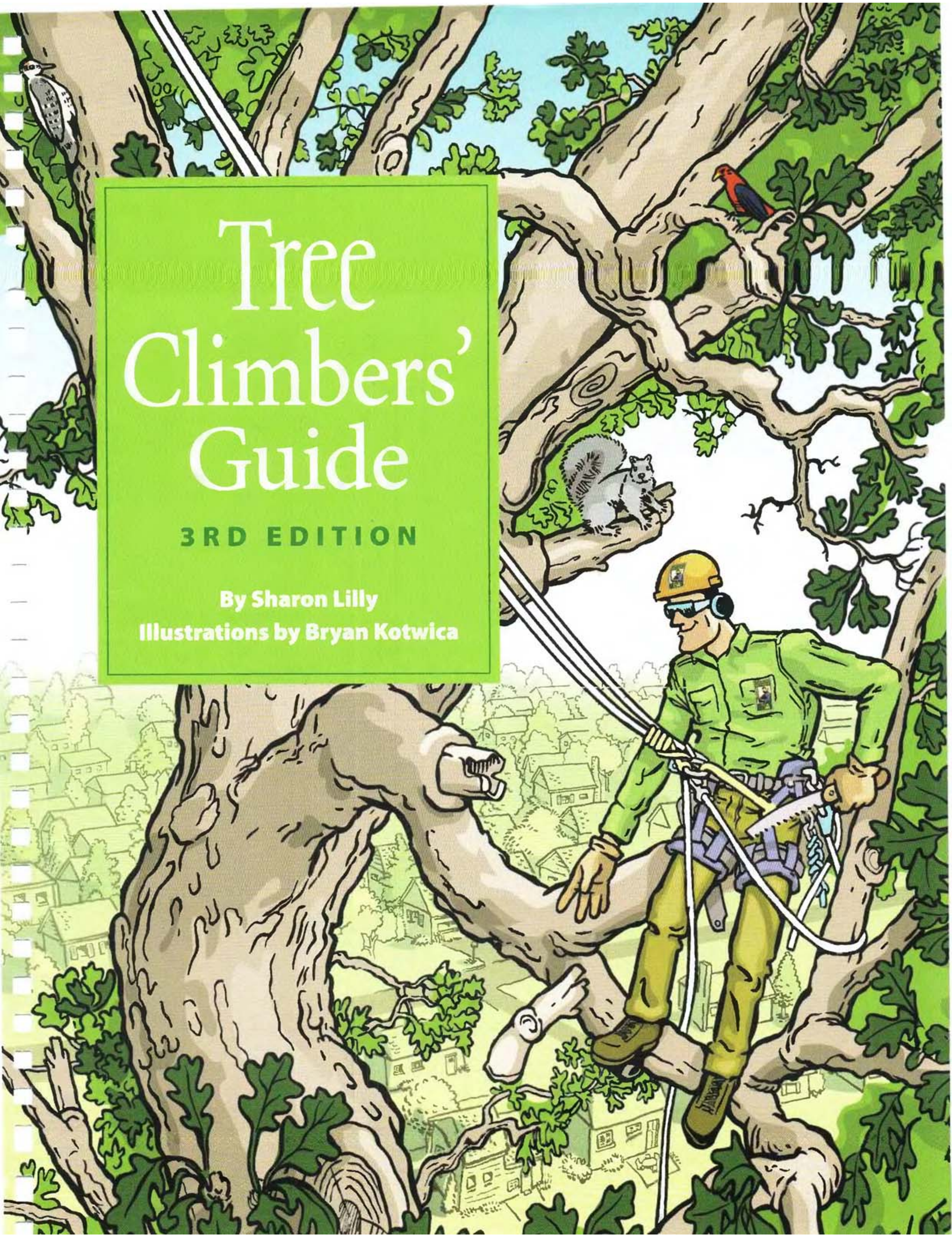
Tree Climbers' Guide

3RD EDITION

By Sharon Lilly

Illustrations by Bryan Kotwica



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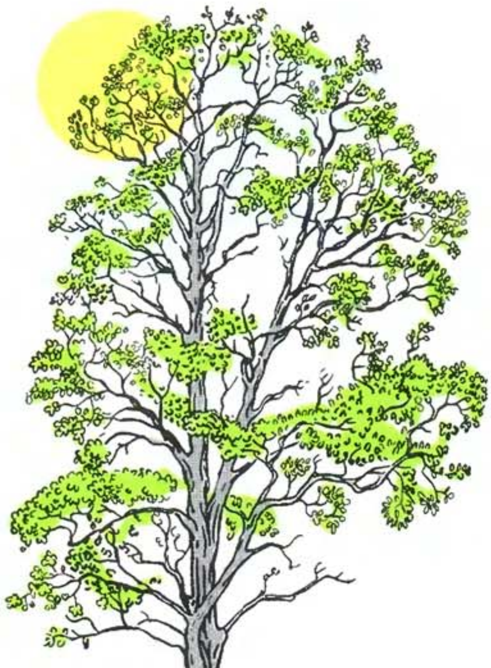
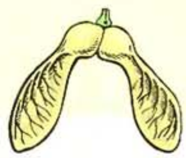


CHAPTER 1

Tree Health and Sciences

IMPORTANT TERMS

minerals
starches
absorbing roots
crown
pore spaces
mycorrhizae
radius
drip line
cambium
phloem
xylem
growth rings
sapwood
heartwood
vascular system
rays
branch collar
branch bark ridge
included bark
photosynthesis
transpiration
conifer
evergreen
deciduous
Compartmentalization of Decay in Trees (CODIT)
reaction zone
barrier zone
cavity
stress
girdling root
abiotic
biotic
vascular wilt
root crown
trunk flare
buttress roots
conk
fruiting bodies
terminal bud
lateral bud
axillary bud
node
leaf scar
opposite leaf arrangement
alternate leaf arrangement
whorled
simple leaf
compound leaf
leaflets
lobe
serration
fascicle sheath



Introduction

Trees have several basic needs, including sunlight, air, water, essential **minerals**, and adequate growing space above and below ground. When all of these fundamental needs are fulfilled, a tree can survive, grow, and flourish. If any of these is lacking, the tree will suffer and perhaps die. Tree climbers should understand the fundamental principles of tree biology to better understand tree health and the stress factors that affect it.

Climbing a hazardous tree can pose a threat not only to the climber but also to all others in the area. Tree climbers should inspect the tree and identify potential hazards prior to climbing and commencing work. Knowing how to identify signs of potential hazards is a critical component of the inspection process.

It is also important for a tree climber to be able to identify trees. Proper tree identification is essential to follow work orders. Climbers must also be familiar with the characteristics of various trees. Knowing the growth habits of a particular species can help achieve more natural forms of pruning. Knowing the strength of its wood and branches may save a life.

A basic knowledge of tree structures and tree functions is the foundation for good quality tree care. Understanding how the tree will respond to stress, wounds, and treatments is necessary in applying tree care techniques. Without this knowledge, workers may employ improper tree care practices or poor techniques, which can be damaging to trees.

Tree Growth and Structure

Roots

The roots of trees serve four primary functions: anchorage, storage, absorption, and conduction. Larger roots are woody like the trunk and branches. They serve to hold the tree in place, store **starches**, and carry water and minerals to the tree top. Larger roots branch many times, forming smaller networks of roots. It is the small, fibrous **absorbing roots** that take up water and minerals. These slender roots branch out to form fanlike mats just under the soil surface.

Roots grow where moisture and oxygen are available. Although tree roots can grow very deep in certain sites, most absorbing roots are found in the upper 6 inches of soil. Even the largest roots are found predominantly in the upper 3 feet of soil. The idea that the root system is a mirror image of the tree's **crown** is absolutely false.

Roots grow outward from the tips. The tiny root tips grow where conditions are most favorable. **Pore spaces** between the soil particles contain the necessary oxygen and water

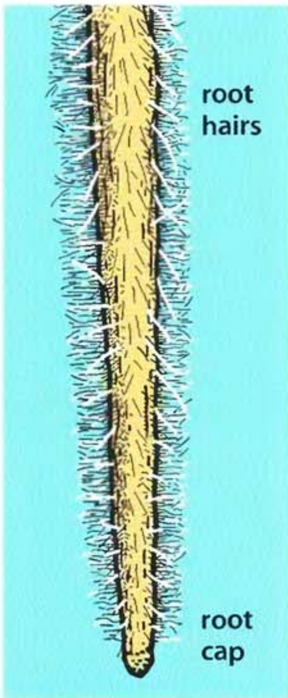


FIGURE 1.2 Root tip anatomy.

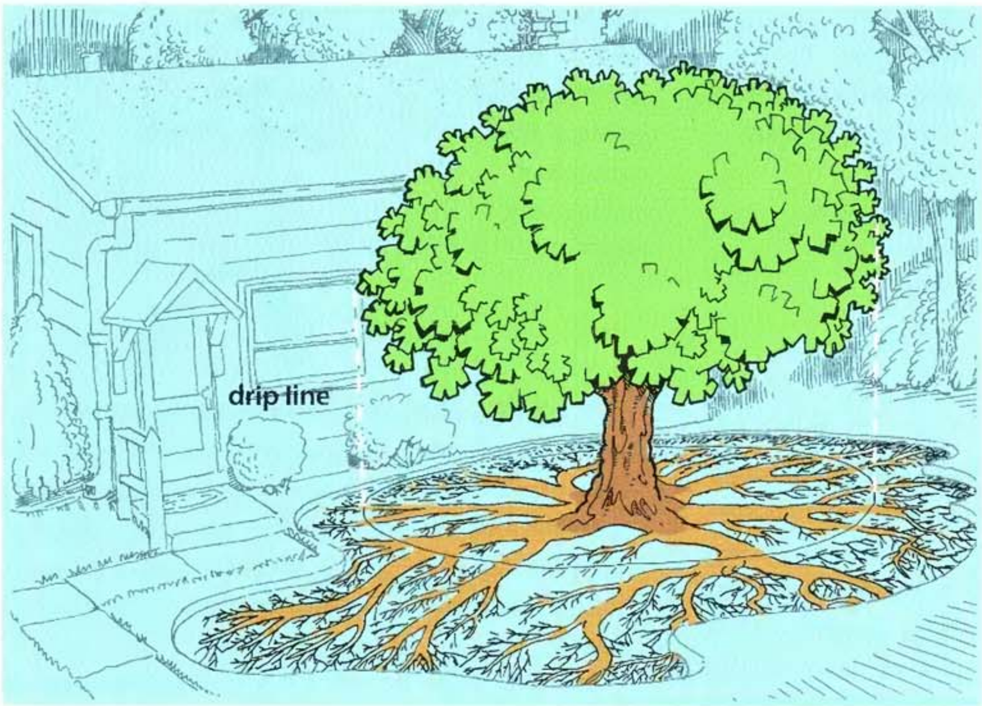


FIGURE 1.1 Most absorbing roots grow very near the surface. There is generally little root growth under buildings or paved surfaces.

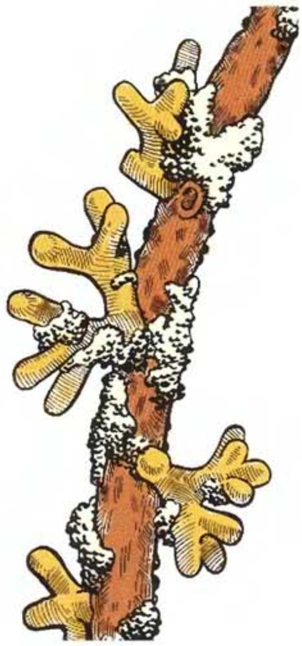


FIGURE 1.3 Most tree roots coexist in a beneficial relationship with fungi, which helps in the absorption of water and minerals. This relationship is called mycorrhizae.

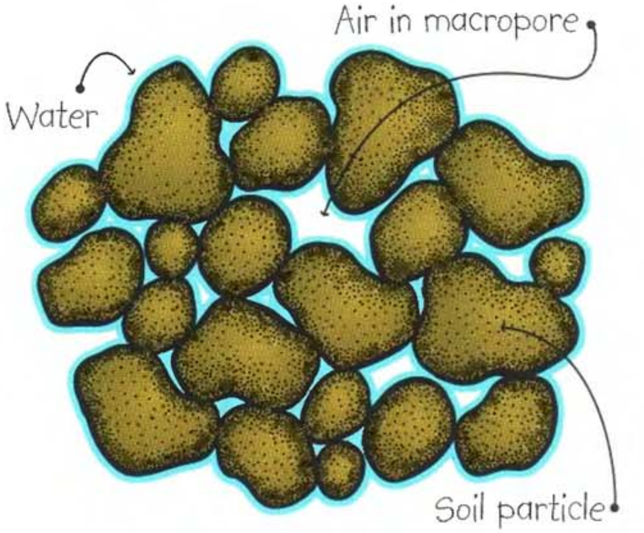


FIGURE 1.4 An ideal soil is about 50 percent pore space. The spaces between the soil particles may be filled with air or water.

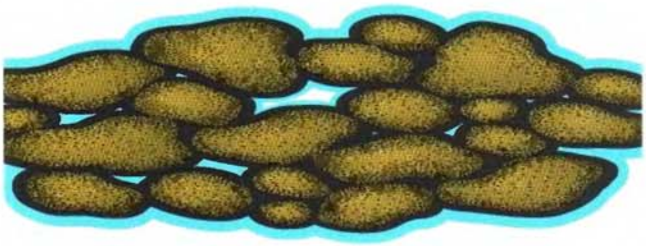


FIGURE 1.5 When a soil is compacted, the pore space is reduced. Oxygen levels decrease, and root growth is inhibited.

for root growth. If pore space is inadequate or if there is not sufficient oxygen, roots cannot function. Thus, roots are less likely to be found in compacted soils or under paved areas. Where soils are severely compacted, tree growth and health usually suffer.

The direction of root growth and distance from the trunk depend on the surrounding soil conditions. Roots of trees grown in open areas often extend two to three times the **radius** of the tree's crown. However, if structures or pavements limit growth, the roots of a tree may grow only a few feet in one direction and a great distance in the other. Roots normally grow much farther from the tree than the **drip line** (edge of the tree crown).

Trunk and Branches

The trunk and branches of a tree provide the tree's framework. The branches form a scaffold system, or branching structure, which presents the leaves to the sun. Like the roots, the trunk and branches perform several basic functions. They conduct water and minerals from the roots to the leaves. They provide structural support of the tree's crown. They also store energy in the form of sugars or starches.

Not far beneath the bark of the tree is a continuous layer of dividing cells known as the **cambium**. Division of cambium cells results in annual increases in branch and trunk diameter and is important in the closure of wounds. Cells produced by the cambium toward the outside of the tree become part of the **phloem**. The phloem carries the sugars that are produced in the leaves to other parts of the tree for use or storage as starch.

FIGURE 1.6 Roots grow where conditions are most favorable. They may extend much farther than the drip line of the tree.

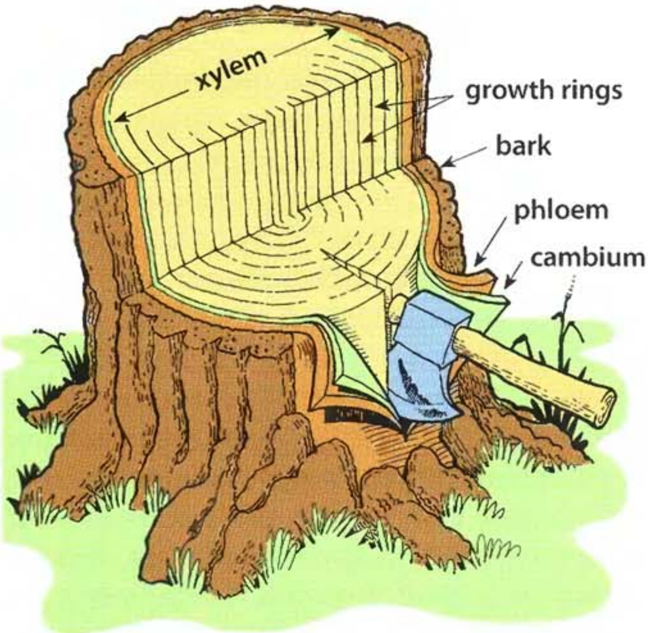


FIGURE 1.7 This figure illustrates the relative locations of the phloem, cambium, and xylem.

The **xylem** is formed by the cambium toward the inside of the tree. The xylem consists of wood fibers and vascular elements that conduct water and minerals up from the roots. It is a complex tissue composed of both living and dead cells that function, not only in water conduction, but also in storage of starch, defense against decay, and structural support of the tree.

When we look at a cut (cross) section of a branch, trunk, or root, the **growth rings** are visible. Normally, each ring represents one year's growth of xylem. The ring just inside the cambium is the most recent year's growth. The thickness of the growth rings is often an indication of growing conditions in various years. For example, several years of drought can cause thin growth rings, representing reduced growth of the tree. It is also true that counting the growth rings can often reveal the age of the tree.

The outermost rings of the xylem, known as the **sapwood**, conduct water and minerals from the roots

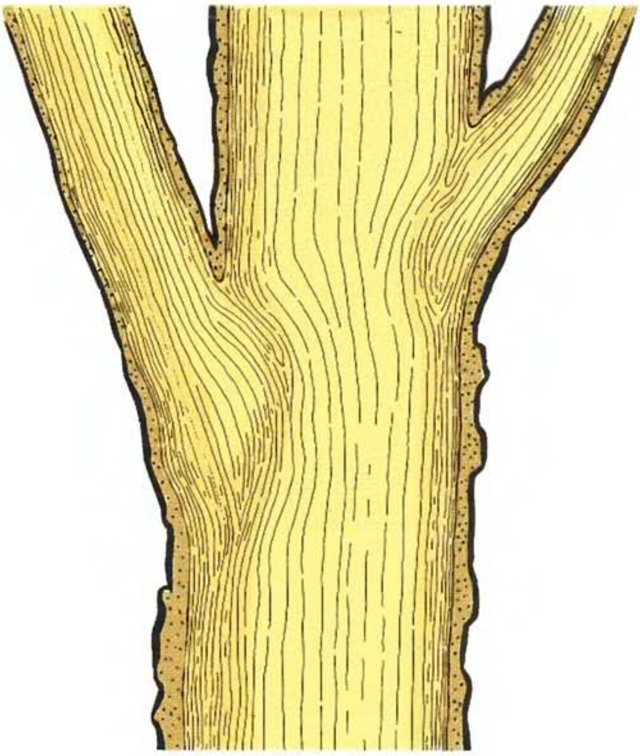


FIGURE 1.8 With the bark removed, the pattern of normal branch attachment is visible. There is no direct vascular connection between a branch and portions of the tree above that branch.

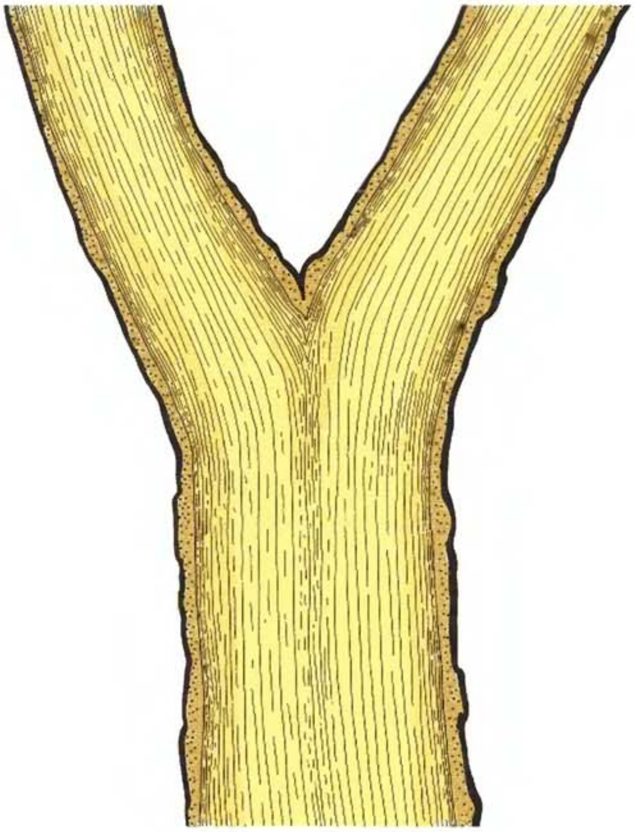


FIGURE 1.9 Codominant stems do not have the same branch attachment.

to leaves. In most trees, the inner growth rings, called the **heartwood**, are dead. They no longer carry water and minerals up through the tree.

The cambium, phloem, and xylem form a continuous system running from the small, woody roots up through the trunk and branches and into the tiny twigs. As cambium cells divide, an additional layer of cells forms, increasing the diameter of the branch or root. But the twig extension growth, growth in height and spread, takes place from the tips of the twigs. This means that branches do not get higher on the trunk as the tree grows.

In addition to the phloem and xylem, the **vascular system** of a tree also contains **rays**. The rays are radial sheets of living cells that cross both the phloem and xylem. They transport sugars and other materials across the stem tissues. They are also the primary food-storage sites within the tree. Most of the stored starch used by the tree for growth, flowering, and fruiting comes from storage sites close to where the starch is utilized.

Each branch of the tree is similar in structure and function to the entire tree crown. Yet branches are not simply outgrowths of the trunk. Instead, branches and trunks have a unique attachment form. Branches are strongly attached to the trunk beneath the branch but weakly attached to the trunk above the branch. There is no connection of vascular tissue between a branch and other branches that originate above it.

The annual production of layers of xylem by the trunk and branches forms a bulge at the base of the branch called the **branch collar**. In the crotch, the branch and trunk expand against each other. As a result, bark is pushed up, forming the **branch bark ridge**. If the bark in the crotch becomes pinched between the branch and trunk, it is called **included bark**. Included bark weakens the crotch.

Leaves

Leaves may be thought of as the "food factories" of the tree. Unlike humans and other animals, plants actually manufacture their own food. The process is called **photosynthesis**, which means made with light.

Sunlight powers the reaction that combines water and carbon dioxide to form sugar. Oxygen is given off

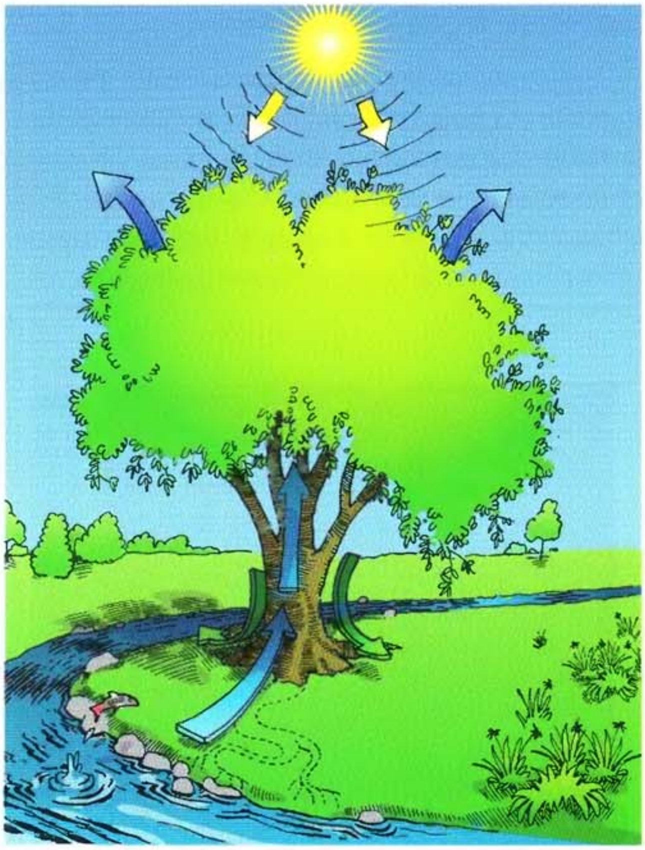


FIGURE 1.10 Sugar is produced in the leaves in a reaction called photosynthesis. Sunlight provides the energy, and oxygen is given off as a byproduct.

into the atmosphere as a byproduct. Some of the sugar is used to provide energy for growth and development. The rest is transported through the phloem and stored as starch in the ray cells or in the roots.

A second function of the leaves is **transpiration**. Transpiration is the loss of water, in the form of water vapor, from tiny pores in the leaf surface. This evaporation cools the leaves. It also creates the "transpirational pull" that helps move water up from the roots through the xylem.

Leaves come in a variety of shapes and sizes. Some are uniquely adapted for extreme environments. Needles, found on pines and firs, are also a form of leaves. Most **conifers**, or cone-bearing trees, are **evergreens**. They keep their leaves more than one year. Trees that lose their leaves in the fall are called **deciduous**.

Defense Against Decay

A developmental process unique to woody plants is the ability to compartmentalize decay. Compartmentalization is a process by which trees limit the spread of discoloration and decay. After a tree has been wounded, reactions are triggered that cause the tree to form boundaries around the wounded area.

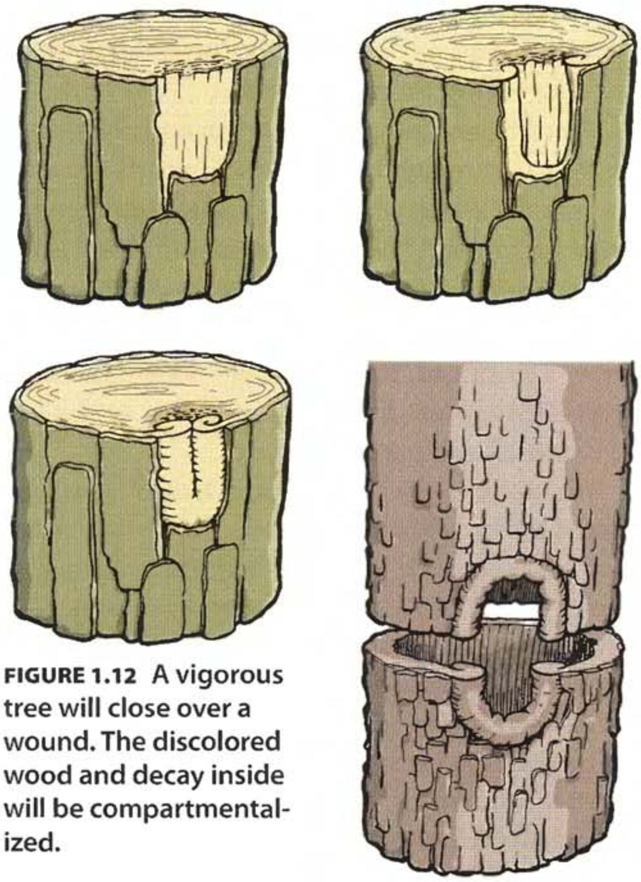


FIGURE 1.12 **A vigorous tree will close over a wound. The discolored wood and decay inside will be compartmentalized.**

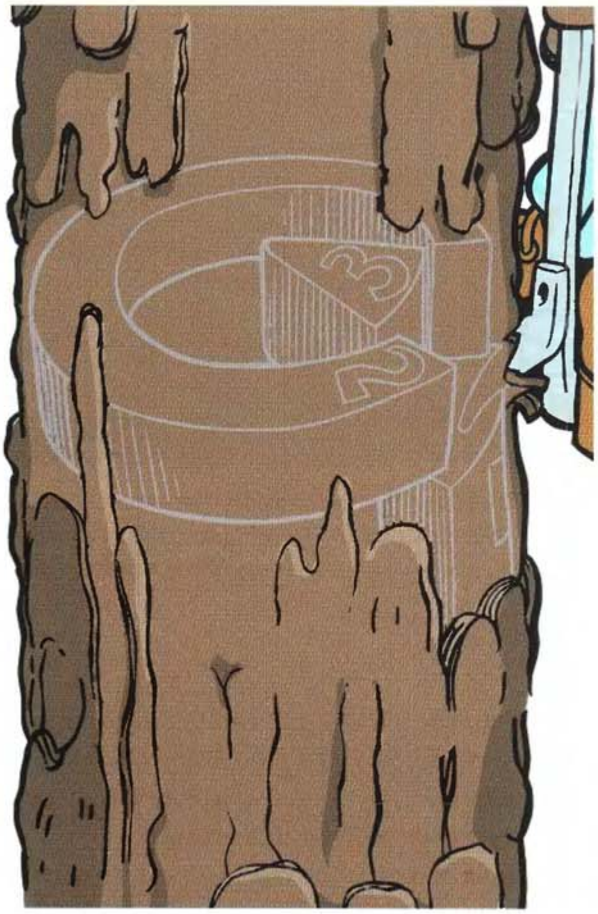


FIGURE 1.11 **Wall 1 is formed when the tree responds to wounding by "plugging" the upper and lower vascular elements to limit vertical spread of decay. Wall 2 is formed by the last cells of the growth ring limiting inward spread. Wall 3 is the ray cells that compartmentalize decay by limiting lateral spread. Wall 4 (shown in Figure 1.12), the strongest wall, is the new growth ring that forms after the injury. Wall 4 prevents decay from entering new wood. Wall 3, not shown, and Wall 2 have failed to prevent the decay from spreading laterally and internally.**

Alex Shigo, a prominent tree researcher, has proposed a model of this compartmentalization process called **CODIT**, **C**ompartmentalization **O**f **D**ecay **I**n **T**rees.

In Dr. Shigo's model, the tree forms four barrier "walls." Wall 1 resists vertical spread by plugging xylem cells. Wall 2 resists inward spread across the annual rings. Wall 3 inhibits lateral spread by activating ray cells to resist decay. These three walls form the **reaction zone**. Wall 4 is formed with the next layer of wood to form after injury. It protects against the outward spread of decay. This is the **barrier zone**. Wall 1 is the weakest barrier, and Wall 4 is the strongest.

At times, the tree cannot resist the spread of aggressive pathogens. It is fairly common for walls 1, 2, and 3 to fail, allowing decay to spread inside the tree. Decay ultimately results in the formation of a **cavity**. Wall 4 normally does not fail unless the cambium is killed or injured. Thus, the decay can often be confined to tissues that were present at the time of injury.

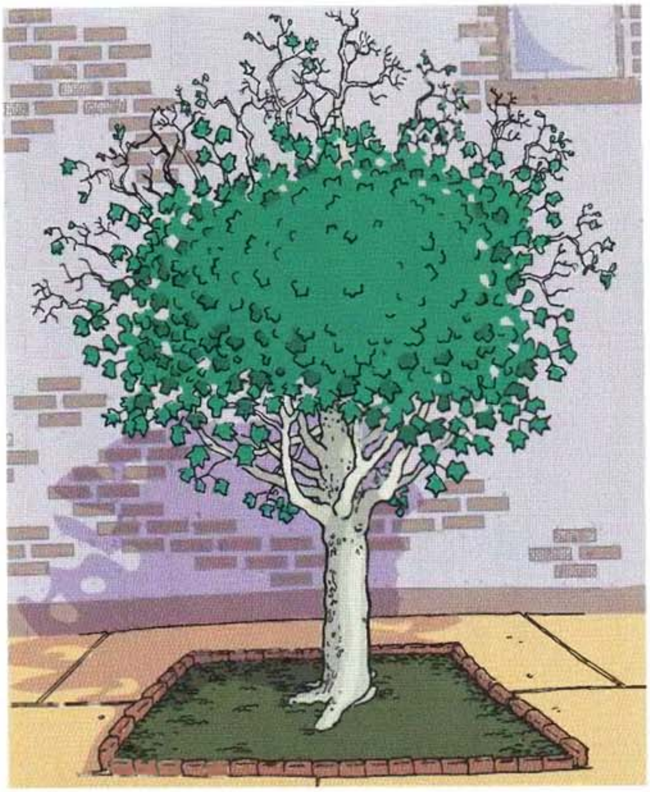


FIGURE 1.13 General decline in the crown of a tree is often a sign of root stress.

A hollow tree can survive because the outer xylem rings (sapwood) continue to conduct water. Like a cylinder or pipe, a hollow tree can be quite strong structurally. However, when decay spreads through the barrier zone into the remaining tissues, the tree may decline in health and become structurally hazardous.

Tree Health and Stress

The basic factors that promote plant health include sufficient water and air, optimum light and temperatures, and a good balance of the essential minerals. Too much or too little of any of these elements can cause **stress** in the tree. Stress is a term used to describe any condition that causes the health of the tree to decline.

Early signs of stress might include reduced growth rate, abnormal leaf color, vigorous production of water sprouts or suckers, or leaf drop. The most common causes of tree stress are related to the site or environment. If the tree is not well suited for the site in which it has been planted, it is more likely to suffer stress at some time in the future. Common stress problems include inadequate or excess water, soil compaction, **girdling roots**, extreme cold, and mechanical injuries (including improper pruning techniques). These are all examples of **abiotic** factors, meaning they are not caused by living organisms.

Root stress is a common problem in city and suburban sites. Soils are often hard, dry, and infertile in the city environment. Compaction reduces the pore space, which reduces oxygen availability. If root growth and function are inhibited, the tree will decline.

Trees in a state of stress become weak and are more prone to attack by insects and diseases. All too often, arborists identify and treat only these secondary problems. However, if the health problems are to be reversed, the primary cause of stress must be identified and corrected.

Many other plant health problems are caused by **biotic** (living) agents, such as insects, mites, fungi, and bacteria. As a rule, insects and diseases that affect only the foliage of deciduous trees are not life threatening. Leaves are temporary organs, and more are produced each year. The exception to this rule is when trees are

FIGURE 1.14 A girdling root can constrict a tree's vascular system. This can sometimes be a cause of stress. It is common with some tree species.

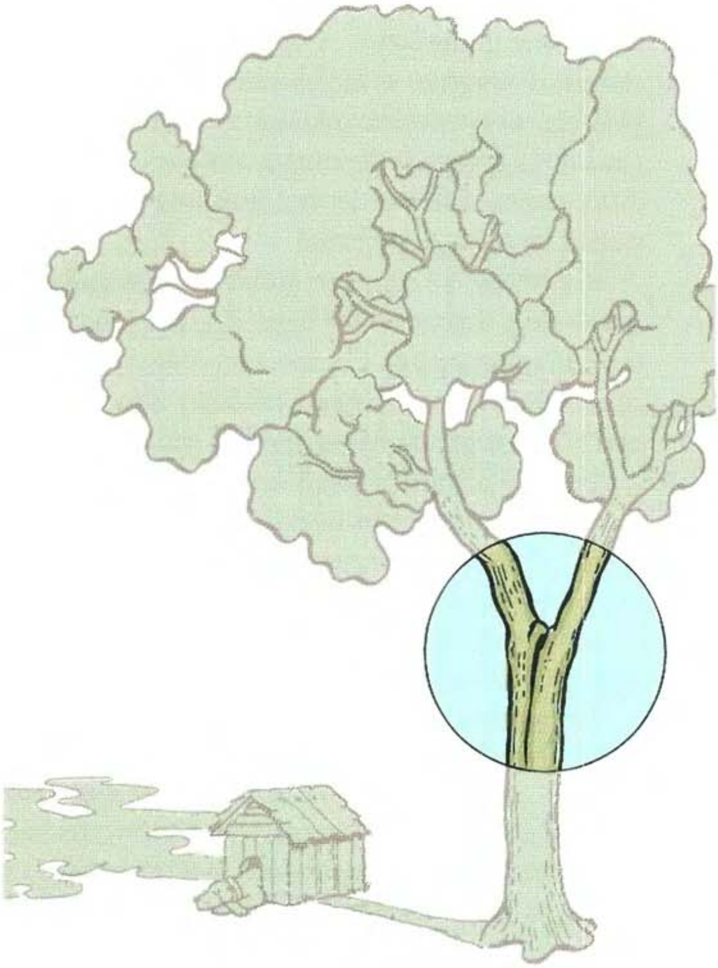


FIGURE 1.15 A split crotch is a potential hazard.

FIGURE 1.17 A conk on the outside of a tree is an indication of decay on the inside.

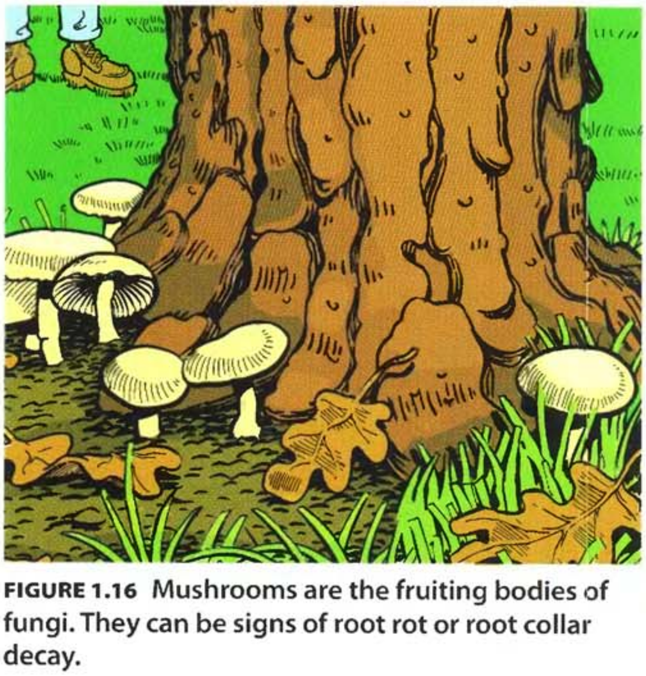


FIGURE 1.16 Mushrooms are the fruiting bodies of fungi. They can be signs of root rot or root collar decay.

defoliated year after year, causing the tree to rely on stored energy reserves. If these "borrowed" energy reserves are not "repaid" through photosynthesis, the tree will eventually die.

Insects, diseases, or wounds that affect the vascular system of a tree are much more serious. The tree must be able to conduct water and nutrients in order to survive. Wood-boring insects and **vascular wilt** diseases are examples of problems that are often fatal.

Hazard Recognition

Before working on any tree, the climber must do an inspection. The tree must be assessed thoroughly for any potential hazards. Some defects and hazards are obvious, such as large cavities or splits in the wood.

Other flaws may not be discovered without a careful search.

One very serious hidden danger is decay at the **root crown (trunk flare)**, the zone where the trunk and roots come together. A number of tree climbers have been injured or killed when the tree they were working in failed at the base. This sort of decay is not always obvious. Decay should always be suspected on dead and severely declining trees. Trees that show a general dieback from the tips are probably suffering from some form of root stress.

Look around the root zone for indications of dead or decayed roots. Mushrooms, especially if they are growing in a line, can be a sign of root decay. Dig and explore around the trunk flare at the base of the trunk. Look for rotted wood and fungi. Probe around the large **buttress roots** at the trunk flare to be sure that they are solid.

The trunk and crown of the tree should also be inspected. If there are **conks** on the trunk or branches, there is decay inside. Conks are the **fruiting bodies** of certain decay fungi. Other potential hazards include cavities, split trunks or branches, crotches with included bark, dead branches, and soil lifting opposite a lean.

If any of these hazards is identified in a tree, some decisions must be made. Is the tree safe to climb? Does it pose an immediate threat to people or structures in the area? Who should be notified, and what actions should be taken? While the tree climber is not always in a position to make the final decision concerning treatment or possible removal, he or she still shares the responsibility for the evaluation. The safety of the climber and other workers on the crew may depend on the ability of the climber to recognize and communicate concerns related to potential hazards.

FIGURE 1.18 **Frass, a mixture of sawdust and insect excrement, is a sign of insect activity. Further investigation is called for to look for decay.**

Principles of Tree Identification

Identification of the tree is usually the first step in any tree care procedure. The tree climber must be able to identify the various trees on a property in order to perform the work. Accurate identification requires a combination of knowledge and experience. Once the basic identification skills are learned, proficiency will come with practice and repeated exposure to the trees during different seasons.

FIGURE 1.19 **With or without the leaves, the color and texture of the bark are good identification features.**

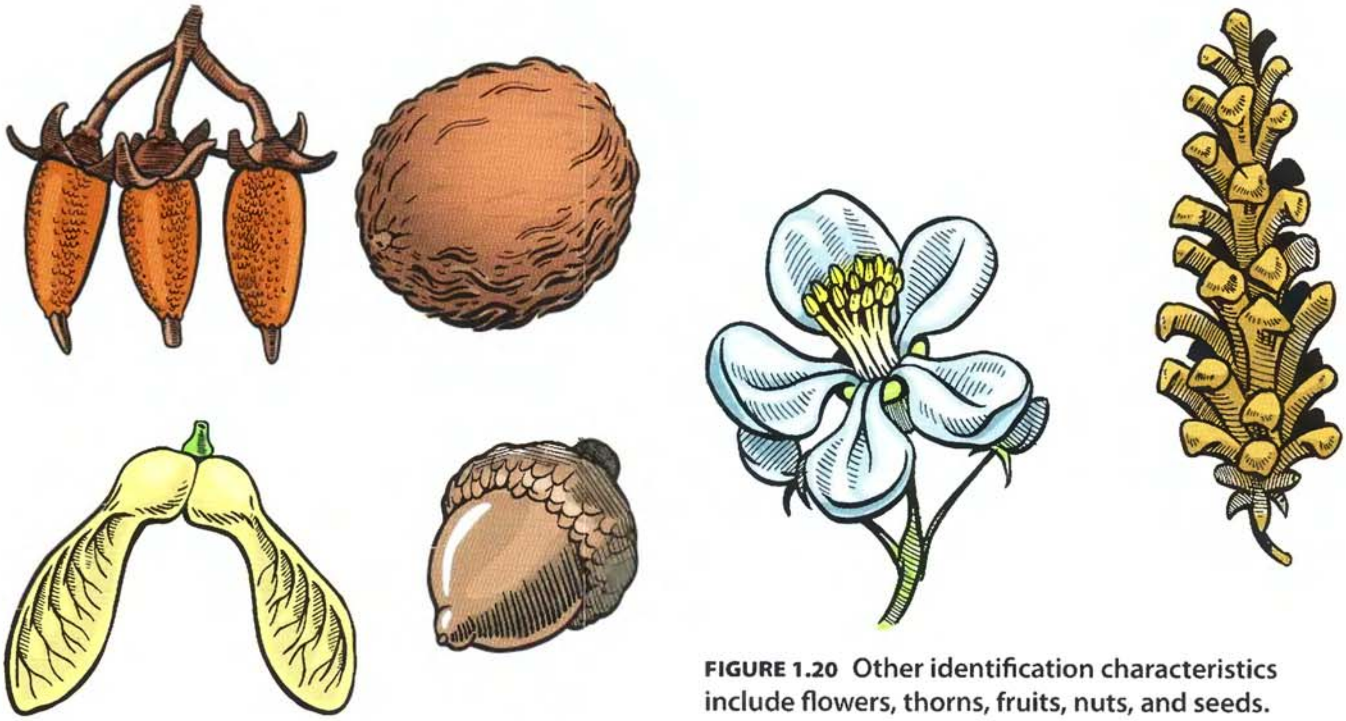


FIGURE 1.20 Other identification characteristics include flowers, thorns, fruits, nuts, and seeds.

Tree identification is based on the size, shape, and appearance of tree parts. Therefore, a fundamental knowledge of tree structure is essential. A good tree climber learns to identify trees by using a tree's many characteristics. Rather than focusing just on the leaves, it is important to examine the buds, twigs, flowers, fruit, and bark. The size and growth habit of the tree are also key identification characteristics. The climber who relies solely on the leaves will only be able to identify deciduous trees half of the year in many regions.

Use all available information during tree identification. This may require close examination of leaves, twigs, and buds. Sometimes tree identification is based on more than the identifier's visual senses. Smell, and even taste, may be useful to determine the unique characteristics of twigs, leaves, flowers, or fruit.

There are a few basic rules and tricks that can be used in tree identification. In order to use them, a little knowledge of twig anatomy is required. The bud at the end of a twig is called the **terminal bud.** Buds along the twig are called **lateral** or **axillary buds.** These may be leaf or flower buds, or they may develop into twigs. Flower buds are generally rounder and plumper than leaf buds. The slightly enlarged point on the stem where leaves or buds arise is called the **node.** Marks left on the twig after leaves have fallen are called **leaf scars**. Their unique sizes and shapes can be very helpful in identifying trees.

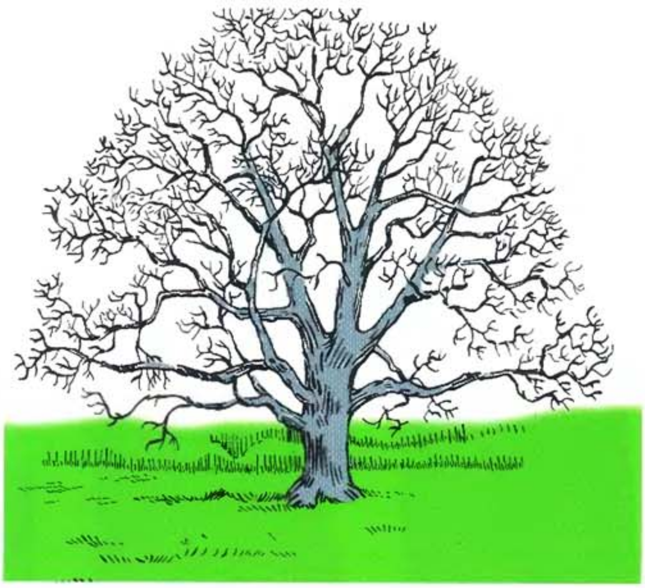


FIGURE 1.21 The growth form of many trees is an identification characteristic (above and opposite).

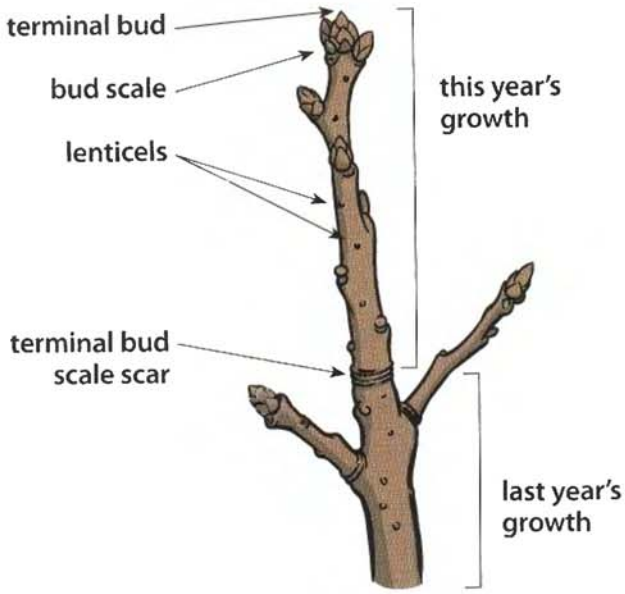


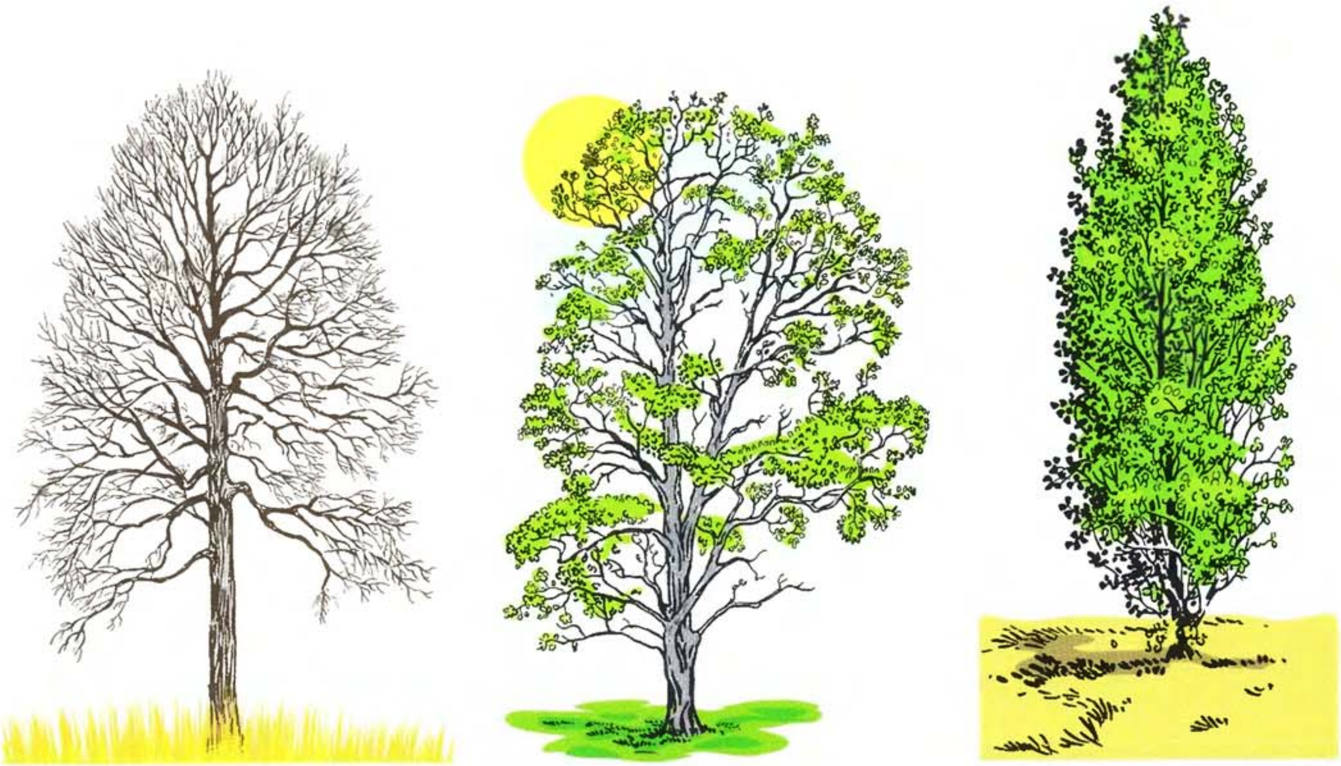
FIGURE 1.22 Twig anatomy showing twig extension growth.

An initial step in tree identification is determining the leaf arrangement on the stem. The leaf (or bud) arrangement is the order in which leaves are attached to the stem. If two buds arise across from one another on a stem, the arrangement is called "opposite." Maples, ashes, most dogwoods, and buckeyes (horsechestnuts) are examples of trees that have **opposite leaf arrangement**. The majority of deciduous tree species have an **alternate leaf arrangement**, in which leaves and buds arise alternately along the stem. If three or more leaves and buds arise from a single node, the arrangement is called **whorled**. Although this is not common on deciduous trees, it is sometimes found in conifers.

The next step is to determine whether the tree has **simple leaves** or **compound leaves**. Simple leaves have one leaf blade and one bud. Compound leaves also have only one bud but branch into multiple **leaflets**. Other leaf characteristics that can be used for identification are **lobes** and **serrations** (teeth along the leaf margin) as shown in Figure 1.27.

In conifers, the size, shape, and arrangement of the needles are important. The needles of spruces, hemlocks, yews, and firs arise singly on the stem. Pine tree needles are borne in a **fascicle sheath**, or bundle, of two, three, or five needles. The number of needles in the fascicle sheath is an indication of the species of pine.

The size, shape, and angle of the buds on the twigs are usually good indicators of tree identity, especially in the winter. The leaf scar below the bud can also be helpful.



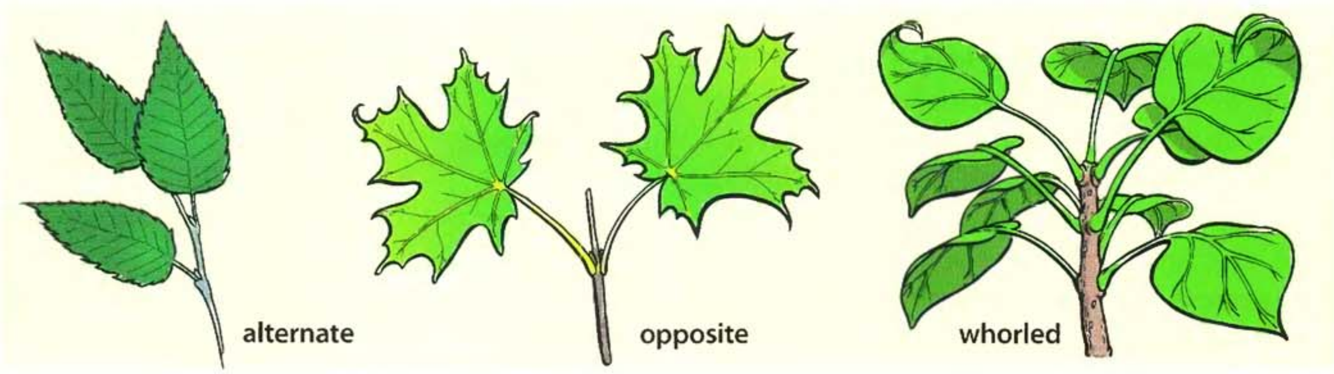


FIGURE 1.23 Leaf arrangements.

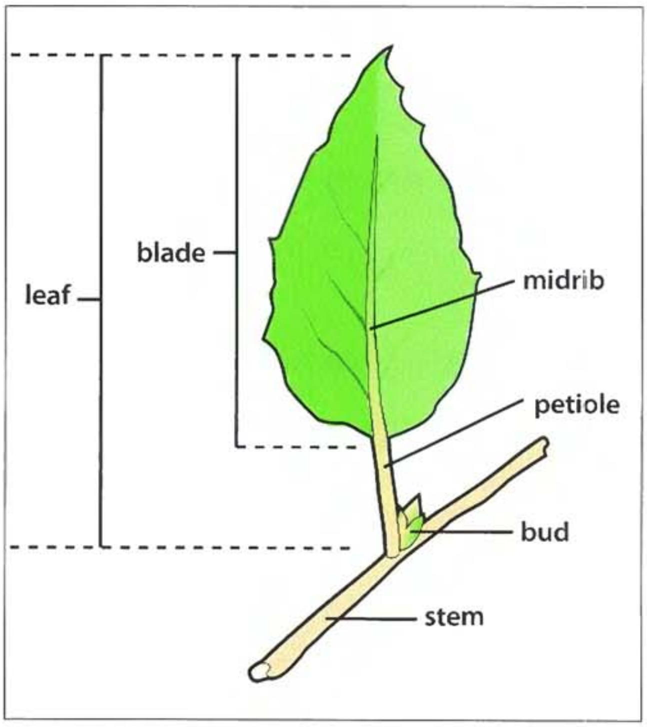


FIGURE 1.24 Anatomy of a simple leaf.

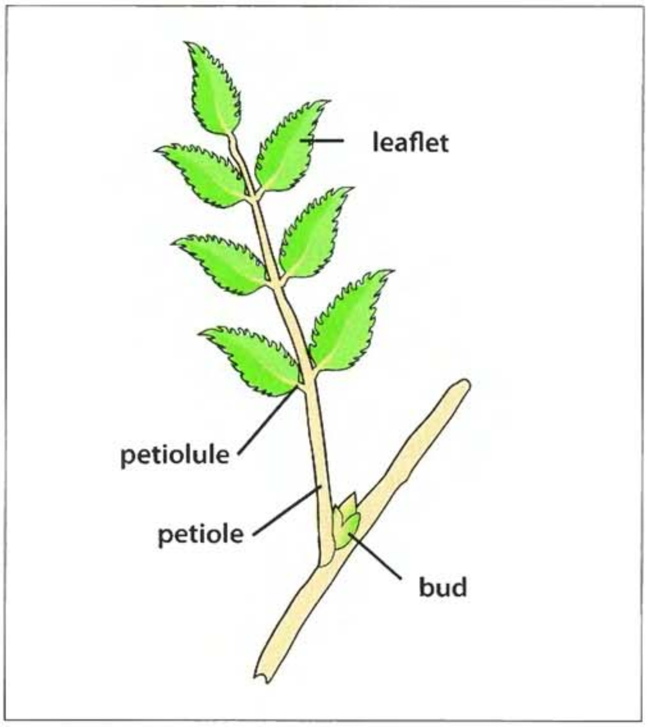


FIGURE 1.25 Compound leaf.

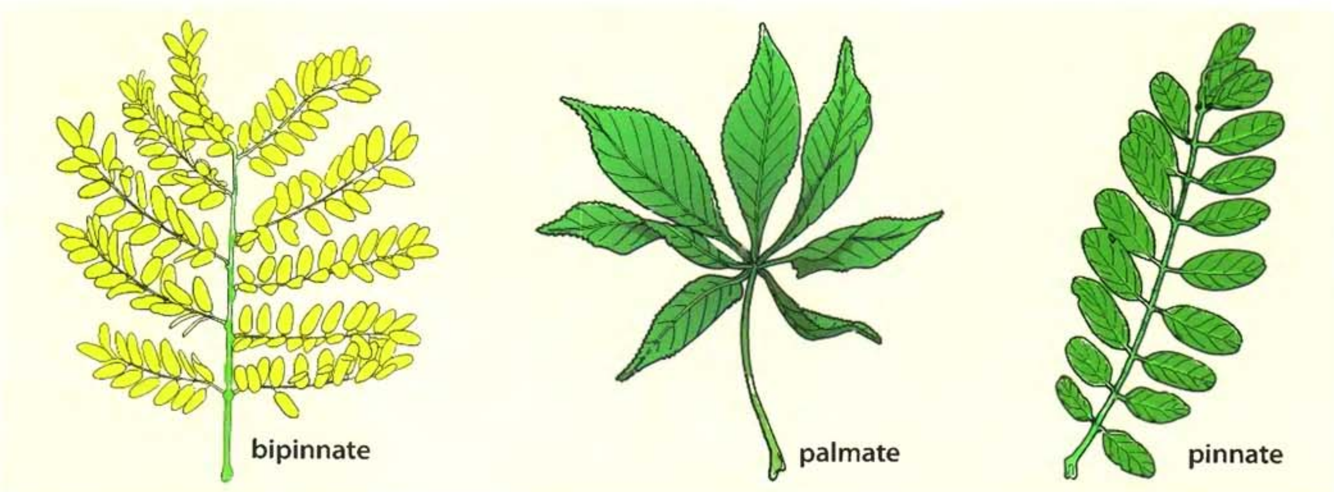


FIGURE 1.26 Arrangement of leaflets on compound leaves.

Even though identification guidelines can be very helpful, there is no substitute for field practice. The more knowledge that can be gained about tree characteristics, the easier the process becomes. Years of experience in observing trees in different settings and at various times of the year can be invaluable.

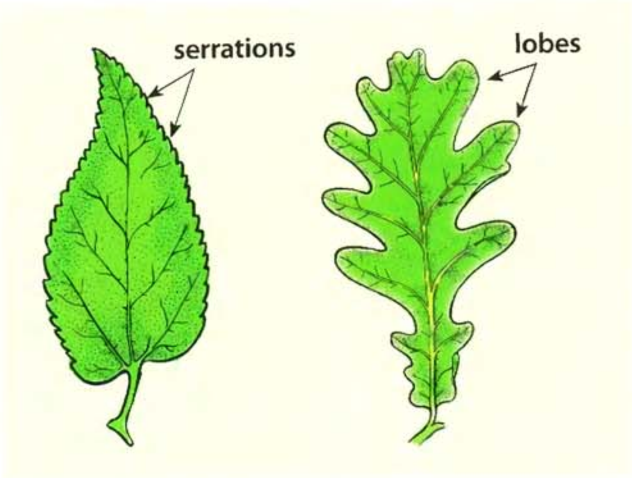


FIGURE 1.27 On the left, a simple leaf with serrations is illustrated. The leaf on the right has lobes.

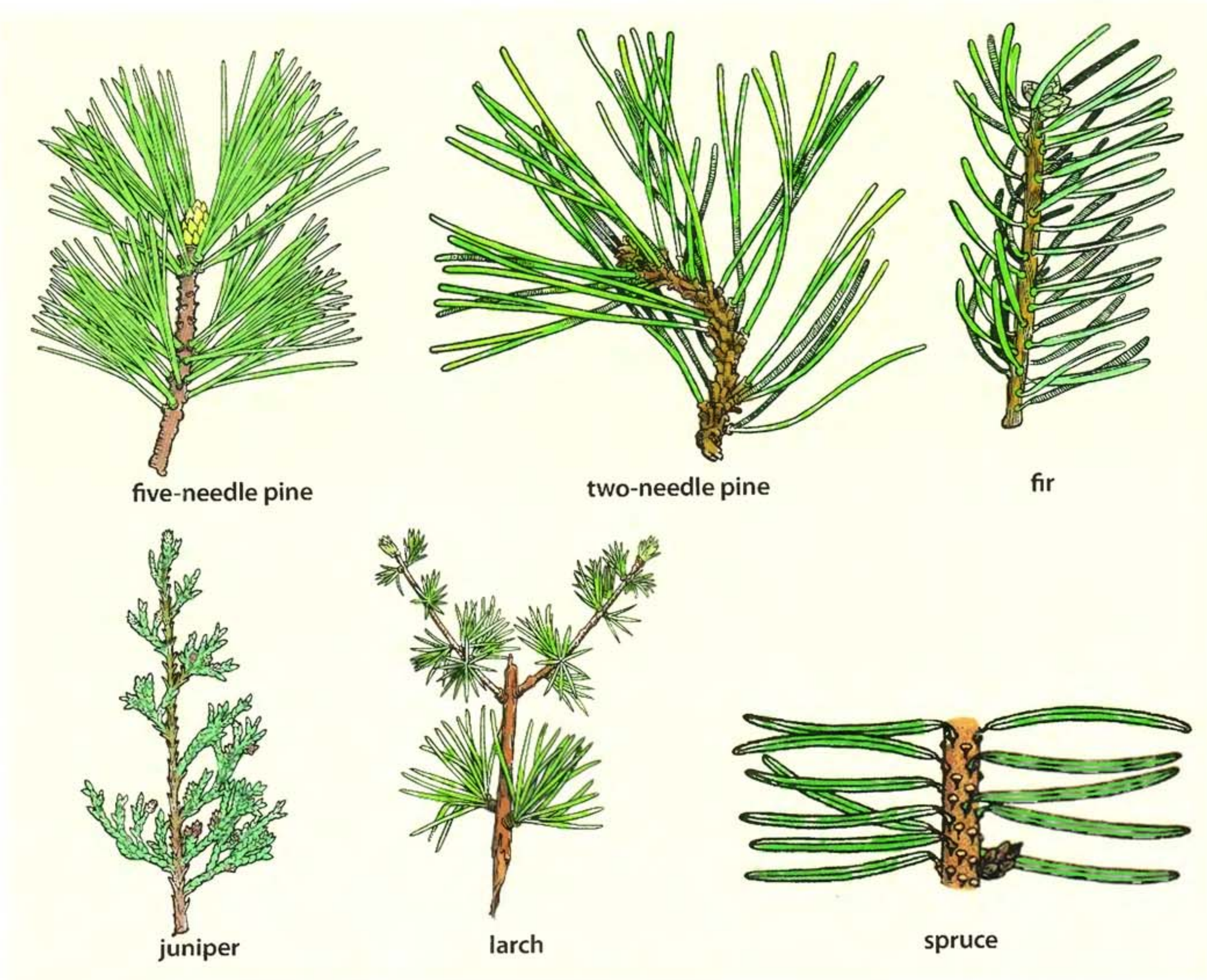


FIGURE 1.28 Conifers can be identified by the characteristics of the needles.

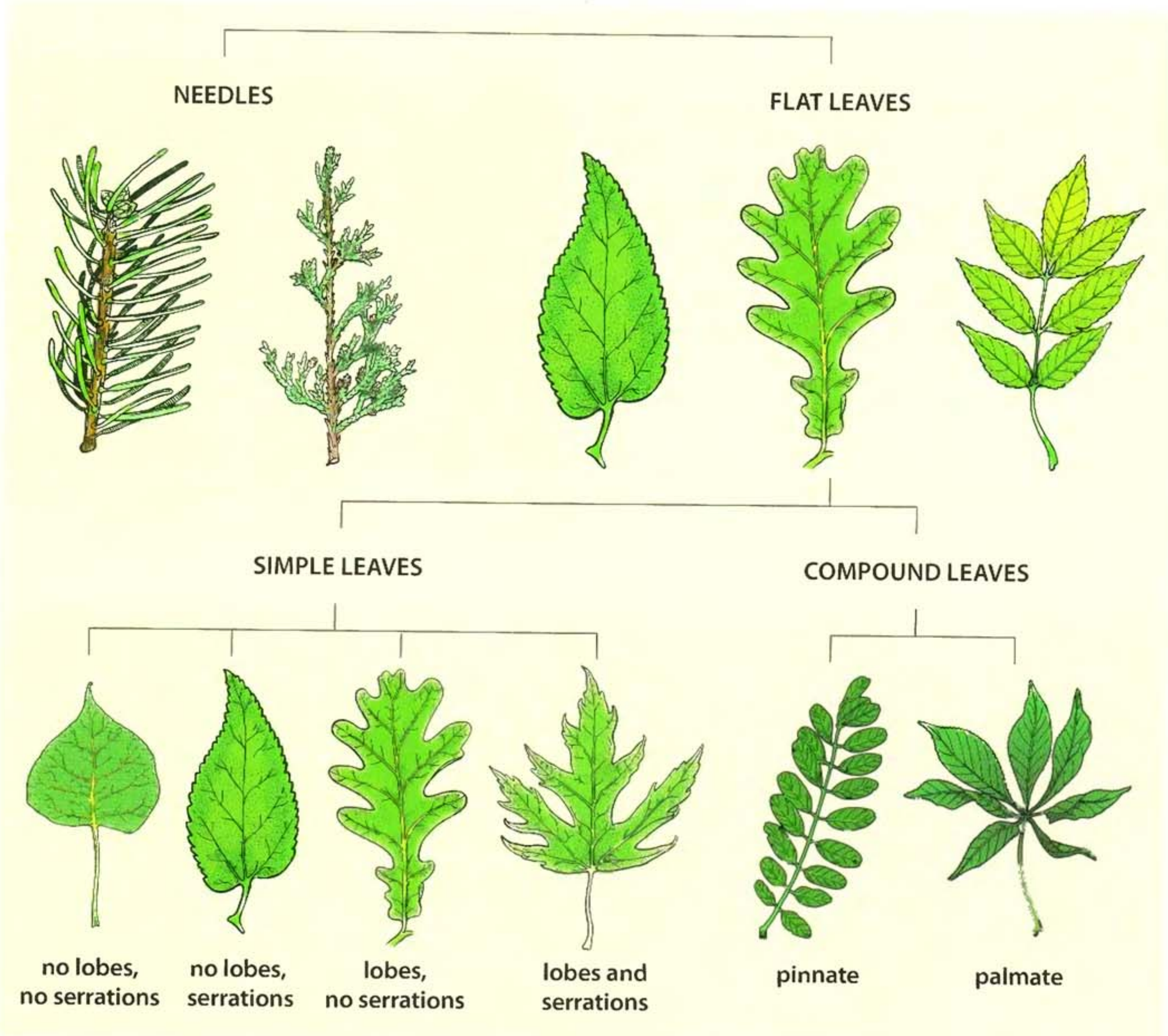


FIGURE 1.29 Many identification charts help arborists identify trees by the characteristics of the leaves.

Matching

_____ xylem	A.	trees that lose all their leaves annually
_____ absorbing roots	B.	food-conducting tissues
_____ included bark	C.	water vapor loss through leaves
_____ phloem	D.	usually in the upper 6 inches of soil
_____ photosynthesis	E.	sugar production by plants
_____ cambium	F.	carries water up through tree
_____ transpiration	G.	bark within a tree crotch
_____ deciduous	H.	zone of diameter growth in tree

True/False

1. T F Small fibrous roots serve to take up water and minerals.
2. T F The root system of a tree is like a mirror image of the top (crown).
3. T F Roots tend to grow where moisture and oxygen are available.
4. T F Tree roots rarely grow beyond the drip line of the tree.
5. T F Starches are stored throughout the trunk and branches of a tree.
6. T F The cambium is located in the center of the trunk and branches.
7. T F The phloem carries sugar only to the roots.
8. T F The xylem is located directly beneath the bark.
9. T F Normally, each growth ring represents one year of growth.
10. T F The thickness of the growth rings is often an indication of growing conditions in previous years.
11. T F The heartwood conducts water and minerals up through the tree.
12. T F In most tree species, only the outermost rings of sapwood conduct water.
13. T F Rays are storage sites for starch.
14. T F The bulge at the base of a branch at the point of attachment to the trunk is called the branch collar.
15. T F Leaves may be considered the "food factories" of a tree.
16. T F A vigorous tree will compartmentalize decay to limit its spread.
17. T F Most of the time, if a tree is stressed, the cause is an insect problem.
18. T F A tree that is showing general decline throughout the crown is likely to be suffering from a root problem.
19. T F Generally, with deciduous trees, insects or diseases that affect only the foliage of the tree are not fatal.
20. T F Insects or diseases that affect the vascular system of a tree are usually serious.

Matching

_____ root crown
_____ conk
_____ simple leaf
_____ compound leaf
_____ branch bark ridge
_____ pore spaces
_____ terminal bud
_____ serration

A. areas between soil particles
B. where roots join the trunk
C. teeth along the leaf margin
D. bark pushed up at the crotch
E. one blade per leaf
F. bud at the tip of a twig
G. sign of decay within the tree
H. leaf with multiple leaflets

Sample Test Questions

1. Most absorbing roots are located
   a. at the base of the sinker roots
   b. along the surface of the tap root
   c. in the upper 6 inches of soil
   d. within the drip line of the crown

2. If two buds arise across from one another on a stem, the arrangement is called
   a. alternate
   b. axillary
   c. whorled
   d. opposite

3. Which evergreen trees have needles in bundles?
   a. pines
   b. hemlocks
   c. firs
   d. spruces

CHAPTER 2

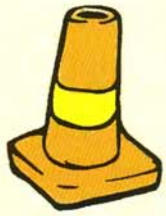
Safety

CHAPTER 2

Safety

IMPORTANT TERMS

OSHA (OHSA in Canada)
ANSI Z133.1
Canadian Standards Association (CSA)
approved
shall
should
personal protective equipment (PPE)
chipper
leg protection
chaps
landing zone
drop zone
command-and-response system
job briefing
work plan
first aid
cardiopulmonary resuscitation (CPR)
emergency response
aerial rescue
electrical conductor
direct contact
indirect contact
leglock method
reactive forces
kickback
kickback quadrant



Introduction

Working in and around trees can be a very hazardous profession if proper care and safety measures are not followed. Safety must always be the first concern. Safety is more than using special equipment, wearing appropriate gear, or attending occasional meetings. Safety is an attitude. It is an ongoing commitment at every level. Safety requires a conscious recognition of potential hazards and the development of a program designed to prevent accidents. Safety precautions must be built into every task performed by tree workers. A small investment of time in safety training can save a great deal in downtime, insurance, injuries, and damages.

Laws and Regulations

In the United States, private employers are subject to the laws of the Occupational Safety and Health Act. The act is administered by the Occupational Safety and Health Administration **(OSHA)**. In Canada, it is the Occupational Health and Safety Act (OHSA, administered by CanOSH). The purpose is to reduce occupational injury, illness, and death through the establishment and enforcement of safety standards and regulations and the provision for mandatory training. Many states also have occupational safety and health laws.

OSHA has established many regulations that affect arboricultural work. For example, OSHA regulates tree work in the vicinity of electrical conductors. Many OSHA regulations are general in nature and govern multiple professions.

ANSI Z133.1 is a set of standards for arboricultural operations published by the American National Standards Institute (ANSI). It is intended to provide safety standards for workers engaged in arboriculture, including pruning, repairing, maintaining, or removing trees or cutting brush. Workers in Canada must comply with the standards established by the **Canadian Standards Association (CSA)**.

ANSI standards are the recognized safety standards for arborists in the United States. They are developed and updated by a committee of tree care professionals, including representatives of the International Society of Arboriculture, the Tree Care Industry Association, and many other organizations. It is important for all tree care workers in the United States to be familiar with and comply with the ANSI Z133.1 standards and all applicable OSHA regulations. State regulations or company policies may be more restrictive. In Canada, regulations governing tree care operations are very similar and sometimes are more stringent. It is the responsibility of employers to ensure that all safety regulations and policies are met. Workers must conform to the regulations of the country, state, province, and region in which they are working. ANSI standards are revised approximately every five years, so users must be aware of and comply with the latest revision.

Certain terminology is consistent throughout most safety regulations in the United States and Canada. **Approved** means acceptable to the federal, state, provincial, or local enforcing authority having jurisdiction. In many cases, the word "approved" appears pertaining to certain equipment. The ANSI Z133.1 standards often reference other pertinent standards that regulate certain types of equipment. You may see references to these other standards on the labels of various pieces of equipment.

Two additional terms are important to know when reading standards. **Shall** denotes a mandatory requirement; **should** denotes an advisory recommendation.

This text is not a substitute for any safety standard, nor can it reference all of the pertinent standards and regulations for tree work performed in all countries or regions. Tree workers are reminded and encouraged to become familiar with the standards and regulations where they work. Also, the content of standards takes precedence over this and other educational texts. ***Because of inconsistencies between standards, and for the sake of readability, the use of the terms "shall," "should," and "must" in this text does not necessarily parallel the requirements of ANSI, OSHA, or CSA standards. This text is based primarily on ANSI Z133.1 standards, although many of the requirements are similar to or the same as those in other standards.***

Personal Protective Equipment (PPE)

Tree workers should wear clothing and footwear appropriate for the work conditions and weather. Fabrics should be durable yet allow for free movement. Loose-fitting clothing may catch in machinery

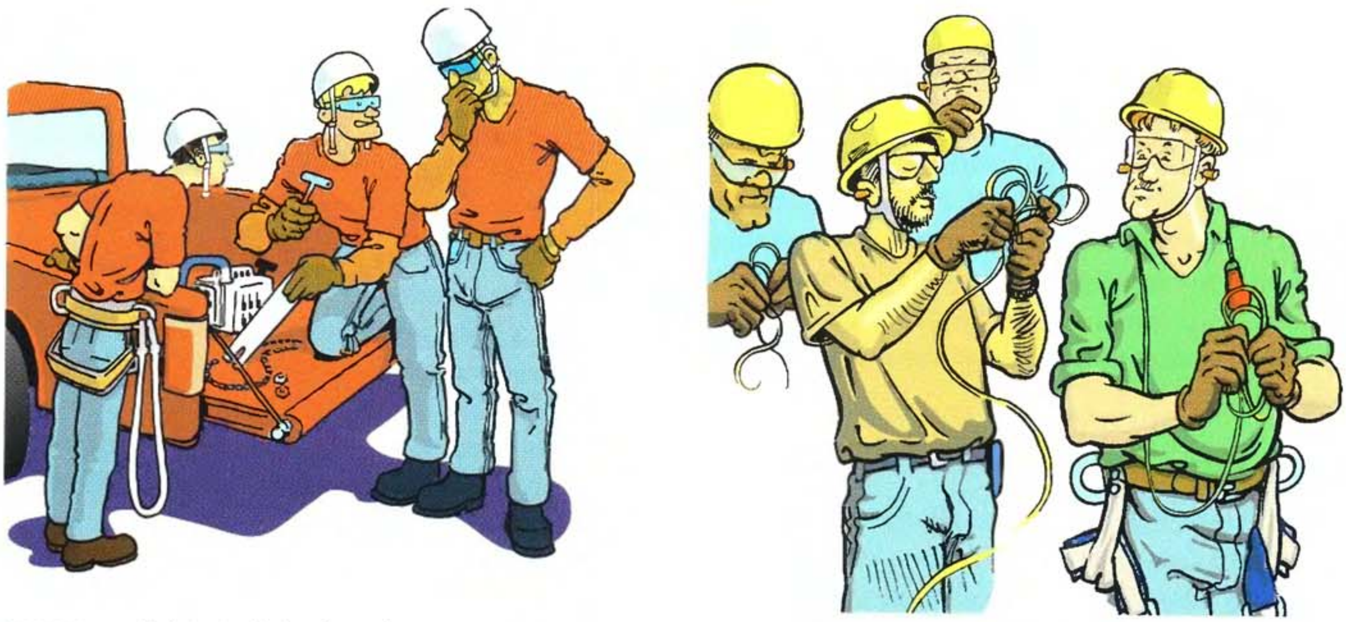


FIGURE 2.1 Safety training is an important part of accident prevention.

and become a hazard. Jewelry should not be worn because it may catch in equipment.

All tree workers must ("shall") wear head protection (hard hats or approved helmets) to comply with federal impact and penetration requirements. Protective headgear must conform to the applicable provisions of ANSI Z89.1, which requires a Type II hard hat for arborists. Those working near electrical conductors must wear a Class E hard hat, which is tested at 20,000 volts. Others can use a Class G hard hat, which is tested at 2,200 volts.

FIGURE 2.2 Head protection and eye protection must be worn by tree workers at all times.

FIGURE 2.3 Goggles provide excellent eye protection and can be worn over eyeglasses.

Eye protection must also be worn when performing tree work. If a worker is poked in the eye by even a small twig, irreparable damage may be done to the eye. Sawdust and wood chips from chain saws and **chippers** pose a significant threat to a worker's eyes. Tree climbers must wear protective glasses or goggles. Some protect against ultraviolet (UV) rays as well. Some workers also prefer to wear face shields, such as those attached to some hard hats. Face shields offer additional protection to the face but must not be considered a substitute for protective glasses, and protective glasses must still be worn.

FIGURE 2.4 A face shield provides added protection against flying debris, but it is not a substitute for eye protection.

It has been demonstrated that prolonged exposure to the noise of chain saws and brush chippers can cause permanent hearing loss. Hearing protection is required for workers who are exposed to loud equipment for prolonged periods of time (90 dB on a time-weighted average for an eight-hour day). Because tree workers use chain saws and chippers frequently, hearing protection must be used whenever they are operated.

FIGURE 2.5 Hearing protection should be worn by workers using chain saws or chippers.

Workers may choose to use either earmuff- or earplug-type hearing protection equipment, provided the devices chosen meet appropriate standards.

FIGURE 2.6 Some hard hats have integrated ear muffs, although earplugs may also be worn.

When chain saws are used on the ground, **leg protection** must be worn. Leg protection may be in the form of **chaps** or chain-saw pants. The fabric of these leg protection devices is designed to jam and slow the cutters of the saw chain if contact is made. Leg protection has been shown to reduce the severity of chain-saw injuries. Newer designs of chain-saw pants are lightweight and less bulky than early models. Many countries and U.S. companies now require climbers to wear chain-saw pants when they are using chain saws in trees. Other work clothing has been developed that has chain-saw protection incorporated into the fabric. Examples include shirts, jackets, gloves, and bib-style pants.

All tree workers should wear sturdy work boots to provide good support, good traction, and protection for the feet. Many styles and types of approved work boots are available. Some newer designs have chain-saw protection. If climbing spurs are used

FIGURE 2.7 **Leg protection is required by ANSI Z133.1 for chain-saw use on the ground.**

frequently, climbers might choose boots with a deep, square heel to brace the stirrup of the climbing spur, and a steel or polymer shank for arch support and comfort. Other boots are designed with flat soles to facilitate footlocking.

Regulations requiring the use of gloves in tree care operations vary. Some regulations require gloves for tree workers. However, ANSI Z133.1 does not make that requirement. Gloves are strongly recommended for certain operations, such as sharpening saw chains and chipping brush. Workers must not wear gauntlet-type gloves while chipping brush because these gloves may get caught up in the brush. If gloves are to be worn when climbing trees, they should be a type that provides a good grip to prevent the climber's hands from slipping.

Good Communication

Good communication among workers is an integral part of working safely. Workers must coordinate operations on the ground and aloft in the trees, and there is

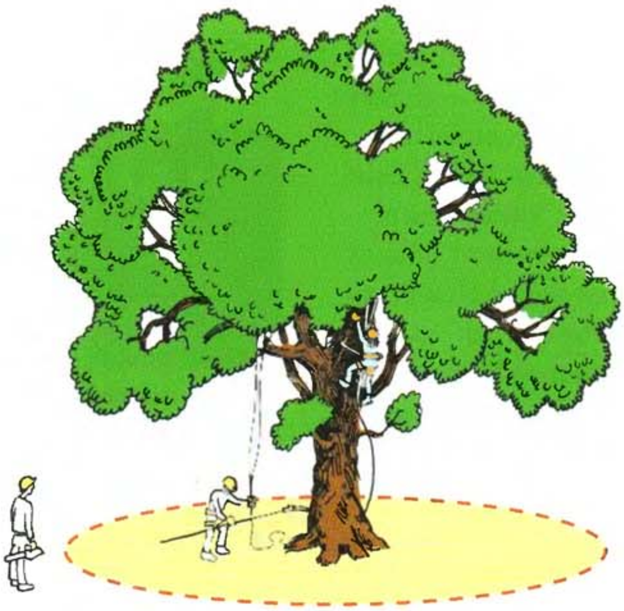


FIGURE 2.8 **Good communication among workers is absolutely essential in tree work.**

little margin for error. Each worker on the crew must always be aware of what the others are doing, and each must take measures to prevent accidents.

There must be a clear and efficient means of communication between climbers and ground workers so that each knows when it is safe for a ground worker to enter the work zone, including the **landing zone**

FIGURE 2.9 **Workers must know when it is safe to enter a work zone. The voice command-and-response system is a good way to maintain safety.**

or **drop zone**, where branches are being dropped or lowered to the ground.

The voice **command-and-response system** ensures that warning signals are heard, acknowledged, and acted upon. The climber warns, "Stand clear," but does not proceed until hearing the acknowledgment, "All clear." When there are multiple workers on the job, reduce confusion by assigning one person to respond to the climber after ensuring that the area is clear and safe.

There are times when it may be difficult for workers to hear each other. In these cases, hand signals can be used as well.

Each job should begin with a job briefing, which coordinates the activities of every worker. The **job briefing** summarizes what has to be done and who will be doing each task, the potential hazards and how to prevent or minimize them, and what special PPE may be required. All workers must have a clear understanding of the communication system that will be used. The on-site supervisor should formulate and communicate the **work plan**. There should be no question about assignments so that the work is well coordinated. Teamwork is essential on a tree crew.

General Safety

General safety at the worksite begins with proper training. All workers must be adequately trained for their work requirements. Workers should be aware of all applicable safety regulations, and employers must ensure that all workers understand the safety requirements. Safe work procedures must be established. Employers must instruct their employees in the proper use of all equipment and require that all safe working practices be followed. It is very important for employers to document all training.

It is recommended, and required in some regions, that all tree workers receive training in **first aid** and **cardiopulmonary resuscitation (CPR)**. In addition, an approved and adequately stocked first-aid kit must be provided on each truck. All employees must be instructed in the use of first-aid kits and in emergency procedures. Emergency phone numbers should be posted in the truck.

FIGURE 2.10 **Every crew must carry an approved and adequately stocked first-aid kit.**

All crew members must be trained in **emergency response** procedures. Each individual must know what to do in an emergency situation. All climbers should be trained and capable of carrying out an **aerial rescue**. Whenever there is a climber in a tree, there should be a second worker on site who is capable of performing an aerial rescue if necessary. Many companies practice aerial rescue procedures on a regular basis. Practice will improve efficiency and skills and will reduce the chance of panic and a second accident in the event of an actual emergency.

FIGURE 2.11 **All tree workers should be instructed in the identification and treatment of poison ivy and other poisonous plants.**

All employees must be instructed in the identification of common poisonous plants, such as poison ivy, poison oak, and poison sumac. Training should include preventive measures as well as treatment following exposure. Workers must also be trained in techniques for dealing with stinging or biting

FIGURE 2.12 Gas must be dispensed into approved containers only.

insects and with vertebrates that could be encountered in trees.

Trucks should be equipped with a fire extinguisher, and all employees should be trained in its use. Gasoline-powered equipment must be refueled only after the engine has been stopped. Any spilled fuel should be removed before starting. Do not start or operate the equipment within 10 feet (3 meters) of the refueling site. Smoking must be prohibited when handling or working around any flammable liquid. Flammable liquids must be stored, handled, and dispensed from approved safety containers and kept separate from all ropes and equipment.

Gas cans must always be placed on the ground before they are filled; otherwise, static electricity can build and arc, starting a fire or explosion. Never fill gas cans in the back of pickup trucks or trunks of cars.

A very important safety consideration is traffic control. (Note: in the United States refer to the *Manual of Uniform Traffic Control Devices*). Effective means for control of pedestrian and vehicular traffic must be instituted on every job site. This may include safety cones, warning signs, barriers, and flags. It is the legal responsibility of work crews to "secure the work zone" to make sure that no individuals or vehicles pass under trees where tree work is in progress and to ensure the safety of the workers. Traffic control devices used in tree operations must conform to the applicable federal, state, or provincial regulations. Traffic control procedures must follow Department of Transportation standards and guidelines.

Electrical Hazards

Before performing tree work on any site, an inspection must be made to determine whether any electrical hazards exist. An electrical hazard exists when there is a risk of injury or death associated with direct or indirect contact with an electrical conductor. All tree workers should receive adequate and documented training in electrical hazard safety awareness. Workers must receive proper training in electrical hazard tree work procedures to perform tree work in proximity

FIGURE 2.13 Protecting vehicles and pedestrians is an important part of safety.

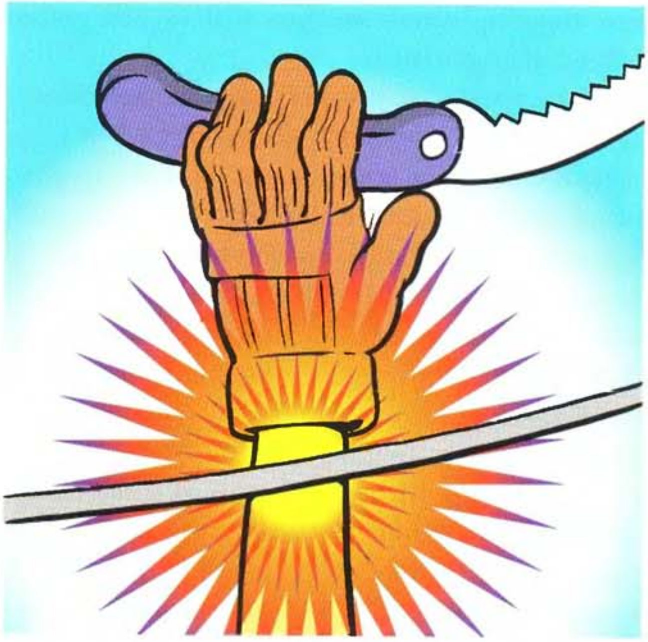


FIGURE 2.14 Direct contact with an energized conductor could be fatal.

to electrical conductors. Employers are required to certify this training.

An **electrical conductor** is defined as any overhead or underground electrical device, including communication wires and cables, power lines, and related components and facilities. All such lines and cables must be considered energized with potentially fatal voltages.

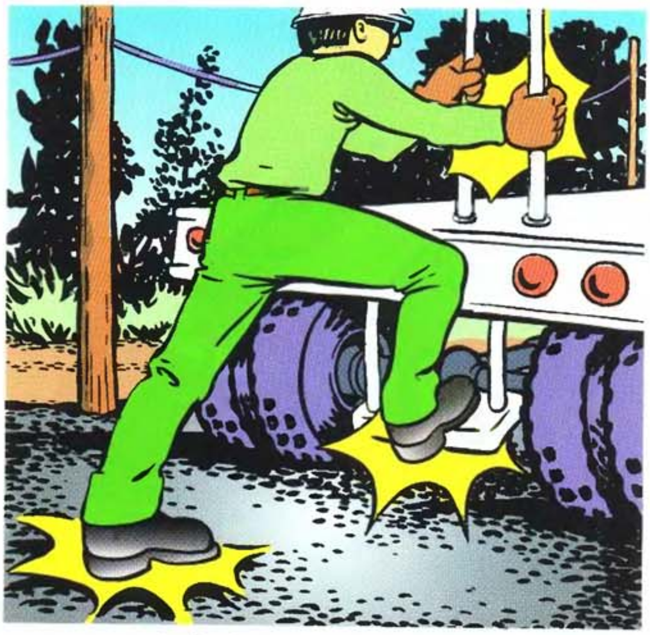


FIGURE 2.15 A climber can be electrocuted as a result of indirect contact with an energized conductor.

Every tree worker shall be instructed that a **direct contact** is made when any part of the body contacts an energized conductor or other energized electrical fixture or apparatus.

An **indirect contact** is made when any part of the body touches any conductive object in contact with an energized conductor. An indirect contact can be made through conductive tools, tree branches, trucks, equipment, or other conductive objects, or as a result of communication wires or cables, fences, or guy wires becoming energized.

Electric shock occurs when a tree worker, by either direct or indirect contact with an energized conductor, energized tree limb, tool, equipment, or other object, provides a path for the flow of electricity from a conductor to a grounded object or to the ground itself. Simultaneous contact with two energized conductors also causes electric shock that may result in serious or fatal injury.

Footwear, including those with electrical resistant soles and lineman's overshoes, shall not be considered as providing any measure of protection from electrical hazards. Rubber gloves, with or without leather or other protective covering, must not be considered as providing any measure of protection from electrical hazards.

Electrical tools (except those with a self-contained power source) must never be used in trees near an energized electrical conductor when there is a possibility of the power cord contacting the conductor. Tool operators must use tools in accordance with the manufacturers' instructions. When tools are used aloft, an independent line or lanyard should support the electrical tool. Operators should prevent cords from becoming entangled or coming in contact with water.

Chain-saw Safety

The chain saw has been ranked as one of the most hazardous pieces of equipment in the industry today. It is also one of the most commonly used. Using a chain saw to prune or remove a tree can greatly reduce the time and effort involved, but care must be taken to ensure the safety of the climber and the ground workers. Careless use of a chain saw in a tree can cause considerable damage to the tree and serious risk of injury to the workers. Safe operation on the ground and in the tree requires proper training and adherence to safety procedures.

Chain-saw operators must follow the manufacturer's operating and maintenance instructions. Personal protective equipment that must be worn by chain-saw operators includes a hard hat, work boots, eye protection, and hearing protection. Regulations vary in different countries regarding leg protection. In the United States, leg protection is required when operating a chain saw on the ground.

The operator must have a secure footing when starting a saw. Be sure the immediate area is clear of debris. Always engage the chain brake before starting a chain saw. Drop starting (the act of pushing the saw away from the body while simultaneously pulling the starter cord) is ***not*** the recommended method for starting a saw. Larger saws should be started on the ground, while firmly braced, with the chain brake engaged. The alternate method is to start the saw using the **leglock method**, with the saw braced behind the right knee.

The saw should be gripped with both hands. Never operate a chain saw on the ground or aloft in a tree with one hand. The upper handle should be gripped firmly with the thumb wrapped around the handle. When cutting on the ground, it is best to operate the saw to the right of the body with the left arm straight and the right arm bent. The back of the saw may be braced against the operator's right leg. Keeping the chain-saw engine close to the body increases control and reduces operator fatigue.

The chain brake must be engaged if the operator takes one hand off the running saw or when the operator takes more than two steps. If the operator is moving between cuts, the chain brake should be engaged and the operator's hand should be off the throttle lever. The engine must be stopped for all cleaning, refueling, and adjustments except where the manufacturer's procedures require otherwise.

The chain-saw operator must be aware of the presence and activity of other workers in the vicinity. Never approach a chain-saw operator from the rear.

FIGURE 2.16 Safe starting position.

FIGURE 2.17 The chain saw should be firmly gripped with both hands. Keeping the left arm straight helps to control the saw.

If two workers are operating saws simultaneously, they should be at least 10 feet apart.

Chain-saw operators should understand the **reactive forces** of the saw. When cutting with the bottom of the bar, the saw has a tendency to pull into the cut. When cutting with the top of the bar, the saw pushes back toward the operator.

A common cause of chain-saw injury is **kickback**. Kickback occurs when the upper portion of the tip of the guide bar **(kickback quadrant)** contacts a log or other object. Operators must always be aware of where the tip of the guide bar is and should prevent the upper quadrant of the guide-bar tip from coming in contact with objects. A firm grip should be maintained with the thumb wrapped around the forward handle. Kickback occurs at a speed many times faster than a human can react. The operator must be positioned such that the saw could not hit him or her if it were to kick back. Never operate a chain saw above shoulder level.

Climbers must take extra precautions when using a chain saw aloft in a tree. Only experienced climbers with proper chain-saw training should ever use a chain

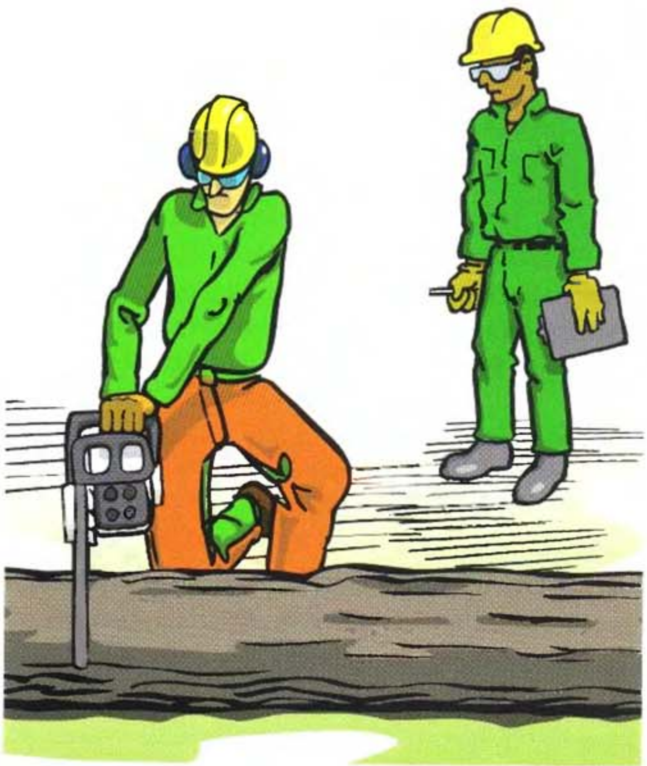


FIGURE 2.18 All workers should be trained in the safe operation of equipment.

FIGURE 2.19 Never operate a chain saw with one hand.

saw in a tree. The climber must use a second means of securing himself in the tree, such as a safety lanyard, before making a chain-saw cut. Stable footing and work positioning are important to maintain control. All chain-saw safety procedures apply, including the two-hand rule and avoiding making cuts above shoulder level. Chain saws weighing more than 15 pounds must be supported by a separate line unless no supporting limb is available.

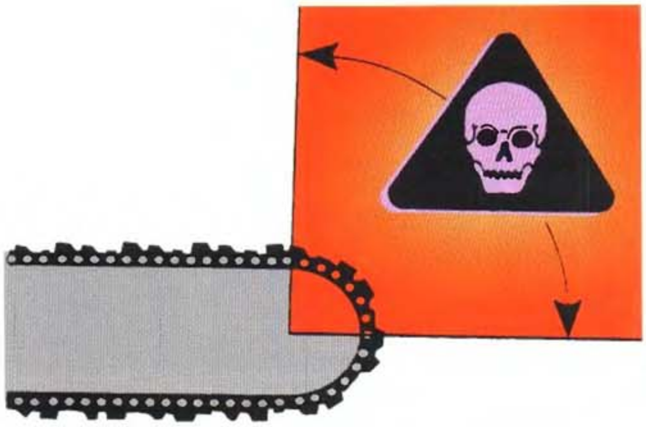


FIGURE 2.20 Avoid allowing the kickback zone of the bar to contact an object.

FIGURE 2.21 Kickback results when the upper tip of the guide bar contacts an object.

FIGURE 2.22 Care must be taken when cutting a limb under pressure.

FIGURE 2.23 When using a chain saw in a tree, climbers must be aware of the position of the climbing line and all other ropes to avoid accidental cutting.

Work positioning is an important safety consideration when using a chain saw in a tree. Climbers must be sure they are in a safe, stable position before cutting, usually above or to the side of the limb being cut. This means avoiding being in a position that could cause the climber to be injured in the follow-through from the cut or if the saw kicks back. Climbers must also be aware of the position of the climbing line, safety lanyard, and all other ropes to avoid accidental cutting. Finally, it is important to avoid being in a position of being struck by the limb that is cut.

The Role of the Ground Worker

No climber can be effective in a tree without the assistance of a good ground worker. Ground workers are an important part of any tree care operation; they set up friction devices, run lines, detach ropes, move wood and brush, and send equipment and lines up to the climber. As mentioned earlier, good communication between the climber and ground workers is essential.

In pruning and removal work with a climber in the tree, operation of the lines is one of the most important roles of a ground worker in supporting the climber. A good ground worker knows which ropes to use for various purposes and knows how to tie all of the basic knots. The ability to operate the lines safely and efficiently is critical to the safety of all present. Often ground workers must take wraps in a rigging line, either on the trunk of a tree or on a friction device. These wraps add friction back into the system for controlled lowering. The ground worker must stay outside the rigging; that is, stand where there is no chance of becoming entangled in running lines or of being hit by moving pieces. It is also important for the ground worker to avoid wrapping a line around any part of the body and to avoid standing where he or she could be entangled in running lines.

It is common sense not to stand under the piece being lowered, but that is not enough. All workers must consider what would happen if any element of the rigging system failed. This means staying "outside" of the rigging so that, if a rope snaps or a piece of equipment breaks, nobody will be struck.

Once a piece is cut and begins to fall, it will create a dynamic load on the rigging line. A skillful ground worker can minimize this effect by gradually letting out more rigging line into the system—letting it run—before bringing the piece to a stop. Of course, this technique can be used only if the situation allows for the piece to be lowered in this manner.

Ground workers must keep the lines clear and never stand on a rope or in a position where the rope feeds from behind. The climber's line should be kept clear from being tangled in rigging lines or limbs on the ground. Rope bags are a big help in keeping the lines clear and clean. Workers should always wear gloves when running rigging lines.

In addition to sending up equipment and running and returning the lines, ground workers can assist the climber in judging distances and selecting methods. Climbers and ground workers function most safely and efficiently when they learn to work as a team.

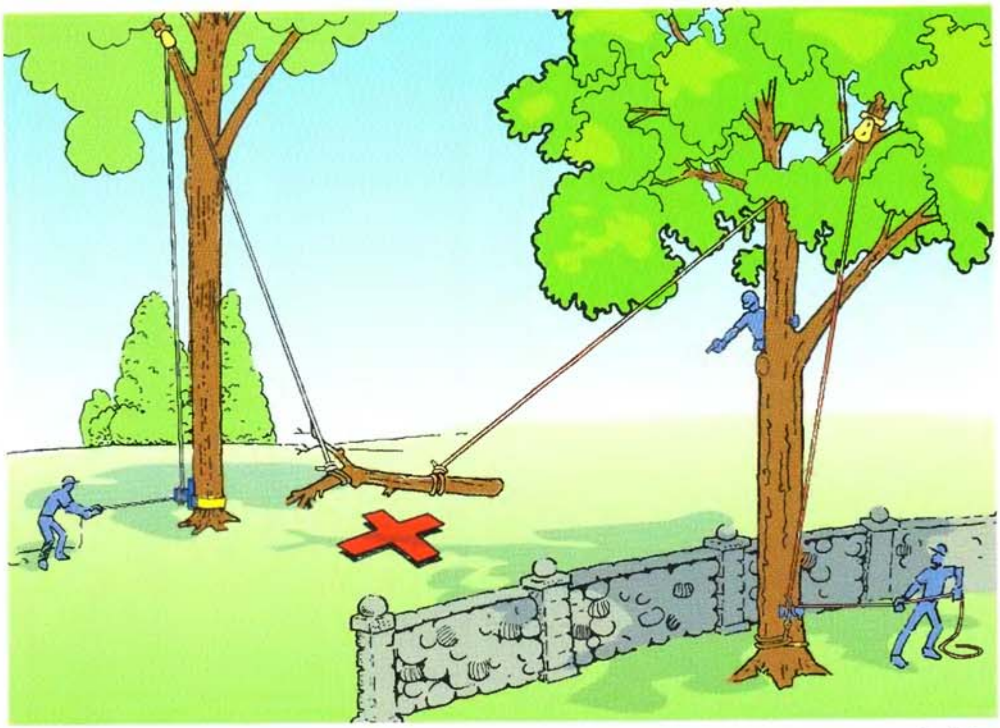


FIGURE 2.24 The ability of the ground worker to operate the lines safely and efficiently is critical to the safety of all present.

Chipper Safety

Brush chippers can be very dangerous machines, and proper training and safe work practices are essential when operating them. Training should include instruction on daily inspection and maintenance, towing procedures, starting the chipper, feeding brush, and the potential safety hazards involved with operation. All instructional and warning stickers and labels on the chipper must be in place and legible.

Proper PPE is required, and loose clothing, jewelry, climbing saddles, harnesses or body belts, and gauntlet-type gloves must not be worn while operating chippers because they could be caught on brush and could pull the operator into the chipper.

Brush should always be fed from the side, and the worker feeding the brush should move away after the brush is fed. The larger butt end of each branch should be fed in first. Smaller limbs should be pushed into the chipper with larger limbs. No part of the operator's body should ever reach beyond the back edge of the infeed chute. The operator should be careful to avoid placing foreign material, such as rocks, wires, or other debris, into the chipper because such material could damage the knives or cause projectiles to be thrown from the machine.

FIGURE 2.25 **Brush should always be fed from the side, and the worker feeding the brush should move away after the brush is fed. The larger butt end of each branch should be fed in first.**

Many accidents have occurred when workers attempted to perform maintenance while the chipper disk or drum was still moving. No person should ever work on a chipper unless the engine is turned off, the ignition key is removed, and the cutter wheel is completely stopped (with lock pin in place, if applicable) and prevented from moving.

Matching

_____ shall
_____ approved
_____ CPR
_____ direct contact
_____ should
_____ indirect contact
_____ ANSI Z133.1
_____ chaps

A. leg protection for chain-saw use
B. advisory recommendation
C. cardiopulmonary resuscitation
D. body touches energized conductor
E. safety standards for tree work
F. mandatory requirement
G. meets applicable safety standards
H. touching an object in contact with an energized conductor

True/False

1. T F OSHA (OHSA, in Canada) regulates industrial safety and health issues.
2. T F ANSI Z133.1 is the OSHA safety standard for tree trimming.
3. T F The ANSI standards were developed by the U.S. Department of Labor.
4. T F Head protection need only be worn while there are climbers in the trees.
5. T F Eye protection is a good idea but is not required for tree work.
6. T F Hearing protection may be in the form of earplugs or earmuff-type devices.
7. T F Workers must not wear gauntlet-type gloves while chipping brush.
8. T F Employers shall instruct their employees in the proper use of all equipment.
9. T F Carrying a first-aid kit on each truck is recommended but optional.
10. T F Equipment should not be started or operated within 10 feet of the refueling site.
11. T F All power and communications wires shall be considered charged with potentially fatal voltages.
12. T F Any tree workers who work in proximity to electrical conductors must receive approved training.
13. T F An electrical conductor is defined as any overhead or underground electrical device, including wires and cables, power lines, and other such facilities.
14. T F Rubber footwear and gloves provide absolute protection from electrical hazards.
15. T F Drop starting is the recommended method for starting a saw.
16. T F On the ground, both hands are required for chain-saw operation, but one hand can be used in the tree.
17. T F Chain-saw engines must be stopped for refueling.
18. T F Kickback can occur when the upper tip of the guide bar contacts an object.

19. T F A well-trained climber, in good condition, should be able to dodge the kickback of a chain saw.

20. T F Safety is the responsibility of all employees, from the ground worker to the company owner.

Sample Test Questions

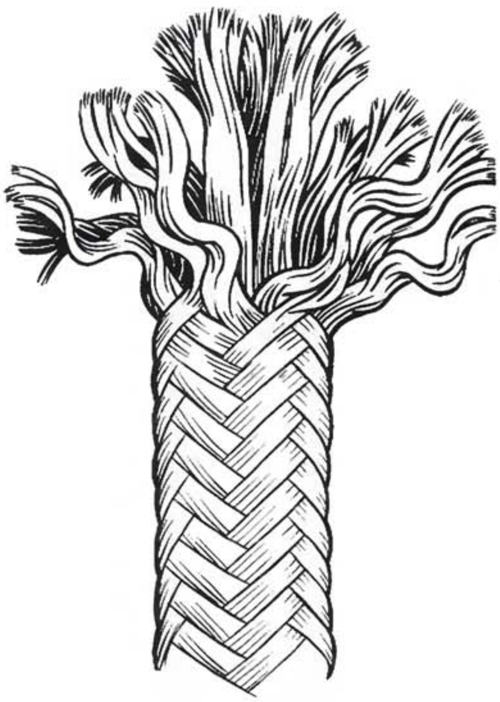
1. Which of the following should be considered energized with a potentially fatal voltage?
   a. overhead electric lines
   b. underground electric lines
   c. telephone and cable TV wires
   d. all of the above

2. Head protection is required for tree workers
   a. whenever performing tree care operations
   b. when specified by the supervisor
   c. whenever there are climbers working aloft
   d. only if chain saws or chippers are in use

3. The situation that can cause chain-saw kickback is
   a. failure to maintain adequate chain tension
   b. a worn sprocket or guide bar
   c. the upper tip of the guide bar contacting an object
   d. uneven sharpening of the chain-saw teeth

CHAPTER 3

Ropes and Knots



CHAPTER 3

Ropes and Knots

IMPORTANT TERMS

3-strand rope	standing part	climbing hitch	slip knot
kernmantle	bight	tautline hitch	sheet bend
16-strand rope	lead	friction hitch	double fisherman's knot
12-strand rope	fall	figure-8 knot	Prusik hitch
hollow braid	knot	Blake's hitch	cow hitch
24-strand rope	hitch	bowline	timber hitch
double braid	bend	running bowline	
working end	endline knot	clove hitch	
running end	carabiner	clove + half hitches	

Ropes Used in Tree Care

Rope may be considered the arborist's most important tool. The characteristics of a rope (strength, stretch, durability, etc.) are the result of the materials and techniques used to make it. To date, polyester is the material most widely used by arborists, and most commercially available climbing and rigging lines are made from this fiber. Nylon has high strength, stretch, and energy absorption but tends to lose strength when wet. Natural fibers are not generally as strong as the new, synthetic fibers and can rot over time. Newer fibers such as Kevlar show some promise but have not been widely developed for arborist rigging applications.

Many types of ropes are used in arborist climbing and rigging. **3-strand rope** has relatively low strength and high elongation and is relatively inexpensive. It is appropriate to run through natural crotches for climbing or rigging, but it also runs well through a false crotch. A major drawback to 3-strand rope is the twisting, or hockling, that occurs as the line is used.

FIGURE 3.1 3-strand rope.

Kernmantle ropes are those with a core and a cover. Most of the lines typically called kernmantle, however, are dynamic, rock-climbing lines. They are designed for the core to bear most of the load and the cover to serve primarily as a protective sheath.

16-strand braided arborist lines have relatively large cover strands for strength and abrasion resistance and a parallel core to keep the rope round and firm under load. In this construction, the core does not carry the load. **16-strand ropes** are the most commonly used ropes for climbing.

FIGURE 3.2 16-strand rope.

FIGURE 3.3 12-strand rope.

FIGURE 3.4 Double-braid rope.

12-strand rope is braided rope, usually without a core. Tightly woven, solid-braid, polyester-blend 12-strand lines are a popular choice for climbing and natural-crotch rigging. Loosely woven, **hollow-braid**, polyester, 12-strand rope is often used for rigging slings but would not be appropriate as a climbing or a rigging line. The number and diameter of the strands compared to the diameter of the rope determine whether the lines can be spliced. They also determine abrasion resistance and whether the rope remains round.

24-strand rope is a relative newcomer to the arboriculture industry. Like 16-strand lines, they have a core and cover, and they are primarily designated as climbing lines.

Double-braid lines are just that: a rope inside a rope. The core and cover are balanced and share the load almost equally. For this reason, they are not recommended for natural-crotch rigging, in which the friction of the cover with the tree causes an imbalance in the load taken by the core and cover braids. It is an exceptionally strong and low-stretch line but should be run only over the smooth sheaves of a block or pulley or the bollard of a friction device.

Knots

All tree workers should be familiar with the knots used in tree work. A climber should know how to tie and untie each of these knots.

A rope has a **working end** and a **running end**, or the ends in use and not in use, respectively. Anything not in use in between is the **standing part**. The illustration also shows examples of a **bight**, loop, turn, round turn, and the **lead** and **fall** of a line in use.

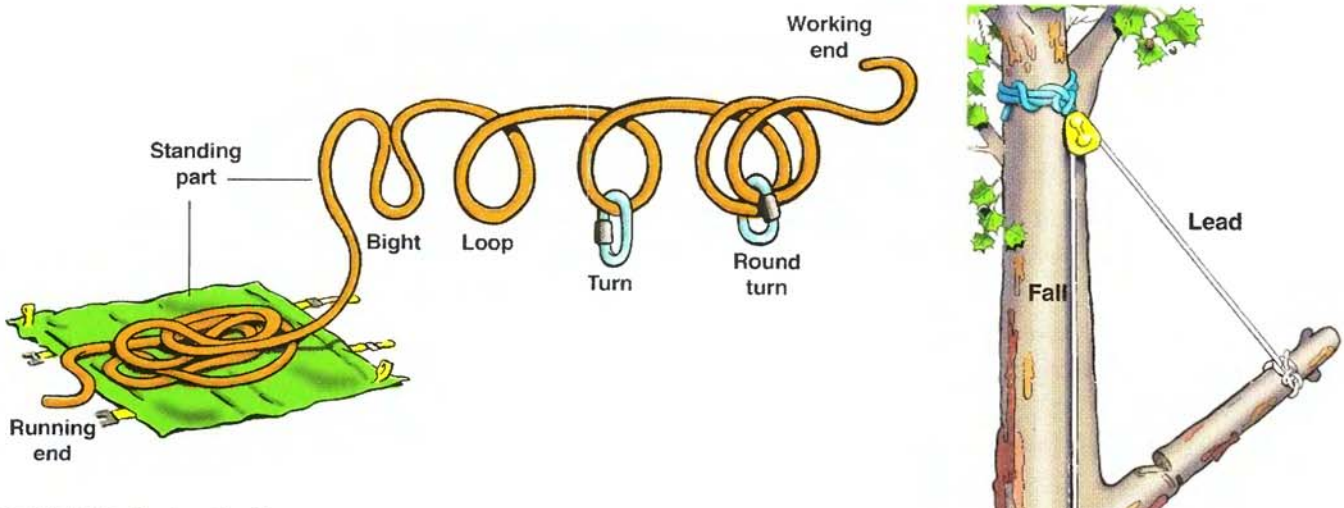


FIGURE 3.5 Parts of a line.

Part of knowing how to tie a knot is knowing how to "dress" and "set" the knot properly. To tie a knot, one must first correctly form the knot in the rope. The dressing of the knot is the aligning of the parts; setting it tightens the knot in place. A climber must know how each of the common knots is used and the advantages and disadvantages of each.

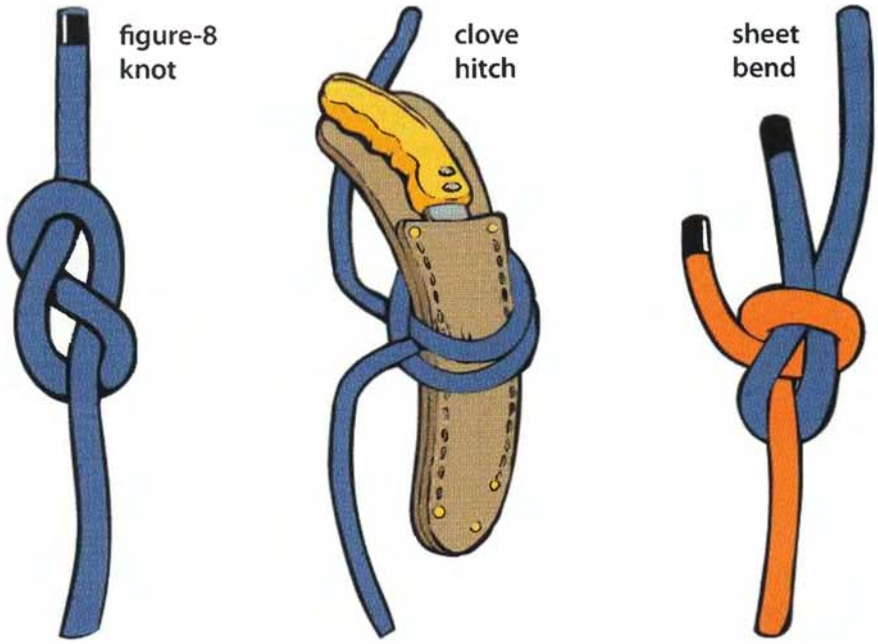


FIGURE 3.6 Knot, hitch, and bend.

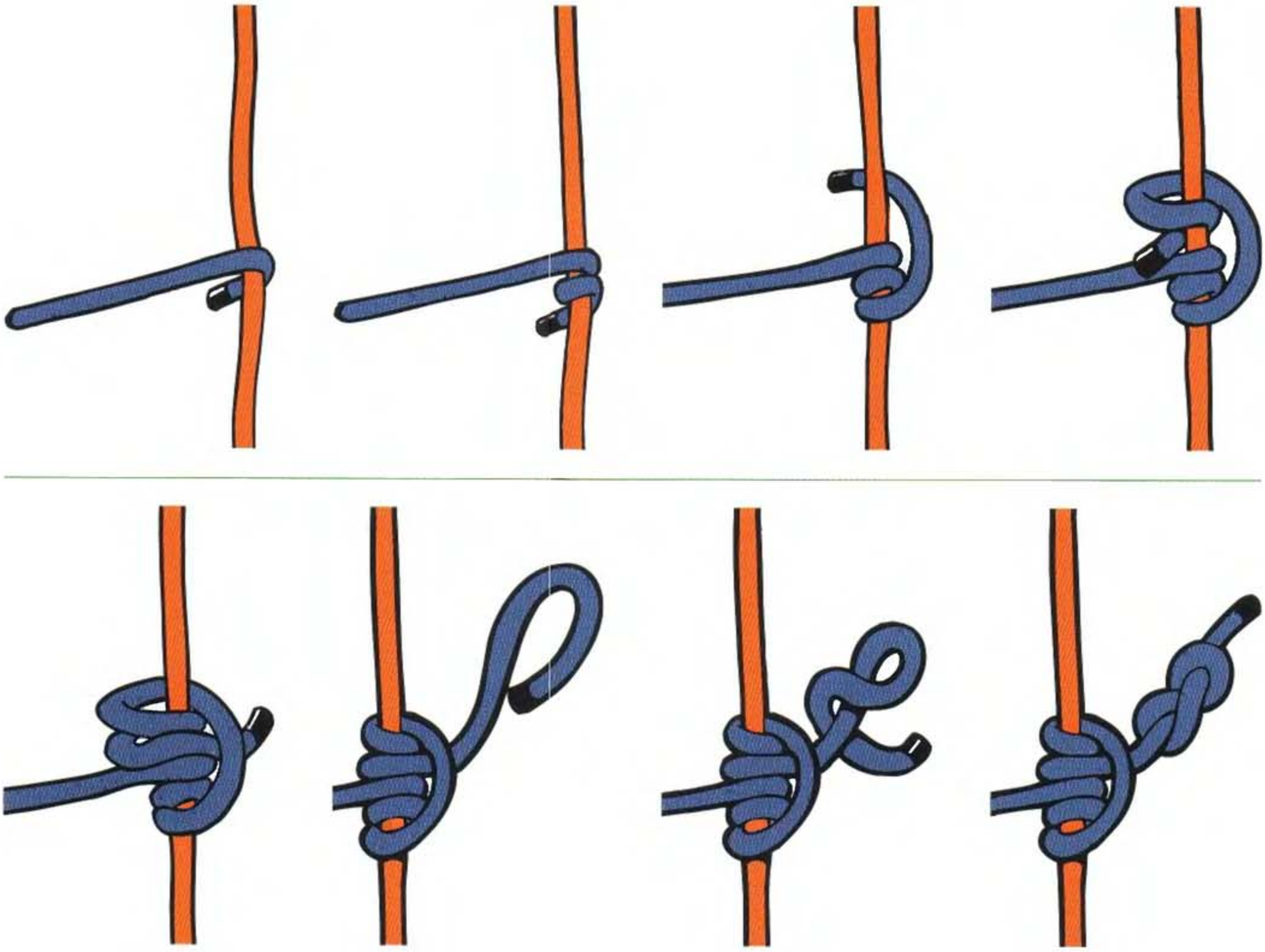
"**Knot**" is the general term given for all knots, hitches, and bends. A **hitch** is a type of knot used to secure a rope to an object, another rope, or the standing part of the same rope. A **bend** joins two rope ends together. There are several categories of knots, hitches, and bends. Tree climbers use **endline knots**, hitches, and bends to secure the climbing line to **carabiners** or rope snaps. Endline knots are also used to tie off branches being rigged.

A type of knot important in tree climbing is the **climbing hitch**. Climbing hitches are the "climbing knots" used by climbers to position themselves as they move and work in the tree.

Tautline Hitch

For years, the primary climbing hitch used by climbers in the United States has been the **tautline hitch.**

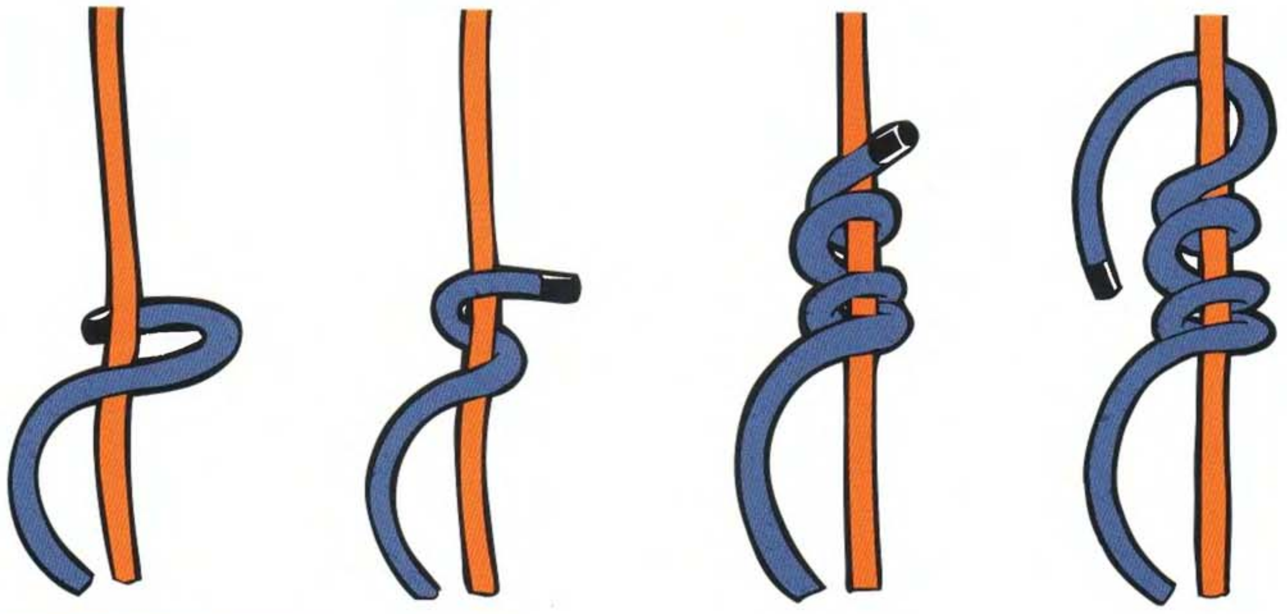
- Used as a climbing **(friction) hitch**
- Requires a stopper knot **(figure 8)**
- Has a tendency to roll out
- Must be adjusted (tended) frequently



Blake's Hitch

Blake's hitch is growing in popularity because it maintains more uniform friction and does not roll out.

- Climbing (friction) hitch, often preferred over the tautline
- Stays dressed and set, less need to tend
- Doesn't roll out (although a stopper knot is still recommended)
- Higher tendency to glaze on a long or rapid descent



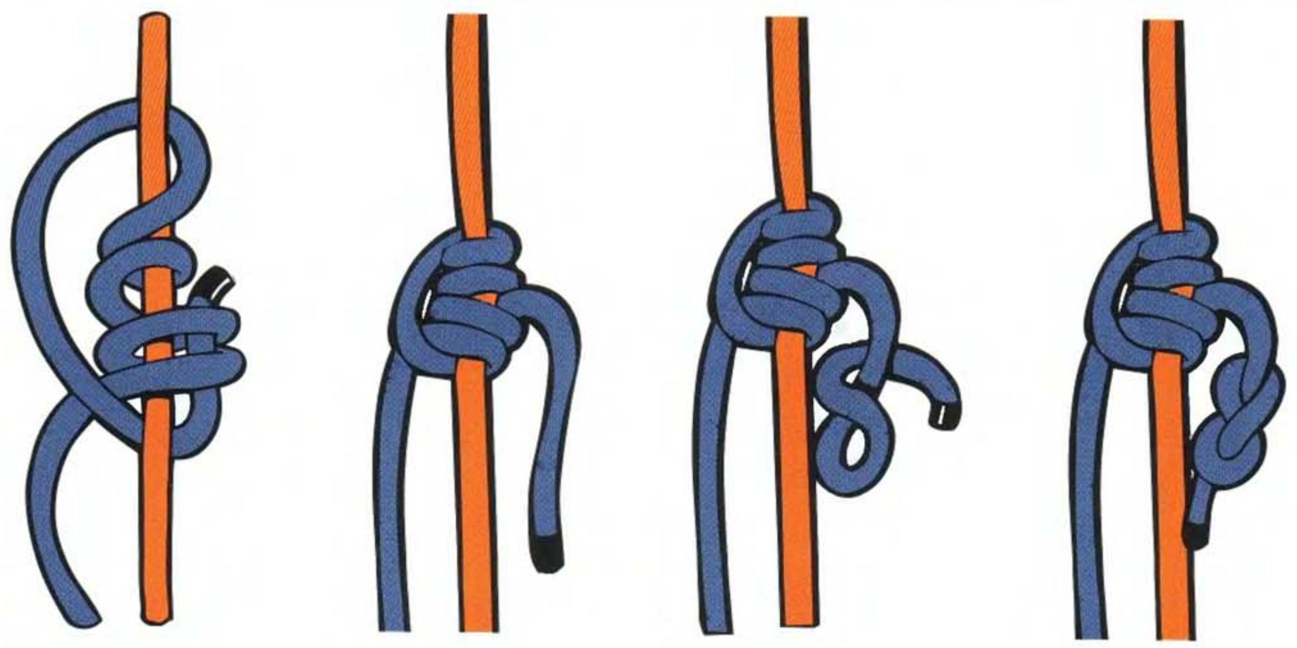
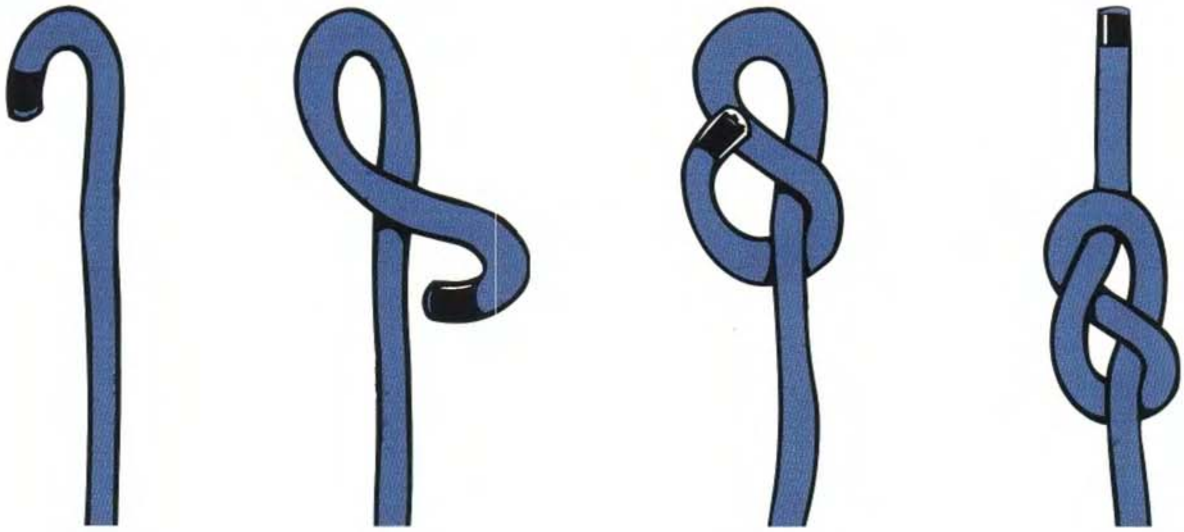


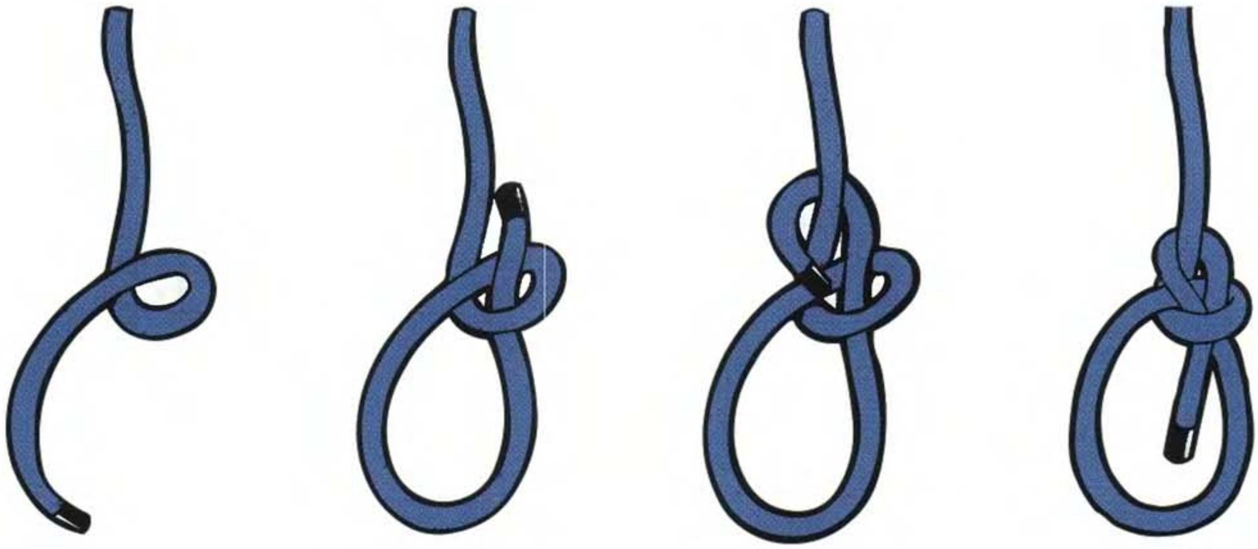
Figure-8 Knot

- Used as a stopper knot
- Fast and easy-to-tie endline knot



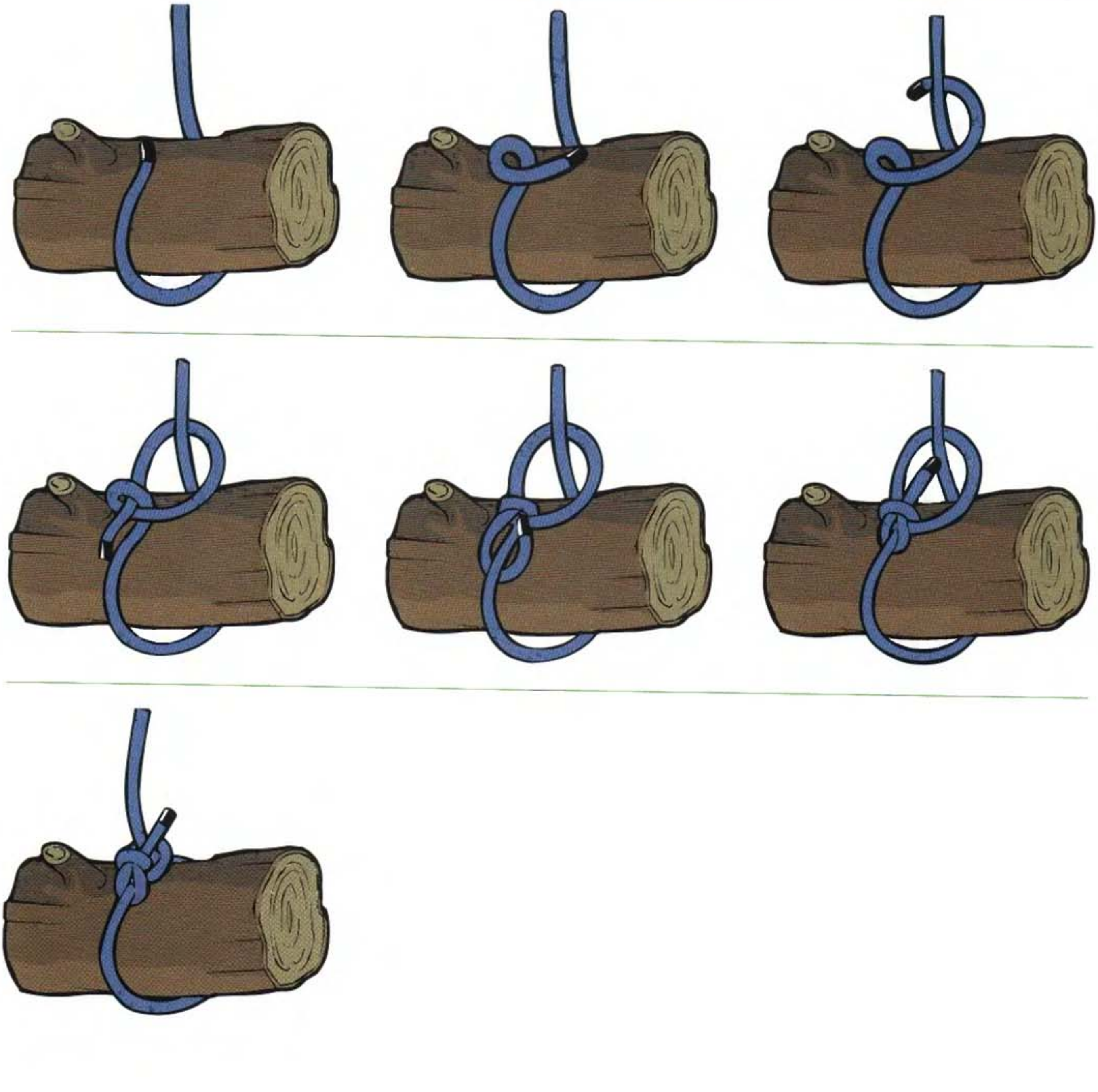
Bowline

- Strong knot for forming a loop
- Easy to untie, even after loading
- The basis for other knots in the "bowline family" (running bowline, bowline on a bight, sheet bend, double bowline)



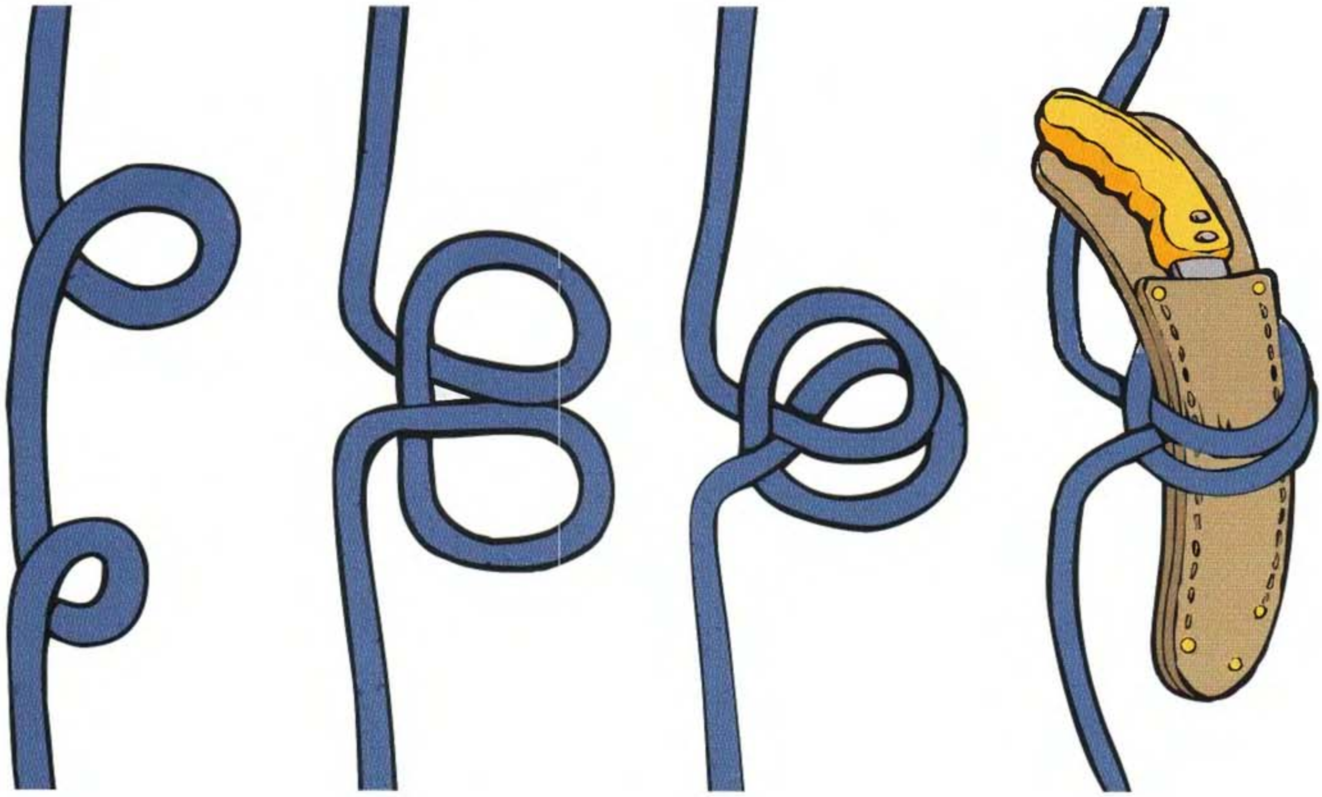
Running Bowline

- Often used in tying off limbs
- Functions as a slip knot; can be tied around something that is far away and "run up" the line
- Easy to untie after loading



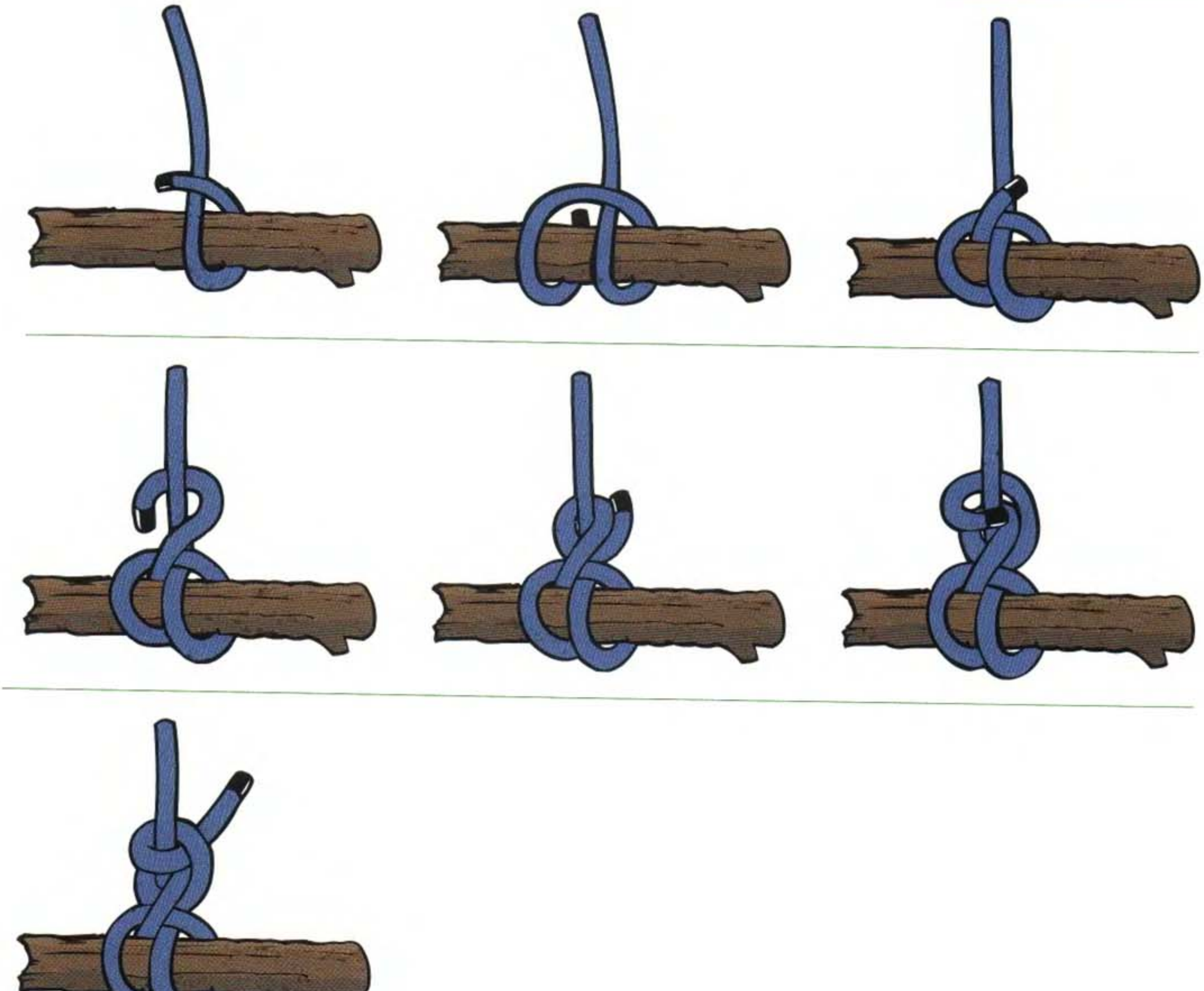
Midline Clove Hitch

- Used to send equipment up to the climber
- Quick to tie in the "bight" of a line



Endline Clove Hitch with Two Half Hitches

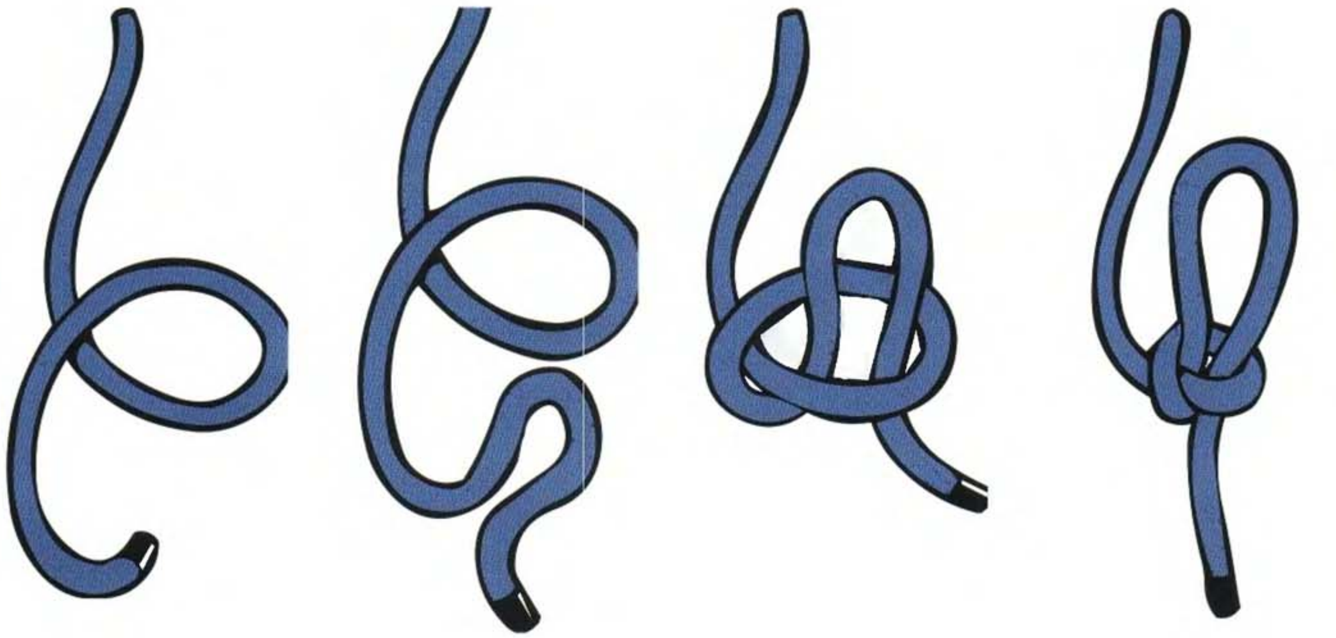
- Used (when backed up with at least two half hitches) to tie off limbs or sections of wood
- Quick and easy to tie

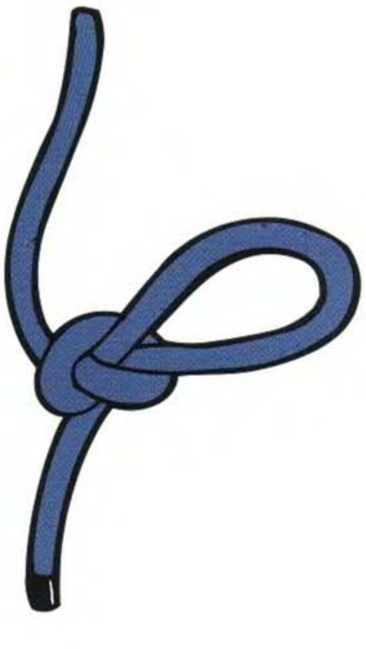


Slip Knot

Almost any knot can be "slipped." Typically this means the final tuck of the working end is replaced by tucking a bight instead so that the knot can be rapidly untied by pulling on the working end. The knot known as the slip knot is a slipped overhand knot. The bow with which we tie our shoes is a doubly slipped square knot.

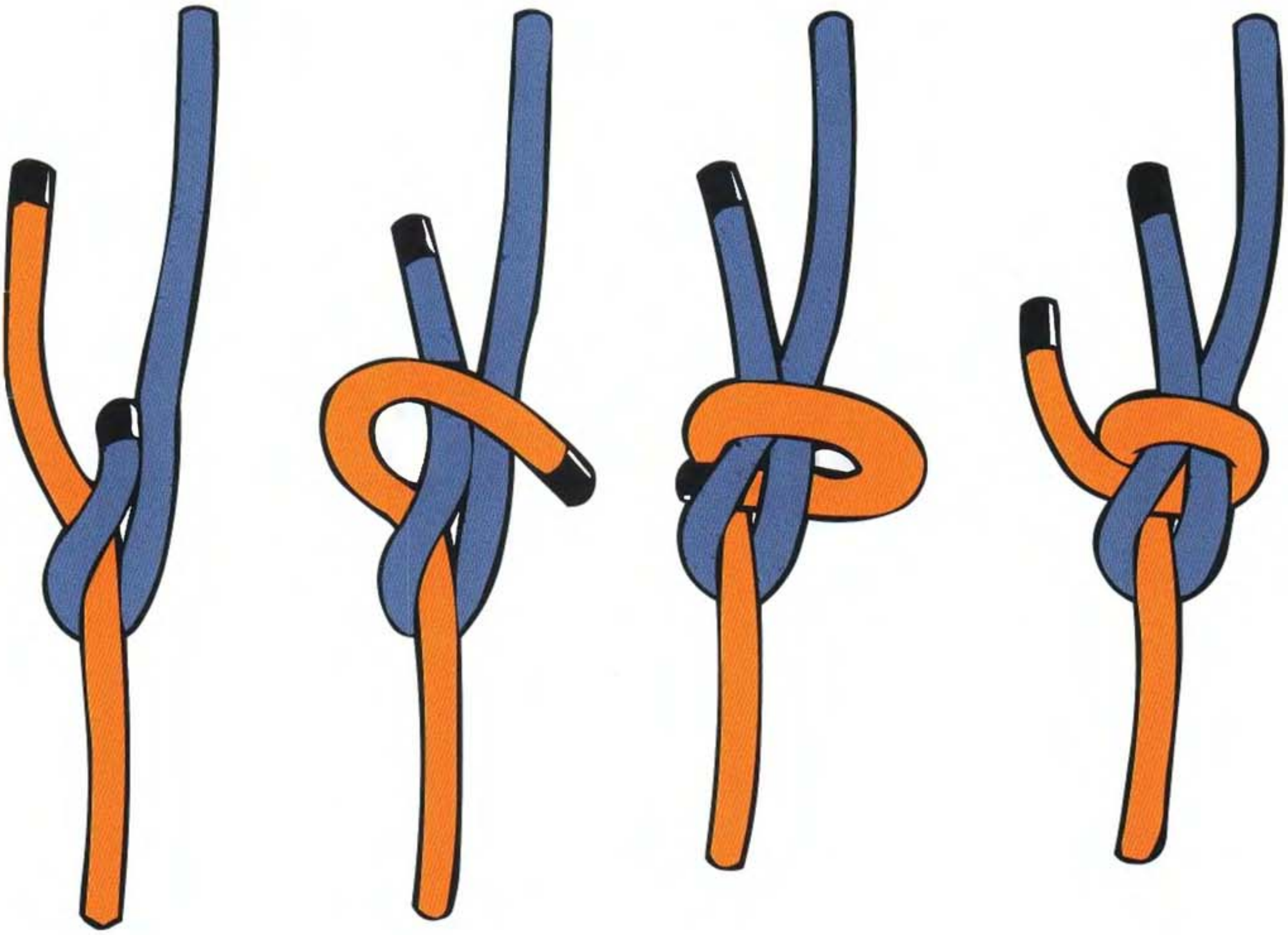
- Easy to tie, even with one hand
- Experienced climbers find many uses for this knot
- A directional knot—it tightens when loaded one way but spills when pulled from the other side





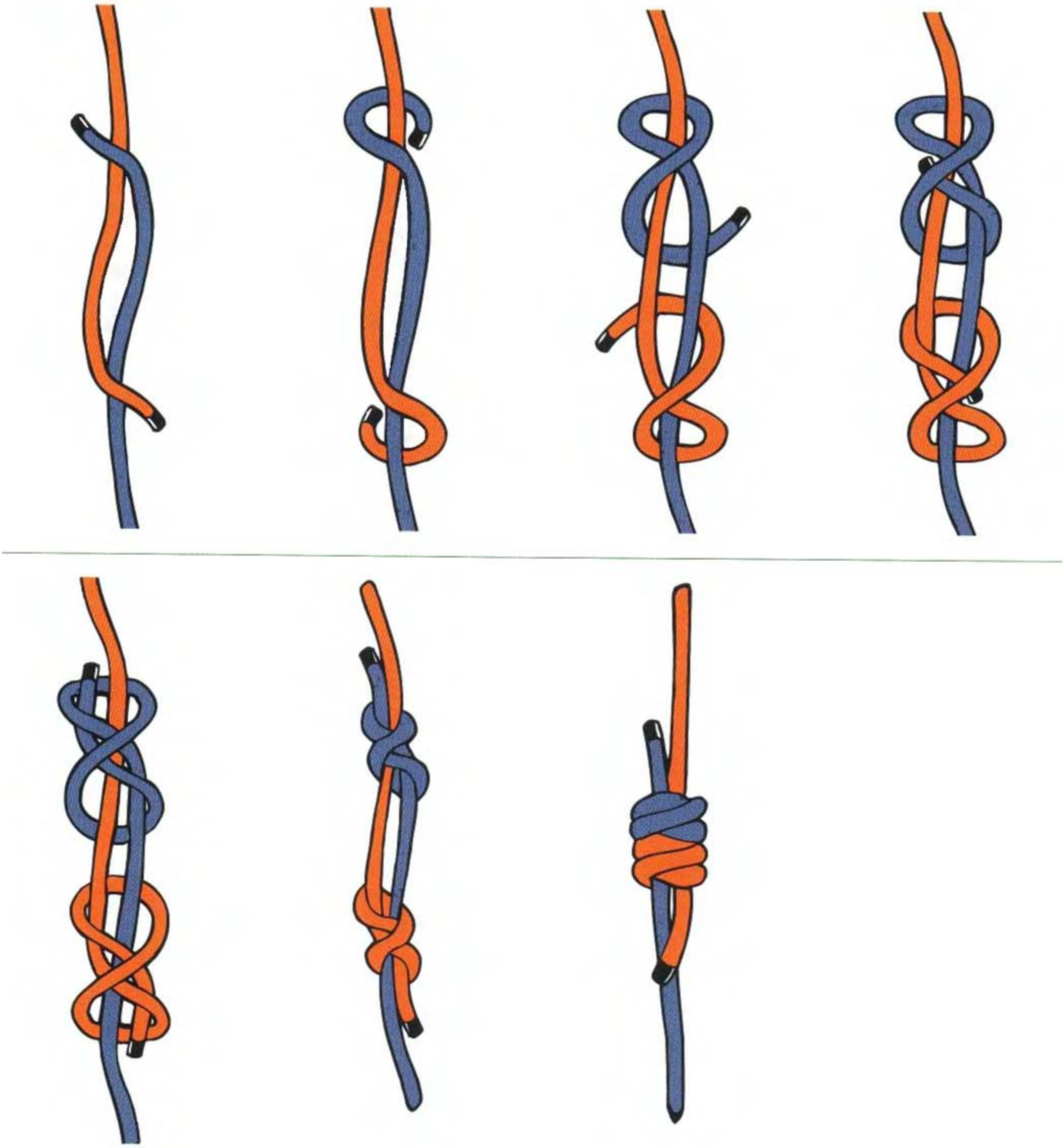
Sheet Bend

- Used to join two ropes of different diameters; often used to send a line up to the climber
- The smaller line should be the one tucked under its own standing part



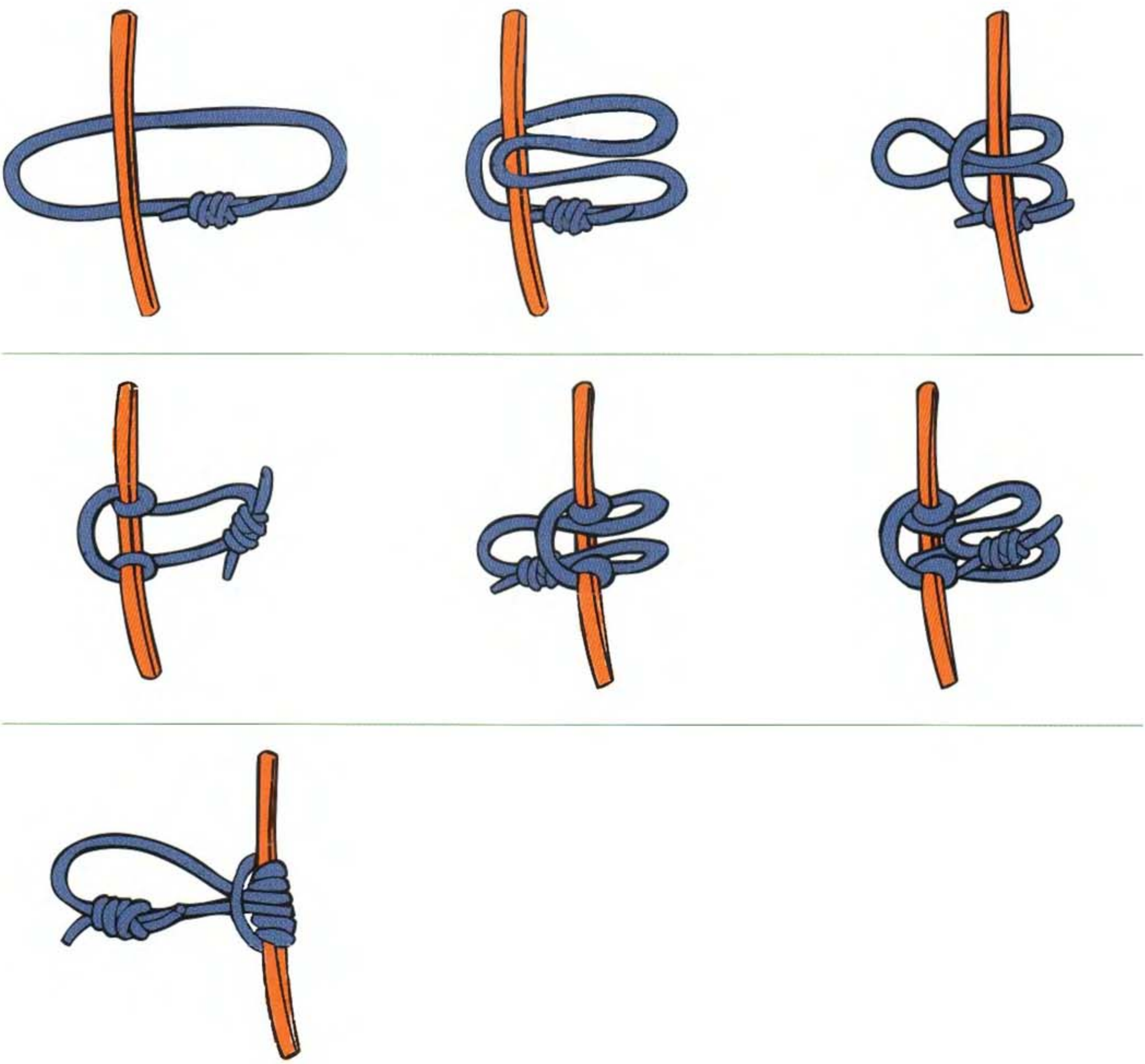
Double Fisherman's Knot

- Primary arborist use is to form a Prusik loop
- May be difficult to untie after it has been loaded



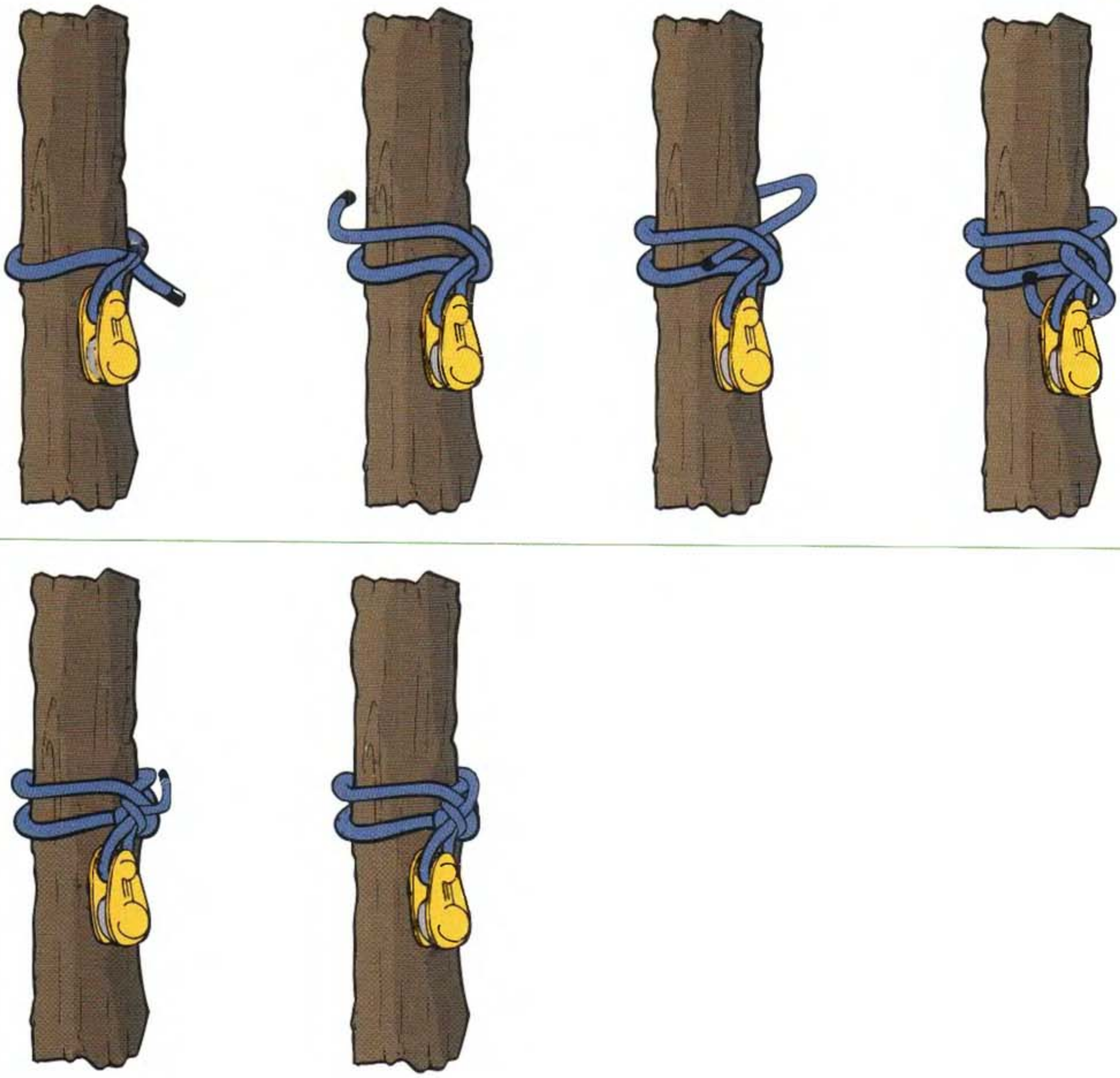
Prusik Hitch

- Friction hitch used in both climbing and rigging applications
- Bi-directional in some applications
- When used as a Prusik loop (as in the secured footlocking technique), a smaller-diameter rope is used to attach the Prusik to a working line. The type of rope affects how the knot will work



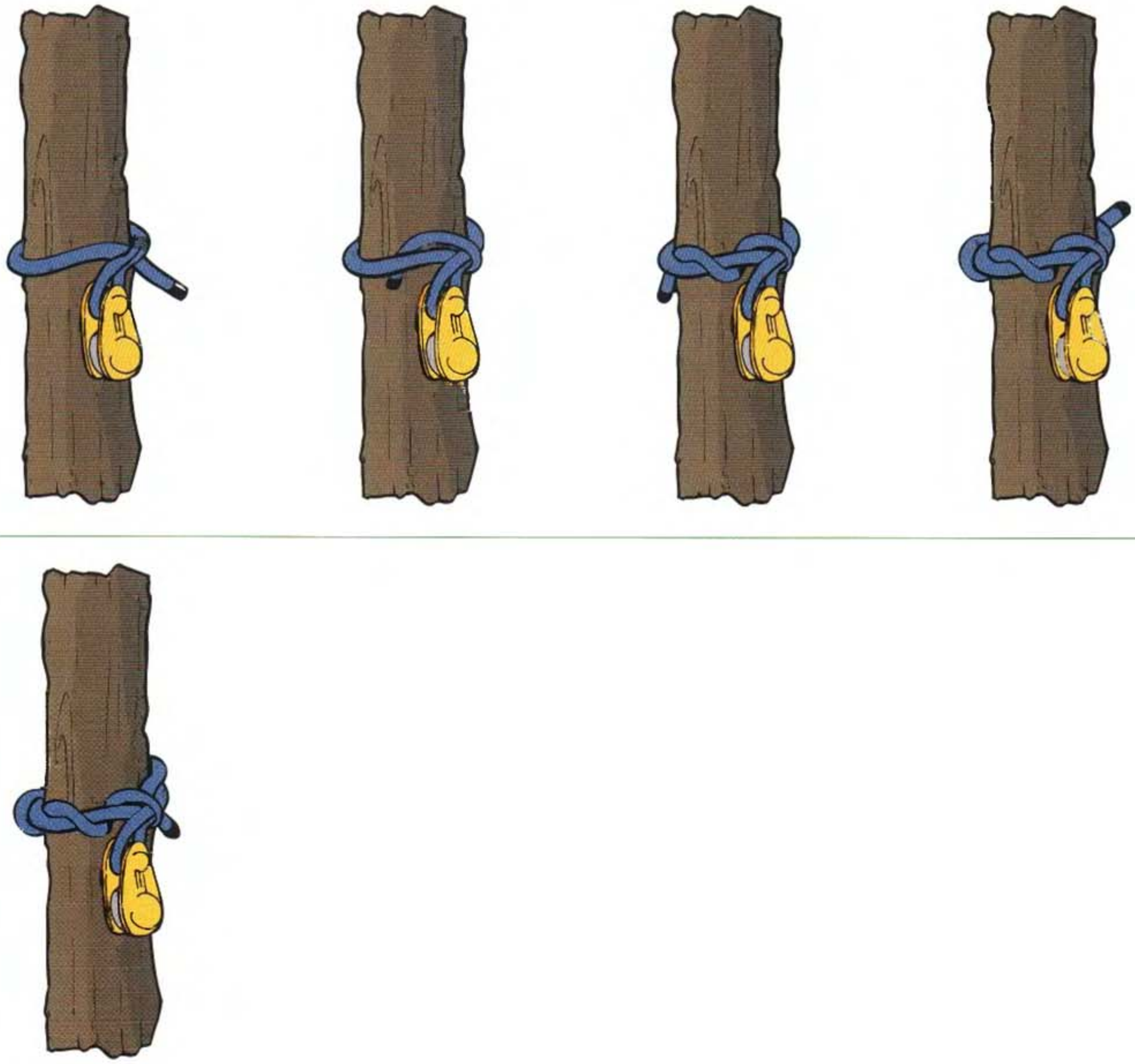
Cow Hitch with Half Hitch

- Tied with a sling and used for securing hardware to a tree
- Variation on a simple girth hitch but formed with a line instead of a loop



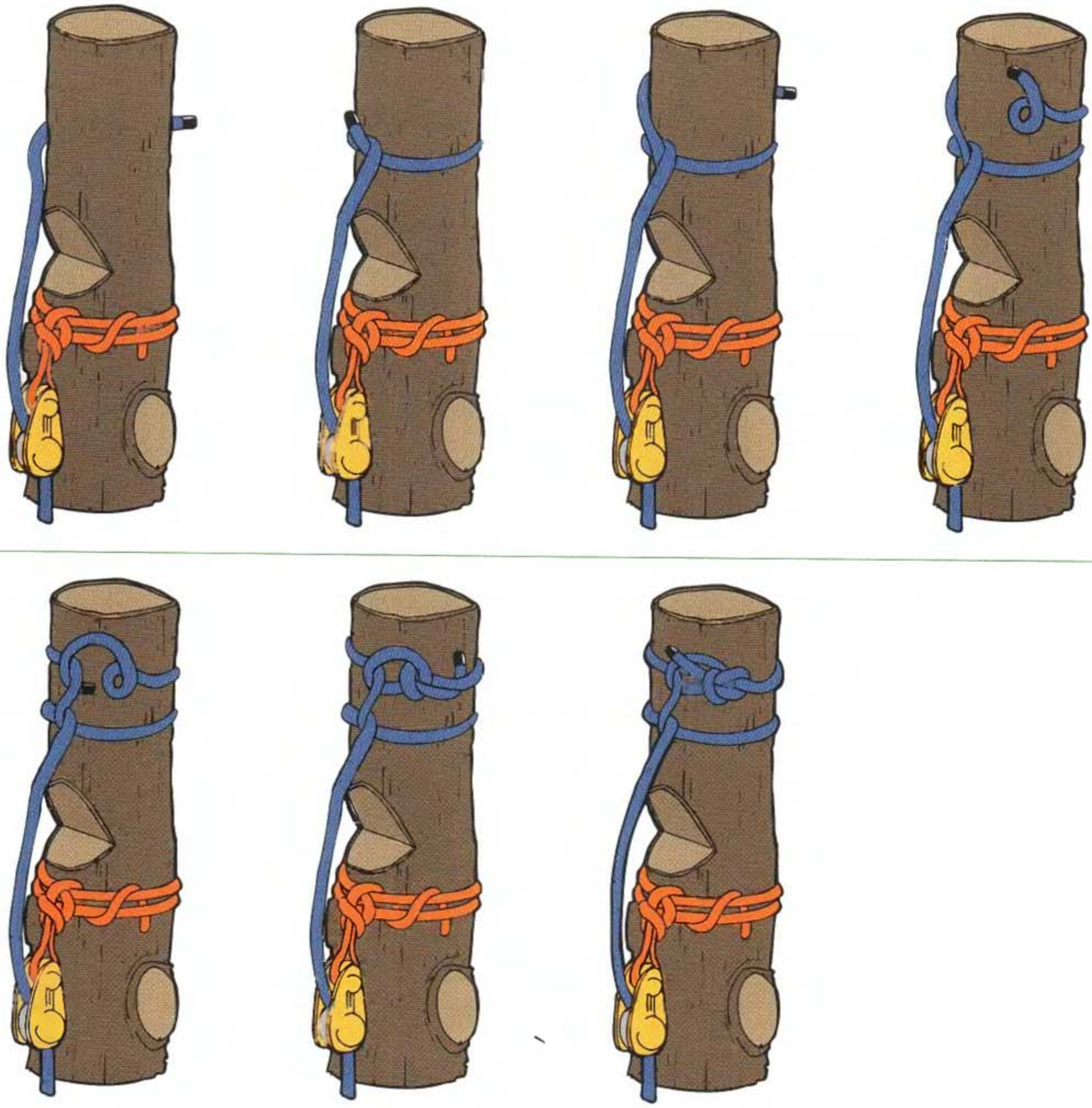
Timber Hitch

- Tied with a sling and used for securing hardware to a tree (especially on large trees when the rope sling is not long enough to tie a cow hitch)
- Always make at least five wraps, spread around the stem
- This hitch is most secure when tied on larger pieces and when the pull is always against the bight so that it tightens the hitch on the stem. The sling should never be loaded away from the bight because doing so could loosen it



Half Hitch and Running Bowline Tied for Butt-Hitching

- Used to tie off a section when butt-hitching or when there is no secure point for a running bowline alone
- The half hitch shares the load with the running bowline and reduces the chances of the knot slipping off the piece, once cut



Matching

_____ 16-strand rope	A. curve or arc in a rope
_____ working end	B. common climber's friction hitch
_____ double fisherman's knot	C. used to secure hardware to a tree
_____ cow hitch	D. core and cover share the load
_____ figure-8 knot	E. most commonly used for tree climbing
_____ double braid	F. the end of a rope in use
_____ Blake's hitch	G. used as a stopper knot
_____ bight	H. often used to form a Prusik loop

True/False

1. T F Polyester and polyester blends are the materials most commonly used for arborists' ropes.
2. T F 3-strand rope is known for its high strength, high price, and resistance to twisting and hockling.
3. T F Double-braid lines are recommended for natural-crotch rigging.
4. T F The standing part of a rope is between the working end and the running end.
5. T F "Knot" is the general term given for all knots, hitches, and bends.
6. T F A hitch is a type of knot used to secure a rope to an object, another rope, or the standing part of the same rope.
7. T F "Dressing" a knot aligns the parts; setting it tightens the knot in place.
8. T F For years, the primary climbing hitch used by climbers in the United States has been the running bowline.
9. T F One limitation of the Blake's hitch is a tendency to glaze on a long or rapid descent.
10. T F An advantage to using the running bowline to tie off limbs is that it is easy to untie after loading.
11. T F The figure-8 knot is a good example of a "slipped" knot.
12. T F A midline clove hitch is commonly used to send equipment up to a climber.
13. T F When using an endline clove hitch to tie off limbs, it should be backed up by at least two half hitches.
14. T F There are very few knots that can be "slipped."
15. T F The knot known as the slip knot is a slipped overhand knot.
16. T F The primary arborist purpose of a sheet bend is to form a Prusik loop.
17. T F When using a Prusik loop (as in the secured footlocking technique), a smaller-diameter rope is used to attach the Prusik to a working line.

18. T F When tying a timber hitch in a sling to attach hardware to a tree, you should always make at least five wraps and spread them around the stem.

19. T F A sheet bend is used to join two ropes of different diameters and is often used to send a line up to a climber.

20. T F Natural fibers are not generally as strong as the new, synthetic fibers and can rot over time.

Sample Test Questions

1. A type of knot used to secure a rope to an object, another rope, or the standing part of the same rope is
   a. bend
   b. bight
   c. hitch
   d. slip

2. A common, easy-to-untie knot for forming a loop is
   a. bowline
   b. clove hitch
   c. tautline hitch
   d. sheet bend

3. Which of the following is an advantage of the Blake's hitch over the tautline hitch?
   a. it stays dressed and set
   b. less need to tend
   c. it doesn't roll out (although a stopper knot is still recommended)
   d. all of the above

CHAPTER 4

Climbing

CHAPTER 4

Climbing

IMPORTANT TERMS

- personal protective equipment (PPE)
- climbing saddle
- snap
- climbing line
- lanyard
- carabiner
- positive-locking
- tensile strength
- work-positioning lanyard
- Prusik loop
- split-tail
- job briefing
- work plan
- conks
- fruiting bodies
- root crown
- trunk flare
- climbing spurs
- throwline
- shot pouch
- throwing knot
- body-thrust
- secured footlock
- D-ring
- micropulley
- footlocking
- locking snap
- pole saw
- pole pruner
- false crotch
- tautline hitch
- Blake's hitch
- figure-8 knot
- stopper knot
- double-crotch
- scabbard
- clove hitch
- emergency response
- aerial rescue
- rescue kit
- access line

Introduction

Tree climbing is a very physical and potentially hazardous profession. However, a well-trained worker who follows all established safety standards and procedures can work safely and efficiently in a tree. Before climbing a tree, a climber should first inspect all safety equipment. Then the tree itself should be inspected for hazards, and all workers must be made aware of any potential hazards. A good climber plans ahead where to tie in and how to work the tree. A little forethought saves energy and may prevent accidents.

Tree climbers must be familiar with and comply with all applicable safety standards, particularly the current version of ANSI Z133.1, in the United States.

This book is an educational tool for introductory arboriculture. It may be used as part of, but not as a replacement for, a comprehensive training program. While some equipment and techniques are explained and illustrated, actual use requires knowledge of and experience with the equipment and techniques prior to use in an actual work environment. The techniques depicted or described in this book must be analyzed, and at times modified, to meet the specific needs of the individual situation.

Familiarize yourself with local, state, provincial, national, and federal government standards applicable to the job assignment and requirements. Utilize the many training tools available through the International Society of Arboriculture.

Inspection of Gear

A tree climber's safety depends on the reliability of the safety gear. A worker's safety gear is called **personal protective equipment (PPE).** This equipment includes

FIGURE 4.1 This butt-strap-style saddle has leg straps and double front D-rings, as well as two side D-rings.

a hard hat, safety glasses or goggles, hearing protection, and chain-saw protective clothing. Approved head and eye protection are to be worn at all times by workers engaged in tree care operations.

All equipment used by tree workers, including climbing gear and tools, must conform to applicable safety standards and should not be altered. Equipment should be inspected according to manufacturers' guidelines. **Climbing saddles** should be checked for excessive wear and to see that stitching and rivets are strong and intact.

Snaps used in securing the **climbing line** or **lanyard** must be self-closing and locking. **Carabiners** used for climbing must be self-closing and **positive-locking**. Both must have a minimum **tensile strength** of 5,000 pounds (23 kN). Snaps and carabiners should be checked before and during use to see that they are functioning properly. If carabiners are used, they must be loaded only along their major axes.

Climbing lines must be identified by the manufacturer as suitable for tree climbing with adequate strength, wear, and stretch characteristics. ANSI standards in the United States require climbing lines to be ½ inch in diameter (with some exceptions), constructed of synthetic materials, and have a minimum tensile strength when new of at least 5,400 pounds.

Climbing lines should be inspected before each use. Check for cuts, puffs, abrasions, changes in diameter, discoloration, and glazing of the fibers. Be sure that rope ends are sealed by taping or whipping.

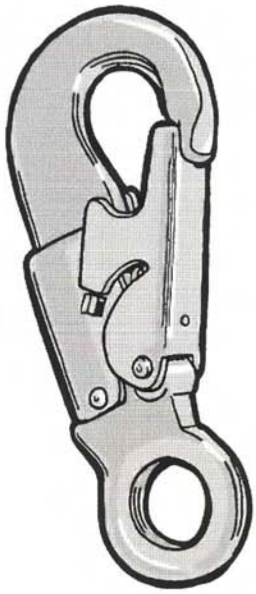


FIGURE 4.3 Snaps used on climbing ropes and safety lanyards must be of the locking type.

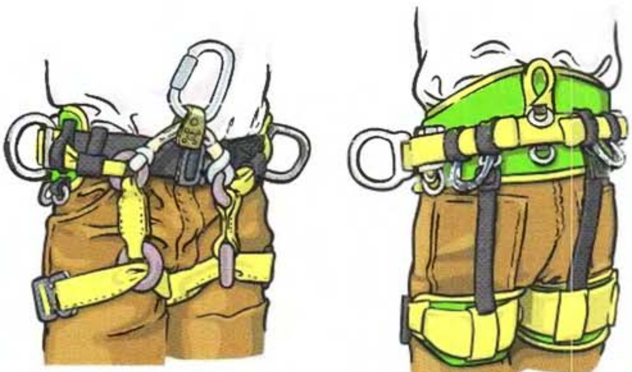


FIGURE 4.2 This leg-strap saddle is fitted with a floating attachment point in the front and two fixed D-rings on the sides.

FIGURE 4.4 Climbers should always inspect their climbing line before each use. Retire ropes with excessive wear or cuts.

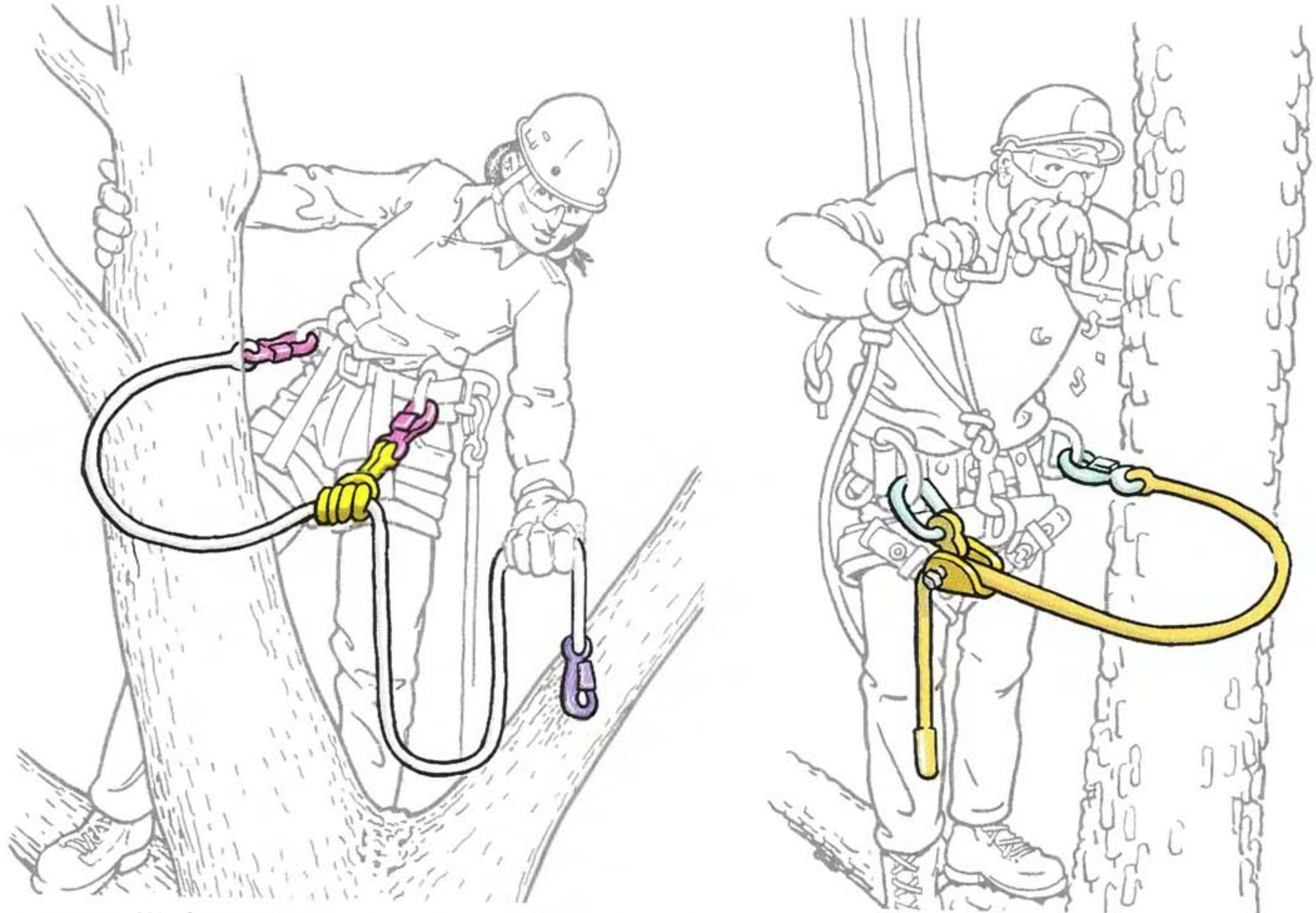


FIGURE 4.5 Work-positioning lanyards come in a variety of types. The two-in-one Prusik lanyard on the left allows the climber to move the lanyard while remaining secured.

Snaps should be routinely moved to the opposite end of the line so that the line wears evenly. If one end of the climbing line shows signs of excessive wear, it can be cut off. Climbers should be diligent in inspecting for wear on eye-spliced lines. Old, worn, or cut ropes must be retired from use.

Work-positioning lanyards must also be inspected carefully before each climb. They must meet strength requirements for ropes and snaps. Look for abrasions, excessive wear, or faulty snaps.

Prusik loops and **split-tails** used in a climbing system must meet the minimum strength standards for climbing lines.

All equipment used by tree workers must conform to employer safety requirements and the applicable American National Standards Institute (ANSI) standards for tree workers or equivalent standards within the jurisdiction (OHSA, CSA in Canada).

All equipment should be inspected according to applicable ANSI guidelines and manufacturers' recommendations.

Inspection of the Tree and Site

Every job must begin with a **job briefing** that covers the **work plan**, potential hazards, and all required gear and procedures. Before climbing a tree, a climber must always look carefully and locate any electrical conductors or utility lines. Check for hazards, such as dead or broken limbs, cracks, insects or other animals, weak branch unions, or signs of decay such as **conks** or **fruiting bodies**.

Always check the **root crown (trunk flare)** of a tree as well. Soil, bark, or vines may hide signs or symptoms of decay. Severe crown rot may cause the tree to fall over.

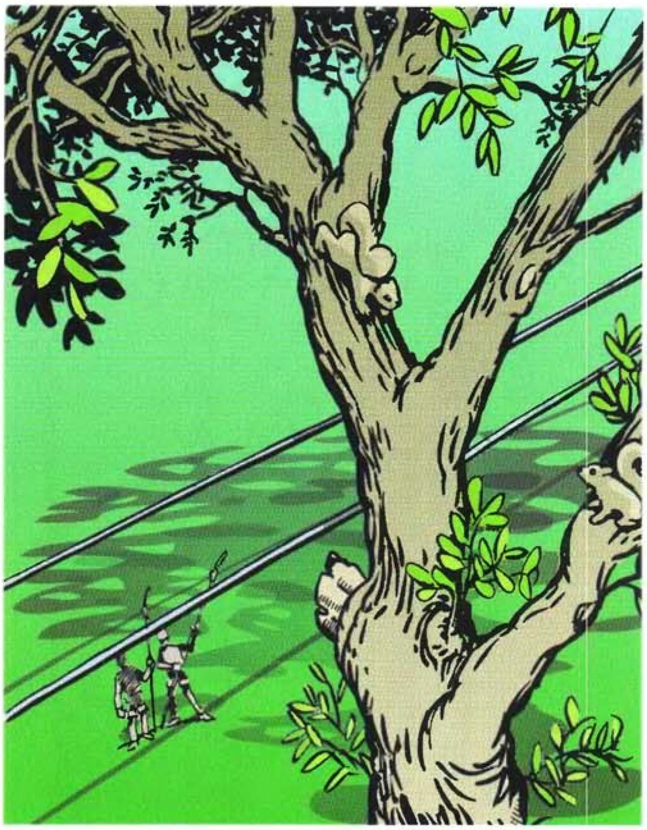


FIGURE 4.6 Identify any electrical hazards before beginning work. Climbers must have appropriate training to work near conductors.

FIGURE 4.7 Climbers must always inspect the tree and root crown for hazards before climbing.

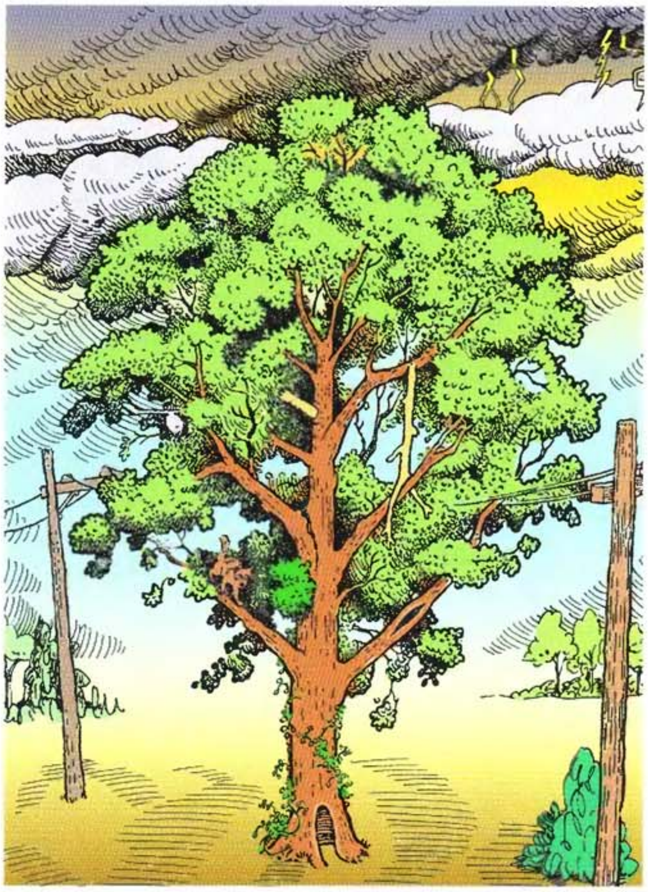


FIGURE 4.8 Any tree can pose a variety of hazards to the tree crew. How many can you find in this picture?

A pre-climb inspection should also be used to plan how the tree will be climbed. It is usually a good idea to plan the climbing route while you are still on the ground and to choose a safe tie-in point from which the tree can be accessed. An experienced climber will also become familiar with the characteristics of various trees. It is essential to know how strong or brittle a tree's wood is.

Ascent

When the tree, site, and climbing gear have been inspected and deemed to be safe, the climber can plan a climbing strategy. There are many ways of getting into and ascending a tree. The climber can use the climbing line, a ladder, or **climbing spurs** (if the tree is to be removed). Each method has advantages and limitations. A climber must be tied in or otherwise secured while entering or working in a tree. One tech-

FIGURE 4.9 A second worker should always support the ladder while a climber ascends.

nique is to use two lanyards (or a two-in-one lanyard) so that the second can be secured when the first must be moved around a limb. The climber should climb on the side of the tree away from any electrical conductors that are present.

To set a rope in the tree, a climber may choose to use a **throwline.** A **shot pouch** attached to the throwline can be thrown with amazing accuracy through crotches 70 feet or higher. Shot pouches are available in various weights, and selection depends on conditions and personal preference.

FIGURE 4.11 An alternate throwline technique.

Arborists have developed a number of techniques for throwing, launching, and manipulating throwlines to put them in the specific tree crotch desired. After the throwline passes through the crotch, it falls to the ground. Sometimes the climber must manipulate

FIGURE 4.10 Preparing to throw the throwline.

FIGURE 4.12 The climbing rope may be thrown into a tree using a throwing knot.

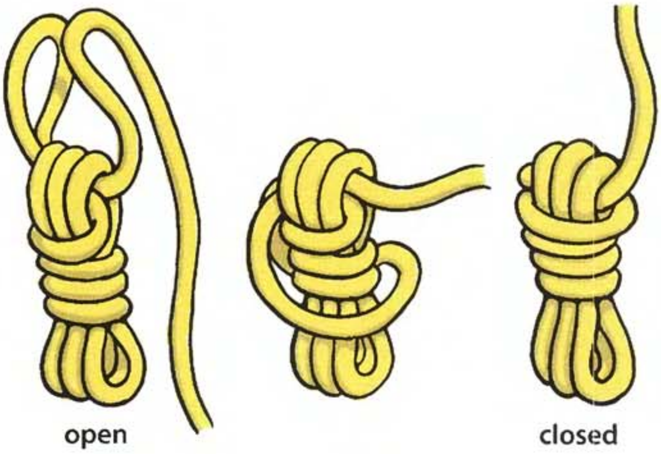


FIGURE 4.13 **The throwing knot can be tied in an open or closed form.**

the cord to encourage the weight to come down. The climber's line can then be attached to the cord of the throw weight (shot pouch) and pulled through the crotch.

Sometimes a climber may throw the climbing line directly into the tree. On short, open throws, it may be easiest to simply loop the rope over a low limb. For trickier throws, the climber may use a **throwing knot**. A throwing knot is simply a series of wraps that hold the rope together and provide end weight to facilitate throwing. The throwing knot can be used in an open or closed form; the closed version will not come undone when the rope is thrown.

Once a rope has been set in the tree, there are several methods of ascending. One method is the **body-thrust** technique, in which the climber uses the rope to climb the tree. Another method is the **secured footlock** technique, in which the climber climbs the rope itself. Other alternatives are variations of the two or techniques that employ mechanical ascending devices.

In body-thrusting, the climber attaches one end of the climbing line to the center **D-ring** or rings of the saddle. This can be accomplished using a locking snap or double-locking carabiner. After attaching the rope to the hardware, a tail piece of rope is left or a split-tail is used to form the climbing hitch around the standing part of the climbing line.

Technique is important in the body-thrust. The climber should place his or her feet high on the trunk of the tree. The hips are thrust upward, creating slack in the line, and simultaneously the other side of the line is pulled down, taking up the slack and keeping the line taut. The climber who relies solely on upper body strength to body-thrust can be exhausted after reaching the top. The addition of a **micropulley** below the climbing hitch allows a ground worker to advance the knot and pull slack out of the climber's line while the climber ascends.

Footlocking is another method of ascending a tree once a rope has been set. When footlocking, the climber actually climbs the rope and might not contact the tree until the top. If the footlocking method is used, the climber must use the secured footlock technique. In the secured footlock technique, the use of a Prusik loop makes footlocking much safer. The Prusik loop is tied to the climber's line using a

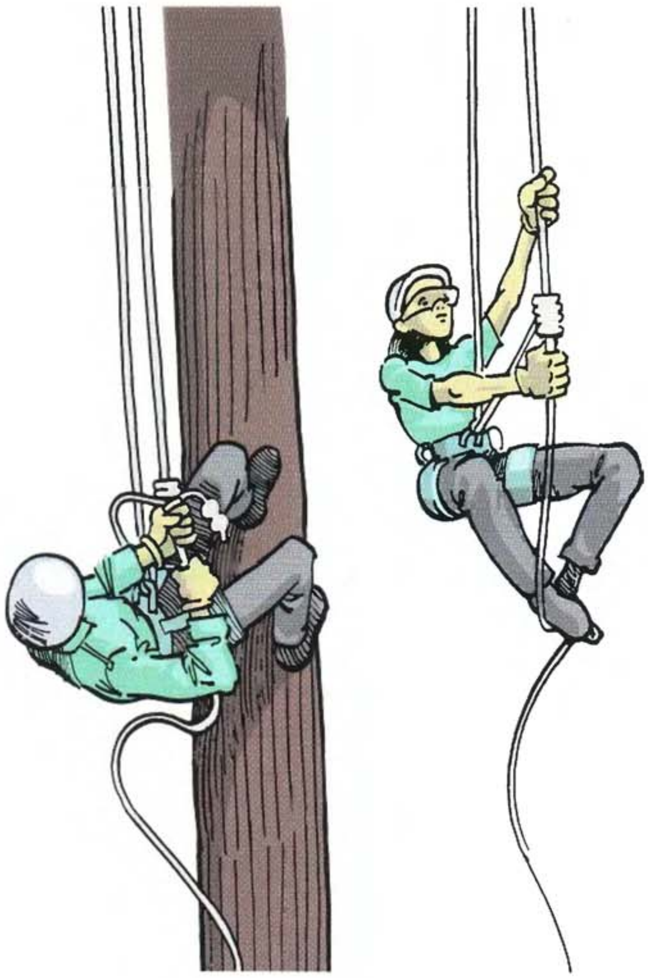


FIGURE 4.14 **Two techniques of ascending are body-thrusting (left) and footlocking the tail (right).**

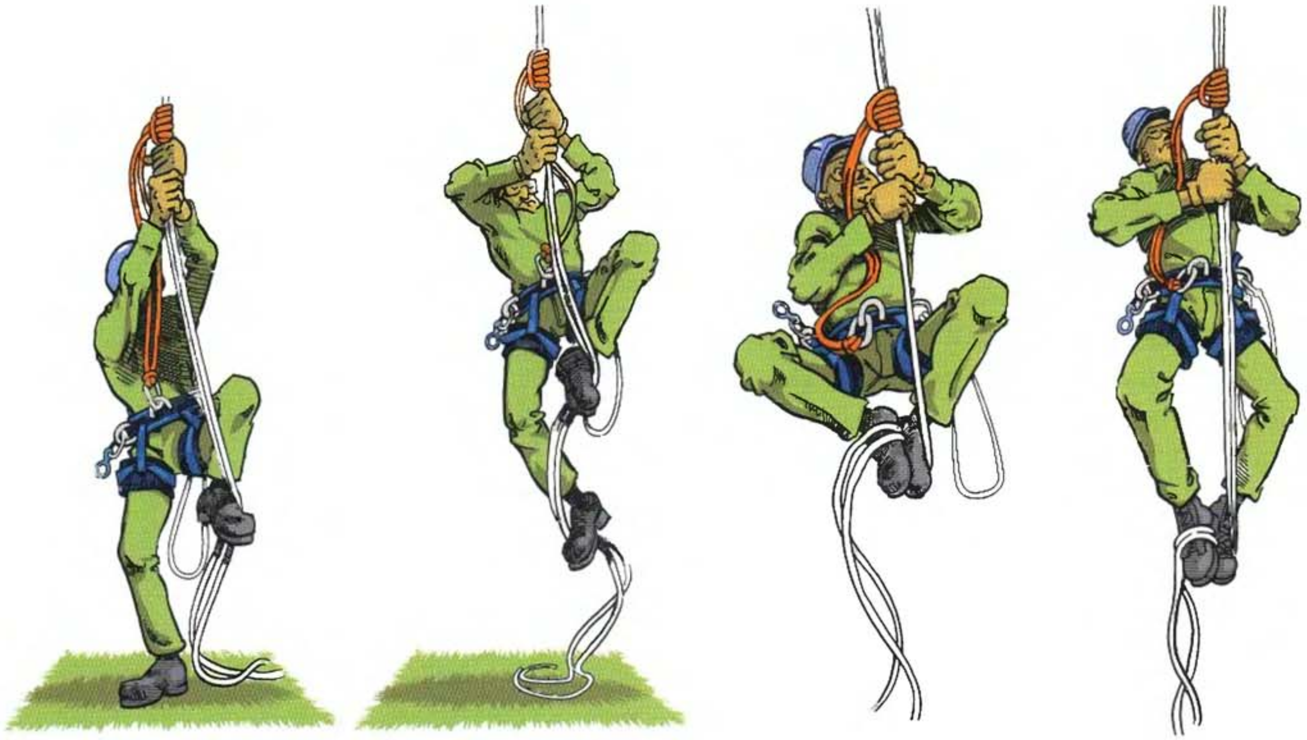


FIGURE 4.15 The secured footlock technique.

Prusik hitch (or a mechanical device) and attached to the front D-rings of the saddle, using an approved double-locking carabiner or **locking snap**. This serves as a means of securing the climber.

Standing with hands high on the climbing line and with the Prusik hitch above the hands, the climber grabs the rope, raises one foot, and aligns the rope on the inside of his or her knee and across the top of the instep. Then, with knees apart, the feet are raised high, and the second foot pulls the rope from below and over the first foot. The rope is locked off by standing on top of the section of rope that is wrapped around the foot. The climber then stands up, pushing the Prusik up with the hands, and the process is repeated. The climber's hands must always stay below the Prusik hitch. Putting the hands on or above the hitch could cause it to slide down the climbing line, creating a fall.

After ascending, the climber must transfer into the tree. This is a potentially dangerous transfer, so the climber must either tie in or use a work-positioning lanyard before removing the Prusik. If the footlocking rope has been set above a lower limb, the climber

FIGURE 4.16 The climber must remain secured when transferring from the footlock to the dynamic tie-in configuration.

will be able to enter the tree onto the lower limb and transfer will be facilitated.

Another method of ascending a tree is the use of climbing spurs. Because spurs can damage a tree, they are approved for use only on trees to be removed or for aerial rescues. A climber should never spur up a tree without using a work-positioning lanyard and/or being tied in with a climbing line. Lanyards are available in a number of lengths and styles. Some have a wire core that makes the line more rigid. This type should never be used around electrical conductors. It should also not be assumed to provide protection from cutting with a chain saw.

When ascending large trees, it may be necessary to reset the climbing line several times. While this is being done, the climber should be secured with a work-positioning lanyard. Another technique is to alternate the ends of the climbing line when recrotching. This way, the climber is still tied in while recrotching the other end. In large trees, the climber should use two separate ropes so that one line is in contact with the ground for access or emergency descent.

FIGURE 4.17 Climbing spurs should be used only on removals. They can cause damage to the cambium and vascular tissues of the tree.

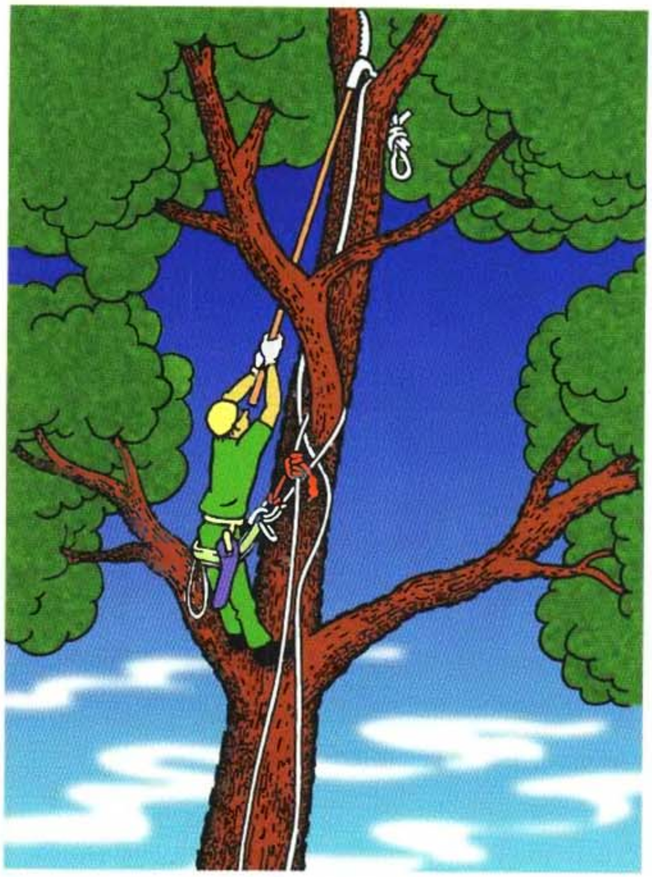


FIGURE 4.18 One way to advance the climbing line when the throwing angle is awkward is to use a pole. Drape a closed or open throwing knot over the pole head. Be sure to avoid the cutting surface. The climber should be secured at all times.

Often the climbing line must be set in a crotch well above the climber's head. One technique is to throw the rope over a higher limb. Another method is to set the rope higher in the tree using a pole. When using a **pole saw** or **pole pruner**, be sure to keep the rope away from the cutting portion. Some climbers use a pole saw with no blade, just a hook, for setting ropes.

Tying In

The choice of where to tie in is very important. Generally, it is desirable to pick a high, central location in the tree. This allows freedom of movement and easy access to most points in the tree. The higher the tie-in

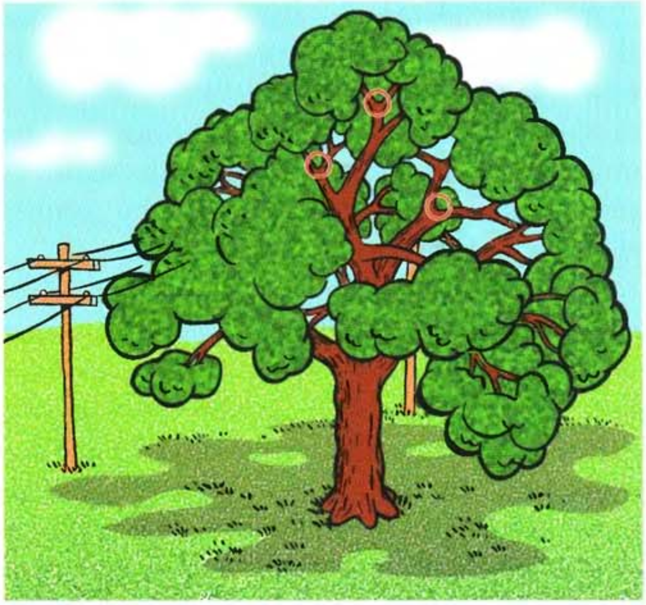


FIGURE 4.19 **The higher the tie-in point, the farther the climber can move out on the limbs. It is easiest to work when tied in directly above the working area. It is very important not to tie in to a crotch that would allow a swing toward power lines in the event of a slip or fall.**

point, the farther the climber can move out on the limbs. It is easiest to work when tied in directly above the working area. The more vertical the climbing line, the more secure the climber. It is very important not to tie in to a crotch that would allow a swing toward power lines in the event of a slip or fall.

FIGURE 4.20 **Choice of where to place the line is important. Choose a sturdy limb and lateral branch. Tie in around the parent limb or trunk and over the lateral limb.**

The crotch selected for tying in should be wide enough for the rope to pass through easily. The size of the limbs varies with species and wood strength, but generally the main branch should be at least 4 inches in diameter. The climbing line is tied in by passing it through a crotch, around the larger limb or trunk, and over the smaller or lateral branch. This way, if the smaller branch breaks clean, the rope will simply drop to the next branch down, rather than out of the tree.

Climbers may also choose to use a **false crotch** when tying in. This can reduce wear on the rope and damage to the tree and can, in some cases, facilitate climbing.

The climber can tie in by first attaching the climbing line to a carabiner or snap that is attached to the D-rings of the climbing saddle. In a traditional climbing system, the climber would leave a long tail in the

FIGURE 4.21 **When tying in, the climbing line is usually attached to both front D-rings or the floating front D-ring.**

climbing line beyond where it attaches to the rope snap or carabiner. An alternate means of tying in involves tying the end of the climbing line (or girth hitching a spliced eye) to an appropriate carabiner attached to one front D-ring. A split-tail is attached to another carabiner on a second front D-ring. The tail, either from the climbing line attachment to the saddle or the split-tail, is then used to tie a friction hitch to the other leg of the climbing line. When tying in with a **tautline hitch**, a **Blake's hitch**, or any other open-ended knot, a **figure-8 knot** should be tied in the tail from the climbing hitch as a **stopper knot** to prevent the end from going through the climbing hitch.

FIGURE 4.22 A split-tail is a separate, short length of rope used to tie the friction hitch in a climbing system.

It is a good idea to use a climbing line that is long enough to allow the climber to reach the ground. If there is any question of this, the climber should tie a stopper knot in the opposite end of the climbing line when working in tall trees to prevent the end from passing through the climbing hitch if the climber reaches the end of the line when descending.

Sometimes it is helpful for a climber to **double-crotch**. Double-crotching is simply tying in at a second crotch, using the far end of the climbing line, or a second line in large trees. The climber can be secured against a fall while crotching the climbing line at a higher point. The lower tie-in would be untied as the worker climbs past. The double-crotching technique may also be used if the climber is ascending a second leader in a tree with a wide spread. The climbing line can be used to help climb the upright limb without sacrificing the original tie-in point. Another use of the double-crotching technique is to allow the climber to be suspended between limbs. This can be useful for installing cables, working on hazardous lower limbs, working on storm-damaged trees, or transferring from one tree to another.

There are, however, limitations with the double-crotching technique. When using the opposite end of the climbing line for the second tie-in, a loop of line is created. If this loop does not reach the ground, ground workers will be unable to use the line to send anything up to the climber. Also, unless the climbing line is long enough, the climber may not be able to descend to the ground without untying one of the tie-in points. This could present an extra difficulty in an emergency situation.

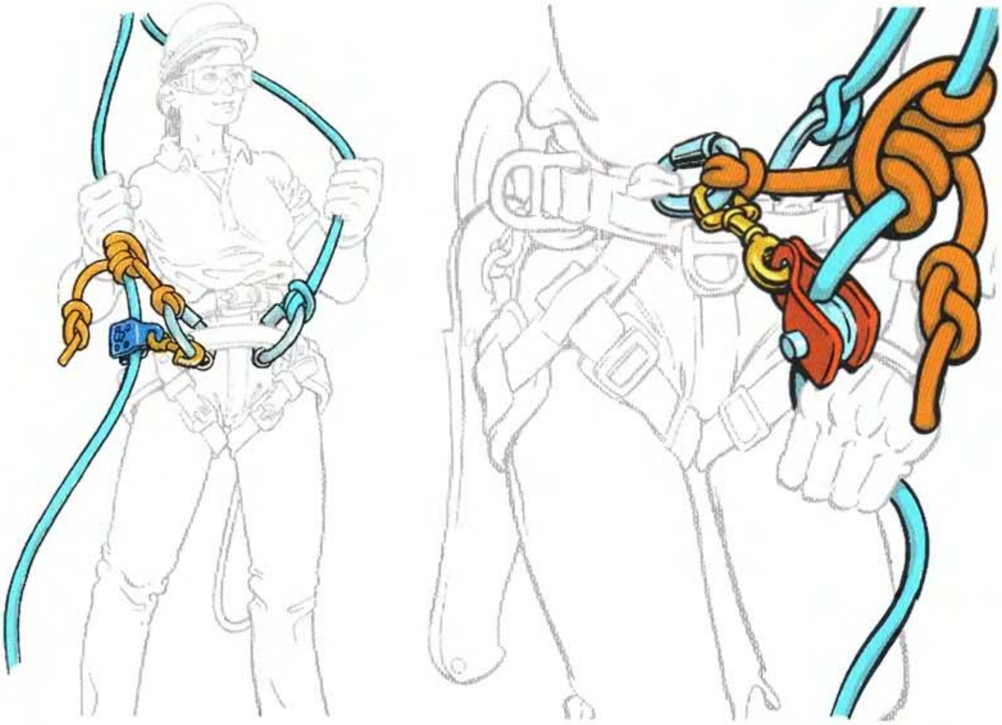


FIGURE 4.23 Innovations in climbing techniques and equipment have brought about alternative climbing systems. This drawing illustrates dual tie-in points using double-locking carabiners, a split-tail for tying in, and a micropulley fair lead to tend the friction hitch.

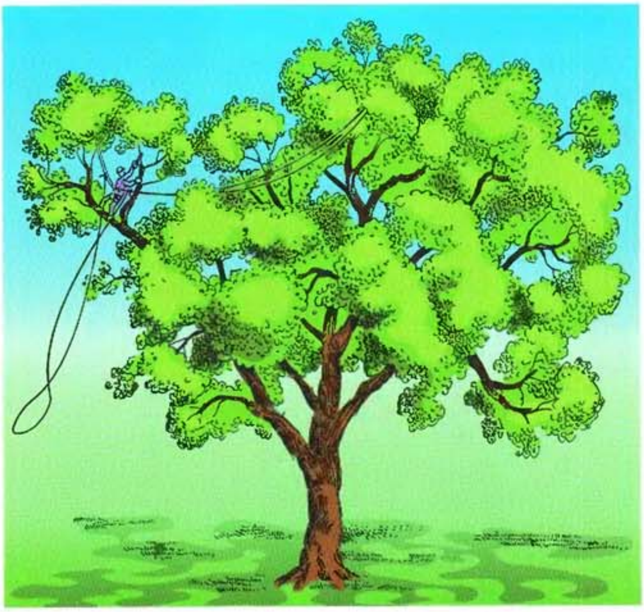


FIGURE 4.24 Double-crotching is a good technique for working in a wide-spreading tree or to move to a second tree.

Working in a Tree

The climbing line is more than a safety device to secure the climber against falling. A good climber uses the rope to ascend the tree, access branch tips, maintain balance, and move freely within the tree. If the climber is able to keep his or her weight on the climbing line, both hands can be used for working.

FIGURE 4.25 A climber can walk out on limbs for access to tips for proper thinning. Generally, the preferred method is to walk backward or sideways on the limb, keeping tension on the line.

FIGURE 4.26 Whenever the climber is out toward the tip of a horizontal limb, it is important to keep his or her weight on the rope.

To be stable, a climber should maintain three points of contact with the tree. Each of the climber's hands and feet can be considered a point of contact. The climbing line, when taut, can be considered one point of contact. The lanyard, if used, is also a contact point and must be as secure as the primary tie-in point. Whenever the climber's weight is not on the climbing line, a three-point contact should be maintained with the tree.

A climber can walk out on limbs for access to tips for proper thinning. Generally, the preferred method is to walk backward or sideways on the limb, keeping tension on the line. Whenever the climber is out toward the tip of a horizontal limb, it is important to keep his or her weight on the rope. If the climber allows his or her weight to be on the limb, the limb may break. The angle of tie-in is important. As a rule, the higher above the work station the tie-in point is, the greater the distance the climber can move out from the trunk.

Another technique in which the climber relies on the rope is swinging. When suspended on his or her climbing line, the climber can sometimes swing to reach the other parts of the tree. Control is crucial when swinging to avoid crashing back into the trunk of the tree.

While in a tree, the climber may require various tools and equipment, including a chain saw, pole

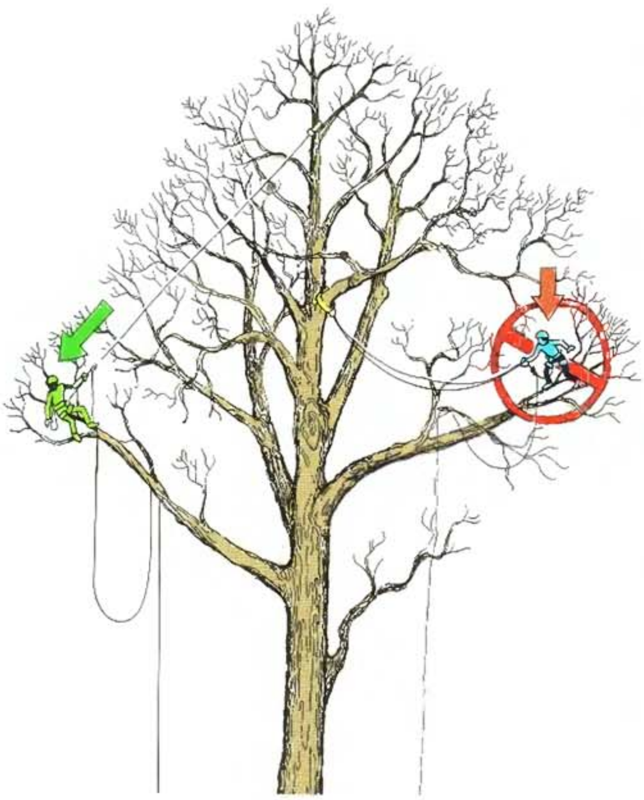


FIGURE 4.27 If the climber allows his or her weight to be on the limb, the limb may break. The angle of tie-in is important. As a rule, the higher above the work station the tie-in point is, the greater the distance the climber can move out from the trunk.

pruner, pole saw, cabling hardware, and/or other tools. Most climbers climb with their handsaw and **scabbard** (sheath for the handsaw). The ground workers send up other tools. Workers may tie equipment onto the climber's line using a **clove hitch** or a similar hitch. If pole pruners or pole saws are used in the tree, they should be hung vertically in the tree when not in use. They should be hung in such a way that the sharp edge is away from the worker and so that they will not accidentally dislodge. If a tool lanyard is used to hang the pole, it should be long enough to keep the cutting edge of the saw below the climber's feet.

FIGURE 4.28 Most climbers climb with their handsaw and scabbard (sheath for the handsaw).

FIGURE 4.29 If pole pruners or pole saws are used in the tree, they should be hung vertically in the tree when not in use. They should be hung in such a way that the sharp edge is away from the worker and so that they will not accidentally dislodge.

Chain saws can be equipped with a chain-saw lanyard for use in a tree. Chain saws weighing more than 15 pounds must be supported by a separate line when used in a tree. The climber must be stable and secure when using a chain saw and other equipment in the tree. Chain saws should be shut off, with the chain brake engaged, when the climber moves to another position. Because it is extremely hazardous to use a chain saw in a tree, safety precautions are important. A climber must be secured with a work-positioning lanyard or another line in addition to the climbing line when using a chain saw in a tree. These precautions are taken for added stability and safety in case either line is severed accidentally.

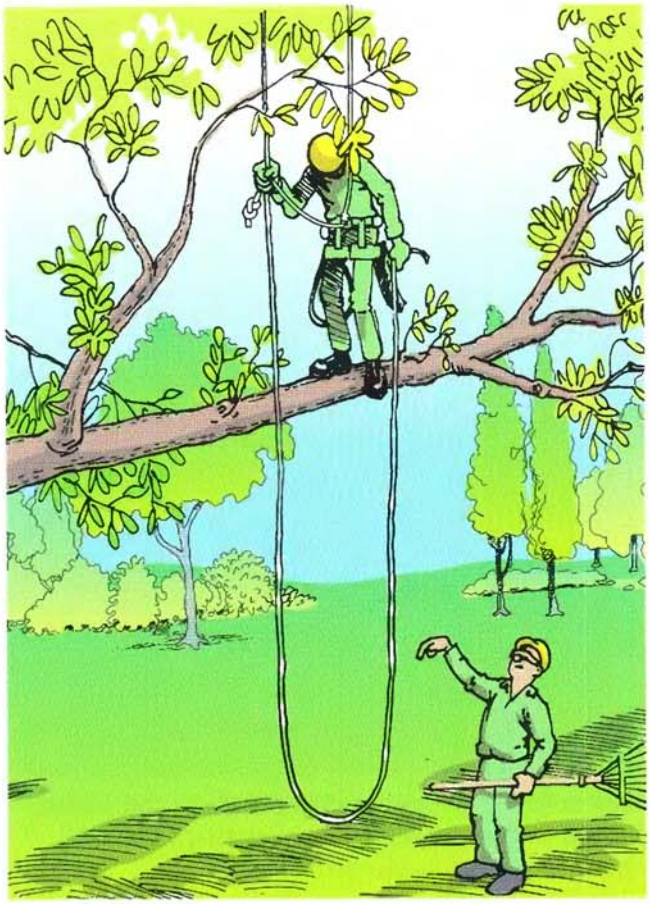


FIGURE 4.30 This drawing illustrates the technique a climber can use to determine whether he or she has enough rope to reach the ground.

When pruning a tree, the climber usually works from the top down. Limbs may be pruned evenly out to the tips. The climber normally works radially around the tree to access each limb, while working down through the tree. Normally, the lowest limbs are the last to be pruned, but this may vary from tree to tree. The climber should think ahead and plan the descent, especially in large trees.

Emergency Response

Accidents are prevented through the conscious recognition of potential hazards in the workplace and the effort to avoid them. Yet it takes only one lax moment or unexpected event for an accident to happen. Because of this, every worker on the crew should be trained in first aid, cardiopulmonary resuscitation (CPR), and **aerial rescue**. Aerial rescue is the process of safely bringing an injured or unconscious worker to the ground.

The most important aspect of aerial rescue is safety. Workers must be trained to assess the emergency situation and make decisions based on the circumstances, the victim's perceived condition, and the help that may be available. Good training and practice help workers handle emergencies more safely and efficiently. There is no time for panic. A rescuer who fails to take the proper precautions may become a second victim.

There are a number of ways a climber can be injured in a tree. Electrocution, heart attack, heat exhaustion, insect or animal attack, a blow from a swinging limb, or a chain-saw cut could leave a worker dangling helplessly in a tree. Ground workers should maintain a close watch on climbers and remain in voice contact. A climber could get hurt and lose consciousness without ever calling for help.

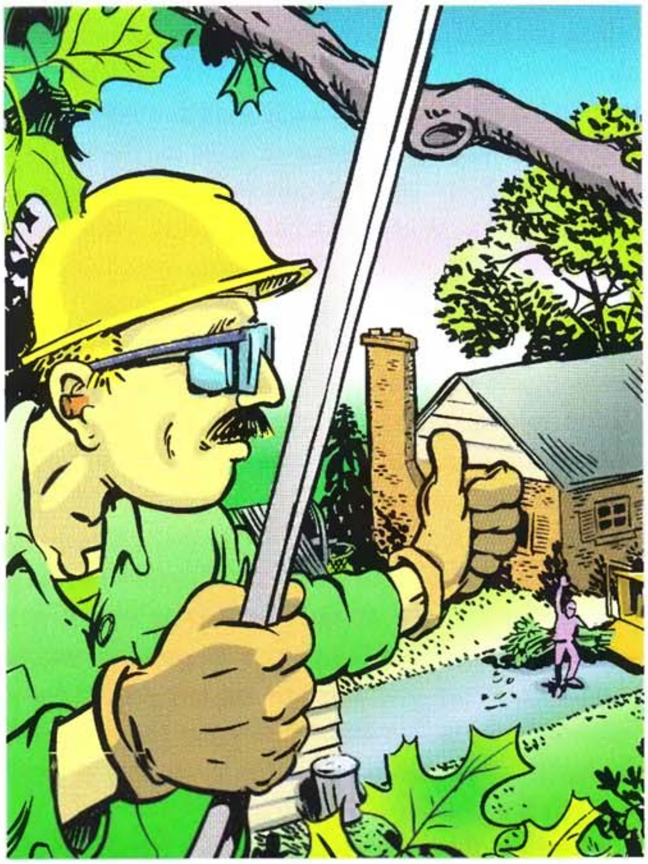


FIGURE 4.31 A climber can be injured in a tree and may not be able to call for help. Ground workers should maintain visual and verbal contact with climbers.

When a climber is injured or unconscious in a tree, the rescue procedure should begin immediately. If there is more than one worker in the area, one worker should call or go for help immediately. Emergency numbers should be posted in the vehicle and employees instructed in their location. When calling for emergency assistance, be sure to give the exact location of the accident and the nature of the emergency. Be sure to tell the operator if it involves a high-angle rescue. Do not hang up first. Let the emergency personnel obtain all necessary information and be the first to hang up. If there is only one rescuer, he or she should first call for assistance, then stay and help the injured worker if possible. No rescue attempt should be started without first contacting emergency help.

The first step in assessing the emergency situation is to determine whether there is an electrical hazard. Because the chance of the rescuer becoming a second victim is great, utility company experts recommend calling the local electric company to avoid any further direct or indirect contact. If the victim has been electrocuted, the rescuer must make an informed decision whether to attempt a rescue or wait for the utility's emergency help. Minutes can mean the difference between life and death. Yet a hasty rescue attempt may lead to the electrocution of the rescuer. Never attempt to climb a tree or rope that may be energized.

If there is no electrical hazard and the tree is deemed safe to climb, it is important to get to the victim to assess his or her condition. The rescuer must first assess what may have caused the accident (for example, hanging limbs, insects, or a defect in the tree) before ascending. The rescuer should use proper climbing equipment and remain secured while climbing to the victim. **The rescuer must never risk becoming a second victim or putting others in danger.** When practical, the rescuer should use a second climbing line and tie in above the victim. If the tree is not energized, climbing spurs may be used to reach the victim.

Upon reaching the victim, a quick check should be made to determine the nature of the injury. If the victim appears to have a broken neck or spinal injury and is breathing, no attempt should be made to move the victim. Be sure the victim is secure and his or her equipment is safe and wait for emergency help to arrive. One of the first tenets of first aid is to avoid moving the victim unless necessary. Although all first-aid procedures can be performed more effectively on the ground, moving the victim may complicate injuries. However, an injured worker hanging for a prolonged period in the climbing harness could lose consciousness and/or go into shock, so continue to closely monitor breathing, pulse, and overall condition.

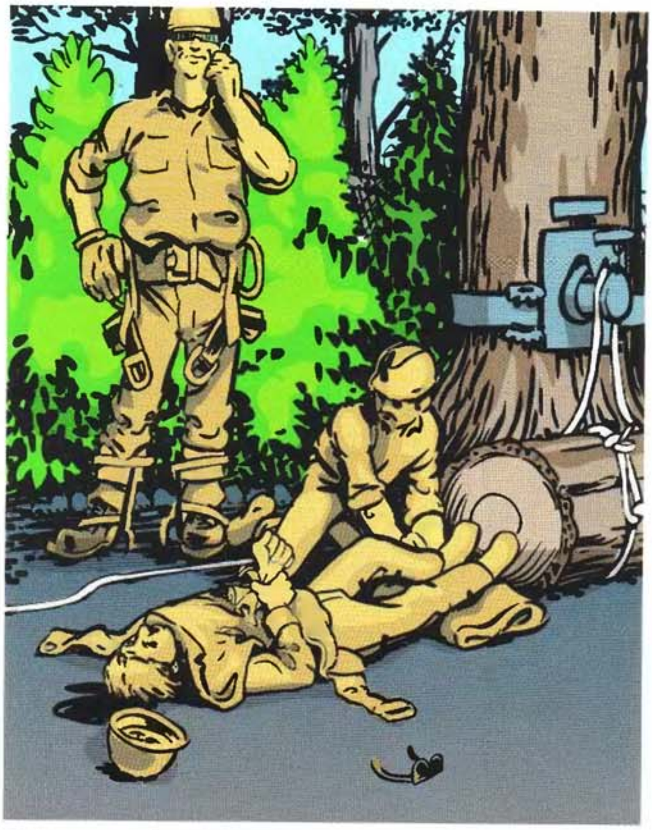


FIGURE 4.32 In an emergency situation, the victim should not be moved unless necessary. Call for emergency help immediately.

The rescuer must exercise good judgment based on training and the severity of the situation when deciding whether it is necessary to move the victim. In some cases, the best decision may be to await emergency personnel who will have the equipment that can prevent further injuries while lowering the victim. Most emergency rescue teams have training and equipment to reduce further injury but are not trained or equipped to rescue victims out of trees. In many cases, it will still be up to the tree workers to get the victim down, preferably working together with emergency personnel. Specific training and practice are essential for aerial rescue and first-aid procedures.

The necessary rescue equipment must be in good condition and readily available. Some companies keep a separate **rescue kit** that is not used for routine daily work. This should include a climbing line and saddle, a lanyard, a throwline, climbing spurs, a pole pruner, a sharp knife, and a first-aid kit. The rescue kit should be taken off the truck at the start of each job. It may not be accessible if it is on an energized truck.

Some companies now advocate that a second line, called an **access line**, be hung when working above 50 feet, particularly if the tree is difficult to enter or ascend. This can save valuable minutes if an aerial rescue becomes necessary.

The ability to react swiftly and safely to save a life depends on keeping a cool head, using common sense, and being prepared. Proper training and practice can save crucial minutes that could mean the difference between life and death.

Matching

_____ Prusik loop	A. personal protective equipment
_____ double-crotch	B. weighted cord used to set rope
_____ aerial rescue	C. rope-climbing technique
_____ footlock	D. fungal fruiting body, sign of decay
_____ PPE	E. bringing injured climber down
_____ conk	F. sheath for handsaw
_____ throwline	G. used for secured footlocking
_____ scabbard	H. tied in at two points with rope

True/False

1. T F In the United States, tree climbers must comply with all applicable safety standards, particularly the current version of ANSI Z133.1.
2. T F Approved head and eye protection are to be worn by all ground workers, but not necessarily climbers.
3. T F If carabiners are used, they must be loaded only along their major axes.
4. T F Carabiners and snaps used for climbing must have a minimum tensile strength of 5,000 pounds (23 kN).
5. T F Old, worn, or cut climbing lines must be used for rigging applications only.
6. T F Work-positioning lanyards must meet strength requirements for ropes and snaps.
7. T F Climbing ropes should be inspected before each use.
8. T F Body-thrusting is a method of ascending a tree.
9. T F Every job must begin with a job briefing that covers the work plan, potential hazards, and all required gear and procedures.
10. T F Climbing spurs are acceptable for use in climbing trees whenever the spurs' marks will not be obvious.
11. T F A climber must be tied in or otherwise secured while entering or working in a tree.
12. T F A throwline can be used to set a climbing line in a tree, but accuracy is limited to 50 feet or less.
13. T F Lanyards with a wire core should never be used when working in the vicinity of electrical conductors.
14. T F It is against safety regulations for climbers to use a pole to set the climbing line higher in the tree.
15. T F In the body-thrust technique, the climber uses the rope to climb the tree, but in the secured footlock technique, the climber climbs the rope itself.
16. T F A Prusik loop is typically used in the body-thrust technique to secure the climber.
17. T F Footlocking is generally slower and more energy consuming than body-thrusting.

18. T F In the body-thrust technique, the addition of a micropulley below the climbing hitch allows a ground worker to advance the knot and pull slack out of the climber's line while the climber ascends.

19. T F Climbing spikes are acceptable to use for removals or an aerial rescue emergency.

20. T F Double-crotching involves taking two wraps around the trunk at the tie-in point.

21. T F A good climber uses the rope to ascend the tree, access branch tips, maintain balance, and move freely within the tree.

22. T F Climbers must always tie in so that a swing or fall will not allow contact with electrical conductors.

23. T F As a rule, it is best to tie in at a point high and central in the tree.

24. T F A high tie-in point allows ease of access to most of the tree.

25. T F A low tie-in point allows a climber to walk out farther on horizontal limbs.

26. T F A climber must be secured with a work-positioning lanyard or another line in addition to the climbing line when using a chain saw in a tree.

27. T F In addition to calling for help, a first step in an aerial rescue situation is to determine whether there is an electrical hazard.

28. T F Avoid moving an injured climber if neck or spinal damage is suspected.

29. T F CPR must be performed immediately in the tree if the victim has no pulse.

30. T F Advantages to using a false crotch when tying in include reduced wear on the rope and less chance of damaging the tree.

Sample Test Questions

1. When footlocking with a Prusik loop, it is important to keep both hands below the knot because
   a. it is impossible to advance the knot otherwise
   b. doing so prevents inadvertently releasing the knot when weight is applied to the loop to slide down the climbing line, creating a fall
   c. it avoids contact with the micropulley
   d. all of the above

2. In addition to being a safety device, the climbing line helps a climber to
   a. access branch tips
   b. maintain balance in the tree
   c. keep both hands free for working
   d. all of the above

3. If a pole pruner or a pole saw is used in a tree,
   a. it should be hung in such a way that the sharp edge is away from the worker and so that it cannot be accidentally dislodged
   b. it should be laid horizontally between the crotches of two separate lateral branches
   c. if a lanyard is used, it should be short enough to keep the cutting edge of the tool near your D-rings, within easy use
   d. all of the above

CHAPTER 5

Pruning

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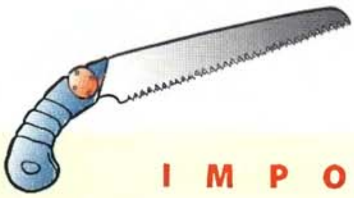
Pruning



IMPORTANT TERMS

hand pruners	pole saw	codominant stems	thinning
secateurs	branch protection zone	included bark	lion tailing
lopping shears	branch collar	caliper	watersprouts
loppers	branch bark ridge	taper	raising
hedge shears	reduction cut	cleaning	reduction
pruning saw	heading cut	crown cleaning	topping
scabbard	kerf	deadwooding	restoration
pole pruner	scaffold branches	risk reduction pruning	wound dressing

Introduction

Pruning is the most common tree maintenance procedure for urban trees. Forest trees grow quite well with little or no pruning. Dead or weak branches simply die and are shed as they decay. However, landscape trees usually require pruning to remove dead branches, improve tree structure, and maintain safety. Pruning cuts must be made with an understanding of how the tree will respond to the cut. Improper pruning can cause damage that will affect the future health and structure of the tree. Knowledge of proper pruning standards and techniques is essential to the tree climber.

Reasons for Pruning

Because each cut changes the growth of the tree, no branch should be removed without a reason. Common reasons for pruning are to remove dead, diseased, and damaged branches; to remove crowded or crossing limbs; and to increase safety. Trees may also be pruned to reduce wind resistance or to increase light and air penetration to the inside of the crown and plantings underneath. In most cases, tree pruning is of a corrective or preventive nature.

Pruning Tools

When pruning trees, it is important to have the right tool for the job. When doing fine pruning, with cuts less than ½ inch in diameter, **hand pruners (secateurs)** can be used. The scissor-type hand pruners, with a bypass blade configuration, are preferred over the anvil type. They make cleaner, more accurate cuts. The bypass blade configuration is also preferred

FIGURE 5.1 Hand pruning shears (secateurs) work best with two bypass blades. Avoid the blade and anvil design, which can damage stem tissues.

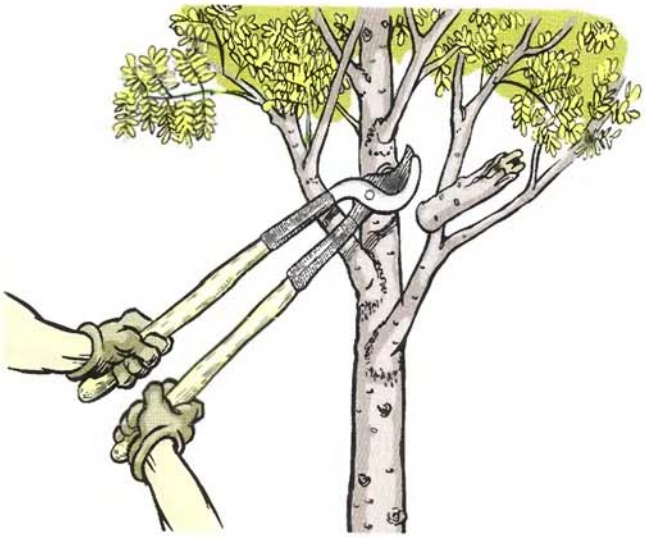


FIGURE 5.2 **Lopping shears are used to prune small to medium stems.**

when choosing **lopping shears (loppers)**. Lopping shears have long handles and can cut branches ½ inch to 2 inches in diameter.

Hedge shears are a less useful tool. They are used for shearing hedges or formal-shaped plants and are generally not recommended for pruning trees.

Pruning saws are specially designed for pruning trees. Most have an arched blade and cut primarily on the back (pull) stroke. Pruning saws are available in various sizes and with different teeth configurations. New technology has helped to develop some pruning saws that are extremely sharp and efficient.

FIGURE 5.3 **Hedge shears have a very specific purpose. They are generally NOT recommended for pruning trees.**

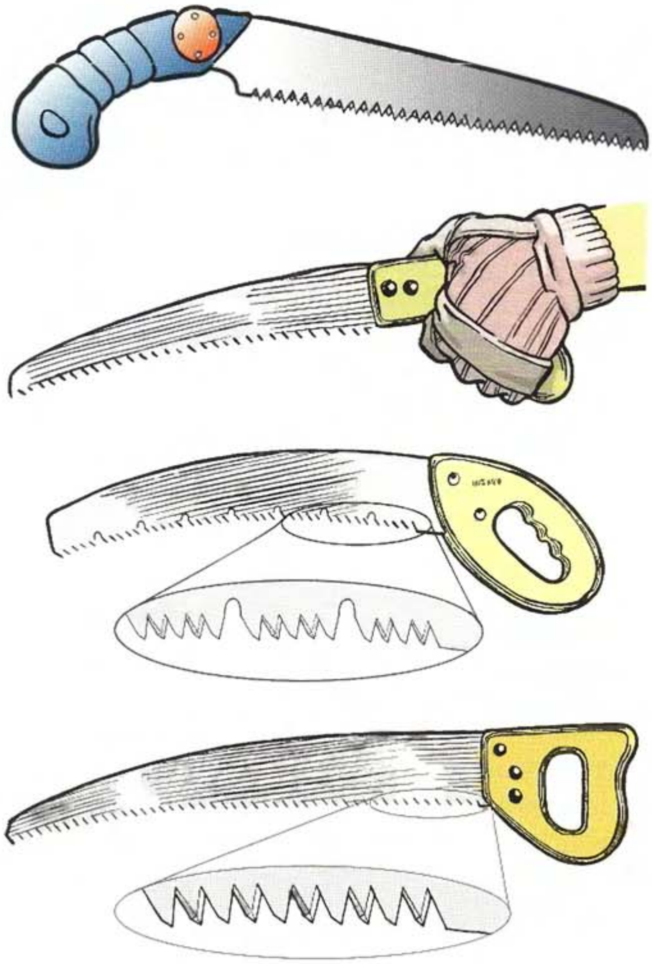


FIGURE 5.4 **There are many types and sizes of pruning saws available, with a variety of blade configurations.**

Climbers usually carry at least one pruning saw when pruning trees aloft. For safety and convenience, the saw is carried in a sheath called a **scabbard**. Some scabbards have pouches that carry hand pruners.

It is often difficult to reach certain branches when pruning trees. Two additional tools can make these cuts possible. A **pole pruner** can be compared to lopping shears on the end of a pole. Pole pruners, if used correctly, can make a clean cut up to about 2 inches in diameter. A **pole saw** can make larger cuts from a distance. However, they should be used with care as clean, accurate cuts are made only when the climber is in a good position.

Climbers can use a chain saw when pruning, but its use should be limited to large cuts. The chain must be sharp in order to make clean, straight cuts. Using

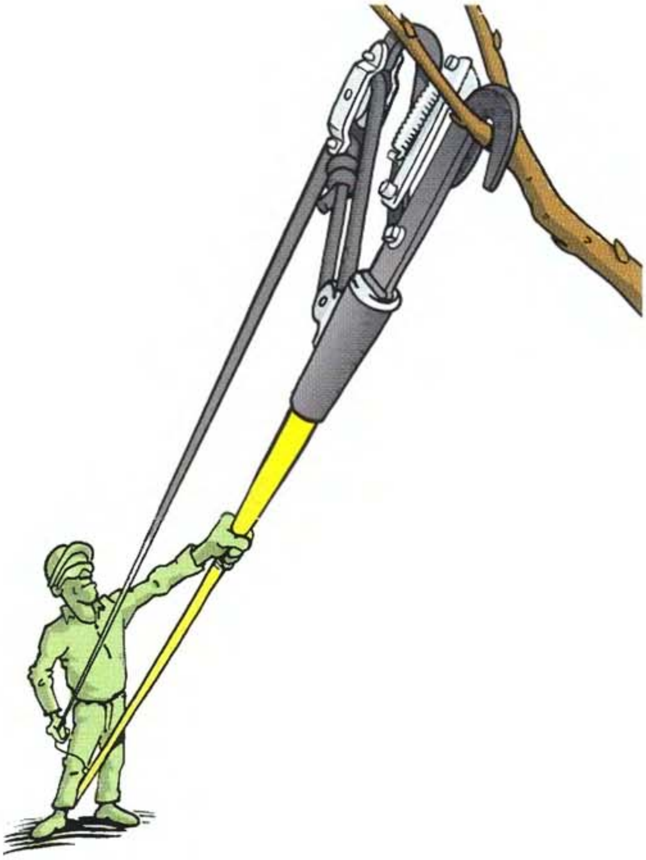


FIGURE 5.5 Pole pruners cut like lopping shears but can reach much farther.

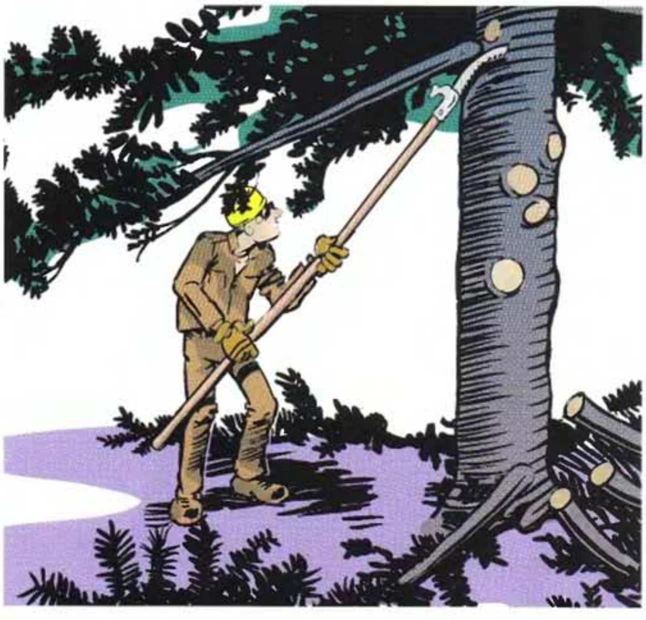


FIGURE 5.6 Pole saws can be used to cut limbs that cannot be reached with a handsaw.

a chain saw in a tree is very dangerous and should not be attempted without proper training.

When to Prune

Most routine pruning to remove weak, diseased, undesirable, or dead limbs can be accomplished at any time of the year with little effect on the tree. As a rule, growth is maximized and wound closure is fastest if pruning takes place just before the initial growth flush in the spring. Some trees, such as maples and birches, tend to "bleed" if pruned in the early spring. This may be unsightly but has little negative effect on the tree. Some tree diseases, such as oak wilt, can be spread when pruning wounds allow access into the tree. Susceptible trees should not be pruned when diseases can be spread.

Pruning Cuts

Each pruning cut should be made carefully at the correct location, leaving a smooth surface with no jagged edges or torn bark. When a tree sheds a branch naturally, it is typically shed back to its point of origin (the trunk or a larger branch). Inside this branch union is a **branch protection zone**, which helps protect the remaining stem from decay.

The correct location for a cut that removes a branch back to its point of origin (sometimes called a thinning cut) is just beyond the **branch collar**. It is important to take care not to cut into the collar (which contains trunk tissue) or the **branch bark ridge**. Cutting at the proper place allows the tree's natural defense system to control the spread of decay and compartmentalize the wound. A well-made cut will close evenly from all sides.

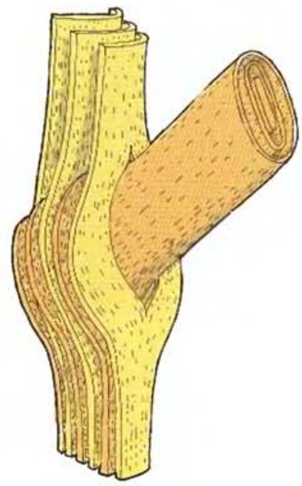


FIGURE 5.7 It is important to understand tree anatomy to understand proper pruning cuts. Never cut into the branch collar, which contains trunk tissues.

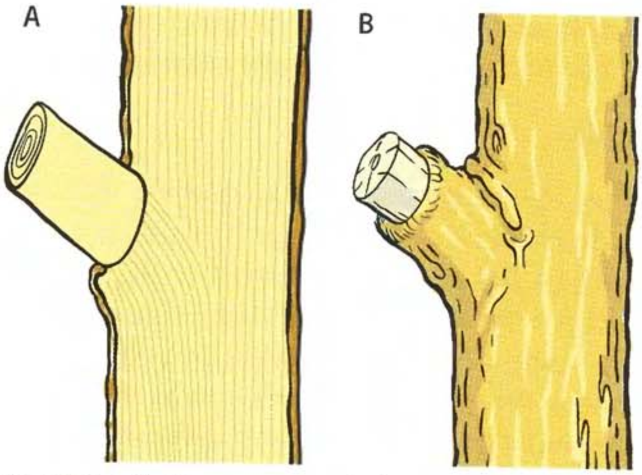


FIGURE 5.8 A. The anatomy of a branch inhibits the spread of decay from a dead branch into the parent stem. B. If the tree has started closing over a stub, cut just the dead stub and not the live tissue.

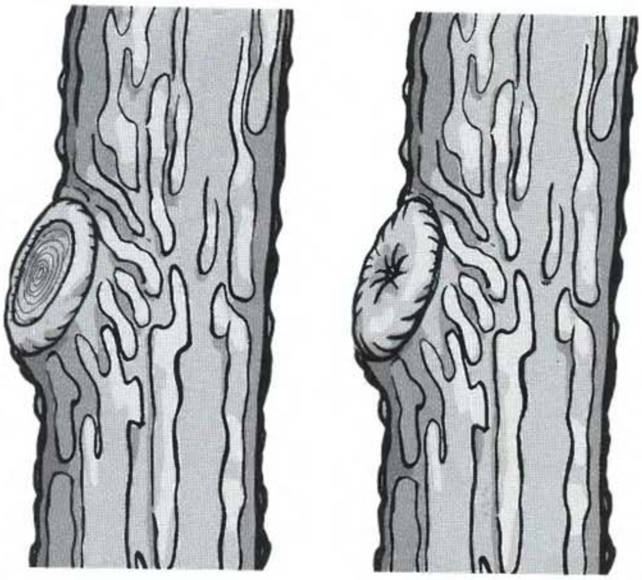


FIGURE 5.10 A well-made cut will close evenly from all sides.

Another type of cut, which prunes a leader back to a lateral branch, is called a **reduction cut**. The lateral chosen for the remaining branch should be large enough to sustain growth and assume the terminal role. A general rule of thumb is that the lateral should be at least one-third the diameter of the leader being removed. Figure 5.9 illustrates the

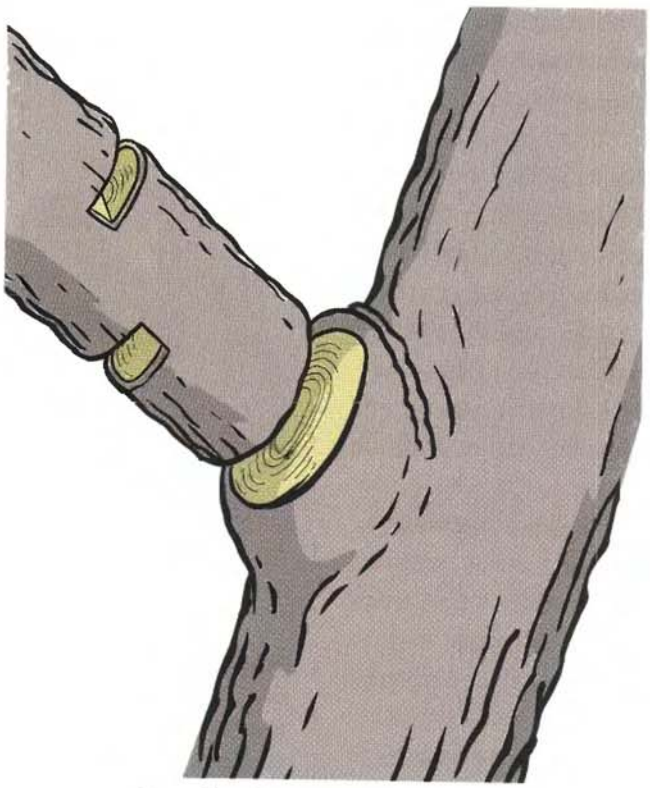


FIGURE 5.9 Cuts should be made to the branch collar. Leaving a stub inhibits proper closure of the wound.

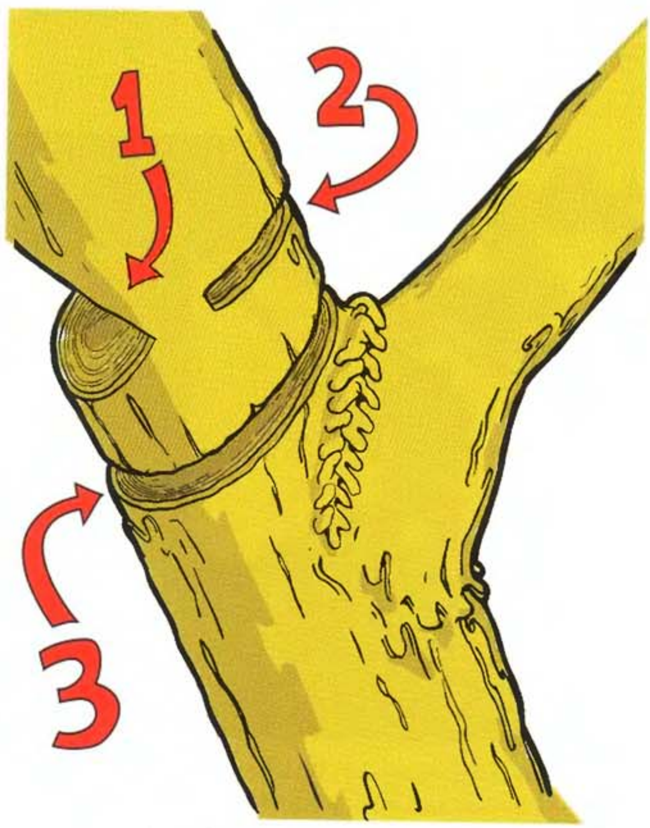


FIGURE 5.11 A reduction cut prunes a leader back to a lateral branch.

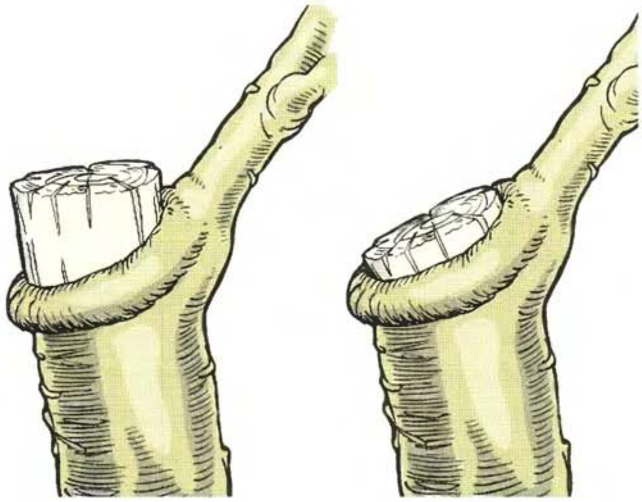


FIGURE 5.12 A reduction cut made in the wrong place or at the wrong angle will close slowly, if at all.

placement of a reduction cut. A reduction cut cannot take advantage of a tree's natural defense system for closing and compartmentalizing wounds because there is not a collar or branch protection zone at the point of the cut. Therefore, it is best to limit reduction cuts to smaller cuts that are more likely to close and outgrow decay.

A **heading cut** prunes a branch back to a bud, stub, or lateral branch not large enough to assume the terminal role. Heading cuts are usually not the first choice for arborists, and their use is more common in nursery production and shrub pruning. Sometimes, however, a heading cut is the lesser of two evils when restoring trees from damage due to storms or other factors. Making a cut back to the point of origin of a branch or cutting

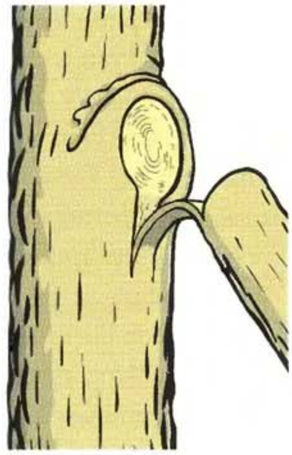


FIGURE 5.14 A properly made undercut will eliminate the chance of the branch "peeling," or tearing bark as it is removed.

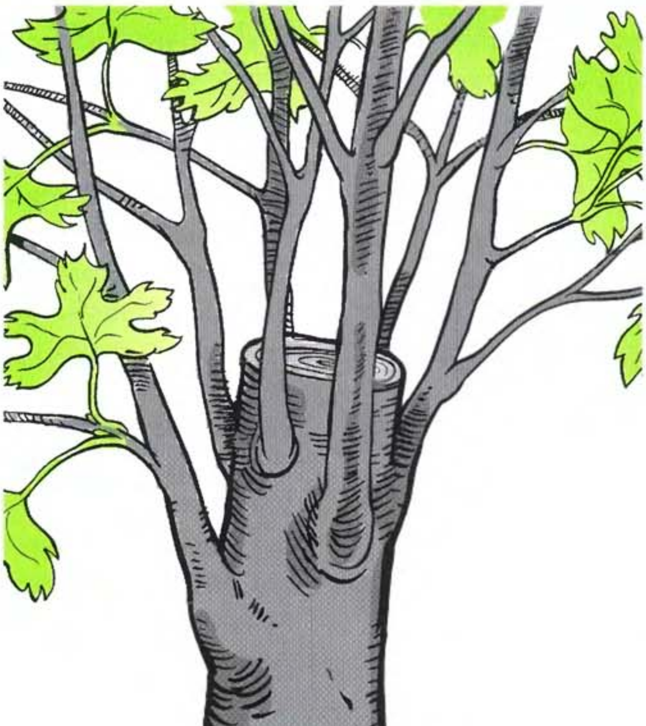


FIGURE 5.13 Often multiple watersprouts develop following a heading cut.

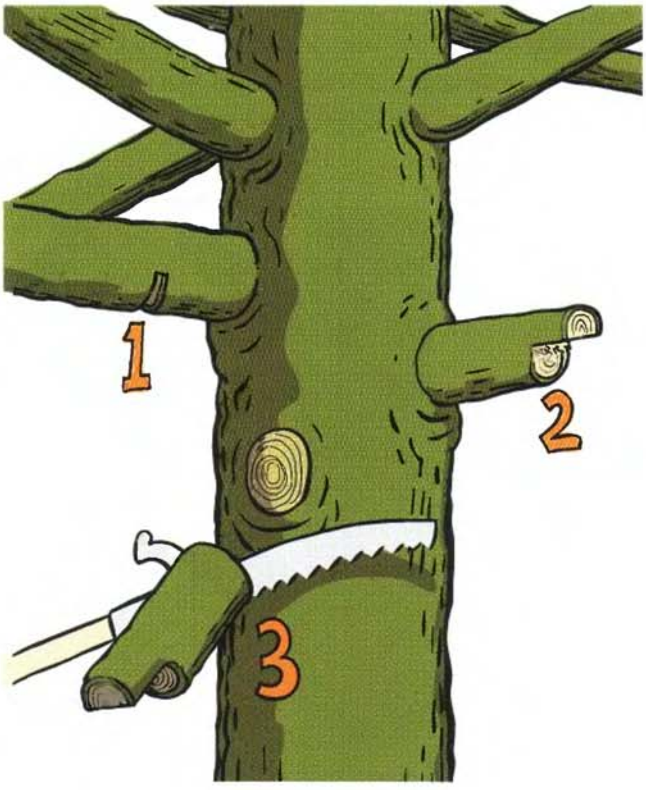


FIGURE 5.15 Pruning principles. The first cut (1) undercuts the limb. The second cut (2) removes the limb. The final cut (3) should be just outside the branch collar to remove the stub.

a branch back to a large lateral can sometimes remove much more than is desirable.

Large or heavy limbs should be removed using three cuts. The first cut is on the underside of the limb 1 or 2 feet out from the parent branch or trunk. A properly made undercut will eliminate the chance of the branch "peeling," or tearing bark as it is removed. The second cut is the top cut, which is made slightly farther out on the limb than the undercut. This allows the limb to drop smoothly. The third cut, called the collar cut, removes the remaining stub. If large limbs are being removed with a chain saw, care must be exercised in using this three-cut method. The **kerf** that is created as the saw makes the second (top) cut can pinch the saw bar as the branch is cut and can pull the saw out of the climber's hands as the limb falls away. This can be avoided if the top cut is made directly above the undercut.

Pruning to Establish Good Structure

A good structure of **scaffold branches** should be established while the tree is young. Scaffold branches provide the primary framework of the mature tree. Properly trained young trees will develop into trees with a strong structure and will require less corrective pruning as they mature. In addition, young trees can more easily close and compartmentalize relatively small pruning wounds.

The goal in pruning for structure is to establish a good framework with sturdy branches and strong crotches. The strength of the branch structure is dependent upon the relative sizes, spacing, and attachment of the limbs. Naturally, this will vary with the growth habit of the tree. Pin oaks and sweetgums have a strong conical shape with a central leader. Elms are wide spreading without a central leader. Other trees, such as lindens and Bradford pears, are densely branched. Good pruning techniques remove or reduce structurally weak branches while maintaining the natural form of the tree.

Branches that are to be part of the permanent branch scaffold should be selected for good structural integrity. Generally, it is best if they are no more than half the diameter of the parent branch or trunk. Choose branches that do not have flaws or defects, especially at the point of attachment. If two branches develop from terminal buds at the tip of the same stem, they will form **codominant stems** (codominant branches). Each codominant stem is a direct extension of the trunk, so there is no normal branch-to-trunk attachment, no branch collar or branch bark ridge, and no natural protection zone associated with branch-to-trunk unions. Because codominant stems are inherently weaker than branch-to-trunk unions, it is usually best if one of the codominant stems is removed or reduced while the tree is young.

Branches that have narrow angles of attachment and codominant branches may break at the crotch, especially if there is **included bark**.

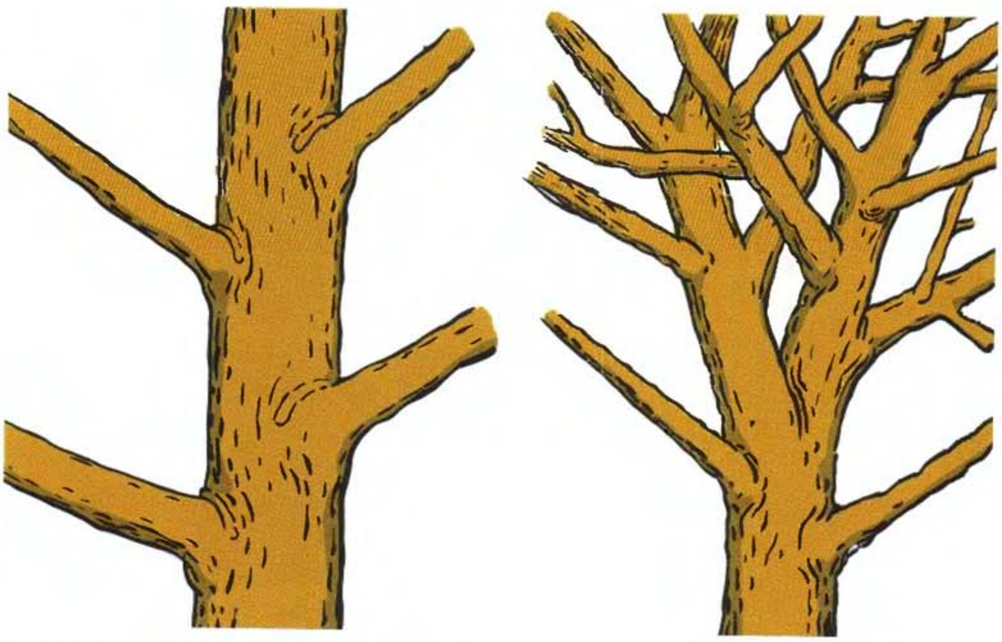


FIGURE 5.16 Trees should be pruned when young to establish a strong scaffold system like the tree on the left. The tree on the right will become more prone to failure as it matures.

FIGURE 5.17 **Codominant stems. The nearly equal diameters of the two stems can make them more prone to failure. If the branch is growing at a very tight angle, it may be preferable to make the final cut from the bottom up.**

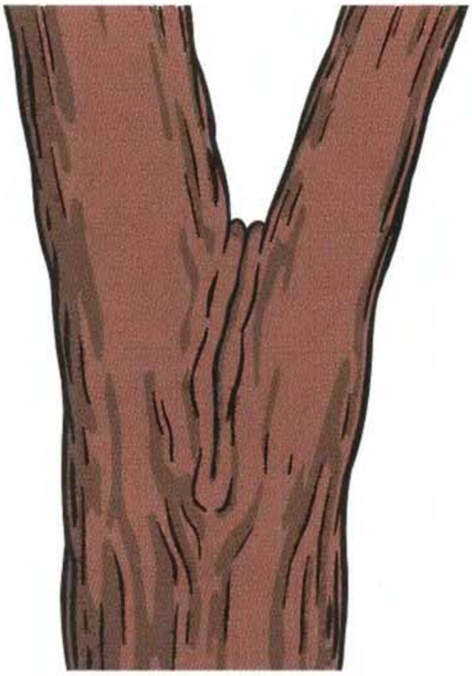


FIGURE 5.18 **Included bark can be a problem in tight crotches. This weakens branch attachment.**

Included bark is bark that gets enclosed inside the crotch as the branch and stem increase in diameter. This weakens the branch attachment, making the tree more prone to serious damage.

The spacing of branches, both vertically and radially in the tree, is very important. Scaffold branches should be well spaced on the trunk. Balance must be maintained around the trunk (radially) with branches growing outward in each direction. If two major scaffold branches arise one directly above another on the same side of the tree, it is best to remove one while they are small.

Generally, the leader in a tree is not pruned back unless a multiple-stemmed tree is desired or if the leader has become too dominant. If a young tree has more than one leader, one leader should be selected and the others reduced or removed.

There is often a tendency to remove too many lower branches and inside branches. It is best to maintain half of the foliage (leaves) on branches arising from the lower two-thirds of the tree. This helps to center wind loading where the tree is strongest and promotes optimal development of **caliper** (diameter) and branch or trunk **taper.** This concept is also important for individual limbs. Leave lower and inside branches along the limb so that the limb can grow thicker and stronger.

Pruning Mature Trees

Whether pruning a young nursery tree or a large, mature park tree, most of the principles remain the same. There are, however, a few significant differences. Mature trees have developed large scaffold branches. If one is removed, the large wound will not close readily, and compartmentalization may be less effective. A widely accepted rule of thumb when pruning is never to remove more than 25 percent of a tree's leaf-bearing crown. With mature trees, removal of even 10 percent can have negative effects. And, if the tree is very old or not healthy, it may not have the energy reserves to recover from the removal of a single large limb. Proper training of a tree when it is young will minimize the amount of pruning required when it is mature. It is best to minimize the removal of live branches on mature trees.

Pruning Techniques

The primary types of pruning include cleaning, thinning, raising, and reduction. The pruning type employed will depend on the goals, such as reducing risk, providing clearance, or increasing light.

Cleaning (crown cleaning) is the selective removal of dead, diseased, detached, and/or broken branches. Cleaning is the preferred pruning type for mature trees because it does not remove live branches unnecessarily.

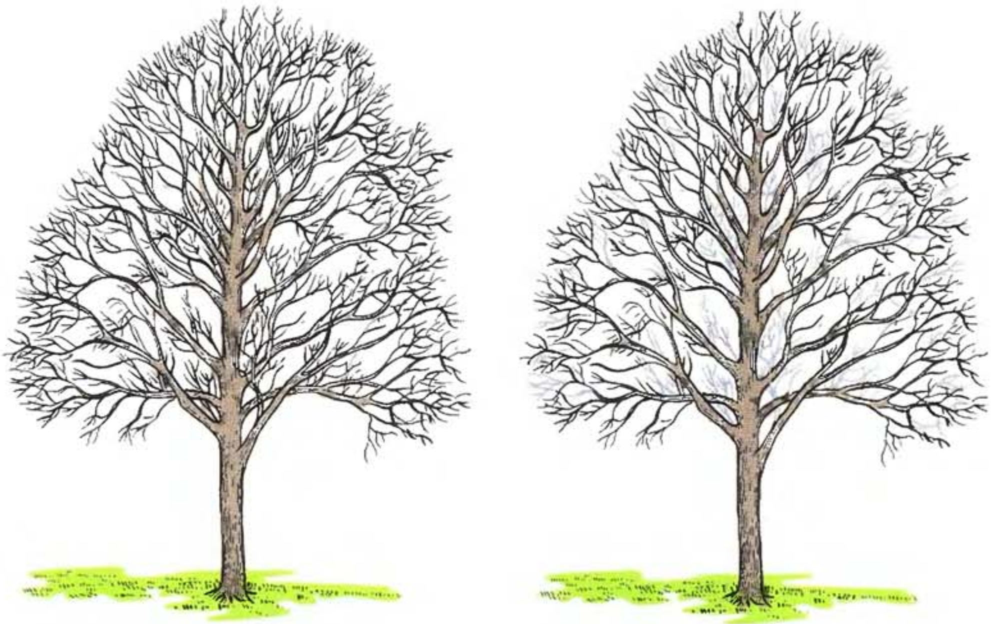


FIGURE 5.19 When thinning a tree, an effort should be made to maintain well-spaced inner branches. It is important to achieve an even distribution of foliage along each branch.

The removal of dead branches is sometimes referred to as **deadwooding**. The removal of dead, broken, and weak branches is considered **risk reduction pruning**. The goal of risk reduction pruning is to reduce the danger posed by visible, defined defects in the tree.

Thinning is the selective removal of small live branches to reduce crown density. Thinning retains crown shape and should provide an even distribution of foliage throughout the crown. Thinning can reduce the wind-sail effect of dense foliage in the crown and relieves the weight of heavy limbs. Thinning the crown can emphasize the structural beauty of the tree while maintaining its natural shape.

When thinning a limb, an effort should be made to maintain well-spaced inner branches. It is important to achieve an even distribution of foliage along the branch. Avoid hollowing out the center of the crown and be careful not to create an effect known as **lion tailing**, which is caused by removing all of the inner laterals and foliage. This displaces the weight of the limbs to the ends and may result in sunburned bark tissue, **watersprouts**, and weakened branches. Lion-tailed branches tend to whip and break in the wind.

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

Sometimes the height or spread of a tree's crown must be reduced, as is the case with utility line clearance. **Reduction** is used

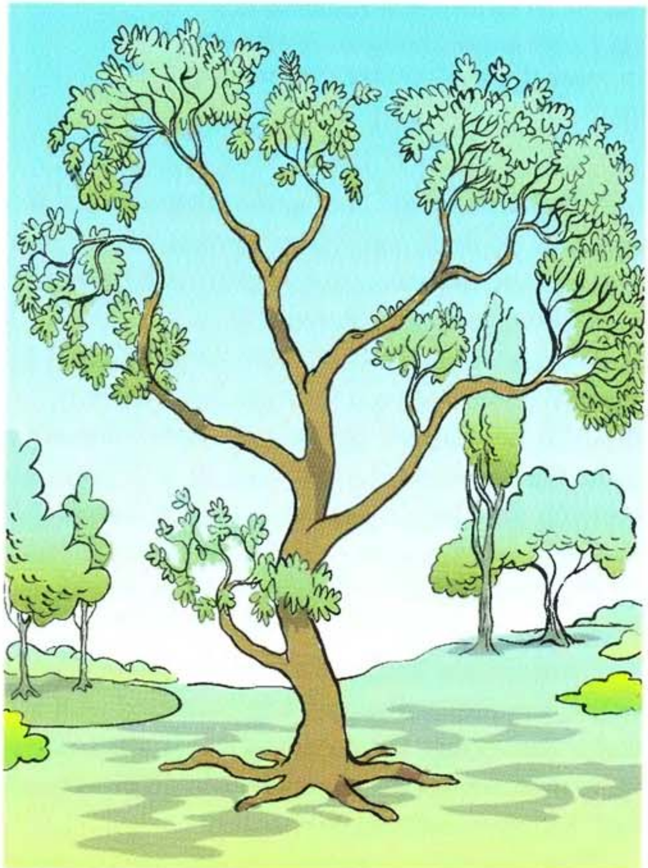


FIGURE 5.20 Climbers should avoid lion tailing. It makes the limbs more prone to breakage. It can also be an energy drain on the tree.

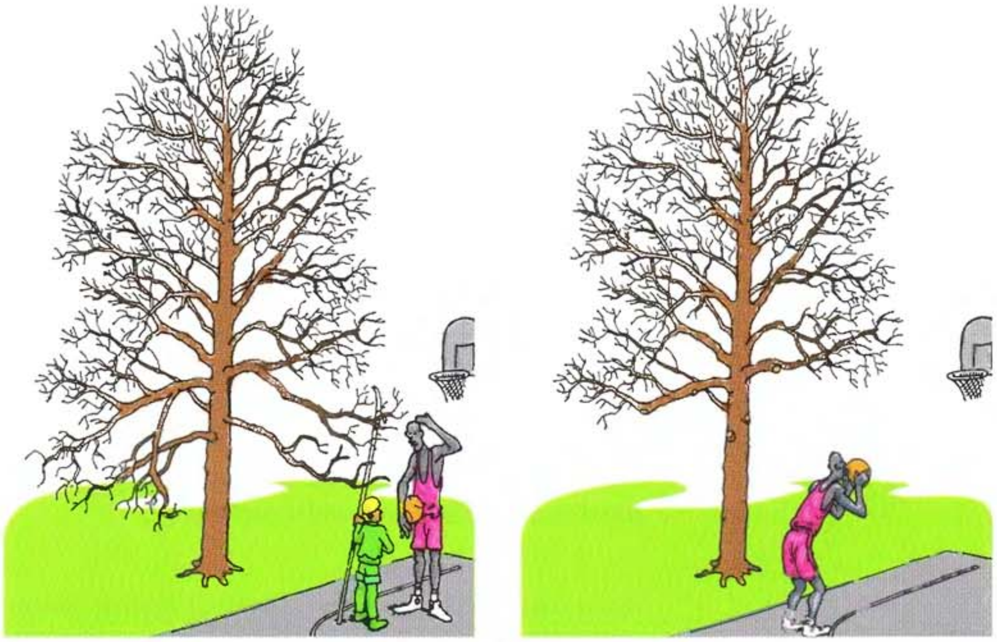


FIGURE 5.21 Raising, before and after.

to reduce the height or width of a tree. This is best accomplished by cutting limbs back to laterals that are large enough to assume the leader role. One rule of thumb is to cut back to a lateral that is at least one-third the diameter of the branch being reduced. When reducing the top or length of a branch, the final cut should not cut through any part of the branch bark ridge and it should not leave a stub. Proper reduction maintains the structural integrity and natural form of the tree and requires less follow-up work.

Reduction is more stressful to mature trees than thinning. Because cuts are being made into leaders, there is no natural protection zone as when a branch is attached to the trunk. Therefore, the closure of the wound and compartmentalization of decay are much less efficient. Small reduction cuts are more likely to close and compartmentalize than large cuts. Some species of trees are more tolerant of reduction than others, but technique is important for all trees.

Topping involves the cutting of limbs back to stubs, buds, or small lateral branches, often to a predetermined crown size. Topping causes decay and sprout production from the cut ends of the branches. These sprouts are weakly attached and can become hazardous when they become larger and heavy. Many of the stubs that are left are likely to decay, and decay

FIGURE 5.22 Side pruning, before and after.

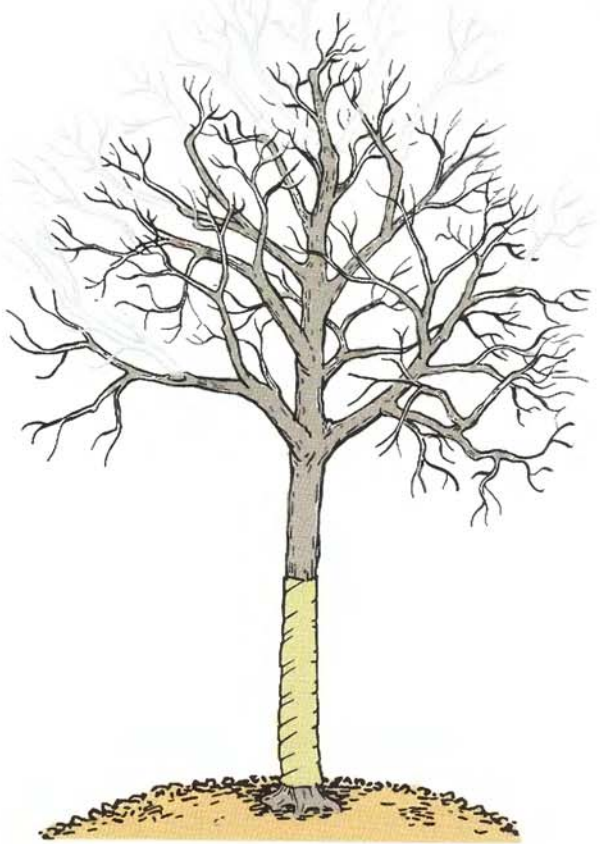


FIGURE 5.23 If the height of the tree must be reduced, all cuts should be made to strong laterals or to the parent limb. Do not cut limbs back to stubs or small laterals.

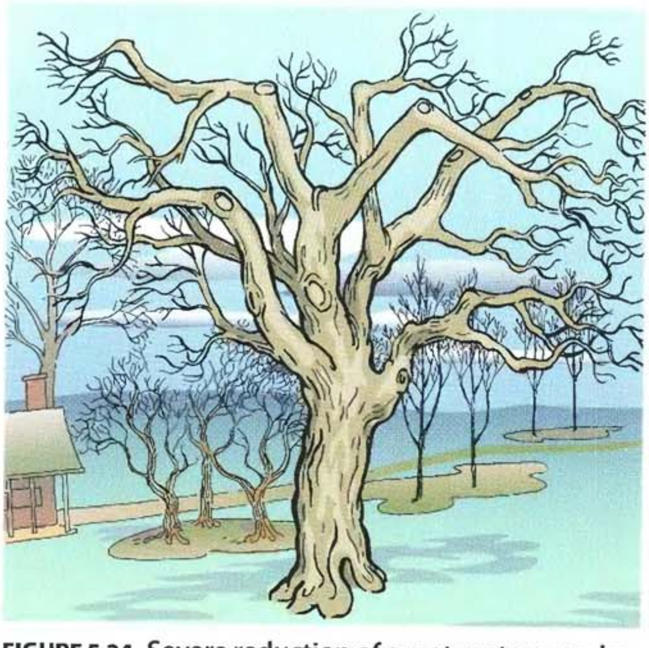


FIGURE 5.24 Severe reduction of a mature tree can be stressful to the tree, even when proper cuts are made.

FIGURE 5.25 Trees that have been topped may become hazardous and are unsightly.

may progress down the stem. Topping is not a recommended pruning practice.

If a tree has been topped, it is unlikely to regain its natural shape and structural strength. However, **restoration** techniques can help improve the tree's safety and appearance. Decaying stubs and branches should be pruned back to structurally sound limbs.

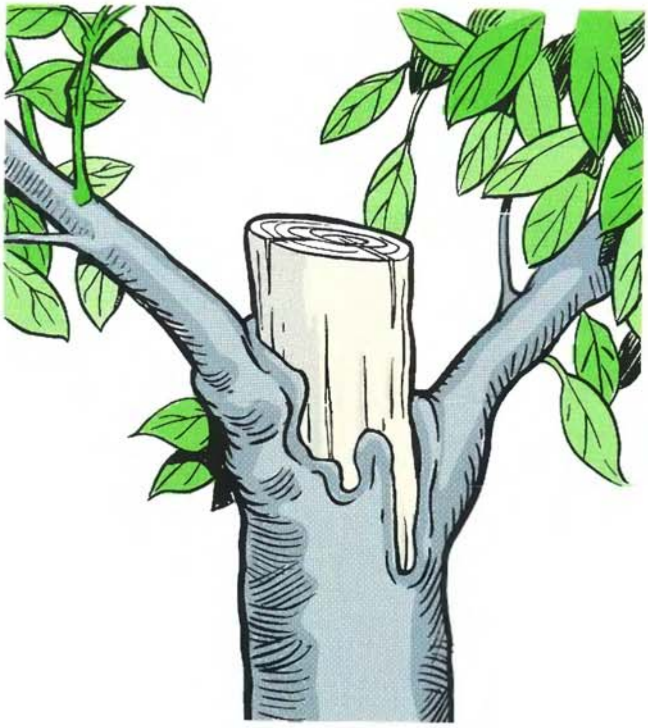


FIGURE 5.26 Stubs left from topping usually decay. The shoots that are produced below the cut are weakly attached and often become a hazard.

One or two sprouts on main branches are selected to become permanent branches, and the rest are removed. Select sprouts with the strongest attachment to the limb. These sprouts may have to be pruned to control and direct their growth. Restoration usually requires several prunings over a number of years. Restoration pruning techniques are also employed following storm damage.

Wound Dressings

Wound dressings were once thought to accelerate wound closure, protect against insects and diseases, and reduce decay. However, research has shown that conventional, asphalt-based dressings do not reduce decay. With few exceptions, dressings usually are not effective in preventing insect or disease penetration or accelerating wound closure. Although some studies have shown beneficial effects in specific cases, wound dressings are primarily used for cosmetic purposes. If they are used, only a light coating of a material that is not toxic to the tree should be applied.

Matching

_____ topping	A. removal of dead, broken branches
_____ scabbard	B. hand pruning shears
_____ raising	C. removal of lower branches
_____ included bark	D. very poor thinning technique
_____ branch collar	E. sheath for pruning saw
_____ secateurs	F. "swollen" zone at base of branch
_____ lion tailing	G. poor crown reduction technique
_____ cleaning	H. can make crotch prone to failure

True/False

1. T F Improper pruning can cause permanent damage to a tree.
2. T F Anvil-type pruning shears are preferred over the bypass blade type.
3. T F Hedge shears are the best tool for pruning most small trees.
4. T F Most pruning saws are designed to cut on the forward or push stroke.
5. T F "Bleeding" that results when certain trees are pruned in the spring has little negative effect on the tree.
6. T F The final pruning cut in branch removal should be made just outside the branch collar.
7. T F Large or heavy limbs should be removed using the three-cut technique.
8. T F It is preferable to develop a sturdy scaffold branch structure while the tree is young.
9. T F The branch bark ridge is located under the branch.
10. T F A tree's growth habit and rate are irrelevant in pruning.
11. T F Removing a large limb from a very mature tree can cause serious stress.
12. T F Codominant stems represent a strong structure that is resistant to failure in windstorms.
13. T F Included bark in a crotch can weaken branch attachment.
14. T F Lower branches should be removed from young trees to help prevent the development of trunk taper.
15. T F A general recommendation in pruning is that half the foliage be maintained in the lower two-thirds of the tree.
16. T F Cleaning is the selective removal of dead, diseased, detached, and/or broken branches.
17. T F The correct location for a cut that removes a branch back to its point of origin is just beyond the branch collar.
18. T F Topping is the recommended technique for crown reduction.
19. T F Topping is recommended for fast-growing or weak-wooded trees.
20. T F Topping is only acceptable after a tree has suffered major root loss.

21. T F Over-thinning the inside of a tree can reduce energy reserves and make limbs more prone to failure.

22. T F Restoration pruning may improve the structure and appearance of a tree that has been topped previously.

23. T F In general, removal of more than 25 percent of a tree's crown when pruning should be avoided.

24. T F Large, mature trees are generally more tolerant of severe pruning.

25. T F Tree wound dressings are widely recommended to accelerate healing and prevent insect and disease penetration in wounds.

Sample Test Questions

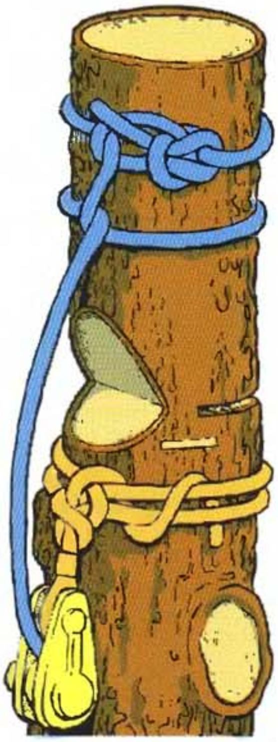
1. Reduction pruning is a technique in which
   a. trees are topped or headed back
   b. leaders are cut back to lateral branches
   c. the lower branches are removed
   d. branches are cut back to stubs

2. The final cut in removing a branch should be made just outside the
   a. branch collar
   b. cambium layer
   c. trunk taper
   d. internode

3. The selective removal of small, live branches to reduce crown density is called
   a. restoration
   b. drop-crotch pruning
   c. raising
   d. thinning

CHAPTER 6

Rigging



CHAPTER 6

Rigging

IMPORTANT TERMS

- rigging
- forces
- friction
- rigging point
- shock-loading
- static load
- dynamic load
- tensile strength
- cycles to failure
- design factor
- working-load limit (WLL)
- block
- pulley
- block and tackle
- mechanical advantage
- false crotch
- arborist block
- rescue pulley
- bend ratio
- connecting link
- screw link
- clevis
- shackle
- carabiner
- locking gate
- double-locking gate
- sling
- eye-spliced rope
- girth hitch
- whoopie sling
- eye-to-eye sling
- friction device
- bollard
- load line
- cow hitch
- half hitch
- running bowline
- clove hitch
- butt-tied
- tip-tie
- balance
- tagline
- pull line
- butt-hitching
- drop cut
- kerf
- snap cut
- hinge cut
- notch
- landing zone
- command-and-response system

Introduction

In arboriculture, **rigging** is the use of ropes and other equipment to take down trees or remove limbs. Rigging is often associated with removals, but the procedures can be very important in pruning operations. Rigging is necessary when it is not possible to "free fall" or drop tree sections due to potential hazards, obstacles below, or power lines. When removing limbs from a tree that is being trimmed, care must be taken not to damage the remaining branches, trunk, and root system. Rigging techniques can allow the climber to remove large limbs in less time and with more control than if the sections had to be "pieced out."

This chapter will describe and illustrate common rigging equipment and techniques. The procedures discussed will be limited to the more basic practices. The terminology will be explained, and the more commonly accepted terms will be used.

Rigging involves the use of ropes and various pieces of hardware to remove large sections of trees safely and efficiently. All ropes and equipment have strength ratings and limitations. It is vitally important not to exceed these limits. There are techniques that can limit the load placed on rigging equipment. Because the weight of any tree section or limb to be cut can only be estimated, experience with rigging equipment and the use of proper techniques are essential.

The rigging of large sections of trees to be removed is without a doubt the most dangerous aspect of tree work. Even for veteran climbers, it is always best to practice new techniques in open areas so that safety and control will not be in question on those trees for which experience counts.

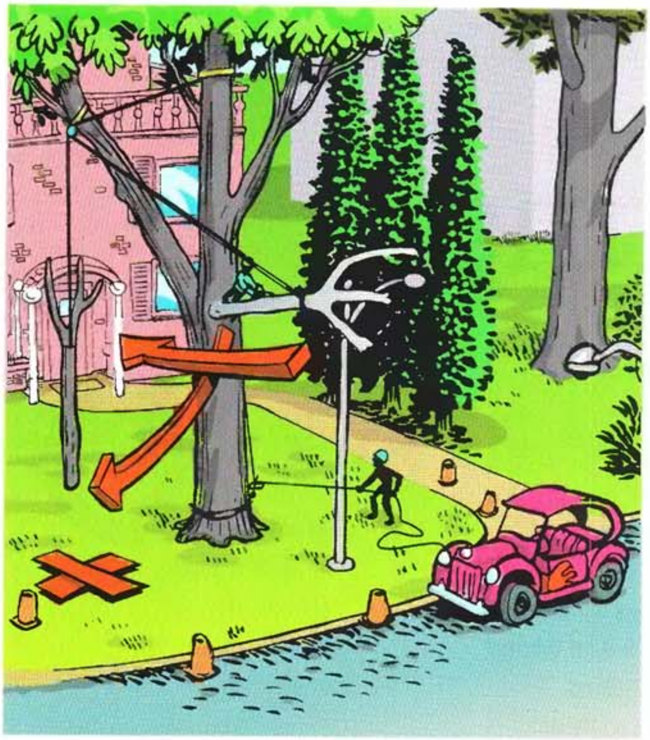


FIGURE 6.1 Rigging involves the use of ropes and various pieces of hardware to remove large sections of trees safely and efficiently.

This text is an educational tool for introductory arboriculture. It may be used as part of, but not as a replacement for, a comprehensive training program. While some equipment and techniques are explained and illustrated, actual use requires knowledge of and experience with them prior to use in an actual work environment. The techniques described or depicted in this book must be analyzed, and at times modified, to meet the specific needs of the individual situation.

Be sure to understand the proper use of all equipment required and use safe work practices at all times. Familiarize yourself with local, state, provincial, national, or federal government standards as applicable to the job assignment and requirements. Take advantage of the other sources of information and training available from the International Society of Arboriculture.

FIGURE 6.2 It is always best to practice new techniques in open areas so that safety and control will not be in question.

Forces in Rigging

Arborists are only beginning to investigate and understand the **forces** in rigging. It is clear that removing large, heavy sections of trees using ropes and other equipment generates large forces. These forces are greatly affected by the equipment and techniques employed. The size and weight of the piece removed is the base factor in determining the force involved, but forces are also affected by the distance of fall, the type and amount of rope in the system, and the angles involved. By selecting appropriate equipment and employing rigging techniques that minimize forces, arborists can mitigate the inherent risks of rigging. Remember: although equipment and ropes have improved over the years, the tree itself imposes the ultimate limitation on the magnitude of forces that can be withstood when rigging.

Friction is essential in rigging systems. Without it, ground workers could not lower pieces that weigh more than they do. Friction is a force acting opposite the relative motion between two objects. A rope absorbs the energy of a falling piece of wood by stretching. With more friction at the **rigging point**, as with natural-crotch rigging, the lead (the part of the line from the rigging point to the piece) experiences significantly more of the force in this relatively short length of rope. Over time, these forces shorten the life of the rigging line. While friction is always a concern, it is most important for large pieces and in cases where there will be significant **shock-loading**.

One of the first concepts to understand is the difference between **static** and **dynamic loads**. Statics

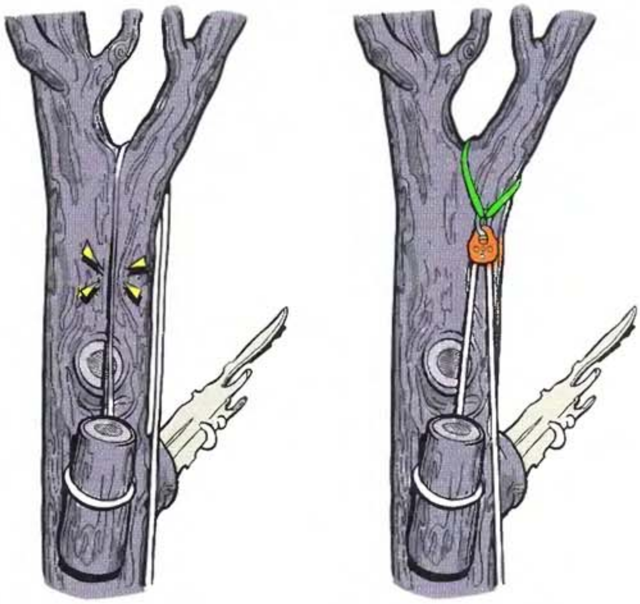


FIGURE 6.3 With more friction at the rigging point, as with natural-crotch rigging, the lead (the part of the line from the rigging point to the piece) experiences significantly more of the force in this relatively short length of rope. Using an arborist block helps distribute the force along a greater length of rope.

deals with forces on stationary objects. In arborist rigging, an example of a static load is the weight of a tree section or piece of wood. Dynamics is the study of the action of forces on bodies and the changes in motion they produce. An example of a dynamic load in arborist rigging is the load experienced by stopping a piece of wood that is falling. The dynamic load can be many times the static load (the weight of the piece of wood).

Dynamic loads damage ropes and other equipment more quickly than equivalent static loads. That is, dropping 200 pounds to produce a 1,000-pound dynamic load is worse for the rope than slowly lifting a 1,000-pound load. Failure to account for dynamic loads can lead to equipment failure.

The **tensile strength** reported by the manufacturer is the breaking strength (force at which the tested item fails) of a rope or piece of hardware. As a rope is used, its strength is reduced due to dirt, wear, knots, and, of course, loading. **Cycles to failure** must also be considered. One cycle means one lift or drop for a rigging line. Each cycle creates permanent damage

FIGURE 6.4 Shock-loading occurs when a dynamic, sudden force is placed on a rope or rigging apparatus when a moving load/piece is stopped.

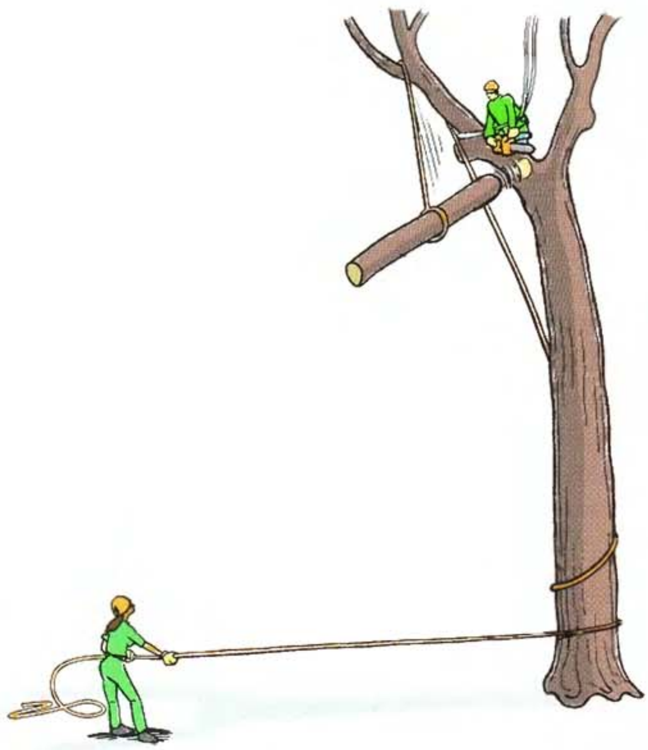


FIGURE 6.5 A dynamic load is created by moving forces acting upon an object.

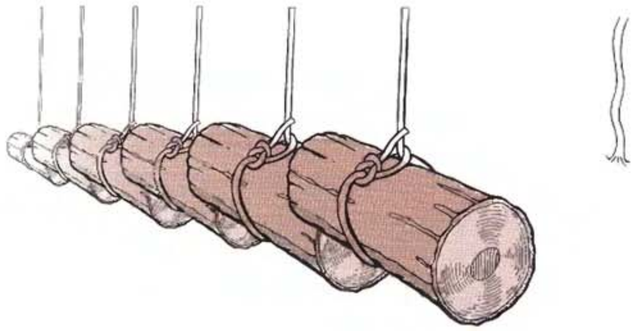


FIGURE 6.6 **Each time a rope or piece of rigging equipment is used, it is considered one cycle. Every piece of equipment has a finite number of cycles to failure. That number decreases with increases in loads.**

in the rope, and eventually the rope will fail. At larger loads, this number of cycles-to-failure is reduced. If the load in a rope is equal to its tensile strength, the rope may fail when used only once (one cycle to failure).

A **design factor** (sometimes called safety factor) must be established based on the application and conditions of use. For arborist rigging, with dynamic loading, high wear, and dirty conditions, a design factor of 5 or greater is often chosen. Dividing the published tensile strength of a rope or piece of equipment by the design factor yields the **working-load limit (WLL)**, which should not be exceeded. The working-load limit is significantly lower than the tensile strength. For example, if the published tensile strength of a piece of equipment is 20,000 pounds and a design factor of 5 has been established, then the working-load limit will be 4,000 pounds for that tool. Keep in mind that the load on the equipment is often many times greater than the actual weight of the log!

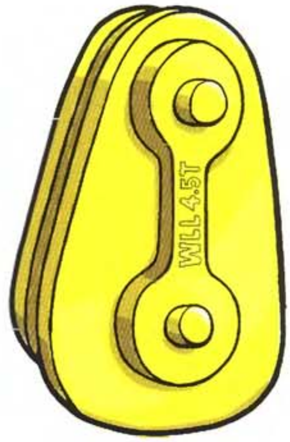


FIGURE 6.7 **Some equipment lists the manufacturer's recommended working-load limit (WLL).**

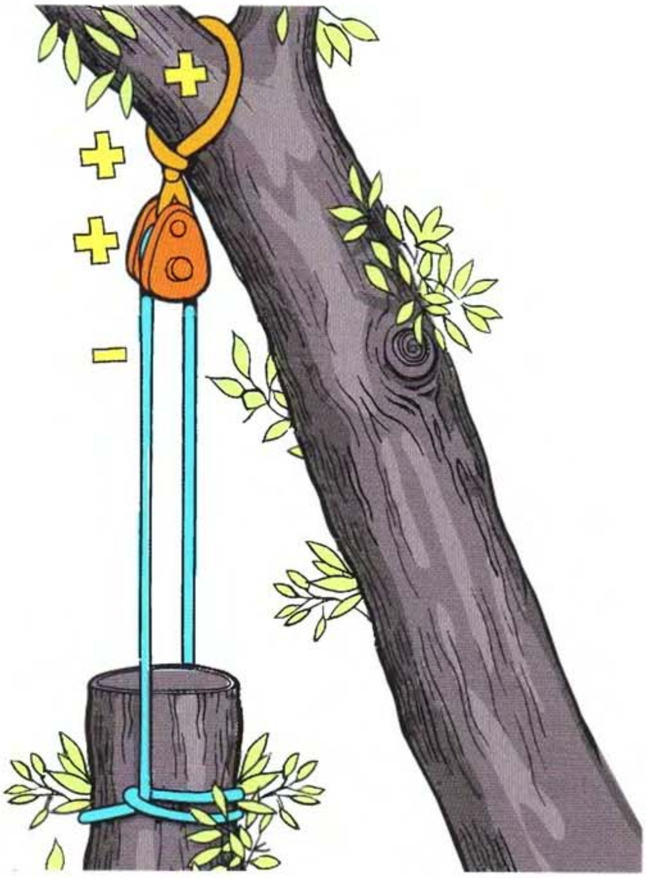


FIGURE 6.8 **Arborists generally design rigging systems so that the rigging line (load line) is the weakest link in the system.**

Various components of any rigging system have different working load limits, and it is important to consider each component. Arborists generally design rigging systems so that the rigging line (load line) is the weakest link in the system. Understanding the design and limitations of each piece of equipment employed, as well as the tree itself, is an important part of setting up a safe and efficient rigging system. Too often, arborists fail to think through the forces and loads that might be involved in rigging out large limbs. The failure of any link in the system can have disastrous effects, including property damage, injuries, or even a fatality. Few practices in arboriculture are as involved or as inherently dangerous as rigging; professional knowledge and experience are essential.

Learning the Ropes

The "Ropes and Knots" chapter of this study guide contains a comparison of several rope types. Materials and construction methods are described briefly. Ropes used in rigging must have certain characteristics. They must be strong enough to support heavy loads, they must be durable enough to withstand the friction of being run over coarse bark while under load, and they must have limited stretch because the dropping distance of the loads must be controlled. Arborists should limit their rope selections to those ropes that are recommended by manufacturers for tree care operations.

For rigging, the ropes selected must be large enough and strong enough for the job required. The working-load limit for new, unused ropes used in tree care procedures is often considered to be 10 percent of the tensile strength. This may need to be lowered for "veteran" ropes that have seen a lot of action. The working-load limit is an estimate of the limit at which a rope can be loaded safely and repeatedly. Obviously, as a rope is worn by repeated use or subjected to shock-loading, its working-load limit will decrease. Another important consideration is the use of knots. Knots can reduce the working-load limit by as much as 50 percent, depending on the knot used.

FIGURE 6.9 **Ropes should always be inspected before use. Look for cuts, shredding, glazing, or inconsistencies in the rope diameter.**

Remember that the tensile strength of a rope is determined by using a steady load. In tree work, loading is rarely steady. Ropes are often used to "catch" a moving (dropping) section of tree. The farther the load drops, the greater the force on the rope. Stopping a falling load puts a shock load (sudden dynamic load) on the rope that is much greater than the weight of the object itself. It is easy to exceed the working-load limit of the rope in this manner.

Ropes should always be inspected before use. Look for cuts, shredding, or glazing (melted rope fiber). Look for inconsistencies in the rope diameter. Shock-loading or stretching can ruin a rope's construction. This may show up as lumps or an hourglass-shaped narrowing in the rope.

Proper care of ropes is essential if they are to be relied upon. Never store ropes near fuels, oils, salt, batteries, or chemicals. Keep them away from sharp edges or pointed objects, such as pruning equipment and chain saws. Try to keep ropes clean and dry. The extended use of a dirty rope can accelerate wear of the fibers.

Equipment

Choosing the correct equipment for a given situation can make the job safer and much more productive, provided the science behind a given device is understood. New equipment seems to come on the market every day. Some of this equipment has been adapted from other industries, and some has been designed for arborist uses. Arborists demand a great deal from the equipment used in rigging, so using appropriate equipment within its design limitations is imperative. Arborists need to understand the advantages

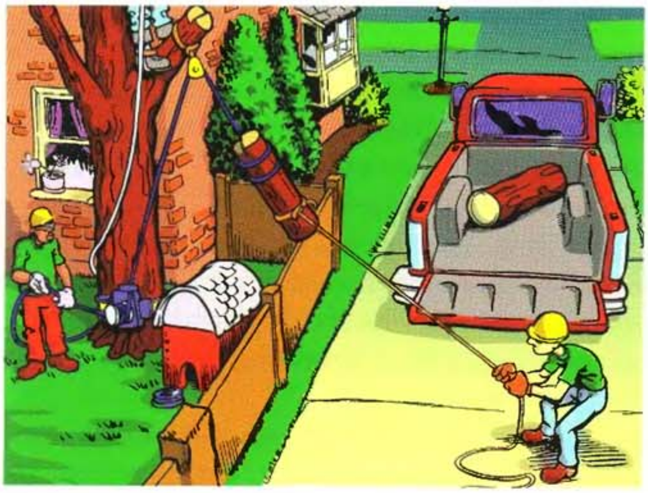


FIGURE 6.10 **Arborists must choose equipment and techniques that are appropriate for the job.**

and limitations of each equipment choice in order to select equipment appropriate to the job.

Blocks and Pulleys

The terms **block** and **pulley** are sometimes used interchangeably. A pulley is a small wheel with a grooved rim (sheave) where a rope can run. Most pulleys require a separate connecting link to attach them to a rope or other equipment. The term "block" refers to heavy-duty pulleys that have an integrated connection point for attaching a rope sling. Many blocks are designed to be opened from the side to insert the bight of a rope. This is a nice feature because the climber does not have to run the rope through from the end.

Tree workers sometimes use blocks in rigging. A **block and tackle** can be used as part of a **mechanical advantage** system to increase the pulling power on a rope. More commonly, blocks are hung in trees to form a **false crotch**. This technique will be described later.

Using a block can reduce wear on the rigging lines. Friction created by running the ropes through tree crotches can be virtually eliminated when the rope is run through a block instead. The use of blocks, when rigged correctly, can decrease the force needed to pull or lift an object. Compared to running lines through tree crotches, blocks can decrease wear on ropes, reduce dynamic loading, allow ropes to be loaded more evenly, and limit damage to the tree.

Blocks and pulleys are constructed of steel, aluminum, or some combination of the two. Because these devices can be subjected to dynamic loading, strength and fatigue properties are a concern. **Arborist blocks** are heavy-duty pulleys with a large, rotating sheave for the lowering line and a smaller fixed sheave to accept a rope sling. These blocks are designed specifically for arborists and are descendants of large, industrial snatch blocks. Most significantly, the side plates of an arborist block extend beyond the sheaves to protect the line from abrasion.

Another type of pulley commonly used in arboriculture is the **rescue pulley**. Rescue pulleys are designed for static, overhead rigging, where the loads are known and very low friction is required. They are not designed for heavy or dynamic loading.

FIGURE 6.11 Rescue pulley.

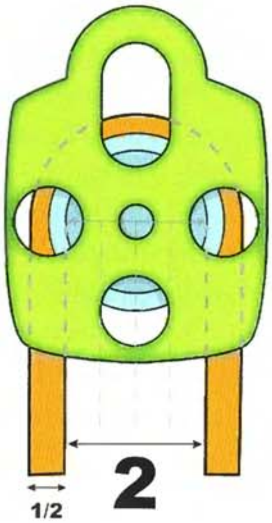


FIGURE 6.12 A rule of thumb is to use a pulley with a diameter that is at least four times the rope diameter, a bend ratio of 4:1.

It is important to consider rope type and size when using blocks in rigging. Never try to squeeze an oversized rope into the block; it will not function properly and could damage both the block and the rope. A rule of thumb is to use a pulley with a diameter that is at least four times the rope diameter, that is, a **bend ratio** of 4:1. Braided ropes generally work better with blocks than 3-strand ropes. Also, be sure to inspect and maintain the blocks. A spur of metal can destroy a rigging line.

Connecting Links

Connecting links are used to make a faster or more convenient connection between a rope and another piece of equipment. Most connecting links are not designed for dynamic loading, which eliminates their use in most trunk- and top-removal operations.

While aluminum is preferred for climbing because of its light weight, steel has far better strength and fatigue properties. With heavy loads, many loading cycles, and the potential for dynamic loading, steel connecting links are the correct choice in rigging.

Screw links (also known as quick links) can be a useful tool for a connector that does not need to be opened frequently. They are strong for their compact size, but, as with other screw-locking connectors, there is the potential to open accidentally. Any case

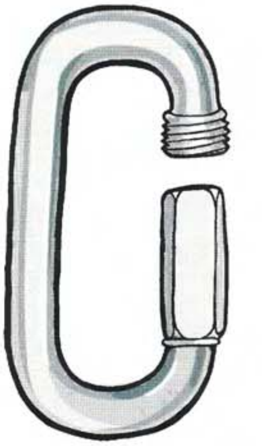


FIGURE 6.13 Screw link.

FIGURE 6.14 Clevis.

in which a rope may run over the screw gate should be avoided. Unlike screw-lock carabiners, the screw link can be secured with a wrench.

Clevises or **shackles** are common in industrial rigging. They are easily found in large sizes and are a good substitute when large screw links are not available. The constraints on their use are also similar to those of screw links.

Carabiners are used to attach or connect rigging equipment and ropes. They may be used to hang pulleys, secure ropes, or connect rigging devices together. Carabiners are available in a variety of sizes and strengths. Only heavy-duty steel carabiners should be used in rigging operations, and carabiners with **locking** or **double-locking gates** should be selected. Carabiners must always be loaded along their major axes. This reduces the stress on the gate, which is the weakest point of the carabiner. Note that the rated tensile strength of a carabiner is based on loading along the major axis. When loaded in any other manner, the carabiner will not be as strong. Carabiners should be inspected regularly. Always check to see that the gate is functioning properly.

Slings

A **sling** is a loop of rope, sewn nylon tubing or webbing, or a section of **eye-spliced rope** designed as a quick, convenient way to attach ropes, tools, and equipment together or to tree parts. Slings come in a variety of sizes and lengths. Most are capable of withstanding heavy loads. Usually a webbing sling is placed in a tree by wrapping it around the limb and looping it upon itself in a choker fashion (girth-hitch), although there are other ways to configure a webbing loop sling.

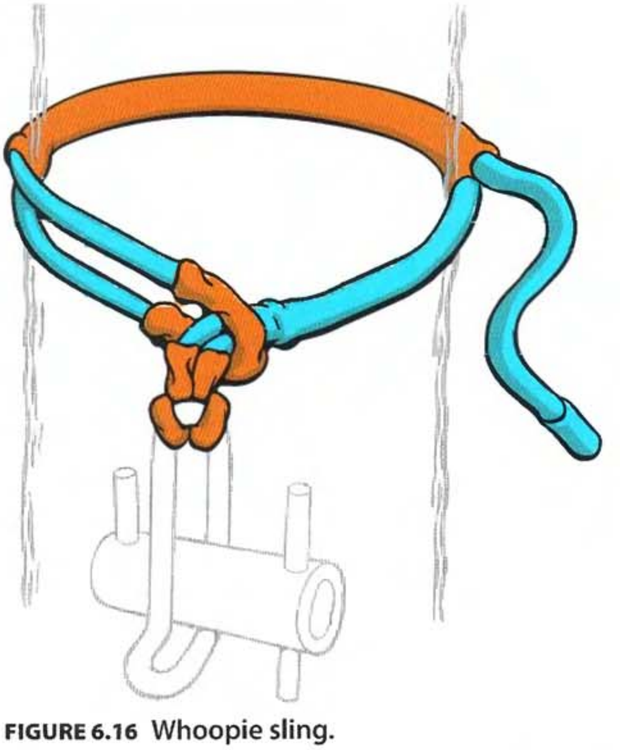


FIGURE 6.16 Whoopie sling.

FIGURE 6.15 Carabiners are available in a variety of sizes and strengths. Only heavy-duty steel carabiners should be used in rigging operations, and carabiners with locking or double-locking gates should be selected.

An alternative to using a webbing sling is the use of an eye-spliced rope sling to secure rigging in a tree. It may be attached to the tree using a cow hitch, a timber hitch, or various other knots. The "eye" of the sling is used to hang the block or other rigging equipment, usually girth-hitched to the hardware. Never pass the load line through the eye of a sling. Another variation is the adjustable eye-to-eye sling, sometimes called a "**whoopie sling**." This type of sling has a fixed eye and an adjustable eye, which allow for great versatility in length adjustment.

Slings also can be spliced with an eye at both ends. In larger diameters, these slings are useful in balancing limbs; in smaller diameters, they are useful to tie a midline attachment. **Eye-to-eye slings** also can be made adjustable.

Friction Devices

Arborists rely on friction to help control loads when lowering branches out of a tree. Historically, rigging lines were wrapped around the trunk of the tree to add some friction. It takes experience to get this right, because not all trees are alike and carrying armfuls of rope around the tree has never been much fun. **Friction devices** have been designed for tree work, and they have some obvious control advantages over taking wraps around the tree. The wear on the rope is much less, and taking up slack is easier. With a friction device, wraps can be taken in the middle of the rope.

Designed specifically for tree work, the Port-a-Wrap III™ is the lightest-duty portable friction device for use in lowering limbs. It is available in steel or aluminum. It is tied to the tree with a sling, and the rigging line is wrapped around it any number of times to add friction.

In tree work, a **bollard** is a post that straps to the tree and is used for taking wraps in a **load line**. The large diameter provides a favorable bend ratio, which minimizes strength loss in the rigging line. This type of device is more appropriate than a Port-a-Wrap™ for very heavy loads.

Some bollard-type lowering devices are designed with a ratcheting system that allows the arborist to remove slack from the line or even lift a load and then lower it. The Hobbs Lowering Device™ is an example of a ratcheting bollard.

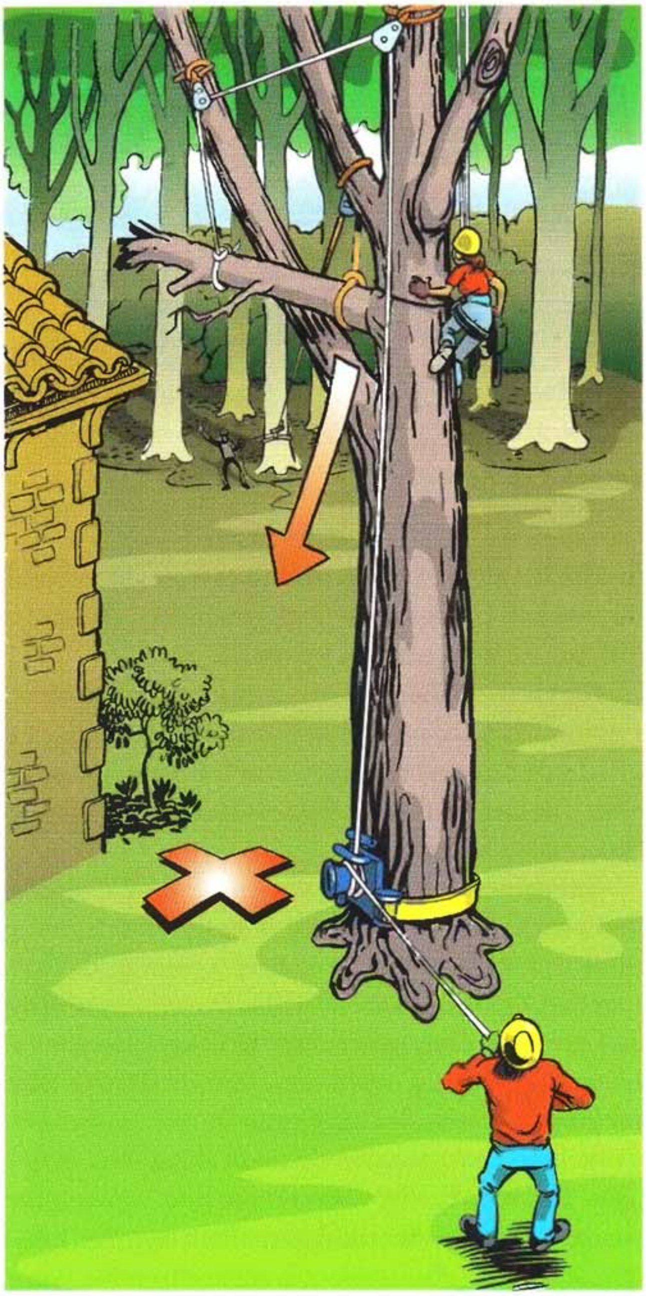


FIGURE 6.17 **Friction devices have been designed for tree work, and they have some obvious control advantages over taking wraps around the tree. The wear on the rope is much less, and taking up slack is easier. With a friction device, wraps can be taken in the middle of the rope.**

The Good Rigging Control System (GRCS)™ is a self-tailing nautical winch that can be installed on a tree-mount frame. The winch provides a powerful, efficient means of lifting. The modular design allows a fixed aluminum drum to replace the winch in the frame strapped to the tree for use in controlling friction when there will be heavy shock-loading. This will save wear on the winch.

A number of other devices have been developed for similar rigging or belaying purposes. Most are designed with steel or aluminum piping, around which wraps can be taken with a rope. Some of these, such as the Port-a-Wrap™, have proven very effective for rigging small to moderately sized loads. They are significantly less expensive than heavy-duty lowering devices, but they should not be used for heavy loads.

Any friction device dissipates energy from the falling wood by converting it to heat, rather than stretching the rigging line. Therefore, arborists must be aware of possible heat damage to rigging lines running on metal surfaces. Some bollards are designed with cooling systems to help with heat dissipation.

As with all equipment, it is important to receive proper training before using these devices. Most manufacturers provide instructions and safety precautions for use. Never integrate a new piece of equipment or technique into your rigging arsenal without first gaining experience by using it in situations where damage is unlikely.

Basic Rigging Techniques

Knowledge and experience will improve a climber's arsenal of rigging techniques. As learning progresses, a climber will come to understand more of the variables to be considered. It is important for novice riggers to be introduced to the thought processes involved in planning a rigging operation. What are the limitations of the tree and site? What equipment and techniques will be employed? Skill in planning for different options comes with experience and can make rigging operations safer and more efficient.

The tools and techniques used in rigging vary with the situation. When removing limbs from a tree that is being pruned, care must be taken not to damage the remaining branches and trunk. When rigging for removal, the climber has more options in how to work the tree. The simplest form of rigging involves the use of ropes, wraps on the trunk, and natural crotches used as rigging points. More sophisticated techniques require a better understanding of the advantages and limitations of the equipment and methods involved.

There is always more than one way to get the wood and brush to the ground, but the best method is the one that maximizes productivity while still maintaining safety. An investment in equipment and education into the science behind the equipment can pay off by making the work easier, reducing wear on tools, and allowing larger sections to be safely removed.

Sometimes the branches or wood to be removed can be landed safely on the ground without the use of ropes, that is, by using the cut-and-chuck method. If pieces must be roped down, the generally preferred technique is to position the rigging point above the work. This technique helps minimize the load on the rigging line and provides more control of the piece. A load line (rigging line) is run through a rigging point above the limb or piece to be removed and then tied to the piece.

The first choice to be made is whether to run ropes through natural crotches or through a false-crotch block. Natural crotches can be fast and effective, but the running rope can injure the tree and increase wear on the rope.

Installing a False Crotch

The use of arborist blocks for rigging points has gained widespread use—and with good reason. They provide more consistent friction, and the entire rigging line can function to absorb shock load. Placement is not limited to location of natural crotches.

The block should be as high as possible and away from the climber's tie-in point, if safe and practical. More rope in the system functions to reduce shock loads, so height can be an advantage for force reduction. It is best for the rigging point and the climber's tie-in point to be in different parts of the tree whenever possible. Position the block so limbs swing away from the climber and obstacles. Ideally, the rigging point is positioned so that the piece being removed will not become entangled in the rigging, the climber's line,

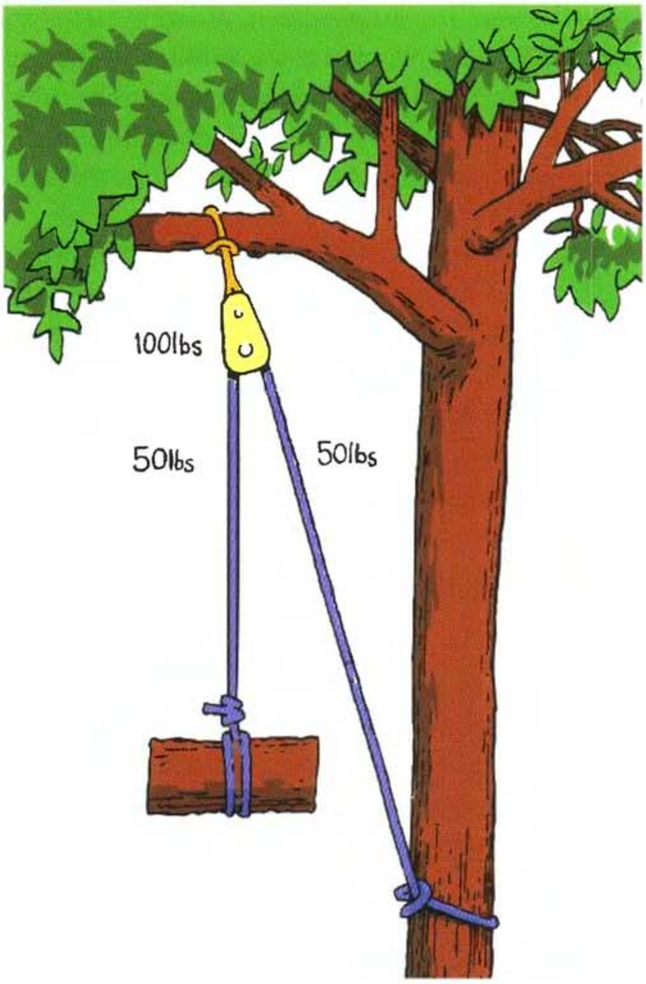


FIGURE 6.18 Reaction forces at the block can be as much as twice the load in the rigging line.

or other parts of the tree. Exercise care when setting blocks away from the main stem. Bending caused by reaction forces on limbs can cause limb failure.

The spliced-eye rope sling that holds the block should have a working load limit *twice* that of the rigging line. Reaction forces at the block can be as much as twice the load in the rigging line (plus friction). Place the eye splice over the fixed sheave of the block. The diameter of the fixed sheave should be at least three times the diameter of the sling (a bend ratio of 3:1). The length of the eye splice should be at least three times the diameter of the sheave so there is not undue stress on the throat of the splice.

Attach the block to the tree with a **cow hitch**. To make this knot, lead the working end of the sling around the stem, under the splice, and back around in the opposite direction. Pass the end through the bight formed at the splice and remove all slack. Tie a **half hitch** around the splice so it jams against the bight formed earlier. Spiral any excess rope between the tree and the turns of the hitch.

Tying Off the Wood

Most limbs or wood sections are tied off with one of two knots, a **running bowline** or a **clove hitch** with two half hitches. A running bowline is easily tied and removed, even after loading. It can be tied at a distance from the object and slid up the line to the desired location. If a clove hitch is used, it must be followed up with two half hitches to prevent the hitch from rolling out. With a clove hitch, bends in the knot are more favorable (less strength loss) than with the running bowline.

If the rigging line is attached at the butt end of the piece to be removed, it is said to be **butt-tied**. The piece will normally drop tip down. The climber must

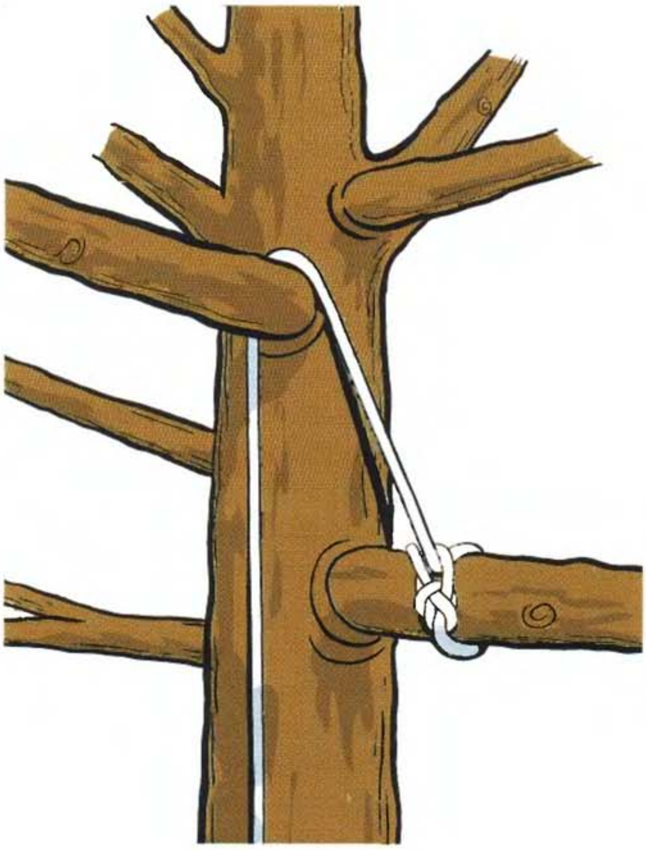


FIGURE 6.19 A limb is said to be butt-tied if the load line is attached at the butt end.

be positioned to avoid contact with the rigging line or being hit by the butt.

Tip-tying attaches the rigging line toward the tip of the branch being removed. If the limb is tip-tied and dropped, the butt end will drop away from the cut, and the swing of the limb will depend on the placement of the rigging point. The climber must be positioned to avoid being struck by the swinging limb. A limb might also be tip-tied and lifted to avoid hitting an obstacle below.

At times, it is essential to minimize the swing or drop of a limb. Rather than tip-tying or butt-tying, a separate rope tool can be used to **balance** the limb, helping reduce swing and dynamic loading. An advantage is that it allows the climber to remove a limb as one piece. Also, dynamic loading can be minimized, especially if the rigging point is directly above the work. Various types of equipment and procedures can be used with this technique.

A balancer can be nothing more than a length of rope tied to the limb at the tip and butt with running bowlines (or other means of attachment). A separate loop is tied into a Prusik at the center and provides a way to adjust in order to find the balance point. The rigging line can have either a loop tied into the end or an eye splice to clip a heavy-duty steel carabiner (or other heavy-duty connecting link) to the Prusik loop. Always consider whether the limb will swing and whether a tagline is needed.

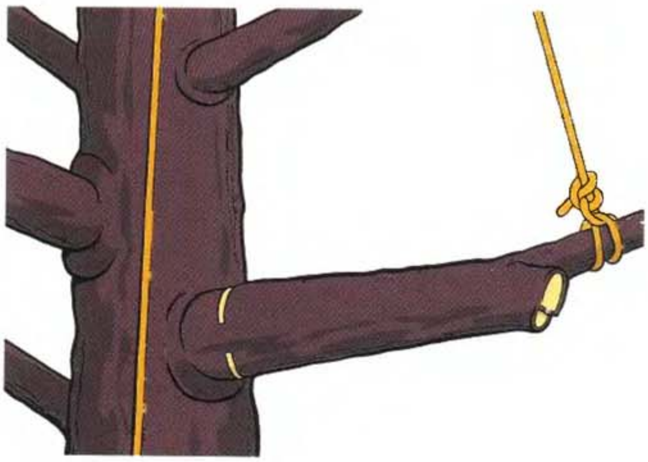


FIGURE 6.20 **If the rope rigging line is attached at the far (brush) end, the piece is tip-tied.**

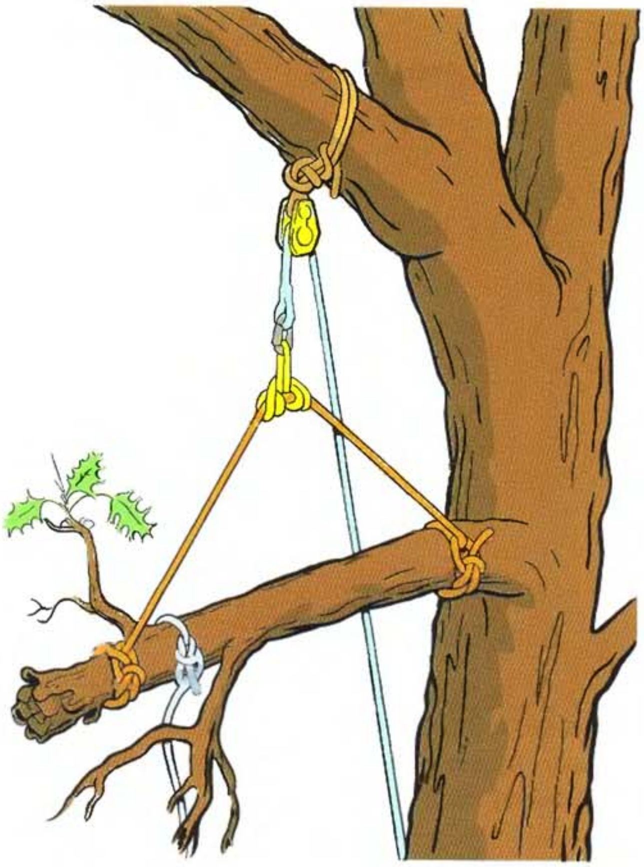


FIGURE 6.21 **Rather than tip-tying or butt-tying, a separate rope tool can be used to balance the limb, helping reduce swing and dynamic loading.**

A **tagline/pull line** is a rope tied to the piece and controlled by a ground worker, but which is neither run through a rigging point nor used for lowering. A tagline may be used with any of the other techniques.

It can be attached at any point to help control the swing or direction of the limb, or it may be pulled or tied off to prevent unwanted movement. A tagline may be attached to pull over the top of a tree (pull line) or pulled to cause a limb to swing in a particular direction (as with a limb hinged to the side).

As mentioned previously, it is always preferable to establish a rigging point above the work. There are situations, however, where a rigging line cannot be anchored above the work, such as in removals after all the brush has been removed and the trunk remains. **Butt-hitching** is a common technique in which a piece is tied above a cut and the line is run through a block or crotch below the cut. This can be one of the most demanding techniques for a rope

FIGURE 6.22 A tagline may be attached to help the ground worker control the piece being removed.

techniques and discusses the science involved.

Cutting Techniques

Once the limb is rigged for removal, the climber must decide on the appropriate method of cutting the limb. The **drop cut**—the classic three-point cut—dates back to the early years of arboriculture and appears in almost every pruning text as the recommended technique for removing large limbs. It consists of an undercut and a top cut farther out on the limb, then a final cut to remove the stub after the limb has been removed.

When using a chain saw, arborists should form the top cut directly above the undercut to avoid getting

FIGURE 6.23 Butt-hitching is a common technique in which a piece is tied above a cut and the line is run through a block or crotch below the cut.

because the possibility of shock-loading is so high. Because there are no high tie-in points, it can also be dangerous for the climber. Specific training for this technique is essential.

This text is introductory in nature and presents only the most basic of rigging techniques. Arborists wanting to advance their skill and knowledge of rigging are encouraged to study *The Art and Science of Practical Rigging*, an eight-part video series and study guide published by the International Society of Arboriculture. This series details many of the more advanced rigging

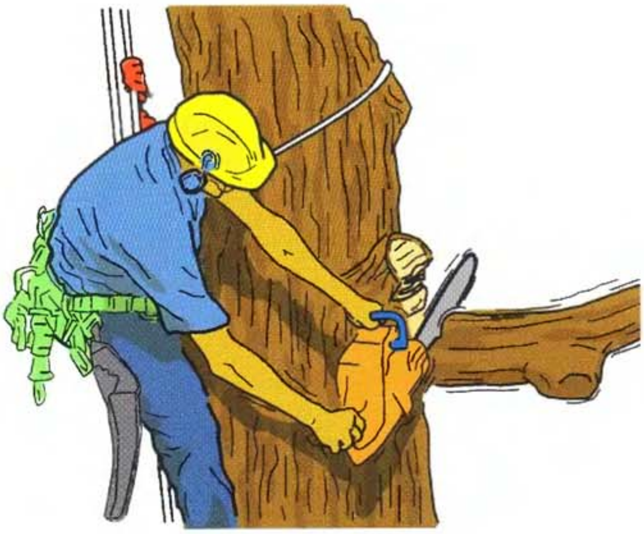


FIGURE 6.24 When using a chain saw to make a drop cut, climbers should form the top cut directly above the undercut to avoid getting the bar stuck in the kerf of the cut as the limb breaks free.

FIGURE 6.25 A snap cut is made by cutting slightly more than halfway through a section from the side, then cutting from the opposite side, about an inch or more offset from the first cut.

the bar stuck in the **kerf** of the cut as the limb breaks free.

A cut that is handy for controlling relatively small sections of wood that may not require roping is the **snap cut.** This cut is made by cutting slightly more than halfway through a section from the side, then cutting from the opposite side, about an inch or more offset from the first cut. The distance apart will need to be larger for larger limbs. The two cuts will bypass, but the fibers should hold. The saw can then be shut off and the remaining piece broken off manually. A snap cut can be used to remove the final stub from a large branch that has been removed.

FIGURE 6.26 A snap cut can be used to remove the final stub from a large branch that has been removed.

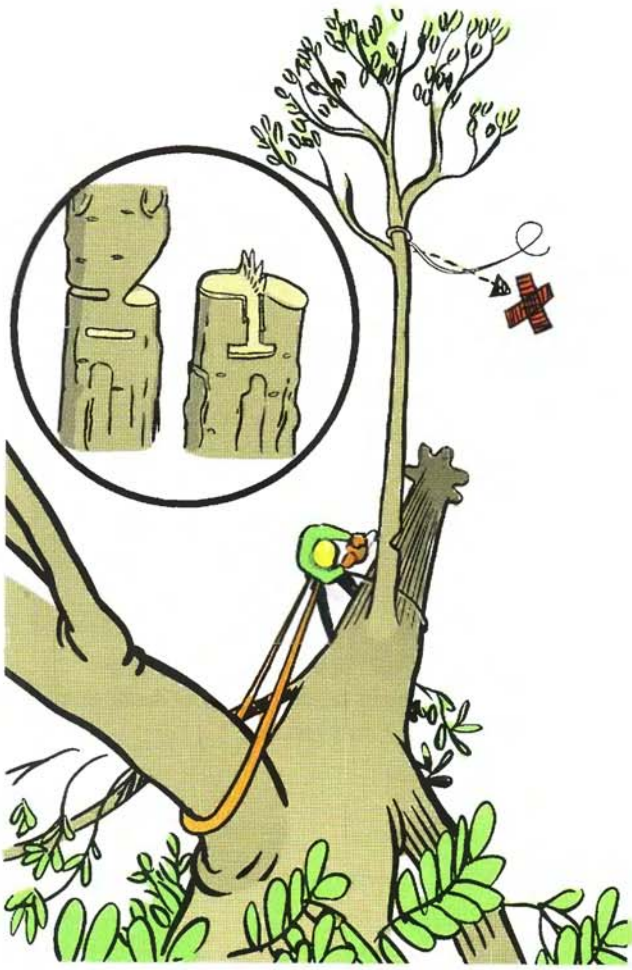


FIGURE 6.27 A hinge cut uses a notch and back cut to form a hinge that can help "steer" the limb.

The **hinge cut** is a variation of standard tree-felling techniques and is referred to as a topping cut when taking a vertical top out of a tree. It employs the use of a **notch** and back cut to form a hinge and "steer" the limb. It can be used to swing a limb around rather than simply dropping the branch to the ground. Unless the limb is supported with a rigging line, there is a limit to how much the climber will be able to swing the limb before the hinge breaks. If the hinge is formed too far around the side of the limb, the hinge may be ineffective and may break before the limb swings.

The strategy for piecing out a tree depends on the circumstances. The climber must plan the order of removal to avoid being left with a limb that is too difficult or dangerous to remove. A general rule of thumb is

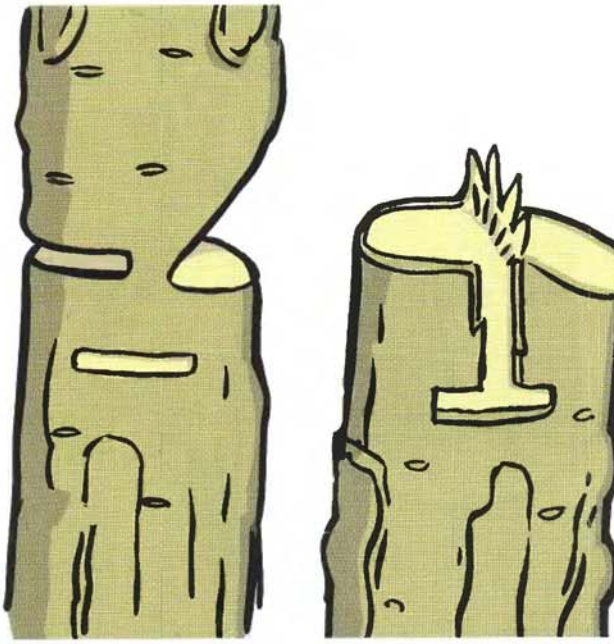


FIGURE 6.28 **Small "kerf" cuts can be made to prevent the fibers from tearing too far back and damaging limbs that will remain.**

to clear a pathway for the limbs, removing brush first. It is often better to leave a few limbs with brush to dampen the rigging forces, especially when taking out the top. Removing the easiest limbs first can sometimes cause problems when trying to rig limbs later. As with all aspects of removal, the key to safety is to use equipment that can handle the load and to ensure that the tree can handle the load. Workers must avoid trying to take out a section that is too big and must always consider what could happen if some component of the rigging failed. The climber and all ground workers must be clear of danger in the event of something breaking unexpectedly.

Role of the Ground Worker

Ground workers are an essential part of a rigging operation; they set up friction devices, run lines, detach ropes, and send equipment and lines up to the climber. Safety is dependent on good communication between the climber and the ground workers. The **landing zone** (drop zone) is the area beneath the tree where pieces are to be dropped or lowered. There must be a clear and efficient means of communication between climbers and ground workers so that each knows when it is safe for a ground worker to enter the landing zone.

The voice **command-and-response system** ensures that warning signals are heard, acknowledged, and acted upon. The climber warns, "Stand clear," but does not proceed until hearing the acknowledgment, "All clear." Additionally, when ground workers want

FIGURE 6.29 **The voice command-and-response system ensures that warning signals are heard, acknowledged, and acted upon. The climber warns, "Stand clear," but does not proceed until hearing the acknowledgment, "All clear."**

to enter the landing zone, they must communicate with the climber to indicate that they want to come underneath and must wait for the acknowledgment before entering. Sometimes hand signals are used as well.

Perhaps the ground worker's primary role in rigging operations is "running the ropes." The ground worker takes wraps in the rigging line, either on the trunk of a tree or on a friction device. These wraps add friction back into the system for controlled lowering. **Note: Never wrap a line around any part of your body or stand where you could be entangled in running lines.**

Once a piece is cut and begins to fall, it will create a dynamic load on the rigging line. A skillful ground worker can minimize this effect by gradually letting out more rigging line into the system before bringing the piece to a stop. This is called "letting it run." It can be used only if the situation allows for the piece to be lowered in this manner.

It is common sense not to stand under the piece being lowered, but that is not enough. All workers must consider what would happen if any element of the rigging system failed or if a section of the tree were to break off. This means staying "outside" of the rigging so that if a rope snaps or a piece of equipment breaks, nobody will be struck. Never stand on a rope or in a position where the rope feeds from behind you. Keep the climber's line from being tangled in rigging lines or limbs on the ground. Rope bags are a big help in keeping the lines clear and clean. Always wear gloves when running rigging lines.

In addition to sending up equipment and running and returning the lines, ground workers can assist the climber in judging distances and selecting methods. Climbers and ground workers function most safely and efficiently when they learn to work as a team.

Matching

_____ tensile strength	A. rope that controls swing of piece
_____ carabiner	B. heavy-duty pulley for rigging
_____ sling	C. breaking strength under static load
_____ block	D. attach rope to far (brush) end of limb
_____ false crotch	E. length of rope or webbing to attach hardware
_____ butt-tied	F. used to connect ropes and equipment
_____ tip-tie	G. installed rigging point, not at a natural crotch
_____ tagline	H. tied off at large end of limb

True/False

1. T F Shock-loading results when ropes are used to stop heavy limbs in motion or free fall.
2. T F The greater distance a limb drops before its motion is stopped, the greater the load on the rope.
3. T F The use of knots increases the working-load limit of a rope.
4. T F Dividing the published tensile strength of a rope or piece of equipment by the design factor yields the working-load limit (WLL).
5. T F Tensile strength is determined under a steady load.
6. T F Dynamic loads damage ropes and other equipment more quickly than equivalent static loads.
7. T F Heat and friction are not a problem with synthetic ropes.
8. T F Carabiners are always oval, aluminum, and have a spring-loaded gate.
9. T F Compared to running lines through tree crotches, blocks can decrease wear on ropes, reduce dynamic loading, and limit damage to the tree.
10. T F Rescue pulleys are heavy-duty pulleys, with a large rotating sheave for the lowering line and a smaller fixed sheave to accept a rope sling.
11. T F The advantages of friction devices over taking wraps on the tree trunk include reduced wear on the rope and ease of taking up slack.
12. T F In tree work, a bollard is a post that straps to the tree and is used for taking wraps in a load line.
13. T F Using pulleys can reduce the wear on rigging lines.
14. T F If the load line is rigged at the brushy end of a limb, it is butt-tied.
15. T F Taglines, or pull lines, are used to carry the weight in lowering limbs.
16. T F An advantage to balancing a limb is that it can help reduce swing and dynamic loading.
17. T F A hinge cut is made by cutting slightly more than halfway through a section from the side, then cutting from the opposite side, about an inch or more offset from the first cut.

18. T F A cut that is handy for controlling relatively small sections of wood that may not require roping is the snap cut.

19. T F A skillful ground worker can minimize the effect of dynamic loading created by stopping a falling limb with the rigging line by "letting it run."

20. T F Ground workers should never wear gloves when operating the ropes in rigging operations.

Matching

_____ drop cut	A. force opposite the relative motion
_____ running bowline	B. used to take wraps on load line
_____ false crotch	C. area where pieces are dropped or lowered
_____ friction device	D. classic three-point cut
_____ landing zone	E. forces on stationary objects
_____ mechanical advantage	F. knot used to tie off limbs
_____ statics	G. can multiply pulling power
_____ friction	H. rigging point for load line

Sample Test Questions

1. An advantage to using a false crotch instead of a natural-crotch rigging point is
   a. more flexibility in placement of the rigging point
   b. the friction is more controlled
   c. it minimizes damage to the tree
   d. all of the above

2. The reaction force at the rigging block can be
   a. half the load in the rigging line
   b. twice the load in the rigging line
   c. greater when lifting limbs
   d. increased if a low-friction block is used

3. Dynamic loads in a rigging system are a concern because
   a. the load can be many times the weight of the piece
   b. shock-loading is tougher than static-loading on the hardware and ropes
   c. they can be more difficult to estimate or predict
   d. all of the above

CHAPTER 7

Removal

CHAPTER 7

Removal

IMPORTANT TERMS

tagline
pull line
notch
back cut
open-face notch
conventional notch
Humboldt notch
hinge
barber chair
bore cut
limbing
bucking
cant hook
peavey

Introduction

Tree removal is a significant part of the tree care profession. Trees may have to be removed for a variety of reasons. The most obvious reason for removal is death of the tree. Often trees must be removed because they pose a hazard to people or structures. Some trees have to be removed for future construction.

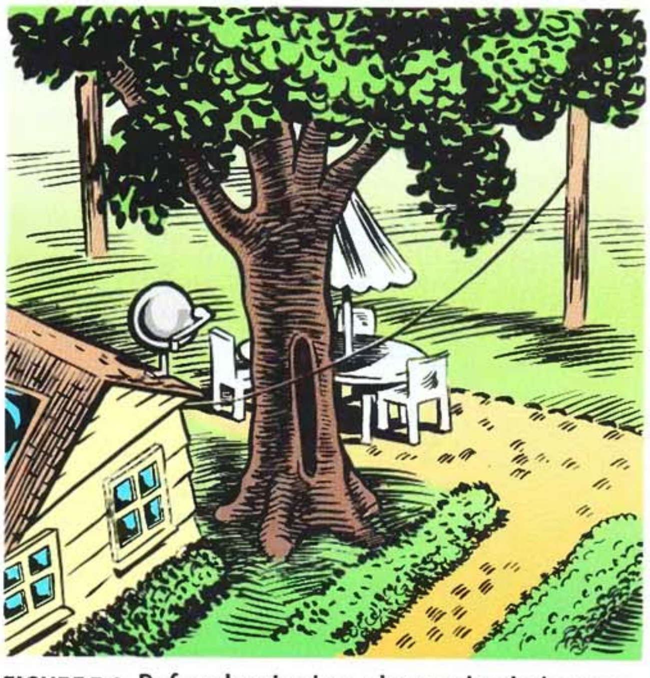


FIGURE 7.1 Before beginning, always check the tree and site for potential hazards, obstacles, or anything that could affect the removal operation.

Whatever the reason for removal, safety is the most important concern. A tree climber should be proficient in tree removal techniques. Some of these techniques are described in the previous chapter. This chapter will deal mostly with felling, bucking, and limbing procedures.

Preparation

Before beginning any felling operation, it is important to inspect the tree and site. As with all tree care operations, a job briefing and work plan are essential before beginning work. The surrounding area should be checked and cleared of obstacles, such as lawn furniture and play equipment. Note the tree height and width of the crown. There must be no doubt of adequate space to drop the tree. Also be aware of any utility lines in the vicinity. Consider the possibility of branches breaking off upon impact and being hurled from the tree. If necessary, protect windows and other structures in the area.

Consider the condition of the tree. Beware of decay, broken or dead branches, cracks, cavities,

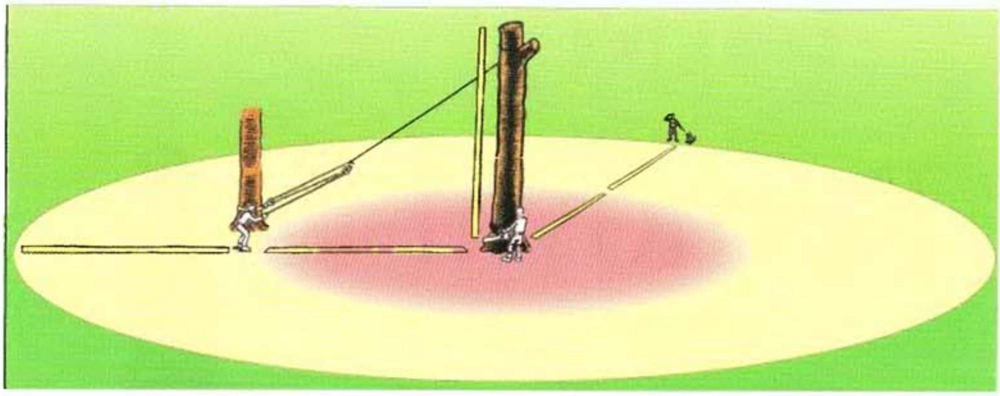


FIGURE 7.2 **Workers who are not directly involved in the removal operation should be two tree lengths away from the tree being felled. Those involved, including those on the tagline, must be at least one tree length away, have an established means of communication with the feller, and have a planned escape route.**

is side lean, the worker should finish the felling cut on the opposite side. Take the weight distribution of the crown into account. A good tree worker is also familiar with the properties of various trees, such as wood strength and weight.

Another important factor to consider is the wind. Note the direction of the wind and its force. Is it steady and regular or gusty? A strong gust of wind can alter the direction in which a tree falls.

Once the site has been prepared and the tree inspected, the felling should be planned. The workers must decide what method will be used to fell the tree and what equipment will be needed. All workers must have a clear understanding of their responsibilities.

Workers who are not directly involved in the removal operation should be two tree lengths away from the tree being felled. Those involved, including those on the tagline, must be at least one tree length away, have an established means of communication with the feller, and have a planned escape route. The preferred escape route for the chain-saw operator in

and other faults that may affect the felling operation. Extra precautions must be taken when felling decayed or hollow trees to control the direction of fall. Note the shape and lean of the tree. These factors affect not only the felling direction but also where the saw operator should stand when making the cut. If there

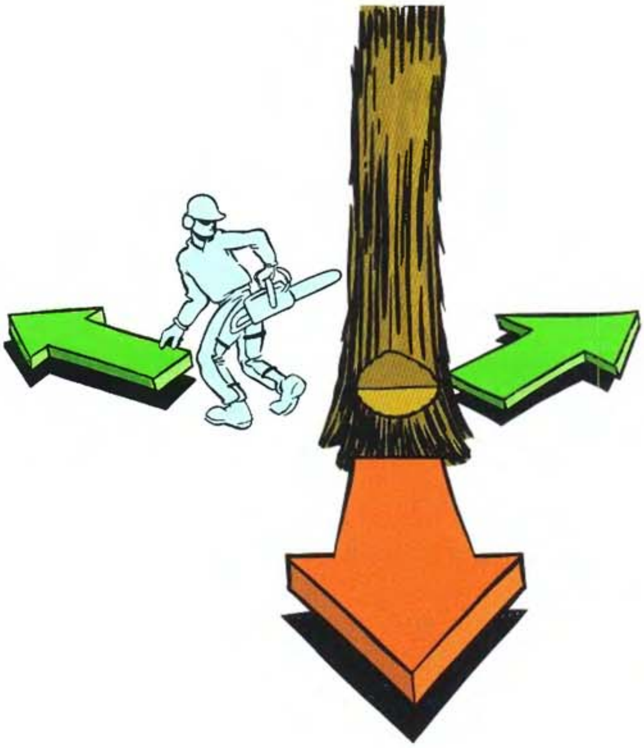


FIGURE 7.3 **The preferred escape route for the chain-saw operator in a felling operation is 45 degrees on either side of a line drawn opposite the intended direction of fall.**

FIGURE 7.4 **Use of a pull line for extra control in tree felling.**

FIGURE 7.5 A pulley added to the system will reduce friction on the rope.

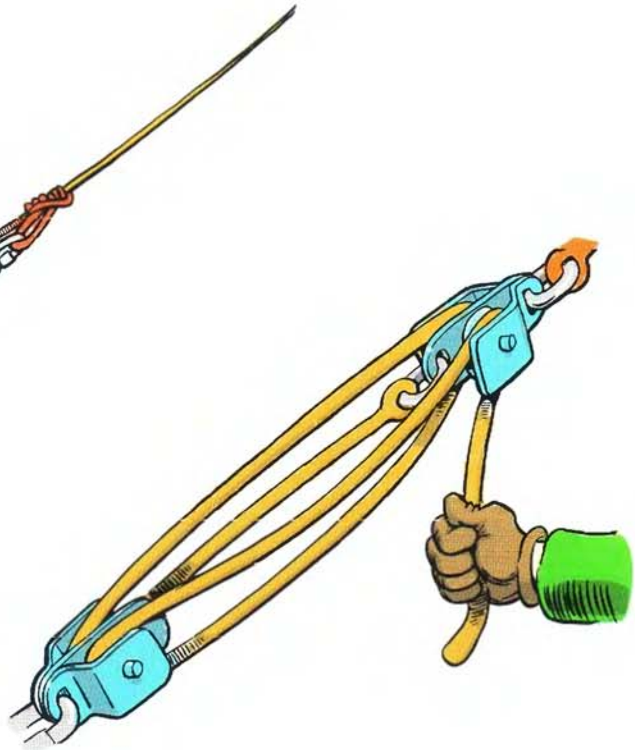


FIGURE 7.6 Mechanical advantage can be added to the pull line by using a block and tackle.

a felling operation is 45 degrees on either side of a line drawn opposite the intended direction of fall. As soon as the tree starts to fall, the feller should move away in this direction but should not turn his back to the tree.

Many times, in the situations under which arborists work, trees must be rigged for removal. Other times, they can be felled using a **tagline (pull line)** for added control. This can often be accomplished without climbing the tree. A rope can be set using a throwline. The pull line can then be attached and pulled through the crotch. A running bowline can be tied at ground level and pulled up into the tree. Be sure the pull of the rope is in a direct line that will not create a twisting or torquing pull. If the rope detours around a limb creating a dogleg in the rope, the tree may pivot, breaking the hinge and misdirecting the fall. Mechanical advantage systems such as a block and tackle may be used to apply extra tension to a rope or to compensate for the lean of a tree.

Estimation of Height

It is important for tree workers to be able to estimate the height of the tree (and thus its position when felled). Accurate height estimation will help avoid hitting obstacles. Remember that the height of the felling cut will affect the distance that the top of the tree reaches when it is felled.

Most techniques for height estimation are based upon a geometric principle of similar right triangles. There are devices available to assist workers with height estimation. Another technique employs nothing more than a straight stick.

Hold the stick so that the distance from your eye to your hand equals the distance from your hand to the top of the stick. Hold your arm horizontally and the stick vertically. Walk forward or backward until the distance from your hand to the top of the stick is proportional (visually equal) to the distance from the felling cut to the top of the tree.

There are some limitations to this method. The estimation technique assumes that the tree is vertical, the ground is level, and the top of the tree can be seen. Also, it may be necessary to adjust for the difference between your height and the height of the felling cut.

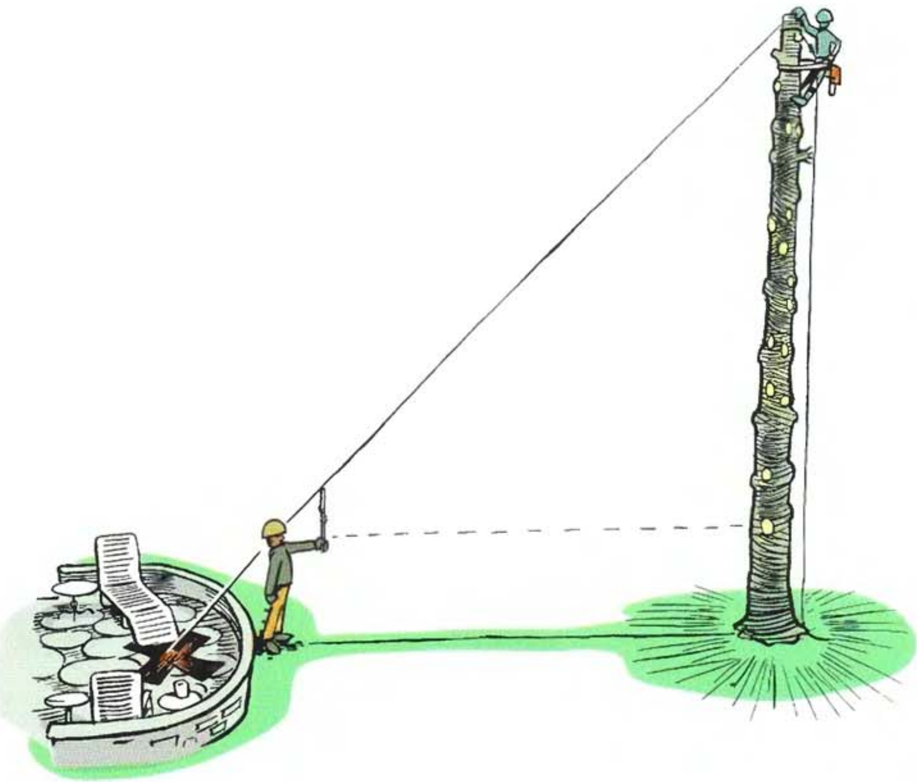


FIGURE 7.7A Most techniques for height estimation are based upon a geometric principle of similar right triangles.

FIGURE 7.7B Find the position at which the distance from your hand to the top of the stick visually equals the height of the tree from the cut.

Felling

Trees should be felled using a **notch** and **back cut**. Felling notches and back cuts must be made high enough above ground level to enable the chain-saw operator to begin the cut safely, control the saw, and have freedom of movement for escape. A number of notch configurations can be used for felling trees, including an **open-face notch**, a **conventional notch**, and a **Humboldt notch**. In the past, a 45-degree notch was commonly used. However, an open-face notch of 70 degrees or more allows the **hinge** to control the tree longer.

A rule of thumb for the depth of the notch is one-third or less of the diameter of the tree. The length of the hinge should be about 80 percent of the tree's diameter. If possible, the notch should not be placed in the vicinity of cracks or decay, because it is important to have solid fiber to form the hinge. It is very easy to bypass the apex of the notch when making the cuts. Bypassing cuts sever the crucial fibers of the hinge and must be avoided.

The hinge is critical in controlling the direction of fall. If the hinge is the proper thickness, the wood fibers should break when the face notch closes. The rule for felling trees is to allow a hinge with a thickness of 10 percent of the tree's diameter, but flexibility in

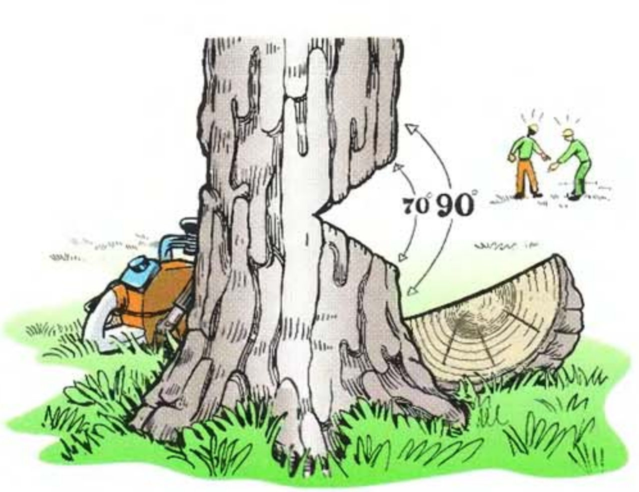


FIGURE 7.8 An open-face notch of 70 degrees or more allows the hinge to control the tree longer.

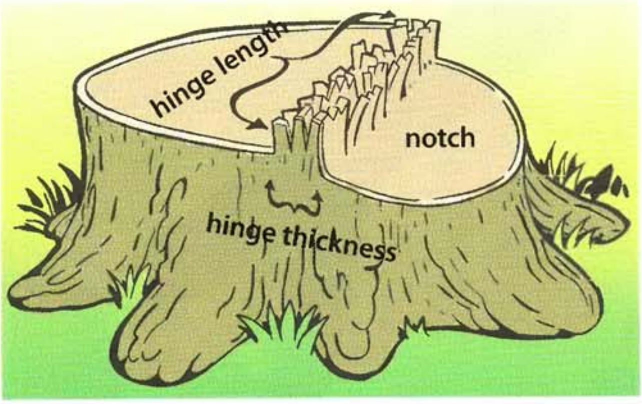


FIGURE 7.9 The hinge length should be about 80 percent of the tree's diameter. The rule of thumb for hinge thickness is about 10 percent of the tree's diameter.

this guideline is in order. For example, when cutting short sections, a hinge thickness of 10 percent may be too much for the climber to break off with limited leverage. Also, for large-diameter trees, establishing a hinge of less than 10 percent may be necessary for the hinge to function effectively. Avoid cutting into the hinge when making the back cut.

The traditional, straight back cut is made from the back of the tree toward the notch. The hinge is formed as the back cut approaches the notch. It is easy to cut through the hinge while making the back cut, especially if the saw operator is looking toward the top of the tree. Most texts recommend making the back cut slightly higher than the apex of the notch to reduce the possibility of the tree kicking back toward the operator when the hinge breaks. This is important when using a traditional (45-degree) notch.

Most instructors now teach the open-face notch, which allows the hinge to control the fall of the tree longer than with the traditional (45-degree) notch. With the open-face notch, the back cut does not need to be stepped higher. It can be cut at the same level as the apex of the notch.

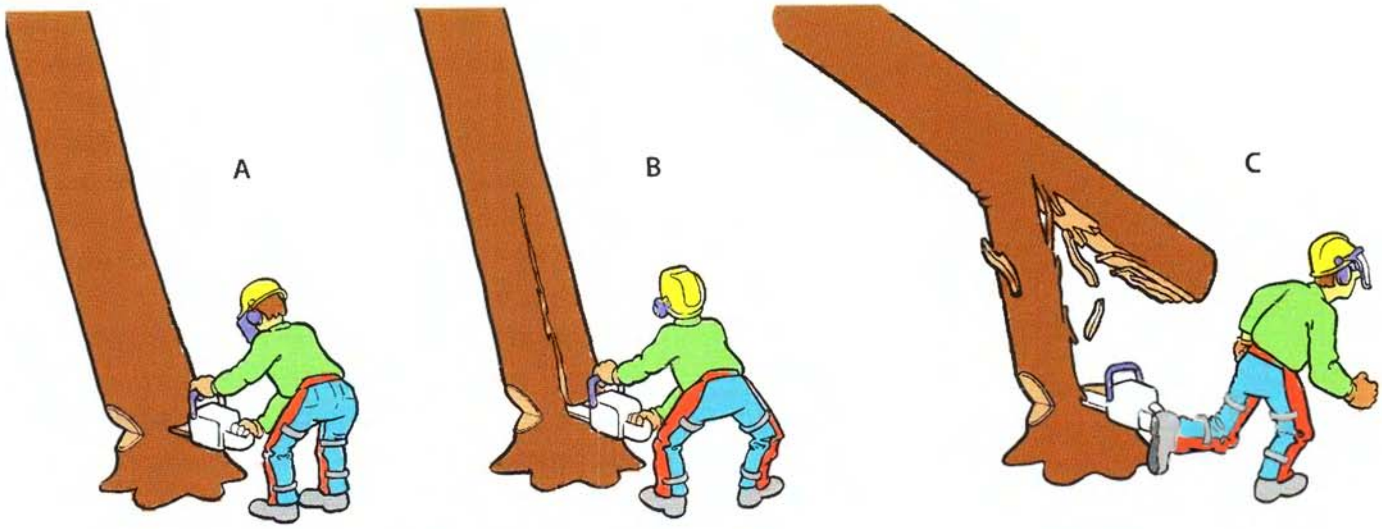
Sometimes, if the tree is leaning in the direction of fall or has internal faults, the tree can split upward from the back cut. This is called a **barber chair**, and it can be very dangerous. The split trunk can hit the person felling the tree, which is often fatal.

One technique that can reduce the chance of creating a barber chair is to use a **bore cut**. The bore cut is made by boring into the tree several inches behind the apex of the notch. Start the cut well behind the desired position of the hinge; once in, carefully cut to the desired thickness of the hinge. Establish the entire hinge to the desired thickness behind the apex of the notch. Cut back from the hinge on both sides of the tree, leaving a strap of wood in the back as holding wood.

If the tree is larger than the bar length of the saw, the "bad" side, or the side with the lean, should be cut first, taking care to cut less than 50 percent through the diameter. Then cut the good side, meeting the cut from the other side. An advantage of this technique is that the operator can stop if necessary, without being committed. If the tree has side lean or significant decay on one side, be sure to finish the back cut on the "good" side of the tree.

Specific training in cutting techniques for felling trees with lean or with flaws can reduce the possibil-

FIGURE 7.10 The worker can position himself to cut the notch facing the desired direction of fall.



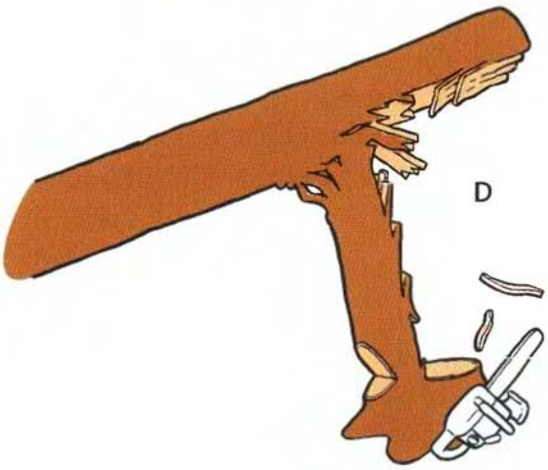


FIGURE 7.11A–D Sometimes, if the tree is leaning in the direction of fall or has internal faults, the tree can split upward from the back cut. This is called a barber chair, and it can be very dangerous. The split trunk can hit the person felling the tree, which is often fatal.

ity of a barber chair occurring. Also, a load strap or logging chain could be secured around the tree above the notch to reduce or prevent splitting. No other workers should be in the area directly behind the tree. The worker making the back cut should plan an escape route at a 45-degree angle to either side of a line drawn opposite the intended direction of fall.

It is a good idea to have felling wedges ready when making the back cut. Wedges can be driven into the back cut to prevent the tree from closing on the back cut and pinching the bar of the chain saw. They may also be used to help initiate the fall.

Limbing and Bucking

After the tree has been felled, it must be sawed up, using a process called **limbing** and **bucking**. Limbing is the process of cutting off all of the side or lateral branches of the tree. Cutting up the main logs and trunk is called bucking. Of course, all chain-saw safety principles apply when limbing and bucking, but some additional safety principles should also be remembered.

First, if more than one worker is working on the tree, extra care should be taken. The cuts that one worker makes can affect the part of the tree where another person is working. One worker may cause the

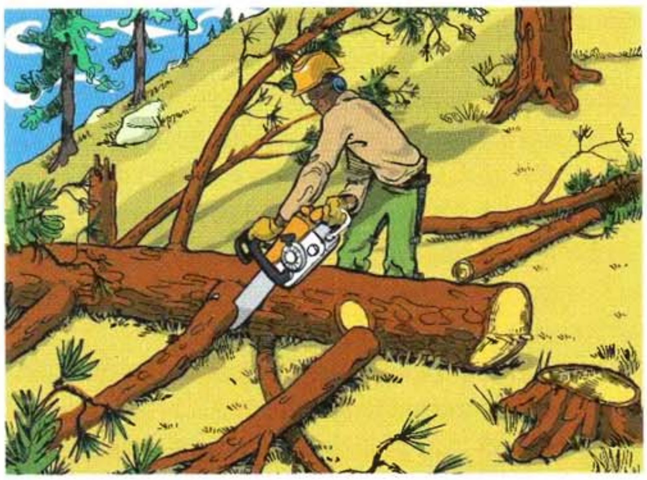


FIGURE 7.12 When limbing a felled tree, stand away from the possible roll of the tree. When practical, cut the limbs on the opposite side. Maintain control of the chain saw using safe operating procedures.

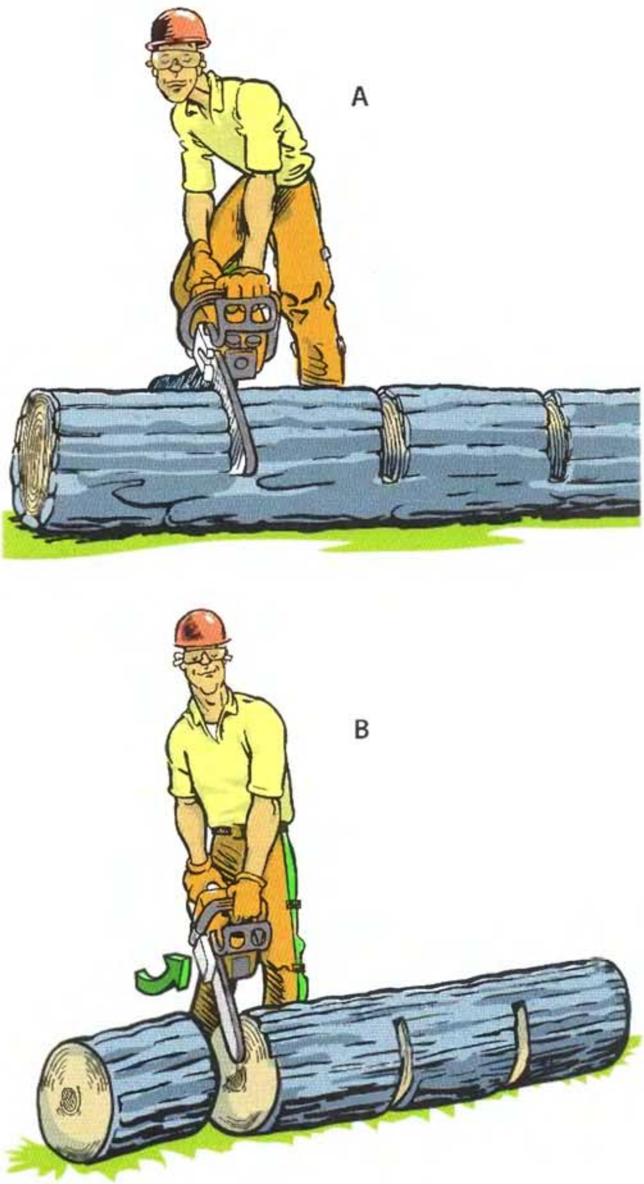


FIGURE 7.13A–B When bucking, cut three-fourths of the way through each cut (top). Then roll the log over to finish the cuts (bottom).

tree to shift or roll, greatly endangering other workers. Each worker must be aware of what the other workers are doing, and care must be taken when approaching a saw operator. Workers should stay on the uphill side of the tree or log and avoid working where the tree could roll toward them. If necessary, the log should be blocked to prevent rolling.

All chain-saw safety regulations and guidelines apply when limbing and bucking trees. Always engage the chain brake when taking one hand off the saw to move a limb or when taking more than two steps

FIGURE 7.14 Position yourself so as to avoid grounding the saw.

with the saw running. It is easy to trip or lose balance when walking around logs and limbs.

The worker should always be aware of the tension of the logs and branches. Branches bent under tension can be hazardous. When the tension is relieved in making the cut, branches can spring back toward the worker. If the worker cuts from the wrong side of a limb under tension, the saw may become pinched. If the limb is under downward pressure, start with a small undercut (or a small notch on the underside of the limb) and then finish the cut from the top to release the branch. If there is upward tension, start

FIGURE 7.15 When bucking a log, keep your body away from the chain-saw path. Leg protection is required by ANSI.

FIGURE 7.16 Take care when sawing to avoid a kick-back situation.

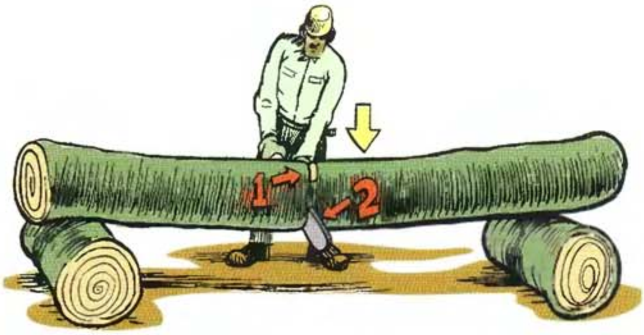


FIGURE 7.17 If there is upward pressure on the limb, start with a small top cut and finish from below.

FIGURE 7.18 If the limb is under downward pressure, start with a small undercut, then finish from the top.

FIGURE 7.19 Safe and proper use of tools, such as the cant hook and peavey, can eliminate many accidents.

with a small top cut or notch and then release from below.

When bucking up the major logs or trunk, wedges can be used to prevent binding of the guide bar. Another trick is to place smaller logs under the trunk before it drops to relieve the tension and allow the worker to cut all the way through with the chain saw. If large logs must be rolled, a **cant hook** or **peavey** should be used as illustrated in Figure 7.19.

Lifting

The most common injury causing missed work among tree workers is back injury. Before lifting any weight, the tree worker should:

1. Be sure the path is clear if the weight is to be carried from one place to another.
2. Decide exactly how the object should be grasped to avoid sharp edges, slivers, splinters, or other things that might cause injury.
3. Make a preliminary lift to be sure the load can be handled safely.
4. Place feet solidly.
5. Crouch as close to the load as possible with legs bent.
6. Maintain normal back curvature. It is not necessary to attempt to keep the back straight.
7. Lift with the legs, not the back.
8. Use a second worker when necessary.

FIGURE 7.20 Proper lifting technique can help prevent back injuries.

Matching

_____ cant hook	A. tree removal technique
_____ notch cut	B. device used to roll large logs
_____ bucking	C. should never cut into the hinge
_____ limbing	D. helps steer the tree in a felling operation
_____ felling	E. removing side limbs of felled trees
_____ barber chair	F. wedge-shaped cut to direct tree fall
_____ back cut	G. cutting log into smaller lengths
_____ hinge	H. tree pivots or splits up behind hinge when felling

True/False

1. T F Before beginning any felling operation, the site should be inspected for potential hazards.
2. T F Hollow trees can present difficulties in controlling the direction of fall.
3. T F The lean and shape of the tree are important, but species characteristics are irrelevant in felling operations.
4. T F A gust of wind can alter the direction of a tree's fall.
5. T F It is best to plan a tree's removal before any cuts are made.
6. T F A pull line or wedges can be used to help control a tree's fall.
7. T F When felling a tree, the notch should be cut at least 50 percent of the way through the tree.
8. T F A "dogleg" in the pull line can cause the tree to rotate on the cut, misdirecting the fall.
9. T F A rule of thumb for the depth of the notch is one-third or less of the diameter of the tree.
10. T F An advantage of the open-face notch is that the hinge breaks as the notch closes.
11. T F The back cut should always be made slightly lower than the apex of the notch.
12. T F The hinge of wood formed behind the notch helps to control the tree's fall.
13. T F After a tree has been felled, bucking should take place before limbing.
14. T F Branches or logs that are under tension can present a hazard when cut.
15. T F When lifting heavy objects, the worker should maintain normal back curvature.

Sample Test Questions

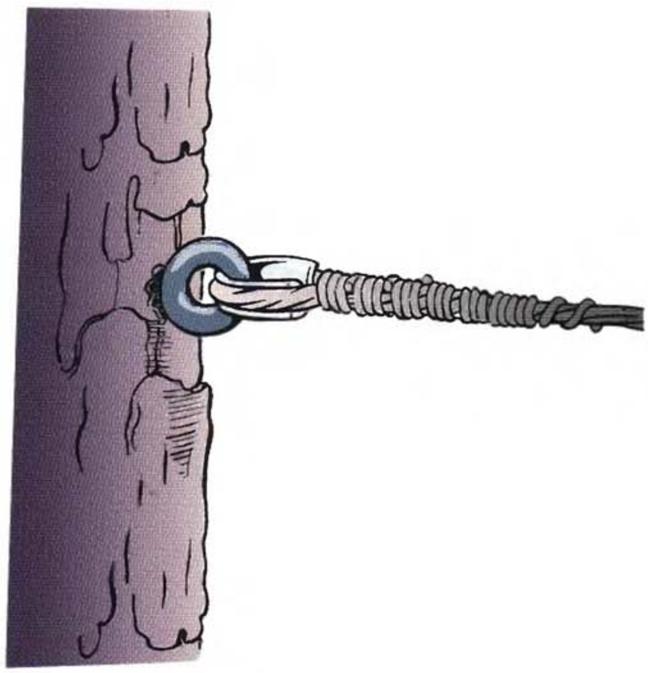
1. Cutting large logs into smaller sections is known as
   a. felling
   b. limbing
   c. bucking
   d. notching

2. If a tree pivots or splits upward during felling, it is sometimes called
   a. bucking
   b. barber chairing
   c. hinging
   d. wedging

3. When felling a tree using the traditional 45-degree notch, the back cut should be made
   a. even with the apex of the notch
   b. just below the apex of the notch
   c. just above the apex of the notch
   d. directly through the apex of the notch

CHAPTER 8

Cabling

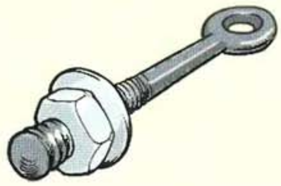


CHAPTER 8

Cabling

IMPORTANT TERMS

included bark
common-grade, 7-strand, galvanized cable
extra-high-strength (EHS) cable
lag hook
eye bolt
threaded rod
amon-eye nut
peened
thimble
dead-end grips
come-along
Haven grips
Chicago™ grips
ship auger
cable aid
eye splice



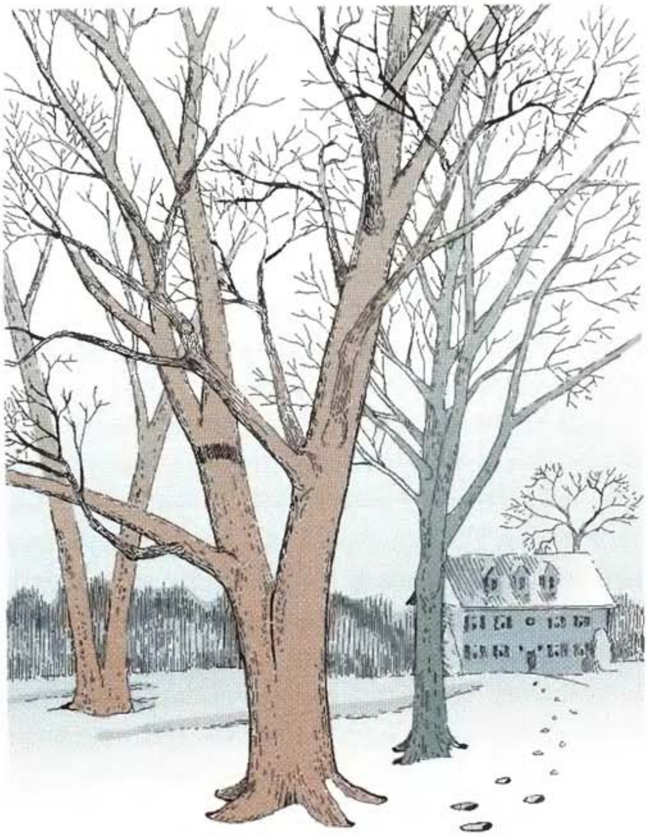


FIGURE 8.1 Trees with codominant stems may have included bark in the crotch and may be candidates for cabling.

Introduction

Cables are installed in trees to provide extra support. When used wisely, they may extend the life of a tree or make it safer.

Whenever hardware is installed in a tree, the tree is wounded. Once wounded, there is the risk of decay advancing into wood that supports or holds the hardware. Therefore, the situation must be assessed carefully when deciding whether to install steel cables or dynamic (rope) cables, to prune out the potentially hazardous limbs, or to remove the tree.

In determining whether cabling is warranted, the condition, species, and value of the tree should be considered. If the root system is not structurally sound or if the tree contains excessive decay, removal may be preferable. Cables cannot always be relied upon to make a hazardous tree safe.

Sometimes the most revealing inspection of tree defects is made aloft by the tree climber. Thus, it is important that the tree climber be able to recognize tree defects and be able to predict hazard potential. If a cable has been called for but the tree condition is unsound, it is up to the climber to notify the job supervisor. Installing a cable in an unstable or declining branch or tree may create a false sense of security and could be a source of legal action should the limb fail and result in personal injury or property damage. Remember that any cable installation should be accompanied by a commitment by the owner to ongoing inspections.

Reasons for Installing Cables

1. support split or decayed crotches
2. support codominant branches, especially those that may contain **included bark**
3. support heavy limbs or limbs that extend over structures or traffic areas
4. support wide-spreading branches or multi-stemmed trees that may be threatened by ice, snow, or other loads

Hardware and Tools

Cables

It is important to select the appropriate hardware for cabling a tree. Cables, eye bolts, and other cabling hardware come in various sizes and types. Consider the size of the limbs, the weight to be supported, and the presence of decay when choosing materials. If the hardware is too small or inadequate, the cable may fail.

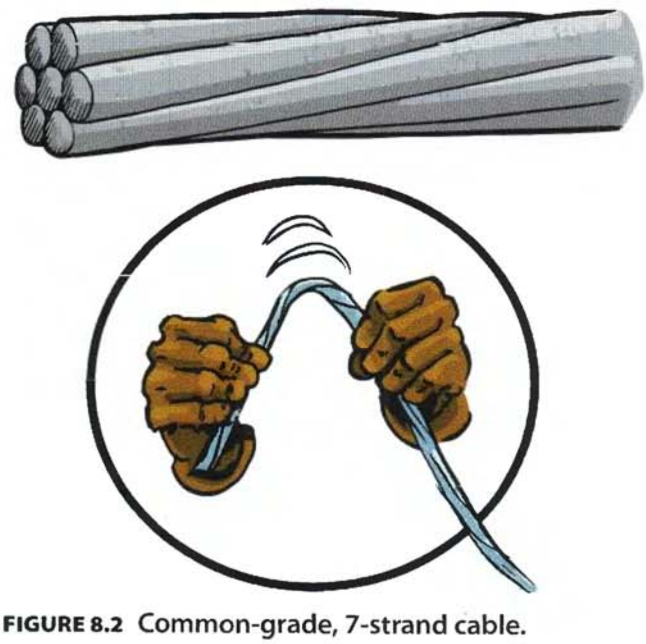


FIGURE 8.2 Common-grade, 7-strand cable.

Two types of cable are commonly used in cabling trees, **common-grade, 7-strand, galvanized cable** and **extra-high-strength (EHS)** cable. The common-grade cable is relatively malleable (bendable) and easy to work with. The EHS cable is much stronger but less flexible than common-grade cable. Both are available in a wide range of sizes. Cables ranging from $3/16$ inch in diameter to $3/8$ inch in diameter are commonly used in trees.

Lag Hooks

A **lag hook**, or J-lag, is a threaded device in the shape of a "J." It is made out of steel and is usually hot-dipped galvanized or bent metal that has been zinc plated to slow rusting. Lag hooks are J-shaped with the long end threaded with wood screw threads. Standard lag sizes used in tree cabling are $5/16$ inch, $3/8$ inch, $1/2$ inch, and $5/8$ inch in diameter. Lag hooks come with right- and left-handed threads so that when each end is twisted into the branch to tension the cable, the cable will not come unlaid or unwound.

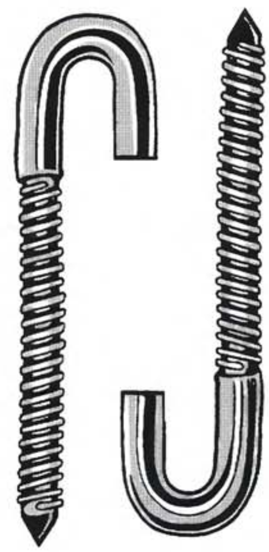


FIGURE 8.3 Left- and right-lay lag hooks.

Lag hooks are installed by screwing into a pre-drilled hole that is smaller in diameter than the lag. The rule of thumb is to drill the hole $1/16$ inch smaller than the lag. The lags should be screwed into the tree so that the J-loop ends up vertical (facing up or down), with the open end just contacting the bark. Take care not to injure the bark. It is not uncommon for a cable to "jump off" a lag when a gap has been left between the open end of the lag and the bark. If the lag must be installed at an angle that will prevent screwing it in completely, it may be preferable to install an eye bolt or other anchoring hardware.

Lag hooks work quite well on small limbs and trees with hard wood but should not be installed in

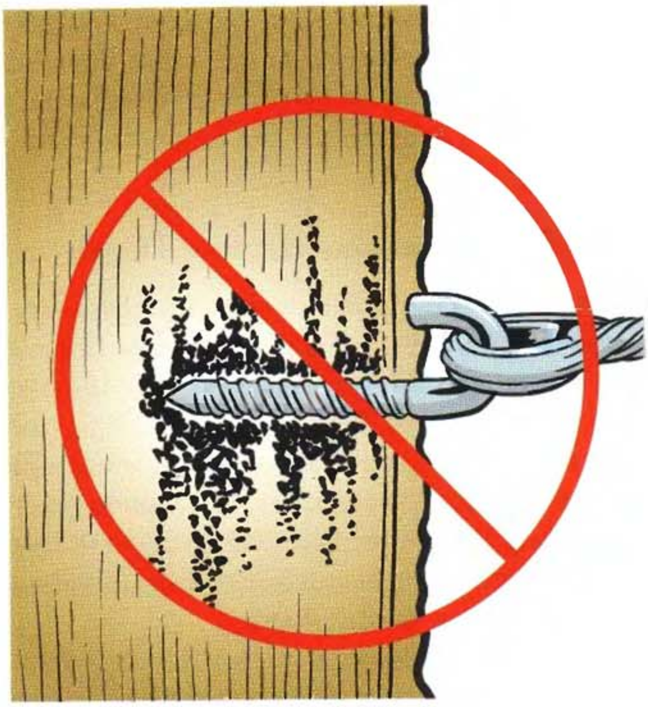


FIGURE 8.4 **Lag hooks should NOT be installed in decayed wood.**

limbs that are greater than 8 inches in diameter. Lag hooks should never be installed in limbs with decay. The decay will limit the holding capacity of the lags and may spread into healthy wood. Lags are generally considered less reliable than hardware that bolts through the limb.

Eye Bolts and Amon-eye Nuts

When lag hooks are not appropriate, or as a standard practice for all trees, **eye bolts** or **threaded rods** with **amon-eye nuts** may be used. Both are drop forged and machine threaded, and their installation is similar.

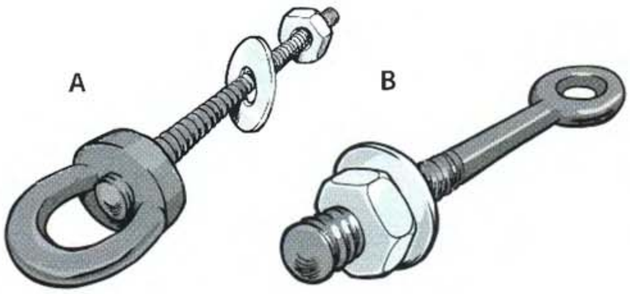


FIGURE 8.5 **A: threaded rod with amon-eye nut. B: eye bolt.**

A hole usually 1/16 inch larger than the hardware is drilled through the limb to be cabled. The eye bolt or threaded rod is installed with a round, heavy-duty washer and nut on the outside end. The washer should be seated against the bark. On trees with very thick bark, the bark should be chiseled away to countersink the washer against the sapwood. Excess rod should be cut off, and the exposed threads on the end of the eye bolt and both ends of the threaded rod used with the amon-eye should be **peened** to prevent the nut from unscrewing.

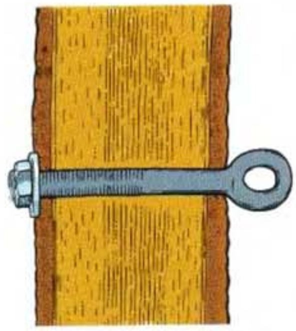


FIGURE 8.6 **Installation of an eye bolt.**

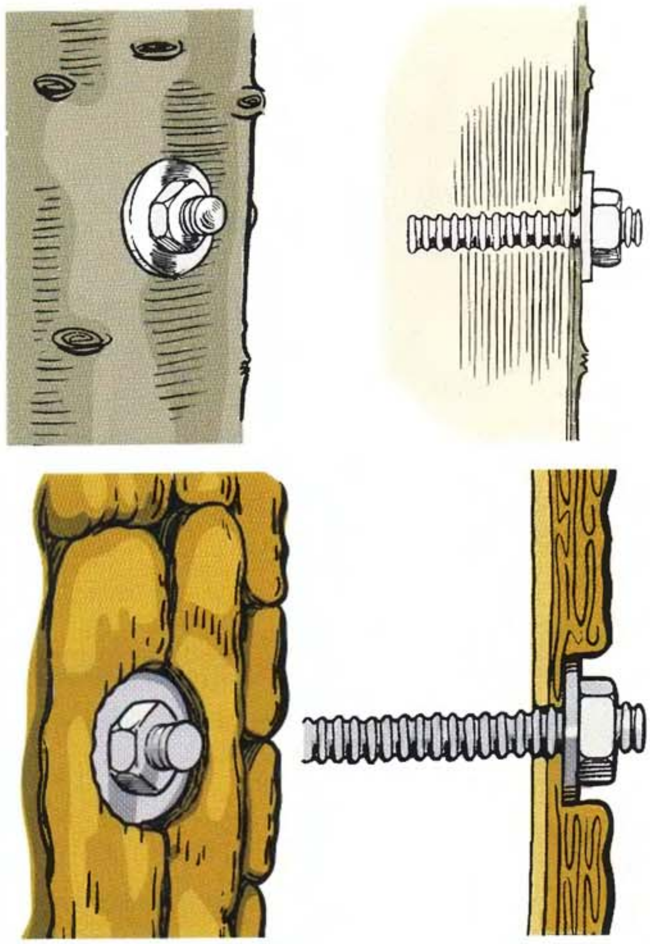


FIGURE 8.7 **On most trees, seat the washer directly on the bark. On trees with very thick bark, countersink the washer to the sapwood.**

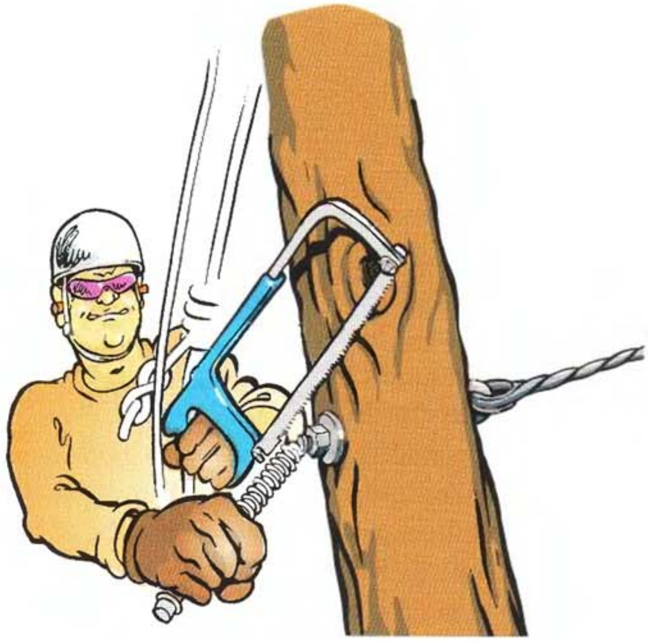


FIGURE 8.8 Cut off excess just beyond the nut.

FIGURE 8.9 Peen the end of the bolt to prevent the nut from backing off.

Drop-forged eye bolts are considered slightly stronger than amon-eye nuts used with threaded rods. However, an advantage of the amon-eye system is that the length of the rod can be adjusted easily for any job.

Thimbles, Splices, and Dead-end Grips

When attaching the cable to its anchoring hardware, **thimbles** must be used. The purpose of the thimble is to protect the cable from excessive wear. If cables or grips are installed directly on the hardware, the steel-to-steel contact and abrasion may eventually cause wear and cable breakage. For common-grade cable, thimbles are closed after installing on the eye bolt. For EHS cable, thimbles are left open to conform to the bend in the **dead-end grips**.

Thimbles must also be used when installing dead-end grips. Dead-end grips are installed over the thimble and then wrapped upon the cable. They are used to attach EHS cable to the hardware. The cable is not malleable enough to form an eye splice.

Cable grips have been found to be quite satisfactory for small and medium-sized trees. However, cable grips are not designed to withstand the dynamic loads that can be created by branches twisting and swaying, particularly in gusting winds. Excessive wind sway in large trees may cause metal fatigue in the dead-end grips, which could lead to failure. When installing this hardware in large trees, it is important to take into account the wind conditions and potential for twisting.

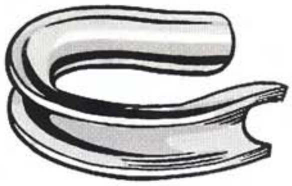


FIGURE 8.10 Thimble.

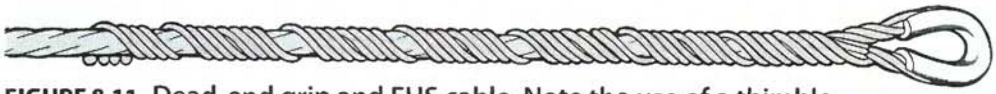


FIGURE 8.11 Dead-end grip and EHS cable. Note the use of a thimble.

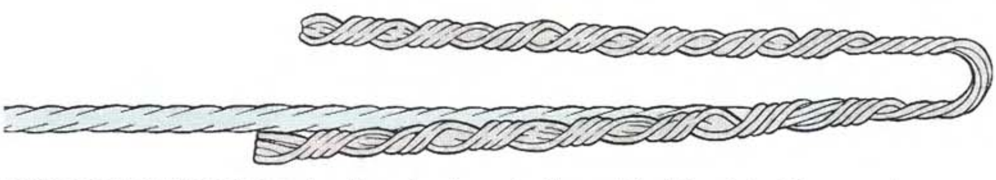


FIGURE 8.12 Wrapping a dead-end grip onto the cable. The thimble must be installed before wrapping the other side.

Cabling Tools and Equipment

The installation of cables in trees requires a number of tools. Sometimes, especially when installing lag hooks, a **come-along** is used to bring two branches closer together. The use of a come-along is illustrated in Figure 8.13. A second commonly used tool is a **Haven grip**. This cammed device is used to grip the cable and help the climber pull the cable for tensioning or attaching to anchor hardware. **Chicago™ grips** are designed for use with EHS cable.

In order to install the hardware in the tree, holes must be drilled. This can be accomplished using either a brace and bit, a gas-powered drill, or an electric drill. Though fast and efficient, electric drills can be difficult to work with in the tree, and an electrical source is not always available. Battery-powered, rechargeable drills offer a solution to these problems. With all drill types, the bit should be a **ship auger**. This will work more efficiently in green wood and will pull the shavings from the hole.

Another handy piece of equipment is the **cable-aid**. A cable-aid can be used to spread open thimbles, to tighten lags, and to help wrap dead-end grips onto the cable. A cable-aid is illustrated in Figure 8.18.

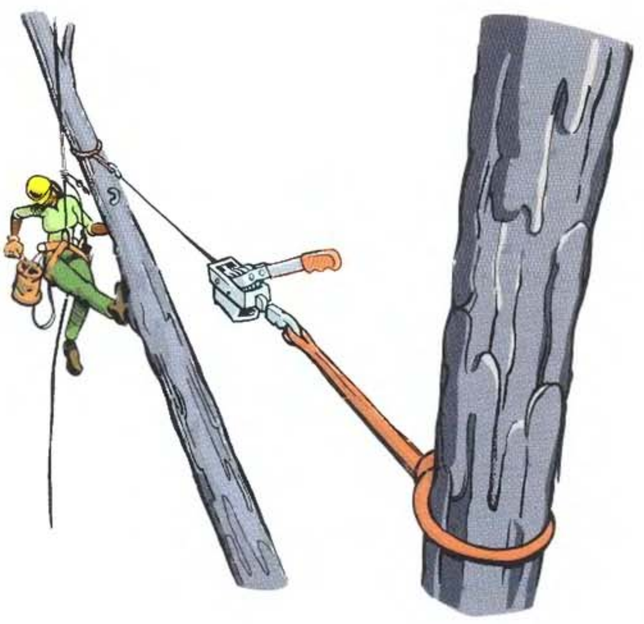


FIGURE 8.13 A come-along may be used to pull the limbs closer together in order to keep the cable taut.

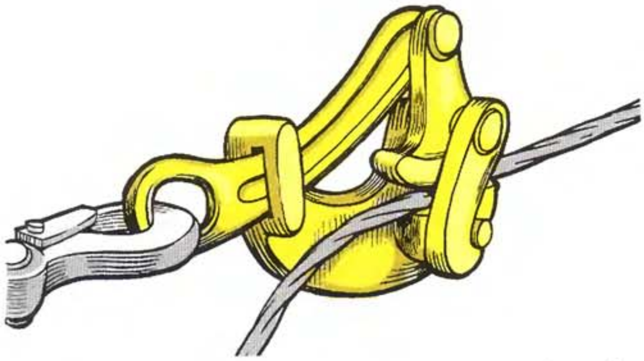


FIGURE 8.14 Haven grips clamp onto the cable and are used to pull tension.

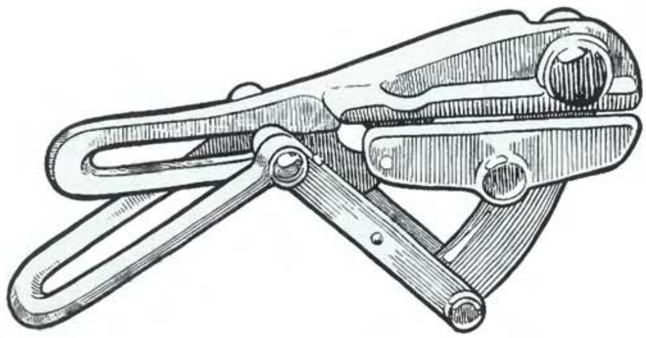


FIGURE 8.15 Chicago™ grips are designed for use with EHS cable. They tend not to kink the cable.

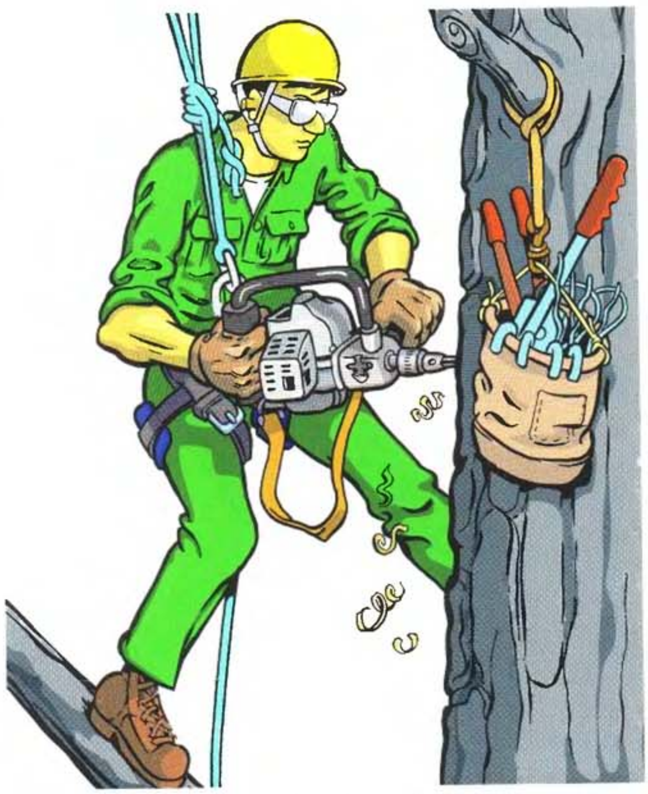


FIGURE 8.16 Drilling for hardware installation.

FIGURE 8.17 **A ship auger is used to pre-drill the holes for cable hardware installation.**

Other tools that are useful in cabling operations include cable cutters, hacksaws, hammers, chisels and mallets, slings, and wire cutters. It is helpful for a climber to carry these tools in a bag, bucket, or belt that will prevent them from being accidentally dropped.

Attaching the Cable to the Hardware

As previously mentioned, if EHS cable is used, it must be attached to the hardware using dead-end grips. However, if common-grade cable is used, there are alternatives. Common-grade, 7-strand cable is usually attached to the hardware using an **eye splice**. An eye splice is actually a series of wraps and not a true splice. A thimble is always used to form the eye in the end of the cable. Remember to use the right size of thimble for the cable. If the bend in the thimble is too tight, the cable will be weakened. The eye splice is made by wrapping the end of the cable around the thimble, then separating the cable strands. Each strand is wrapped individually around the cable two to three complete turns per strand in the same direction. When complete, the finished splice will have a neat appearance and will provide optimal holding capacity.

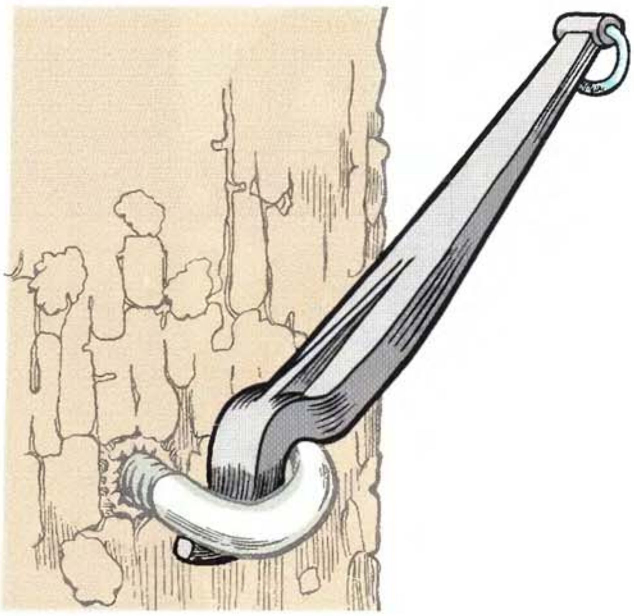


FIGURE 8.18 **A cable aid may be used for tightening hardware.**

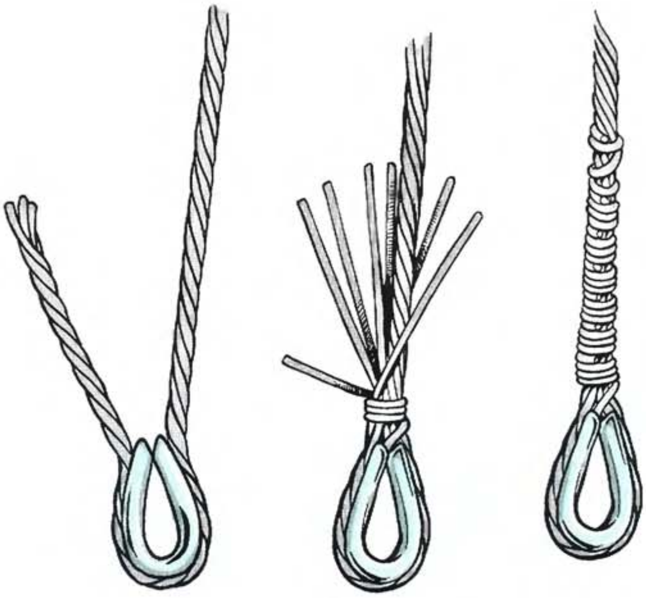


FIGURE 8.19 **Forming an eye splice.**

Cable Installation

Before installing cables in a tree, the tree should be pruned as needed. Hazardous limbs should be removed. If necessary, the tree should be pruned for balance and to reduce excessive weight.

A general rule of thumb is to install the cable at least two-thirds the distance from the weak junction to the ends of the limbs. Exact placement will depend upon the location of lateral branches and defects. The branches at the point of cable attachment must be large enough and solid enough to provide adequate support of the hardware.

The angle of the cable and its distance from the crotch determine its strength and effectiveness. The support can be maximized by installing the cable directly across the crotch being supported and at least two-thirds the distance up. "Directly across" can be

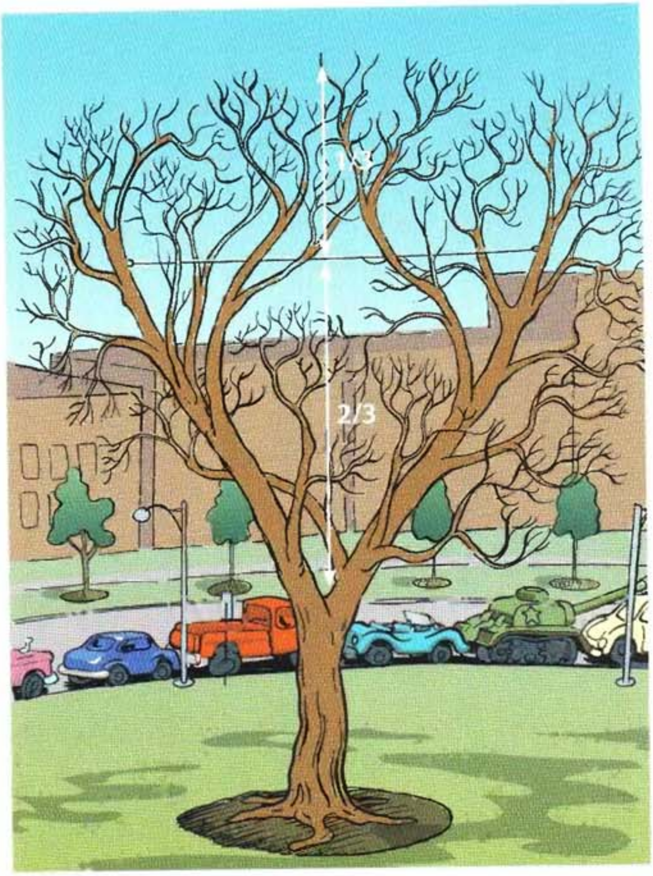


FIGURE 8.20 **Cables should be installed at least two-thirds the distance from the crotch to the branch tips.**

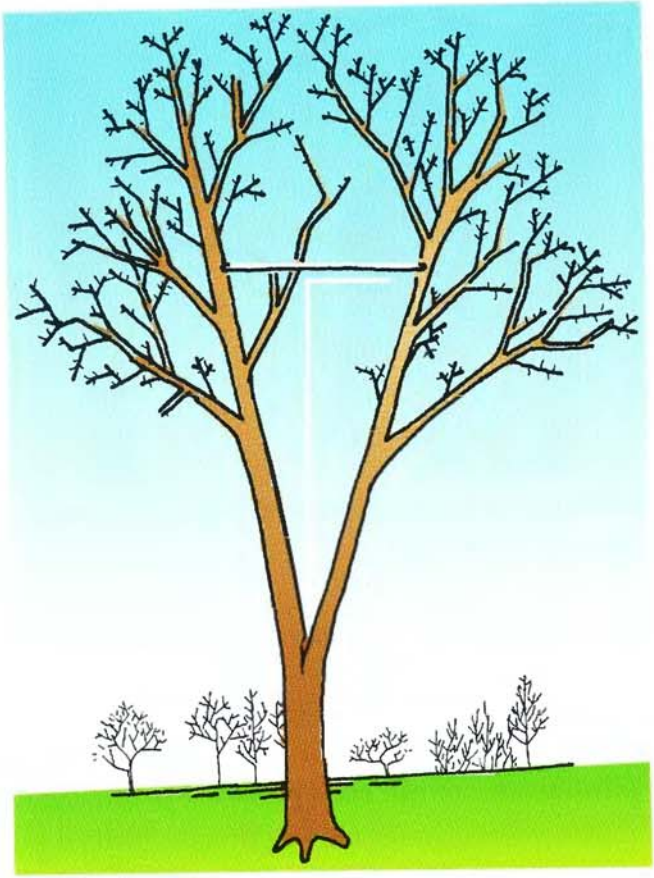


FIGURE 8.21 **The cable should be installed perpendicular to (at a 90-degree angle with) an imaginary line that bisects the crotch.**

determined by setting the cable perpendicular to (at a 90 degree angle with) an imaginary line through the center of the crotch.

Hardware should be installed with the pull of the cable in a direct line with the installed bolt or lag. If the cable is installed correctly, at right angles with the line that bisects the crotch, the hardware will usually not be installed perpendicular to either branch. To maximize the strength of the system, it is important not to have the cable's pull at an angle to the hardware.

Once installed, the cable should be just taut. A cable that is too tight may put excessive stress on the wood fibers, result in more damage at the defect, or cause the hardware to pull out. The limbs may be brought closer together with ropes, or slings and a come-along. This will make the installation easier, and the cable should be taut when the limbs are released. If the cable is installed while the tree is in foliage, it

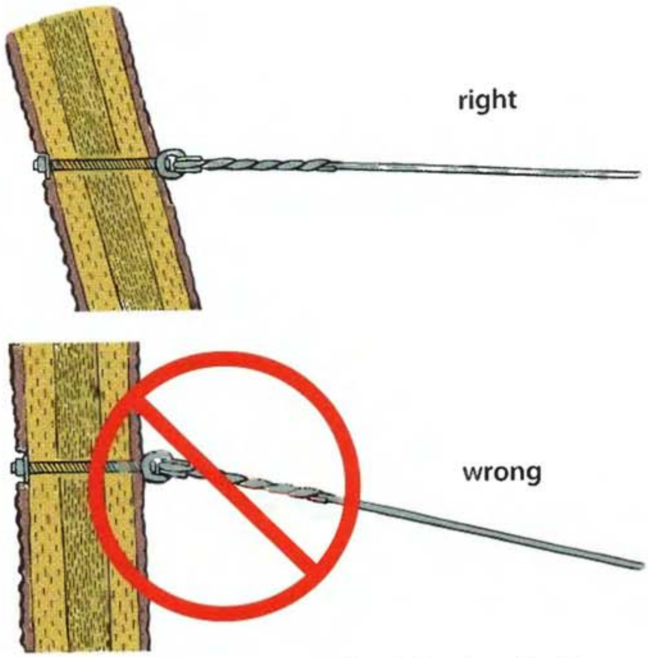


FIGURE 8.22 **The hardware should be installed in a direct line with the pull of the cable.**

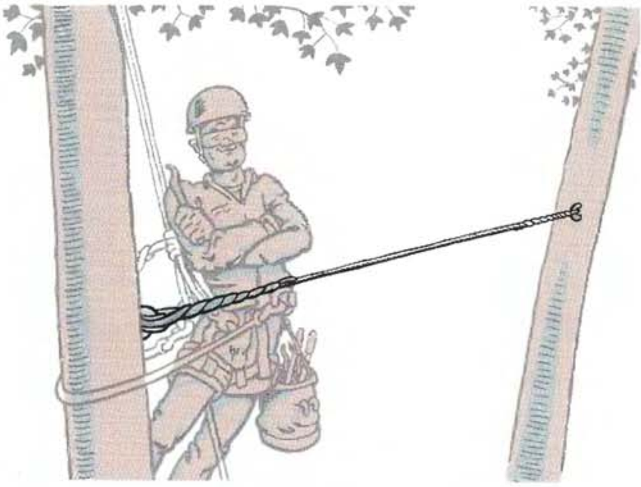


FIGURE 8.23 A properly installed cable should look neat and professional.

should be tight enough that it will not be slack after the leaves have fallen.

The most common cable installation is the simple or direct cable (one cable between two limbs). Sometimes a tree will require more than one cable. Several cabling systems are illustrated in Figure 8.25. If multiple cables are required, extra strength can be added to the system by cabling the branches together in threes (in a triangle). If more crown movement is desired, a box or rotary system can be installed.

When more than one cable is being installed on the same limb, vertical spacing between the hardware should be greater than or equal to the diameter of

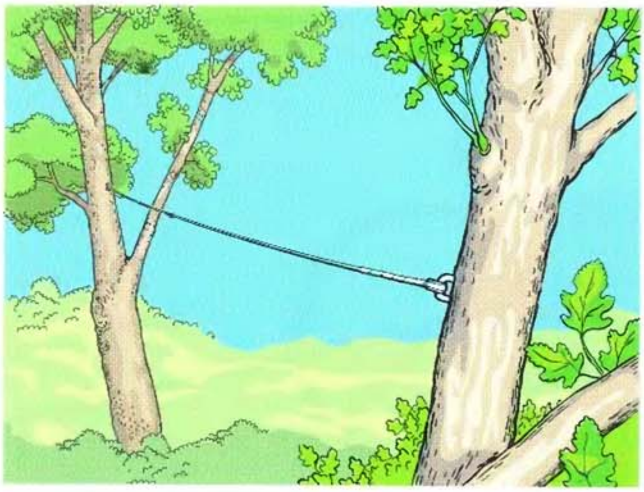


FIGURE 8.24 The most common cable configuration is a single direct cable.

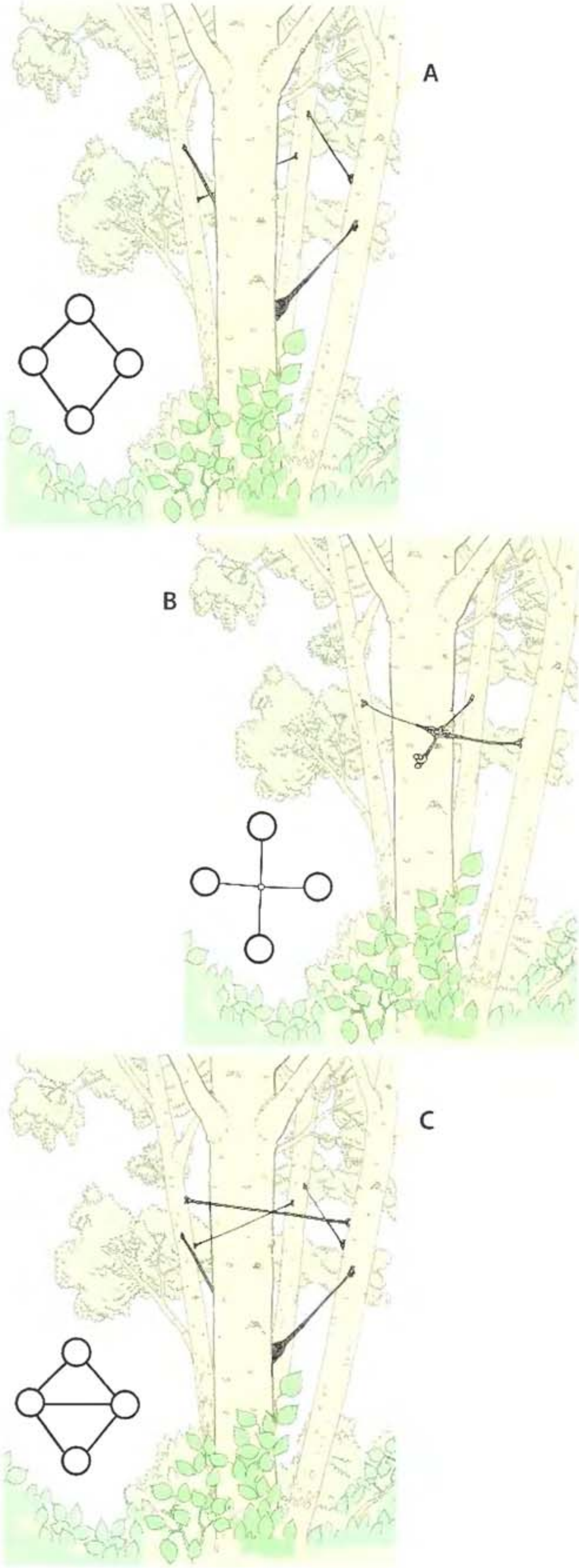


FIGURE 8.25A–C Cabling systems.

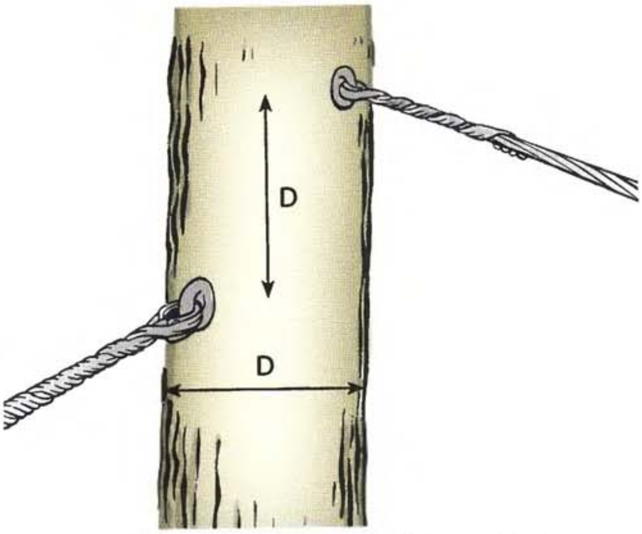


FIGURE 8.26 **If more than one cable must be installed, keep the hardware at least one branch diameter's distance apart, if practical. Do not install the hardware in vertical alignment.**

the limb if possible. Never install one anchor directly above another. Only one cable should be attached to each bolt or lag.

The installation of cables in a tree represents an ongoing responsibility. Cables should be inspected annually. Check to see that the hardware remains securely anchored. As the tree grows older and taller, new cables may need to be installed higher in the tree.

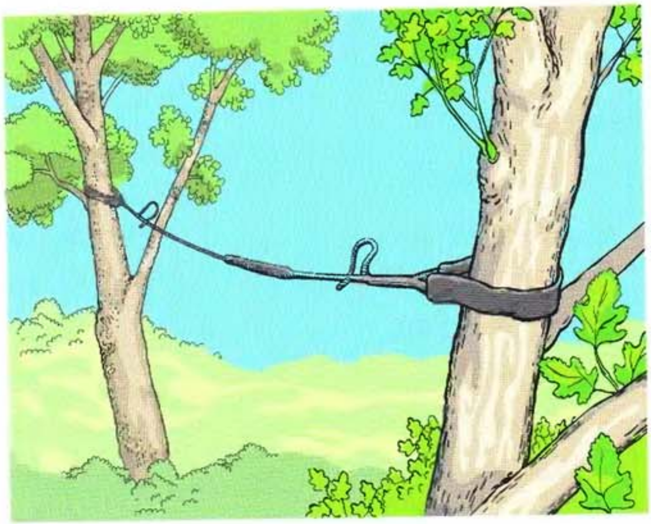


FIGURE 8.28 **Cobra is a commonly used rope (dynamic) cabling system.**

Trees that have been cabled may need to be pruned periodically to remove excess weight and reduce wind resistance.

This text deals only with steel cable installation as performed in North America and is consistent with the ANSI A300 standards for tree support systems. Although some of the installation principles apply to rope cabling systems, each propriety cable system must be installed according to manufacturer's instructions.

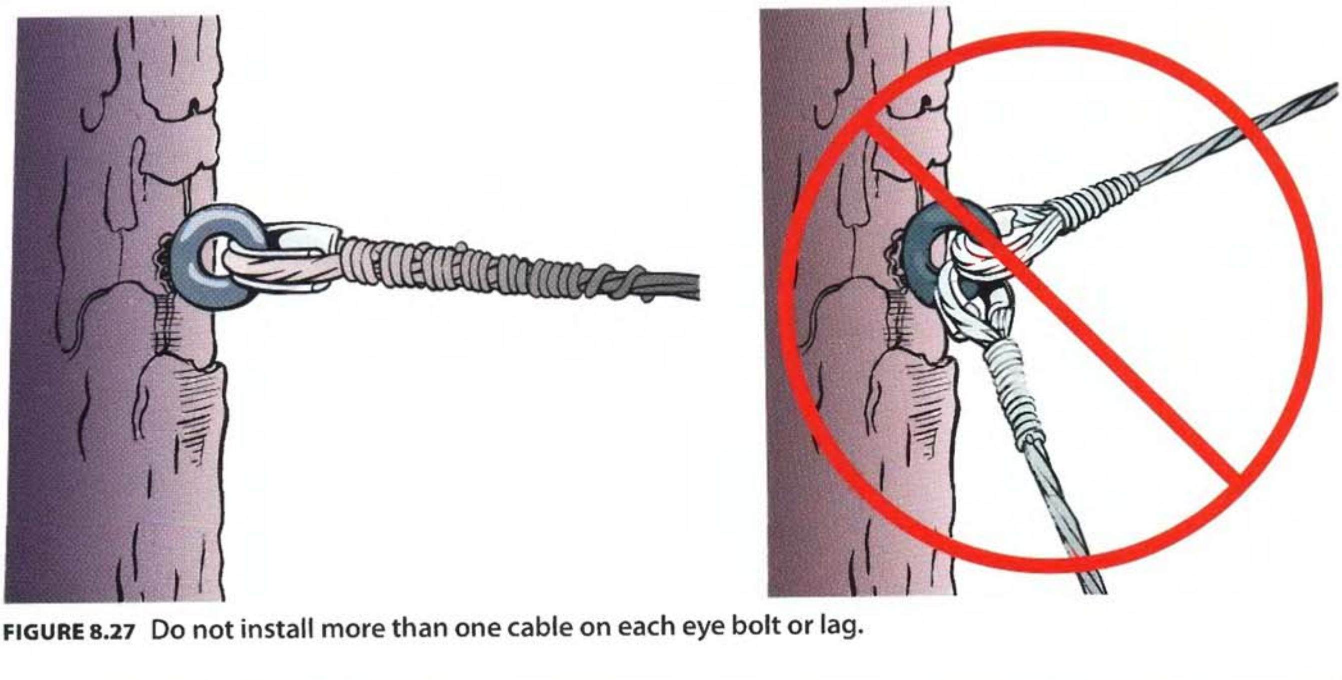


FIGURE 8.27 **Do not install more than one cable on each eye bolt or lag.**

Matching

_____ lag hooks
_____ eye splice
_____ eye bolt
_____ amon-eye nut
_____ ship auger
_____ thimble
_____ Haven grips
_____ come-along

A. brings limbs closer together
B. used with threaded rod
C. reduces wear on cable
D. attaches soft cable to hardware
E. do not use in decayed wood
F. helps pull cable taut
G. for pre-drilling holes
H. hardware that is through-bolted

True/False

1. T F In most cases, a tree should be pruned before cables are installed.
2. T F Cables should be installed one-third the distance from the crotch to the branch tips.
3. T F Properly installed cables should be parallel to the ground.
4. T F Cables should always be installed perpendicular to the larger limb.
5. T F When properly installed, the cable should be just taut.
6. T F Cables installed while a tree is in foliage may slacken following leaf drop.
7. T F Lags should only be used in limbs less than 8 inches in diameter and when no decay is present.
8. T F When installing more than one cable on a limb, the cables must be installed directly over each other.
9. T F Two cables should never be installed on a single eye bolt or lag.
10. T F If EHS cable is used, dead-end grips must be used to attach the cable to the hardware.
11. T F Thimbles are not required with dead-end grips.
12. T F When installing lags, the hole should be drilled approximately 1⁄16 inch smaller than the lag diameter.
13. T F An eye splice cannot be formed when using common-grade, 7-strand cable.
14. T F The cable should be installed in direct line with the hardware.
15. T F Diamond-shaped washers are preferred for bolt installation and should never be countersunk.

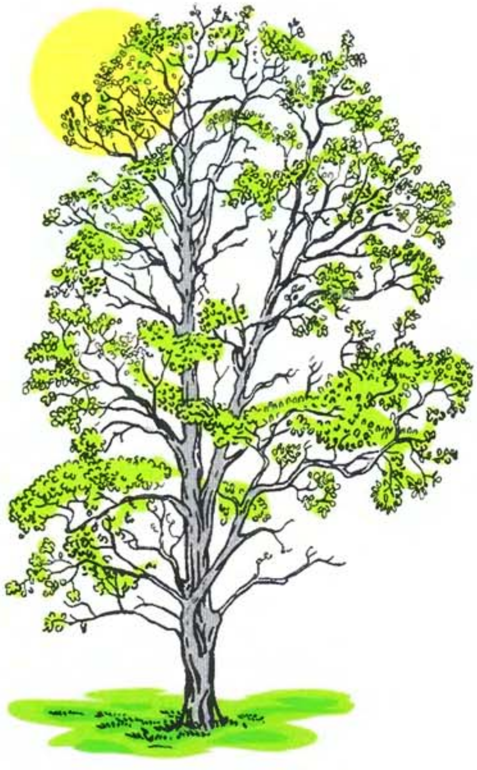
Sample Test Questions

1. A device commonly used to bring two limbs closer together in cabling operations is a
   a. Haven grips
   b. come-along
   c. cable-aid
   d. cable clamp

2. When installing extra-high-strength (EHS) cable, the cable can be attached to the hardware using
   a. dead-end grips
   b. an eye splice
   c. cable clamps
   d. all of the above

3. The recommended height for installing cables is
   a. as close to the crotch as possible
   b. one-third the distance from the crotch to the tips
   c. half the distance from the crotch to the tips
   d. two-thirds the distance from the crotch to the tips

Appendices



APPENDIX A

Advanced Climbing Knots

The last decade has seen many advances in the equipment and techniques used by tree climbers. The arboriculture profession has benefited from techniques borrowed from related fields such as rock climbing and rescue applications, as well as from improvements in ropes and cordage. Along with this new technology, some newer friction hitches have also been introduced.

Each of these friction hitches is typically tied with a separate split-tail, which may be a length of cord or a loop of cord. The split-tail must meet strength requirements for climbing lines. Usually the split-tail is used in an eye-and-eye configuration with the eyes formed either with splices or with double fisherman's knots. The construction, diameter, and length of the split-tail can affect (sometimes dramatically) the performance of the hitch. Even the buried part of the splice can affect how the split-tail will grip the climbing line.

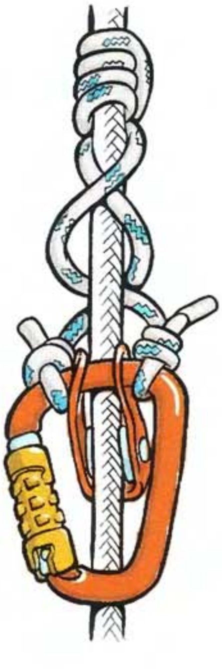
Most of these friction hitches are used as closed hitches, which means the tail of the hitch is incorporated into the hitch. In an open climbing hitch, the tail is not incorporated and usually a stopper knot is required.

French Prusik is a name that includes a number of friction hitches, including the *Machard*, *Machard tresse*, *Valdôtain*, and *Valdôtain tresse*. The most commonly used variation, the Valdôtain tresse, is shown here. All of the French Prusiks, as well as the Schwabisch and Distel, are often considered to be advanced climbing hitches. They tend to be fluid and very responsive to quick adjustment, but they can also require close attention. Their behavior on the climbing line is affected by the number of wraps and/or braids, and climbers sometimes experiment to find the best combination to suit their individual climbing style and equipment.

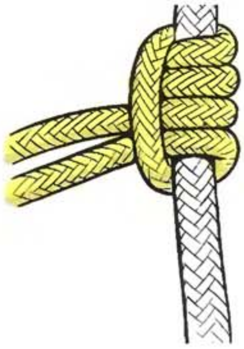
The knots are shown here for informational purposes, without explanation for tying or putting into use. These hitches should be used only after proper qualified instruction. As with all climbing techniques and equipment, adopting a new friction hitch should start low and slow. Experiment carefully, low to the ground, and in a situation where there is no risk of falling.

Valdôtain tresse (Vt)

- Probably the most commonly used of the variations of the French Prusik
- Tied with a length of cord (eye-and-eye split-tail), which is smaller in diameter than the line on which it is tied
- Holds securely and releases easily
- Also used in rigging applications



Schwabisch



- Essentially an asymmetric Prusik hitch
- Holds securely but can bind
- Neither as fluid nor as temperamental as a French Prusik

Distel

- Tied similarly to the tautline hitch but performs differently because it is used as a closed hitch
- Used as a closed climbing hitch, with both legs of the splittail attaching to a carabiner
- Neither as fluid nor as temperamental as a French Prusik

APPENDIX B

Answers to Workbook Questions

CHAPTER 1 • WORKBOOK

Matching

F xylem
D absorbing roots
G included bark
B phloem
E photosynthesis
H cambium
C transpiration
A deciduous

A. trees that lose all their leaves annually
B. food-conducting tissues
C. water vapor loss through leaves
D. usually in the upper 6 inches of soil
E. sugar production by plants
F. carries water up through tree
G. bark within a tree crotch
H. zone of diameter growth in tree

True/False

1. TRUE Small fibrous roots serve to take up water and minerals.
2. FALSE The root system of a tree is like a mirror image of the top (crown).
3. TRUE Roots tend to grow where moisture and oxygen are available.
4. FALSE Tree roots rarely grow beyond the dripline of the tree.
5. TRUE Starches are stored throughout the trunk and branches of a tree.
6. FALSE The cambium is located in the center of the trunk and branches.
7. FALSE The phloem carries sugar only to the roots.
8. FALSE The xylem is located directly beneath the bark.
9. TRUE Normally, each growth ring represents one year of growth.
10. TRUE The thickness of the growth rings is often an indication of growing conditions in previous years.
11. FALSE The heartwood conducts water and minerals up through the tree.
12. TRUE In most tree species, only the outermost rings of sapwood conduct water.

13.	TRUE	Rays are storage sites for starch.
14.	TRUE	The bulge at the base of a branch at the point of attachment to the trunk is called the branch collar.
15.	TRUE	Leaves may be considered the "food factories" of a tree.
16.	TRUE	A vigorous tree will compartmentalize decay to limit its spread.
17.	FALSE	Most of the time, if a tree is stressed, the cause is an insect problem.
18.	TRUE	A tree that is showing general decline throughout the crown is likely to be suffering from a root problem.
19.	TRUE	Generally, with deciduous trees, insects or diseases that affect only the foliage of the tree are not fatal.
20.	TRUE	Insects or diseases that affect the vascular system of a tree are usually serious.

Matching

B root crown	A.	areas between soil particles
G conk	B.	where roots join the trunk
E simple leaf	C.	teeth along the leaf margin
H compound leaf	D.	bark pushed up at the crotch
D branch bark ridge	E.	one blade per leaf
A pore spaces	F.	bud at the tip of a twig
F terminal bud	G.	sign of decay within the tree
C serration	H.	leaf with multiple leaflets

Sample Test Questions

1. Most absorbing roots are located
   a. at the base of the sinker roots
   b. along the surface of the tap root
   c. in the upper 6 inches of soil
   d. within the drip line of the crown

2. If two buds arise across from one another on a stem, the arrangement is called
   a. alternate
   b. axillary
   c. whorled
   d. opposite

3. Which evergreen trees have needles in bundles?
   a. pines
   b. hemlocks
   c. firs
   d. spruces

Matching

F	shall	A.	leg protection for chain-saw use
G	approved	B.	advisory recommendation
C	CPR	C.	cardiopulmonary resuscitation
D	direct contact	D.	body touches energized conductor
B	should	E.	safety standards for tree work
H	indirect contact	F.	mandatory requirement
E	ANSI Z133.1	G.	meets applicable safety standards
A	chaps	H.	touching an object in contact with an energized conductor

True/False

1.	TRUE	OSHA (OHSA, in Canada) regulates industrial safety and health issues.
2.	FALSE	ANSI Z133.1 is the OSHA safety standard for tree trimming.
3.	FALSE	The ANSI standards were developed by the U.S. Department of Labor.
4.	FALSE	Head protection need only be worn while there are climbers in the trees.
5.	FALSE	Eye protection is a good idea but is not required for tree work.
6.	TRUE	Hearing protection may be in the form of earplugs or earmuff-type devices.
7.	TRUE	Workers must not wear gauntlet-type gloves while chipping brush.
8.	TRUE	Employers shall instruct their employees in the proper use of all equipment.
9.	FALSE	Carrying a first-aid kit on each truck is recommended but optional.
10.	TRUE	Equipment should not be started or operated within 10 feet of the refueling site.
11.	TRUE	All power and communications wires shall be considered charged with potentially fatal voltages.
12.	TRUE	Any tree workers who work in proximity to electrical conductors must receive approved training.
13.	TRUE	An electrical conductor is defined as any overhead or underground electrical device, including wires and cables, power lines, and other such facilities.
14.	FALSE	Rubber footwear and gloves provide absolute protection from electrical hazards.
15.	FALSE	Drop starting is the recommended method for starting a saw.
16.	FALSE	On the ground, both hands are required for chain-saw operation, but one hand can be used in the tree.
17.	TRUE	Chain-saw engines must be stopped for refueling.
18.	TRUE	Kickback can occur when the upper tip of the guide bar contacts an object.
19.	FALSE	A well-trained climber, in good condition, should be able to dodge the kickback of a chain saw.
20.	TRUE	Safety is the responsibility of all employees, from the ground worker to the company owner.

Sample Test Questions

1. Which of the following should be considered energized with a potentially fatal voltage?
   a. overhead electric lines
   b. underground electric lines
   c. telephone and cable TV wires
   d. all of the above

2. Head protection is required for tree workers
   a. whenever performing tree care operations
   b. when specified by the supervisor
   c. whenever there are climbers working aloft
   d. only if chain saws or chippers are in use

3. The situation that can cause chain-saw kickback is
   a. failure to maintain adequate chain tension
   b. a worn sprocket or guide bar
   c. the upper tip of the guide bar contacting an object
   d. uneven sharpening of the chain-saw teeth

CHAPTER 3 • WORKBOOK

Matching

E	16-strand rope	A.	curve or arc in a rope
F	working end	B.	common climber's friction hitch
H	double fisherman's knot	C.	used to secure hardware to a tree
C	cow hitch	D.	core and cover share the load
G	figure-8 knot	E.	most commonly used for tree climbing
D	double braid	F.	the end of a rope in use
B	Blake's hitch	G.	used as a stopper knot
A	bight	H.	often used to form a Prusik loop

True/False

1.	TRUE	Polyester and polyester blends are the materials most commonly used for arborists' ropes.
2.	FALSE	3-strand rope is known for its high strength, high price, and resistance to twisting and hockling.
3.	FALSE	Double-braid lines are recommended for natural-crotch rigging.
4.	TRUE	The standing part of a rope is between the working end and the running end.
5.	TRUE	"Knot" is the general term given for all knots, hitches, and bends.
6.	TRUE	A hitch is a type of knot used to secure a rope to an object, another rope, or the standing part of the same rope.

7. TRUE "Dressing" a knot aligns the parts; setting it tightens the knot in place.
8. FALSE For years, the primary climbing hitch used by climbers in the United States has been the running bowline.
9. TRUE One limitation of the Blake's hitch is a tendency to glaze on a long or rapid descent.
10. TRUE An advantage to using the running bowline to tie off limbs is that it is easy to untie after loading.
11. FALSE The figure-8 knot is a good example of a "slipped" knot.
12. TRUE A midline clove hitch is commonly used to send equipment up to a climber.
13. TRUE When using an endline clove hitch to tie off limbs, it should be backed up by at least two half hitches.
14. FALSE There are very few knots that can be "slipped."
15. TRUE The knot known as the slip knot is a slipped overhand knot.
16. FALSE The primary arborist purpose of a sheet bend is to form a Prusik loop.
17. TRUE When using a Prusik loop (as in the secured footlocking technique), a smaller-diameter rope is used to attach the Prusik to a working line.
18. TRUE When tying a timber hitch in a sling to attach hardware to a tree, you should always make at least five wraps and spread them around the stem.
19. TRUE A sheet bend is used to join two ropes of different diameters and is often used to send a line up to a climber.
20. TRUE Natural fibers are not generally as strong as the new, synthetic fibers and can rot over time.

Sample Test Questions

1. A type of knot used to secure a rope to an object, another rope, or the standing part of the same rope is
   a. bend
   b. bight
   c. hitch
   d. slip

2. A common, easy-to-untie knot for forming a loop is
   a. bowline
   b. clove hitch
   c. tautline hitch
   d. sheet bend

3. Which of the following is an advantage of the Blake's hitch over the tautline hitch?
   a. it stays dressed and set
   b. less need to tend
   c. it doesn't roll out (although a stopper knot is still recommended)
   d. all of the above

Matching

G	Prusik loop	A. personal protective equipment
H	double-crotch	B. weighted cord used to set rope
E	aerial rescue	C. rope-climbing technique
C	footlock	D. fungal fruiting body, sign of decay
A	PPE	E. bringing injured climber down
D	conk	F. sheath for handsaw
B	throwline	G. used for secured footlocking
F	scabbard	H. tied in at two points with rope

True/False

1. TRUE In the United States, tree climbers must comply with all applicable safety standards, particularly the current version of ANSI Z133.1.
2. FALSE Approved head and eye protection are to be worn by all ground workers, but not necessarily climbers.
3. TRUE If carabiners are used, they must be loaded only along their major axes.
4. TRUE Carabiners and snaps used for climbing must have a minimum tensile strength of 5,000 pounds (23 kN).
5. FALSE Old, worn, or cut climbing lines must be used for rigging applications only.
6. TRUE Work-positioning lanyards must meet strength requirements for ropes and snaps.
7. TRUE Climbing ropes should be inspected before each use.
8. TRUE Body-thrusting is a method of ascending a tree.
9. TRUE Every job must begin with a job briefing that covers the work plan, potential hazards, and all required gear and procedures.
10. FALSE Climbing spurs are acceptable for use in climbing trees whenever the spurs' marks will not be obvious.
11. TRUE A climber must be tied in or otherwise secured while entering or working in a tree.
12. FALSE A throwline can be used to set a climbing line in a tree, but accuracy is limited to 50 feet or less.
13. TRUE Flip lines (lanyards) with a wire core should never be used when working in the vicinity of electrical conductors.
14. FALSE It is against safety regulations for climbers to use a pole to set the climbing line higher in the tree.
15. TRUE In the body-thrust technique, the climber uses the rope to climb the tree, but in the secured footlock technique, the climber climbs the rope itself.
16. FALSE A Prusik loop is typically used in the body-thrust technique to secure the climber.
17. FALSE Footlocking is generally slower and more energy consuming than body-thrusting.

18.	TRUE	In the body-thrust technique, the addition of a micropulley below the climbing hitch allows a ground worker to advance the knot and pull slack out of the climber's line while the climber ascends.
19.	TRUE	Climbing spikes are acceptable to use for removals or an aerial rescue emergency.
20.	FALSE	Double-crotching involves taking two wraps around the trunk at the tie-in point.
21.	TRUE	A good climber uses the climbing rope to ascend the tree, access branch tips, maintain balance, and move freely within the tree.
22.	TRUE	Climbers must always tie in so that a swing or fall will not allow contact with electrical conductors.
23.	TRUE	As a rule, it is best to tie in at a point high and central in the tree.
24.	TRUE	A high tie-in point allows ease of access to most of the tree.
25.	FALSE	A low tie-in point allows a climber to walk out farther on horizontal limbs.
26.	TRUE	A climber must be secured with a work-positioning lanyard or another line in addition to the climbing line when using a chain saw in a tree.
27.	TRUE	In addition to calling for help, a first step in an aerial rescue situation is to determine whether there is an electrical hazard.
28.	TRUE	Avoid moving an injured climber if neck or spinal damage is suspected.
29.	FALSE	CPR must be performed immediately in the tree if the victim has no pulse.
30.	TRUE	Advantages to using a false crotch when tying in include reduced wear on the rope and less chance of damaging the tree.

Sample Test Questions

1. When footlocking with a Prusik loop, it is important to keep both hands below the knot because
   a. it is impossible to advance the knot otherwise
   b. doing so prevents inadvertently releasing the knot when weight is applied to the loop to slide down the climbing line, creating a fall
   c. it avoids contact with the micropulley
   d. all of the above

2. In addition to being a safety device, the climbing line helps a climber to
   a. access branch tips
   b. maintain balance in the tree
   c. keep both hands free for working
   d. all of the above

3. If a pole pruner or a pole saw is used in a tree,
   a. it should be hung in such a way that the sharp edge is away from the worker and so that it cannot be accidentally dislodged
   b. it should be laid horizontally between the crotches of two separate lateral branches
   c. if a lanyard is used, it should be short enough to keep the cutting edge of the tool near your D-rings, within easy use
   d. all of the above

Matching

G	topping	A.	removal of dead, broken branches
E	scabbard	B.	hand pruning shears
C	raising	C.	removal of lower branches
H	included bark	D.	very poor thinning technique
F	branch collar	E.	sheath for pruning saw
B	secateurs	F.	"swollen" zone at base of branch
D	lion tailing	G.	poor crown reduction technique
A	cleaning	H.	can make crotch prone to failure

True/False

1. TRUE Improper pruning can cause permanent damage to a tree.
2. FALSE Anvil-type pruning shears are preferred over the bypass blade type.
3. FALSE Hedge shears are the best tool for pruning most small trees.
4. FALSE Most pruning saws are designed to cut on the forward or push stroke.
5. TRUE "Bleeding" that results when certain trees are pruned in the spring has little negative effect on the tree.
6. TRUE The final pruning cut in branch removal should be made just outside the branch collar.
7. TRUE Large or heavy limbs should be removed using the three-cut technique.
8. TRUE It is preferable to develop a sturdy scaffold branch structure while the tree is young.
9. FALSE The branch bark ridge is located under the branch.
10. FALSE A tree's growth habit and rate are irrelevant in pruning.
11. TRUE Removing a large limb from a very mature tree can cause serious stress.
12. FALSE Codominant stems represent a strong structure that is resistant to failure in windstorms.
13. TRUE Included bark in a crotch can weaken branch attachment.
14. FALSE Lower branches should be removed from young trees to help prevent the development of trunk taper.
15. TRUE A general recommendation in pruning is that half the foliage be maintained in the lower two-thirds of the tree.
16. TRUE Cleaning is the selective removal of dead, diseased, detached, and/or broken branches.
17. TRUE The correct location for a cut that removes a branch back to its point of origin is just beyond the branch collar.
18. FALSE Topping is the recommended technique for crown reduction.
19. FALSE Topping is recommended for fast-growing or weak-wooded trees.
20. FALSE Topping is only acceptable after a tree has suffered major root loss.
21. TRUE Over-thinning the inside of a tree can reduce energy reserves and make limbs more prone to failure.

22. TRUE Restoration pruning may improve the structure and appearance of a tree that has been topped previously.

23. TRUE In general, removal of more than 25 percent of a tree's crown when pruning should be avoided.

24. FALSE Large, mature trees are generally more tolerant of severe pruning.

25. FALSE Tree wound dressings are widely recommended to accelerate healing and prevent insect and disease penetration in wounds.

Sample Test Questions

1. Reduction pruning is a technique in which
   a. trees are topped or headed back
   b. leaders are cut back to lateral branches
   c. the lower branches are removed
   d. branches are cut back to stubs

2. The final cut in removing a branch should be made just outside the
   a. branch collar
   b. cambium layer
   c. trunk taper
   d. internode

3. The selective removal of small, live branches to reduce crown density is called
   a. restoration
   b. drop-crotch pruning
   c. raising
   d. thinning

CHAPTER 6 • WORKBOOK

Matching

C tensile strength
F carabiner
E sling
B block
G false crotch
H butt-tied
D tip-tie
A tagline

A. rope that controls swing of piece
B. heavy-duty pulley for rigging
C. breaking strength under static load
D. attach rope to far (brush) end of limb
E. length of rope or webbing to attach hardware
F. used to connect ropes and equipment
G. installed rigging point, not at a natural crotch
H. tied off at large end of limb

True/False

1. TRUE Shock-loading results when ropes are used to stop heavy limbs in motion or free fall.
2. TRUE The greater distance a limb drops before its motion is stopped, the greater the load on the rope.
3. FALSE The use of knots increases the working-load limit of a rope.
4. TRUE Dividing the published tensile strength of a rope or piece of equipment by the design factor yields the working-load limit (WLL).
5. TRUE Tensile strength is determined under a steady load.
6. TRUE Dynamic loads damage ropes and other equipment more quickly than equivalent static loads.
7. FALSE Heat and friction are not a problem with synthetic ropes.
8. FALSE Carabiners are always oval, aluminum, and have a spring-loaded gate.
9. TRUE Compared to running lines through tree crotches, blocks can decrease wear on ropes, reduce dynamic loading, and limit damage to the tree.
10. FALSE Rescue pulleys are heavy-duty pulleys, with a large rotating sheave for the lowering line and a smaller fixed sheave to accept a rope sling.
11. TRUE The advantages of friction devices over taking wraps on the tree trunk include reduced wear on the rope and ease of taking up slack.
12. TRUE In tree work, a bollard is a post that straps to the tree and is used for taking wraps in a load line.
13. TRUE Using pulleys can reduce the wear on rigging lines.
14. FALSE If the load line is rigged at the brushy end of a limb, it is butt-tied.
15. FALSE Taglines, or pull lines, are used to carry the weight in lowering limbs.
16. TRUE An advantage to balancing a limb is that it can help reduce swing and dynamic loading.
17. FALSE A hinge cut is made by cutting slightly more than halfway through a section from the side, then cutting from the opposite side, about an inch or more offset from the first cut.
18. TRUE A cut that is handy for controlling relatively small sections of wood that may not require roping is the snap cut.
19. TRUE A skillful ground worker can minimize the effect of dynamic loading created by stopping a falling limb with the rigging line by "letting it run."
20. FALSE Ground workers should never wear gloves when operating the ropes in rigging operations.

Matching

D drop cut

F running bowline

H false crotch

B friction device

C landing zone

G mechanical advantage

A. force opposite the relative motion

B. used to take wraps on load line

C. area where pieces are dropped or lowered

D. classic three-point cut

E. forces on stationary objects

F. knot used to tie off limbs

E statics

A friction

G. can multiply pulling power

H. rigging point for load line

Sample Test Questions

1. An advantage to using a false crotch instead of a natural-crotch rigging point is
   a. more flexibility in placement of the rigging point
   b. the friction is more controlled
   c. it minimizes damage to the tree
   d. all of the above

2. The reaction force at the rigging block can be
   a. half the load in the rigging line
   b. twice the load in the rigging line
   c. greater when lifting limbs
   d. increased if a low-friction block is used

3. Dynamic loads in a rigging system are a concern because
   a. the load can be many times the weight of the piece
   b. shock-loading is tougher than static loading on the hardware and ropes
   c. they can be more difficult to estimate or predict
   d. all of the above

CHAPTER 7 • WORKBOOK

Matching

B cant hook

F notch cut

G bucking

E limbing

A felling

H barber chair

C back cut

D hinge

A. tree removal technique

B. device used to roll large logs

C. should never cut into the hinge

D. helps steer the tree in a felling operation

E. removing side limbs of felled trees

F. wedge-shaped cut to direct tree fall

G. cutting log into smaller lengths

H. tree pivots or splits up behind hinge when felling

True/False

1.	TRUE	Before beginning any felling operation, the site should be inspected for potential hazards.
2.	TRUE	Hollow trees can present difficulties in controlling the direction of fall.
3.	FALSE	The lean and shape of the tree are important, but species characteristics are irrelevant in felling operations.
4.	TRUE	A gust of wind can alter the direction of a tree's fall.
5.	TRUE	It is best to plan a tree's removal before any cuts are made.

6.	TRUE	A pull line or wedges can be used to help control a tree's fall.
7.	FALSE	When felling a tree, the notch should be cut at least 50 percent of the way through the tree.
8.	TRUE	A "dogleg" in the pull line can cause the tree to rotate on the cut, misdirecting the fall.
9.	TRUE	A rule of thumb for the depth of the notch is one-third or less of the diameter of the tree.
10.	TRUE	An advantage of the open-face notch is that the hinge breaks as the notch closes.
11.	FALSE	The back cut should always be made slightly lower than the apex of the notch.
12.	TRUE	The hinge of wood formed behind the notch helps to control the tree's fall.
13.	FALSE	After a tree has been felled, bucking should take place before limbing.
14.	TRUE	Branches or logs that are under tension can present a hazard when cut.
15.	TRUE	When lifting heavy objects, the worker should maintain normal back curvature.

Sample Test Questions

1. Cutting large logs into smaller sections is known as
   a. felling
   b. limbing
   c. bucking
   d. notching

2. If a tree pivots or splits upward during felling, it is sometimes called
   a. bucking
   b. barber chairing
   c. hinging
   d. wedging

3. When felling a tree using the traditional 45-degree notch, the back cut should be made
   a. even with the apex of the notch
   b. just below the apex of the notch
   c. just above the apex of the notch
   d. directly through the apex of the notch

CHAPTER 8 • WORKBOOK

Matching

E	lag hooks	A. brings limbs closer together
D	eye splice	B. used with threaded rod
H	eye bolt	C. reduces wear on cable
B	amon-eye nut	D. attaches soft cable to hardware
G	ship auger	E. do not use in decayed wood
C	thimble	F. helps pull cable taut

F Haven grips

A come-along

G. for pre-drilling holes

H. hardware that is through-bolted

True/False

1.	TRUE	In most cases, a tree should be pruned before cables are installed.
2.	FALSE	Cables should be installed one-third the distance from the crotch to the branch tips.
3.	FALSE	Properly installed cables should be parallel to the ground.
4.	FALSE	Cables should always be installed perpendicular to the larger limb.
5.	TRUE	When properly installed, the cable should be just taut.
6.	TRUE	Cables installed while a tree is in foliage may slacken following leaf drop.
7.	TRUE	Lags should only be used in limbs less than 8 inches in diameter and when no decay is present.
8.	FALSE	When installing more than one cable on a limb, the cables must be installed directly over each other.
9.	TRUE	Two cables should never be installed on a single eye bolt or lag.
10.	TRUE	If EHS cable is used, dead-end grips must be used to attach the cable to the hardware.
11.	FALSE	Thimbles are not required with dead-end grips.
12.	TRUE	When installing lags, the hole should be drilled approximately 1/16 inch smaller than the lag diameter.
13.	FALSE	An eye splice cannot be formed when using common-grade, 7-strand cable.
14.	TRUE	The cable should be installed in direct line with the hardware.
15.	FALSE	Diamond-shaped washers are preferred for bolt installation and should never be countersunk.

Sample Test Questions

1. A device commonly used to bring two limbs closer together in cabling operations is a
   a. Haven grips
   b. come-along
   c. cable aid
   d. cable clamp

2. When installing extra-high-strength (EHS) cable, the cable can be attached to the hardware using
   a. dead-end grips
   b. an eye splice
   c. cable clamps
   d. all of the above

3. The recommended height for installing cables is
   a. as close to the crotch as possible
   b. one-third the distance from the crotch to the tips
   c. half the distance from the crotch to the tips
   d. two-thirds the distance from the crotch to the tips

APPENDIX C

Glossary of Arboricultural Terms

3-strand rope—rope construction in which three strands are twisted together in a spiral pattern

12-strand rope—for arborist ropes, a braided-rope construction consisting of 12 strands, most are coreless; there are two types of 12-strand construction: a tight braid that is not easily spliceable, used for climbing and rigging lines, and a loose, easily spliceable "hollow" (e.g., coreless) braid, commonly used for slings

16-strand rope—for arborist ropes, a rope construction that has a 16-strand, braided, load-bearing cover and a filler core that is not significant in load carrying

24-strand rope—for arborist ropes, refers to a rope construction that has a 24-strand, braided cover and is available in double-braided or kernmantle construction

abiotic—nonliving

absorbing roots—fine, fibrous roots that take up water and minerals; most absorbing roots are within the top 12 inches (30 centimeters) of soil

access line—(1) second climbing line hung in a tree to reach a victim in an emergency. (2) climbing line installed in a tree

aerial rescue—method of bringing an injured worker down from a tree or aerial lift device

alternate leaf arrangement—one leaf or bud at each node, situated at alternating positions along the stem; in this arrangement, the leaves are not directly across from each other; compare to *opposite leaf arrangement*

amon-eye nut—specialized nut used in cabling trees that has a large eye for attaching a cable to a threaded rod

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

approved—in the context of standards and specifications, that which is acceptable to federal, state, provincial, or local enforcement authorities or is an accepted industry standard

arborist block—heavy-duty pulley with an integrated connection point (bushing) for attaching a rope sling, a rotating sheave for the rope, and extended cheek plates; used in tree rigging operations

axillary bud—bud in the axil of a leaf; lateral bud

back cut—cut made on a tree trunk or branch, opposite from the notch and toward the notch cut or face cut, to complete felling or branch removal

balance—in rigging, a technique for lowering a limb without allowing either end to drop

barber chair—dangerous condition created when a tree or branch splits upward vertically from the back cut, slab up

barrier zone—chemically defended tissue formed by the still-living cambium, after a tree is wounded or invaded by pathogens, to inhibit the spread of decay into new annual growth rings; compare to *reaction zone*

bend—type of knot used to join two rope ends together

bend ratio—ratio of the diameter of a branch, sheave, or other object to the diameter of the rope that is wrapped around it

bight—curve or arc in a rope between the working end and the standing part

biotic—pertaining to living organisms

Blake's hitch—friction knot climbers use, sometimes in place of the tautline hitch or Prusik knot

block—heavy-duty pulley used in rigging; designed for dynamic loading

block and tackle—a mechanism of pulleys and rope used to gain mechanical advantage in lifting and pulling

body-thrust—method of ascending a tree using a climbing rope

bollard—post on which wraps can be taken with a rope to tie it off or to provide friction for control

bore cut—back-cut technique in which the hinge is established by plunge cutting through the stem, then cutting back away from the hinge; plunge cut

bowline—looped knot used to attach items to a rope

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 subordinate branch that retards the spread of discoloration and decay from the subordinate stem into the trunk or parent branch

bucking—cutting of a tree trunk or log into shorter, manageable sections

butt-hitching—method of lowering pieces when the rigging point is below the work, traditionally without the use of a block

buttress roots—roots at the trunk base that help support the tree and equalize mechanical stress; trunk flare

butt-tied (butt-tying)—tying off a limb at the butt end for rigging

cable aid—device used to tighten lags and aid in cable installation

caliper—the thickness of a tree; diameter

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

Canadian Standards Association—an association that serves as a neutral third party, providing a means for industries to discuss and develop standards

cant hook—peavey having a blunt end instead of a spike; used for handling logs

carabiner (karabiner)—oblong metal ring used in climbing and static rigging that is opened and closed by a spring-loaded gate

cardiopulmonary resuscitation (CPR)—procedure used by a trained person to force air into the lungs and to force blood circulation in a person whose heart has stopped beating

cavity—open or closed hollow within a tree stem, usually associated with decay

chaps—form of leg protection; worn when operating a chain saw

Chicago™ grip—a device designed to clasp and hold cable

chipper—equipment used to grind tree branches into wood chips

cleaning—in pruning, the selective removal of dead, dying, diseased, and broken branches

clevis—U-shaped fitting with a pin running through it; shackle

climbing hitch—hitch used to secure a tree climber to the climbing line, permitting controlled ascent, descent, and work positioning

climbing line—rope that meets specifications for use in tree climbing

climbing saddle—work-positioning harness designed for climbing trees

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

clove + half hitches—a combination of knots used to secure a rope to a tree section in rigging

clove hitch—knot used to secure an object to a rope or a rope to an object

codominant branches/codominant stems—forked branches nearly the same size in diameter, arising from a common junction and lacking a normal branch union

come-along—portable device, consisting of cable winches or rope winches, used to draw two objects closer together; simple arrangement of rope knots and loops to create mechanical advantage

command-and-response system—system of vocal communication used in tree care operations

common grade, 7-strand, galvanized cable—steel-cable construction in which seven strands are twisted together in a spiral pattern; often used to add structural support to trees; terminated by wrapping onto itself

Compartmentalization of Decay in Trees (CODIT)—natural defense process in trees by which chemical and physical boundaries are created that act to limit the spread of disease and decay organisms

compound leaf—leaf with two or more leaflets; compare to *simple leaf*

conifer—cone-bearing tree or other plant that has its seeds in a structure called a cone

conk—fruiting body or nonfruiting body (sterile conk) of a fungus, often associated with decay

connecting link—component of a rigging or climbing system that connects other components

conventional notch—45-degree notch with a horizontal bottom cut; used in removing trees or branches; also called common notch; compare to *Humboldt notch* and *open-face notch*

cow hitch—knot commonly used to attach hardware to a tree; should be backed up with a half hitch

crown—upper part of a tree, measured from the lowest branch, including all the branches and foliage

crown cleaning—removing dead, dying, diseased, and/or broken branches from the tree crown

cycles to failure—number of times a rope or other piece of equipment can be used with a given load before mechanical failure

dead-end grips—cable-termination devices that must be used to terminate extra-high-strength cable; may be used to terminate common cable

dead-end hardware—lag-threaded cable anchor or bracing rod that is screwed directly into an undersized, pre-drilled hole in the tree but which does not pass through to the other side; compare to *through-hardware*

dead-eye sling—rope sling with a single eye spliced in one end; also called an eye sling, a fixed-eye sling, or a spliced-eye sling

deadwooding—removing dead and dying branches from a tree

deciduous—tree or other plant that sheds all of its leaves according to a genetically scheduled cycle during the cold season in temperate zones; compare to *evergreen*

design factor—factor by which the rated or minimum breaking strength of a rope or piece of equipment is divided in determining its working-load limit

direct contact—any part of the body touching an energized electrical conductor; compare to *indirect contact*

double braid—rope construction consisting of a braided rope within a braided rope, both of which carry part of the load

double-crotch—technique consisting of tying one climbing line or two climbing lines into two places in a tree

double fisherman's knot (bend)—knot commonly used to join two ropes or two ends of the same rope, as when forming a Prusik loop

double-locking (gate)—pertaining to a carabiner, requiring two distinct motions to prepare the gate to open

D-rings—D-shaped metal rings on a climber's saddle for attaching ropes and snaps

drip line—imaginary boundary on the soil surface defined by the branch spread of a single plant or group of plants

drop cut—branch-removal technique consisting of an undercut and then a top cut, usually made farther out on the branch

drop zone—area where cut branches or wood sections will be dropped or lowered from a tree

dynamic load—forces created by a moving load; load that changes with time and motion; compare to *static load*

electrical conductor—any body or medium allowing the passage of electricity; while working on trees, this generally would be any overhead or underground electrical wires; includes communication cables and power lines that have electricity or have the potential to carry electricity

emergency response—predetermined set of procedures by which emergency situations are assessed and handled

endline knots—knots tied at the end of a line (such as a bowline or clove hitch)

evergreen—tree or other plant that does not shed all of its foliage annually; compare to *deciduous*

extra-high-strength (EHS) cable—type of 7-strand, steel cable, often used to cable trees; stronger but less flexible than common-grade cable; terminated with dead-end tree grips

eye bolt—cable anchor with a closed eye, usually machine-threaded; only drop-forged eye bolts are accepted and approved for tree support systems in the United States

eye splice—(1) closed-eye termination, hand-formed in common-grade cable, to attach the cable to eye bolts or lags. (2) rope termination forming an eye and made by splicing the rope back upon itself

eye-spliced rope—a length of rope that has been spliced back upon itself to form an eye in the end

eye-to-eye sling—sling (usually a length of spliced rope) with an eye at each end; also called eye-and-eye sling

fall—part of the rigging line from the rigging point to the anchor point; compare to *lead*

false crotch—device installed in a tree to set ropes during climbing or rigging because there is not a suitable natural crotch available, or to protect an available crotch, and/or to reduce wear on ropes

fascicle sheath—the tubular encasement of conifer needles (especially pines) at the point of attachment to the stem

figure-8 knot—safety knot or stopper knot tied in a line

first aid—emergency care or treatment of the injuries or illnesses of a person to stabilize his or her condition before medical help is available

footlock (footlocking)—method of ascending a rope by wrapping the rope around the feet; see *secured footlock*

force—any action or influence causing an object to accelerate/decelerate; calculated as mass multiplied by acceleration; is a vector quantity

friction—specific type of force that resists the relative motion between two objects in contact; the direction is always opposite the motion

friction device—device used to take wraps in a load line to provide friction for controlled lowering or climbing

friction hitch—any of numerous knots used in tree climbing or rigging that may alternately slide along and then grip a rope

fruiting body—reproductive structure of a fungus; the presence of certain species may indicate decay in a tree; see *conk*

girdling root—root that encircles all or part of the trunk of a tree, or other roots, that constricts the vascular tissue and inhibits secondary growth and the movement of water and photosynthates

girth hitch—simple knot used to attach a line, spliced eye, or endless loop to an object

growth rings—rings of xylem that are visible in a cross section of the stem, branches, and roots of some trees; in temperate zones, the rings typically represent one year of growth and are sometimes referred to as annual rings

half hitch—simple knot used to temporarily attach a line to an object; also used as a backup in combination with other knots

hand pruners—tool used for pruning small twigs of less than ½ inch in diameter

Haven grip—device used to clasp and hold cable

heading cut (heading back)—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

heartwood—inner, nonfunctional xylem tissues that provide structural strength to the trunk and chemical defense against decay-causing organisms; compare to *sapwood*

hedge shears—tool used to trim (shear) hedges

hinge—strip of wood fibers created between the face cut or notch and the back cut that helps control direction in tree or limb removal

hinge cut—sequence of cuts used to control the direction of a limb being removed

hitch—knot made when a rope is secured around an object or its own standing part

hollow braid—rope construction consisting of a braided rope with no core

Humboldt notch—felling notch that is horizontal on the top and angled on the bottom; also called Humboldt scarf or reverse scarf; compare to *conventional*, or *common, notch* and *open-face notch*

included bark—bark that becomes embedded in a crotch (union) between branch and trunk or between codominant stems; causes a weak structure

indirect contact—touching any conductive object that is in contact with an energized electrical conductor; compare to *direct contact*

job briefing—brief meeting of a tree crew at the start of every job to communicate the work plan, responsibilities and requirements, and any potential hazards

kerf—slit or cut made by a saw in a log; space created by a saw cut

kernmantle—rope with a cover and a core in which the core yarns are not braided but consist of twisted fibers

kickback—sudden, sometimes violent and uncontrolled backward or upward movement of a chain saw

kickback quadrant—upper quadrant of the tip of a chain-saw bar

knot—general term referring to all knots, bends, and hitches

lag hook (J-hook)—lag-threaded cable anchor with an open eye (J-shaped)

landing zone—predetermined area where tree sections will be brought down in a rigging operation

lanyard—short rope equipped with carabiners, snaps, and/or eye splices; work-positioning lanyards are used for temporarily securing a climber in one place

lateral bud—vegetative bud on the side of a stem; compare to *terminal bud*

lead—part of a rigging line from the rigging point to the load; compare to *fall*

leaf scar—scar left on the twig after a leaf is shed

leaflet—separate part of a compound leaf blade

leg protection—chaps or other chain-saw-resistant clothing worn over the legs when operating a chain saw

leglock method—method of starting a chain saw in which the saw's top handle is held with the left hand and the back of the saw is held tightly between the operator's legs, leaving the right hand free to pull the starting cord. The chain brake must always be engaged when starting a saw

limbing—cutting off the side branches of a felled tree

lion tailing (lion's tailing)—poor pruning practice in which an excessive number of branches is thinned from the inside (lower part) of limbs into a clump of terminal foliage

load line—rope used to lower a tree branch or segment that has been cut

lobe—leaf segment that projects outward, creating voids (sinuses) between the segments

locking (gate)—pertaining to carabiners and snaps, requiring at least one distinct motion to prepare the gate to open (to unlock) but not to actually open

locking snap—connecting device that is self-closing and requires one motion to unlock and a separate motion to open the gate; used by tree climbers primarily for connecting the climbing line to the saddle

lopping shears (loppers)—long-handled, two-handed tools used for cutting stems and branches that are too large for hand pruners

mechanical advantage—system by which effort can be multiplied

micropulley—small, light-duty pulley used in climbing and rigging operations; often used as a knot tender

mineral—naturally occurring, inorganic solid that has a definite chemical composition and possesses characteristic physical properties

mycorrhizae—symbiotic association between certain fungi and the roots of a plant

notch—wedge cut into a log or tree for felling

node—slightly enlarged portion of a stem where leaves and buds arise

Occupational Safety and Health Act (OSHA)—in the United States, the legislative act dealing with health and safety in the workplace; administered by the Occupational Safety and Health Administration; in Canada, Occupational Health and Safety Administration (OHSA)

open-face notch—wedge-shaped cut (about 70 degrees or greater) used in felling trees or removing tree sections; compare to *conventional,* or *common, notch* and *Humboldt notch*

opposite leaf arrangement—leaves or branches situated two at each node, across from each other on the stem; compare to *alternate leaf arrangement*

peavey—stout, wooden lever fitted with a strong, sharp spike and a hook; used for rolling logs

peen—act of bending, rounding, or flattening the end of through-hardware for the purpose of preventing the nut from backing off

personal protective equipment (PPE)—personal safety gear such as hard hat, safety glasses, hearing protection, and chain saw-protective trousers or chaps

phloem—plant vascular tissue that transports photosynthates and growth regulators; situated on the inside of the bark, just outside the cambium; is bidirectional (transports up and down); compare to *xylem*

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

pole pruner—long-handled tool used to make scissorslike, small pruning cuts that cannot be reached with hand tools

pole saw—long-handled tool with a pruning saw on the end

pore space—air- and water-filled spaces between soil particles

positive-locking—in reference to carabiners, locking automatically and requiring two or more motions to prepare the gate to open; prevents unintentional opening

pruning saw—handsaw used for pruning trees; generally cuts primarily on the pull stroke

Prusik hitch—type of multi-wrapped friction hitch used in climbing and rigging; a common use is to attach the Prusik loop to the climbing line when footlocking

Prusik loop—loop of rope used to form a Prusik hitch for climbing or rigging

pull line—tagline or a line tied near the top of a tree or section of a tree to be removed; used to help pull the piece in the desired direction

pulley—device consisting of a rotating, grooved wheel between two side plates; used to change the direction of pull in a line

radius—distance from the center to the perimeter of a circle

raising—selective removal of lower limbs from a tree to provide clearance; lifting

ray—parenchyma tissues that extend radially across the xylem and phloem of a tree and function in transport, storage, and defense

reaction zone—natural boundary formed chemically within a tree to separate damaged wood from existing healthy wood; important in the process of compartmentalization; compare to *barrier zone*

reactive force—force generated in response and opposite to another force, often demonstrated when operating a chain saw

reduction—pruning to decrease height and/or spread of a branch or crown

reduction cut—pruning cut that reduces the length of a branch or stem back to a lateral branch large enough to assume apical dominance

rescue kit—climbing gear and emergency equipment that should be set out on every job site and available to conduct an aerial rescue and apply first aid

rescue pulley—light-duty pulley used in light rigging operations

restoration—(1) pruning to improve the structure, form, and appearance of trees that have been severely headed, vandalized, or damaged. (2) management and planting to restore altered or damaged ecosystems

rigging—method of using ropes and hardware to remove large limbs or take down trees

rigging point—placement in the tree (in a natural or false crotch) or any other point through which the load line passes to control rigging operations

risk reduction pruning—pruning that is designed to reduce the risk of tree failure and mitigate potential safety hazards

root crown—area where the main roots join the plant stem, usually at or near ground level; root collar

running bowline—knot often used to tie off and control limbs that are to be removed; can be used when the desired tying point cannot be directly accessed by the worker

running end—the end of a rope not in use; compare to *standing part* and *working end*

sapwood—outer wood (xylem) that actively transports water and minerals; compare to *heartwood*

scabbard—protective sheath for a pruning saw or other tool

scaffold branches—permanent or structural branches of a tree

screw link—connecting device with a threaded closure mechanism; used to secure equipment or tree sections in rigging operations

secateurs—pruning tool intended for cutting single, small-diameter stems; also called pruning shears or hand pruners

secured footlock—method of ascending a rope by wrapping the rope around the feet, in which the climber utilizes an additional means of securing against a fall

serration—sawtoothed margin of a leaf, with the teeth pointed forward

shackle—U-shaped fitting with a pin running through it; clevis

shall—word that designates a mandatory requirement within the ANSI standards or contract documents; compare to *should*

sheet bend—knot used to attach two lines; the lines can be of unequal diameter; ***not*** to be used for life support

ship auger—type of drill bit with an open spiral form; used to drill holes in trees for cable or bracing installation

shock-loading—dynamic, sudden force placed on a rope or rigging apparatus when a moving load or piece is stopped

shot pouch— weighted sack used to set climbing or rigging lines in trees; usually a shot-filled, teardrop-shaped canvas bag; also know as a throwbag

should—word that designates an advisory recommendation in the ANSI standards or contract documents; compare to *shall*

simple leaf—single-bladed leaf; not composed of leaflets; compare to *compound leaf*

sling—device used in rigging to secure equipment or pieces being rigged

slip knot—slipped overhand knot

snap—connecting device used by tree climbers, primarily for connecting the climbing line to the saddle

snap cut—cutting technique in which offset, bypassing cuts are made so that a section can be broken off easily; also known as mismatch cut

split-tail—separate, short length of rope used to tie the friction hitch in a climbing system

standing part—inactive part of a rope, as opposed to the working end; compare to *running end* and *working end*

starch—chain of sugar molecules linked together that serves as a form of energy storage in plants

static load—constant load exerted by a mass due to its weight; compare to *dynamic load*

stopper knot—knot, usually a figure-8 knot, tied in the end of a line or in the tail of a knot to prevent the end or tail from passing through the knot

stress—factor that negatively affects the health of a tree

tagline—rope used to control the swing of a limb being removed; rope used to control the direction or fall of a tree or limb being removed

taper—change in diameter over the length of trunks, branches, and roots

tautline hitch—type of friction hitch used by climbers for fall protection during ascent, descent, and work positioning

tensile strength—force at which a new piece of equipment or rope in testing fails under a static load

terminal bud—bud at the tip of a twig or shoot; apical bud; compare to *lateral bud*

thimble—device used in cabling to form and protect the termination loop in the cable; also used in rope attachment to increase the bend radius and reduce wear on the rope

thinning—selective pruning to reduce density of live branches; removing unwanted branches and limbs to provide light or air penetration through the tree or to lighten the weight of the remaining branches

threaded rod—metal rod used to support weak sections or crotches of a tree; bracing rod

through-hardware—cable anchors or bracing rods that pass completely through an oversized, pre-drilled hole in a trunk or branch and are secured with nuts and washers; compare to *dead-end hardware*

throwing knot—series of loops and wraps tied in a rope to form a weight for throwing

throwline—device consisting of a small weight attached to a thin, lightweight cord; used as a pilot line to set climbing or rigging lines in trees

timber hitch—knot consisting of a series of wraps on a line and used to secure the line to a limb or tree

tip-tied (tip-tying)—tying a line on the tip (brush) end of a limb to be removed

topping—inappropriate pruning technique to reduce tree size; cutting back a tree to buds, stubs, internodes, or laterals not large enough to assume apical dominance

transpiration—water vapor loss through the stomata of leaves

trunk flare—transition zone from trunk to roots where the trunk expands into the structural roots; root flare

vascular system—phloem and xylem, the parts of a tree that conduct water or nutrients

vascular wilt—wilting of a tree caused by disease of the vascular system

watersprout—upright, epicormic shoot arising from the trunk or branches of a plant above the root graft or soil line; although incorrect, also called a sucker, which is a shoot arising from the roots

whoopie sling—sling with one fixed eye and one adjustable eye, made from hollow-braid rope

whorled—leaves, twigs, or branches arranged in a circle around a point on the stem

working end—end part of a rope in use for rigging or climbing; compare to *running end* and *standing part*

working-load limit (WLL)—tensile strength divided by design factor; maximum load that should not be exceeded in a piece of equipment, rope, or rope assembly when performing its normal working function

work plan—predetermined, orderly means for job completion

work-positioning lanyard—lanyard used in climbing; often as a secondary means of attachment

wound dressing—compound applied to tree wounds or pruning cuts

xylem—main water- and mineral-conducting tissue in trees and other plants; provides structural support, becoming wood after lignifying; is unidirectional (conducts up only); compare to *phloem*

APPENDIX D

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