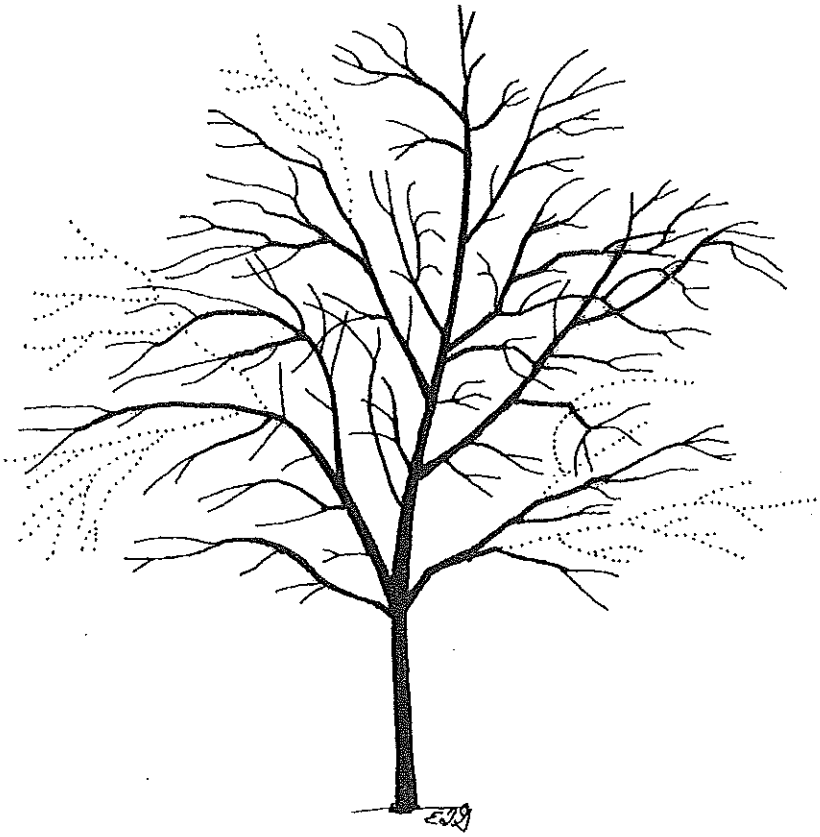
Best Management Practices

TREE PRUNING
(Revised 2008)



Companion publication to the ANSI A300 Part 1: Tree, Shrub, and Other Woody Plant Maintenance—Standard Practices, Pruning

ty of Arboriculture

ox 3129
L 61826-3129
arbor.com

Best Management Practices

TREE PRUNING
(Revised, 2008)

Edward F. Gilman and Sharon J. Lilly

Companion publication to the ANSI A300 Part 1: Tree, Shrub, and Other Woody Plant Maintenance—Standard Practices, Pruning

ISBN: 1-881956-31-8

Editorial Coordinators: Peggy Currid and Sharon Lilly
Text and Cover Composition: Kathy Ashmore
Illustrations courtesy of Edward F. Gilman and *Horticopia: Illustrated Pruning and Planting, Horticopia, Inc., Purcellville, VA*
Printed by: Premier, Champaign, IL

International Society of Arboriculture
P.O. Box 3129
Champaign, IL 61826-3129
(217) 355-9411
www.isa-arbor.com
isa@isa-arbor.com

10
1111-RF-1800

Acknowledgments

Best Management Practices Review Committee

Dane Buell, Sav-A-Tree, Bedford Hills, NY

Pedro Mendes Castro, CEMIG, Belo Horizonte MG, Brazil

Jim Clark, HortScienc, Inc., Pleasanton, CA

Larry Costello, University of California, Half Moon Bay, CA

Steve Day, Day & Associates, Littleton, CO

Tom Dunlap, Canopy Tree Care, Dallas, TX

Bruce Fraedrich, Bartlett Tree Research Lab, Charlotte, NC

C. Way Hoyt, Tree Trimmers & Associates, Fort Lauderdale, FL

Martin Norris, Wellington Shire Council, Australia

Dennis P. Ryan III, University of Massachusetts, Amherst, MA

Tom Smiley, Bartlett Tree Research Lab, Charlotte, NC

Thanks to the *Best Management Practices: Tree Pruning* review commitee who made this document better through their timely reviews.

Special thanks to Tom Smiley and Jim Clark for taking a great deal of time and effort to thoroughly review this document.

We want to thank the Environmental Horticulture Department at the University of Florida in Gainesville, Florida, for their support of this project. Ed Gilman is a professor in the department that enabled him to take the time to help develop this concept into a final document.

Table of Contents

Purpose

Professionals in the field of arboriculture established a committee to develop standards for tree maintenance designed to provide a more uniform level of service and to help ensure public safety. This committee, working under the auspices of the American National Standards Institute (ANSI), developed standards for pruning, fertilization, support systems, and other aspects of tree care. *ANSI A300, The American National Standard for Tree Care Operations—Tree, Shrub, and Other Woody Plant Maintenance—Standard Practices* was written to provide minimal performance standards for use in writing maintenance specifications.

The International Society of Arboriculture (ISA) has developed companion publications known as Best Management Practices to aid in the interpretation and implementation of ANSI A300 standards. These publications are intended as guides for practicing arborists, tree workers, their supervisors, and the people who employ their services.

Because trees are unique living organisms, not all practices can be applied to all trees. It is important that contracts and specifications developed using these guidelines and the ANSI A300 standards are written or reviewed by a knowledgeable arborist. Departures from the standards should be made with careful consideration of the objectives and with supporting rationale.

Best Management Practices: Tree Pruning is the companion publication to *ANSI A300 Part 1—Tree, Shrub, and Other Woody Plant Maintenance—Standard Practices, Pruning.*

Introduction

This document addresses the question "How do I ensure that my pruning meets industry standards and customer expectations while causing minimal harm to the tree?" It provides reasons why pruning is undertaken, explains pruning types and amounts, provides background on pruning cuts, reviews sample specifications, and comments on timing of these operations. Experience and observation teach the truth in Alex Shigo's observation: "Pruning is one of the best things an arborist can do for a tree but one of the worst things we can do to a tree." Pruning is a double-edged sword, either helping or hurting—depending on where, when, how, and why it is applied.

When pruning is properly executed, a variety of benefits are derived. Benefits include reduced risk of branch and stem breakage, better clearance for vehicles and pedestrians, improved health and appearance, enhanced view, and increased flowering. When improperly performed, pruning can harm the tree's health, stability, and appearance. Several consequences occur when pruning is not performed at all (Figure 1). These consequences include development of low limbs; weak, codominant stems; defects such as included bark; and accumulation of dead branches. Formation of codominant stems and defects such as included bark can lead to increased risk of breakage.

One of the most common defects in planted trees is formation of large, low limbs. They could overextend and break, or they may droop under their own weight and have to be removed later, leaving a large pruning wound. Removal of large branches and those more than about half the trunk diameter is more likely to initiate decay than removal of smaller branches. Therefore, measures should be taken to minimize occurrence of this defect.

On mature trees, live branch removal is less desirable than it is on young trees, but sometimes it is necessary. However, cleaning the crown by removing dead, diseased, or broken branches is a highly recommended practice on mature trees. Because reduction cuts can initiate problems, perform crown reduction only after other options have been considered. Do not remove small interior branches because doing so adversely affects tree structure and can increase failure potential. Trees planted for use as shade trees should not be topped or rounded-over with heading cuts because this practice creates weak structure, exposes wood to infection, can initiate cracks and decay, and looks terrible. Topping also has been shown to increase risk of failure. Reaction zones can reduce available stored energy reserves, making such reserves less available for tree growth and defense.

It is essential first to evaluate the tree and the customer's needs to determine which objectives should be accomplished with pruning. Appropriate pruning meth-

ods can be chosen to meet these objectives. The arborist then enters the tree and makes appropriate pruning cuts for the chosen pruning methods. This decision is based on an understanding of branch attachment and tree biology.

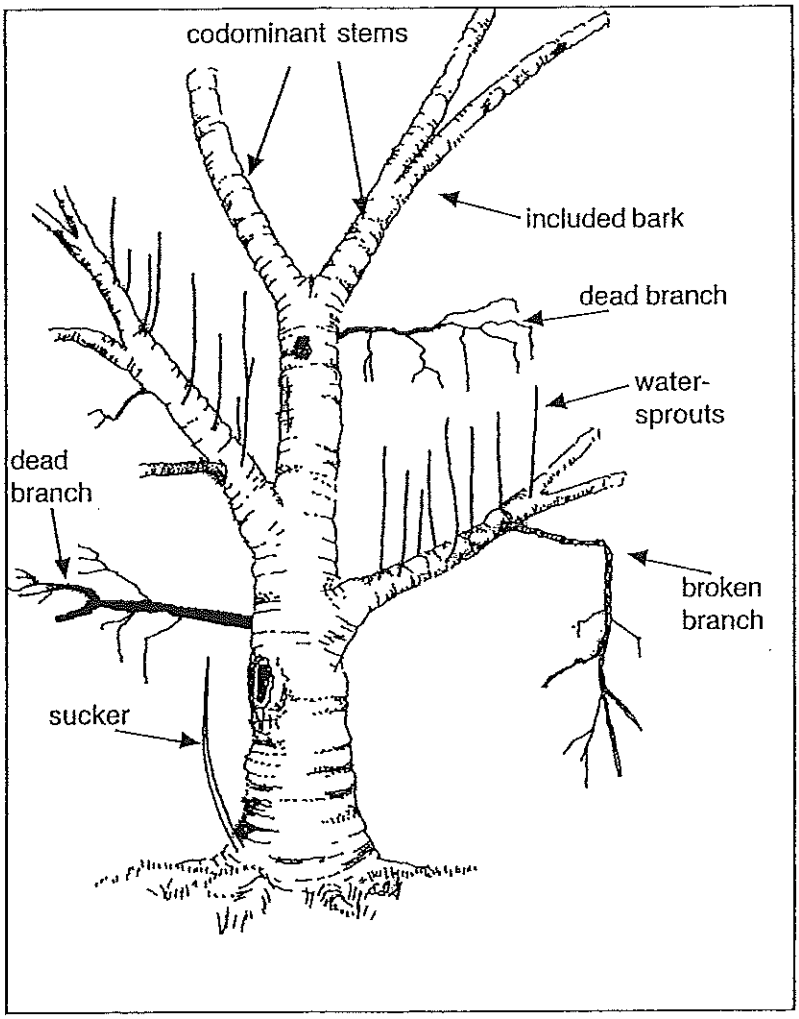


Figure 1. Problems can develop on trees—including codominant stems; included bark; broken and dead branches; suckers and watersprouts; and large, low limbs that require removal.

Pruning Objectives

No tree should be pruned without first establishing clearly defined objectives. Seven main objectives are described (Table 1), along with pruning types that help meet those objectives. These objectives serve as examples and can be expanded or shortened to meet site conditions and customer expectations. Removing the correct stems and branches to accomplish specified objectives is as important as making correct pruning cuts. Even with proper pruning cuts, if the wrong branches—or too many branches—are removed, nothing of merit has been accomplished.

Table 1. Objectives of pruning.

- Reduce risk of failure
- Provide clearance
- Reduce shade and wind resistance
- Maintain health
- Influence flower or fruit production
- Improve a view
- Improve aesthetics

Reduce Risk of Failure

Risk of tree failure can be reduced by establishing a structural pruning program that begins at planting and could carry through the first 25 years or more, depending on the species. This program should be designed to create structurally sound trunk and branch architecture that will sustain the tree for a long period. Some structural pruning can be conducted on older trees as well. Medium-aged and mature trees can be cleaned, thinned, reduced, raised, or restored to manage risk. The choice among these pruning methods depends on the tree and the situation.

Provide Clearance

Growth can be directed away from an object such as a building, security light, or power line by reducing or removing limbs on that side of the tree. However, trees often grow back to fill the void created by pruning. Regular pruning is required to maintain artificial clearance. Shortening or removing low branches can raise the crown. Crown reduction or pollarding helps maintain a tree smaller than it would be without pruning. Utility pruning keeps limbs clear of overhead wires and other utility structures.

Reduce Shade and Wind Resistance

Lawns, ground covers, or shrubs can receive more sunlight when live foliage is removed from the crowns of large overstory trees. The tree's resistance to wind also can be reduced with pruning. Structural pruning, thinning, reduction, and pollarding are used to accomplish this objective.

Maintain Health

Health can be maintained by cleaning the crown, especially in medium-aged and mature trees. Removing dead, diseased, and rubbing branches in the crowns of young trees also is important.

Influence Flower or Fruit Production

Pruning can influence the number and/or size of flowers or fruit. Fruit size can be increased on certain plants, such as peach, by removing some of the developing fruit or flowers. Flower cluster size can be increased on certain species, such as crapemyrtle, by heading. Fruit production can be eliminated by removing flowers or developing fruit.

Improve a View

A view can be enhanced or created by removing live branches at the edge of the crown, at the top of the tree, or on the lower side of the crown. This pruning can include thinning, reducing, pollarding, and raising.

Improve Aesthetics

A tree can be pruned to improve appearance. Cleaning, reducing, thinning, pollarding, and restoring can be used to meet this objective.

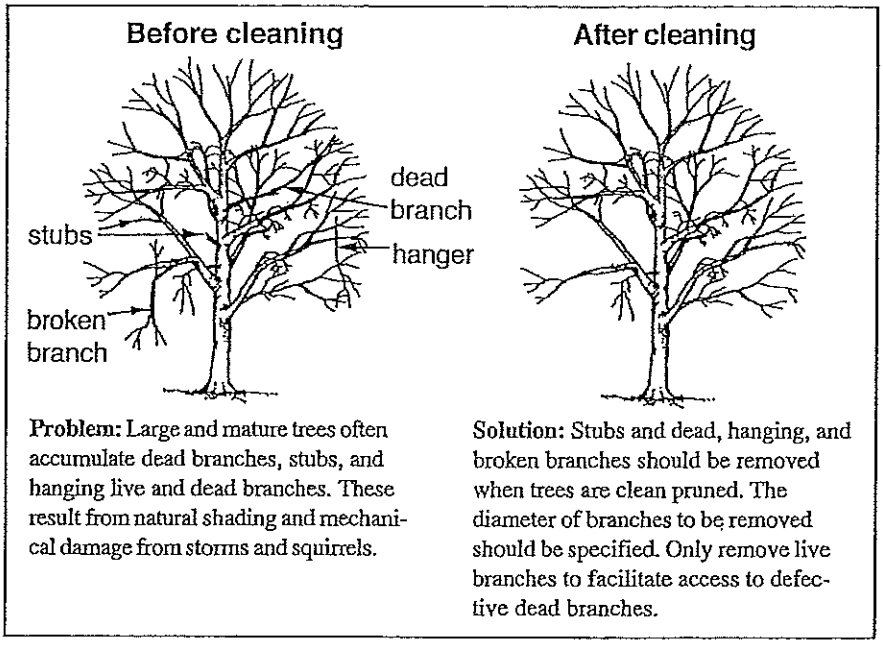
Pruning Methods (Types)

Several pruning methods (types) are used in arboriculture to achieve the tree owner's or manager's objective. The four primary pruning methods include cleaning, thinning, raising, and reducing. Trees are also pruned to improve structure and for crown restoration. When writing job specifications the diameter range and location of the branches and stems to be removed should always be included.

Pruning to Clean

Cleaning is the selective removal of dead, diseased, detached, cracked, and broken branches. This type of pruning is done to reduce the risk of branches falling from the tree and to reduce the movement of decay, insects, and diseases from dead or dying branches into the rest of the tree. It can be performed on trees of any age but is most common on medium-aged and mature trees. Cleaning is the preferred pruning type for mature trees because it does not remove live branches unnecessarily.

The location of branches to be removed should be specified if the entire crown is not going to be cleaned. The diameter of branches to be removed also should be specified. This usually is done by specifying the smallest branch to remove (for example, "clean branches 1 inch [2.5 cm] in diameter and larger").



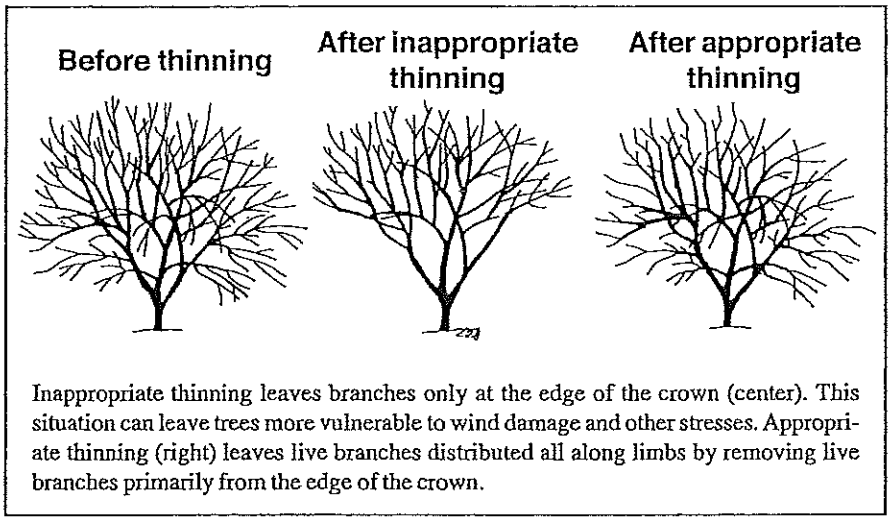
Problem: Large and mature trees often accumulate dead branches, stubs, and hanging live and dead branches. These result from natural shading and mechanical damage from storms and squirrels.

Solution: Stubs and dead, hanging, and broken branches should be removed when trees are clean pruned. The diameter of branches to be removed should be specified. Only remove live branches to facilitate access to defective dead branches.

Figure 2. Pruning to clean

Pruning to Thin

Thinning is the selective removal of small live branches to reduce crown density (Figure 3). Because the majority of small branches are at the outside edge of the crown, thinning is focused in that area. Proper thinning retains crown shape and size and should provide an even distribution of foliage throughout the crown.



Inappropriate thinning leaves branches only at the edge of the crown (center). This situation can leave trees more vulnerable to wind damage and other stresses. Appropriate thinning (right) leaves live branches distributed all along limbs by removing live branches primarily from the edge of the crown.

Figure 3. Thinning trees reduces density at the edge of the crown, not on the interior.

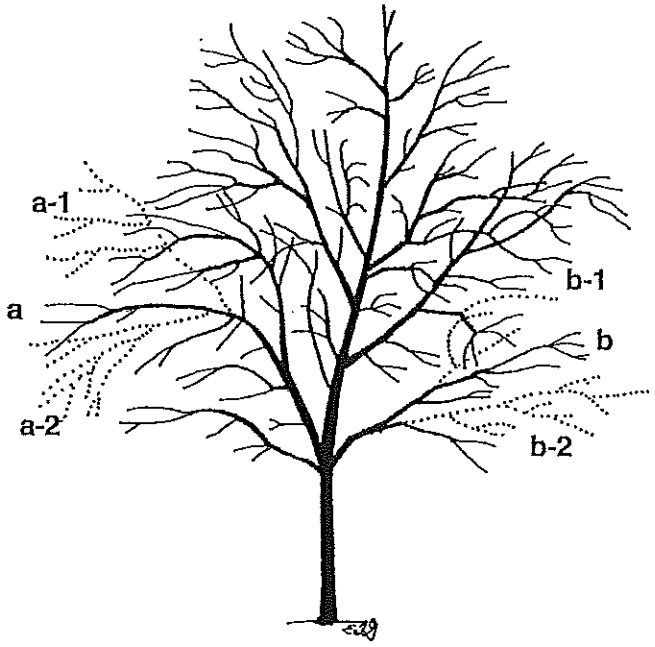
Thinning increases sunlight penetration and air movement through the crown. Increased light and air stimulate and maintain interior foliage, which can encourage taper on scaffold branches. Thinning a limb should be considered if cabling will be performed. Thinning also can remove suckers from the base of the tree and *some* watersprouts on the interior. Excessive removal of watersprouts often produces more watersprouts, so it is not recommended. Vigorous production of watersprouts on interior limbs often is a sign of overthinning, topping, or lion tailing.

Excessive branch removal on the lower two-thirds of a branch or stem (lion tailing) can have adverse effects on the tree and therefore is not an acceptable pruning practice (Figure 3). Lion tailing concentrates foliage at the ends of branches and may result in sunburned bark tissue, watersprouts, cracks in branches, reduced branch taper, increased load on branch unions, and weakened branch structure. Lion tailing also changes the dynamics of the limb and often results in excessive branch breakage.

If the entire crown will not be thinned, the areas to be thinned must be specified. The size range and percentage of foliage to be removed also must be specified—usually in the 10 to 15 percent range—but should not exceed 25 percent of the

foilage, especially on mature trees. Most thinning removes branches 1/2 inch (1.5 cm, small trees) to 2.5 inches (6.5 cm, mature trees) in diameter. If larger branches are removed, large gaps may be created in the crown, or watersprouts can result.

Raising removes indicated branches



Lower branches *a* and *b* can be removed to raise the crown. However, subordinating branches *a* and *b* by removing upper and lower lateral branches *a-1, a-2, b-1,* and *b-2* will cause less stress for the tree. Removing *a-2* and *b-2* helps raise the crown. Removing *a-1* and *b-1* ensures that the branches will not grow up to become part of the permanent canopy. This consideration is important because left unpruned, these branches are likely to remain vigorous—forming low, codominant stems.

Figure 4. Raising

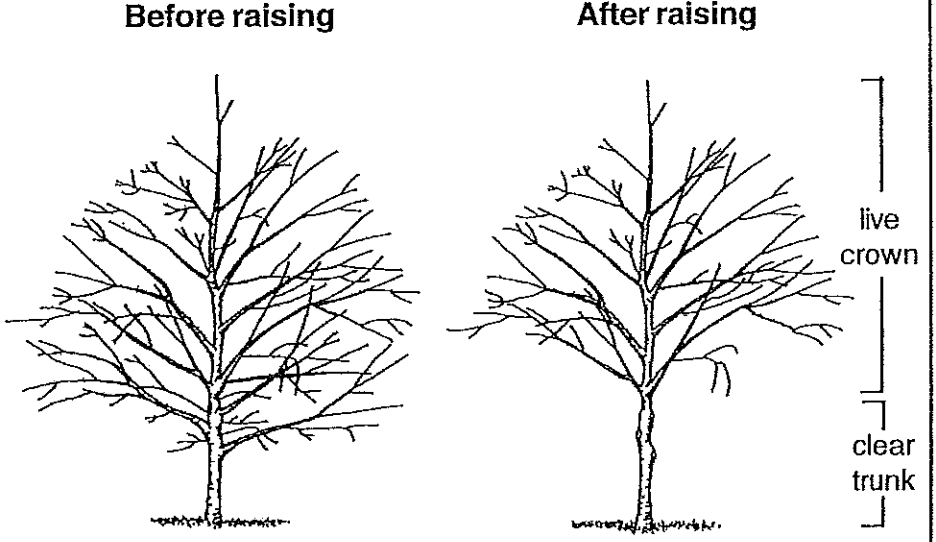
Pruning to Raise (Elevate, Lift)

Raising is the selective removal of branches to provide vertical clearance. Crown raising shortens or removes lower branches of a tree to provide clearance for buildings, signs, vehicles, pedestrians, and vistas.

Excessive removal of lower limbs can slow development of trunk taper, can cause cracks or decay in the trunk, and concentrates foliage at the top of the tree.

Mature trees could become stressed if large-diameter lower branches are removed. Clearance sometimes can be achieved by shortening some of the low branches rather than removing them to prevent these problems. Live crown ratio should be no less than 50 percent when raising is completed (Figure 4), and more is better. Structural pruning should be considered along with raising.

When raising, the desired clearance should be specified. To differentiate between complete branch removal and shortening, specify the size range of the limbs to remove and their location (for example, "raise 12 feet [3.5 m] above the road by removing downward-growing branches 2 inches [5 cm] in diameter and smaller").



Problem: Many trees develop large low branches when planted in the open. As a result they develop a low spreading crown. Low branches often block visibility of signs, buildings and vehicles and have to be removed.

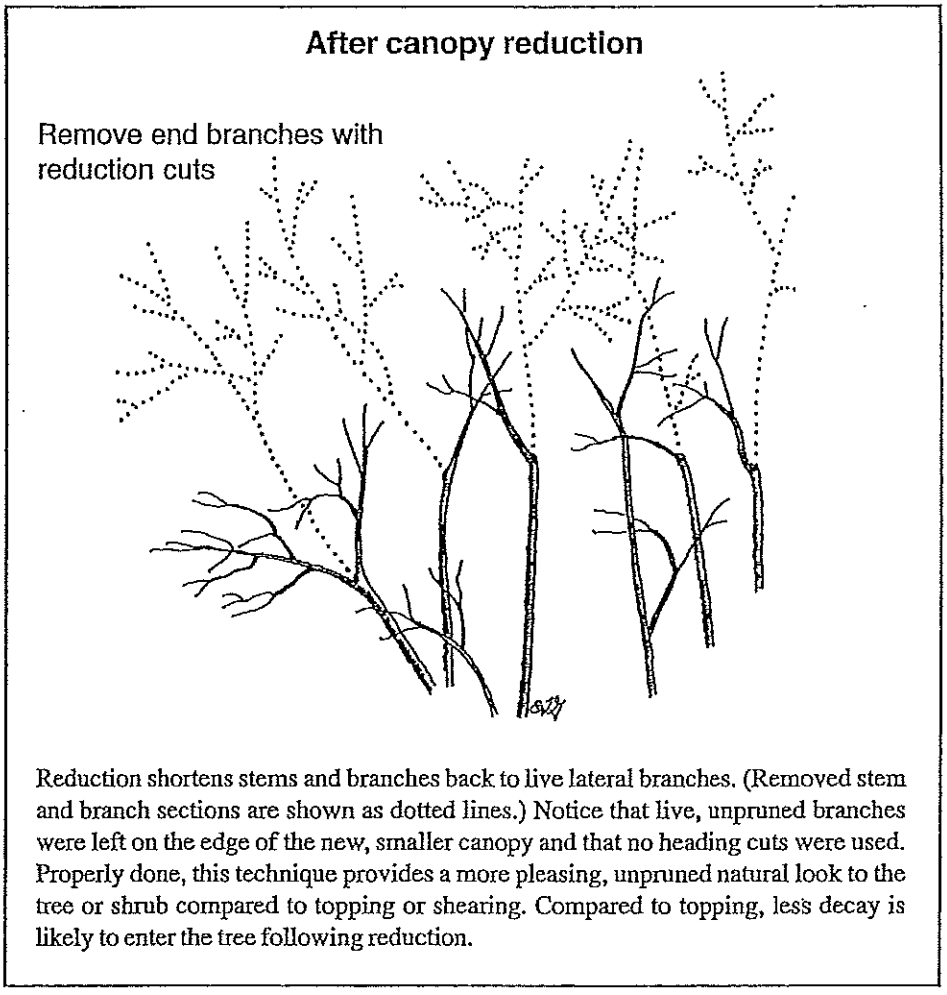
Solution: Remove low branches back to the trunk using an appropriate pruning cut. The ratio of live crown to clear trunk (live crown ratio) should be no less than 50 percent.

Figure 5. Raising the crown by removing low branches.

Pruning to Reduce (Shape, Drop Crotch)

Reduction is the selective removal of branches and stems to decrease the height and/or spread of a tree or shrub (Figure 6). This type of pruning is done to minimize risk of failure, to reduce height or spread, for utility line clearance, to clear vegetation from buildings or other structures, or to improve the appearance of the plant. Portions of the crown, such as individual limbs, can be reduced to balance the canopy, provide clearance, or reduce likelihood of breakage on limbs with defects. Occasionally, the entire crown is reduced. Reducing or thinning should be considered if cabling would be performed. Crown reduction should be accomplished with reduction cuts, not heading cuts.

Not all tree and shrub species can be reduced. Therefore, the species and plant health should be considered before starting work. Old, stressed, or mature trees could decline or become more stressed as a result of this treatment. When a limb on a



Reduction shortens stems and branches back to live lateral branches. (Removed stem and branch sections are shown as dotted lines.) Notice that live, unpruned branches were left on the edge of the new, smaller canopy and that no heading cuts were used. Properly done, this technique provides a more pleasing, unpruned natural look to the tree or shrub compared to topping or shearing. Compared to topping, less decay is likely to enter the tree following reduction.

Figure 6. Reduction makes a plant, or portion of a plant, smaller in size.

mature tree is cut back to a lateral, no more than one-fourth of its foliage should be removed in routine tree care. More can be removed when pruning to reduce risk, or on a young tree to accomplish particular objectives. Decay is more likely to enter the tree following reduction than following other pruning types.

The clearance distance or percentage of size reduction should be specified. Because making many small cuts or just a few larger-diameter cuts can reduce a tree, it is important also to specify the size range of cuts. Reduction usually should be done on smaller-diameter branches (for example, 1 to 4 inches [2.5 to 10 cm] for trees and 1/4 to 1 inch [0.5 to 2.5 cm] for shrubs).

Structural Pruning

Structural pruning is the removal of live branches and stems to influence the orientation, spacing, growth rate, strength of attachment, and ultimate size of branches and stems. Structural pruning is used on young and medium-aged trees to help engineer a sustainable trunk and branch arrangement. If young trees are pruned to promote good structure, they likely will remain serviceable in the landscape for more years than trees that have not been structurally pruned. Waiting until the tree grows larger makes structural pruning difficult and is more damaging to the tree.

Structural pruning of large-maturing trees such as maples, eucalyptus, and oaks reduces certain defects and spaces main branches along one dominant trunk. Subordination can reduce branches, so they remain smaller than about half the trunk diameter, which helps prevent structural failure later. This pruning type can be summed up in the phrase: subordinate or remove codominant stems. Small-maturing trees can be trained to several trunks or pruned to develop only one, depending on the situation. Small-maturing trees and shrubs are structurally pruned to properly space codominant stems, reduce or remove rubbing limbs, and provide desirable crown configuration. The maximum diameter of the reduction cuts used with this pruning type should be specified.

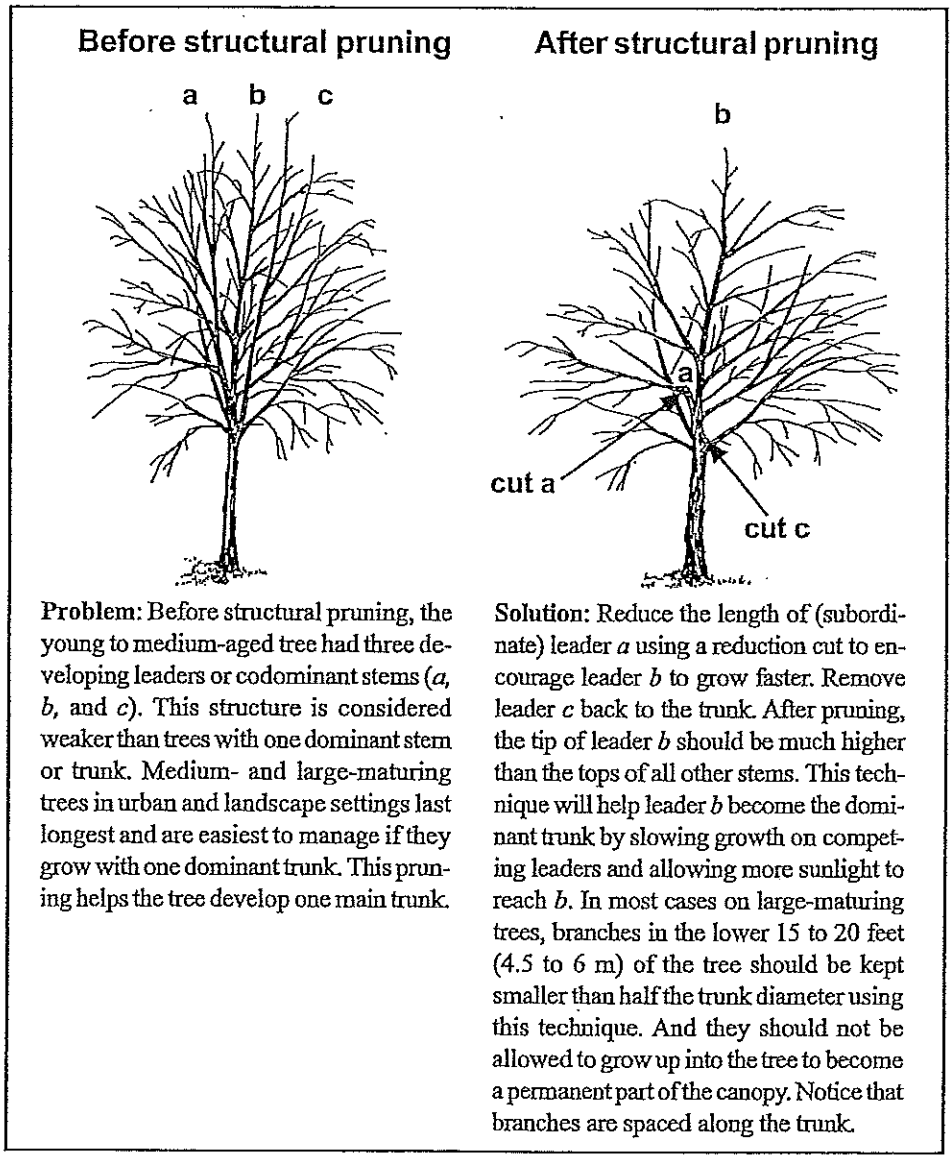
Multiple prunings over time (for example, 15 to 25 years) usually are required to develop a dominant leader (Table 2). Competing stems and branches are subordinated (reduced in length) or removed (Figure 7). Subordination usually is preferred over removal, especially if the problem stem or stems are larger than half the trunk diameter. Subordination may cause less trunk decay than removal. The offending

Table 2. To establish a dominant leader on a young or medium-aged tree, follow these four steps to encourage a leader to dominate the crown.

1. Choose the one stem that will make the best leader.
2. Identify which stems and branches are competing with this leader.
3. Decide how much to shorten these competing stems.
4. Prevent branches from growing larger than half the trunk diameter by regular pruning.

stem(s) can always be removed later, if necessary. Cleaning and raising are usually done in conjunction with structural pruning.

The lowest permanent limb should be established by shortening vigorous branches below it and any lower branches that grow up into the crown (Figure 7). This procedure may not be possible on a young tree if all branches are below the best position for the lowest permanent limb. The height of the lowest limb is determined by the location and intended function of the tree. For example, the lowest permanent limb on a street tree might be higher than that on an arboretum specimen.

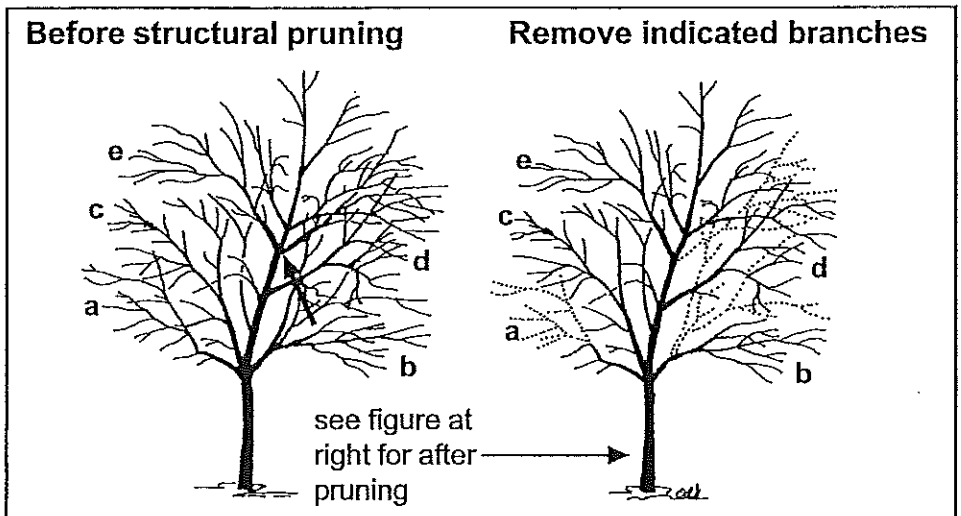


Problem: Before structural pruning, the young to medium-aged tree had three developing leaders or codominant stems (*a*, *b*, and *c*). This structure is considered weaker than trees with one dominant stem or trunk. Medium- and large-maturing trees in urban and landscape settings last longest and are easiest to manage if they grow with one dominant trunk. This pruning helps the tree develop one main trunk.

Solution: Reduce the length of (subordinate) leader *a* using a reduction cut to encourage leader *b* to grow faster. Remove leader *c* back to the trunk. After pruning, the tip of leader *b* should be much higher than the tops of all other stems. This technique will help leader *b* become the dominant trunk by slowing growth on competing leaders and allowing more sunlight to reach *b*. In most cases on large-maturing trees, branches in the lower 15 to 20 feet (4.5 to 6 m) of the tree should be kept smaller than half the trunk diameter using this technique. And they should not be allowed to grow up into the tree to become a permanent part of the canopy. Notice that branches are spaced along the trunk.

Figure 7. Structural pruning of a small tree.

Select and establish scaffold limbs by subordinating or removing competing stems or branches (Figure 8). Scaffold selection can take 10 to 20 years or more depending on climate, the type of tree, and its location. Scaffold limbs are located above the lowest permanent limb and provide the base on which to build the permanent crown. Scaffold limbs should be free of serious defects such as crooks, included bark, and cracks; should be among the largest on the tree; and should be appropriately spaced. Vertical spacing should be at least 18 inches (46 cm) for large-maturing trees and about 12 inches (30 cm) for smaller trees.



Problems: 1. Branches *a, b,* and *c* are clustered together because they originate from the same point on the trunk. 2. Branches *a* and *b* are too close to the ground. 3. There is a main branch (see arrow) directly opposite where branch *e* is attached to the trunk. Opposite or clustered branches often starve the leader above and grow to become more dominant and larger than the leader. Only one main branch should originate from any one spot on the trunk. Notice the upright-oriented branches growing from lower branches. These branches should be shortened.

Solutions: 1. Cut back on branches *a* and *b* so that branch *c* will become the lowest scaffold branch at this position on the trunk. The upright portion of *b* was removed because it was growing up into the canopy. 2. Remove or cut back (removal is shown) the main branch opposite *e* so that *e* can become the scaffold branch at this point on the trunk. Notice that branches *c, d,* and *e* are now spaced along the trunk. Also notice the two small branches left on the trunk opposite branch *d*. These small branches can remain because they are not likely to grow fast to compete with *d*. This procedure is less appropriate on mature trees because the permanent branch structure is set.

Figure 8. Structural pruning is done to ensure more sustainable growth patterns.

Pruning to Restore

Restoration (remedial pruning) is the selective removal of branches, sprouts, and stubs from trees and shrubs that have been topped, severely headed, vandalized, lion tailed, broken in a storm, or otherwise damaged (Figure 9). The goal of restoration is to improve a tree or shrub's structure, form, or appearance.

On trees with many sprouts originating at the ends of branch stubs, one to three sprouts are selected to become permanent branches and to reform a more natural-appearing crown. To accomplish this objective, consider shortening some sprouts, removing others, and leaving some untouched. Some vigorous sprouts that will remain as branches may need to be shortened to control growth and ensure adequate attachment for the size of the sprout.

Lion-tailed trees can be restored by allowing sprouts to develop along the interior portion of limbs for one to three years depending on size, age, and condition of the tree. Then remove and shorten some of the sprouts along the entire length of the limbs, so they are evenly distributed and spaced apart. Restoration usually requires several prunings over a number of years.

Restoration may require a variety of types of cuts. At times, heading cuts may be preferable to branch removal cuts or reduction cuts to preserve as much of a damaged branch as practical. This is sometimes the case in restoration after storm damage.

Specify the location in the tree (for example, top or interior) and the percentage of sprouts to be removed or reduced. Typically, one-third of the sprouts are removed and one-third are reduced each pruning until adequate branches have developed.

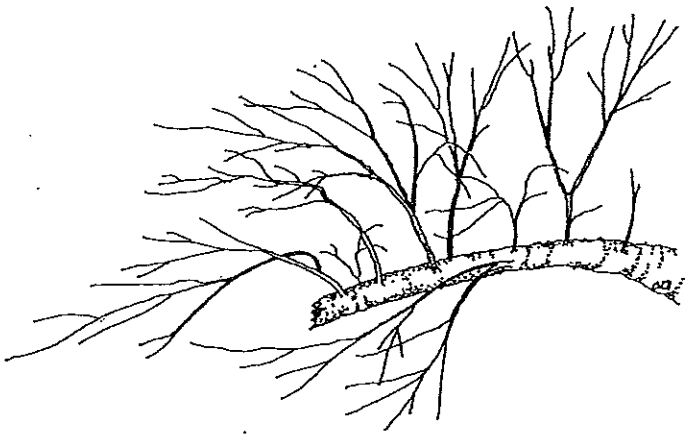
Pollarding

Pollarding is a training system that involves heading the first year followed by annual sprout removal to maintain trees or shrubs at a predetermined size or to maintain a "formal" appearance. Pollarding is not topping. Pollarding historically was used to generate shoots for fuel, shelter, and various products because of the abundance of adventitious sprouts that a tree or shrub produces in this process. The pollarding process should be started on deciduous trees when the tree is young by making heading cuts through stems and branches no more than about three years old.

Table 3. Some species in these genera are known to tolerate pollarding.

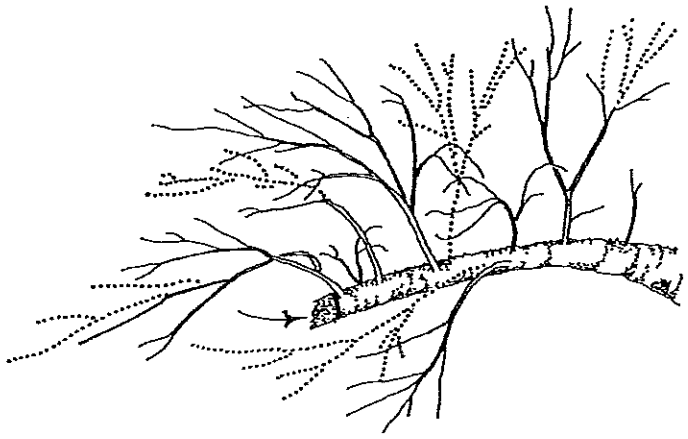
Ash *(Fraxinus)*
Beech *(Fagus)*
Catalpa *(Catalpa)*
Crapemyrtle *(Lagerstroemia)*
Elm *(Ulmus)*
Hawthorn *(Crataegus)*
Horsechestnut *(Aesculus)*
Japanese quince *(Chaenomales)*
Linden *(Tilia)*
Maple *(Acer)*
Oak *(Quercus)*
Pear *(Pyrus)*
Plane tree *(Platanus)*
Sweetgum *(Liquidambar)*

Before restoration



Problem: Many sprouts form from the cut ends of topped or storm-damaged trees. Some sprouts also develop behind the cuts. All are poorly attached to the tree—at least for several years—and can break easily. Notice the eight sprouts that developed from the damaged branch. There are too many sprouts too close together.

After restoration



Solution: Begin by removing dead stubs (see arrow), removing some sprouts completely, and shortening others using reduction cuts (indicated by dotted lines). This procedure helps rebuild structure by spacing unpruned sprouts apart so that they can develop into branches. The shortened branches help protect the sprouts that remain.

Figure 9. Restoration attempts to improve structure by removing or reducing sprouts.

Severe heading (topping) through older tissue may kill or start a decline syndrome on some tree species. Table 3 lists several trees that can tolerate pollarding.

Heading cuts are made at strategic locations so that the sprouts from all cuts have access to sunlight. After the initial cuts are made, no additional heading cuts should be necessary. After a few pruning cycles, pollard heads (also called knuckles or knobs) develop, and the tree produces sprouts from these knuckles. Sprouts that grow from knuckles should be removed during the dormant season, taking care not to cut into or below the knobs. The knobs are the key differentiating factor between pollarding and topping. If knobs are damaged or removed in subsequent pruning, the branches react as they would on a topped tree.

Pruning Palms

Palm pruning is the removal of fronds, flowers, fruit, stems, or loose petioles that may create a hazardous condition. Palms also may be pruned for aesthetic reasons to eliminate sprouts and stems or dead fronds and seedpods. Live, healthy fronds should not be removed. If they must be removed, however, avoid removing those that initiate above horizontal (Figure 10). Fronds removed should be severed close to the petiole base without damaging living trunk tissue. Climbing spikes should not be used to climb palms for pruning.

Pruning Conifers

Some pruning types are not appropriate for all conifers. For example, branch spacing and scaffold limb development in conifers usually are not necessary. Thinning on spruces and firs rarely is needed, although in windy area thinning (spiral thinning) could reduce wind resistance and therefore tree failures. Pine growth may be managed by shortening new growth (candles) and removing older needles rather than branch removal. Few conifers respond well to pollarding or reduction.

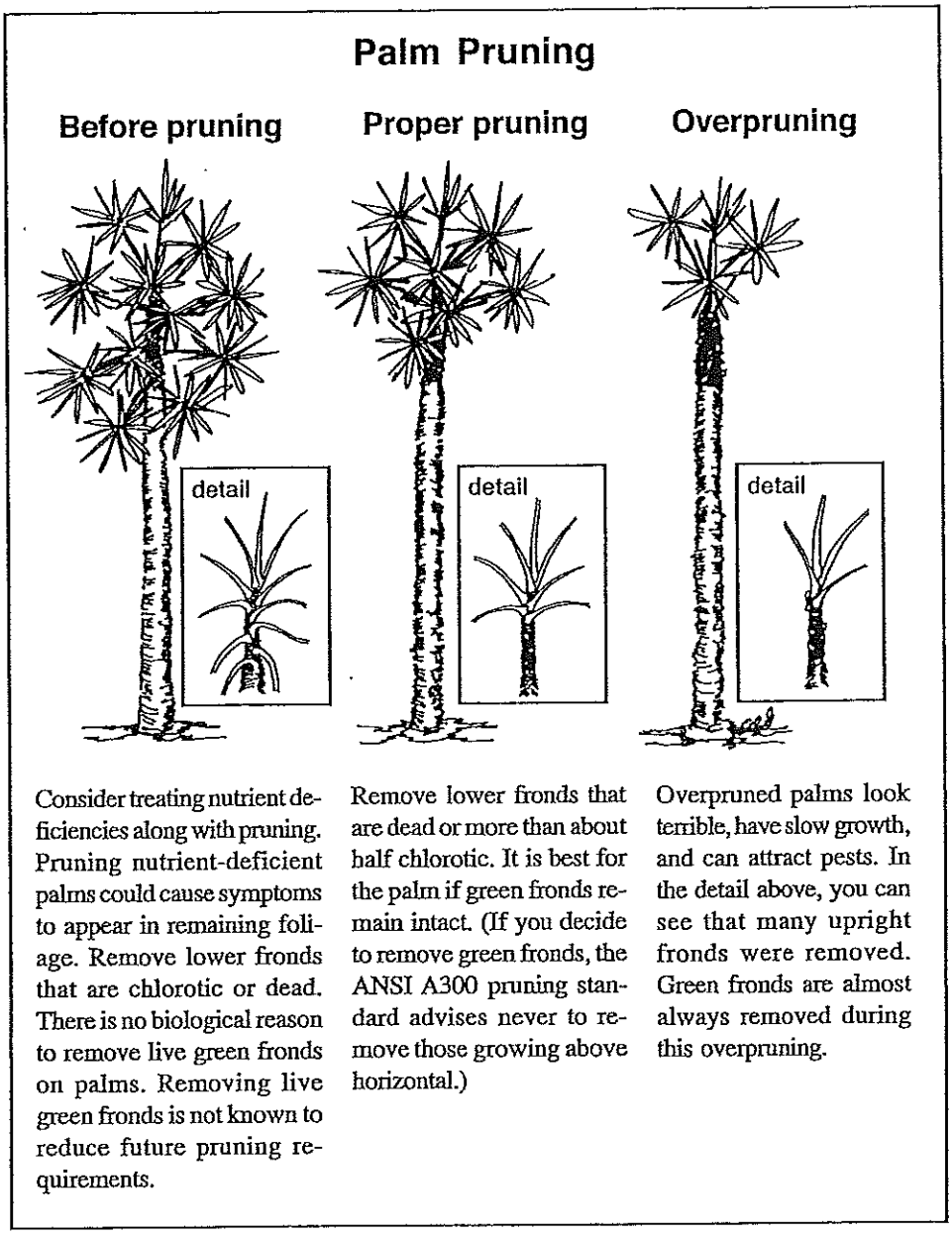
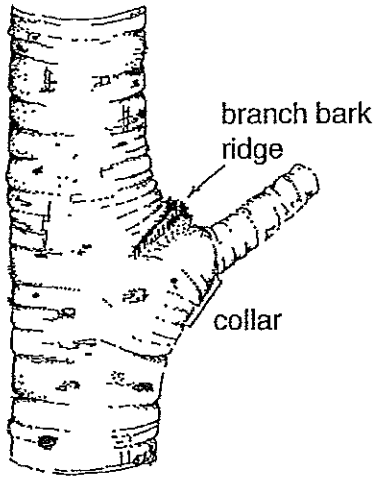


Figure 10. Palm pruning primarily removes dead or chlorotic fronds.

Branch Attachment

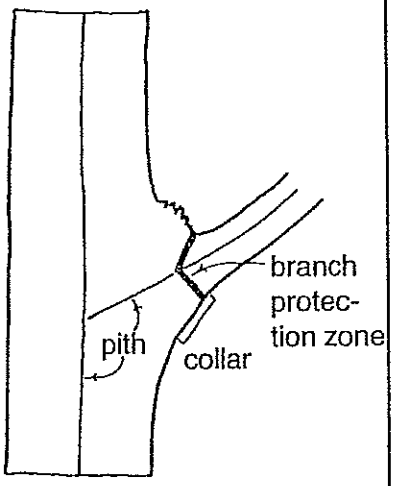
When branches remain small relative to the trunk diameter, a swollen collar often develops around the base of the branch. The collar is formed by overlapping and deflected branch and trunk wood (Figure 11). The overlapping wood makes a union strong. Inside the collar on most trees is a unique chemical barrier called the branch protection zone (Figure 11). Its function is to retard the spread of decay organisms into the trunk. If the collar is removed or severely damaged, decay can more easily enter trunk wood and lead to defects.

Branch union, intact



A collar forms around the base of many branches that remain small relative to the size of the trunk. The branch above is about one-third the diameter of the trunk, so the collar is quite prominent. It appears as a swollen area at the base of the branch where it joins the trunk. Research suggests that the protection zone forms best on branches that remain smaller than about half the trunk diameter.

Branch union, split through the pith



A branch protection zone forms near the edge of the collar on branches that remain small relative to the trunk. This zone has chemical and physical properties that retard the spread of decay into the trunk. As branches grow larger than about half the trunk diameter, the ability to form a protection zone diminishes. When large branches are removed from the trunk, decay often enters the trunk because there is no protection zone. Cracks also can form in the wood.

Figure 11. A collar containing a branch protection zone forms when branches remain small compared to the trunk.

When two stems of approximately equal size (codominant stems, diameter ratios greater than 80 percent) arise from a union, there is little overlapping wood (Figure 12). The result is a weaker union. Decay can enter when one stem is removed because there is no branch protection zone at the base of a codominant stem. The union is even weaker when included bark is part of the condition. Included bark becomes trapped and embedded inside the union as the two stems grow and develop. This condition weakens the union, making the tree prone to failure at that point. There is no traditionally shaped branch bark ridge at the top of the union when included bark is present (Figure 13). Branches and stems with included bark should be removed or shortened on young trees. Removal on large trees may not be a good option because of the potential for decay. Reducing the stem's length or installing a structural support system (see *Best Management Practices: Tree Support Systems*) can minimize the likelihood of the limb failure.

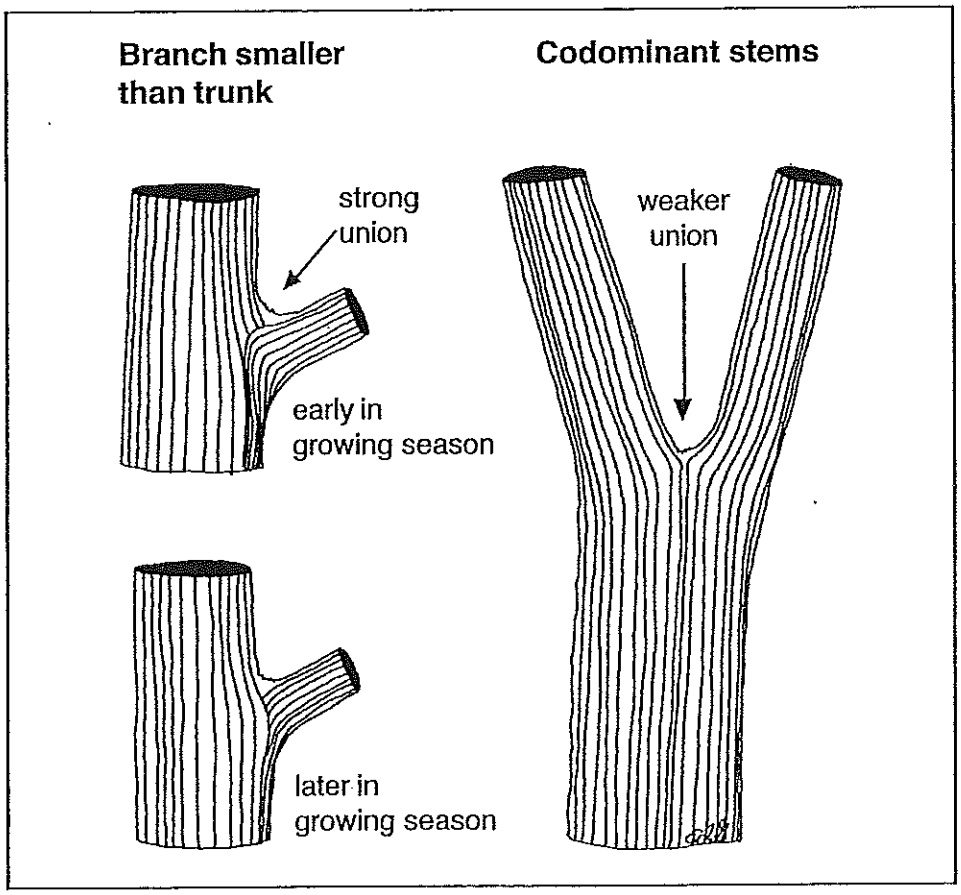
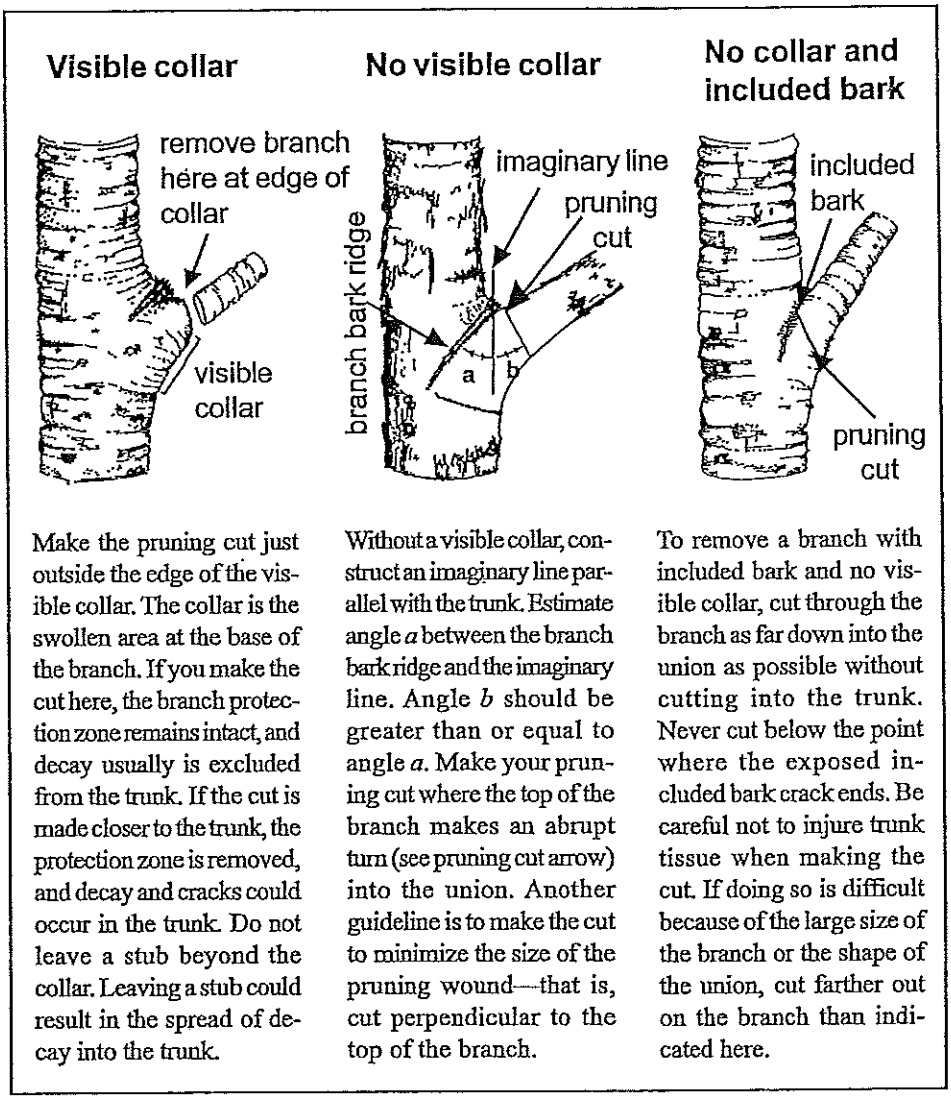


Figure 12. Small branches are well connected to the trunk as a result of overlapping trunk and branch tissue in the union (left). Codominant stems are not as well connected because wood tissue does not overlap in the union (right).



Make the pruning cut just outside the edge of the visible collar. The collar is the swollen area at the base of the branch. If you make the cut here, the branch protection zone remains intact, and decay usually is excluded from the trunk. If the cut is made closer to the trunk, the protection zone is removed, and decay and cracks could occur in the trunk. Do not leave a stub beyond the collar. Leaving a stub could result in the spread of decay into the trunk.

Without a visible collar, construct an imaginary line parallel with the trunk. Estimate angle *a* between the branch bark ridge and the imaginary line. Angle *b* should be greater than or equal to angle *a*. Make your pruning cut where the top of the branch makes an abrupt turn (see pruning cut arrow) into the union. Another guideline is to make the cut to minimize the size of the pruning wound—that is, cut perpendicular to the top of the branch.

To remove a branch with included bark and no visible collar, cut through the branch as far down into the union as possible without cutting into the trunk. Never cut below the point where the exposed included bark crack ends. Be careful not to injure trunk tissue when making the cut. If doing so is difficult because of the large size of the branch or the shape of the union, cut farther out on the branch than indicated here.

Figure 13. Removing branches from trunks or from parent branches.

Pruning Cuts

Three general types of cuts are used in arboricultural pruning: branch removal cut (thinning cut), reduction cut, and heading cut. Removal cuts are preferred because they leave the branch protection zone intact.

Branch Removal Cut (Thinning Cut)

When removing a branch at its point of origin on a trunk, stem, or larger branch, make the cut as close to the trunk as possible without cutting into the branch bark ridge or branch collar and without leaving a stub (Figure 13). The cut should leave a smooth surface with no jagged edges or torn bark. If there is no collar, the top of the cut should be located where the top of the branch makes an abrupt upward turn into the union. The correct position varies among trees and branches. Pruning here most closely simulates where branches are shed naturally. The bottom of the cut can be located according to Figure 13. Except on large limbs, the branch protection zone allows for compartmentalization of the wound. If there is a bark inclusion in the union, cut as far down into the union as possible without injuring trunk wood.

Large or heavy branches should be removed using three cuts. The first one undercuts the limb 1 to 2 feet (0.3 to 0.6 m) out from the parent branch or trunk. The undercut reduces the chance of the branch "peeling" or tearing bark as it is removed. The second cut is the top cut, which on small branches should be made directly above the undercut or slightly farther out on the limb than the undercut. The third and final cut is to remove the stub carefully without tearing bark below the cut.

With large trees, branches often need to be lowered rather than dropped to the ground to reduce damage to the tree and objects below the tree. This procedure is done with ropes, cranes, or other equipment. Details on these procedures can be found in *The Art and Science of Practical Rigging* (DVDs and accompanying book published by the International Society of Arboriculture).

When removing a dead branch, the final cut should be made just outside the collar of living tissue (Figure 14). If the collar has grown along a dead branch stub, only the dead stub should be removed. The collar contains live tissue and should not be injured or removed.

Reduction Cut (Cutting to a Lateral, Lateral Cut, Drop-Crotch Cut)

A reduction cut shortens a limb or branch back to a smaller lateral branch or similarly sized limb (Figure 15). Reduction cuts commonly are used in

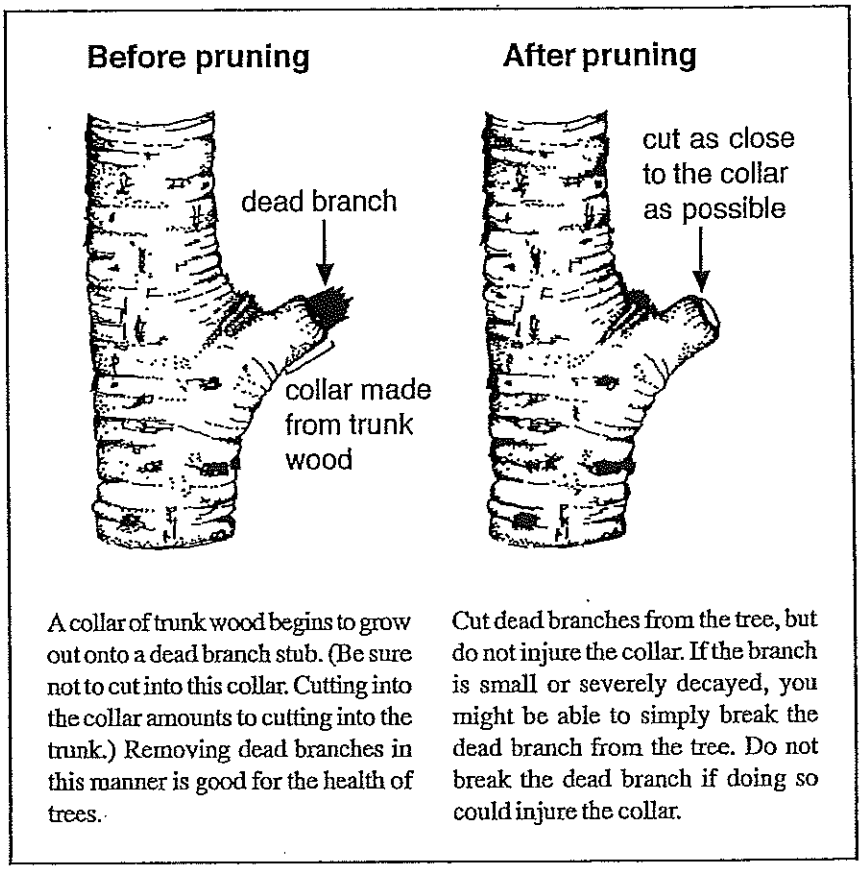


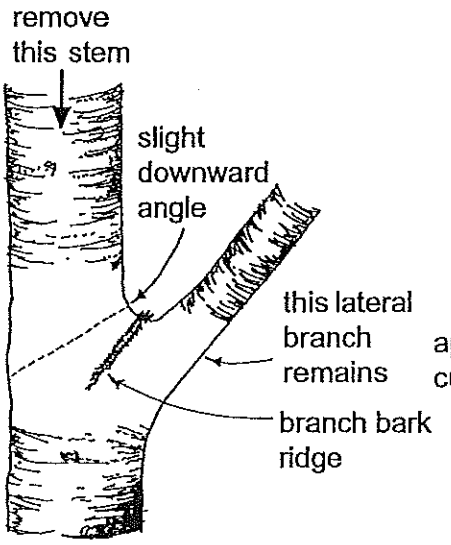
Figure 14. Removing a dead branch should not remove the swollen collar.

structural pruning or when reducing tree size. A stem is cut back to a lateral capable of sustaining the remaining limb and assuming the terminal role. A common rule of thumb is that the remaining lateral branch should be at least one-third to one-half the diameter of the removed portion. At such a size, the lateral branch should be able to produce enough energy to keep the parent branch alive, and enough growth regulator should be present to suppress excessive sprouting on many species. This rule varies with tree species, age, and condition, and with climate. Old, stressed, or mature trees could decline or become more stressed if too much foliage is removed.

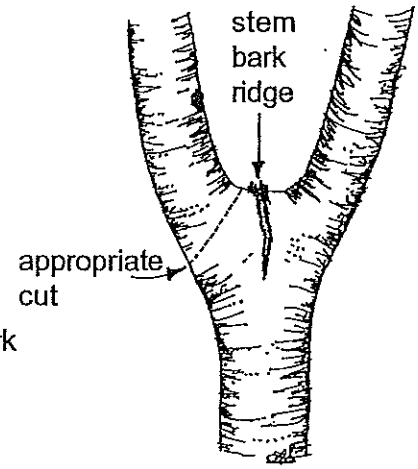
When possible, avoid large reduction cuts (more than 2 inches [5 cm] diameter) on permanent scaffold limbs. Avoiding large cuts is less important on limbs that will be removed from the tree later. On permanent branches, it also is important to consider the ability of the lateral branch to sustain the limb. Cutting back to

Reduction Cuts

Removed stem larger than branch



Stems of equal size



Determining where to make an appropriate reduction cut: To reduce a stem back to a lateral branch, make the cut at a slight downward angle without damaging the remaining stem or cutting any part of the branch bark ridge.

Determining where to make an appropriate reduction cut: Begin the cut just beyond the edge of the stem bark ridge. Cut at an angle to minimize the size of the exposed pruning wound. This location is approximately along the dashed line. There is no natural boundary to resist decay inside the cut stem from reduction cuts.

A reduction cut removes a stem or branch back to a lateral branch or stem that is large enough to assume the terminal role. Typically, this lateral branch should be at least one-third the diameter of the removed portion. If the lateral branch that remains is less than one-third the diameter of the removed stem, then the cut is considered a heading cut. A heading cut is considered inappropriate on most landscape trees. A reduction cut may cause some decay behind the cut. The extent of decay depends on the diameter of the cut and the tree species. Larger-diameter cuts (greater than about 2 to 3 inches [5 to 7.6 cm]) are likely to cause more decay than smaller cuts.

Figure 15. A reduction cut shortens a stem back to a lateral branch.

a lateral that is insufficient in size is much like making a topping or heading cut. 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. (Figure 15). Cutting *toward* the branch bark ridge reduces the risk of the union splitting out.

Trees do not compartmentalize this type of wound as well as the wound created following a removal cut. The ability of the tree to compartmentalize the wound is a function of the size of the cut, the age of the cut stem or branch, tree vigor or vitality, species, and perhaps the time of year. The smaller the cut and the more vigorous the tree, the better the wound closure and compartmentalization.

Heading Cut

A heading cut (topping cut, lopping cut) is made between branches. This type of cut leaves a stub. These cuts rarely are appropriate on established trees. They can, however, be used on current season's growth to remove old flower heads and developing fruit or to reduce the length of a branch or sprout to improve appearance. Heading cuts are used in the first year of pollarding. Heading should not be used to reduce the height or size of trees in other instances. This practice is called topping and is extremely damaging to shade trees. Shearing (or rounding-over) large-maturing trees also is inappropriate because it causes a profusion of sprouts that grow rapidly into a dense mass of foliage. This practice spoils good tree architecture and can significantly increase maintenance requirements. Shearing is appropriate and commonly practiced on shrubs to maintain size.

Wound Dressing

Wound dressings are treatments applied to pruning cuts or other tree wounds. Traditionally, they were formulated with asphalt-based products in paint or spray form. Wound dressings once were thought to accelerate wound closure and reduce decay. Research shows that these products do not reduce the spread of decay. However, studies have shown beneficial effects of wound dressings in reducing borer attack and oak wilt infection and controlling sprout production and mistletoe. Wound dressings are used primarily for cosmetic purposes, and neither are required nor recommended in most cases. If a dressing must be applied, only a light coating of a nonphytotoxic material should be used.

How Much to Prune

Energy reserves (starch, sugars, and oils) are stored in branches, stems, trunk, and roots. This energy can be preserved by removing the fewest number of live branches necessary to accomplish the desired objective. Excessive branch removal depletes these reserves and reduces the ability of the tree to photosynthesize more energy. There should be a good reason to remove more than 25 percent of the live crown in a single year. Many trees generate adventitious sprouts in response to overpruning as they attempt to replace the stored energy. Live branch pruning, however, is an essential ingredient to forming good structure, so it is a necessary procedure in an urban tree care program.

When to Prune

The best time to prune live branches depends on the desired results. Removal of dying, diseased, broken, rubbing, or dead limbs can be accomplished any time, with little negative effect on the tree.

Growth is maximized and defects are easier to see on deciduous trees if live-branch pruning is done in the winter or before growth resumes in early spring. Pruning when trees are dormant can minimize the risk of pest problems associated with wounding and allows trees to take advantage of the full growing season to close and compartmentalize wounds. Trees with Dutch elm disease should have diseased branches removed as soon as a branch shows flagging.

The timing of pruning can be an important part of a Plant Health Care program. For example, one of the ways to reduce the spread of oak wilt or Dutch elm disease fungus is to prune during the dormant season and avoid pruning susceptible species during the time of the vector beetle flight in areas where disease is a problem.

Plant growth rate can be reduced if live-branch pruning takes place during or soon after the initial growth flush. This is the period when trees have just expended a great deal of stored energy to produce roots, foliage, and early shoot growth, so pruning at this time usually is not recommended because of the potential stresses. Do not prune live branches from stressed trees at this time because they need all their live foliage to help recover.

Flowering can be prevented or enhanced by pruning at the appropriate time of the year. To retain the most flowers on landscape trees that bloom on current season's growth, such as crapemyrtle (*Lagerstroemia* spp.) or linden (*Tilia* spp.), prune these trees in winter, prior to leaf emergence, or in the summer just after bloom. Plants that bloom on last season's wood, such as crabapples (*Malus* spp.) and cherries (*Prunus* spp.), should be pruned just after bloom in order to preserve the flower display. Fruit trees can be pruned during the dormant season to enhance structure and distribute fruiting wood, and they are pruned after bloom to thin fruit.

Certain species of trees, such as maples (*Acer* spp.) and birches (*Betula* spp.), drip sap (bleed) when pruned in the early spring when sap flow is heavy (Table 4). Although unattractive, sap drainage has little negative effect on tree growth or health. Some of the sap dripping can be avoided by pruning in summer or at other times of the year.

Table 4. Trees that often drip sap (bleed) when pruned in late winter or early spring.

Avocado *(Persea americana)*
Birch (*Betula* spp.)
Cottonwood (*Populus* spp.)
Elm (*Ulmus* spp.)
Flowering dogwood *(Cornus florida)*
Hackberry (*Celtis* spp.)
Honeylocust *(Gleditsia triacanthos)*
Magnolia (*Magnolia* spp.)
Maple (*Acer* spp.)
Mesquite (*Prosopis* spp.)
Poplar (*Populus* spp.)
Silk-oak *(Grevillea robusta)*
Walnut (*Juglans* spp.)
Willow (*Salix* spp.)

Tools

Pruning tools adequate for the size of cuts being made should be selected. Tools should be sharp so as to make clean cuts without jagged edges or stubs. Dull, anvil-type pruning tools, with a blade that cuts to a flat surface, should be avoided because they crush tissue; tools with bypass (scissors-type) blades are preferred. Place the blade side of the pruner toward the tree and squeeze the blade *up* through or *across* the branch. Passing the blade *down* through the branch can cause the union to split.

Equipment and work practices that damage living tissue and bark beyond the scope of the work should be avoided. Climbing spurs are not to be used to climb trees for pruning operations except when limbs are more than a throwline distance apart and there are no other means of climbing the tree, when the bark is thick enough to prevent damage to the cork cambium (for example, on thick-barked species such as mature redwoods), to reach an injured worker, or when removing the entire tree.

Although probably a rare occurrence, the probability of spreading pathogens on pruning tools varies with the particular disease, the plant, the pruning tools used, the environmental conditions, and the timing. Chain saws are difficult, if not impossible, to sterilize during pruning operations. If tools are sterilized, it is important to use a material that will not injure plant tissues or damage tools. Materials commonly used to sterilize tools include bleach (10 percent solution), Lysol, and automotive antifreeze.

Pruning Specifications

Written specifications are the core of executing good pruning. Without good specifications, each arborist bidding on a pruning job bids on the work he or she thinks should be done, and this decision could vary widely among arborists. Municipalities, condominium and home owner associations, and commercial property managers may benefit most from using specifications. Commercial tree care companies should use ANSI A300 terms when writing pruning specifications on their work orders.

Specifications should include objectives of the pruning, pruning types to be used, size range of branches to remove, percentage of live crown to remove, and location of branches (Table 5). The specifications should state that all work shall be performed according to the ANSI A300 pruning standard and the ANSI Z133.1 safety standard.

Table 5. Minimum pruning specification requirements.

- Clearly state which trees are to be pruned.
- Include a statement that all work shall be performed in accordance with the ANSI A300 pruning standard and the ANSI Z133.1 safety standard.
- Include clearly defined pruning objectives.
- Specify the pruning types to be performed to meet the objectives.
- State the size specifications of the minimum and/or maximum branch size to be removed.
- Specify the maximum amount (expressed as a percentage) of live tissue that can be removed.

Example 1
Specification example to include in a request for bids for pruning medium-aged and mature trees

(The following is only an example and should not be used as is. Develop specifications based on your needs, the objectives of the customer, and the condition and size of the trees to be pruned.)

"Shall" refers to a practice that is mandatory; "should" refers to a practice that is recommended. If a "should" recommendation will not be followed, a written explanation must be provided.

Objectives

Twenty-seven oak trees along Sweetwater Lane from 1600 block to 1800 block shall be pruned to improve structure and reduce the risk of limb failure by

1. cleaning the entire crown of each tree by removing all undesirable branches greater than 1-inch (2.5 cm) diameter.
2. reducing the length of long, horizontal branches by about 5 feet (1.5 m).
3. reducing the length of branches or stems with included bark by 5 to 10 feet (1.5 to 3 m).
4. reducing or thinning by 20 percent any limbs that require cabling.

Procedures

1. Live branches less than 1-inch (2.5 cm) diameter should not be removed from the interior of the crown (some branches may need to be removed to allow the arborist to enter and work in the trees). No live branches greater than 4-inch (10 cm) diameter shall be removed from the tree without authorization from owner or owner's agent.
2. Dead, diseased, or broken branches greater than 1-inch (2.5 cm) diameter (measured at the base of the branch) shall be removed from the canopy of all trees.
3. No more than 20 percent of live foliage shall be removed from any tree.
4. Swollen collars, even if they are quite large, shall remain on the tree following removal of dead branches.
5. Pruning cuts shall be in accordance with ANSI A300 pruning standard, and work shall be performed in accordance with the ANSI Z133.1 safety standard. Pruning shall be in accordance with ISA's *Best Management Practices: Tree Pruning.*

Personnel Qualifications

All work should be performed under the supervision of an ISA Certified Arborist or state licensed arborist.

Example 2
Sample work order for residential tree work

(The following is only an example and should not be used as is. Develop work orders based on your needs, the desires and objectives of the customer, and the condition and size of the trees to be pruned.)

"Shall" refers to a practice that is mandatory; "should" refers to a practice that is recommended. If a "should" recommendation will not be followed, a written explanation must be provided.

Pruning Types to Execute on This Job (Check All That Apply)

❑ structural ❑ clean ❑ thin ❑ raise ❑ reduce ❑ restore

Objectives and Procedures

1. Reduce potential for failure in large, front-yard white oak *(Quercus alba)* by
   - cleaning (1-inch [2.5 cm] diameter and larger).
   - removing north limb (8-inch [20 cm] diameter) with split crotch and included bark.
2. Raise 12-inch (30 cm) green ash *(Fraxinus pennsylvanica)* in rear to allow under-clearance of 8 feet (2.5 m).
3. Clean (branches greater than 1-inch [2.5 cm] diameter) and thin (remove branches between 1/2- and 1-inch [1.2 to 2.5 cm] diameter only) maple by vegetable garden to allow greater sunlight penetration.

General

No live branches greater than 5-inch (12.5 cm) diameter shall be removed from the tree without authorization from the home owner. No more than 20 percent of live foliage will be removed from the tree. Pruning cuts shall be in accordance with ANSI A300 pruning standard, and work shall be performed in accordance with the ANSI Z133.1 operations standard. Pruning shall be in accordance with ISA's *Best Management Practices: Tree Pruning*.

Glossary

ANSI A300–In the United States, industry-developed, national consensus standards of practice for tree care.

ANSI Z133.1–In the United States, industry-developed, national consensus safety standards of practice for tree care.

arboriculture–Practice and study of the care of trees and other woody plants in the landscape.

arborist–Professional who possesses the technical competence gained through experience and related training to provide for or supervise the management of trees and other woody plants in residential, commercial, and public landscapes.

bark inclusion–See included bark.

best management practices–Best-available, industry-recognized courses of action, in consideration of the benefits and limitations, based on scientific research and current knowledge.

branch–A stem arising from a larger stem; a subdominant stem; the pith in true branches has no connection to the parent stem.

branch bark ridge–Raised strip of bark at the top of a branch union, where the growth and expansion of the trunk or parent stem and adjoining branch push the bark into a ridge.

branch collar–Area where a branch joins another branch or trunk that is created by the overlapping vascular tissues from both the branch and the trunk. Typically enlarged at the base of the branch.

branch protection zone–Chemically and physically modified tissue within the trunk or parent branch at the base of a smaller, subordinate branch that retards the spread of discoloration and decay from the subordinate stem into the trunk or parent branch.

cambium–Thin layer(s) of meristematic cells that give rise (outward) to the phloem and (inward) to the xylem, increasing stem and root diameter.

cleaning–Selective pruning to remove dead, diseased, cracked, and broken branches and foreign objects.

climbing spurs–Sharp devices strapped to a climber's lower legs to assist in climbing poles or trees being removed. Also called spikes, gaffs, irons, hooks, or climbers.

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

codominant stem–Forked branches nearly the same diameter (diameter ratios > 80 percent), arising from a common junction and lacking a normal branch union.

compartmentalization–Natural defense process in trees by which chemical and physical boundaries are created that act to limit the spread of disease and decay organisms.

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

decay–(1) (*noun*) An area of wood that is undergoing decomposition. (2) (*verb*) decomposition of organic tissues by fungi or bacteria.

dominant leader/trunk/stem–The stem that grows much larger than all other stems and branches.

frond–Large, divided leaf structure found in palms and ferns.

good structure/architecture/form–Branch and trunk architecture resulting in a canopy form that resists failure.

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

included bark–Bark that becomes embedded in a crotch (union) between branch and trunk or between codominant stems. Causes a weak structure.

interior foliage–Typically small-diameter (less than 3 inches [7.6 cm]) branches with foliage on the interior or inner portion of the crown.

kerf–Slit or cut made by a saw in a log. Space created by a saw cut.

lateral–A branch arising from a larger stem or branch.

leader–Primary terminal shoot or trunk of a tree. Large, usually upright stem. A stem that dominates a portion of the crown by suppressing lateral branches.

lion tailing–Poor pruning practice in which an excessive number of branches are thinned from the inside and lower part of specific limbs or a tree crown, leaving mostly terminal foliage. Results in poor branch taper, poor wind load distribution, and a higher risk of branch failure.

live crown ratio–The ratio of the height of the crown containing live foliage to the overall height of the tree.

mature trees–Trees that have reached at least 75 percent of their typical final height and spread.

method–A procedure or process for achieving an objective.

parent branch or stem–A tree trunk or branch from which other branches or shoots grow.

peeling–The removal of dead frond bases without damaging living trunk tissue at the point they make contact with the trunk.

petiole–Stalk or support axis of a leaf.

permanent branches (permanent limbs)–In structural pruning of young trees, branches that will be left in place, often forming the initial scaffold framework of a tree.

photosynthesis–Process in green plants (and in algae and some bacteria) by which light energy is used to form glucose (chemical energy) from water and carbon dioxide.

phytotoxic–Term to describe a compound that is poisonous to plants.

pollarding–Specialty pruning technique in which a tree with a large-maturing form is kept relatively short. Starting on a young tree, internodal cuts are made at a chosen height, resulting in the development of callus knobs at the cut height. Requires regular (usually annual) removal of the sprouts arising from the cuts.

pruning–Removing branches (or occasionally roots) from a tree or other plant using approved practices, to achieve a specified objective.

raising–Selective pruning to provide vertical clearance; also known as lifting.

reaction zone–Natural boundary formed chemically within a tree to separate damaged wood from existing healthy wood. Important in the process of compartmentalization.

reducing–Pruning to decrease height or spread on entire tree or one section; also referred to as reduction or reduction pruning.

reduction cut (drop-crotch cut, lateral cut)–Pruning cut that reduces the length of a branch or stem back to a lateral branch large enough to assume apical dominance—typically at least one-third of the diameter of the cut stem.

removal cut (thinning cut)–Cut that removes a branch at its point of origin. Collar cut.

restoring–The process of pruning to improve the structure, form, and appearance of trees that have been improperly trimmed, vandalized, or damaged.

scaffold limb–A limb or branch that is among the largest diameter on the tree and will remain on the tree perhaps to maturity.

shoot–New stem or branch growth on a plant.

specifications–Detailed plans, requirements, and statements of particular procedures and/or standards used to define and guide work.

stem–Woody structure bearing foliage and buds that gives rise to other stems (branches).

starch–Chain of sugar molecules linked together that serves as a form of energy storage in plants.

structural pruning–Pruning to establish a strong arrangement or system of scaffold branches.

stub–Portion of a branch or stem remaining after a stub cut, branch breakage, or branch death.

subordination–Pruning to reduce the size and ensuing growth of a branch in relation to other branches or leaders.

sucker–Shoot arising from the roots. Contrast with *watersprout.*

thinning–In pruning, the selective removal of live branches to provide light or air penetration through the tree or to lighten the weight of the remaining branches.

throwline–Thin, lightweight cord attached to a throwbag or throwing ball used to set climbing or rigging lines in trees.

topping–Inappropriate pruning technique to reduce tree size. Cutting back a tree to a predetermined crown limit, often at internodes.

trunk–Stem of a tree.

union (crotch)–The junction between stem and branch or between stems.

watersprouts–Upright, epicormic shoots arising from the trunk or branches of a plant above the root graft or soil line. Incorrectly called a sucker. Contrast with *sucker.*

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

wound dressing–Compound applied to tree wounds or pruning cuts.

Other Sources of Information

Tree Care Industry Association. 2007. *American National Standard for Tree Care Operations—Tree, Shrub, and Other Woody Plant Maintenance—Standard Practices (Pruning)* (A300, Part 1). Tree Care Industry Association, Manchester, NH. 9 pp.

International Society of Arboriculture. 2006. *American National Standard for Arboricultural Operations—Safety Requirements* (Z133.1). International Society of Arboriculture, Champaign, IL.

Costello, L. 1999. *Training Young Trees for Structure and Form* (videocassette). International Society of Arboriculture, Champaign, IL.

Florida Chapter of the International Society of Arboriculture. *Pruning Specifications*. www.floridaisa.org/specifications.php. Florida Chapter, ISA, Gainesville, FL.

Gilman, E.F. 2001. *Horticopia: Illustrated Pruning and Planting* (CD-ROM). Horticopia, Inc., Purcellville, VA.

Gilman, E.F. 2002. *An Illustrated Guide to Pruning* (2nd ed.). Delmar Publishers, Albany NY. 330 pp.

Harris, R.W., J.R. Clark, and N.P. Matheny. 2004. *Arboriculture: Integrated Management of Landscape Trees, Shrubs, and Vines* (4th ed.). Prentice Hall, Upper Saddle River, NJ.

Shigo, A.L. 1989. *Tree Pruning: A Worldwide Photo Guide*. Shigo and Trees, Associates. Durham, NH.

About the Authors

Edward F. Gilman is professor in the Environmental Horticulture Department at the University of Florida in Gainesville. He has been studying and teaching pruning since he arrived there in 1986. He received a B.S. in forestry and a Ph.D. in plant pathology from Rutgers University. Before joining the faculty at the University of Florida, Ed worked in the tree care and landscape industry for four years.

He continues to conduct tree care research, seminars, and workshops throughout the world. He has authored five books and more than a dozen horticultural software programs. Ed received the ISA author's citation award in 1999 and the American Horticultural Society's Gunlogson Award in 2001 for achievements demonstrating a commitment to the highest standards of horticultural excellence. He has published more than 200 research and trade journal articles on tree and landscape care during the past 20 years.

Sharon J. Lilly is director of educational goods and services for ISA. She received her B.S. and M.S. from The Ohio State University and has more than 30 years of experience as a practicing arborist. Sharon is the author of many books, articles, and training materials in the field of arboriculture.

P.O. Box 3129
Champaign, IL 61826-3129
www.isa-arbor.com