, utility, municipal and federal sectors, landscape and nursery industries, and other interested organizations.

Suggestions for improvement of this standard should be forwarded to: A300 Secretary, c/o Tree Care Industry Association, Inc., 136 Harvey Road - Suite B101-B110, Londonderry, NH, 03053.

ANSI A300 (Part 1)-2008 Pruning was approved as an American National Standard by ANSI on May 1, 2008. ANSI approval does not require unanimous approval by ASC A300. The ASC A300 committee contained the following members at the time of ANSI approval:

Tim Johnson, Chair
(Artistic Arborist, Inc.)

Bob Rouse, Secretary
(Tree Care Industry Association, Inc.)

(Continued)

Organizations Represented	*Name of Representative*
American Nursery and Landscape Association	Warren Quinn
	Craig J. Regelbrugge (Alt.)
American Society of Consulting Arborists	Donald Zimar
American Society of Landscape Architects	Ron Leighton
Asplundh Tree Expert Company	Geoff Kempter
	Peter Fengler (Alt.)
Bartlett Tree Expert Company	Peter Becker
	Dr. Thomas Smiley (Alt.)
Davey Tree Expert Company	Joseph Tommasi
	R.J. Laverne (Alt.)
International Society of Arboriculture	Bruce Hagen
	Sharon Lilly (Alt.)
National Park Service	Robert DeFeo
	Dr. James Sherald (Alt.)
Professional Grounds Management Society	Thomas Shaner
Professional Land Care Network	Preston Leyshon
Society of Municipal Arborists	Gordon Mann
	Andy Hillman (Alt.)
Tree Care Industry Association	Dane Buell
	James McGuire (Alt.)
USDA Forest Service	Ed Macie
	Keith Cline (Alt.)
Utility Arborist Association	Matthew Simons
	Jeffrey Smith (Alt.)

Additional organizations and individuals:

American Forests (Observer)
Mike Galvin (Observer)
Peter Gerstenberger (Observer)
Dick Jones (Observer)
Myron Laible (Observer)
Beth Palys (Observer)
Richard Rathjens (Observer)
Richard Roux (NFPA-780 Liaison)

ASC A300 mission statement:

Mission: To develop consensus performance standards based on current research and sound practice for writing specifications to manage trees, shrubs, and other woody plants.

American National Standard for Tree Care Operations –

Tree, Shrub, and Other Woody Plant Management – Standard Practices *(Pruning)*

1 ANSI A300 standards

1.1 Scope

ANSI A300 standards present performance standards for the care and management of trees, shrubs, and other woody plants.

1.2 Purpose

ANSI A300 performance standards are intended for use by federal, state, municipal and private entities including arborists, property owners, property managers, and utilities for developing written specifications.

1.3 Application

ANSI A300 performance standards shall apply to any person or entity engaged in the management of trees, shrubs, or other woody plants.

2 Part 1 – Pruning standards

2.1 Purpose

The purpose of Part 1 – *Pruning* is to provide performance standards for developing written specifications for pruning.

2.2 Reasons for pruning

The reasons for tree pruning may include, but are not limited to, reducing risk, managing tree health and structure, improving aesthetics, or achieving other specific objectives. Pruning practices for agricultural, horticultural production, or silvicultural purposes are exempt from this standard unless this standard, or a portion thereof, is expressly referenced in standards for these other related areas.

2.3 Implementation

2.3.1 Specifications for pruning should be written and administered by an arborist.

2.3.1.1 Specifications should include location of tree(s), objectives, methods (types), and extent of pruning (location, percentage, part size, etc).

2.3.2 Pruning specifications shall be adhered to.

2.4 Safety

2.4.1 Pruning shall be implemented by an arborist, familiar with the practices and hazards of pruning and the equipment used in such operations.

2.4.2 This performance standard shall not take precedence over applicable industry safe work practices.

2.4.3 Performance shall comply with applicable Federal and State Occupational Safety and Health standards, ANSI Z133.1, Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and other Federal Environmental Protection Agency (EPA) regulations, as well as state and local regulations.

3 Normative references

The following standards contain provisions, which, through reference in the text, constitute provisions of this American National Standard. All standards are subject to revision, and parties to agreements based on this American National Standard shall apply the most recent edition of the standards indicated below.

ANSI Z60.1, Nursery stock
ANSI Z133.1, Arboriculture – Safety requirements
29 CFR 1910, General industry [1)]
29 CFR 1910.268, Telecommunications [1)]
29 CFR 1910.269, Electric power generation, transmission, and distribution [1)]
29 CFR 1910.331 - 335, Electrical safety-related work practices [1)]

4 Definitions

4.1 arboriculture: The art, science, technology, and business of commercial, public, and utility tree care.

1) Available from U.S. Department of Labor, 200 Constitution Avenue, NW, Washington, DC 20210

4.2 arborist: An individual engaged in the profession of arboriculture who, through experience, education, and related training, possesses the competence to provide for or supervise the management of trees and other woody plants.

4.3 arborist trainee: An individual undergoing on-the-job training to obtain the experience and the competence required to provide for or supervise the management of trees and other woody plants. Such trainees shall be under the direct supervision of an arborist.

4.4 branch: A shoot or stem growing from a parent branch or stem (See Fig. 4.4).

4.4.1 codominant branches/codominant leaders: Branches or stems arising from a common junction, having nearly the same size diameter (See Fig. 4.4).

4.4.2 lateral branch: A shoot or stem growing from another branch (See Fig. 4.4).

4.4.3 parent branch or stem: A tree trunk or branch from which other branches or shoots grow (See Fig. 4.4).

4.4.4 scaffold branch: A primary branch that forms part of the main structure of the crown (See Fig. 4.4).

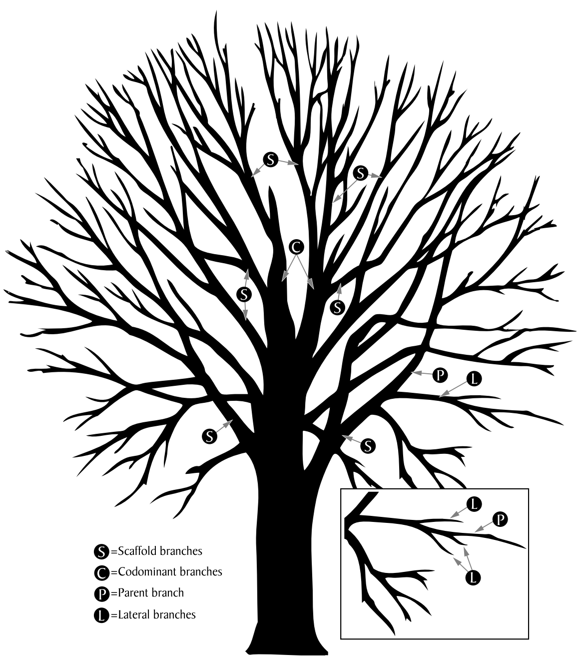


Figure 4.4 Standard branch definitions.

4.5 branch bark ridge: The raised area of bark in the branch crotch that marks where the branch and parent stem meet. (See Figs. 5.3.2 and 5.3.3).

4.6 branch collar: The swollen area at the base of a branch.

4.7 callus: Undifferentiated tissue formed by the cambium around a wound.

4.8 cambium: The dividing layer of cells that forms sapwood (xylem) to the inside and inner bark (phloem) to the outside.

4.9 clean: Selective pruning to remove one or more of the following non-beneficial parts: dead, diseased, and/or broken branches (7.2).

4.10 climbing spurs: Sharp, pointed devices strapped to a climber's lower legs used to assist in climbing trees. (syn.: gaffs, hooks, spurs, spikes, climbers)

4.11 closure: The process in a woody plant by which woundwood grows over a pruning cut or injury.

4.12 crown: Upper part of a tree, measured from the lowest branch, including all the branches and foliage.

4.13 decay: The degradation of woody tissue caused by microorganisms.

4.14 espalier: The combination of pruning, supporting, and training branches to orient a plant in one plane (6.5).

4.15 establishment: The point after planting when a tree's root system has grown sufficiently into the surrounding soil to support growth and anchor the tree.

4.16 facility: A structure or equipment used to deliver or provide protection for the delivery of an essential service, such as electricity or communications.

4.17 frond: A leaf structure of a palm.

4.18 heading: The reduction of a shoot, stem, or branch back to a bud or to a lateral branch not large enough to assume the terminal role.

4.19 interfering branches: Crossing, rubbing, or upright branches that have the potential to damage tree structure and/or health.

4.20 internode: The area between lateral branches or buds.

4.21 job briefing: The communication of at least the following subjects for arboricultural operations: work specifications, hazards associated with the job, work procedures involved, special precautions, electrical hazards, job assignments, and personal protective equipment.

4.22 leader: A dominant, typically upright, stem – usually the main trunk. There can be several leaders in one tree.

4.23 lion's tailing: The removal of an excessive number of inner and/or lower lateral branches from parent branches. Lion's tailing is not an acceptable pruning practice (6.1.7).

4.24 live crown ratio: Crown height relative to overall plant height.

4.25 mechanical pruning: A pruning technique where large-scale power equipment is used to cut back branches (9.3.2).

4.26 method: A procedure or process for achieving an objective.

4.27 peeling: The removal of dead frond bases without damaging living trunk tissue at the point they make contact with the trunk. (syn.: shaving)

4.28 petiole: A stalk of a leaf or frond.

4.29 pollarding: Pruning method in which tree branches are initially headed and then reduced on a regular basis without disturbing the callus knob (6.6).

4.30 pruning: The selective removal of plant parts to meet specific goals and objectives.

4.31 qualified line-clearance arborist: An individual who, through related training and on-the-job experience, is familiar with the equipment and hazards in line clearance and has demonstrated the ability to perform the special techniques involved. This individual may or may not be currently employed by a line-clearance contractor.

4.32 qualified line-clearance arborist trainee: An individual undergoing line-clearance training under the direct supervision of a qualified line-clearance arborist. In the course of such training, the trainee becomes familiar with the equipment and hazards in line clearance and demonstrates ability in the performance of the special techniques involved.

4.33 raise: Pruning to provide vertical clearance (7.3).

4.34 reduce: Pruning to decrease height and/or spread (7.4).

4.35 remote area: As used in the utility pruning section of this standard, an unpopulated area.

4.36 restoration: Pruning to redevelop structure, form, and appearance of topped or damaged trees (6.3).

4.37 rural area: As used in the utility pruning section of this standard, a sparsely populated place away from large cities, suburbs, or towns but distinct from remote areas.

4.38 shall: As used in this standard, denotes a mandatory requirement.

4.39 shoot: Stem or branch and its leaves, especially when young.

4.40 should: As used in this standard, denotes an advisory recommendation.

4.41 specifications: A document stating a detailed, measurable plan or proposal for provision of a product or service.

4.42 sprouts: New shoots originating from epicormic or adventitious buds, not to be confused with suckers. (syn.: watersprouts, epicormic shoots)

4.43 standard, ANSI A300: The performance parameters established by industry consensus as a rule for the measure of extent, quality, quantity, value or weight used to write specifications.

4.44 stem: A woody structure bearing buds, foliage, and giving rise to other stems.

4.45 structural pruning: Pruning to improve branch architecture (6.2).

4.46 stub: Portion of a branch or stem remaining after an internodal cut or branch breakage.

4.47 subordination: Pruning to reduce the size and ensuing growth rate of a branch or leader in relation to other branches or leaders.

4.48 sucker: Shoot arising from the roots.

4.49 thin: pruning to reduce density of live branches (7.5).

4.50 throw line: A small, lightweight line with a weighted end used to position a climber's rope in a tree.

4.51 topping: Reduction of tree size using internodal cuts without regard to tree health or structural integrity. Topping is not an acceptable pruning practice (6.1.7).

4.52 tracing: The removal of loose, damaged tissue from in and around the wound.

4.53 trunk: The main woody part of a tree beginning at and including the trunk flare and extending up into the crown from which scaffold branches grow.

4.54 trunk flare: 1. The area at the base of the plant's trunk where it broadens to form roots. 2. The area of transition between the root system and trunk (syn.: root flare).

4.55 urban/residential areas: Populated areas including public and private property that are normally associated with human activity.

4.56 utility: A public or private entity that delivers a public service, such as electricity or communications.

4.57 utility space: The physical area occupied by a utility's facilities and the additional space required to ensure its operation.

4.58 vista/view prune: Pruning to enhance a specific view without jeopardizing the health of the tree (6.4).

4.59 wound: An opening that is created when the bark of a live branch or stem is cut, penetrated, damaged, or removed.

4.60 woundwood: Partially differentiated tissue responsible for closing wounds. Woundwood develops from callus associated with wounds.

5 Pruning practices

5.1 Tree inspection

5.1.1 An arborist or arborist trainee shall visually inspect each tree before beginning work.

5.1.2 If a condition is observed requiring attention beyond the original scope of the work, the condition should be reported to an immediate supervisor, the owner, or the person responsible for authorizing the work.

5.1.3 Job briefings shall be performed as outlined in ANSI Z133.1, subclause 3.1.4.

5.2 Tools and equipment

5.2.1 Equipment, tools, and work practices that damage living tissue and bark beyond the scope of normal work practices shall be avoided.

5.2.2 Climbing spurs shall not be used when entering and climbing trees for the purpose of pruning.

Exceptions:
- when branches are more than throw-line distance apart and there is no other means of climbing the tree;
- when the outer bark is thick enough to prevent damage to the inner bark and cambium;
- in remote or rural utility rights-of-way.

5.3 Pruning cuts

5.3.1 Pruning tools used in making pruning cuts shall be sharp.

5.3.2 A pruning cut that removes a branch at its point of origin shall be made close to the trunk or parent branch without cutting into the branch bark ridge or branch collar or leaving a stub (see Figure 5.3.2).

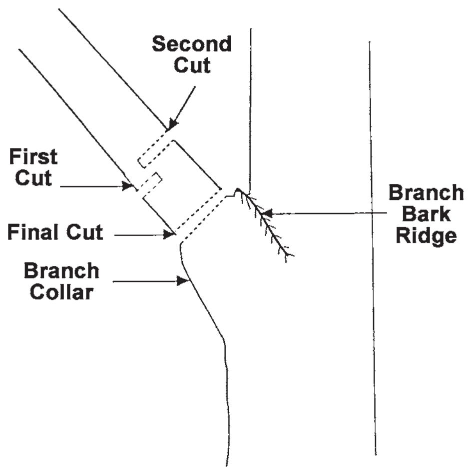


Figure 5.3.2. A cut that removes a branch at its point of origin. (See Annex A – Pruning cut guideline).

5.3.3 A pruning cut that reduces the length of a branch or parent stem shall be made at a slight downward angle relative to the remaining stem and not damage the remaining stem. Smaller cuts shall be preferred (see Fig. 5.3.3).

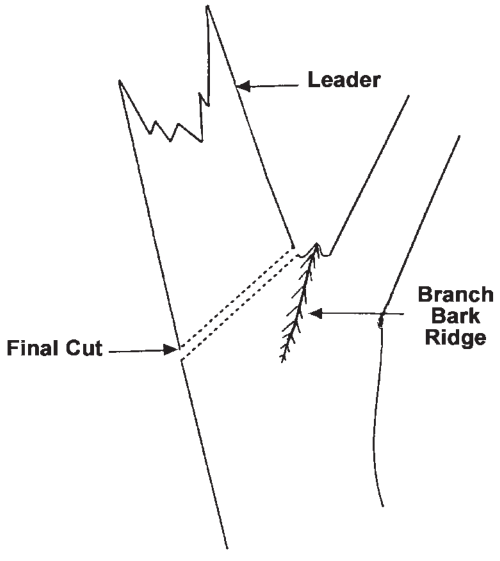


Figure 5.3.3. A cut that reduces the length of a branch or parent stem.

5.3.4 When pruning to a lateral, the remaining lateral branch should be large enough to assume the terminal role.

5.3.5 The final cut should result in a flat surface with adjacent bark firmly attached.

5.3.6 When removing a dead branch, the final cut shall be made just outside the collar of living tissue.

5.3.7 Tree branches shall be removed in such a manner so as to avoid damage to other parts of the tree or to other plants or property. Branches too large to support with one hand shall be precut to avoid splitting of the wood or tearing of the bark (see Figure 5.3.2). Where necessary, ropes or other equipment shall be used to lower large branches or portions of branches to the ground.

5.3.8 A cut that removes a branch with a narrow angle of attachment should be made from the outside of the branch to prevent damage to the parent branch (see Figure 5.3.8).

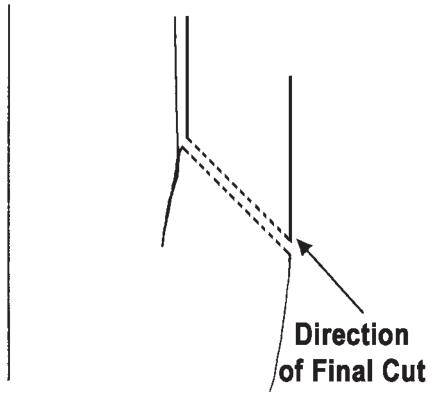


Figure 5.3.8. A cut that removes a branch with a narrow angle of attachment.

5.3.9 Severed branches shall be removed from the crown upon completion of the pruning, at times when the tree would be left unattended, or at the end of the workday.

5.4 Wound treatment

5.4.1 Wound treatments shall not be used to cover wounds or pruning cuts, except when necessary for disease, insect, mistletoe, or sprout control, or for cosmetic reasons.

5.4.2 Wound treatments that are damaging to tree tissues shall not be used.

5.4.3 When tracing wounds, only loose, damaged tissue shall be removed.

6 Pruning objectives

6.1 Pruning objectives shall be established prior to beginning any pruning operation.

6.1.1 Objectives should include, but are not limited to, one or more of the following:

- Risk reduction
- Manage health
- Clearance
- Structural improvement/correction
- View improvement/creation
- Aesthetic improvement
- Restoration

6.1.2 Established objectives should be specified in writing (See Annex B – *Specification writing guideline*).

6.1.3 To obtain the defined objective, the growth cycles, structure, species, and the extent of pruning to be performed shall be considered.

6.1.4 Not more than 25 percent of the foliage should be removed within an annual growing season. The percentage and distribution of foliage to be removed shall be adjusted according to the plant's species, age, health, and site.

6.1.5 When frequent excessive pruning is necessary for a tree to avoid conflicts with elements such as infrastructure, view, traffic, or utilities, removal or relocation of the tree shall be considered.

6.1.6 Pruning cuts should be made in accordance with section 5.3 *Pruning cuts*.

6.1.7 Topping and lion's tailing shall be considered unacceptable pruning practices for trees.

6.2 **Structural:** Structural pruning shall consist of selective pruning to improve tree and branch architecture primarily on young- and medium-aged trees.

6.2.1 Size and location of leaders or branches to be subordinated or removed should be specified.

6.2.2 Dominant leader(s) should be selected for development as appropriate.

6.2.3 Strong, properly spaced scaffold branch structure should be selected and maintained by reducing or removing others.

6.2.4 Temporary branches should be retained or reduced as appropriate.

6.2.5 Interfering, overextended, defective, weak, and poorly attached branches should be removed or reduced.

6.2.6 At planting, pruning should be limited to cleaning (7.2).

6.3 **Restoration:** Restoration shall consist of selective pruning to redevelop structure, form, and appearance of severely pruned, vandalized, or damaged trees.

6.3.1 Location in tree, size range of parts, and percentage of sprouts to be removed should be specified.

6.4 **Vista/view:** Vista/view pruning shall consist of the use of one or more pruning methods (types) to enhance a specific line of sight.

6.4.1 Pruning methods (types) shall be specified.

6.4.2 Size range of parts, location in tree, and percentage of foliage to be removed should be specified.

6.5 Espalier

6.5.1 Branches that extend outside the desired plane of growth shall be pruned or tied back.

6.5.2 Ties should be replaced as needed to prevent girdling the branches at the attachment site.

6.6 Pollarding

6.6.1 Consideration shall be given to the ability of the individual tree to respond to pollarding.

6.6.2 Management plans shall be made prior to the start of the pollarding process for routine removal of sprouts.

6.6.3 Heading cuts shall be made at specific locations to start the pollarding process. After the initial cuts are made, no additional heading cuts shall be made.

6.6.4 Sprouts growing from the cut ends of branches (knuckles) should be removed annually during the dormant season.

7 Pruning methods (types)

7.1 One or more of the following methods (types) shall be specified to achieve the objective.

7.2 **Clean:** Cleaning shall consist of pruning to remove one or more of the following non-beneficial parts: dead, diseased, and/or broken branches.

7.2.1 Location of parts to be removed shall be specified.

7.2.2 Size range of parts to be removed shall be specified.

7.3 **Raise:** Raising shall consist of pruning to provide vertical clearance.

7.3.1 Clearance distance shall be specified.

7.3.2 Location and size range of parts to be removed should be specified.

7.3.3 Live crown ratio should not be reduced to less than 50 percent.

7.4 **Reduce:** Reducing shall consist of pruning to decrease height and/or spread.

7.4.1 Consideration shall be given to the ability of a species to tolerate this type of pruning.

7.4.2 Location of parts to be removed or clearance requirements shall be specified.

7.4.3 Size of parts should be specified.

7.5 **Thin:** Thinning shall consist of selective pruning to reduce density of live branches.

7.5.1 Thinning should result in an even distribution of branches on individual branches and throughout the crown.

7.5.2 Not more than 25 percent of the crown should be removed within an annual growing season.

7.5.3 Location of parts to be removed shall be specified.

7.5.4 Percentage of foliage and size range of parts to be removed shall be specified.

8 Palm pruning

8.1 Palm pruning should be performed when fronds, fruit, or loose petioles may create a dangerous condition.

8.2 Live healthy fronds should not be removed.

8.3 Live, healthy fronds above horizontal shall not be removed. Exception: Palms encroaching on electric supply lines (see Fig. 8.3a and 8.3b).

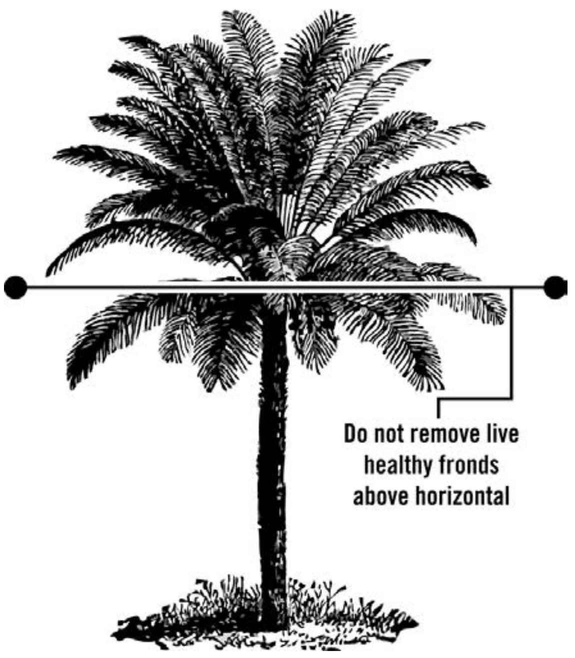


Figure 8.3a Frond removal location.

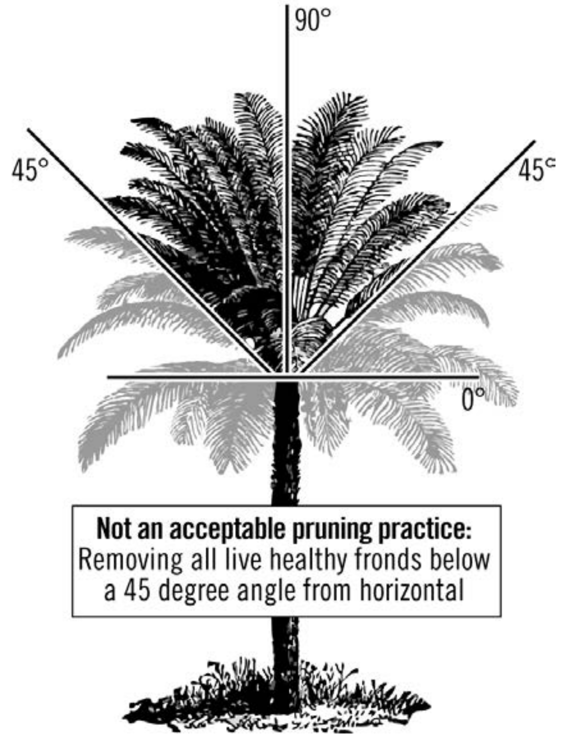


Figure 8.3b An overpruned palm (not an acceptable pruning practice).

8.4 Fronds removed should be severed close to the petiole base without damaging living trunk tissue.

8.5 Palm peeling (shaving) should consist of the removal of only the dead frond bases at the point they make contact with the trunk without damaging living trunk tissue.

9 Utility pruning

9.1 Purpose

The purpose of utility pruning is to prevent the loss of service, comply with mandated clearance laws, prevent damage to equipment, maintain access, and uphold the intended usage of the facility/utility space while adhering to accepted tree care performance standards.

9.2 General

9.2.1 Only a qualified line-clearance arborist or line-clearance arborist trainee shall be assigned to line clearance work in accordance with ANSI Z133.1, 29 CFR 1910.331 – 335, 29 CFR 1910.268 or 29 CFR 1910.269.

9.2.2 Utility pruning operations are exempt from requirements in subclause 5.1, *Tree Inspection*, for conditions outside the utility pruning scope of work.

9.2.3 Job briefings shall be performed as outlined in ANSI Z133.1, subclause 3.1.4.

9.3 Utility crown reduction pruning

9.3.1 Urban/residential areas

9.3.1.1 Pruning cuts should be made in accordance with subclause 5.3, *Pruning cuts*. The following requirements and recommendations of 9.3.1.1 are repeated from subclause 5.3 *Pruning cuts*.

9.3.1.1.1 A pruning cut that removes a branch at its point of origin shall be made close to the trunk or parent branch, without cutting into the branch bark ridge or collar, or leaving a stub (see Figure 5.3.2).

9.3.1.1.2 A pruning cut that reduces the length of a branch or parent stem shall be made at a slight downward angle relative to the remaining stem and not damage the remaining stem. Smaller cuts shall be preferred (see Fig. 5.3.3).

9.3.1.1.3 The final cut shall result in a flat surface with adjacent bark firmly attached.

9.3.1.1.4 When removing a dead branch, the final cut shall be made just outside the collar of living tissue.

9.3.1.1.5 Tree branches shall be removed in such a manner so as not to cause damage to other parts of the tree or to other plants or property. Branches too large to support with one hand shall be precut to avoid splitting of the wood or tearing of the bark (see Figure 5.3.2). Where necessary, ropes or other equipment shall be used to lower large branches or portions of branches to the ground.

9.3.1.1.6 A cut that removes a branch with a narrow angle of attachment should be made from the outside of the branch to prevent damage to the parent branch (see Figure 5.3.8).

9.3.1.2 A minimum number of pruning cuts should be made to accomplish the purpose of facility/utility pruning. The structure and growth habit of the tree should be considered.

9.3.1.3 Trees directly under and growing into facility/utility spaces should be removed or pruned. Such pruning should be done by removing entire branches or leaders or by removing branches that have laterals growing into (or once pruned, will grow into) the facility/utility space.

9.3.1.4 Trees growing next to, and into or toward, facility/utility spaces should be pruned by reducing branches to laterals (5.3.3) to direct growth away from the utility space or by removing entire branches. Branches that, when cut, will produce sprouts that would grow into facilities and/or utility space should be removed.

9.3.1.5 Branches should be cut to laterals or the parent branch and not at a pre-established clearing limit. If clearance limits are established, pruning cuts should be made at laterals or parent branches outside the specified clearance zone.

9.3.2 Rural/remote locations – mechanical pruning

Cuts should be made close to the main stem, outside of th branch bark ridge and branch collar. Precautions should be taken to avoid stripping or tearing of bark or excessive wounding.

9.4 Emergency service restoration

During a utility-declared emergency, service must be restored as quickly as possible in accordance with ANSI Z133.1, 29 CFR 1910.331 – 335, 29 CFR 1910.268, or 29 CFR 1910.269. At such times, it may be necessary, because of safety and the urgency of service restoration, to deviate from the use of proper pruning techniques as defined in this standard. Following the emergency, corrective pruning should be done as necessary.

Annex A
Pruning cut guideline

A-1 Three-cut method
Multiple cutting techniques exist for application of a three-cut method. A number of them may be used to implement an acceptable three-cut method.

A-1.1 The technique depicted in *Figure 5.3.2* demonstrates one example of a three-cut method that is common to hand-saw usage. It is not intended to depict all acceptable three-cut method techniques.

Annex B
Specification writing guideline

A300 (Part 1)-2008 *Pruning* standards are performance standards, and shall not be used as job specifications. Job specifications should be clearly detailed and contain measurable criteria.

The words "should" and "shall" are both used when writing standards. The word "shall" is used when writing specifications.

Writing specifications can be simple or complex and can be written in a format that suits your company/the job. The specifications consist of two sections.

I. General:

This section contains all aspects of the work to be performed that needs to be documented, yet does not need to be detailed.

Saying under the General section that "all work shall be completed in compliance with A300 Standards" means the clauses covering safety, inspections, cuts, etc. will be adhered to. There is no need to write each and every clause into every job specification.

Other items that may be covered in the General section could be: work hours and dates, traffic issues, disposal criteria, etc.

The second section under Job Specifications would be:

II. Details:

This section provides the clear and measurable criteria; the deliverables to the client.

This section, to be written in compliance with A300 standards, shall contain the following information:

1. **Objective – Clause 6**
   These objectives originate from/with the tree owner or manager. The arborist shall clearly state what is going to be done to achieve the objective(s).

   Objectives can be written for the entire job or individual trees. Rarely can one or two words clearly convey an objective so that all parties involved (client, sales, crew, etc.) can visualize the outcome.
2. **Method – Clause 7**
   Here the method(s) to be used to achieve the objective are stated. Again, depending on the type of job, this can be stated for the individual tree or a group of trees.
3. **Location – Clause 7.2.1, 7.3.2, 7.4.2, 7.5.3**
   This is the location in the tree(s) that the work methods are to take place.
4. **Density – Clause 7.3.1, 7.3.3, 7.5.1, 7.5.2, 7.5.4**
   This is the amount or volume of parts that are to be removed and can be stated exactly or in ranges.
5. **Size – Clause 7.2.2, 7.3.2, 7.4.3, 7.5.4**
   This is the size or range of sizes of cut(s) utilized to remove the volume specified.

   NOTE: Items # 4 & 5 are directly related to resource allocation, staffing and dollars.

SAMPLE PRUNING SPECIFICATIONS

#1. **Scope:** Large live oak on west side of pool

Objectives: Increase light penetration through east side of tree. Reduce risk potential of 1-inch-diameter branches falling.

Specifications: All broken branches and 1-inch-plus diameter dead branches shall be removed from the crown.

The three lowest 8-inch-plus diameter branches on the east side shall be thinned 25 percent with 1-inch- to 3-inch-diameter cuts.

NOTE: All work shall be completed in compliance with ANSI A300 and Z133.1 Standards.

Annex B
Specification writing guideline

#2. Scope: 1 Arizona ash

Objective: Enhance structure/structural development.

Specifications: General:

All pruning shall be completed in compliance with A300 Standards.

Detail:

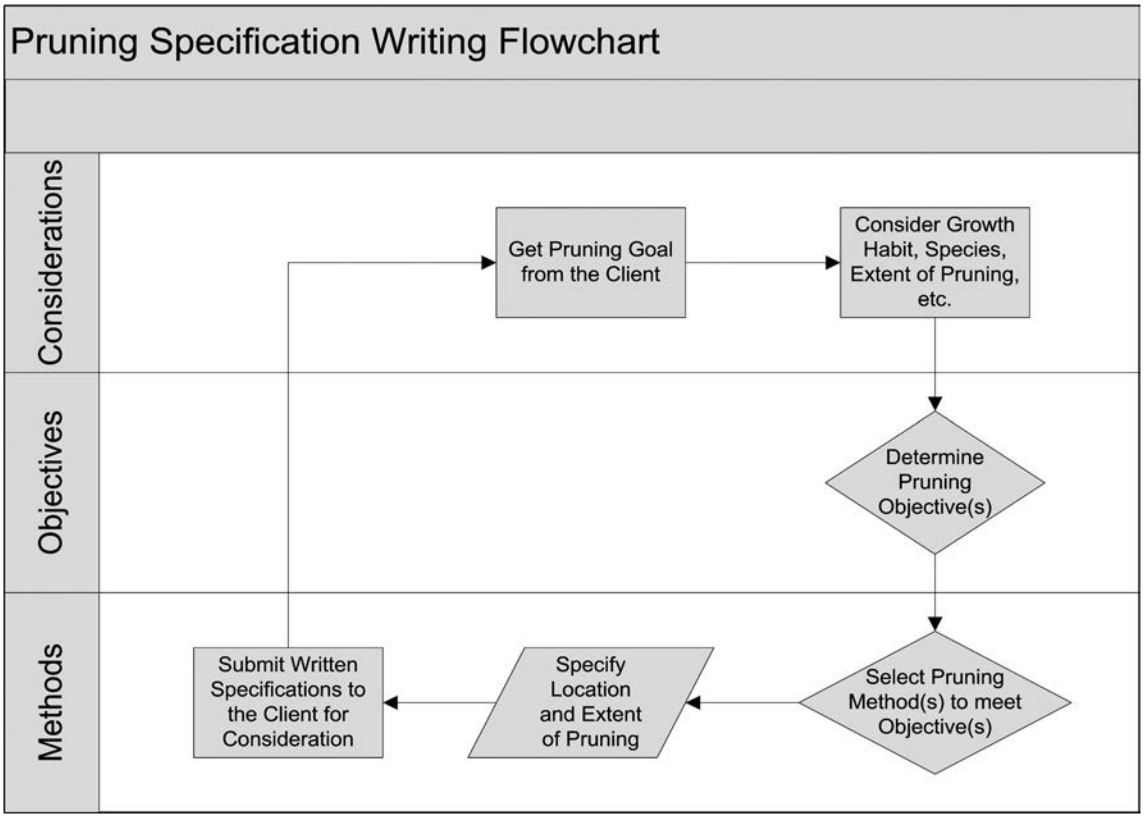
Thin crown 20-25 percent with 1-inch- to 4-inch-diameter cuts. Reduce west codominant leader by approximately 12 feet.

#3. Scope: Twenty-three newly installed evergreen elms

Objective: Maximize establishment – reduce nuisance while enhancing natural growth habit.

All work shall be completed in compliance with A300 Standards and the following specifications.

Specifications:
- Retain as much size as possible and 80-90 percent density of foliage.
- Lowest permanent branch will be 6 feet above grade in four to five years.
- Retain all sprout growth originating 18 inches above grade on trunk and 4 inches out from branch attachments throughout crown.
- Remove weakest rubbing branches.
- Remove dead branches.
- Reduce broken branches or branches with dead ends back to live laterals or buds. Heading cuts can be used.
- Maintain 6 inches behind adjacent edge of walks all growth that originates between 1.5 feet (18 inches) and 6 feet (72 inches) above grade. Heading cuts are acceptable.



Annex C
Applicable ANSI A300 interpretations

The following interpretations apply to Part 1 – *Pruning:*

C-1 Interpretation of "should" in ANSI A300 standards

"An advisory recommendation" is the common definition of "should" used in the standards development community and the common definition of "should" used in ANSI standards. An advisory notice is not a mandatory requirement. Advisory recommendations may not be followed when defensible reasons for non-compliance exist.

C-2 Interpretation of "shall" in ANSI A300 standards

"A mandatory requirement" is the common definition of "shall" used in the standards development community and the common definition of "shall" used in ANSI standards. A mandatory requirement is not optional and must be followed for ANSI A300 compliance.

ANSI A300 (Part 3)-2006
Revision of ANSI A300 (Part 3)-2000

American National Standard

Tree, Shrub, and Other Woody Plant Maintenance — Standard Practices (Supplemental Support Systems)

ANSI A300 (Part 3)-2006 Supplemental Support Systems
Revision of ANSI A300 (Part 3)-2000

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American National Standard
for Tree Care Operations –

Tree, Shrub, and Other Woody Plant Maintenance – Standard Practices *(Supplemental Support Systems)*

Secretariat

Tree Care Industry Association, Inc.

Approved August 4, 2006
American National Standards Institute, Inc.
Headquarters:
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Washington, DC 20036
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New York, NY 10036

American National Standard

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Figures and Tables

* indicates illustration adapted and formatted, with permission, from *Arborist Equipment: A Guide to the Tools and Equipment of Tree Maintenance and Removal*. International Society of Arboriculture Publishing, Champaign, IL.

Foreword (This foreword is not part of American National Standard A300 Part 3-2006)

An industry-consensus standard must have the input of the industry that it is intended to affect. The Accredited Standards Committee A300 was approved June 28, 1991. The committee includes representatives from the residential and commercial tree care industry, the utility, municipal, and federal sectors, the landscape and nursery industries, and other interested organizations. Representatives from varied geographic areas with broad knowledge and technical expertise contributed.

The A300 standards are placed in proper context if one reads the Scope, Purpose, and Application. This document presents performance standards for the care and maintenance of trees, shrubs, and other woody plants. It is intended as a guide in the drafting of maintenance specifications for federal, state, municipal, and private authorities including property owners, property managers, and utilities.

The A300 standards stipulate that specifications for tree work should be written and administered by a professional possessing the technical competence to provide for, or supervise, the management of woody landscape plants. Users of this standard must first interpret its wording, then apply their knowledge of growth habits of certain plant species in a given environment. In this manner, the users ultimately develop their own specifications for plant maintenance.

ANSI A300 Part 3 – *Supplemental Support Systems*, should be used in conjunction with the rest of the A300 standard when writing specifications for tree care operations.

Suggestions for improvement of this standard should be forwarded to: A300 Secretary, c/o Tree Care Industry Association, 3 Perimeter Road – Unit 1, Manchester, NH 03103, USA or e-mail: tcia@treecareindustry.org

This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee on Tree, Shrub, and Other Woody Plant Maintenance Operations – Standard Practices, A300. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the A300 committee had the following members:

Tim Johnson, Chair
(Artistic Arborist, Inc.)
Bob Rouse, Secretary
(Tree Care Industry Association, Inc.)

Organizations Represented	**Name of Representative**
American Nursery and Landscape Association	*Warren Quinn*
	Craig J. Regelbrugge (Alt.)
American Society of Consulting Arborists	*Tom Mugridge*
	Donald Zimar (Alt.)
American Society of Landscape Architects	*Ron Leighton*
Asplundh Tree Expert Company	*Geoff Kempter*
	Peter Fengler (Alt.)
Bartlett Tree Expert Company	*Peter Becker*
	Dr. Thomas Smiley (Alt.)

Davey Tree Expert Company .... *Joseph Tommasi*
Dick Jones (Alt.)
International Society of Arboriculture .... *Bruce Hagen*
Sharon Lilly (Alt.)
National Park Service .... *Robert DeFeo*
Dr. James Sherald (Alt.)
Professional Landcare Network .... *Preston Leyshon*
Tanya Tolpegin (Alt.)
Professional Grounds Management Society .... *Tom Shaner*
Society of Municipal Arborists .... *Andrew Hillman*
Tom Russo (Alt.)
Tree Care Industry Association .... *Dane Buell*
James McGuire (Alt.)
U.S. Forest Service .... *Ed Macie*
Keith Cline (Alt.)
Utility Arborist Association .... *Matthew Simons*
Jeffrey Smith (Alt.)

Additional organizations and individuals:

American Forests (Observer)
Beth Palys (Observer)
Peter Gerstenberger (Observer)
Mike Galvin (Observer)
Myron Laible (Observer)
Richard Rathjens (Observer)

American National Standard for Tree Care Operations –

Tree, Shrub, and Other Woody Plant Maintenance – Standard Practices *(Supplemental Support Systems)*

Clause 1 excerpted from ANSI A300 (Part 1) – 2001 *Pruning*

1 ANSI A300 standards

1.1 Scope

ANSI A300 standards present performance standards for the care and maintenance of trees, shrubs, and other woody plants.

1.2 Purpose

ANSI A300 standards are intended as guides for federal, state, municipal and private authorities including property owners, property managers, and utilities in the drafting of their maintenance specifications.

1.3 Application

ANSI A300 standards shall apply to any person or entity engaged in the business, trade, or performance of repairing, maintaining, or preserving trees, shrubs, or other woody plants.

1.4 Implementation

Specifications for tree maintenance should be written and administered by an arborist.

30 Part 3 – Supplemental Support Systems standards

30.1 Purpose

The purpose of Part 3 is to provide standards for writing specifications for supplemental support systems.

30.2 Reasons for supplemental support systems

Supplemental support systems are used to provide additional support or limit movement of a tree or tree part.

30.3 Safety

30.3.1 Tree maintenance shall only be performed by an arborist or arborist trainee.

30.3.2 This standard shall not take precedence over arboricultural safe work practices.

30.3.3 Operations shall comply with applicable Occupational Safety and Health Administration (OSHA) standards, ANSI Z133.1, as well as state and local regulations.

31 Normative references

The following standards contain provisions which, through reference in the text, constitute provisions of this American National Standard. All standards are subject to revision, and parties to agreements based on this American National Standard shall apply the most recent edition of the standards indicated below.

ANSI A300 Part 1 *Pruning*

ANSI A300 Part 4 *Lightning Protection Systems*

ANSI A300 Part 6 *Transplanting*

ANSI B18.12, *Glossary of Terms for Mechanical Fasteners*

ANSI Z60.1, *Nursery stock*

ANSI Z133.1, *Arboricultural operations – safety requirements*

ANSI/UL 96, *Lightning Protection Components*

ASTM A475, *Standard Specification for Zinc-Coated Steel Wire Strand*

Federal Standard: FF-T-276b, *Thimbles, Rope*

29 CFR 1910, *General industry*[1]

[1)] ***Available from U.S. Department of Labor, 200 Constitution Avenue, NW, Washington, DC 20210.***

29 CFR 1910.268, *Telecommunications* [1]

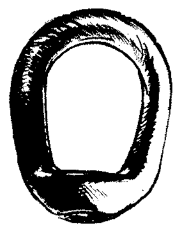
29 CFR 1910.269, *Electric power generation, transmission, and distribution* [1]

29 CFR 1910.331 - 335, *Electrical safety-related work practices* [1]

32 Definitions

32.1 amon-eye nut: A drop-forged eye nut.

Fig. 32.1 amon-eye nut



32.2 anchor: A cable-to-tree attachment.

32.3 anchor-tree: A tree used as an anchor in guying.

32.4 arborist: An individual engaged in the profession of arboriculture who, through experience, education and related training, possesses the competence to provide for or supervise the management of trees and other woody ornamentals.

32.5 arborist trainee: An individual undergoing on-the-job training to obtain the experience and the competence required to provide for, or supervise, the management of trees and woody ornamentals. Such trainees shall be under the direct supervision of an arborist.

32.6 bond: An electrical connection between an electrically conductive object and a component of a lightning protection system that is intended to significantly reduce potential differences created by lightning currents.

32.7 brace: Lag- or machine-threaded rods installed in or through limbs, leaders, or trunks used to provide supplemental support.

32.8 bracing: The installation of a brace system.

32.9 cable: 1) Zinc-coated strand per ASTM A475, such as extra-high strength (EHS) and common-grade, 7-strand. 2) Stainless steel or galvanized wire rope, such as aircraft cable. 3) Single strand wire. 4) Synthetic-fiber rope or synthetic-fiber webbing.

32.10 cable grip: A mechanical device that temporarily grasps and holds a wire rope or strand cable during installation.

32.11 cabling: The installation of a cable system between leaders, limbs, and branches within a tree to provide supplemental support.

32.12 connector clamp: A device meeting ANSI/UL-96 standard, used to bond a conductor to a steel cable.

32.13 dead-end brace: A brace formed by threading a lag-thread screw rod directly into the limb, leader, or trunk, but not through the side opposite the installation.

32.14 dead-end grip: A manufactured wire wrap designed to form a termination at the end of 1 X 7, left-hand lay cable that meets the specifications of ASTM A475 for zinc-coated strand.

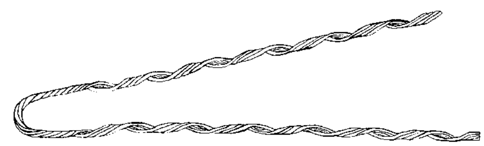


Fig. 32.14 dead-end grip

32.15 dead-end hardware: Anchors or braces that are threaded directly into the limb, leader, or trunk, but not through the side opposite the installation. Dead-end hardware includes but is not limited to: lag hooks, lag eyes, and lag-thread screw rod.

32.16 eye bolt: A drop-forged, closed-eye bolt.

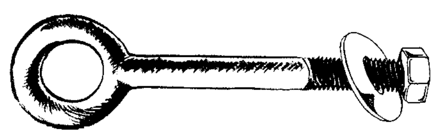


Fig. 32.16 eye bolt

32.17 eye splice: A closed-eye termination.

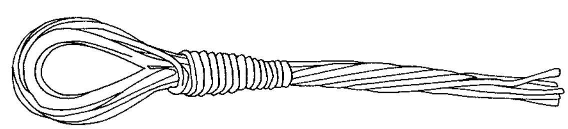


Fig. 32.17 eye splice

[1] *Available from U.S. Department of Labor, 200 Constitution Avenue, NW, Washington, DC 20210.*

32.18 ground anchor: A cable to ground attachment.

32.19 guy: A steel cable or synthetic-fiber cable system installed between a tree and an external anchor to provide supplemental support

32.20 guying: The installation of a guy system.

32.21 lag eye: A lag-thread, drop-forged, closed-eye anchor.

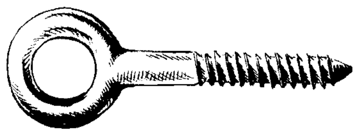


Fig. 32.21 lag eye

32.22 lag hook (J-hook): A lag-thread, J-shaped anchor.

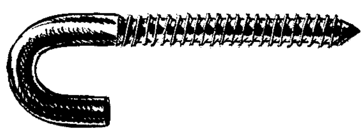


Fig. 32.22 lag hook

32.23 lag thread: A coarse screw thread designed for self-tapping into wood.

32.24 lag-thread hardware: Anchors or braces with lag-threads. Lag-thread hardware includes, but is not limited to, lag eyes, lag hooks, and lag-thread screw rod.

32.25 lag-thread screw rod: A lag-thread, steel rod used for dead-end and through-brace installations.

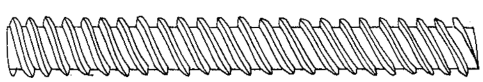


Fig. 32.25 lag-thread screw rod

32.26 loop anchor: A synthetic fiber termination that serves as an anchor.

32.27 machine thread: A fine screw thread designed for fittings (such as nuts).

32.28 machine-threaded rod: A machine-thread, steel rod used for through-brace installations.

32.29 peen: The act of bending, rounding or flattening the fastening end(s) of through-hardware for the purpose of preventing a nut from "backing-off."

32.30 prop: Rigid support placed between a trunk, limb, or branch and the ground.

32.31 propping: The installation of a prop to provide supplemental support.

32.32 shall: As used in this standard, denotes a mandatory requirement.

32.33 should: As used in this standard, denotes an advisory recommendation.

32.34 specifications: A document stating a detailed, measurable plan or proposal for provision of a product or service.

32.35 standards, ANSI A300: Performance parameters established by industry consensus as a rule for the measure of quantity, weight, extent, value, or quality.

32.36 supplemental support system: A system designed to provide additional support or limit movement of a tree or tree part.

32.37 taut: Tightened to the point of eliminating visible slack.

32.38 termination: A device or configuration that secures the end of a cable to the anchor in a cabling or guying installation.

32.39 termination hardware: Hardware used to form a termination. Termination hardware includes, but is not limited to, dead-end grips and thimbles used in eye-splice configurations.

32.40 thimble: An oblong galvanized or stainless steel fitting with flared margins and an open-ended base.

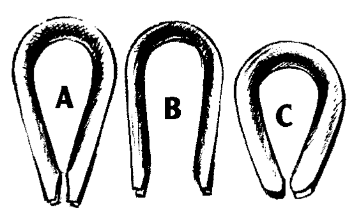


Fig. 32.40 thimble

32.41 through-brace: A brace formed by installing through-hardware into a limb, leader, or trunk completely through the side opposite the installation.

32.42 through-hardware: Anchors or braces that pass completely through a limb, leader, or trunk. Through-hardware includes but is not limited to: eye-bolts, lag-thread screw rod, and machine-threaded rod.

32.43 turnbuckle: A drop-forged, closed-eye device for adjusting tension.

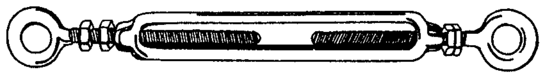
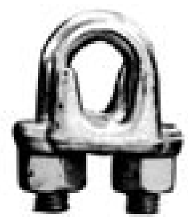


Fig. 32.43 turnbuckle

32.44 wire rope clamp: A clamp consisting of a "U" bolt, saddle plate, and fastening nuts.

Fig. 32.44 wire rope clamp



33 Supplemental support systems practices

33.1 Supplemental support systems objectives

Objectives for supplemental support systems shall be clearly defined prior to installation.

33.2 Tree inspection

33.2.1 A qualified arborist or arborist trainee shall visually inspect each tree before beginning work.

33.2.2 Structural integrity and potential changes in tree dynamics shall be considered prior to installing a supplemental support system.

33.2.3 If a condition is observed requiring attention beyond the original scope of work, the condition shall be reported to an immediate supervisor, the owner, or the person responsible for authorizing the work.

33.3 Tools and equipment

33.3.1 Climbing spurs shall not be used when climbing trees to install supplemental support systems, except in the case of emergencies, such as aerial rescue, or when the tree cannot be climbed safely by other methods.

33.3.2 Equipment and work practices that damage bark, cambium, live palm tissue, or any combination of these, beyond the scope of the work, should be avoided.

33.3.3 Cable grips used to tension the cable shall be designed for use with the type of cable being installed.

33.4 General

33.4.1 System design shall be specified.

33.4.2 When necessary to accomplish the objective, pruning should be performed prior to installing a supplemental support system. Pruning shall be in accordance with ANSI A300 Part 1 – *Pruning*.

33.4.3 Prior to installation, the owner or owner's agent should be notified of the need for periodic inspection of the supplemental support system by an arborist (see subclause 34.1). Scheduling inspections shall be the responsibility of the tree owner.

33.4.4 Anchors and braces shall not be installed into decayed areas where sound wood is less than 30 percent of the trunk or branch diameter (refer to Fig. 33.4.4).

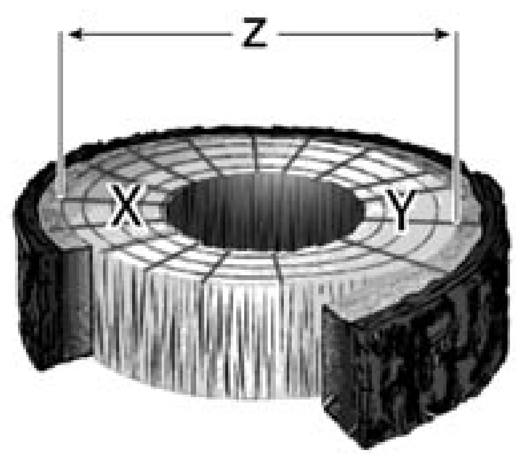


Fig. 33.4.4 Equations for finding the percentage of sound wood.

Symbol Key for Equations:
X = sound wood depth, working side.
Y = sound wood depth, opposite side.
Z = total trunk/branch diameter, bark diameter not included.

Equation for percentage of sound wood for through-bolt applications:

[(X + Y) ÷ Z] x 100 = % of sound wood for through-bolt applications.

Equation for percentage of sound wood for dead-end applications:

(X ÷ Z) x 100 = % of sound wood for dead-end applications.

33.4.5 Steel cables or guys in trees with existing lightning protection conductors shall be bonded to the lightning protection system. A connector clamp, designed for use in lightning protection systems, shall be used to bond steel cables or guys to the lightning protection system. Refer to ANSI A300 Part 4 – *Lightning Protection Systems*.

33.4.6 Supplemental support systems shall be installed in compliance with minimum distance specification in Table 1 in ANSI Z133.1 for overhead, energized conductors.

33.4.7 Steel hardware shall be corrosion resistant. Synthetic fiber cable systems shall be ultra-violet (UV) light resistant.

33.4.8 Wire rope clamps shall not be used to form terminations in cables larger than 1/8 inch (3 mm).

33.4.9 Treatment of cavities by filling shall not be considered to provide support.

33.5 Installation practices

33.5.1 Holes should not be drilled closer together than the diameter of the branch or trunk being drilled or 12 inches (30 cm), whichever is less. The diameter of the hole shall not be greater than one-sixth (1/6) the diameter of the limb, trunk, or branch at the point of installation (see Fig. 33.5.1).

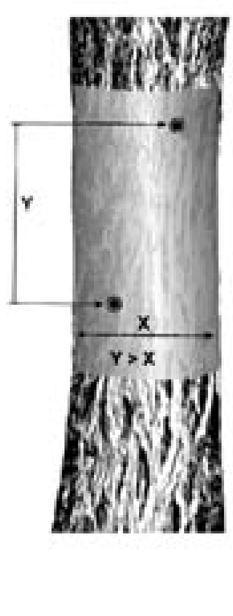


Fig. 33.5.1 Correct brace positioning

33.5.2 Longitudinal alignment of anchors and/or braces should be avoided.

33.5.3 Anchor(s) shall be installed in alignment with the cable and termination hardware, and not be subjected to side loading (see Fig. 33.5.3).

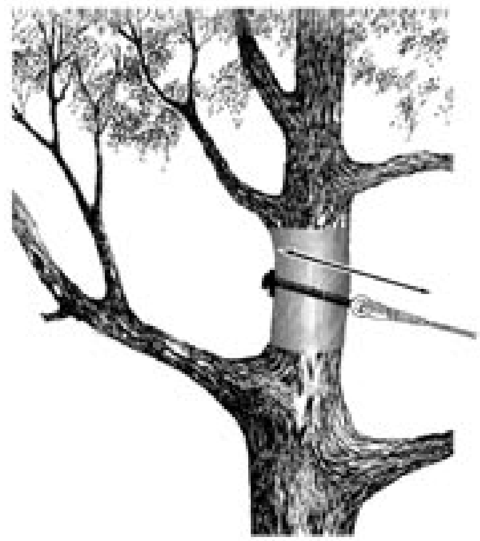


Fig. 33.5.3 Correct cable and hardware alignment

33.5.4 Synthetic cable systems shall have a restraint to prevent movement of the loop anchor and shall not girdle the trunk, limb or branch.

33.5.5 Only one termination shall be attached to an anchor.

33.5.6 Lag-thread hardware shall only be installed in sound wood. The hole shall be 1/16” to 1/8” (1.5-3 mm) smaller than the diameter of the lag-thread hardware.

33.5.7 For through-hardware applications, holes should be no greater than 1/8” (3 mm) larger in diameter than the hardware being installed.

33.5.8 Lag hooks shall only be used when they can be seated to the full length of the threads. If it is not possible to seat the full length of lag hook threads, other hardware shall be selected.

33.5.9 Lag hooks shall be installed to prevent the termination from coming off the hook. Bark should not be damaged beyond the scope of the work during installation.

33.5.10 When installing through-hardware, heavy-duty or heat-treated, heavy-duty round steel washers shall be installed between the nut(s) and the wood or bark (see Fig. 33.5.3).

33.5.11 Washers shall not be countersunk into the wood.

33.5.12 Fasteners for threaded hardware, such as nuts, amon eyes, and turnbuckles, shall be secured to prevent loosening.

33.5.13 Any excess portion of the through-hardware shall be removed.

33.5.14 Terminations shall be specified in the system design specifications.

33.5.15 Termination hardware shall be the appropriate size and type for the cable to be installed.

33.5.16 Terminations formed by eye-splice configurations shall incorporate thimbles.

33.5.17 Dead-end grip terminations shall only be used on cable that meets the specifications of ASTM A475.

33.5.18 Dead-end grip terminations shall incorporate extra heavy-duty wire rope thimbles – Type III, that meet the performance specifications of federal standard FF-T276b.

33.5.19 All hardware within a system shall meet or exceed the minimum strength required to achieve the objective.

33.5.20 Installations shall follow manufacturers' recommendations.

33.6 Cabling

33.6.1 Cabling objectives

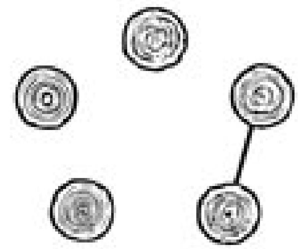
Cabling objectives shall be established prior to beginning any cabling operation.

33.6.2 Cabling types

Cabling system specifications should include one or more of the following types:

33.6.2.1 Direct: Direct cabling consists of a single cable between two tree parts (see Fig 33.6.2.1).

33.6.2.1.1 Location of hardware shall be specified.



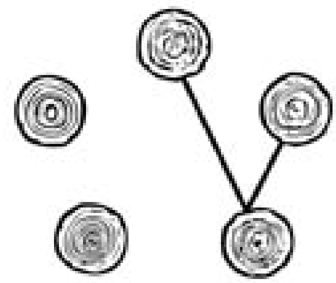
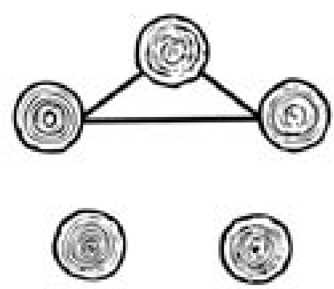


Fig. 33.6.2.1 Direct system with one cable (above), and direct system with two cables

33.6.2.2 Triangular: Consists of connecting tree parts in combination of threes. This method should be applied when maximum direct support is required (see Fig. 33.6.2.2).

33.6.2.2.1 Location of hardware shall be specified.



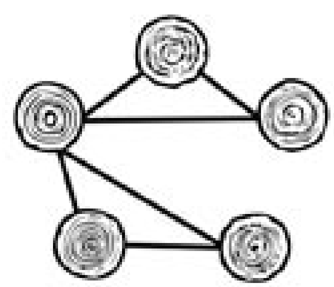


Fig. 33.6.2.2 One triangular system, and two triangular systems

33.6.2.3 Box: Consists of connecting four or more tree parts in a closed series. This system should be used only when minimal direct support is needed (see Fig. 33.6.2.3).

33.6.2.3.1 Location of hardware shall be specified.

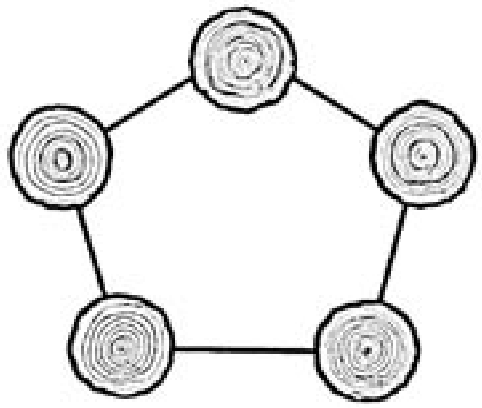


Fig. 33.6.2.3 Box system

33.6.2.4 Hub and Spoke: Consists of a center attachment (hub) with spans (spokes) of cable radiating to three or more leaders. Hub and Spoke cabling should only be used when other installation techniques cannot be installed to achieve the objective (see Fig. 33.6.2.4).

33.6.2.4.1 Location of hardware shall be specified.

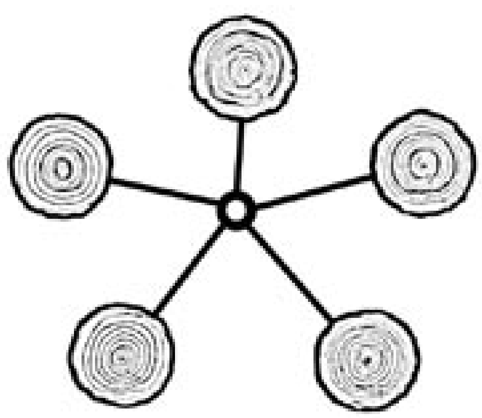


Fig. 33.6.2.4 Hub and spoke system

33.6.3 Cabling installation

33.6.3.1 Steel cables should be taut following installation.

33.6.3.2 Anchor(s) should be installed at or near a point two-thirds (2/3) of the length/height of the limb or leader to be supported (see Fig. 33.6.3.2).

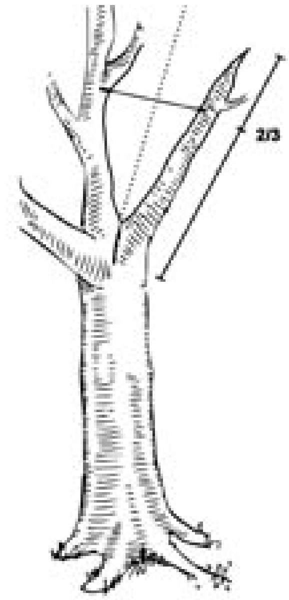


Fig. 33.6.3.2 Correct cable installation

33.6.3.3 The correct angle of cable installation should be perpendicular to an imaginary line bisecting the angle between the tree parts being cabled (see Fig. 33.6.3.2).

33.6.3.4 The continuous support function of existing cables shall be maintained when replacing or upgrading cable systems.

33.7 Bracing

33.7.1 Bracing objectives

Bracing objectives shall be established prior to beginning any bracing operation.

33.7.2 Bracing types

Bracing system specifications should include one or more of the following types:

33.7.2.1 Single: Single bracing consists of one installed rod (see Fig. 33.7.2.1).

Fig. 33.7.2.1 Single brace system

33.7.2.2 Parallel: Parallel bracing consists of two or more rods installed in vertical and directional alignment (see Fig. 33.7.2.2).

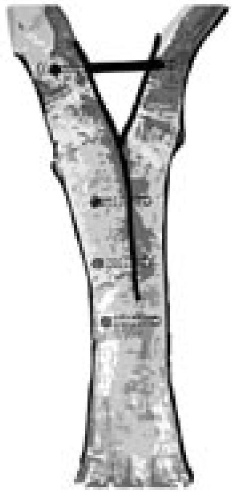


Fig. 33.7.2.2 Parallel brace system

33.7.2.3 Alternating: Alternating bracing consists of two or more rods installed in directional alignment but not in vertical alignment (see Fig. 33.7.2.3).

Fig. 33.7.2.3 Alternating brace system

33.7.2.4 Crossing: Crossing bracing consists of two or more rods installed in a non-aligned pattern (see Fig. 33.7.2.4).

Fig. 33.7.2.4 Crossing brace system

33.7.3 Bracing installation

33.7.3.1 A cabling system should be used to provide supplemental support for the limbs forming the crotch being braced.

33.7.3.2 The preferred location for a single rod for a non-split crotch should be one to two times the branch diameter above the crotch.

33.7.3.3 Brace systems using multiple rods should have at least one rod installed above the crotch.

33.7.3.4 Bracing shall be installed in either a through-brace or dead-end brace configuration.

33.7.3.5 The minimum hardware requirements for braces should be in accordance with Table 1 (English and metric equivalent).

33.7.3.6 Through-bracing

33.7.3.6.1 Through-braces shall be used when bracing through decayed wood in trees that are prone to decay, or in trees that have weak wood characteristics.

33.7.3.6.2 Through braces shall be terminated with heavy duty washers and nuts.

33.7.3.7 Dead-end bracing

33.7.3.7.1 Dead-end bracing shall be performed with lag-thread screw rod.

33.7.3.7.2 The brace shall be installed completely through the smaller or equal portion and at least halfway into the other portion (see Fig. 33.7.3.7.2).

33.7.3.7.3 The exposed end of the lag-thread screw rod shall be inside the bark or shall be fastened with a heavy duty or heat-treated washer and a nut (see Fig. 33.7.3.7.2).

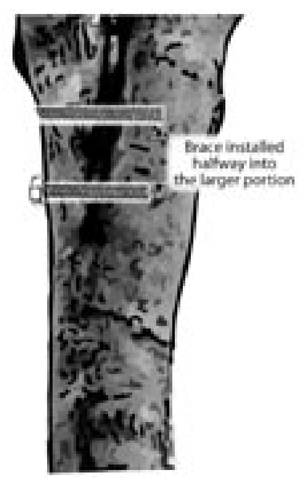


Fig. 33.7.3.7.2 Dead-end brace installation

Table 1 Minimum hardware requirements for bracing trees, English and metric equivalent

Diameter at Brace (in inches)	Brace Rod Diameter (in inches)	Minimum number of rods with split or included bark	Minimum number of rods with no apparent split or included bark
<5	1/4	1	1
5-8	3/8	1	1
8-14	1/2	2	1
14-20	5/8	2	1
20-40	3/4	3 min. with one additional for each 8" in excess of 30"	2 min. with one additional for each 8" in excess of 30"
>40	7/8	4 min. with one additional for each 8" in excess of 40"	3 min. with one additional for each 12" in excess of 40"

Diameter at Brace (in cm)	Brace Rod Diameter (in mm)	Minimum number of rods with split or included bark	Minimum number of rods with no apparent split or included bark
<13	6	1	1
13-20	10	1	1
20-36	12	2	1
36-51	16	2	1
51-102	20	3 min. with one additional for each 20 cm in excess of 76 cm	2 min. with one additional for each 20 cm in excess of 76 cm
>102	22	4 min. with one additional for each 20 cm in excess of 102 cm	3 min. with one additional for each 30 cm in excess of 102 cm

33.8 Propping

33.8.1 Propping objectives

Propping objectives shall be established prior to beginning any propping operation.

33.8.2 Propping installation

33.8.2.1 Props shall be of sufficient strength and durability to meet the objective.

33.8.2.2 Props shall be fastened to the branch in such a manner as to minimize damage and prevent the branch from falling off the prop.

33.8.2.3 Props shall be constructed in a manner so as not to restrict future growth of the branch.

33.8.2.4 Equipment and work practices that damage roots beyond the scope of the work shall be avoided.

33.8.2.5 Props shall be supported by the ground.

33.9 Guying established trees

33.9.1 Guying established trees – objectives

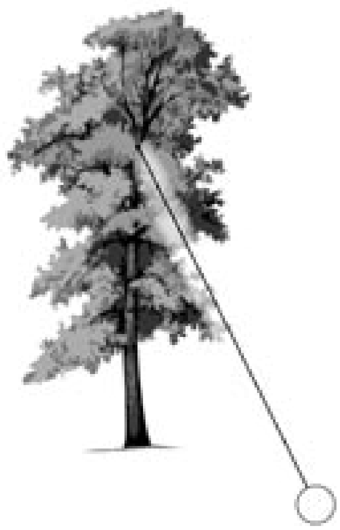
Objectives for guying established trees shall be established prior to beginning any guying operation.

33.9.2 Guying established trees – types

Specifications for guying established trees should include one or more of the following types:

33.9.2.1 Tree-to-ground: Tree-to-ground guying consists of installing at least one cable between a ground anchor and the tree to be guyed (see Fig. 33.9.2.1).

Fig. 33.9.2.1 Tree-to-ground system



33.9.2.2 Tree-to-tree: Tree-to-tree guying consists of installing at least one cable between an anchor-tree and the tree to be guyed (see Fig. 33.9.2.2).

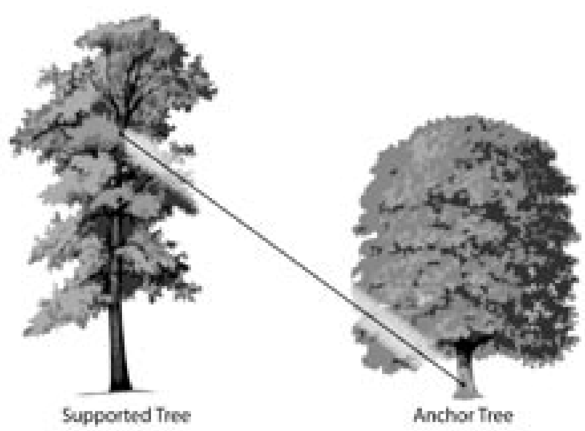


Fig. 33.9.2.2 Tree-to-tree system

33.9.3 Safety

33.9.3.1 The risk of damage or injury due to contact with guying installation components shall be considered.

33.9.4 Guying installation

33.9.4.1 Hardware in the tree shall be installed in alignment with the direction of pull and not be subjected to side loading.

33.9.4.2 Permanent guys shall be attached to the tree with dead-end hardware or through-hardware.

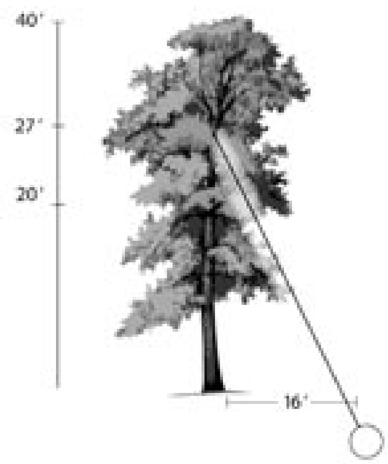
33.9.4.3 Tree-to-ground guying

33.9.4.3.1 Guys shall be secured to a ground-anchor(s) sufficient to achieve the objective.

33.9.4.3.2 Guys should be attached to the tree at or above a point not less than one-half the height of the tree (see Fig. 33.9.4.3.2).

33.9.4.3.3 Ground-anchor(s) should be placed no closer to the trunk than two-thirds the distance from the ground to the height of the lowest point of attachment in the tree, adjusted for slope and site conditions (see Fig. 33.9.4.3.2).

Fig. 33.9.4.3.2 Guy location in tree-to-ground systems



33.9.4.4 Tree-to-tree guying

33.9.4.4.1 Anchor-tree(s) shall be inspected for structural integrity.

33.9.4.4.2 Anchor-tree(s) shall have the ability to meet the objective.

33.9.4.4.3 Anchors shall be attached in the upper half of the tree to be guyed and in the lower half of the anchor-tree(s).

33.10 Guying newly installed landscape plants

33.10.1 Guying newly installed landscape plants – objectives

Guying objectives shall be established prior to beginning any guying operation.

33.10.2 Guying installation

33.10.2.1 Guys shall be attached using a method that minimizes damage to the tree.

33.10.2.2 A minimum of two guys should be installed at an angle sufficient to support the landscape plant.

33.10.2.3 For trees over 10-inch diameter, guys should be installed in accordance with subclause 33.9.

33.10.2.4 Guys shall be secured to a ground anchor(s) sufficient to achieve the objective.

33.10.2.5 Guys should be taut following installation.

33.10.2.6 Guys or other supplemental support systems shall be maintained and be removed when they are no longer needed as part of post planting care practices (see ANSI A300 Part 6 Transplanting).

34 Supplemental support systems inspection and maintenance

34.1 Systems should be inspected periodically for wear, corrosion, degradation of hardware and damage to the tree. The inspection should include the system's condition, position, cable tension, and the tree's structural integrity.

34.2 If problems are detected they should be corrected or the system should be repaired, replaced or modified.

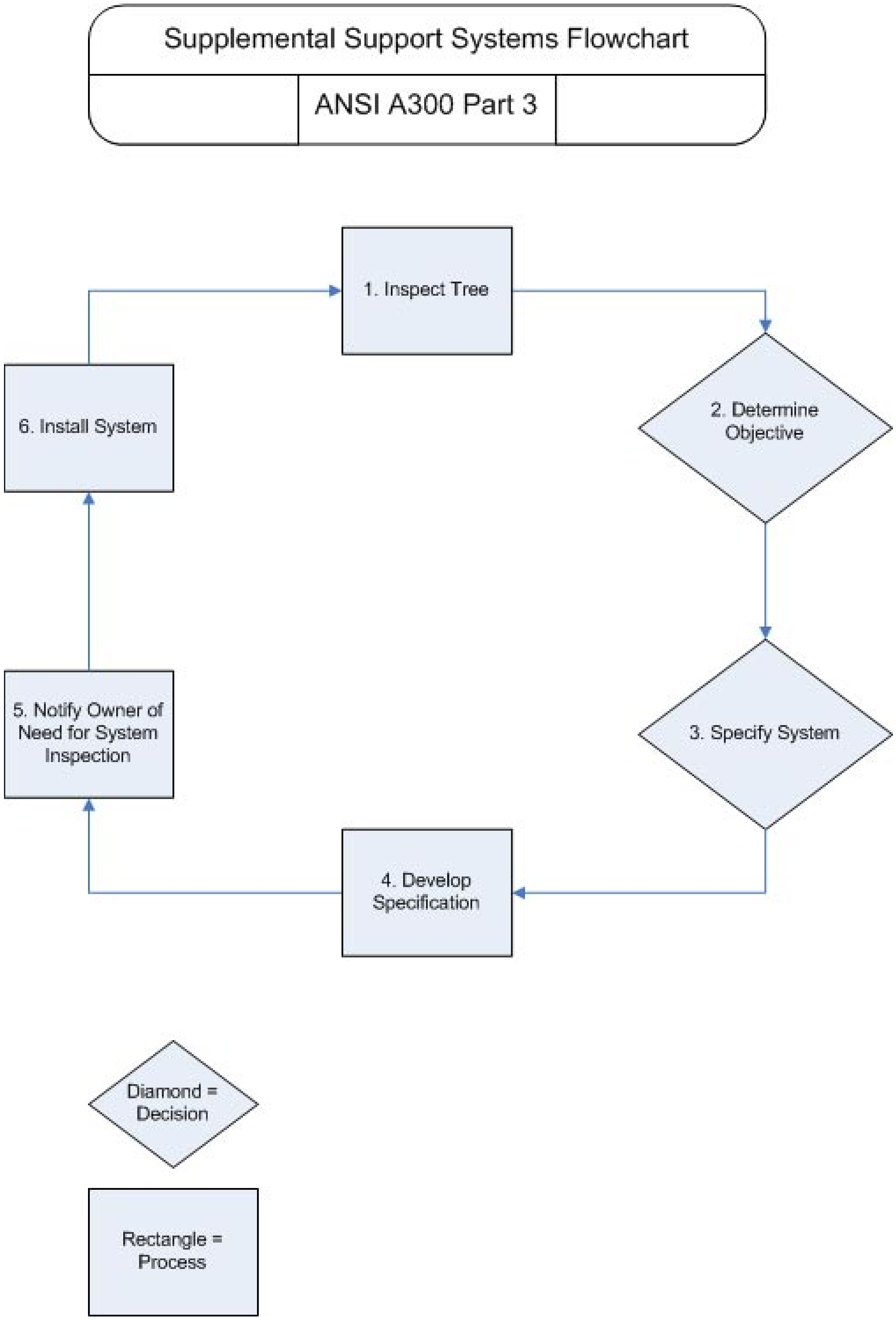
Annex A – Additional hardware information

Table A-1 Minimum hardware size for cabling trees

Maximum Limb Diameter at anchor attachment point in inches	**Estimated Load** in pounds	**Lag Hook** diameter in inches	**Eye Bolt** diameter in inches	**Amon nut / Loop nut** Threaded-rod diameter in inches	**Common Grade Cable** (galvanized, 1 x 7) diameter in inches	**Extra High Strength Cable** (1 x 7) diameter in inches	**Aircraft Cable** (galvanized, 7 x 19) diameter in inches
2	100	1/4	1/4	1/4	1/8	3/16	1/8
3.5	200	5/16	1/4	1/4	3/16	3/16	1/8
5	300	3/8	1/4	1/4	1/4	3/16	1/8
8	600	1/2	5/16	5/16	5/16	3/16	3/16
10	900	5/8	3/8	3/8	3/8	1/4	1/4
15	1000	N/A	3/8	3/8	7/16	1/4	1/4
18	1200	N/A	3/8	3/8	1/2	1/4	1/4
20	1400	N/A	1/2	7/16	1/2	5/16	1/4
24	2200	N/A	1/2	1/2	N/A	5/16	3/8
28	3300	N/A	5/8	5/8	N/A	7/16	1/2
30	3700	N/A	N/A	7/8	N/A	7/16	1/2

* N/A indicates not an acceptable application.

Annex B – Supplemental Support Systems specification flowchart



Annex C – Applicable ANSI A300 interpretations

The following interpretations apply to the ANSI A300 Part 3 Supplemental Support Systems standard.

C-1 Interpretation of "should" and "shall" in ANSI A300 standards

"An advisory recommendation" is the common definition of "should" used in the standards development community and the common definition of "should" used in ANSI standards. An advisory notice is not a mandatory requirement. Advisory recommendations might not be followed when defensible reasons for non-compliance exist.

C-2 Interpretation for compliant lag hooks, ANSI A300 Part 3 – 2000, subclauses 38.5 and 38.7 (see subclause 33.5.6 and 33.5.8 in ANSI A300 Part 3 – 2006)

38.5 Lag-thread hardware shall only be installed in sound wood. The hole for the lag-thread hardware shall be 1/16" to 1/8" (1.5-3 mm) smaller than the diameter of the lag.

38.7 Lag hooks shall not be used if it is not possible to seat the full length of the threads.

Interpretation: Lag hooks that have a thread depth variance greater than 1/16 inch make determination of correct hole size impossible and cannot be installed in a manner compliant with the ANSI A300 Part 3 standard. Lag hooks with threads cut beyond the bent portion of the hook cannot be installed in a manner that allows the full length of the threads to be seated and cannot be installed in a manner compliant with the ANSI A300 Part 3 standard.

C-3 Interpretation for cable selection when using dead-end grip terminations, ANSI A300 Part 3 – 2006 standard

The user of ANSI A300 standards is instructed to cross-reference definition subclauses **32.9 cable** and **32.14 dead-end grip** and subclause **33.5.17**.

Interpretation: Dead-end cable grips that meets the ANSI ASTM A475 standard specification for zinc coated steel wire strand can be used with common grade and extra high strength grade cable that also meets the ANSI ASTM A475 standard when approved by the manufacturer.

ANSI A300 (Part 4)-2008 Lightning Protection Systems
Revision of ANSI A300 (Part 4)-2002

American National Standard

for Tree Care Operations —

Tree, Shrub, and Other Woody Plant Management — Standard Practices (Lightning Protection Systems)

ANSI A300 (Part 4)-2008 Lightning Protection Systems
Revision of ANSI A300 (Part 4)-2002

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for Tree Care Operations —

Tree, Shrub, and Other Woody Plant Management — Standard Practices *(Lightning Protection Systems)*

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Contents

Figures and Tables

Annex

Foreword (This foreword is not part of American National Standard A300 (Part 4)-2008 Lightning Protection Systems)

ANSI A300 Standards are divided into multiple parts, each focusing on a specific aspect of woody plant management (e.g. Pruning, Fertilization, etc).

These standards are used to develop written specifications for work assignments. They are not intended to be used as specifications in and of themselves. Management objectives may differ considerably and therefore must be specifically defined by the user. Specifications are then written to meet the established objectives and must include measurable criteria.

ANSI A300 standards apply to professionals who provide for or supervise the management of trees, shrubs, and other woody landscape plants. Intended users include businesses, government agencies, property owners, property managers, and utilities. The standard does not apply to agriculture, horticultural production, or silviculture, except where explicitly noted otherwise.

This standard has been developed by the Tree Care Industry Association (TCIA), an ANSI-accredited Standards Developing Organization (SDO). TCIA is secretariat of the ANSI A300 standards, and develops standards using procedures accredited by the American National Standards Institute (ANSI).

Consensus for standards writing was developed by the Accredited Standards Committee on Tree, Shrub, and Other Woody Plant Management Operations – Standard Practices, A300 (ASC A300).

Prior to 1991, various industry associations and practitioners developed their own standards and recommendations for tree care practices. Recognizing the need for a standardized, scientific approach, green industry associations, government agencies and tree care companies agreed to develop consensus for an official American National Standard.

The result – ANSI A300 standards – unify and take authoritative precedence over all previously existing tree care industry standards. ANSI requires that approved standards be developed according to accepted principles, and that they be reviewed and, if necessary, revised every five years.

TCIA was accredited as a standards developing organization with ASC A300 as the consensus body on June 28, 1991. ASC A300 meets regularly to write new, and review and revise existing ANSI A300 standards. The committee includes industry representatives with broad knowledge and technical expertise from residential and commercial tree care, utility, municipal and federal sectors, landscape and nursery industries, and other interested organizations.

Suggestions for improvement of this standard should be forwarded to: A300 Secretary,
c/o Tree Care Industry Association, Inc., 136 Harvey Road - Suite B101-B110, Londonderry, NH, 03053.

ANSI A300 (Part 4)-2008 Lightning Protection Systems was approved as an American National Standard by ANSI on March 20, 2008. ANSI approval does not require unanimous approval by ASC A300. The ASC A300 committee contained the following members at the time of ANSI approval:

Tim Johnson, Chair
(Artistic Arborist, Inc.)

Bob Rouse, Secretary
(Tree Care Industry Association, Inc.)

(Continued)

Organizations Represented	***Name of Representative***
American Nursery and Landscape Association	*Warren Quinn*
	Craig J. Regelbrugge (Alt.)
American Society of Consulting Arborists	*Donald Zimar*
American Society of Landscape Architects	*Ron Leighton*
Asplundh Tree Expert Company	*Geoff Kempter*
	Peter Fengler (Alt.)
Bartlett Tree Expert Company	*Peter Becker*
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Davey Tree Expert Company	*Joseph Tommasi*
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International Society of Arboriculture	*Bruce Hagen*
	Sharon Lilly (Alt.)
National Park Service	*Robert DeFeo*
	Dr. James Sherald (Alt.)
Professional Grounds Management Society	*Thomas Shaner*
Professional Land Care Network	*Preston Leyshon*
Society of Municipal Arborists	*Gordon Mann*
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Tree Care Industry Association	*James McGuire (Alt.)*
USDA Forest Service	*Ed Macie*
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Additional organizations and individuals:

American Forests *(Observer)*
Mike Galvin *(Observer)*
Peter Gerstenberger *(Observer)*
Dick Jones *(Observer)*
Myron Laible *(Observer)*
Beth Palys *(Observer)*
Richard Rathjens *(Observer)*
Richard Roux *(NFPA-780 Liaison)*

ASC A300 mission statement:

Mission: To develop consensus performance standards based on current research and sound practice for writing specifications to manage trees, shrubs, and other woody plants.

American National Standard
for Tree Care Operations –

Tree, Shrub, and Other Woody Plant Management –Standard Practices *(Lightning Protection Systems)*

Clause 1 excerpted from ANSI A300 (Part 1)–2008 Pruning

1 ANSI A300 standards

1.1 Scope

ANSI A300 standards present performance standards for the care and management of trees, shrubs, and other woody plants.

1.2 Purpose

ANSI A300 performance standards are intended for use by federal, state, municipal and private entities including arborists, property owners, property managers, and utilities for developing written specifications.

1.3 Application

ANSI A300 performance standards shall apply to any person or entity engaged in the management of trees, shrubs, or other woody plants.

43 Part 4 – Lightning protection systems standards

43.1 Purpose

The purpose of this document is to provide standards for developing specifications for tree lightning protection system installation.*

43.2 Reasons for tree lightning protection systems

Lightning protection systems are used to reduce the risk of damage to trees from lightning strikes. Protected trees shall not be considered a safe haven from lightning strikes.*

43.3 Implementation

Specifications for tree maintenance should be written and administered by an arborist.

43.4 Safety

43.4.1 Lightning protection systems for trees shall be implemented by an arborist familiar with the practices and hazards of lightning protection systems for trees and the equipment used in such operations.

43.4.2 This standard shall not take precedence over applicable industry safe work practices.

43.4.3 Operations shall comply with applicable Federal and State Occupational Safety and Health standards, ANSI Z133.1, Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and other Federal Environmental Protection Agency (EPA) regulations, as well as state and local regulations.

44 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. All standards are subject to revision, and parties to agreements based on this American National Standard shall apply the most recent edition of the standards indicated below.

ANSI/UL 96 *Lightning Protection Components*

ANSI/UL 96A *Installation Requirements for Lightning Protection Systems*

ANSI/UL 467 *Grounding and Bonding Equipment*

ANSI Z60.1 *Nursery stock*

ANSI Z133.1 *Arboriculture – Safety Requirements*

NFPA 780 *Standard for the Installation of Lightning Protection Systems*

29 CFR 1910, *General industry*[1]

29 CFR 1910.268, *Telecommunications*[1]

29 CFR 1910.269, *Electric power generation, transmission and distribution*[1]

29 CFR 1910.331 - 335, *Electrical safety-related work practices*[1]

*See Annex C Interpretations.

1) Available from U.S. Department of Labor, 200 Constitution Avenue, NW, Washington, DC 20210

45 Definitions

45.1 air terminal: The end of a lightning protection system that is intended to intercept lightning strikes.

45.2 arborist: An individual engaged in the profession of arboriculture who, through experience, education, and related training, possesses the competence to provide for, or supervise the management of, trees and other woody plants.

45.3 arborist trainee: An individual undergoing on-the-job training to obtain the experience and the competence required to provide for or supervise the management of trees and other woody plants. Such trainees shall be under the direct supervision of an arborist.

45.4 bond: Electrical connection between a conductive object and a component of a lightning protection system intended to reduce electrical potential differences.

45.5 cable splicer: A cast or stamped crimp-type connector used to connect conductors in either an end-to-end, side-by-side or Y configuration.

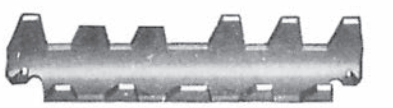


Fig. 45.5a End-to-end cable splicer.

Fig. 45.5b Side-by-side cable splicer.

Fig. 45.5c Y cable splicer.

45.6 clamp-type (multi-use) connector: A cast connector fitting that uses one or more bolts to secure the connection.

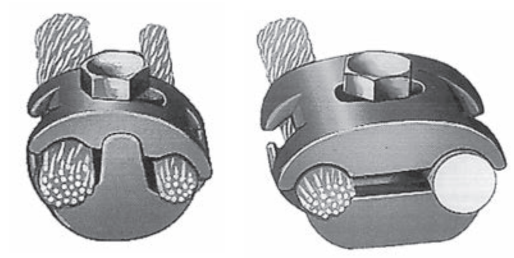


Fig. 45.6 Clamp-type connectors.

45.7 conductor: A copper cable used in a lightning protection system intended to carry the lightning discharge to ground.

45.7.1 bonding conductor: A conductor that connects a tree support cable or metal conduit to the lightning protection system.

45.7.2 branch conductor: A conductor that connects an air terminal to a main conductor.

45.7.3 main conductor: A conductor that connects the main air terminal and the ground terminal.

45.8 electrolytic couple: Contact between metals that are not galvanically compatible, causing an accelerated degradation (corrosion or oxidation) in the presence of moisture. Examples of these combinations are copper and zinc galvanization.

45.9 fastener: An attachment to secure a conductor to a tree.

Fig. 45.9 Pinch-type fastener.

45.10 grounded: Connected to earth or to a conductive material that is connected to earth.

45.11 ground plate: A copper plate used to form a ground terminal in shallow soils.

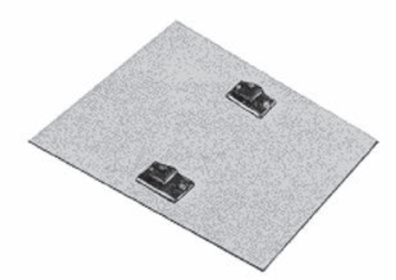


Fig. 45.11 Ground plate.

45.12 ground rod: A copper-clad steel, solid copper, stainless steel, or stainless steel clad rod used to form a ground terminal.

Fig. 45.12 Ground rod.

45.13 ground-rod clamp: A fitting that is specifically designed to connect a conductor to a ground terminal.

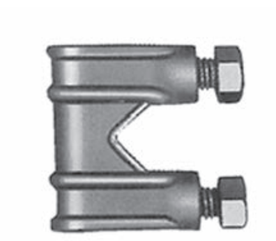


Fig. 45.13a Ground-rod clamp.

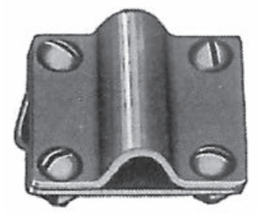


Fig. 45.13b Right-angle ground-rod clamp.

45.14 ground terminal: The portion of a lightning protection system – such as a conductor, ground rod or ground plate – that is installed for the purpose of providing electrical ground.

45.15 multiple ground system: A ground terminal composed of two or more ground rods or copper ground plates.

45.16 shall: As used in this standard, denotes a mandatory requirement.

45.17 should: As used in this standard, denotes an advisory recommendation.

45.18 specifications: A document stating a detailed, measurable plan or proposal for provision of a product or service.

45.19 standards, ANSI A300: Performance parameters established by industry consensus as a rule for the measure of quantity, weight, extent, value, or quality.

45.20 taut: Tightened to the point of eliminating visible slack.

45.21 tree support system: A support system used to provide supplemental support to leaders, individual limbs, and/or the whole plant.

46 Lightning protection practices for trees

46.1 Lightning protection objectives for trees

The objective of a tree lightning protection system is to provide a preferred path to ground for the electrical charge; protected trees shall not be considered a safe haven from lightning strikes.*

46.2 Tree and site inspection

46.2.1 An arborist or arborist trainee shall visually inspect each tree before beginning work.

46.2.2 If a condition is observed requiring attention beyond the original scope of work, the condition shall be reported to an immediate supervisor, the owner, or the person responsible for authorizing the work.

46.2.3 Prior to installation, underground utilities shall be located. Other underground infrastructure should be located.

46.3 Tools and equipment

46.3.1 Equipment and work practices that damage bark, cambium, live palm tissue or any combination of these, beyond the scope of the work, shall be avoided.

46.3.2 Climbing spurs shall not be used when climbing trees to install lightning protection systems.

Exception: When limbs are more than throwline distance apart and there is no other means of climbing the tree.

*See Annex C Interpretations.

46.4 General

46.4.1 Prior to installation, the owner or owner's agent shall be notified of the need for periodic inspection of the system's condition, position and grounding integrity. Scheduling inspections shall be the responsibility of the tree owner.

46.4.2 Tree lightning protection system conductors shall be installed in compliance with minimum distance Table 1 in ANSI Z133.1 for overhead, energized conductors.

46.4.3 Existing metal support cables, guys, and conduits in trees shall be bonded to the lightning protection system.

46.4.4 Soil type and the physical character of the surrounding area shall be considered before grounding the system.

46.5 Materials

46.5.1 General

46.5.1.1 Lightning protection system design shall be specified to achieve the established objective.

46.5.1.2 Components of tree lightning protection systems shall be made of copper of commercial electrical grade, or a copper alloy with similar resistance to corrosion as copper, stainless steel, bronze, or clad using one of these metals.

46.5.1.3 Incompatible metals shall not be used in combinations that form an electrolytic couple, except when bonded to the tree lightning protection system as required or recommended by this standard.

46.5.2 Conductors

46.5.2.1 Acceptable construction for conductors shall be rope-lay, smooth-twist or loose-weave cable.

46.5.2.2 Conductors shall be stranded tightly enough to form a symmetrical cable and remain in a fixed position when installed.

46.5.2.3 Conductors shall be at least 14 strand of 17 AWG copper wire.

46.5.3 Connectors and fasteners

46.5.3.1 All hardware shall be of proper size for the conductors.

46.5.3.2 Cable splicers and clamp-type (multi-use) connector shall be constructed so that a minimum of 1½ inches (38 mm) of each conductor can be secured within the fitting.

46.5.3.3 Cable splicers and clamp-type (multi-use) connectors shall be installed so as to withstand a pull of 200 pounds (890 N).

46.5.3.4 Cable splicers shall have at least two 1/8-inch (3.2 mm) high projections on the interior surface.

46.5.3.5 Pinch-type fasteners shall be of substantial construction that can be closed by bending.

46.5.4 Ground terminals

46.5.4.1 Ground rods shall be a minimum ½-inch (12.7 mm) diameter and not less than 8 feet (2.4 m) long and shall be made of copper-clad steel, solid copper, stainless steel, or stainless steel clad.

46.5.4.2 Ground-rod clamps shall have a minimum of two bolts, machine screws, or cap screws for applying compression to the conductor and ground rod.

46.5.4.3 Ground-rod clamps shall have a length that makes contact with the ground rod for a minimum distance of 1½ inches (38 mm) measured parallel to the axis of the ground rod.

46.5.4.4 Copper ground plates shall have a minimum thickness of 0.032 inch (0.8 mm) and a minimum surface area of 2 square feet (0.19 m2).

46.6 Installation practices

46.6.1 Above-ground system

46.6.1.1 Air terminals shall be located on leaders, limbs and/or branches as far out as practical in the crown.

46.6.1.2 Branch conductors shall be connected to a main conductor.

46.6.1.3 Branch conductors should be installed so that no aerial portion of the tree is farther than 35 feet from a conductor.

46.6.1.4 No bend of a conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches (20 cm) other than at the ground rod. (see Figure 46.6.1.4).

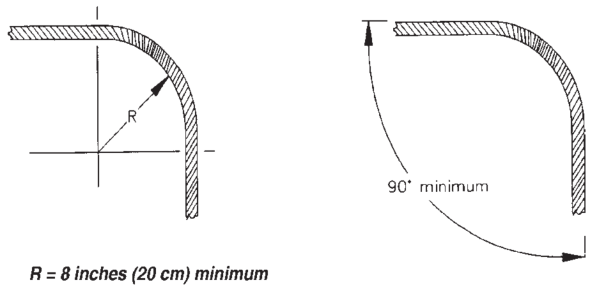


Fig.46.6.1.4 Bends in conductors.

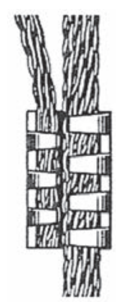
46.6.1.5 Conductors should be installed taut.

46.6.1.6 Conductor fasteners shall be installed to the tree at intervals no greater than 6 feet (1.8 m).

46.6.1.7 A bimetallic or bronze clamp-type connector shall be used to connect metals that form an electrolytic couple, such as when bonding galvanized steel cables or guys to the tree lightning protection system.

46.6.1.8 Cable splicers or clamp-type (multi-use) connectors shall be used to form end-to-end, side-by-side, or Y splices in conductors (see Figure 46.6.1.8).

Fig. 46.6.1.8 An installed, side-by-side cable splicer.



46.6.1.9 Conductors subject to mechanical damage should be protected.

46.6.2 Below-ground system

46.6.2.1 Ground terminal installation should not damage roots greater than 2 inches (5 cm) in diameter.

46.6.2.2 Conductors shall extend away from the tree at a minimum depth of 8 inches (20 cm), except when impenetrable conditions do not allow. Maximum contact with the soil shall be achieved.

46.6.2.3 Ground rod connections shall be made with ground-rod clamp connectors.

46.6.2.4 Ground terminals shall not be located within 2 feet (61 cm) of a structure's foundation or other known underground installation.

46.6.2.5 Ground terminals shall extend into the earth to a minimum depth of 9 feet (2.74 m) except as specified in 46.6.2.9 and 46.6.2.10.

46.6.2.6 The soil shall be in contact with the ground system.

46.6.2.7 The method of grounding shall be specified as one of the following types (see Figures 46.6.2.7a and 46.6.2.7b):

- **A. Single Ground Rod System**
- **B. Multiple Ground System**
- **C. Horizontal Ground System**

46.6.2.8 Single ground rod system

46.6.2.8.1 A single ground rod should be installed a minimum of 10 feet (3 m) from the trunk.

46.6.2.9 Multiple ground system

46.6.2.9.1 Multiple ground systems shall be used when the full length of the ground rod cannot be driven into the soil (see Figures 46.6.2.9a and 46.6.2.9b).

46.6.2.9.2 A minimum 8 feet (2.4 m) of total ground rod length shall be installed.

46.6.2.9.3 A minimum 16 feet (4.9 m) of total ground rod length shall be installed in sandy or gravelly soils.

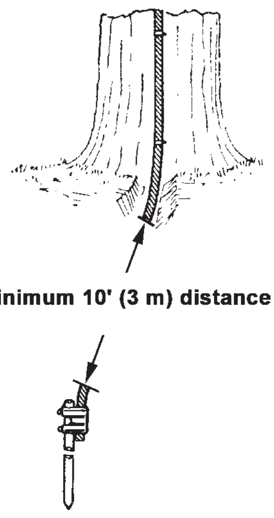


Fig. 46.6.2.7a Single ground rod system.

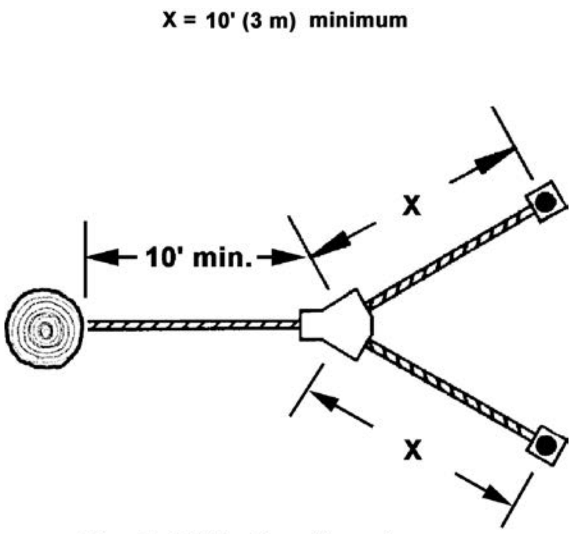


Fig. 46.6.2.9b Y configuration.

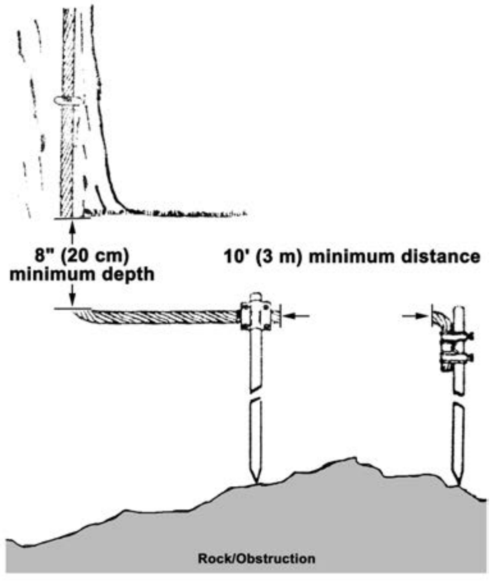


Fig. 46.6.2.7b Multipe ground system (in-line configuration shown).

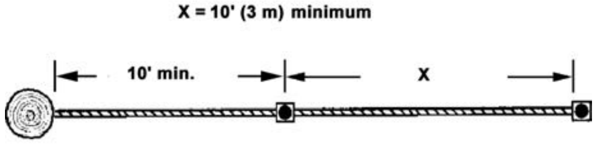


Fig. 46.6.2.9a In-line configuration.

46.6.2.9.4 When using in-line or Y configurations in sandy or gravelly soils, ground rods or copper ground plates shall be located a minimum distance of 10 feet (3 m) from each other and from tree trunk (see Figures 46.6.2.9a and 46.6.2.9b).

46.6.2.10 Horizontal ground system

46.6.2.10.1 Horizontal ground systems shall be used when ground rods cannot be driven at least 2 feet (61 cm).

46.6.2.10.2 Horizontal systems should be terminated with a ground plate

46.6.2.10.3 Conductors shall be installed in trenches extending away from the tree. These trenches shall be at least:

A) For sandy or gravelly soil: a total of 24 feet (7.3 m) long.

B) For all other soils: a total of 12 feet (3.7 m) long.

46.6.2.10.4 The ground plate shall be installed 8 inches or deeper below the soil surface, except when impenetrable conditions do not allow. Maximum contact with the soil shall be achieved.

Annex A
Tree lightning protection systems information

A-1 When to install lightning protection systems in trees.

A-1.1 According to the National Fire Protection Association:

Trees with trunks within 10 feet (3 m) of a structure, or with branches that extend to a height above the structure, should be equipped with a lightning protection system because of the danger of side flash, fire, or superheating of the moisture in the tree, which could result in the splintering of the tree. (NFPA – 780 F-1)

A-1.2 According to the Tree Care Industry Association:

A-1.2.1 Trees of historical interest; trees of unusual value; shade trees within 10 feet (3 m) of a building; trees with branches overhanging buildings; tall trees in recreational or park areas; trees that are more likely to be struck by lightning due to their location, such as isolated trees on a hill, in a golf course, or in a pasture, etc.; and similar trees; should be equipped with tree lightning protection systems.

A-1.2.2 Tree lightning protection systems are usually not necessary for small trees located under the drip line or very close to a larger tree with a lightning protection system.

A-2 Lightning strike susceptibility of non-protected, temperate zone trees table.

Table A-2 Strike frequency assessed from visual indications of a strike and therefore may not reflect actual likelihood of being struck. This table is presented as a guide to the prioritization of trees for lightning protection, if all other factors (e.g. height, location, distance from house) are equal, trees rated as high or very high should be protected before trees of low or moderate susceptibility.

Tree species	Susceptibility to Lightning Damage
Acer (maple)	moderate
Aesculus (horsechestnut)	low
Betula (birch)	moderate to low
Catalpa (catalpa)	moderate
Fagus (beech)	low
Fraxinus (ash)	high
Ilex (holly)	low
Liriodendron (tulip poplar)	very high
Picea (spruce)	moderate
Pinus (pine)	high
Platanus (sycamore)	moderate
Populus (poplar)	moderate
Quercus (oak)	high
Robinia (black locust	very high
Tsuga (hemlock)	high
Ulmus (elm)	moderate

A-3 Ground system selection based on site considerations.

A-3.1 Single ground rod systems are preferred for tree lightning protection system grounding. Root damage can be minimized when single ground rod systems are installed correctly.

A-3.2 Multiple ground systems can be specified to address a variety of reasons, such as:

1) Inability to drive the full length of a ground rod into the soil.

2) Poor soil conductivity, such as what can occur in sandy, gravelly and/or dry soils.

3) When obstructions prevent a single ground rod system from being installed in an effective manner.

A-3.3 Horizontal ground systems can be specified when ground rods cannot be driven at least 2 feet (61 cm) deep.

Annex B
Ground measurement techniques

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Appendix I Ground Measurement Techniques

This appendix is not a part of the requirements of the NFPA document but is included for informational purposes only.

I-1 General

I-1.1 In order to determine the ground resistance of a lightning protection system, it is necessary to remove it from any other ground connection. This may prove a virtually impossible task necessitating certain assumptions. In reality, ground resistance measuring equipment works at low frequencies relative to the lightning discharge. The resistance it computes is therefore often affected by the resistance of power-system ground electrodes or a similar ground medium that may be several thousand feet from the structure being protected. The ground resistance to be used to calculate lightning conductor potentials when a high-frequency lightning discharge strikes a building must be the grounds in the immediate area of the building, not the remote ones that ground measuring equipment probably monitor.

I-1.2 If the building is small, and the lightning protections system can be disconnected totally from any other grounding network, its resistance can be measured by the three-point technique described in I-1.3. If the building is large or cannot be disconnected totally from any other grounding network, then the ground resistance of individual isolated lightning protection ground rods should be measured by the three-point techniques described in I-1.3 and this resistance multiplied by a factor depending on the number of ground rods.

I-1.3 The principle of ground resistance measurement is shown in Figure I-1.3. L is the lightning ground rod or ground rod system, P is a test probe, and A is an auxiliary current probe. M is the standard ac measuring equipment for three-point technique ground resistance measurements. Convenient distances for LP and LA are 75 ft (22 m) and 120 ft (36 m), respectively. In general, P should be at 62 percent of the distance from L to A. If 120 ft (36 m) is not convenient, it could be increased significantly [or reduced to no less than 50 ft (15.2 m)], provided LP is increased proportionately.

A current, I, is passed through the electrode or electrodes to be tested, L, and through an auxiliary probe, A. The distance, LA, is long compared to the electrode length. The voltage, V, between L and P is measured by the test equipment, which also monitors I and calculates the ground resistance, R, as V/I. Alternating current is used to avoid errors due to electrolytic factors in the soil and to remove effects due to stray currents.

Three-point ground resistance measuring equipment using these principles is relatively inexpensive and allows direct reading of R.

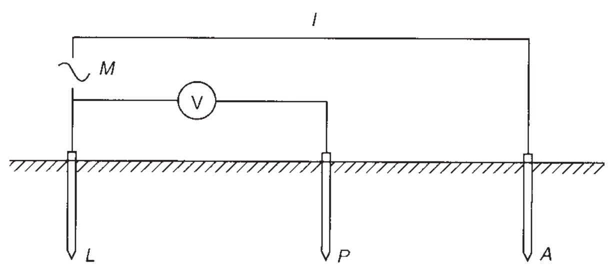


Figure I-1.3 Measurement of ground resistance.

I-1.4 Variations in soil resistivity due to temperature and moisture fluctuations can affect the measured ground resistance. A good designer will measure ground resistance under average or high resistivity conditions in order to design a lightning protection system to function adequately.

If the building ground is complex in nature, the resistance of single ground rods may be measured and certain assumptions made. The average single ground rod resistance, RM, must be multiplied by a factor depending on the number of lightning-protection ground rods, n, spaced at least 35 ft (10.7 m) apart. The total system ground resistance, R, can be calculated from the following formula:

$$R = 1.1\left(\frac{R_m}{n}\right)$$

Annex C
Interpretations

Tree lightning protections systems, purpose, reason, and objective:

When considering tree lightning protection systems, the user has to keep in mind that the purpose of the ANSI A300 (Part 4)-2008 standard is to provide standards for developing specifications for tree lightning protection system installation (43.1). The only reason for installing a tree lightning protection system is to reduce the risk of damage to trees from lightning strikes (43.2). Tree lightning protection systems do not protect buildings or property from damage or provide safe havens from lightning. The user needs to understand that the only objective for a tree lightning protection system is to provide a preferred path to ground for the electrical charge (46.1).

If there is danger from side flash or other lightning-induced damage to non-tree components, property, buildings, etc., or, the tree's owner or owner's agent have a different objective than outlined in this standard (46.1), then the appropriate standard practices must be followed as detailed by this standard's normative references (44).

BARTLETT TREE RESEARCH LABORATORIES
CHARLOTTE, NC
Technical Report

Girdling Roots

Bruce R. Fraedrich, Ph. D., Plant Pathologist

Girdling roots are usually lateral roots at or slightly below the soil line that cut into at least one side of the main trunk. These roots restrict water and nutrients, which may be translocated to the leaves. Branches will eventually become weakened and the tree may die in five to fifteen years from the girdling roots alone, or in conjunction with environmental stresses or attacks by insects or diseases. Cultural practices like fertilization, irrigation and pruning will not offset the slow growth caused by girdled roots. Once diagnosed, they should be treated promptly.

CAUSES AND PREVENTION

Girdling roots are caused by nursery and transplanting practices, soil obstructions and unknown factors.

When plants are held in containers for too long a period of time, many roots begin to circle around the pot (Figure 1). These eventually can girdle the tree. When planting trees and shrubs with this condition, be sure to loosen these roots from the container root ball and spread them out in the planting hole before back filling. Circling roots two or more years old will be woody and may have to be cut and removed from the root system, because they will have taken the permanent shape of the container and cannot bend enough without breaking. Although this reduces the size of the root system, it will prevent the development of girdling roots in the future.

Figure 1. Roots growing in containers frequently begin circling if held in the container for too long.

When a planting hole is not dug wide enough or deep enough, bare-rooted stock can be twisted into the hole in order to make it fit. This undesirable practice can cause root growth encircle the trunk and produce girdling.

Be certain to make planting holes wider than the root area in order to prevent encircling roots from forming.

The third major cause of girdling roots is planting in very compacted soil, where the new roots have difficulty growing out of the planting hole and into the surrounding hard soil. Roots can circle the bottom of the planting hole, not unlike those growing in an undersized container. Eventually, several of these roots can begin girdling the trunk. Other soil obstructions like foundations, curbs or large rocks can deflect roots and may contribute in some cases to the development of girdling roots.

SYMPTOMS AND DETECTION

Trees which leaf out late, have small chlorotic leaves or needles, drop their leaves early, and are dying back should be checked for a girdling root, particularly if the normal flare or buttress swell is absent. This condition is associated with placing too much fill over the roots, a procedure not uncommon in new housing developments.

Probably the most reliable aboveground characteristic of a girdling root is a trunk indentation of flattening or the base of the bole. Non-girdled trees rarely show this abnormal development. Note that not all girdled trees show crown symptoms commonly attributed to girdling roots.

Most girdled trees are not severely girdled, with few roots ever circling more than 50% around the bole. Since most girdled trees are girdled by more than one root, careful examination around the entire circumference may be necessary. Species like sugar, Norway maple, and white pine particularly are prone to forming girdling roots. Soil excavation is often needed to find girdling roots.

A large majority of girdling roots is found in the top several inches of soil, although they can develop at a somewhat greater depth. Frequently they can be seen on the surface where erosion has removed one or two inches of soil from around the base of the trunk. Some girdling roots are present at the soil line.

TREATMENT AND REMOVAL

A girdling root must be removed in a manner that will minimize injury to the trunk cambium beneath the root. First excavate soil from around the root uncovering the entire length to be removed. Using a chisel or saw, cut the root at a point 6 – 12” out from the trunk. The final cut is made where the root attaches to the trunk (figure 2). This prevents the root from being pulled violently away from the embedded area causing extensive cambium injury if the root happens to be under tension. This is important since occasionally it is best to leave the girdled root in the tree after cutting because the trunk and cambium would be damaged severely by gouging out the deeply embedded root so that it does not grow back together. Detach the root if it is not embedded very deeply.

Prune deadwood, and if large roots were removed, thin the crown to compensate for the loss of roots. Very large girdling roots should not be cut or removed.

BARTLETT BARTLETT TREE RESEARCH LABORATORIES
CHARLOTTE, NC
Technical Report
Plant PHC HealthCare

Lightning Protection for Trees

E. Thomas Smiley, Ph.D.

Thousands of trees are struck by lightning every year. These trees will have varying degrees of damage ranging from complete shattering and destruction of the tree to a slow lingering death to virtually no apparent damage at all (Fig. 1). When severe damage does occur, parts of the tree can fall or be thrown hundreds of yards causing extensive damage to people or property. In dry conditions the electrical current may also flow through the root system, potentially damaging and, destroying it. Trees with lightning damaged roots rarely survive.

Lightning is a transient, high current electric discharge whose path length is measured in miles. The main type of lightning we are concerned with is between clouds and ground. The first portion of lightning typically seen is the "stepped leader" that descends from a storm cloud. As it nears earth, "streamers" are drawn from tall and /or conductive structures. The streamers and the leader attach 30 to 100 yards above the structure. At this connection the first stroke of lightning occurs. After this initial stroke there are usually two or three more exchanges of current that comprise a strike. Each stroke lasts about 1/100 to 3/100 of a second and each strike 2/10 or 5/10 of a second. The total current in a strike is usually between 20,000 and 50,000 amps at about 100,000 volts or 10 to 30 Coulombs. Some strikes have a longer lasting, continuous flow of current (100 amps for 0.1 second). These strikes are more likely to start fires.

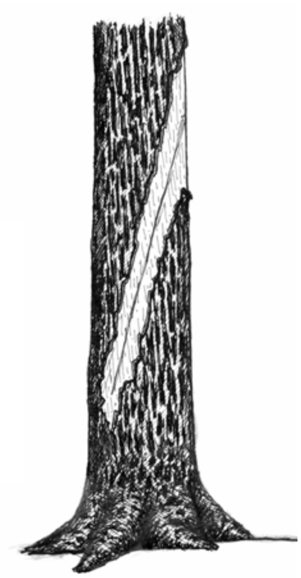


Figure 1. Moderate lightning damage showing spiral bark damage and groove in the sapwood.

Sideflash. When lightning strikes a tall tree it may travel down the stem for a distance, then leave the tree "jumping" to a more conductive tree, structure or animal. This is called sideflash. In urban areas this sideflash can cause serious damage to structures, often starting fires. It is also responsible for the death of groups of trees or people/animals taking refuge under the tree during a storm.

Step voltage. As lightning leaves an unprotected tree it goes into the soil. At the soil surface there will be a great difference in the electrical potential. This is called "step voltage". If people or animals are standing in the area, potentially deadly electricity may flow through them rather than staying in the soil.

The National Fire Protection Association (780 F-1) recommends that trees within 10 feet (3m) of a structure, that are taller than the structure or have limbs over the structure should be protected. This is to reduce the risk of sideflash and to reduce the risk of damage from the tree being splintered by lightning. The National Arborist Association goes beyond this to recommend protecting trees of historical interest; high value; in recreational areas, parks, golf courses; and those more prone to strikes because of their location, isolated on hills, pastures or near water.

Table 1. Susceptibility of non-protected temperate zone trees to lightning strikes.

Tree genera	Susceptibility to Lightning Strikes
Acer (maple)	high
Aesculus (horsechestnut)	low
Betula (birch)	mod to low
Catalpa (catalpa)	moderate
Fagus (beech)	low
Fraxinus (ash)	high
Ilex (holly)	low
Liriodendron (tulip poplar)	very high
Palm	high/moderate
Picea (spruce)	moderate
Pinus (pine)	moderate
Platnus (sycamore)	moderate
Populus (poplar)	high
Quercus (oak)	high
Robinia (black locust)	high
Tsuga (hemlock)	high
Ulmus (elm)	high

Lightning protection systems are installed in trees to provide a preferred (not through the tree), non-damaging path to ground for a lightning strike. Since trees are often much taller than adjacent houses or other structures the streamer produced at the top of a trees lightning protection system will be much higher than those from most adjacent structures. This results in the tree's lightning protection systems being more likely to be struck. Lightning protection systems in trees are not intended to dissipate the electrical charge, but rather they are intended to be receptive to a strike and safely conduct it to ground. This local receptiveness may act to protect adjacent structures. Protected trees should not be considered safe havens for people during storms.

Lightning protection systems are extremely effective at preventing damage to trees. Systems that are new or properly maintained are thought to be over 98% effective at preventing serious damage to trees.

The working life of lightning protection systems can be very long. The conductor and major components may last for 50 to 100 years. If parts do deteriorate, they can be replaced or upgraded.

The objective of a lightning protection system is to provide a preferred path to ground for lightning strikes. To accomplish this objective, a conductor is installed in the tree from near the top, down the trunk and major limbs, to a grounding system (Figure 2). Systems must be inspected regularly and maintained to ensure reliability.

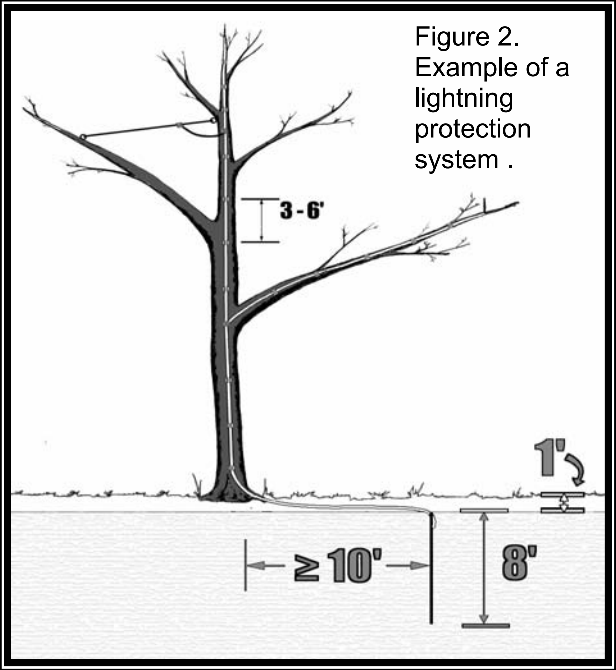


Figure 2. Example of a lightning protection system .

Tree protection system installation and inspection, as with all tree maintenance, needs to be preformed by a qualified arborist.

Materials and installation techniques used in lightning protection systems are specified by the American National Standards Institute (ANSI) A300 standard for Tree Lightning Protection.

Conductors are copper cables composed of 14 strands of 17 gauge copper wire. Solid conductor is not used because it has less surface area to conduct the lightning. Aluminum conductor is not used because of problems with corrosion and its higher electrical resistance that may lead to melting when struck. Copper or bronze fasteners driven into the tree to attach the conductor are **not** toxic to the tree because they are compartmentalized by the xylem.

Susceptibility to Lightning Strikes. Some tree species are thought to be more receptive to lightning than others. The reason for this is not known, it most likely has to do with tree height and electrical conductivity. Lists of susceptibility vary among authors. Table 1 provides a summary of species susceptibility.

When considering susceptibility, often more important than species is the location of the tree. Considered more susceptible to strikes are:
* The tallest tree in a group
* Trees growing in the open or small groups.
* Trees that border woods or line a street
* Trees close to water
* Trees on hill tops
* Trees in local areas or geographic regions with a history of numerous lightning strikes.

Inspection / Maintenance. The working life of lightning protection systems can be very long. However, over time the tree will grow making the system potentially less effective. To avoid this, the system needs to be inspected on a regular basis (e.g. annually on fast growing trees, every two or three years on slow growing trees). Scheduling inspections is the responsibility of the tree's owner.

If the conductor has been grown over by the tree, this does not necessarily mean that the system will not function. However, to find out if the conductor is intact, an electrical continuity test will need to be preformed.

The ground system can also be electrically checked on both new and existing systems to make sure that the electrical ground is adequate.

When problems are found during the inspection, they should be corrected as soon as possible.

BARTLETT TREE RESEARCH LABORATORIES
CHARLOTTE, NC
Technical Report

Maintenance Pruning Standard: A Simplified View

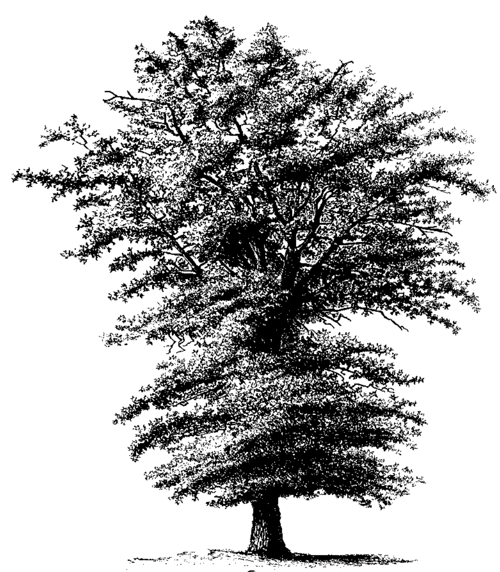
E. Thomas Smiley, Ph. D., Plant Pathologist
Bruce R. Fraedrich, Ph. D., Plant Pathologist

"Correct pruning cuts should be made close to the branch collar. Do not leave stubs and do not injure the collar". For many years, correct removal of branches has been synonymous with proper tree pruning. The new American National Standards Institute (ANSI) A-300 Pruning Standard brings the *tree* back into focus. It places emphasis on developing pruning goals based on specific needs of the plant. The Standard also provides clear, concise and descriptive terminology that arborists, tree workers and consumers can readily understand.

When pruning, arborists must decide which branches to remove. Will only defective limbs be removed or is there a benefit to thinning out live branches? Should the tree remain the same height and spread or are reductions necessary? Are low limbs interfering with traffic and require raising? What is the size limit on branches to be removed?

Before removing any branches, several factors must be considered. What is the condition of the tree? What are the landscape functions provided by the tree? Will pruning maintain or enhance those functions? Are structural defects or storm damage present that should be removed? Are branches interfering with powerlines, houses, and walkways? Is the tree too dense or does it need shaping? Will the tree tolerate removal of live branches? What are the customer's expectations and budget? The answers to these questions will govern how and to what extent the tree is pruned.

Four basic pruning techniques are used to maintain trees. Depending on tree requirements, client expectations and budget, one or more of the techniques will be used to maintain the plant.



Before pruning

Crown thinning is the removal of live, healthy branches on trees with dense crowns. This improves light penetration and air movement, and decreases wind resistance, thus reducing pest infestations and decreasing the risk of storm damage.

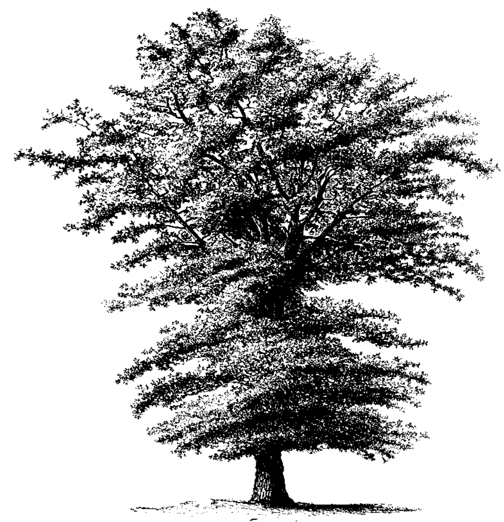
Crown thinning

Thinning can also be used to reduce weight of individual limbs and to slow the growth rate on overly vigorous limbs. This pruning technique is most commonly needed on young, rapidly growing trees.

On slower growing mature trees, thinning is mainly used when weight reduction is needed on individual limbs to compensate for structural defects. Usually, thinning is performed in conjunction with crown cleaning**.**

Virtually all-urban trees benefit from periodic **crown cleaning.** This is the removal of defective limbs including those that are dead, dying, diseased, rubbing, and structurally unsound. Cleaning reduces the risk of branch failures, improves plant health and enhances tree appearance by removing limbs that are unsightly, unhealthy and unsound.

Although removal of healthy branches is technically "thinning", selective removal of watersprouts is included in the cleaning specification. Before selecting this option, arborists must judge whether sprout removal will benefit the tree. Stripping sprouts is rarely beneficial and may eventually create many more problems for the tree. The Standard also states that **one-half of the foliage should be evenly distributed in the lower two-thirds of the crown and *individual limbs*.**



Crown cleaning

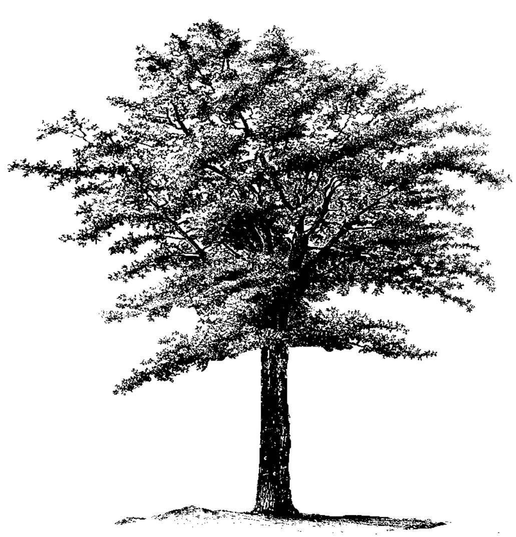
Unnecessary sprout removal and removal of all lower branches would certainly violate this rule. The concept of not removing sprouts must be clearly conveyed to consumers since many homeowners equate proper pruning with removal of interior limbs. There are a few exceptions where removal of watersprouts is beneficial. Removing sprouts on dogwoods in areas where *Discula* anthracnose is present is recommended to reduce risk of cankers in larger branches, for example.

Leaving interior and lower branches on a tree is equally important when thinning the crown. In order not to violate the one-*half the foliage on the lower two-thirds* rule, the majority of thinning cuts are on the outer portion of the crown, not the inside. This means working with pole tools or from an aerial lift. After large deadwood and structural problems have been corrected using a chainsaw, hand or pneumatic tools are used for thinning.

Crown reduction is needed on trees or individual limbs that are growing close to buildings, other trees, or utility wires. Reduction may also be necessary to prevent or correct storm damage and to shorten errant branches to provide a more desirable shape. This type of pruning involves reducing the height or spread of the crown or individual limbs. Certain species such as beech and sugar maple respond poorly to reductions so consideration must be given to the ability of the species to tolerate this procedure.

When reducing a leader or branch cut back to a lateral branch that is large enough to assume dominance. The size of the remaining lateral is not specified in the Standard since it varies with tree species and tree condition. Typically, a lateral one-third the diameter of the parent limb is selected. If the lateral is smaller, the limb will either dieback or sprout profusely. If the lateral is considerably larger than the one-third guideline, then thinning the remaining lateral should be considered due to the risk of storm damage. The remaining lateral should be growing in a direction that will maintain a desirable shape and not interfere with objects within the pruning cycle.

When lower limbs interfere with mowing, traffic, people or utilities, pruning is needed to provide clearance. While removal of lower limbs goes under many names, the one that has been selected is **crown raising**. Limbs can either be removed at

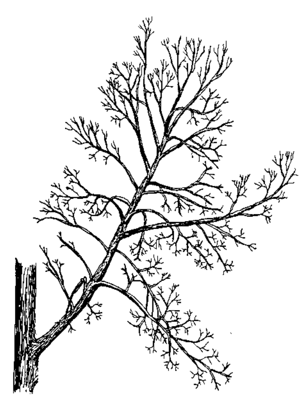


Crowing raising

the trunk or downward growing branches can be removed at the parent limb. Thinning the ends of a heavy limb may accomplish the same goal if the limb raises when weight is removed. When raising is performed, limb levels generally are left at a uniform height around the tree to provide symmetry.

These are the four primary types of maintenance pruning **- thinning, cleaning, reduction and raising.** Other pruning techniques and systems are discussed in the Standard, including **crown restoration, vista pruning, young tree pruning, espalier, pollarding** and **palm pruning**. These techniques are generally performed to achieve specific goals that are separate from maintenance considerations or are oriented to a specific type of tree. Consult the Standard for descriptions of these pruning types.

The majority of established trees can benefit from **one or more** maintenance pruning types. How can you prune a tree in more than one way? Easy! If a tree is



Before pruning

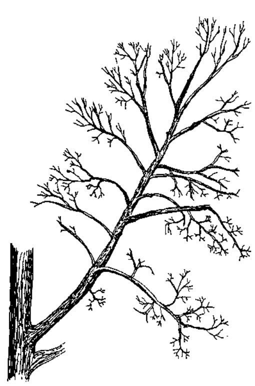
growing next to a house and has deadwood and limbs rubbing against the roof, it needs crown cleaning throughout and reduction or raising of the limbs over the residence. You may use any of the techniques, or combination of techniques, to provide exactly what the tree needs and the customer wants. Choosing the correct pruning technique(s) is relatively easy, even for an inexperienced arborist, because the tree guides the decision making process. If the tree has deadwood - clean it; if overly thick - thin it; if to tall - reduce it; if too low - raise it. Once the technique(s) have been decided, and then the **size of the smallest limb** to prune is the next consideration. Typically, the sizes that have been used are 1/2”, 1”, 2” or 4”. However, no numbers are specified in the Standard so you can select any size that meets the needs of the specific tree and customer objectives. If 1” minimum is selected, then limbs 1” in diameter at the point of attachment and larger would be removed when the branches meet the requirements of the technique.

The size of the smallest limb to be pruned should be adjusted for the tree and the client’s budget. When crown cleaning a small tree such as a Japanese maple, the smallest branch to remove might be specified at 1/2 inch in diameter. This means that dead, dying, diseased or weak branches greater than 1/2 inch are removed. If 1/4” diameter is chosen instead, the time required to complete the task is easily doubled or tripled.

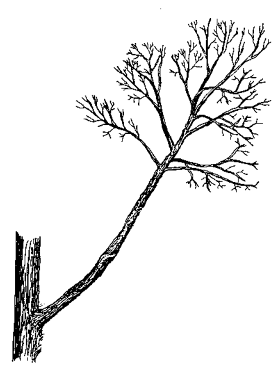
Arborists and consumers must realize that more is **not** always better when it comes to pruning. The amount of foliage that should be pruned from mature trees is now less than before. The Standard specifies that **not more than one quarter of the leaf surface** be removed during a single pruning operation. This will benefit the tree by maintaining a greater leaf surface area for producing photosynthates (energy).

When work is sold, whether to a municipality, commercial account or residential client, the pruning technique and minimum branch size must be specified, explained and discussed. This will foster fair competition and help ensure that both client and arborist understand what is to be accomplished by pruning. There should be no surprises for the client when purchasing tree work. To ensure this, tree workers as well as the arborist must understand the Standard. If a client selects crown cleaning but budget constraints require pruning 2” and larger limbs, then the crew cannot take the time to remove 1/2-inch limbs.

In summary, the new Standard encourages arborists to prune trees based on the tree’s need. This is a significant improvement from the days when we tried to “fit” the tree to a predetermined, artificial classification. Basing pruning on the tree’s needs make the principles described hold true for hardwoods and conifers, small ornamentals and large shade trees, young trees and mature trees. The terminology in the Standard is a change for most arborists, but it is user friendly and descriptive. Industry professionals as well as consumers should readily adopt the terminology and techniques.



Correct pruning



Improper pruning

BARTLETT TREE RESEARCH LABORATORIES

CHARLOTTE, NC

Technical Report

MoniTor IPM program

Bartlett offers a progressive, effective alternative to conventional landscape pest control that I recommend for your property. This would be the most efficient way to manage the insect and disease pest of the plants throughout the property. Bartlett's Integrated Pest Management (IPM) program is called MoniTor, this program requires a greater investment of time, but dramatically reduces the amount of pesticides used by as much as 90 percent. With MoniTor we optimize suppression while minimizing the use of pesticides through preventive maintenance and early detection of problems.

The MoniTor program consists of scheduled visits to inspect the plants around the property for insects, mites, diseases or cultural problems. Nonchemical interference is given first priority. For example, mulching and the release of beneficial insects can be very effective in some instances. When stronger control is needed, we use horticultural oil, insecticidal soap and several of the synthetic pyrethrums. Chemical control is always the last alternative.

Most MoniTor program are designed as follows:

- Schedule a series of inspections for all the woody plants by a trained IPM monitor.
- During each inspection, the monitor will identify and treat insect and disease problems. Low level, non-harmful insect populations will not be treated unless damage to the plant exceeds a tolerable level. Health and aesthetic appearance will determine this level.
- Identification of beneficial insects also would be performed. When present in sufficient numbers, these predatory insects may help control harmful insects, avoiding the use of chemicals.
- If a spray application is warranted, the most benign product available will be used. These products will usually be naturally occurring materials such as oil, soap, pyrethrums or a synthetic material of similar properties. Such products minimally impact both beneficial insects and the environment.
- Cultural treatments such as soil pH adjustment, root collar inspections and mulch adjustments will be included.
- This program will be limited to trees less than 40 feet in height.
- You will receive a written report from the monitor following each inspection. This report will include: description of problems, treatments applied, observations of plant conditions and recommendations.
- As needed, we will perform soil tests in problem areas to identify pH, nutrient or other soil concerns as well as conduct insect and disease analysis from Bartlett's Research Laboratories when problems cannot be identified on site.

An investment in the MoniTor IPM program is an environmentally sound means to maintain your plants in top condition.

BARTLETT TREE RESEARCH LABORATORIES
CHARLOTTE, NC
Technical Report

Mulch Application Guidelines

E. Thomas Smiley, Ph. D., Plant Pathologist

Mulches provide many benefits for trees and shrubs. They moderate soil temperatures, reduce soil moisture loss, reduce soil compaction, provide nutrients, improve soil structure, keep mowers and string trimmers away from the trunk. These benefits result in more root growth and healthier plants. When applying mulch the following guidelines should be observed:

1. The best mulch materials are wood chips, bark nuggets, composted leaves or pine needles. Plastic, stone, sawdust, finely shredded bark, and grass clippings should be avoided. Do not use redwood or walnut mulch due to allelopathic effects.

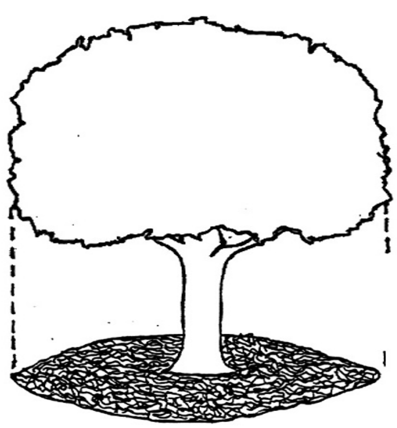


Figure 1. Mulch should be applied from the trunk to the dripline.

2. Mulch should be applied from the dripline to the trunk (Figure 1). If this is not practical, minimum mulch circle radii should be 3 feet for small trees, 8 feet for medium trees and 12 feet for large trees.

3. When applying mulch it is not necessary to kill or remove existing ground cover. However, turf should be mowed very short and clippings removed prior to application. Mulch should be applied directly to the soil surface, do not use landscape fabric to separate the mulch from the soil.

Figure 2. Mulch layer should be 2-4 inches thick and not be against the trunk.

4. Mulch layer should be 2-4 inches thick depending on tree species and mulch (Figure 2).

5. Additional mulch should be added to maintain a 2-4 inch depth.

6. Mulch should not be placed against the trunk (Figure 2). Mulch will retain too much moisture against the trunk, potentially resulting in disease problems.

BARTLETT TREE RESEARCH LABORATORIES
CHARLOTTE, NC

Technical Report

Plant Health Care PHC

Guidelines for Quantifying and Evaluating Wood Decay in Stems and Branches.

Bruce R. Fraedrich, Ph. D., Plant Pathologist

Introduction

Decay is a leading factor that predisposes branches and stems to failure. The size of the decay column relative to the diameter of the branch or stem can be an important determination to assist in assessing whether a stem or branch poses a severe risk of failure. This Technical Report provides guidelines for measuring and evaluating decay in stems and branches to help assess failure potential.

Measurements

Visually assess stem and crown to determine weakest area due to decay. In some instances, several sites on the stem and/or branch may require evaluation.

D = Stem Diameter

C = Circumference = D X 3.14

W = Width of Cavity Opening

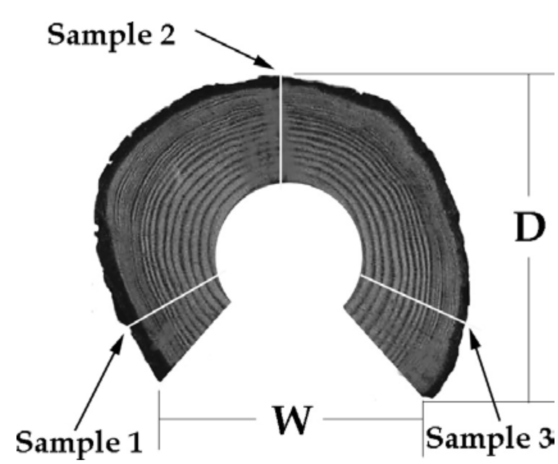
$$\% \text{ Cavity Opening} = \frac{W}{C} \times 100$$

$$\text{Average Thickness of Sound Wood} = \frac{\text{Depth to Decay: Sample 1+2+3}}{3^{*}}$$

* Number of Sample Sites

Measure stem/branch diameter (**D**) at weakest point. Subtract twice the bark thickness to obtain the wood diameter at the defect. If a cavity opening is present, then measure width of opening (**W**). Multiply stem/branch diameter (**D**) by 3.14 to obtain circumference (**C**) at weakest point (**C=D** X **3.14**). Determine the percentage of the circumference with cavity opening by dividing the width of the opening (**W**) by circumference (**C**) and multiplying by 100 **(% Cavity Opening = W/C X 100).**

Calculate the average thickness of sound wood surrounding the defect by probing with a 1/8” drill bit (with long flute) and battery operated drill. Drill into sound wood until resistance



significantly decreases, when decay is encountered. Extract drill bit and measure depth to decay. Subtract bark thickness from measurement. Sample a minimum of three sites on all stem/branches with an additional site per 10 inches of wood diameter. Increase sampling when sample depths vary greatly. A Resistograph or an increment borer can be used in lieu of the drill and drill bit.

Add together the sample values and divide by the number of sample sites to obtain an average thickness of sound wood surrounding the defect.

Thresholds

Refer to **Table 1** for the minimum thickness of sound wood surrounding decay columns with and without cavity openings. Corresponding to the size of the cavity opening (left column), multiply the stem/branch diameter by the fraction in the right hand column to obtain the average minimum thickness of sound wood to support the stem or branch. **If the actual** minimum thickness is less than that value, then the stem/branch probably represents a high risk of failure.

Table 1. Minimum thickness of sound wood surrounding decay columns on stems and branches with and without cavity openings.

Cavity opening % of circumference	Minimum Thickness of Sound Wood Surrounding Decay **(Wood Diameter X)**	
	High Risk	**Critical Risk**
0	0.15	0.10
5%	0.17	0.11
10%	0.18	0.12
15%	0.20	0.14
20%	0.23	0.15
25%	0.26	0.17
30%	0.33	0.18

Many factors interact with decay to cause failure of stems and branches. In many instances such as when multiple defect are present, species wood characteristics are weak or prone to failure or decay is present at stress points, the thickness of sound wood surrounding the decay column must be greater than the minimum specified in Table 1. The minimum thickness of sound wood should be increased in the following instances:

- Leaning stems/branches
- Trees with unbalanced crowns or low crown ratios
- Trees with multiple defects
- Decay present at a stress point (such as mid-crown region of stem, bend in stem or limb, decay in reaction wood)
- Tree species with weak or brittle wood characteristics (including red maple, silver maple, poplar, tulip poplar, linden, horsechestnut, and cottonwood)
- Stem/branch with asymmetrical decay columns
- Trees with declining vitality
- Trees in highly exposed locations
- Sensitive target locations / high use site

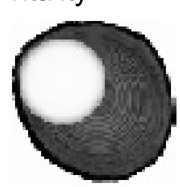


Figure 1. ***Graphic representation showing minimum thickness of sound wood for decayed stems/branches with and without cavity openings*** *(For Severe Risk)*.

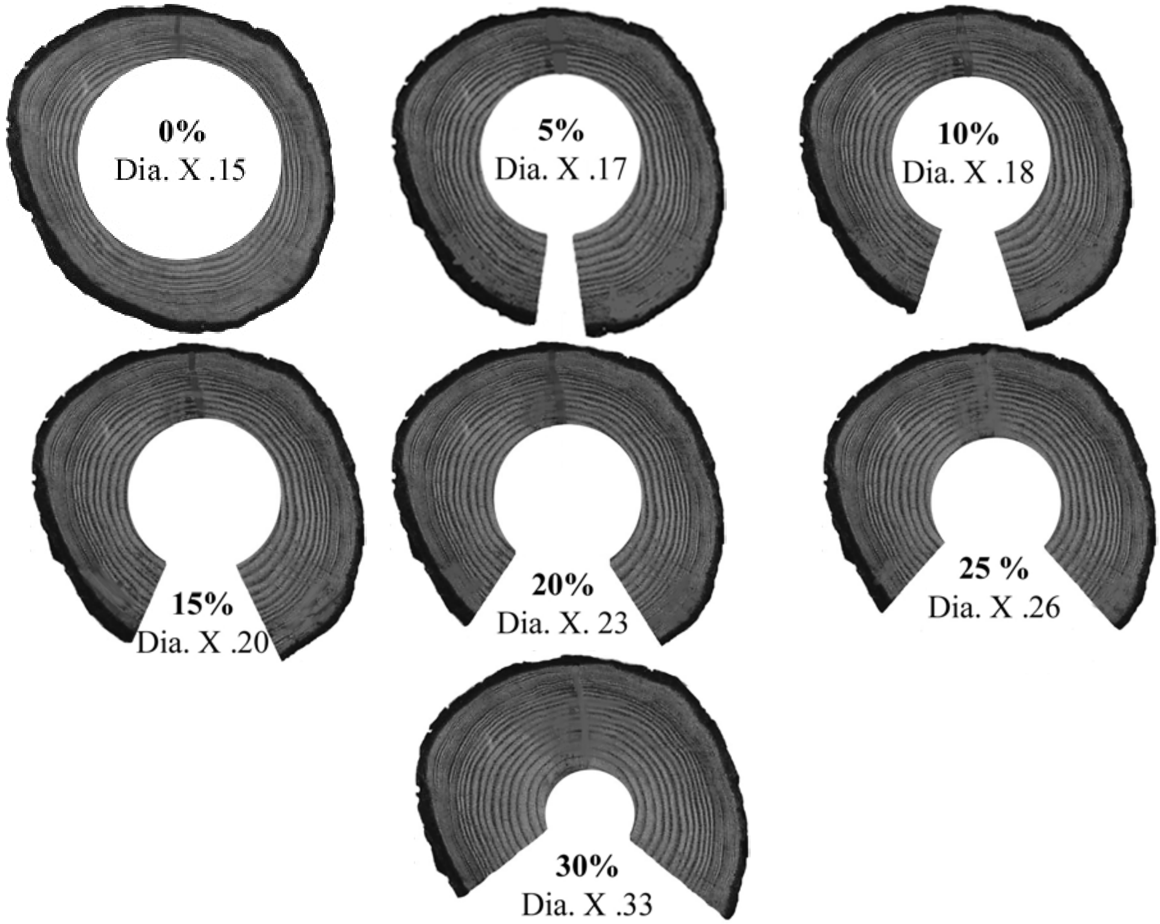


Table 2. Minimum average thickness of sound wood surrounding decay columns with and without cavity opening to be considered a **severe** defect.

	Cavity Opening% Circumference						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Stem Diameter	*(Minimum Thickness (inches) of sound wood)*						
10	1.5	1.7	1.8	2	2.3	2.6	3
15	2.25	2.55	2.7	3	3.45	3.9	4.5
20	3	3.4	3.6	4	4.6	5.2	6
25	3.75	4.25	4.5	5	5.75	6.5	7.5
30	4.5	5.1	5.4	6	6.9	7.8	9
35	5.25	5.95	6.3	7	8.05	9.1	10.5
40	6	6.8	7.2	8	9.2	10.4	12
45	6.75	7.65	8.1	9	10.35	11.7	13.5
50	7.5	8.5	9	10	11.5	13	15
55	8.25	9.35	9.9	11	12.65	14.3	16.5
60	9	10.2	10.8	12	13.8	15.6	18

BARTLETT TREE RESEARCH LABORATORIES
CHARLOTTE, NC
Technical Report
Plant Health Care PHC

Tree Structure Evaluation

Bruce R. Fraedrich, Ph. D., Plant Pathologist

The urban forest is aging and declining at an increasing rate. At the same time, society is becoming more litigious. As a result, detection, evaluation and management of defective trees now are a major concern for arborists, urban foresters and park managers.

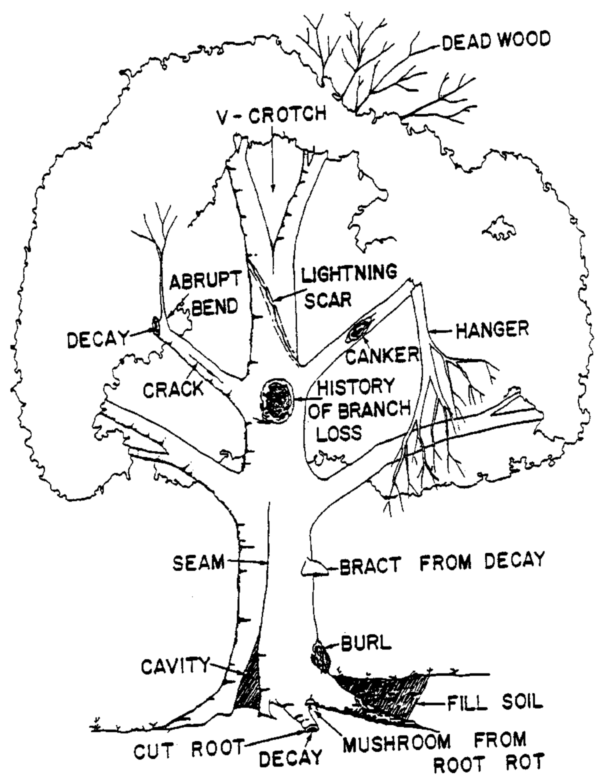
HAZARDOUS TREES DEFINED

A tree is considered hazardous when it has a structural defect that predisposes it to failure and the tree is located near a target (an area where property damage or personal injury could occur if the tree failed). Targets include areas around structures, walkways, roadways, campsites and other areas where there are property and people.

Structurally sound trees also may be hazardous if plant parts interfere with routine activities of people such as obstructing motorists' vision, raising sidewalk, interfering with utilities, roadways or walkways.

LIABILITIES

Property owners/managers have a legal obligation to (1) periodically inspect trees for defects and unsafe conditions and (2) correct defects and unsafe conditions immediately upon detection. If a property owner/manager employs an arborist to perform work on site, the arborist may assume at least some of the responsibility for detecting defective tree conditions and recommending remedial treatments. Arborists are considered "experts" and may be held accountable for uncorrected or unreported tree defects, which are not obvious to the average property owner.



HAZARD TREES DUE TO STRUCTURAL DEFECTS

A thorough inspection of the branches, stem, root crown and area around the root system is essential in detecting hazardous conditions. Binoculars are helpful in detecting defects in the upper crown. In some instances an aerial lift or climber may be needed to provide a detailed evaluation.

Common structural defects include dead trees, dead branches, stubs from topping cuts, broken branches (hangers), abrupt bends in branches, "V" crotches and multiple stems from the root collar (coppice growth). Failure also is more common in trees with an unbalanced crown or leaning stem if there is a defect.

WOOD DECAY DETECTION AND EVALUATION

Many failures in branches and stems result from loss in structural integrity due to wood decay. When evaluating decayed stems and branches, arborists have generally relied on qualitative parameters for formulating recommendations. These parameters include the location and relative size of the defect, tree species characteristics, site exposure, crown size, leaning stems, owner's "attitude" toward the tree and target considerations.

A method is now available that allows the arborist to quantitatively estimate a strength loss value from wood decay which then can be used with the qualitative parameters listed above to determine more precisely if a tree is prone to failure due to wood decay.

Evaluating decay is a four-step process involving:

1. Decay Detection - Symptoms and signs
2. Measuring the size of the decay column
3. Calculating strength loss value due to decay.
4. Selecting a strength loss value "threshold" for wood decay (taking into consideration the strength loss from decay and qualitative factors previously listed).

DETECTION

Symptoms of wood decay can be quite obvious such as open cavities, loose bark/exposed punky wood and fungal fruiting structures growing from the bark or exposed wood. Other symptoms of wood decay can be subtler such as seams, cracks, abnormal flare, burls, stubs and cankers. Decay is often associated with multiple stems from the root collar (coppice growth) and in limbs with abrupt bends. When inspecting trees for decay, make sure the crown and stem is thoroughly examined. Binoculars are helpful for inspecting the crown. In some instances, a climber or aerial lift may be necessary for a satisfactory inspection of the upper crown.

MEASURING THE DECAY COLUMN

The diameter of the decay column is determined by measuring the thickness of sound wood at the weakest point on the stem or branch. The average sound wood thickness is multiplied by 2 and subtracted from the total wood diameter to arrive at the diameter of the decay column. Note wood diameter equals the stem/branch diameter minus twice the bark thickness.

The thickness of the "shell" of sound wood can be rapidly determined with minimum damage using a drill with a 1/8" drill bit. The drill bit is inserted until resistance decreases when decayed tissues are encountered. The inserted portion of the drill is then extracted and measured to determine the thickness of sound wood.

An increment borer also can be used to extract a core of sound wood, which can be measured. This is useful on trees with soft wood where it may be difficult to detect the resistance change between healthy and decayed wood. The increment core is more damaging and slower than the drilling technique.

A Shigometer also can be used to assess healthy, decayed and discolored wood.

A <u>minimum</u> of three sampling sites is used and the values are averaged to calculate the decay column diameter. More sampling is necessary in trees over 30 inches in diameter or when measurements vary greatly.

DETERMINING STRENGTH LOSS VALUES FROM WOOD DECAY IN STANDING TREES

Principally the outer rings of wood provide strength in woody stems and branches. Trees can withstand considerable loss of the inner cylinder without a significant loss in structural integrity. Strength loss resulting from decay in wood tissues can be estimated by comparing the diameter of the decay column to the total diameter of the stem.

This technique is based on engineering formulas used in estimating strength loss in pipes due to corrosion. In pipes, strength loss estimates are as follows:

$$\% \text{ Strength Loss} = \frac{\text{Inside Diameter (hollow)}^4}{\text{Total Diameter}^4} \times 100$$

Wagener (1) modified this formula for trees as follows:

$$\text{Strength Loss (SL)} = \frac{\text{(Diameter of Decay Column)}^3}{\text{(Diameter of Stem)}^3} \times 100$$

$$\text{or SL+} \frac{d^3}{D^3} \times 100$$

Due to the modification, values derived from use of this formula should be viewed as a relative measure of strength loss rather than an actual measure. Values measured against a scale where 0 (zero) equals no strength loss and 100 equals total loss in strength.

When trees have open cavities, the reduction in strength from loss of the outer rings of wood must be entered into the strength loss formula. Loss in strength from open cavities is significant because the outer rings of wood provide most of the structural strength.

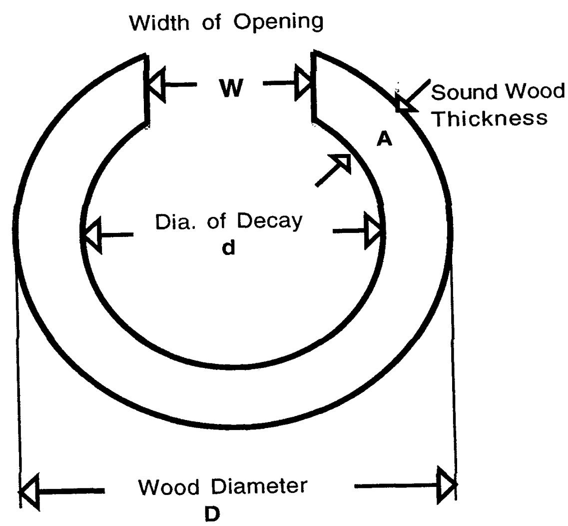
The F.A. Bartlett Tree Expert Co. uses a variation of the formula proposed by Wagener to determine strength loss in stems from open cavities. This formula is as follows:

$$\text{Strength Loss (SL)} = \frac{\text{(Diameter of Decay Column)}^3 + \text{Area of Cavity}}{\text{(Diameter of Stem)}^3}$$

$$\text{or SL} = \frac{d^3 + R\,(D^3 - d^3)}{D^3} \times 100$$

SL = Strength Loss
d = Diameter of Decay Column
D = Stem Diameter (inside bark)
R = Ratio of Cavity Opening to Stem Circumference
(R = width of cavity opening)

Values derived from this formula should also be viewed as a relative measure of strength loss as described above.



STRENGTH LOSS VALUE THRESHOLDS

Wagener (1) stated that West Coast conifers could tolerate up to a one-third loss in strength without predisposing the stem to unreasonable risk of failure if the weakening effect is heart rot uncomplicated by other defects. Wagener emphasizes that the one-third-strength loss value is not absolute and is only a general guideline.

Smiley and Fraedrich (2) surveyed hardwood trees that were broken during 1989's Hurricane Hugo in Charlotte, NC. Sustained winds were 69 miles per hour (mph) with gusts to 90 mph during the storm. They found that 52 of the 54 broken trees had internal decay. Using formulas proposed by Wagener and modified by the Bartlett Tree Lab, strength loss values of broken trees with decay varied from one to

90 with an average of 33. This evidence supports the establishment of a threshold value between 30 and 40 depending on local conditions.

The F. A. Bartlett Tree Expert Co. uses a value of 33 as the maximum strength loss to be tolerated. The threshold is reduced in:

- Leaning Trees
- Trees with inherently weak or brittle wood
- Trees in exposed locations
- Trees with large/full crowns
- Declining trees
- Trees with multiple defects
- Trees in high use areas (sensitive target areas)

STRENGTH LOSS VALUE SIMPLIFIED

The minimum thickness of sound wood surrounding heart rot must be at least 15% of the total wood diameter or the tree is considered an unreasonable risk.

The thickness of sound wood must be greater in trees with cavity openings, species with weak wood, trees with multiple defects, relatively large crowns, leaning stems and trees on exposed sites.

Minimum thickness sound wood = Wood diameter x .015

Wood Diameter (inches)	**Minimum Thickness of Sound Wood** (inches)
10”	1.5”
15”	2.3”
20”	3.0”
25”	3.8”
30”	4.5”
35”	5.3”
40”	6.0”
50”	7.5”

ROOT DEFECT EVALUATION

Up to seventy-five percent of all tree failures are due to root problems. The majority of tree failures occur when winds exceed 50 mph (e.g. hurricane, tornado), however, failures may occur under any wind conditions if the roots are sufficiently weakened. Two types of failure have been classified for this occurrence: Root failure and Ground failure.

Ground failure is extremely difficult to predict. Failure occurs when the soil does not have enough strength to keep the roots intact. Soil and roots are exposed when the tree falls over. This type of failure can occur in any soil texture if the soil is wet. Failure is more common on sandy textured and very shallow (<2’ deep) soils. Soil failure also occurs when trees are surrounded by pavement, which does not allow the root system to develop sufficiently to support the tree.

Root failure occurs when roots break, thus do not provide the necessary support. Root failure occurs more readily on trees, which have root decay or other root problems.

Trees growing in stands, recently thinned stands and recently created edge trees are more susceptible to windthrow due to lack of root spread and increased susceptibility to root disease. Root disease can be detected, however, this is a relatively difficult procedure.

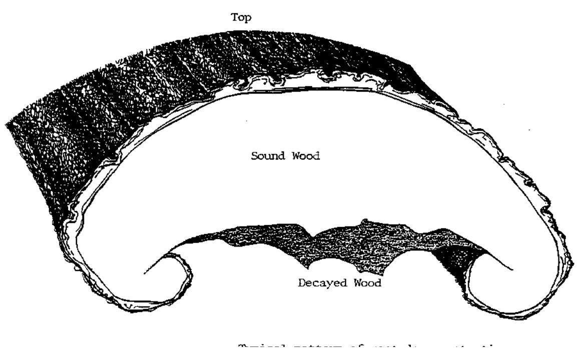
SYMPTOMS OF ROOT FAILURE

Trees with extensive root decay often show little or no symptoms of decline. External indicators of root decay include:

- Dead (loose bark) on the roots, root flare or lower trunk.
- Fungus fruiting structures around the root flare. These include mushrooms, conks and bracts on or immediately adjacent to the tree.
- Oozing from the root flare, lower trunk or wounds on the lower trunk.
- Cuts or fill soil moved beneath the tree.
- Cracks in the soil above or beside major roots.

ASSESSING ROOT DECAY

Root decay is difficult to assess since it starts on the lower section of the root and works its way upward. The most visible section of the root shows the least amount of symptoms. When root decay is present in the buttress or flare roots it is usually



Typical pattern of root decay, starting from the lower side working upward

much more extensive than anticipated. Where root decay is suspected, the first step is to excavate soil from the root collar. Using a penknife, nick the bark on major root flares and valleys between flares to determine whether the bark is healthy.

> **High-risk trees may tolerate a lower percentage of root decay.**
>
> **High-risk trees include the following:**
>
> 1. Leaning trees
> 2. Trees with limited root space
> 3. Trees at the edge of recently cleared areas where severe windstorms frequently occur
> 4. Trees with large and/or dense crowns
> 5. Trees, which have, soil fractures associated with one or more major roots where trees are high risk and any root decay is encountered, always notify the property owner of the increased risk window. Removal may be appropriate.

The next step is to determine if decay is present in the roots or base of the trunk. Using a drill with 1/8” x 8” bit or increment borer, drill downward into each major root issuing from the root collar. Consider the entire root decayed if any defect is encountered. Repeat the same procedures drilling toward the center of the tree in the valleys of the root collar to determine if basal decay is present. Often lower trunk heart rot is associated with root decay. Record the number of healthy and decayed roots.

ROOT DECAY THRESHOLD

Assessing root decay is complicated by the fact that root and basal decay is frequently more severe than detection procedures will indicate. Subsequently, whenever any root/basal decay is encountered the property owner should be advised that root disease might be more severe than anticipated. There is always a risk of failure (windthrow) when root decay is encountered.

The F. A. Bartlett Tree Expert Co. considers that whenever 33% or more of the major roots contain decay, the bark/cambium is dead on more than 33% of the root flare, or when 33% or more of the support root system has been severed, there is high risk of failure. Removal is recommended in the following instances.

INSPECTION AND DOCUMENTATION

Landscape trees should be periodically inspected for defects and other potentially hazardous conditions. Inspections should be performed at least annually and after major storms. Trees growing in high use sites and those with known defects should be inspected more often.

Inspections should be documented in writing whether the trees are considered defective or not. Documentation of inspections (including date), the presence of defects and recommended treatments should be sent to the property owner in writing.

When assessing wood decay and root defects, arborists should not base treatments or removal recommendations solely on strength loss value or percentage of roots with decay. Document all qualitative parameters that may contribute to the hazard as well as the quantitative measurements. Qualitative parameters include species characteristics, crown size, defect location, multiple defects, tree vitality, site exposure, and intensity of site use (target considerations).

Literature Cited

1. Wagener, W.W. 1963. *Judging Hazards From Native Trees in California Recreation Areas: A Guide for Professional Foresters.* US Forest Service Research Paper PSW-P1. 29 pages.

2. Smiley, E.T. and B.R. Fraedrich. 1992. Determining Strength Loss From Wood Decay. Journal of Arboriculture 18:201-204.

Glossary of Terms

arborist: 1. An individual engaged in the profession of arboriculture who, through experience, education and related training, possesses the competence to provide for, or supervise the management of, trees and other woody ornamentals. [ANSI A300 (Part 1, 2, 4, 5, 6)] 2. An individual engaged in the profession of arboriculture. [ANSI Z133.1-2000 Safety Requirements for Arboricultural Operations]

bracing: The installation of lag-thread screw or threaded-steel rods in limbs, leaders, or trunks to provide supplemental support. [ANSI A300 (Part 3)-2000 Support Systems]

branch: An outgrowing shoot, stem or twig that grows from the main stem or trunk. [ANSI Z60.1–2004 Nursery Stock]

buttress roots: Lateral surface roots that aid in stabilizing the tree.

cable: 1) Zinc coated strand per ASTM A-475 for dead-end grip applications. 2) Wire rope or strand for general applications. 3) Synthetic-fiber rope or synthetic-fiber webbing for general applications. [ANSI A300 (Part 3)-2000 Support Systems]

cabling: The installation of a steel wire rope, steel strand, or synthetic-fiber system within a tree between limbs or leaders to limit movement and provide supplemental support. [ANSI A300 (Part 3)-2000 Support Systems]

canopy: collective branches and foliage of a tree or group of trees' crowns

cation exchange capacity(CEC): The ability of soil to absorb nutrients.

cavity: An open wound characterized by the presence of decay and resulting in a hollow.

cleaning: Selective pruning to remove one or more of the following parts: dead, diseased, and/ or broken branches (5.6.1). [ANSI A300 (Part 1)-2001 Pruning]

co-dominant branches: Equal in size and importance, usually associated with either the trunks, stems, or scaffold limbs.

conk: fruiting body or nonfruiting body of a fungus. Often associated with decay.

critical root zone(CRZ): area of soil around a tree trunk where roots are located that provide stability and uptake of water and minerals required for tree survival.

crown: 1. The leaves and branches of a tree measured from the lowest branch on the trunk to the top of the tree. [ANSI A300 (Part 1)-2001 Pruning] [ANSI A300 (Part 6)-2005 Transplanting] 2. The portion of a tree comprising the branches. [ANSI Z60.1-2004 Nursery Stock]

D.B.H. [diameter at breast height]: Measurement of trunk diameter taken at 4.5 feet (1.4 m) off the ground. [ANSI A300 (Part 6)-2005 Transplanting]

decay: The degradation of woody tissue caused by microorganisms. [ANSI A300 (Part 1)-2001 Pruning]

Geographic Information System (GIS): is any system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to earth.

girdling root: A root that may impede proper development of other roots, trunk flare, and/or trunk. [ANSI A300 (Part 6)-2005 Transplanting]

Global Positioning System (GPS): A constellation of at least 24 Medium Earth Orbit satellites that transmit precise microwave signals, the system enables a GPS receiver to determine its location, speed, direction, and time.

Global Positioning System receiver (GPSr): A receiver that receives its input from GPS satellites to determine location, speed, direction, and time.

heading: cutting a shoot back to a bud o cutting branches back to buds, stubs, or lateral branches not large enough to assume apical dominance. Cutting an older branch or stem back to meet a structural objective

integrated pest management (IPM): A pest control strategy that uses an array of complementary methods: mechanical devices, physical devices, genetic, biological, legal, cultural management, and chemical management. These methods are done in three stages of prevention, Observation, and finally Intervention. It is an ecological approach that has its main goal is to significantly reduce or eliminate the use of pesticides.

lateral branch: A shoot or stem growing from a parent branch or stem. [ANSI A300 (Part 1)-2001 Pruning]

leader: A dominant or co-dominant, upright stem. [ANSI A300 (Part 1)-2001 Pruning]

lean: Departure from vertical of the stem, beginning at or near the base of the trunk.

limb: A large, prominent branch. [ANSI A300 (Part 1)-2001 Pruning]

lion's tailing: The removal of an excessive number of inner, lateral branches from parent branches. Lion's tailing is not an acceptable pruning practice (5.5.7). [ANSI A300 (Part 1)-2001 Pruning]

macronutrient: Nutrient required in relatively large amounts by plants, such as nitrogen (N), phosphorus (P), potassium (K), and sulfur (S). [ANSI A300 (Part 2)-2004 Fertilization]

micronutrient: Nutrient required in relatively small amounts by plants, such as iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), and boron (B). [ANSI A300 (Part 2)-2004 Fertilization]

nutrient: Element or compound required for growth, reproduction or development of a plant. [ANSI A300 (Part 2)-2004 Fertilization]

organic matter: material derived from the growth (and death) of living organisms. The organic components of soil.

parent branch or stem: A tree trunk, limb, or prominent branch from which shoots or stems grow. [ANSI A300 (Part 1)-2001 Pruning]

pH: unit of measurement that describes the alkalinity or acidity of a solution. Measured on a scale of 0 to 14. Greater than 7 Is alkaline, less than 7 is acid, and 7 is neutral (pure water).

pruning: The selective removal of plant parts to meet specific goals and objectives. [ANSI A300 (Part 1)-2001 Pruning]

qualified arborist: An individual who, by possession of a recognized degree, certification, or professional standing, or through related training and on-the-job experience, is familiar with the equipment and hazards involved in arboricultural operations and who has demonstrated ability in the performance of the special techniques involved. [ANSI Z133.1-2000 Safety Requirements for Arboricultural Operations]

raising: Selective pruning to provide vertical clearance (5.6.3). [ANSI A300 (Part 1)-2001 Pruning]

reduction: Selective pruning to decrease height and/or spread (5.6.4). [ANSI A300 (Part 1)-2001 Pruning]

risk assessment: process of evaluating what unexpected things could happen, how likely it is, and what the likely outcomes are. In tree management, the systematic process to determine the level of risk posed by a tree, tree part, or group of trees.

root collar: 1. The transition zone between the trunk and the root system. [ANSI A300 (Part 6)-2005 Transplanting] 2. See COLLAR. [ANSI Z60.1-2004 Nursery Stock]

root flare or trunk flare: The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk. [ANSI Z60.1-2004 Nursery Stock] [ANSI A300 (Part 6)-2005 Transplanting]

root zone: The volume of soil containing the roots of a plant. [ANSI A300 (Part 5)-2005

secondary nutrient: Nutrient required in moderate amounts by plants, such as calcium (Ca) and magnesium (Mg). [ANSI A300 (Part 2)-2004 Fertilization]

seam: Vertical line that appears where two edges of wound wood or callus ridge meet.

soil amendment: Any material added to soil to alter its composition and structure, such as sand, fertilizer, or organic matter. [ANSI A300 (Part 6)-2005 Transplanting]

Glossary of Terms

soil pH: A measure of the acidity or alkalinity of the soil.

structural support system: hardware installed in tree, may be; cables, braces, or guys, to provide supplemental support.

sweep: Departure from vertical of the stem, beginning above the base of the trunk.

thinning: Selective pruning to reduce density of live branches (5.6.2). [ANSI A300 (Part 1)-2001 Pruning]

tree risk assessment: Closer inspection of visibly damaged, dead, defected diseased, leaning or dying tree to determine management needs.

topping: The reduction of a tree's size using heading cuts that shorten limbs or branches back to a predetermined crown limit. Topping is not an acceptable pruning practice (5.5.7). [ANSI A300 (Part 1)-2001 Pruning]

tree inventory: A comprehensive list of individual trees providing descriptive information on all or a portion of the project area. [ANSI A300 (Part 5)-2005 Management during site planning, site development, and construction]

tree protection zone: A space above and belowground within which trees are to be retained and protected. [ANSI A300 (Part 5)-2005Management during site planning, site development, and construction]

structural support system: A support system used to provide supplemental support to leaders, individual limbs, and/or the whole plant. [ANSI A300 (Part 4)-2002 Lightning Protection Systems]

trunk: That portion of a stem or stems of a tree before branching occurs. [ANSI Z60.1-2004 Nursery Stock]

wound: An opening that is created when the bark of a live branch or stem is penetrated, cut, or removed. [ANSI A300 (Part 1)-2001 Pruning]