APPENDIX 1. Summary of survey responses, as provided by the authors of urban tree risk rating manuals or systems, published in the U.S.

Survey Questions	Producers of public tree risk rating systems/manuals designed for use in urban areas, published in the United States				
	Bartlett Tree Research Laboratories	**Colorado Tree Coalition**	**ISA**	**Minnesota Department of Natural Resources**	**Safetrees.com**
What is the target audience(s) of your tree risk assessment system?	Commercial arborists	Professionals in the tree care industry including city foresters/arborists, commercial arborists, utility arborists; government agencies, and homeowners.	Arborists of all types.	Public and private recreation site managers, hazard tree trainers, municipal parks, zoos, and campgrounds, state departments of transportation, federal agencies and private tree services.	Arborists, tree care companies, community foresters, resource managers, recreation site managers and owners, highway departments, utility arborists, and educators.
What assessment methodology do you use?	Individual tree examinations (360^{o})	Combination of 360 ^{o} individual tree examination and drive-by surveys. This allows an inventory or crew person to take notes during daily routine activities, and report info to a more qualified individual to conduct an in-depth exam.	Individual tree examinations (360^{o}), using decay detection methods (drill, resistograph), root crown examinations, and aerial inspections as required.	Only individual tree examinations (360^{o})	Individual tree examinations (360^{o}) VTA (Visual Tree Assessment), sounding for tree decay, and probing for decay if needed with drill, increment borer, or Resistograph,
Is your assessment system numeric or non-numeric?	Non-numeric: ranging from low to severe	Numeric: Rating is based on tree species, target, defect and size of defect. System also allows for field notes and photos.	For multi-tree surveys, we use the ISA's 12 point numeric system. For 1-few trees, we use a non-numeric system of describing defects.	Non-numeric. Trees are simply rated as low, moderate or high with no attempt to rate the target importance, size of failing tree part, etc. We feel that the inspected trees need to be rated based on their symptoms and defects. That way, managers know what the hazard tree population looks like and hazard trees can still be prioritized for management work based on recorded location, type of defect, etc., depending on the data recorded for each tree.	Non-numeric. This is a definitive guide on how to evaluate all categories of tree defects

Appendix 1. Summary of survey responses, as provided by the authors of urban tree risk rating manuals or systems, published in the U.S.

On a per tree basis, how long does it take to conduct a risk assessment using your methodology?	5 minutes to hours, depending on the tree.	Less than 5 minutes to 30 minutes, depending on what is needed to conduct the assessment.	It all depends on the nature of the assessments.	1-15 minutes, per tree: longer if invasive tests (increment coring or drilling) are needed or if the upper crown needs to be inspected from above by machinery.	It depends on the extent of tree defects present. If invasive techniques are necessary, the assessment time increases.
How much training is needed to prepare field staff to conduct assessments?	Our usual training session is one 6-hour day.	Level 1: If people can identify tree species it takes about 1-3 days to get them comfortable with the system. Level 2: Much more intense training on extra tools (resistograph, drill test, etc.). They can learn in a day, but it takes a lot of field work to become proficient.	No specific amount of training. We use certified arborists and monitor their work until we are comfortable with their expertise.	A minimum one day training session is required for state employees. This includes a field session to "calibrate" trainees on real, live trees. In terms of supervision, when the 2-tiered system is used, the local manager reviews all hazard trees and spot checks the first crew.	At least a full day workshop. Advanced invasive techniques may be better left in the hands of higher trained professionals.
Have you measured the success of your risk assessment system?	Not systematically.	Yes, through surveys of people who use the system. In fact, the feedback we receive determines the changes we make to the system.	Not directly, no. Indirectly, user have told use how helpful and valuable it is.	12,000 copies of the first two editions of our manual are in use. Sites using our system typically remove less than 1 % of their trees on an annual basis.	The guidelines use the latest research available from the Bartlett Tree Research Laboratories and others. Currently, the guidelines and information presented in the field guide are used as standards for the tree care industry.
Is there other information that you would like to share about your system?	No response given.	It is flexible enough to a adopt to most situations.	No response given.	Our system is simple to use, requires minimal training for implementation, empowers local managers to make decisions, and can be easily adapted for fit local needs. We recommend that hazard tree assessment systems should be fully documented and backed up by a policy statement.	The updated second edition now features 58 color photographs, and 43 illustrations on 34 pages. New sections have been added on evaluating root decay, basic tree biomechanics, introduction to tropical tree defects, and safety issues facing arborists. It is formatted in a compact 7" by 6.5 " size, and is printed on sturdy paper with laminated front and back covers.

Appendix 1. Summary of survey responses, as provided by the authors of urban tree risk rating manuals or systems, published in the U.S.

Are you aware of other published tree risk assessment systems that are designed for use in urban areas?	No response given.	The USFS system (unpublished) and ISA's.	San Francisco uses Lee Paine's system, modified for use in urban areas.	No response given.	No response given.
Do you have a training manual that is available for purchase or distribution? If so, what is the title, cost, and ordering information?	Yes, but we do not sell it. Limited quantities may be available upon request. Cost: Not for sale	Manual is currently being updated. Cost: Price will be determined by the final product.	Yes, the title is: *A Photographic Guide to the Evaluation of Hazard Trees in Urban Areas.* Cost: Retail: $45.00 Member: $35.00	Yes, the title is: *How to Detect, Asses and Correct Hazard Trees in Recreational Areas.* Cost: 3rd Edition is currently being written. Cost is expected to be approximately $20.00.	Yes, the title is: *Evaluating Trees for Defect*s Cost: $22.95 U.S. plus $3.00 S&H
Contact Information	Bartlett Tree Research Laboratories 13768 Hamilton Rd. Charlotte, NC 28278 Contact: Tom Smiley P: 704-588-1150 F: 704-588-5152 E-mail: bartlett.com	Colorado Tree Coalition P.O Box 270968 Fort Collins, CO 80523-0968 Contact: Ralph Zentz P: 970-221-6302 F: 970-221-6849 E-mail: rzentz@ci.fortcollins.co.us	ISA PO Box 3129 Champaign, IL 61826-3129 Contact: ISA E-mail: ias@isa-arbor.com	Minnesota DNR 1201 E. Highway 2 Grand Rapids, MN 55744 Contact: Jana Albers P: 218-327-4234 F: 218-327-4391 E-mail: jana.albers@dnr.state.mn.us	Safetrees 532 22nd St. NE Rochester, MN 55906 Contact: Ed Hayes Fax: 507-282-5739 E-mail: ehayes@safetrees.com website: www. Safetrees.com

APPENDIX 2. California Tree Failure Report Form

Accession #_____

Date of Report _____

CALIFORNIA TREE FAILURE REPORT

University of California, Davis, CA 95616

Tree Genus _____
Species _____
Cultivar (if known) _____
Common name _____
Approx. age _____yrs., Height _____ft., DBH _____in.
Crown spread _____

Tree Owner _____
Site: County _____
City _____
Address/Park _____
_____ Site category (choose one): 1-Residential 2-Street
3-Park 4-School 5-Highway 6-Parking lot 7-Mall 8-Other

DETAILS OF TREE FAILURE

-1 Date of failure: _____ (Mo/Day/Yr)
-2 Time of failure: _____ (Hr/AM or PM)
____ -3 Location of failure on tree (choose one)
1-Trunk: ____ft. above ground, ____inches break diam.
at ground level? ____ (Y/N)
2-Branch: ____ft. from attachment, ____in. break diam.
at point of attachment? ____ (Y/N)
branch attachment ____ ft. high on trunk
estimated branch angle at point of failure ____
weight concentrated at end of branch? ____ (Y/N)
3-Root (including uprooting)
____ -4 Site use (choose one) (Explain on p.2 Additional Info)
1-Undeveloped
2-Low use (intermittent vehicles and/or people)
3-Medium use (permanent structures, intermittent vehicles and/or people)
4-High use (permanent structures, frequent vehicles and/or people)
____ -5 Stand type:
1-Natural 2-Planted 3-Mixed
____ -6 Tree occurring
1-Alone (at least one crown diameter apart)
2-In a group (less than one crown diameter apart)
3-Altered stand (trees removed from stand)

TREE STRUCTURAL DEFECTS

____ -7 Choose up to three, in the order of importance
____ 1-Failed portion dead 8-Embedded bark in crotch
____ 2-Multiple trunks/codom. stems 9-Crook or sweep
3-Dense crown 10-Leaning trunk
4-Heavy lateral limbs (describe p. 2) 11-Cracks or splits
5-Uneven branch distribution: (one 12-Kinked or girdling roots
6-Uneven branch distribution: (top- 13-None apparent
7-Multiple branches at same point 14-Other (describe p. 2)

TREE DECAY OR INJURY

____ -8 Type of decay at failure location (choose one)
1-Root rot
2-Heart rot
3-Sap rot
4-Heart rot and sap rot
5-No decay noted
____ -9 Extent of decay or cavity (% cross-sectional area)
(For root failure estimate % structural roots decayed)
1- 25% or less 4- 75-100%
2- 25-50% 5-Unknown
3- 50-75% 6-None
____ ## Fungal sporophores or conks found near failure location?
1-Yes 2-No
____ ## Other injury at failure location
____ (Choose up to three, in order of importance)
____ 1-Mechanical 4-Animal 7-Fire
2-Lightning 5-Chemical 8-None
3-Insect 6-Vehicle 9-Other (p. 2)
____ ## Other injury, entire tree (same choices as 11)
____ (Choose up to three, in order of importance)
____

MAINTENANCE HISTORY

____ -13 Pruning at failure location (Choose up to three)
____ 1-Heading cuts - moderate - cut diameter ____ in.
____ 2-Heading cuts - severe - cut diameter ____ in.
3-Thinning cuts (or drop-crotching) 6-Root pruning
4-Lion-tailing 7-No pruning
5-Flush cuts 8-Other (p. 2)
____ -14 Pruning on entire tree (Same choices as 13)
____ (Choose up to three)
____
____ -15 Other maintenance (Choose up to two)
____ 1-Cable/hardware failure 4-Cavity treatment
2-Staking/props 5-Injections
3-Girdling wire, rope, etc. 6-None

SOIL AND ROOT CONDITIONS AT SITE

____ -16 Restricted roots (Choose up to two)
____ 1-Raised planter or bed 4-Root cutting
2-Container or boxed tree 5-Not applicable
3-Root barriers 6-Other (p. 2)
____ -17 Irrigation
1-None 3-More than once per mo.
2-Less than once per mo. 4-More than 3X per mo.
____ -18 Ground cover under tree (Choose up to two)
____ 1-Bare soil 6-Shrubs
2-Mulch 7-Mixed planting
3-Turf 8-Paving
4-Native cover 9-Other
5-Herbaceous plants
____ -19 Soil in tree vicinity (Choose one)
1-Good condition 3-Saturated 5-Shallow
2-Compacted 4-Dry 6-Other (p. 2)
____ -20 Site topography/soil changes (Choose up to two)
____ 1-Excavation-depth _____ft., distance from trunk ____ ft.
2-Grade change - cut 5-Streambank erosion
3-Grade change - fill 6-Not applicable
4-Slope erosion

WEATHER AT TIME OF FAILURE

____ -21 Wind speed:
1-Low (less than 5 mph)
2-Moderate (5-25 mph)
3-High (25+ mph)
____ -22 Wind
1-Gusty
2-Steady
____ -23 Wind in prevailing direction for season?
1-Yes
2-No
____ -24 If branch failure, was wind direction (Omit if no wind)
1-Parallel to
2-At right angles to branch direction?
-25 Temperature: _____ degrees F
____ -26 Precipitation (Choose one)
1-Rain 4-Fog or mist
2-Snow 5-None
3-Ice

Appendix 2. California Tree Failure Report Form - *continued*

I. Briefly, in your own words, why did this tree failure occur?

II. Results of this tree failure (i.e., property damage, personal injury, etc.):

III. Damage estimate (costs for clean-up; indicate other costs if known):

IV. Additional information and comments:

Person reporting _____ Date _____

Title _____ Agency _____

Address

_____

Telephone ( ) _____ FAX ( ) _____

Please complete this report to the fullest extent, include any available photographs, and send to TREE FAILURE REPORT, UCCE, 625 Miramontes, Suite 200, Half Moon Bay, 94019-1942. This form may be photocopied. Direct any questions to Larry Costello or Katherine Jones,Cooperative Extension, San Mateo County (650) 726-9059, or to Alison Berry (530) 752-0130.

Additional copies of this form and return envelopes can be requested from Katherine Jones, UCCE, 625 Miramontes Suite 200, Half Moon Bay, CA 94019.

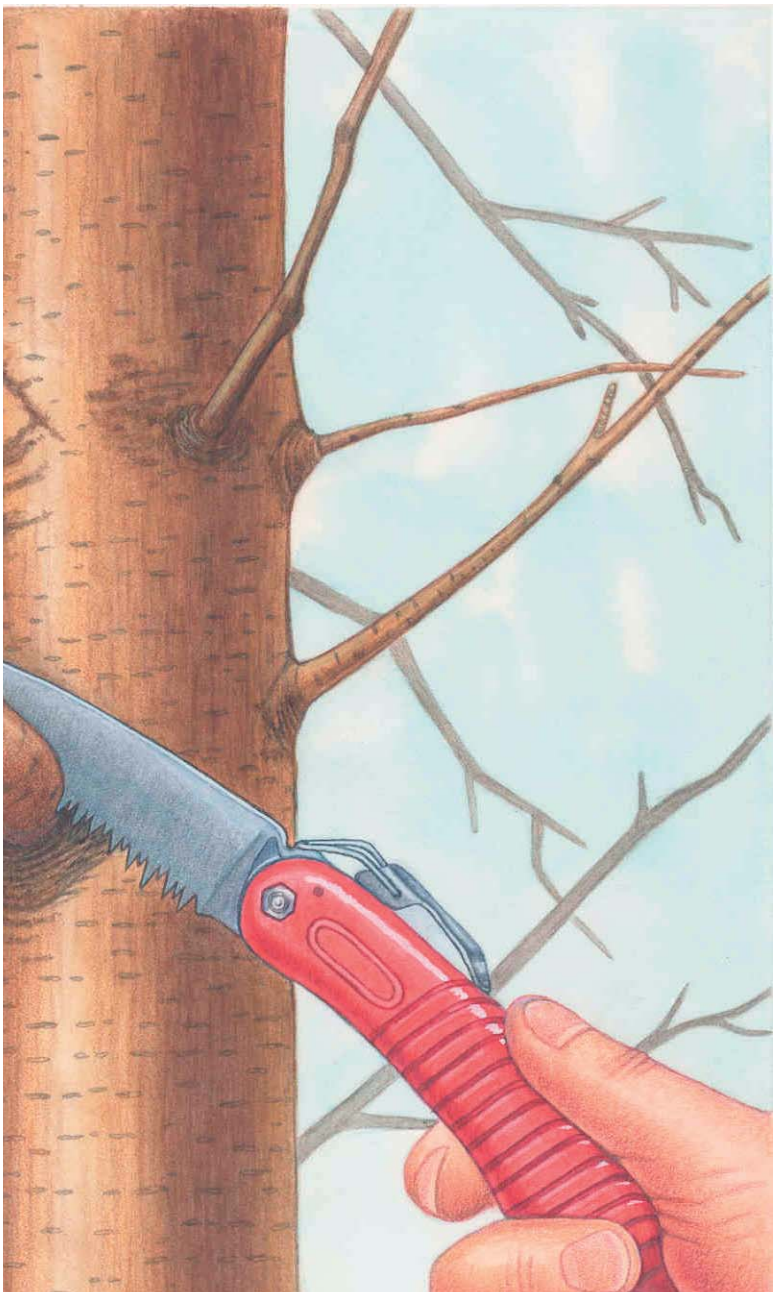
The information in this report will remain confidential, and will only be used to develop statistical and general information about tree failures by species and type of failure.

A.M. Berry, L.R. Costello, R.W. Harris

Revised 9/22/93

APPENDIX 3

HOW to Prune Trees



United States Department of Agriculture

Prepared by Forest Service

Northeastern Area State & Private Forestry

NA-FR-01-95

(*adapted version - February 2003*)

Table of Contents

Introduction

The objective of pruning is to produce strong, healthy, attractive plants. By understanding how, when and why to prune, and by following a few simple principles, this objective can be achieved.

Reasons For Pruning

The main reasons for pruning ornamental and shade trees include safety, health, and aesthetics. In addition, pruning can be used to stimulate fruit production and increase the value of timber. Pruning for safety (Fig. 1A) involves removing branches that could fall and cause injury or property damage, trimming branches that interfere with lines of sight on streets or driveways, and removing branches that grow into utility lines. Safety pruning can be largely avoided by carefully choosing species that will not grow beyond the space available to them, and have strength and form characteristics that are suited to the site.

Pruning for health (Fig. 1B) involves removing diseased or insect-infested wood, thinning the crown to increase airflow and reduce some pest problems, and removing crossing and rubbing branches. Pruning can best be used to encourage trees to develop a strong structure and reduce the likelihood of damage during severe weather. Removing broken or damaged limbs encourages wound closure. Pruning for aesthetics (Fig. 1C) involves enhancing the natural form and character of trees or stimulating flower production. Pruning for form can be especially important on open-grown trees that do very little self-pruning.

All woody plants shed branches in response to shading and competition. Branches that do not produce enough carbohydrates from photosynthesis to sustain themselves die and are eventually

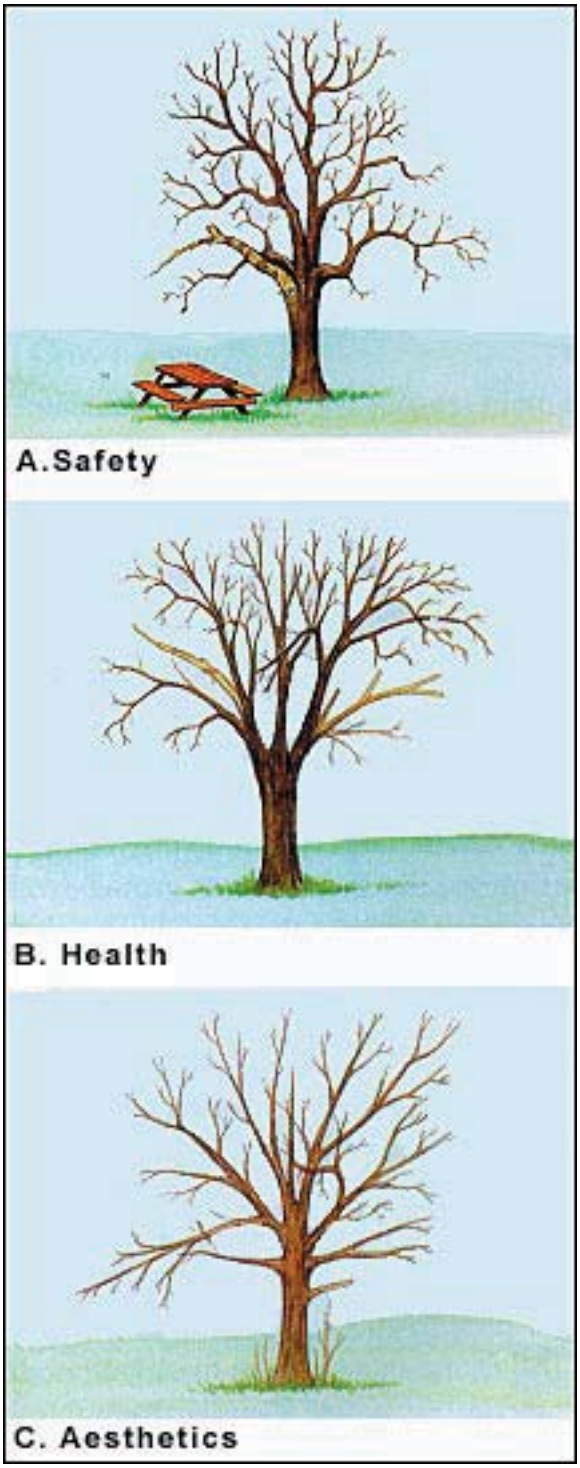


Figure 1. *Reasons for pruning*

shed; the resulting wounds are sealed by woundwood (callus). Branches that are poorly attached may be broken off by wind and accumulation of snow and ice. Branches removed by such natural forces often result in large, ragged wounds that rarely seal. Pruning as a cultural practice can be used to supplement or replace these natural processes and increase the strength and longevity of plants.

Trees have many forms, but the most common types are pyramidal (excurrent) or spherical (decurrent). Trees with pyramidal crowns, e.g., most conifers, have a strong central stem and lateral branches that are more or less horizontal and do not compete with the central stem for dominance. Trees with spherical crowns, e.g., most hardwoods, have many lateral branches that may compete for dominance.

To reduce the need for pruning it is best to consider a tree's natural form. It is very difficult to impose an unnatural form on a tree without a commitment to constant maintenance. Pollarding and topiary are extreme examples of pruning to create a desired, unnatural effect. Pollarding is the practice of pruning trees annually to remove all new growth. The following year, a profusion of new branches is produced at the ends of the branches. Topiary involves pruning trees and shrubs into geometric or animal shapes. Both pollarding and topiary are specialized applications that involve pruning to change the natural form of trees. As topiary demonstrates, given enough care and attention, plants can be pruned into nearly any form. Yet just as proper pruning can enhance the form or character of plants, improper pruning can destroy it.

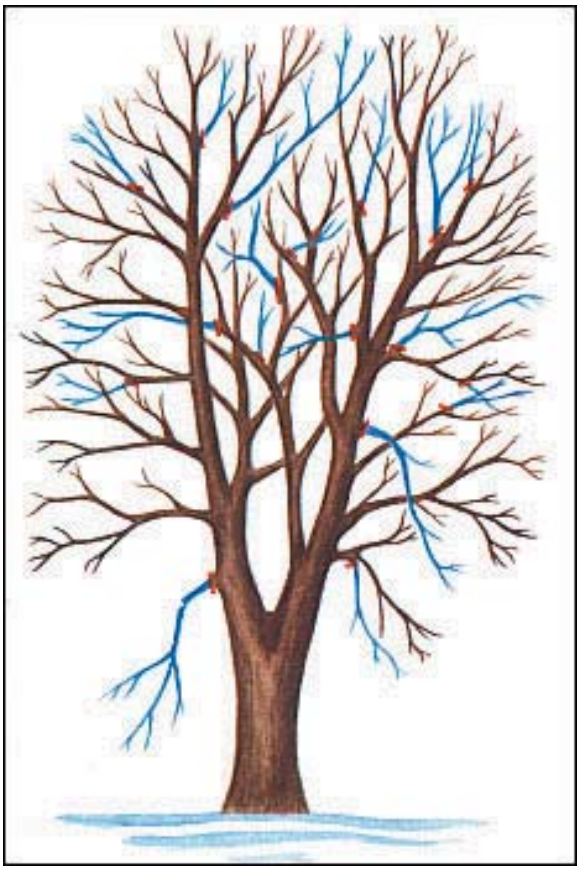


Figure 2. *Crown thinning - branches to be removed are shaded in blue; pruning cuts should be made at the red lines. No more than one-fourth of the living branches should be removed at one time.*

Pruning Approaches

Producing strong structure should be the emphasis when pruning young trees. As trees mature, the aim of pruning will shift to maintaining tree structure, form, health and appearance.

Proper pruning cuts are made at a node, the point at which one branch or twig attaches to another. In the spring of the year growth begins at buds, and twigs grow until a new node is formed. The length of a branch between nodes is called an internode.

The most common types of pruning are:

1. Crown Thinning (Fig. 2)

Crown thinning, primarily for hardwoods, is the selective removal of branches to increase light penetration and air movement throughout the crown of a tree. The intent is to maintain or develop a tree's structure and form. To avoid unnecessary stress and prevent excessive production of epicormic sprouts, no more than one-quarter of the living crown should be removed at a time. If it is necessary to remove more, it should be done over successive years.

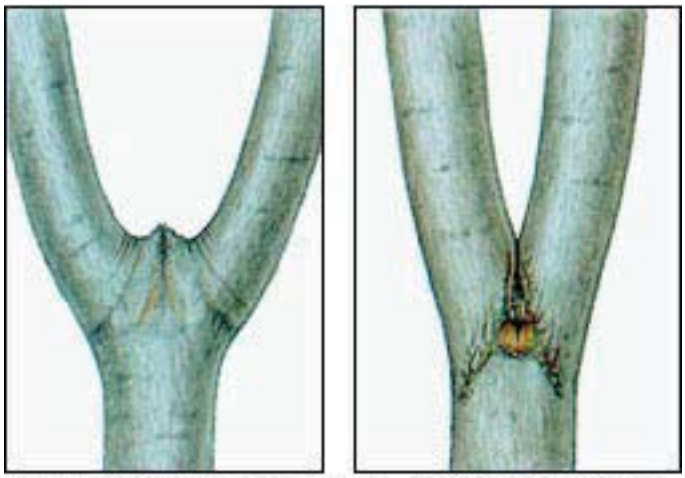


Figure 3. *Type of branch unions.*

Branches with strong U-shaped angles of attachment should be retained (Fig 3A). Branches with narrow, V-shaped angles of attachment often form included bark and should be removed (Fig. 3B). Included bark forms when two branches grow at sharply acute angles to one another, producing a wedge of inward-rolled bark between them. Included bark prevents strong attachment of branches, often causing a crack at the point below where the branches meet. Codominant stems that are approximately the same size and arise from the same position often form included bark. Removing some of the lateral branches from a codominant stem can reduce its growth enough to allow the other stem to become dominant.

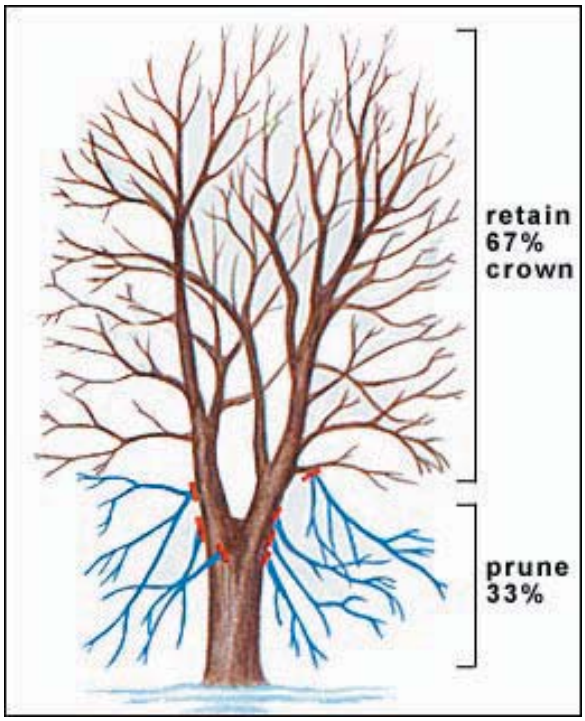


Figure 4. *Crown raising - branches to be removed are shaded in blue; pruning cuts should be made where indicated with red lines. The ratio of live crown to total tree height should be at least two-thirds.*

Lateral branches should be no more than one-half to three-quarters of the diameter of the stem at the point of attachment. Avoid producing "lion's tails," tufts of branches and foliage at the ends of branches, caused by removing all inner lateral branches and foliage. Lion's tails can result in sunscalding, abundant epicormic sprouts, and weak branch structure

and breakage. Branches that rub or cross another branch should be removed.

Conifers that have branches in whorls and pyramidal crowns rarely need crown thinning except to restore a dominant leader. Occasionally, the leader of a tree may be damaged and multiple branches may become codominant. Select the strongest leader and remove competing branches to prevent the development of codominant stems.

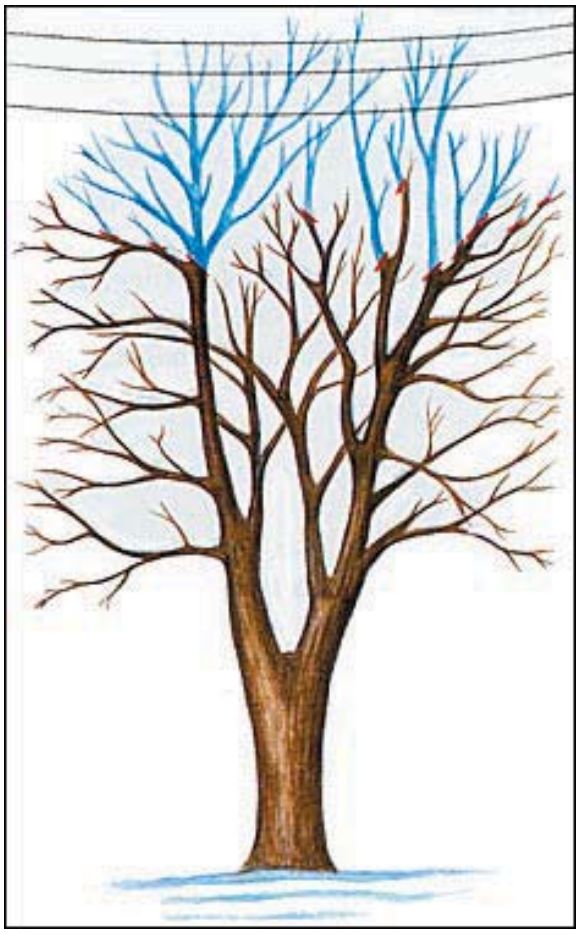


Figure 5. *Crown reduction - branches to be removed are shaded in blue; pruning cuts should be made where indicated with red lines. To prevent branch dieback, cuts should be made at lateral branches that are at least one-third the diameter of the stem at their union.*

2. Crown Raising (Fig. 4)

Crown raising is the practice of removing branches from the bottom of the crown of a tree to provide clearance for pedestrians, vehicles, buildings, lines of site, or to develop a clear stem for timber production. Also, removing lower branches on white pines can prevent blister rust. For street trees the minimum clearance is often specified by municipal ordinance. After pruning, the ratio of the living crown to total tree height should be at least two-thirds (e.g., a 12 m tree should have living branches on at least the upper 8 m).

On young trees "temporary" branches may be retained along the stem to encourage taper and protect trees from vandalism and sun scald. Less vigorous shoots should be selected as temporary branches and should be about 10 to 15 cm apart along the stem. They should be pruned annually to slow their growth and should be removed eventually.

3. Crown Reduction (Fig. 5)

Crown reduction pruning is most often used when a tree has grown too large for its permitted space. This method, sometimes called drop crotch pruning, is preferred to topping because it results in a more natural appearance, increases the time before pruning is needed again, and minimizes stress (see drop crotch cuts in the next section).

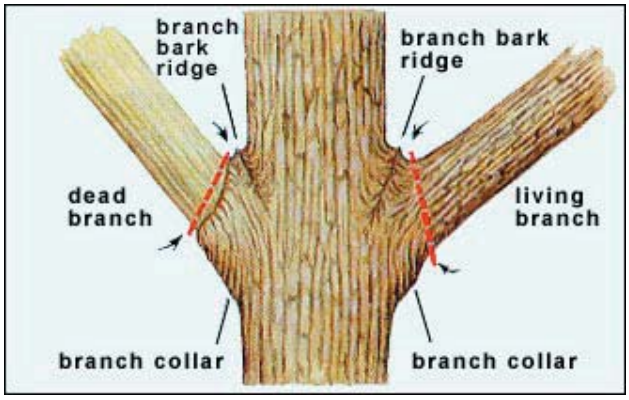
Crown reduction pruning, a method of last resort, often results in large pruning wounds to stems that may lead to decay. This method should never be used on a tree with a pyramidal growth form. A better long term solution is to remove the tree and replace it with a tree that will not grow beyond the available space.

Pruning Cuts

Pruning cuts should be made so that only branch tissue is removed and stem tissue is not damaged. At the point where the branch attaches to the stem, branch and stem tissues remain separate, but are contiguous. If only branch tissues are cut when pruning, the stem tissues of the tree will probably not become decayed, and the wound will seal more effectively.

1. Pruning living branches (Fig. 6)

To find the proper place to cut a branch, look for the branch collar that grows from the stem tissue at the underside of the base of the branch (Fig. 6A). On the upper surface, there is usually a branch bark ridge that runs (more or less) parallel to the branch angle, along the stem of the tree. A proper pruning cut does not damage either the branch bark ridge or the branch collar.



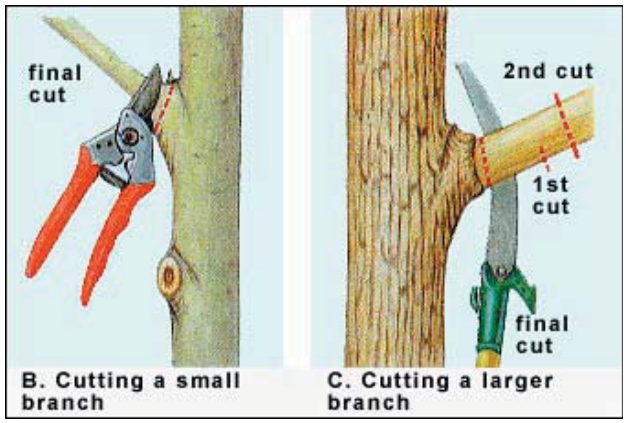


Figure 6A,B,C. *Pruning cuts.*

A proper cut begins just outside the branch bark ridge and angles down away from the stem of the tree, avoiding injury to the branch collar (Fig. 6B). Make the cut as close as possible to the stem in the branch axil, but outside the branch bark ridge, so that stem tissue is not injured and the wound can seal in the shortest time possible. If the cut is too far from the stem, leaving a branch stub, the branch tissue usually dies and woundwood forms from the stem tissue. Wound closure is delayed because the woundwood must seal over the stub that was left.

The quality of pruning cuts can be evaluated by examining pruning wounds after one growing season. A concentric ring of woundwood will form from proper pruning cuts (Fig. 6B). Flush cuts made inside the branch bark ridge or branch collar, result in pronounced development of woundwood on the sides of the pruning wounds with very little woundwood forming on the top or bottom (Fig. 7D). As described above, stub cuts result in the death of the remaining branch and woundwood forms around the base from stem tissues.

When pruning small branches with hand pruners, make sure the tools are sharp enough to cut the branches cleanly without tearing. Branches large enough to require saws should be supported with one hand while the cuts are made. If the branch is too large to support, make a three-step pruning cut to prevent bark ripping (Fig. 6C).

1. The first cut is a shallow notch made on the underside of the branch, outside the branch collar. This cut will prevent a falling branch from tearing the stem tissue as it pulls away from the tree.

2. The second cut should be outside the first cut, all the way through the branch, leaving a short stub.

3. The stub is then cut just outside the branch bark ridge/branch collar, completing the operation.

2. Pruning dead branches (Fig. 6)

Prune dead branches in much the same way as live branches. Making the correct cut is usually easy because the branch collar and the branch bark ridge can be distinguished from the dead branch because they continue to grow (Fig. 6A). Make the pruning cut just outside of the ring of woundwood tissue that has formed, being careful not to cause unnecessary injury (Fig. 6C). Large dead branches should be supported with one hand or cut with the three-step method, just as live branches. Cutting large living branches with the three step method is more critical because of the greater likelihood of bark ripping.

3. Drop Crotch Cuts (Fig. 6D)

A proper cut begins just above the branch bark ridge and extends through the stem parallel to the branch bark ridge. Usually, the stem being removed is too large to be supported with one hand, so the three cut method should be used.

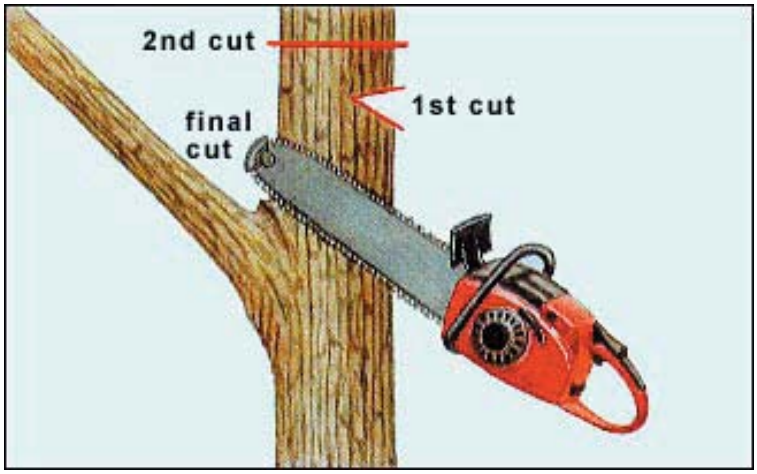


Figure 6D. *Pruning cuts.*

1. With the first cut, make a notch on the side of the stem away from the branch to be retained, well above the branch crotch.

2. Begin the second cut inside the branch crotch, staying well above the branch bark ridge, and cut through the stem above the notch.

3. Cut the remaining stub just inside the branch bark ridge through the stem parallel to the branch bark ridge.

To prevent the abundant growth of epicormic sprouts on the stem below the cut, or dieback of the stem to a lower lateral branch, make the cut at a lateral branch that is at least one-third of the diameter of the stem at their union.

Pruning Practices That Harm Trees

Topping and tipping (Fig. 7A, 7B) are pruning practices that harm trees and should not be used. Crown reduction pruning is the preferred method to reduce the size or height of the crown of a tree, but is rarely needed and should be used infrequently.

Topping, the pruning of large upright branches between nodes, is sometimes done to reduce the height of a tree (Fig. 7A). Tipping is the practice of cutting lateral branches between nodes (Fig. 7B) to reduce crown width.

These practices invariably result in the development of epicormic sprouts, or in the death of the cut branch back to the next lateral branch below. These epicormic sprouts are weakly attached to the stem and eventually will be supported by a decaying branch.

Improper pruning cuts cause unnecessary injury and bark ripping (Fig. 7C). Flush cuts injure stem tissues and can result in decay (Fig. 7D). Stub cuts delay wound closure and can provide entry to canker fungi that kill the cambium, delaying or preventing woundwood formation (Fig. 7E).

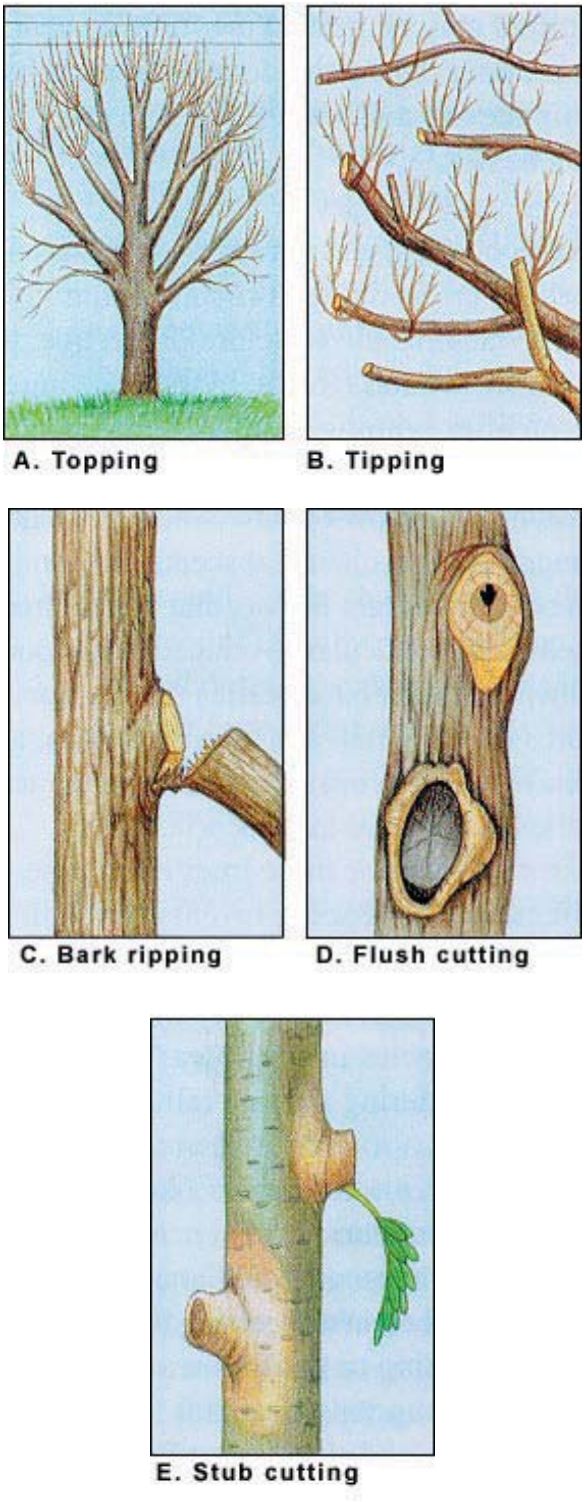


Figure 7. *Practices that harm trees.*

When to Prune

Conifers may be pruned any time of year, but pruning during the dormant season may minimize sap and resin flow from cut branches.

Hardwood trees and shrubs without showy flowers: prune in the dormant season to easily visualize the structure of the tree, to maximize wound closure in the growing season after pruning, to reduce the chance of transmitting disease, and to discourage excessive sap flow from wounds.

Recent wounds and the chemical scents they emit can actually attract insects that spread tree disease. In particular, wounded elm wood is known to attract bark beetles that harbor spores of the Dutch elm disease fungus, and open wounds on oaks are known to attract beetles that spread the oak wilt fungus. Take care to prune these trees during the correct time of year to prevent spread of these fatal diseases. Contact your local tree disease specialist to find out when to prune these tree species in your area. Usually, the best time is during the late fall and winter.

Flowering trees and shrubs: these should also be pruned during the dormant season for the same reasons stated above; however, to preserve the current year's flower crop, prune according to the following schedule:

- Trees and shrubs that flower in early spring (redbud, dogwood, etc.) should be pruned immediately after flowering (flower buds arise the year before they flush, and will form on the new growth).
- Many flowering trees are susceptible to fireblight, a bacterial disease that can be spread by pruning. These trees, including many varieties of crabapple, hawthorn, pear, mountain ash, flowering quince and pyracantha, should be pruned during the dormant season. Check with your county extension agent or a horticulturist for additional information.
- Trees and shrubs that flower in the summer or fall always should be pruned during the dormant season (flower buds will form on new twigs during the next growing season, and the flowers will flush normally).

Dead branches: can be removed any time of the year.

Pruning Tools

Proper tools are essential for satisfactory pruning (Fig.6). The choice of which tool to use depends largely on the size of branches to be pruned and the amount of pruning to be done. If possible, test a tool before you buy it to ensure it suits your specific needs. As with most things, higher quality often equates to higher cost.

Generally speaking, the smaller a branch is when pruned, the sooner the wound created will seal. Hand pruners are used to prune small branches (under 2.5 cm diameter) and many different kinds are available. Hand pruners can be grouped into by-pass or anvil styles based on the blade configuration. Anvil style pruners have a straight blade that cuts the branch against a small anvil or block as the handles are squeezed. By-pass pruners use a curved cutting blade that slides past a broader lower blade, much like scissors. To prevent unnecessary tearing or crushing of tissues, it is best to use a by-pass style pruner. Left- or right-handed types can be purchased.

Slightly larger branches that cannot be cut with a hand pruner may be cut with small pruning saws (up to 10 cm) or lopping shears (up to 7 cm diameter) with larger cutting surfaces and greater leverage. Lopping shears are also available in by-pass and anvil styles. For branches too large to be cut with a hand pruner or lopping shears, pruning saws must be used. Pruning saws differ greatly in handle styles, the length and shape of the blade, and

the layout and type of teeth. Most have tempered metal blades that retain their sharpness for many pruning cuts. Unlike most other saws, pruning saws are often designed to cut on the "pull-stroke."

Chain saws are preferred when pruning branches larger than about 10 cm. Chainsaws should be used only by qualified individuals. To avoid the need to cut branches greater than 10 cm diameter, prune when branches are small.

Pole pruners must be used to cut branches beyond reach. Generally, pruning heads can cut branches up to 4.4 cm diameter and are available in the by-pass and anvil styles. Once again, the by-pass type is preferred. For cutting larger branches, saw blades can be fastened directly to the pruning head, or a separate saw head can be purchased. Because of the danger of electrocution, pole pruners should not be used near utility lines except by qualified utility line clearance personnel.

To ensure that satisfactory cuts are made and to reduce fatigue, keep your pruning tools sharp and in good working condition. Hand pruners, lopping shears, and pole pruners should be periodically sharpened with a sharpening stone. Replacement blades are available for many styles. Pruning saws should be professionally sharpened or periodically replaced. To reduce cost, many styles have replaceable blades.

Tools should be clean and sanitized as well as sharp. Although sanitizing tools may be inconvenient and seldom practiced, doing so may prevent the spread of disease from infected to healthy trees on contaminated tools. Tools become contaminated when they come into contact with fungi, bacteria, viruses and other microorganisms that cause disease in trees. Most pathogens need some way of entering the tree to cause disease, and fresh wounds are perfect places for infections to begin. Microorganisms on tool surfaces are easily introduced into susceptible trees when subsequent cuts are made. The need for sanitizing tools can be greatly reduced by pruning during the dormant season.

If sanitizing is necessary it should be practiced as follows: before each branch is cut, sanitize pruning tools with either 70% denatured alcohol, or with liquid household bleach diluted 1 to 9 with water (1 part bleach, 9 parts water). Tools should be immersed in the solution, preferably for 1-2 minutes, and wood particles should be wiped from all cutting surfaces. Bleach is corrosive to metal surfaces, so tools should be thoroughly cleaned with soap and water after each use.

Treating Wounds

Tree sap, gums, and resins are the natural means by which trees combat invasion by pathogens. Although unsightly, sap flow from pruning wounds is not generally harmful; however, excessive "bleeding" can weaken trees.

When oaks or elms are wounded during a critical time of year (usually spring for oaks, or throughout the growing season for elms) either from storms, other unforeseen mechanical wounds, or from necessary branch removals some type of wound dressing should be applied to the wound. Do this immediately after the wound is created. In most other instances, wound dressings are unnecessary, and may even be detrimental. Wound dressings will not

stop decay or cure infectious diseases. They may actually interfere with the protective benefits of tree gums and resins, and prevent wound surfaces from closing as quickly as they might under natural conditions. The only benefit of wound dressings is to prevent introduction of pathogens in the specific cases of Dutch elm disease and oak wilt.

Pruning Guidelines

To encourage the development of a strong, healthy tree, consider the following guidelines when pruning.

General

- Prune first for safety, next for health, and finally for aesthetics.
- Never prune trees that are touching or near utility lines; instead consult your local utility company.
- Avoid pruning trees when you might increase susceptibility to important pests (e.g. in areas where oak wilt exists, avoid pruning oaks in the spring and early summer; prune trees susceptible to fireblight only during the dormant season).
- Use the following decision guide for size of branches to be removed: 1) under 5 cm diameter - go ahead, 2) between 5 and 10 cm diameter - think twice, and 3) greater than 10 cm diameter - have a good reason.

Crown Thinning

- Assess how a tree will be pruned from the top down.
- Favor branches with strong, U-shaped angles of attachment. Remove branches with weak, V-shaped angles of attachment and/or included bark.
- Ideally, lateral branches should be evenly spaced on the main stem of young trees.
- Remove any branches that rub or cross another branch.
- Make sure that lateral branches are no more than one-half to three-quarters of the diameter of the stem to discourage the development of co-dominant stems.
- Do not remove more than one-quarter of the living crown of a tree at one time. If it is necessary to remove more, do it over successive years.

Crown Raising

- Always maintain live branches on at least two-thirds of a tree's total height. Removing too many lower branches will hinder the development of a strong stem.
- Remove basal sprouts and vigorous epicormic sprouts.

Crown Reduction

- Use crown reduction pruning only when absolutely necessary. Make the pruning cut at a lateral branch that is at least one-third the diameter of the stem to be removed.
- If it is necessary to remove more than half of the foliage from a branch, remove the entire branch.

Glossary

Branch Axil: the angle formed where a branch joins another branch or stem of a woody plant.

Branch Bark Ridge: a ridge of bark that forms in a branch crotch and partially around the stem resulting from the growth of the stem and branch tissues against one another.

Branch Collar: a "shoulder" or bulge formed at the base of a branch by the annual production of overlapping layers of branch and stem tissues.

Crown Raising: a method of pruning to provide clearance for pedestrians, vehicles, buildings, lines of sight, and vistas by removing lower branches.

Crown Reduction Pruning: a method of pruning used to reduce the height of a tree. Branches are cut back to laterals that are at least one-third the diameter of the limb being removed.

Crown Thinning: a method of pruning to increase light penetration and air movement through the crown of a tree by selective removal of branches.

Callus: see woundwood.

Decurrent: a major tree form resulting from weak apical control. Trees with this form have several to many lateral branches that compete with the central stem for dominance resulting in a spherical or globose crown. Most hardwood trees have decurrent forms.

Epicormic Sprout: a shoot that arises from latent or adventitious buds; also known as water sprouts that occur on stems and branches and suckers that are produced from the base of trees. In older wood, epicormic shoots often result from severe defoliation or radical pruning.

Excurrent: a major tree form resulting from strong apical control. Trees with this form have a strong central stem and pyramidal shape. Lateral branches rarely compete for dominance. Most conifers and a few hardwoods, such as sweetgum and tuliptree, have excurrent forms.

Flush Cuts: pruning cuts that originate inside the branch bark ridge or the branch collar, causing unnecessary injury to stem tissues.

Included Bark: bark enclosed between branches with narrow angles of attachment, forming a wedge between the branches.

Pollarding: the annual removal of all of the previous year's growth, resulting in a flush of slender shoots and branches each spring.

Stub Cuts: pruning cuts made too far outside the branch bark ridge or branch collar, that leave branch tissue attached to the stem.

Tipping: a poor maintenance practice used to control the size of tree crowns; involves the cutting of branches at right angles leaving long stubs.

Topping: a poor maintenance practice often used to control the size of trees; involves the indiscriminate cutting of branches and stems at right angles leaving long stubs. Synonyms include rounding-over, heading-back, dehorning, capping and hat-racking. Topping is often improperly referred to as pollarding.

Topiary: the pruning and training of a plant into a desired geometric or animal shape.

Woundwood: lignified, differentiated tissues produced on woody plants as a response to wounding (also known as callus tissue).

Authors

Peter J. Bedker, Plant Pathologist, USDA Forest Service, Northeastern Area State and Private Forestry

Joseph G. O'Brien, Plant Pathologist, USDA Forest Service, Northeastern Area State and Private Forestry

Manfred E. Mielke, Forest Health Specialist, USDA Forest Service, Northeastern Area State and Private Forestry

Illustrations by:
Julie Martinez, Scientific Illustrator, Minneapolis, Minnesota

References

ANSI Z133.1. 1994. Safety standards. American national standard for tree care operators. Washington, DC: American National Standards Institute.

ANSI A300. 1995. Standard practices for tree, shrub, and other woody plant maintenance. Washington, DC: American National Standards Institute.

Fazio, J. R. ed. 1992. Don't top trees. Tree City USA Bulletin No. 8. Nebraska City, NE: The National Arbor Day Foundation.

Harris, R.W. 1994. Clarifying certain pruning terminology: thinning, heading, pollarding. Journal of Arboriculture 20:50-54.

ISA Performance Guidelines Committee. 1994. Tree-pruning guidelines. Savoy, IL: International Society of Arboriculture.

Ryan, H.D.P. III. 1994. Arboricultural pruning methodologies. Arborist News Volume 3(4): 33-38.

Shigo, A. 1991. Modern arboriculture. Durham, NH: Shigo & Trees, Associates.

Shigo, A. 1989. Tree pruning: a worldwide photo guide. Durham, NH: Shigo & Trees, Associates.

Northeastern Area State and Private Forestry Offices

Headquarters Office
Northeastern Area State & Private Forestry
USDA Forest Service
11 Campus Boulevard, Suite 200
Newtown, PA 19073

Durham Field Office
Northeastern Area State & Private Forestry
USDA Forest Service
Louis C. Wyman Forest Services Laboratory
P.O. Box 640
Durham, NH 03824-0640

Morgantown Field Office
Northeastern Area State & Private Forestry
USDA Forest Service
180 Canfield Street
Morgantown, WV 26505-3101

St. Paul Field Office
Northeastern Area State & Private Forestry
USDA Forest Service
1992 Folwell Avenue
St. Paul, MN 55108-1099

HOW TO Prune Trees was written to help people properly prune the trees they care about. If you doubt your ability to safely prune large trees, please hire a professional arborist. Information in this publication can be used to interview and hire a competent arborist.

Glossary

Balled-and-burlapped = Trees and shrubs harvested with the root system enclosed in a soil ball that is held together with burlap and twine, a wire basket, or both.

Bare-root = Trees and shrubs harvested with an exposed root system and with no soil covering their roots.

Barrier zone = An anatomical and chemical wall formed by the cambium tissue as part of the compartmentalization of decay within trees. It separates wood formed before wounding from wood that will form after wounding.

Bole = (Trunk) The main stem of a tree below its first major branch.

Branch bark ridge = Ridge of bark that forms at the junction of the branch and stem. An upturned branch bark ridge indicates a strong branch union. An inrolled branch bark ridge indicates a weak branch union.

Branch collar = A "shoulder" or bulge formed at the base of a branch by the annual production of overlapping layers of branch and stem tissues.

Cabling and bracing = The practice of adding a support system to a tree to reduce the stress on weak branch unions. Materials used include both flexible and rigid braces, metal cables, synthetic-fiber rope, and metal anchoring devices.

Cambium = Layer of living cells between the bark and wood surface that produces a new layer of wood each year.

Canker = Area of dead bark and cambium anywhere on the tree's surface. Cankers can be caused by fungi, insects, weather, or mechanical damage such as lantern-burns or mowers.

Canker-rot = Fungal infection that causes an external canker and extensive internal decay.

Canopy = The topmost layer of twigs and foliage in a tree or group of trees.

Cavity = Hollow area in stem, branch, or root where the wood has decayed and is now missing.

Codominant stems = Stems that are equal in size and relative importance.

Compartmentalization = A physiological process which creates chemical and mechanical boundaries to resist organisms, such as decay fungi. It results in the separation of healthy tissues and infected tissues by reaction and barrier zones.

Conk = Fruiting body of a fungus. Fruiting bodies on trees indicate advanced decay.

Container-grown = Plant material grown in a nursery and placed in a container before shipping.

Crack = Separation of the wood, a fissure, or a deep split in the bark and wood of a tree.

Critical root radius (CRR) = Defines the area of the root system nearest the stem that is critical for the stability and vitality of the tree. The area is determined by allowing 1.5 feet of root radius for each inch of stem diameter at breast height (d.b.h.).

Crown = Portions of the tree above the main stem or trunk; the branches, twigs and leaves.

Deadwood = Non-living wood within a tree. Deadwood is structurally unsound because of pre-existing defects and/or rapid decomposition of the wood.

Decay = Fungal and bacterial decomposition of woody tissues. The decay process reduces structural soundness and stability over a period of years.

Decayed wood = Wood that has rooted or is missing.

Decline = General loss of vigor. It is usually accompanied by crown symptoms, such as branch dieback.

Defect = Any structural weakness or deformity in the tree's branches, stem, or root system. Tree defects can be of two kinds: injury or disease that seriously weakens the stems, roots, or branches or trees, predisposing them to fail *or* structural problems arising from poor tree architecture, including V-shaped crotches in stems and branches that lead to weak unions, shallow rooting habits, inherently brittle wood, etc.

Defective tree = Tree with one or more defects.

D.B.H. = Diameter of the tree measured at breast height, 4.5 feet from the ground.

Dieback = Death of a branch or branches, generally from the tip towards the main stem.

Dripline = The area directly below the branches of a tree.

Epicormic branch = Branches that form on large, old stems or branches as a result of a serious disturbance, such as, improper pruning, disease or extensive dieback in the crown. Epicormic branches usually form weak unions with their stems.

Failure = Breakage of stems or branches or loss of mechanical support in the root system. Trees can fail due to defects or during severe storms.

Fire scar = Triangular scar at the base of a tree due to a past fire. A cavity is generally associated with a fire scar.

Fracture = Cracking or breakage of wood in branches, stems or roots.

Fruiting bodies = Structures where fungal spores are produced. Examples are mushrooms, conks, and shelf fungi. They are indicators of advanced decay.

Hazard tree = A tree that has structural defects in the roots, stem, or branches that may cause the tree or tree part to fail, where such failure may cause property damage or personal injury.

Improper pruning = When removing branches, cutting into the branch collar, cutting flush to the stem, leaving long branch stubs, or removing too many branches at one time.

Included bark = Layers of bark that have formed inside the tree at a branch union or fork between codominant stems. These ingrown layers of bark make a branch union weak.

Increment core = Sample of wood extracted from a tree by an increment borer. The core shows the annual rings.

Inrolled bark or wood = Bark or wood tissues that have turned inward and continue to grow inside the tree. See rams-horning.

Inrolled crack = See Rams-horning.

Inspection = Systematic method of examining trees for visible defects and assessing risk of potential failure.

Lean = Describes a tree trunk that is not growing perpendicular to the ground. If the angle is greater than 45 degrees, it may be hazardous.

Natural target pruning = Method of removing branches that preserves the tree's natural defenses. Only branch tissue is removed leaving the branch collar intact. See diagrams for conifers and hardwoods in the Appendix 3.

Poor architecture = Growth pattern indicates structural imbalance and weakness in the branch, stem, or tree.

Rams-horning = Process that occurs when two wound margins grow together and their bark and wood layers begin to turn inward. The inrolling tissues curl and form the rams-horn over a period of years.

Root collar = The base of the stem where the primary roots first begin to branch away from the stem. Normally, this area appears swollen or flared and is located near or at the soil level.

Seam = Evidence that a tree has successfully closed over a wound. Wound margins meet and grow together. In time, seams become indistinct and less hazardous.

Shell = In trees with wood decay, the shell is the newest and outermost layers of wood that are decay free. Safe shell limits require 1 inch of sound shell for each 6 inches of stem diameter.

Snag tree = A dead, usually hollow or limbless, tree that is left on the site for wildlife habitat purposes.

Stem girdling roots (**SGR**) = Roots that encircle or run tangentially to a tree's stem, eventually compressing the woody and non-woody tissues of the stem.

Target = A person or object within 1.5 times the tree height of a defective tree.

Tipping = Removal of branch tips, usually to decrease the tree's width.

Topping = Removal of the top portion of a tree's live crown, usually to decrease the tree's height.

Tree architecture = Natural growth habit or branching pattern that is characteristic for each tree species.

Tree lawns = The planting area that occurs between street curbs and sidewalks. Also commonly referred to as boulevards, parkways, or medians.

Tree risk management plan = A management plan that focuses on the prevention and correction of hazardous tree defects, and provides a written, systematic procedure for inspecting and evaluating hazardous trees and correcting them before they become unacceptable risks.

Uneven-aged management system = A management system where trees of varying species and with different life expectancies are planted as replacement trees.

Weak branch union = An epicormic branch or branch union with included bark.

Windthrow = Failure of the root system in anchoring the tree to the ground. Often trees are blown over by winds during severe storms.

Wound = Any injury to the bark, cambium, or wood.

Woundwood = Lignified, differentiated tissues produced on woody plants as a response to wounding (also known as callus tissue).

Index

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W