A Training Manual for Virginia Tree Stewards

Volunteers for the Community Forest

TREES VIRGINIA

Virginia Urban Forest Council

A Training Manual for Virginia Tree Stewards, 3rd Edition

Acknowledgments

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Note: This edition is available on CD format for use in tree steward training classes. Print copies of the manual will be the responsibility of local tree steward groups.

To make this edition current, the use of websites is embedded in the text. An appendix lists websites related to trees. Because websites or website links occasionally change, we encourage the reader to search for any Internet site not accessible via this edition.

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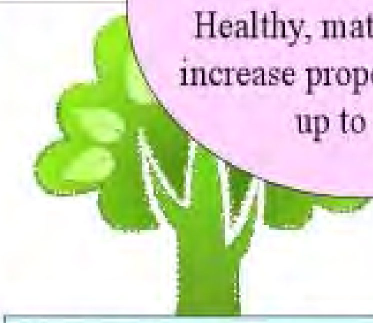
Why We Need Trees

Trees Are Clean

They absorb huge amounts of CO^2 emissions.

Trees Are Cool ☺

Mature trees shading your house can reduce air conditioning needs by up to 30% and cool the air by 9-13° on a hot summer day.



Trees Make You Money !

Healthy, mature trees can increase property values by up to 10%.

Trees Are Diplomats

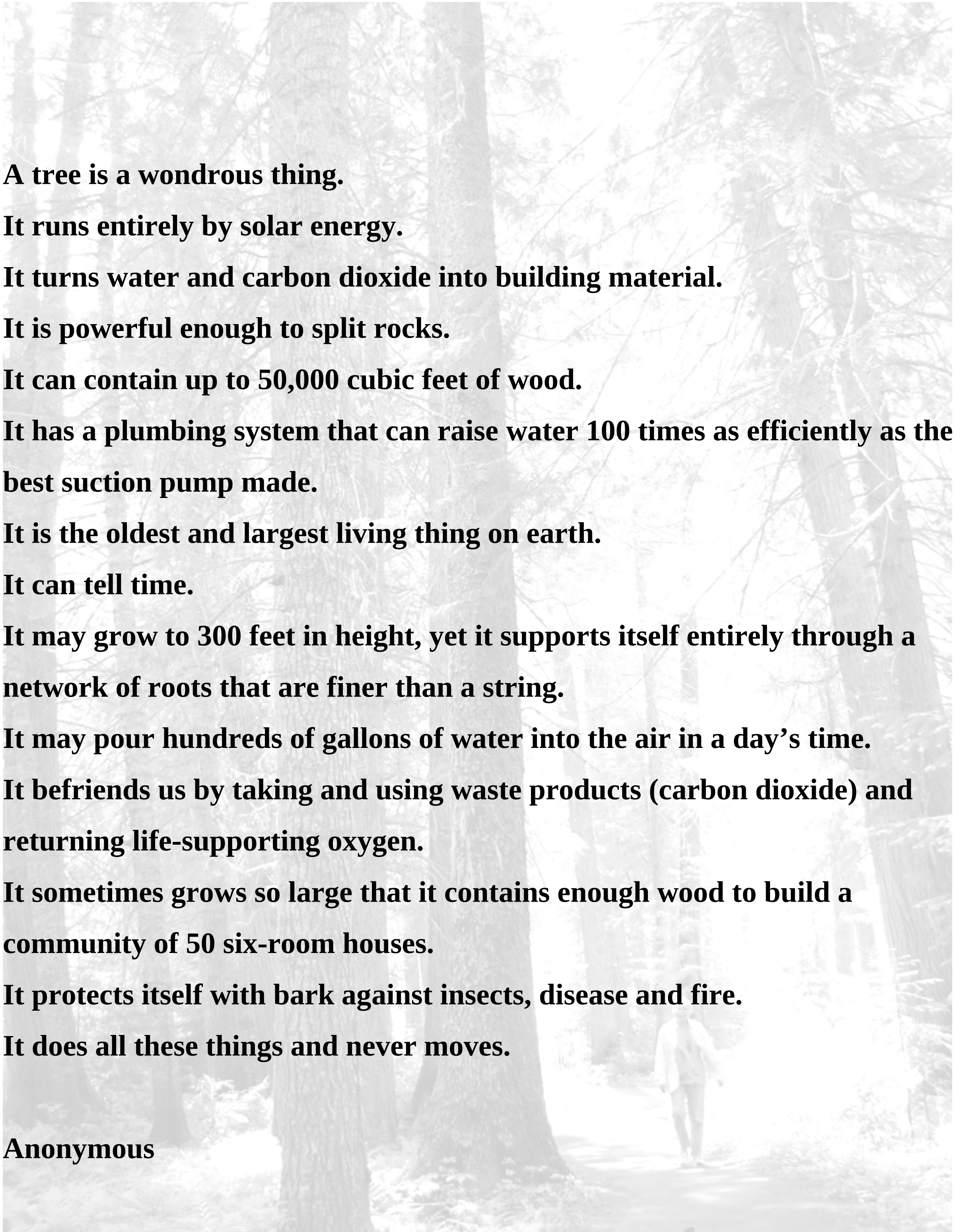
As sound barriers and screens, trees reduce noise levels, provide privacy, and enhance neighbor relations

Trees Make Good Homes

for birds & other wildlife.

Trees Save Our Tax Dollars

Roots absorb rain & filter runoff– improving water quality & saving taxpayers $ millions.



A tree is a wondrous thing.

It runs entirely by solar energy.

It turns water and carbon dioxide into building material.

It is powerful enough to split rocks.

It can contain up to 50,000 cubic feet of wood.

It has a plumbing system that can raise water 100 times as efficiently as the best suction pump made.

It is the oldest and largest living thing on earth.

It can tell time.

It may grow to 300 feet in height, yet it supports itself entirely through a network of roots that are finer than a string.

It may pour hundreds of gallons of water into the air in a day's time.

It befriends us by taking and using waste products (carbon dioxide) and returning life-supporting oxygen.

It sometimes grows so large that it contains enough wood to build a community of 50 six-room houses.

It protects itself with bark against insects, disease and fire.

It does all these things and never moves.

Anonymous

Photo by Maud Henne

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How Trees Grow – Unit 1

WHAT IS A TREE?

Trees are the tallest, most massive, longest-lived freestanding organisms in the world. They are segmented organisms with rigid cell walls restricting movement; trees are not able to move away from potentially dangerous and destructive conditions. Many species cannot adapt to the harshness of urban environments and therefore do not achieve their optimal growth and development.

Forest trees grow in groups and benefit from group protection and group defense. Most city trees grow as individuals and lack group benefits. Knowing how trees grow can help you understand the effects of environmental stresses.

One of three types of woody perennial plants, a tree must meet these criteria:

- Has the potential to grow to at least 20 feet tall at maturity in a temperate climate where reasonable rainfall or irrigation is available.
- Usually has a single trunk that at an early stage may divide into two or more ascending trunk-like branches topped by a canopy of foliage.
- Stands by itself.

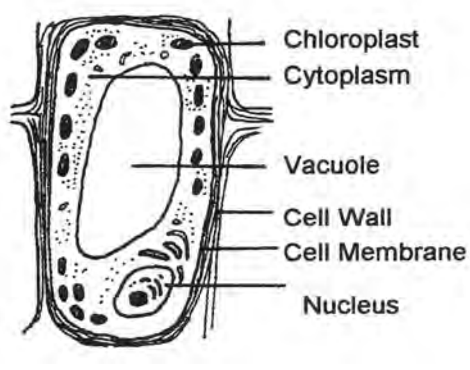
MICROBIOLOGY OF TREES

Trees, like other living things, are made up of cells, tissues, organs and systems. Although the body of a tree may not look or function like our own, the organs and systems work together just as ours do to provide the tree with nutrition, respiration, growth, reproduction and protection.

To understand the nature of plants – trees in this case – we begin with a look at their cells. Under a microscope, plant cells appear squared or rectangular, distinctly different from round animal cells. Surrounding the **cytoplasm,** the jelly-like living material of each cell, are layers of **cellulose** fibers. This cellulose forms a cell wall that strengthens tree tissues, stiffening and supporting them as the tree grows larger. In delicate structures, such as leaves, the cell walls remain relatively thin. In the tree's woody structures that support weight, cells continue to stiffen as they age with a secondary wall of thick cellulose layers.

Did You Know?
Thousands of trees are harvested each year for the cellulose chemically extracted from their wood chips. Cellulose is a thickening agent in ice cream, mayonnaise, hand lotion and paint. Cellophane wrap and rayon fabric are both products of wood cellulose. Chemists hope to replace more plastics and nylon products now produced from oil with tree cellulose.

TREE CELL

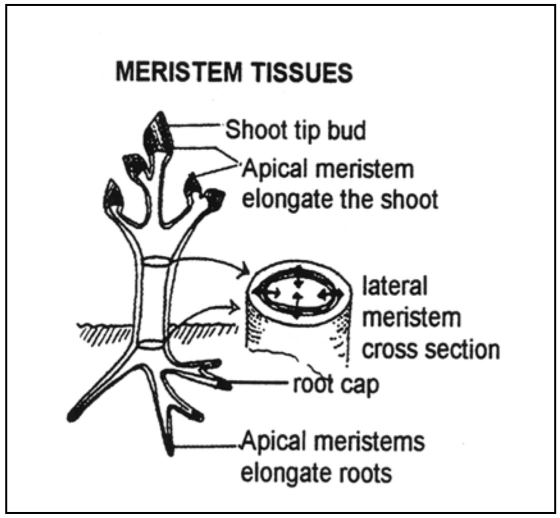


Plant cells are often described as tiny factories, using the energy of sunlight and the raw materials of atmospheric gases, water and minerals to produce sugars and compounds used as food. **Chlorophyll,** the green pigment, concentrates in small oval bodies called **chloroplasts** that move about through the living protoplasm (or cytoplasm) within each cell. These chloroplasts are the site of **photosynthesis**.

As a tree grows, cells of the main body, trunk and branches continue to thicken with cellulose. Each thickening layer forms inside of the previous layer surrounding the cell, gradually reducing the space available for the living **protoplasm** and blocking water and oxygen from the cell. As the cell stiffens, the protoplasm dies, leaving a hollow supportive structure.

More than 95% of a mature living tree's trunk and branches are actually dead hollow cells. These rigid cells form the support and part of the water conduction system within a tree. The cell walls in trees include **lignin,** an additional hardening agent that holds the cells together and increases the rigidity of the trunk and branches.

HOW TREES GROW



Tree growth takes place only in the **meristem** tissue, specialized areas within the tree where cell division (growth) occurs. Cell division in **apical meristems** makes roots and shoots grow longer. The apical meristems of growing shoot tips are protected beneath the scaly **buds**. The apical meristem of each root tip is protected by a **root cap**. **Primary growth**, the elongating growth within these areas, extends or lengthens both branches and roots.

Lateral meristems are found within the trunk and branches of the tree. Here cell division forms the secondary growth of wood that gradually thickens the trunk and branches, allowing support for the great weight of the tree. Every year a tree grows new living tissue on top of and to the outside of the previous year's old, dead tissue. New wood and new bark are produced annually.

MAIN PARTS OF TRUNKS AND BRANCHES

- The **cambium** is the meristematic area of cells located just under the bark. This thin layer of living cells divides, creating new cells on the inside and outside of its surface. It produces **phloem** that later becomes bark on the outside, and **xylem** that becomes sapwood on the inside. Xylem and phloem appear in the stems, roots and leaf veins making up the dominant part of the vascular system.

- As the **outer bark** builds layers, it protects the tree from mechanical injury and insulates it from fire, extreme temperatures and other bad weather. Accumulated wax in these dead cells makes the outer bark relatively waterproof, keeping moisture in during dry periods and protecting against diseases, insects and other pests. As the tree grows larger, the outermost layers of bark tissue crack, gradually flaking or peeling off to be replaced by new bark forming underneath. Depending on species, the outer bark may be very thin as in birch, or up to a foot thick as in the Douglas fir.

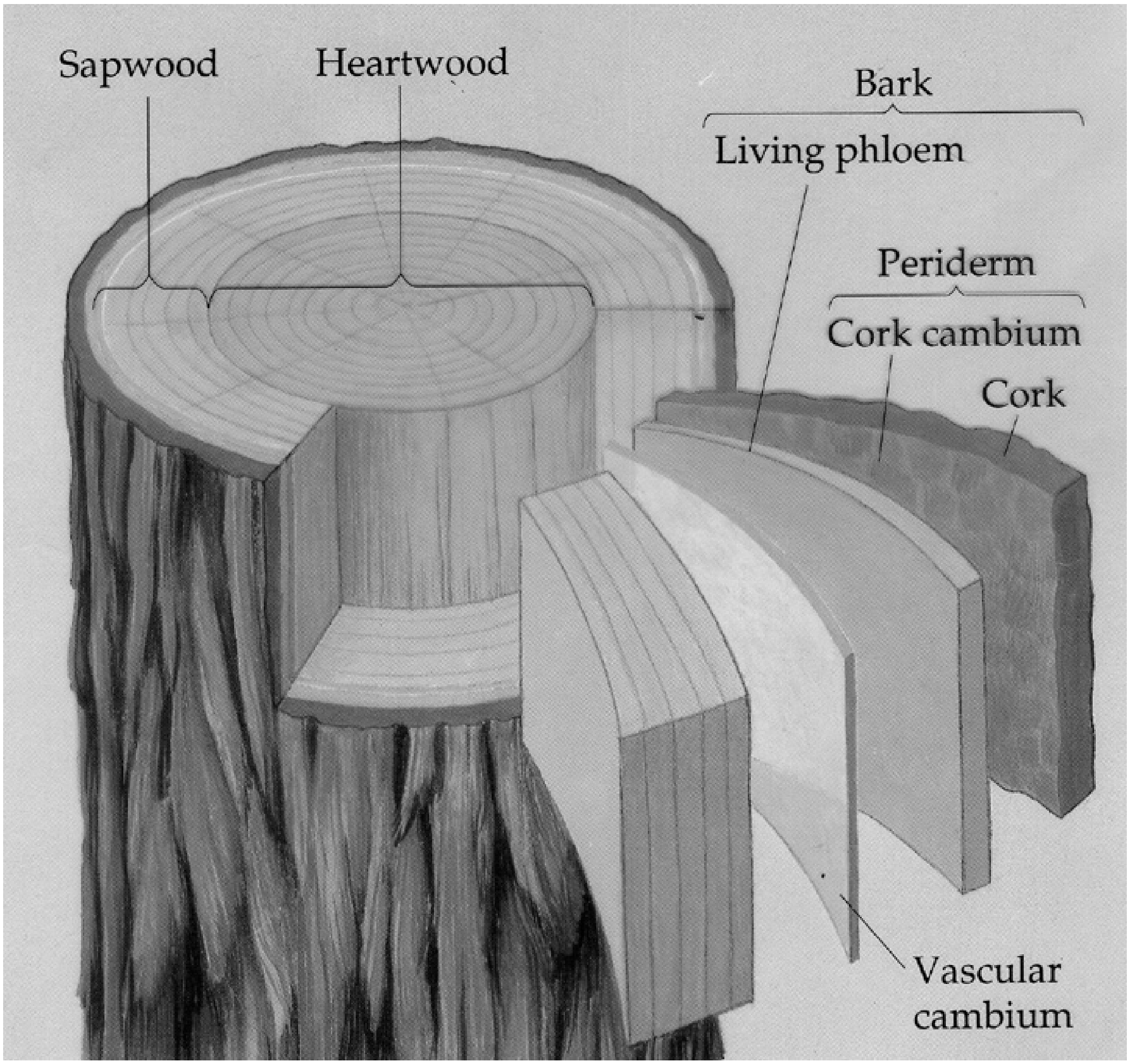
- The **inner bark**, also called phloem, is the pipeline for transporting nutrients produced in the leaves during photosynthesis downward to the rest of the living tree. It lives only a short time before becoming part of the outer bark.

- The **sapwood**, or xylem, is the inside cells of cambium providing an upward passageway for water and nutrients. These cells divide and lay down woody tissue to strengthen the stems and trunk. (Xylem is the Greek word for wood.) As new rings of sapwood are laid on top, older sapwood turns into heartwood.

- The **heartwood** forms the central tree support. This rigid, nonliving xylem tissue is filled with wax and wastes. It supports the tree and inhibits the spread of damage and disease. Heartwood resists decay.

- The **pith** is the core in smaller branches and varies by species.

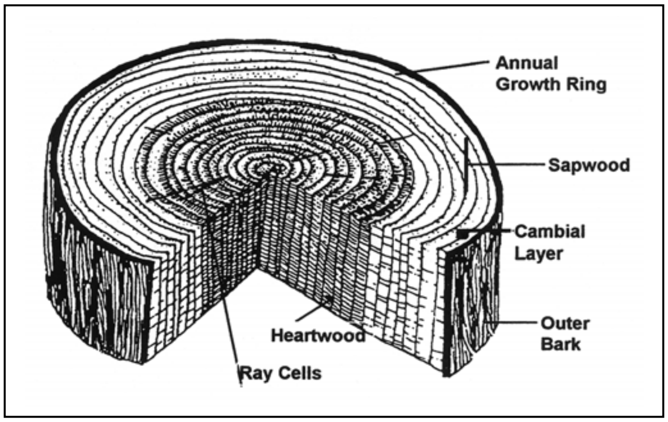
Cross Section – Layers of a Tree Trunk



Lenticels are tiny openings that allow oxygen, carbon dioxide, nitrogen gas and water vapor to enter and leave the tree. They occur on the branches and the trunks.

Rays. Although most water, nutrient and chemical transfers move upward and downward in a tree, some transfers also occur across the tree. Sap travels horizontally to the cambium through **rays**, which transport water and nutrients. Resembling wheel spokes, rays are lines of larger living cells extending from the bark through the heartwood. Rays add to the vascular system by linking the xylem and phloem systems. This provides lateral strength by binding it all together. Rays also store carbohydrates and sugars and play a role in reducing the spread of decay.

Cross Section of a Tree Trunk



Heartwood's Pulse
Heartwood is full of waxes and chemicals, which are waste material to a tree but functional in resisting rot. In certain species, this rot resistance has long been valued for fence posts and other uses that bring the wood into contact with soil. Locust, for example, was harvested and split for fencing well before history framed Abraham Lincoln as a rural farmer splitting rails and posts. Another characteristic of heartwood is a changed color that society has come to prize in certain species like black walnut and black cherry.

GROWTH CYCLES

In a temperate climate where there is a clearly defined growing season and a dormant season, the first activity in the annual growth cycle occurs below ground. In spring when soils warm, fine roots develop. They absorb water and dissolved nutrients for distribution to the emerging buds and leaves. Leaves convert the energy from sunlight into chemical energy used for tree growth.

A tree goes through alternating periods of growth and rest. Cultural practices, such as fertilization and pruning that encourage growth near the growing season's end, tend to interfere with the development of cold tolerance. Roots never really go dormant and therefore can be damaged by temperatures below freezing. This especially affects trees in above-ground containers.

ANNUAL RINGS

The seasonal production of new wood results in **annual growth rings** visible on the cross section of a tree stem. The oldest rings are closest to the center of the tree and form the heartwood. This is the dead xylem layer.

A year's formation of wood begins with larger, thin-walled cells in spring and ends with smaller, thick-walled cells in summer. The larger spring wood cells, called **early wood**, form as the tree is more actively growing. These cells produce the light-colored portion of the annual growth ring. The smaller summer wood cells, called **late wood**, form as tree growth slows and make up the darker portion of the annual ring. Wood is not formed in winter because the cambium is completely inactive during the dormant season.

Did You Know?
Counting annual rings to age a tree is not always accurate. Drought, late frosts, defoliating insects or harsh weather may form false rings. These stressful events trigger the production of late wood cells. If the tree first produces a ring of early wood and then late wood cells, multiple rings result.

WOUNDING A TREE

Trees may suffer damage from a wide range of pests, diseases, natural events and human activities.

Carving a beloved's initials into tree bark was once a romantic custom. Years later, when the tree has grown, the initials remain as a scar at the exact same place.

Plant cells do not repair or replace themselves in the way human cells do. Tree bark is damaged forever.

Trees can live after sustaining substantial damage to the interior wood or to areas of the bark as long as the damage or disease does not spread to living cambium tissues. Structurally, however, these trees are weakened.

Damage from scrapes or girdling wires cutting into the thin cambium layer beneath the bark may kill a tree, even though little damage appears on the surface. String trimmers, mowers, price tags and support wires cause much damage to trees in urban areas.

See Unit 5 and Unit 10 for more on how trees are damaged.

Did You Know?
The difference in width of annual growth rings can be used to postulate environmental conditions affecting the tree's past growth. Archaeologists have used tree rings as clues to detect droughts and other events that may have affected ancient civilizations. The science of using tree ring patterns to calculate time is called dendrochronology.

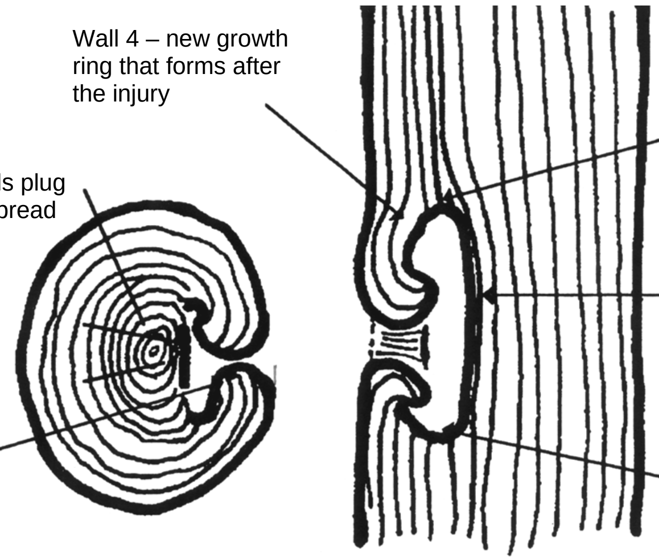
COMPARTMENTALIZATION - CODIT

Trees have no mechanism to form new healthy cells in the same position as those suffering injury; therefore, trees have no healing process. However, as part of their defense mechanism, trees have the unique ability to compartmentalize or "wall off" decay. **Compartmentalization** is the process by which trees limit the spread of discoloration and decay. Alex Shigo's proposed model of this process, **CODIT** (Compartmentalization Of Decay In Trees) identifies four barrier walls that a tree develops in response to an injury or wound. TREES DO NOT HEAL; THEY SEAL.

The first three walls form the **reaction zone**. Wall 1 impedes the spread above and below by plugging inactive xylem vessels. Wall 2 slows inward spread by depositing chemicals in late wood cells. Wall 3 further halts lateral spread by activating ray cells to resist decay. To protect against the outward spread of decay, the next layer of wood to form after injury becomes Wall 4 or the **barrier zone**.

The weakest of the barriers is Wall 1; the strongest is Wall 4. The new cambial ring forming around the injury creates an outer barrier. Interestingly, this explains why trees can continue to grow, forming healthy outer cambium layers, despite a hollow, decayed interior. Wall 4 rarely fails, except in death of the new cambium or if some canker-causing fungus restricts the development of the new growth ring. Sealing off the damage may require more than one growth cycle.

During every growth period, trees form new compartments over older ones. Thus, after injury, a boundary forms that resists the spread of infection. This protects and preserves the water, air and mechanical support systems of the tree.



CODIT

Understanding CODIT makes it clear why most tree wounds require little assistance in closing. Research indicates that applying wound dressings such as tree paint and “cleaning out” or filling wounds may hinder the natural compartmentalization process. A raggedly broken branch should be pruned. Be careful not to cut into the surrounding wood or to remove any healthy bark edges. Interfering with the cambium around the wound can slow or stop compartmentalization.

Trees do not “heal” themselves, but do “seal” or compartmentalize damage and, when possible, continue growing around and over it. It is important to understand that no wound heals, including pruning cuts, but wounds are walled off or covered to protect healthy tissue.

Key Questions:

What two substances make wood stiff and durable?

What tissue is responsible for tree growth? Where is it found?

How can you determine where in a tree photosynthesis is taking place?

What do the phloem and xylem tissues do?

Where is the cambium? Why does this make bark injuries so important?

What can be learned from the annual growth rings of a tree?

What does CODIT stand for?

How do trees counteract bark damage?

Tree Roots, Shoots and Leaves Unit 2

The body of a tree relies on two main systems. The underground root system anchors the tree and conducts a complex process for obtaining water and nutrient resources.

Above ground, the shoot system develops stems, leaves, flowers and fruit, providing nutrition, respiration and reproduction.

These two systems interact, and a change in one system immediately affects the other. For example, both systems rely on each other for proper hormone production that controls certain aspects of growth. This is why some detrimental practices such as topping or severe “root pruning” can result in a growth response that may not be so helpful to the tree.

Within these two main body systems, the tree’s vascular system transports nutrients and water. The reproductive system produces seasonal flowers and fruit, creating the seeds that will become the next generation of trees.

ROOT SYSTEM

While it cannot be said that roots are *more important* than shoots and leaves, they may be deserving of *more attention* because they so often get no attention. “Out of sight – out of mind” truly applies. Most tree species we deal with in Virginia have **coarse-rooted systems** composed of large and small woody and nonwoody roots that branch.

The other major root system is called **fibrous** and is common in palms and grasses. A fibrous root system develops a dense network of fine lateral roots rather than a **taproot** or major lateral branching roots.

The roots in either of these systems can be functionally divided into two main types.

- **Structural roots** primarily serve to support the tree and transport water and nutrients, and to store starches during the dormant season. (The starches are produced during the growing season through **photosynthesis**.)

- **Absorbing roots** primarily function as mechanisms to extract and take up water and nutrients from the soil, which are then carried toward the rest of the tree by the structural roots.

In trees with coarse systems, the roots are further divided into types based on their primary function and location.

- The first roots one would encounter when starting at the trunk of the tree are the **buttress roots** which spread to form the root plate. These are the largest roots of the tree and form the primary system for support and transport. They branch out into secondary and tertiary levels of root "branches." The primary roots may also be called **heart** or **striker roots** as they radiate from the root plate (buttress roots) and form branches of their own.

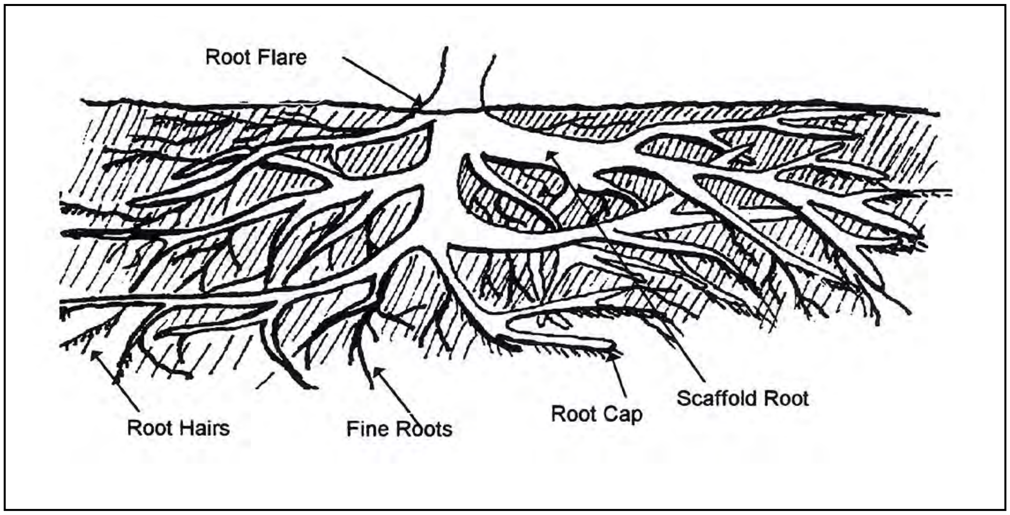
- **Sinker roots**, on the other hand, do not contribute to or form their own branch hierarchy but rather grow downward off of primary, secondary and tertiary roots as root anchors.

What about taproots?
Root structure and development vary with tree maturity, soil conditions and cultural practices. While many tree species naturally start out with a taproot (many pines, gums, hickory, oak, walnut) as seedlings, most trees lose the main taproot as the heart roots develop and take over the primary support and transport roles. Furthermore, while some species, such as hickory trees, would naturally keep their taproots, in most landscape situations, even these have no taproot as a result of nursery practices, transplanting methods and/or soil conditions. The bottom line is that very few trees in developed settings have true taproots that extend many feet beneath the soil surface.

ROOT GROWTH

Roots have **xylem** and **phloem**. They form woody tissues and thick, protective outer coatings. Growth occurs in root tip **meristems**, elongating the root behind the protective **root cap.** Roots absorb water and basic nutrients from the soil and move them into the tree trunk, where they are further transported to the leaves and help with photosynthesis.

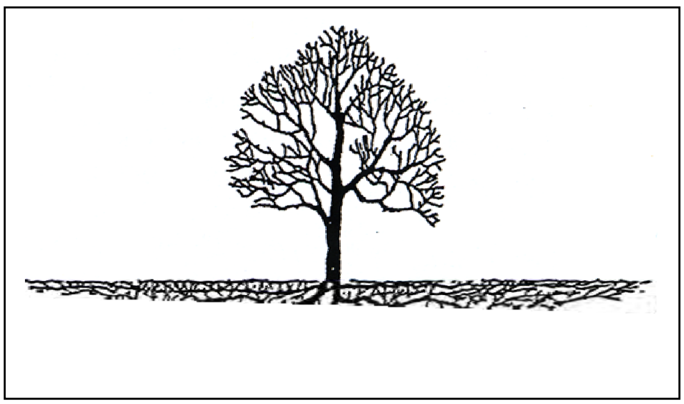
The food resulting from photosynthesis is transported back down through the phloem to nourish the roots.



Roots require food, water and oxygen. Oxygen diffuses from the air into the top portions of the soil. Most tree roots form within the top 18 inches of the soil. **Compacted soils** restrict root growth and smother trees by preventing air and water from reaching the roots. In flooded soils, water can prevent tree roots from obtaining oxygen.

A common misconception is that root growth mirrors the growth of a tree's crown. The majority of a tree's root system extends up to three times wider than the **canopy**.

About 90% of the water and mineral absorption takes place within a foot of the ground surface. Because of this, compaction, over-watering and herbicides applied to the soil within a wide radius can harm root health and growth, directly affecting overall tree health.



Environment strongly influences the direction and extent of root growth in trees. Root damage is a major cause of decline,

Did You Know?
In general, a tree's downhill roots are more numerous and grow farther than those on the uphill side of a tree.

death or other physical failure of trees. Roots are often destroyed or injured by drought, flooding, soil compaction, soil removal or soil filling over roots, or cutting by lawn mowers and trenching.

Shoot System

Trees are usually distinguished from shrubs by having one main stem, called a trunk. This stem divides into branches and smaller twigs that form the **crown** of the tree. Branches and twigs spread out from the trunk to give as much sun and air exposure as possible to the leaves. The arrangement of the crown and its leaves is designed to allow unimpeded development of leaves.

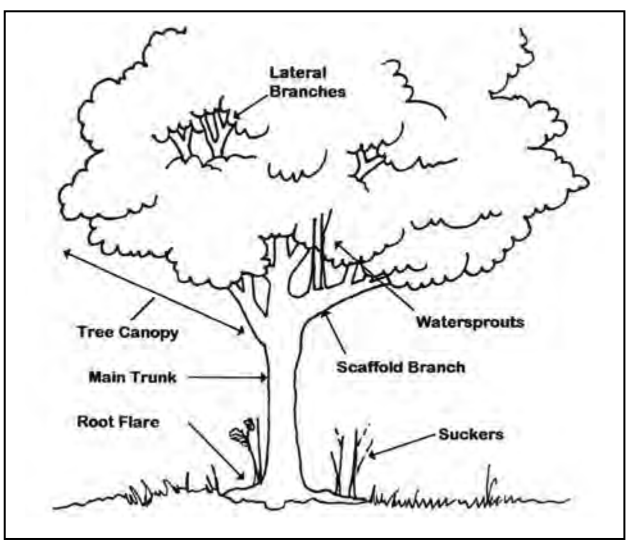
Examination of a twig will reveal enlarged **nodes** where leaves and buds emerge. The stem area between the nodes is called the **internode**. As a twig grows each year, the terminal bud from the previous year leaves a scar. The distance between these annual bud scale scars measures how much the twig has grown.

Shoots are the young stems that form new branches. An **apical bud** (terminal bud) is located at the end of each shoot and **lateral buds** (axillary buds) are found down the sides. Most normal growth occurs at the terminal bud. If this bud is removed, growth hormones release to the lateral, or sometimes dormant, buds along the stem and they begin to form new shoots.

When normal buds are lost, trees may produce **adventitious buds** along their stems or from surface roots. Shoots from these buds can fill in areas left open when diseased or damaged branches are removed. They may also become undesirable suckers at the base of the tree or **watersprouts** on the branches. The presence of many adventitious shoots often indicates that the tree is under stress or signals other underlying problems.

SHOOTS BECOME BRANCHES

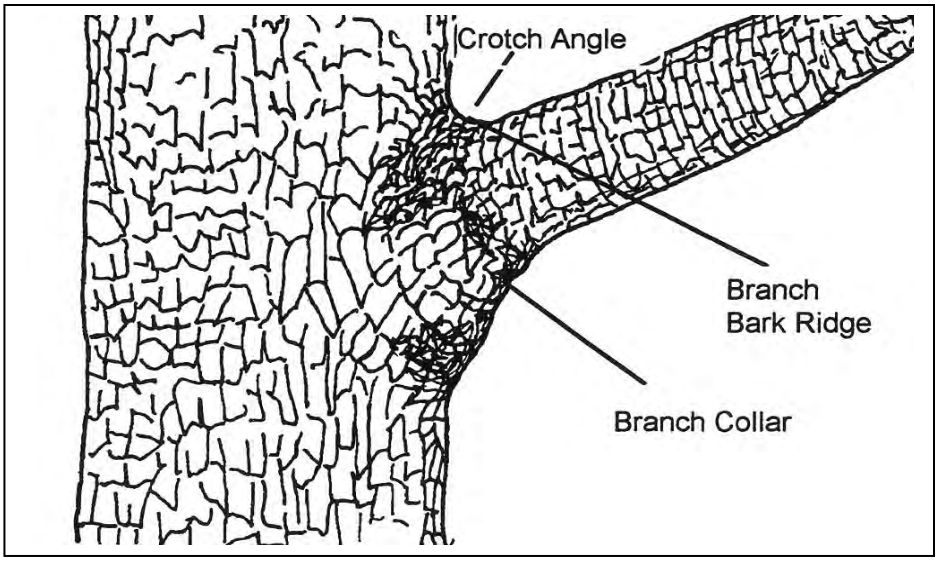
Branches grow out of the tree trunk or parent branch. Weaker tissues form on the upper side, or crotch, of each branch. The angle of attachment is called the **crotch angle**. Stronger tissues under the branch provide support.



As branches grow, the tissues near the trunk form a bulge, or **branch collar**.

In the crotch these tissues are squeezed tight by the expanding diameter of the trunk and form a **branch bark ridge.**

Branch Attachment



LEAVES

Leaves give a tree both life and character. They use water, sunlight energy and carbon dioxide gas from the atmosphere to make food through photosynthesis. They also release oxygen and water vapor back into the atmosphere as byproducts.

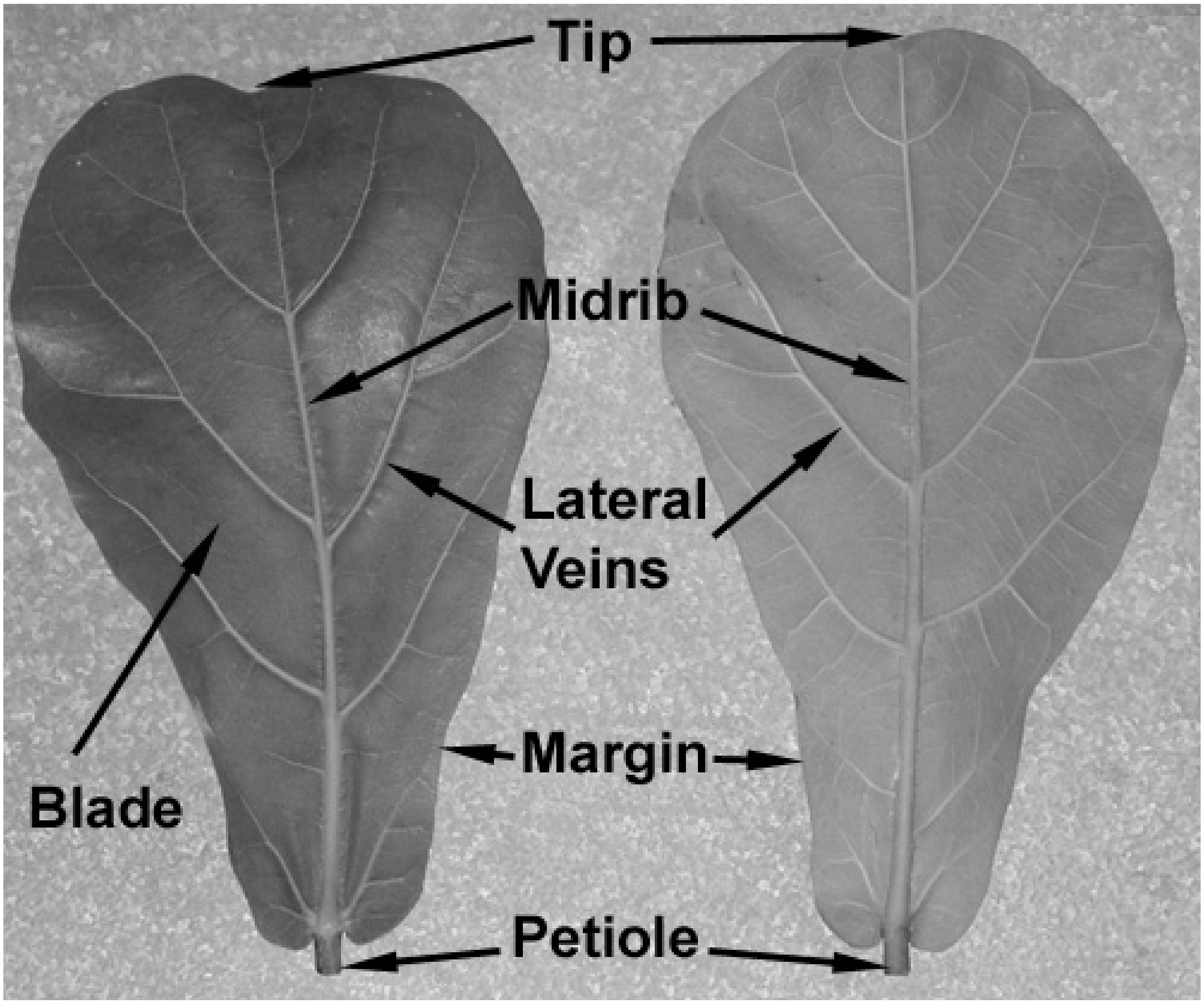
Most leaves develop a large flattened surface called the **leaf blade*,*** which absorbs sunlight. **Chlorophyll** within the millions of **chloroplasts** produces the characteristic green leaf color. Leaves are relatively thin, and all their cells are very close to the surface. This allows sunlight to penetrate easily.

In general, leaves attach to the stem with strong stalks called **petioles.** This flexible connection allows leaves to move freely, receiving the most sunlight while presenting the least wind resistance.

The top and bottom surfaces of the leaf blade are called the **epidermis*.*** This tough outer layer may be smooth, waxy or covered with hairs. A waxy leaf covering called **cuticle** protects the leaf from dehydration and some damage from disease and insects. During long, hot summers, the amount of cuticle increases, protecting the leaves from increased sunlight. Moving young trees quickly from shade into full sun does not allow this cuticle buildup. Sunscald can result.

Looking at the underside of a leaf under a microscope reveals tiny openings called **stomates**. They open and close to regulate **transpiration**, which is the passage of water vapor, oxygen and carbon dioxide in and out of the leaf. The surrounding **guard**

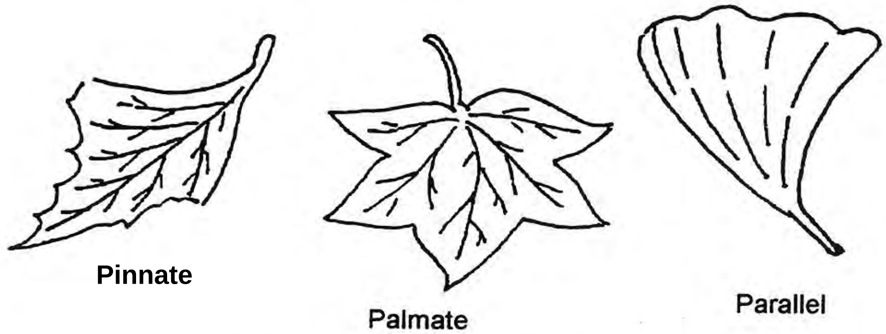
cells open and close the stomates in response to environmental conditions: Heat, dry weather and darkness cause the guard cells to close to prevent excess moisture loss.



The vascular system of the tree is seen in the veins of each leaf. The most common vein patterns (**venation**) are parallel veins or netted veins. Parallel veins are common in the grasses or monocots, as in palms, banana trees and gingko trees. Net-veined leaves are common in the dicots, which include most hardwood trees.

- **Deciduous** trees shed their leaves each year. Deciduous trees drop their leaves to conserve water. During this "dormant" period, root growth continues and the tree survives on the food resources it has accumulated during photosynthesis. Depending on the tree species and its habitat, leaf drop precedes seasons of very low or very high temperatures.

  Short days with cooler nights trigger the bright colors of fall foliage by slowing or ceasing chlorophyll production. The breakdown of chlorophyll allows other pigments within the leaf to appear. Reds and purples are caused by the chemicals called anthocyanins, while carotinoids create the bright yellows, oranges and reds. Carotinoids are always present but are generally masked by the green pigment, chlorophyll. Anthocyanins are produced in the fall by some species. Leaf color change and leaf drop can also occur in trees under stress.



Common Leaf Vein Patterns

- **Evergreens** hold their leaves for more than one year. While many are needled, some are broadleaf evergreens such as Southern Magnolia (*Magnolia grandiflora)* and holly (Ilex). Most **conifers,** which are trees with cones and needle leaves, are evergreen.

  Evergreens protect their leaves through freezing weather with a heavy, waxy cuticle buildup. Thicker leaves and thick needles provide a way to identify many evergreen trees. Needled and broadleaf evergreens do shed their needles or leaves, but not all at once and not on the same seasonal cycles of deciduous species.

Did You Know?
Dawn redwood, larch and bald cypress are conifers that are not evergreens.They are deciduous and shed their needles each winter and produce soft, new foliage each spring.

Key Questions:

What is the function of the root system of a tree? Of the shoot system?
Where on a twig will buds and new growth form?
What happens when the apical (terminal) bud is removed from a twig?
What structures support the weight of the tree canopy?
Can you locate the branch collar and branch bark ridge on a tree branch?
What functions, besides photosynthesis, occur in leaves?
What is the difference between a deciduous tree and an evergreen tree?
Where is the majority of a tree's root system located?
Why is it important to understand a tree's needs, functions and the extent of its root system when planting?

Photo by Maud Henne, White oak (*Quercus alba*)

Tree Life Functions – Unit 3

PHOTOSYNTHESIS

Photosynthesis is the food-making process of plants. The term comes from two root words, *photo*, meaning light, and *synthesis*, meaning to make. Photosynthesis literally means “to make with light.” Plants, algae and photosynthetic bacteria can convert sunlight energy into chemical energy. Fertilizer, often referred to as plant food, is only a mineral supplement and does not feed the plant.

A microscope reveals trains of oval **chloroplasts** containing **chlorophyll** inside leaf cells. The light energy absorbed by the chlorophyll is the catalyst for a complex chemical reaction. The chemical energy is stored as carbohydrates (starches and sugars) called **photosynthates**.

Starches and sugars combine with minerals and elements to produce vitamins, fats, proteins and other compounds necessary for life. Leaves give off both oxygen and water vapor as byproducts of photosynthesis, discharging them into the atmosphere through the **stomata** openings on the lower leaf surfaces.

Did You Know?
The leaves on the top of the tree are often smaller than ones lower down. If you think of leaves as solar collectors, the leaves at the top are positioned for best light exposure and need less surface area than leaves below in order to absorb the same amount of light energy. Leaves on the lowest branches are often much larger and misshapen, making tree identification by these leaves much more difficult.

RESPIRATION

Respiration is the process of using oxygen to break apart stored carbohydrate molecules. The released energy is used in biological processes such as growth. Trees release oxygen to the atmosphere through their leaves. They also take in oxygen for respiration through their roots, **lenticels** and stomates. A tree will decline if its rate of photosynthesis (food creation) exceeds its respiration (food consumption).

When a tree prematurely loses its leaves, it relies on stored energy reserves to produce a second flush of leaves. Repeated **defoliation** through disease, insect damage, drought or excess pruning depletes the reserves over time, and the tree weakens and may die. Flooded and compacted soils can disrupt photosythesis by preventing roots from absorbing needed water, oxygen and nutrients, resulting in starvation of the tree.

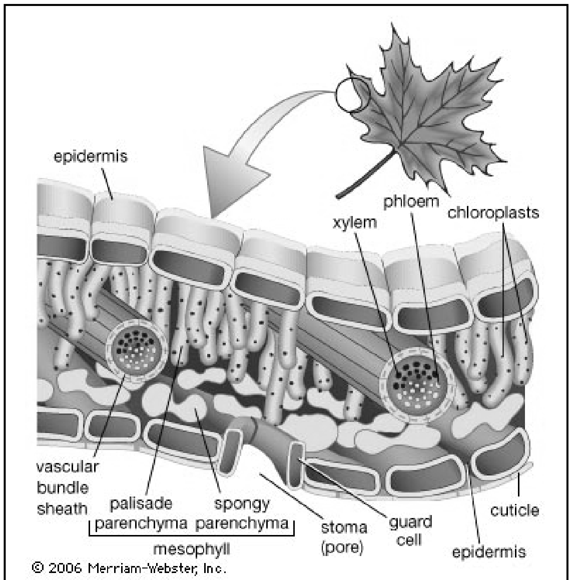
Comparing the Processes

Photosynthesis = carbon dioxide + water + energy ⇨ carbohydrates + oxygen + water vapor
(taken in by leaves + roots) (light) (stored energy) (given off by leaves)

Respiration = carbohydrates + oxygen ⇨ energy + carbon dioxide + water vapor
(stored energy) (taken in by roots) (used) (given off by leaves)

TRANSPIRATION

As photosynthesis takes place, water vapor is released through the leaves' stomates. Water vapor cools the leaves and the surrounding air. The coolness felt in a forest is partly the result of this released water vapor and partly thanks to the shade provided by the leaf canopy.



The rate of water vapor loss through the stomates is controlled by **guard cells**, which shut during periods of high heat, dryness or darkness. Leaves are also protected from excessive water loss by the waxy **cuticle**. Trees adapted to desert environments have developed small, thick, waxy leaves to prevent water loss.

Water vapor escaping from leaves also creates **transpirational pull**, in effect creating a suction in the leaves that helps pull water up through the xylem from the root system. Despite the guard cells' regulation of the stomatal openings, a tree will lose more water on a hot, dry day through transpiration that its roots will absorb.

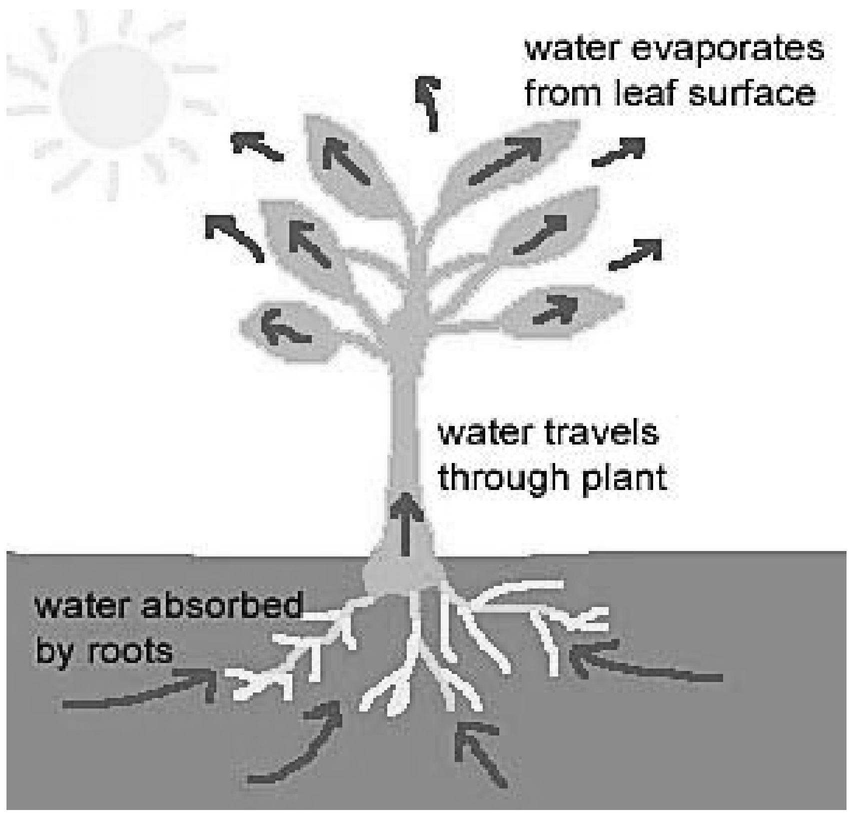
OSMOSIS

100 Feet or 5 Feet … Makes No Difference

How does water get to the topmost leaves of a 100-foot tree? The same way it gets to the end of a blade of grass or the uppermost leaves of a rose bush: transpirational pull. While scientists have not proven the theories of tension/cohesion and transpirational pull, they remain the best explanation for getting water to the top of a tree, regardless of height. The tiny "straws" (tubes) of xylem go from the roots to the tip just like a straw in a glass of water. You can see how water "climbs" a vertical surface such as the inside of a glass of water or a straw. In the same way, the molecular attraction between water and xylem "straws" causes the water to "climb" the xylem while the "pull" (vacuum) exerted as a leaf transpires water vapor keeps the column of water behind those molecules moving.

Leaves lose water during transpiration, making them an area of low water content. Leaves are thus said to have low water potential. **Osmosis** is a process that occurs at the cellular level and that moves water through cell walls and membranes, always moving from areas of higher water concentration to areas of lower water concentration.

Trees absorb water through their roots by osmosis. Roots generally have a lower water potential than the surrounding soil, allowing water to move from the soil into the root cells. Transpirational pull continues to move the water up through the xylem and throughout the tree to cells needing water. In all plants, water is pulled up from the roots to the shoots.



TRANSLOCATION

Food (photosynthates) and other compounds are actively pumped throughout the tree in **phloem** tissue. Leaves high in sugar content are the **source** of the photosynthates. From the leaves the sugars are pumped to areas which are low in sugar content, called **sinks**. Sinks are areas of the tree that use more energy than they produce. Most growing areas are sinks.

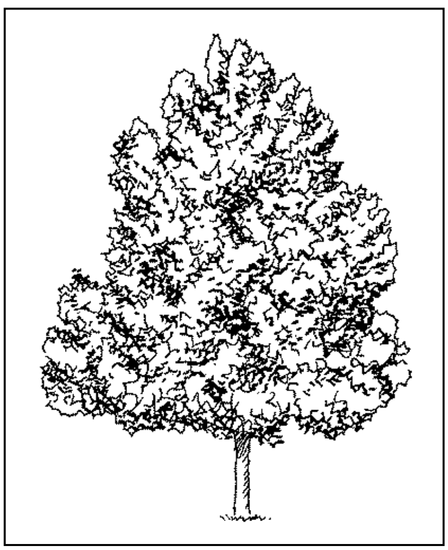
In basic diagrams, manufactured food is shown in leaves and then being transported downward for storage in the roots. In reality, food energy moves up and down the tree to be stored and also used. Water and nutrients move laterally from the **cambium** through **ray cells** to older central cells.

> **Did You Know?**
> *Adding minerals or sugars to water lowers its potential. Because of this, soils that have accumulated salt or mineral concentrations from de-icing and overfertilizing can actually pull water out of tree roots.*

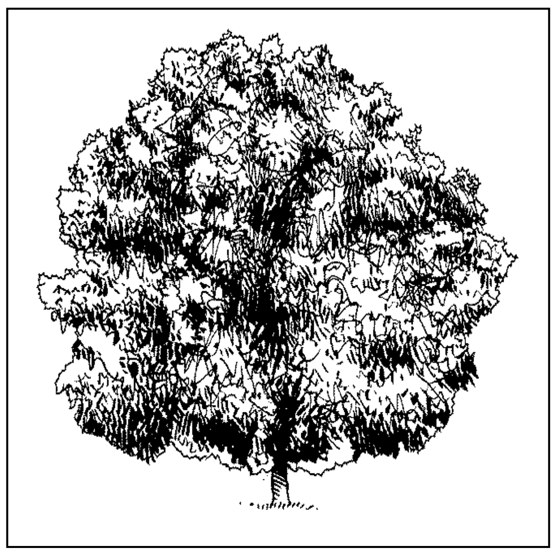
GROWTH FACTORS

A tree's genetics and its environment determine the rate at which it grows and the ultimate size it can attain. No matter what growth potential a tree may have inherited, resource limitations affect its actual size. Typical urban planting environments often limit both the size and the life span of trees.

Hormones control aspects of growth such as flowering, fruit development, root development, and leaf formation and drop. Many of these hormones are produced in response to stimuli in the environment. Like all living things, plants respond to their environment. Unlike animals, plants cannot move about to find more favorable conditions. Instead, plants respond by growth changes and other adaptations.



Excurrent Shape
(one dominant leader)



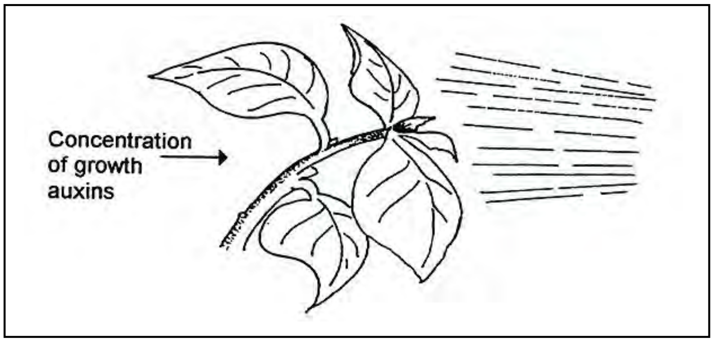
Decurrent Shape
(no dominant leader)

Hormone activity creates a tree's shape. In **apical dominance,** the growing terminal bud of a shoot produces growth regulators, or hormones, and is dominant over lateral bud development. **Excurrent**-shaped trees, such as white pine, bald cypress or tulip tree, with strong central leaders and a triangular form have strong apical dominance.

Rounded, **decurrent**-shaped trees, like oaks and maples, form lateral shoots that outgrow the previous year's leader. Decurrent crowns can also be a sign of older trees that have reached their full height.

Auxins are hormones controlling plant growth. They are concentrated in **meristem** tissues at shoot and root tips. If the tip area is removed, new auxins are re-allocated to lateral buds or lateral roots and stimulate their growth. Commercial growers encourage rooting by dipping plant cuttings in synthetic auxins.

Different directions of plant growth in response to stimuli are called **tropisms**. Cell enlargements generally occur more rapidly on the side of the root or shoot <u>away from</u> the stimulus. This causes the growing area to bend toward the source of the stimulus. **Gravitropism** (or geotropism) is responsible for the downward growth of roots toward the pull of gravity.



One of the best known and most easily observed plant responses is the growth of stems toward light.

This light-seeking adaptation is **phototropism** ("light-growing").

Phototropism is responsible for the upward growth of trees and the leaning of sheltered trees out toward sunlight. Although observers may assume that parts in the sunlight are growing faster, in actuality it is the side of the shoot away from the light that elongates, turning the shoot toward the light.

HOW LONG DO TREES LIVE?

There is tremendous variation of crown form, branching habits, ultimate size and longevity. The life span of a tree is genetically controlled but environmentally influenced by factors such as water, light, temperature, air, pests and cultural practices. The growth rate also depends on site conditions and maintenance. Published growth rates are generally based on optimal growing conditions.

Did You Know?
Weak wood is often associated with fast-growing trees, such as silver maple and ailanthus. Such trees are more susceptible to storm damage and may become hazards when planted near homes.

MONOCOTS

Palms differ greatly from trees and, in fact, are not true trees but are more closely related to grasses and lilies. Palms only have one terminal growing point. Leaves, called fronds, grow from this one apical meristem. Palms do not have a lateral meristem (cambium layer) and form no annual growth rings beneath their bark. The roots of palms appear spaghetti-like, remaining the same diameter for extended distances as they grow in length.

Key Questions:

How do photosynthesis and respiration work together?
How does water move up from tree roots into the leaves?
How do roots absorb water?
What can happen when minerals or salts build up in tree root zones?
What parts of trees are generally energy sources? Energy sinks?
Why do roots grow down?
Why do shoots grow up?

Photo by Maud Henne
Buckeye (*Aesculus X hybrida*)

Tree ID and Propagation – Unit 4

Trees come in a variety of shapes, sizes and colors. Even closely related trees may have fascinating differences in leaf shape and color, bark texture and flowers. A glance at any tree guide will reveal a dozen very different trees that are generally referred to as "oak" or "pine." Much confusion can be avoided by learning to talk about trees using their botanical names.

Page from a Dichotomous Tree Key

If the single leaf is tipped, with a single bristle, is dark green above and hairy beneath, it is a Shingle Oak (*Quercus imbriacaria*).

If the leaf is light green above and veiny beneath, with a yellow midrib, and is a quarter to an inch wide, it is a Willow Oak (*Quercus Phellos*).

Although many people are intimidated by the Latin terms used in botanical naming, identifying trees is a logical, orderly process. It can be successfully accomplished with a reliable field guide and a little practice.

USING AN IDENTIFICATION KEY

One of the most important steps in identifying a tree is learning to use a good field guide. Most guides rely on a simple "keying" system through which you select the characteristics that most closely describe the tree. A full botanical key is referred to as a **dichotomous key**, meaning that the reader is continually making "either/or" choices. Each point in the key will require that you select from two optional characteristics. The first step may be to choose whether the tree has needles or broad leaves. From there, continuous step-by-step choices are made based on the tree's **morphology** or form of growth. The characteristics compared include leaf shape and placement, bud shape and placement, flowers, fruit, bark type and the tree's **habit**, including where and how it grows naturally.

Within every species, there will sometimes be trees that show **natural variations**. Growing conditions affect tree size and shape. Always consider environmental effects when attempting to assess adult tree size. Lack of root growth or adequate water and nutrients will stunt leaf, trunk and canopy growth in trees that might normally grow much larger at maturity.

Simple

Leaves occur in each tree species in a specific, recognizable pattern. Leaves may be **simple**, growing singly, or **compound**, made up of a number of smaller leaflets. The arrangement of leaves on each step is also recognizable.

Compound

Opposite

Leaves that form from buds on the same node may be **opposite**, (occurring on either side of the stem), or **whorled**, (occurring evenly around the stem). **Alternate** leaves appear on separate nodes and the direction of leaf growth on each node changes from the previous node.

Alternate

Entire

Leaf margins are commonly used for general identification. Leaves with smooth, unbroken margins are ***entire***. Other types may show wavy or undulate margins, or a variety of "cut" margins that make lobed, serrate or dentate points.

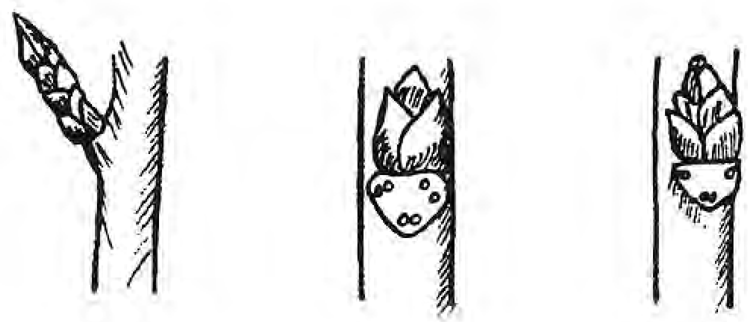
Lobed

Identification of trees with needle-type foliage is made from the shape of the needles and the number and arrangement of the needles in bundles. Only pines have needles in bundles.

Although leaf identification is one way to begin differentiating trees, learn to identify other characteristics as well. Remember that deciduous trees will not be carrying leaves in winter. Some reliable year-round identification clues are: bark texture, pattern and color, and the shape and arrangement of buds on twigs.

After familiarizing yourself with the descriptive terminology, tree identification becomes much easier. One highly recommended reference is http://www.cnr.vt.edu/dendro/forsite/Idtree.htm. Another reference to check for tree information is the *Manual of Woody Landscape Plants* by Michael A. Dirr, Department of Horticulture, University of Georgia.

COMMON BUD SHAPES



Beech Oak Elm

Buds are shown larger than actual size.

MADCap Horse

Most common hardwood trees with opposite branching and leaf patterns can be remembered by the memory aid MADCap Horse.
***M**aple*
***A**sh*
***D**ogwood*
***Cap**rifoliacae (usually shrubs)*
***Horse** chestnut*

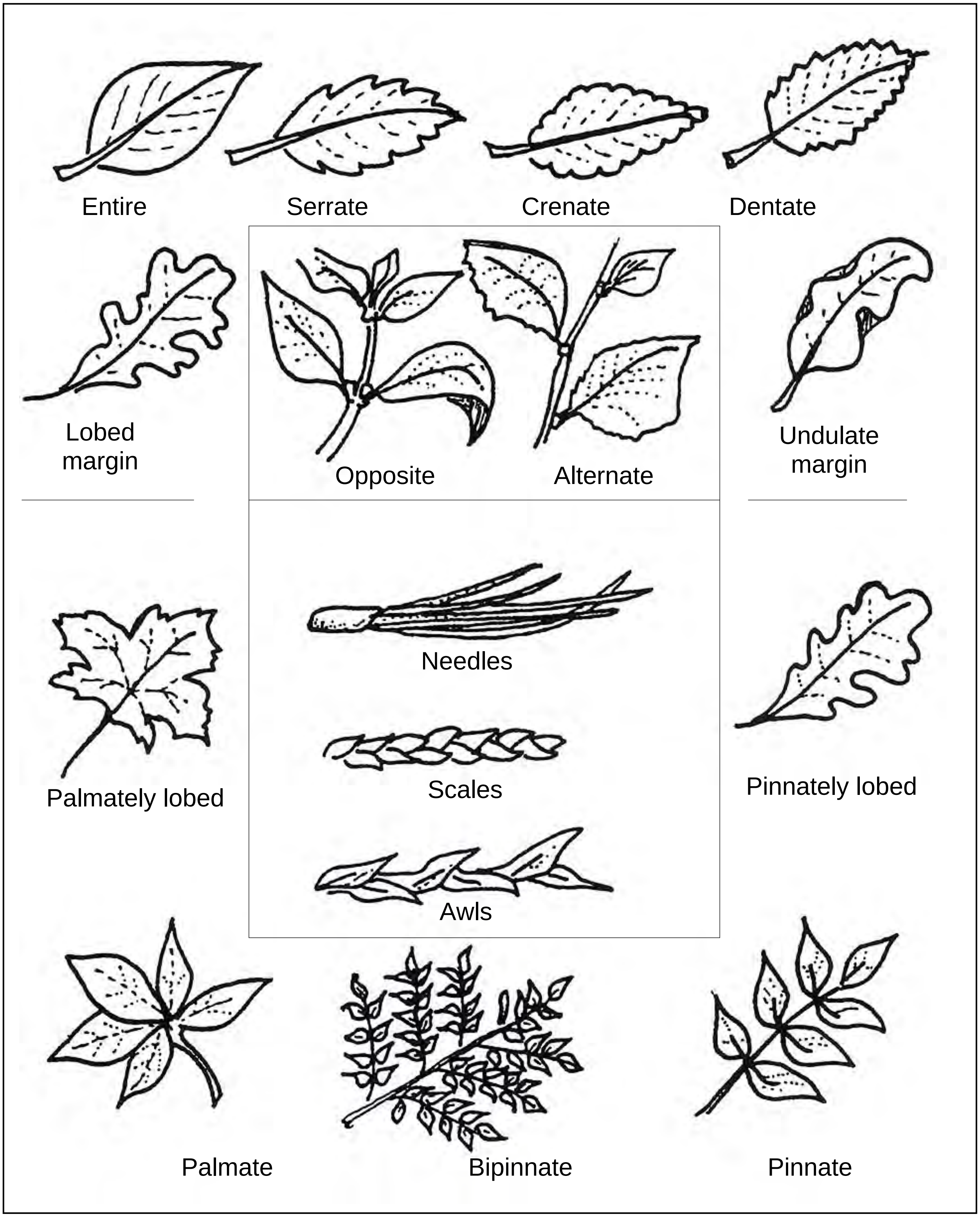
As you become familiar with local trees, make notes on special characteristics that help you recognize them.

A simple leaf collection can be made by pressing a sample leaf and twig from each tree onto a 5x8” index card and carefully covering it with a clear adhesive paper or plastic wrap. Write the common and scientific name of the tree on the front of the index card with the samples. Your own notes about each tree can be written on the back.

Did You Know?

A good field guide includes clear information, illustrations or photographs of the leaves, bark, flowers or fruit, and sometimes autumn foliage. Always read the description carefully. Look for the subtle clues, such as leaf or twig hairs and bud arrangements. These reliably distinguish each tree species and allow proper identification. The best way is to see the tree in the field.

CHARACTERISTICS OF TREE LEAVES



SCIENTIFIC NAMING

A tree's name represents the **genus** and species to which it belongs. Trees within the same genus (pl. *genera*) will have many strong similarities. When identifying trees, consider the genus as the "general" group to which the tree belongs. For example, *Quercus*/oak.

A given plant distributed anywhere in the world always has the same two-part botanical name, or **binomial**. It is always written in Roman characters and italicized or underlined. Thus, in any country, *Juniperus virginiana* (Eastern red cedar) would be written exactly as you see it, regardless of the native language, alphabet and common name.

Following this system, a tree may be identified as *Acer rubrum* ("the maple that is red") or *Acer saccharum* ("the maple that produces sugary sap"). Species names may describe a specific characteristic of the tree, describe where it was discovered or list who discovered it. Not all species names directly relate to the commonly known name as clearly as the examples above. For comparison, the Norway maple is correctly identified as *Acer platanoides*, referring not to Norway but to how its leaves resemble those of the sycamore *(platanoides: "like Platanus").* A ***cultivar*** name such as *Acer rubrum "Red Sunset"* is a plant that is vegetatively propagated.

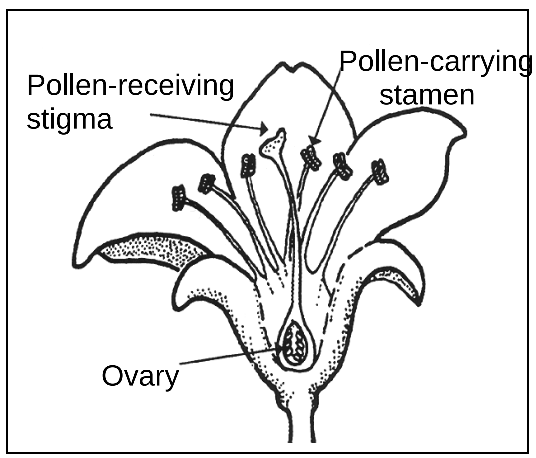
Did You Know?

While Linnaeus' binomial nomenclature may seem cumbersome, it was actually a simplification of older classification systems in which plants were often given Latin "names" that filled an entire page.

TREE REPRODUCTION

POLLINATION

Most trees are flowering plants that are fertilized through pollination. Depending upon the species, trees may be **monoecious**, producing male flowers and female flowers on the same tree, or **dioecious**, with male flowers and female flowers on separate trees. If a tree is dioecious, the seeds/fruits will only be produced on the trees that have female flowers.



Cut-Away View of a Flower

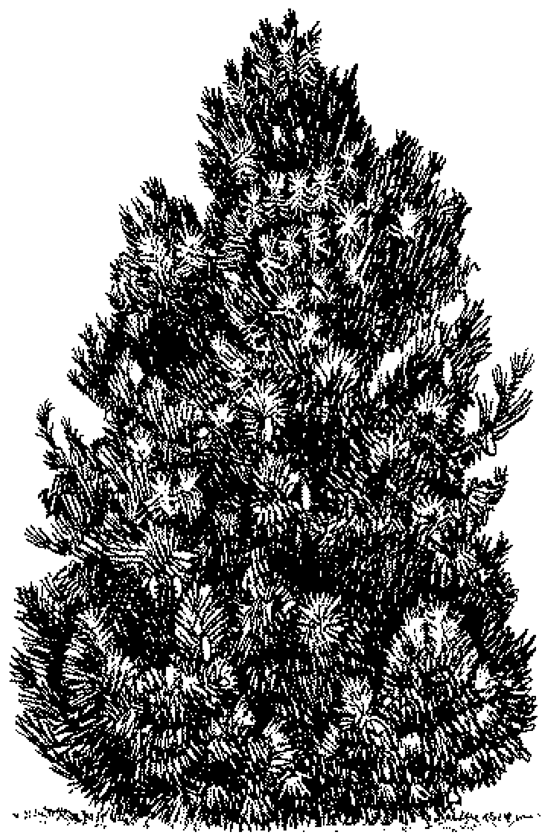
During pollination, pollen "grains" containing sperm cells are deposited onto the female parts of flowers, either on the same tree or on other trees nearby. The fertilized ovum forms seeds commonly recognized as cones, nuts or fruit, depending on the type of tree. Most trees, like maples with their double-winged “samaras,” have very distinctive seed shapes.

In some cases, as with gingko (*Gingko biloba*) trees, planting male trees will avoid unpleasant fruit. Unfortunately, determining the sex of dioecious trees is rarely possible until flowering and fruiting occur. In the case of hollies, planting female trees results in beautiful berries in the fall.

PLANT GROUPS

Trees may be either gymnosperms (*gymnos* = naked + *sperm* = seed) or angiosperms (*angeion* = vessel + *sperm* = seed). ***Gymnosperms***, which include the conifers and ginkgos, are more primitive than angiosperms. Gymnosperms produce seeds that are not protected by elaborate coatings (nuts) or fleshly coverings (fruit). Their seeds are exposed between the scales of cones; thus they are often referred to as ***conifers***.

Gymnosperms generally have unshowy flowers with open parts that are adapted to wind pollination. ***Angiosperms*** are pollinated by wind, insects, birds and other animals. They are characterized by flowers that secrete nectar to attract the pollinators. Trees that produce “covered” seeds like nuts or fruits are angiosperms.



Gymnosperms include conifers and gingkos.

PROPAGATION

Trees can be propagated both naturally and artificially. Trees may be sexually reproduced by germinating seeds or asexually reproduced (vegetatively) by rooting cuttings, grafting or layering.

Starting seedlings: Tree seeds begin in a dormant state and remain dormant until their environment supplies the right conditions for growth. Seeds may require special treatments to break dormancy and begin growing. A seed’s internal dormancy (resting state) is maintained by a tough seed covering and/or chemical growth inhibitors commonly present in the seed coat. Many tree seeds will not germinate unless they endure a period of cold weather. **Stratification** involves refrigerating seeds to simulate a natural cold cycle. In some cases the tough seed coat must be scratched or worn through, a process called **scarification**.

Cuttings are produced by cutting sections from shoots on the parent tree. These cuttings are placed in sand or potting mix and kept moist until the buds open and roots develop. Dipping the cuttings in powdered or liquid hormones may encourage rooting.

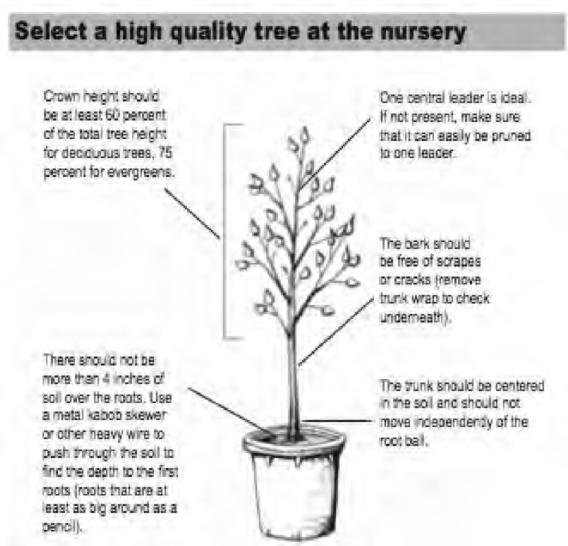
Grafting involves taking dormant scion cuttings or buds from the desired tree and inserting or binding them to a chosen rootstock. Grafting is often used to dwarf trees by grafting the desired species scion to rootstock from a smaller related species. Grafting requires skill and is best learned from an experienced plant propagator.

Layering generally refers to the practice of gently bending down selected shoots to the ground and covering them with soil until roots develop. Although layering may be used in special circumstances, it is not commonly employed to grow trees.

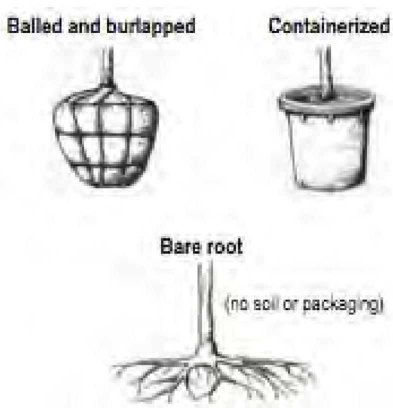
Did You Know?

Seeds of longleaf pine are tightly sealed into cones that open only in the heat of forest fires. The extreme heat explodes the pine's cones, sending seed in all directions.

NURSERY TREES



Trees can be purchased from a grower as seedlings or transplants. Seedlings are germinated from seed and grown for one or two years in a field.



Bare-root seedlings have been dug directly from the field and are shipped without dirt or planting pots around their roots. If not planted immediately, these seedlings must be "heeled in," or temporarily planted in a holding bed to prevent drying out. Seedling trees are the most economical for planting because growers can raise more trees per acre and can minimize the cost of materials and handling. Seedlings dug and placed into nursery beds or pots and grown for another year or two are known as **transplants**. Transplants cost more, but are generally stronger and sturdier and have better root development.

Nursery stock with sturdy, compact root balls can better withstand planting stress. While growing in the nursery, container stock can also be moved apart as they grow to allow better and more even development of each young tree's shoot system.

Key Questions:

What differentiates gymnosperms and angiosperms?

Which group produces cones?

What two classification groups are used to make up a scientific name?

How do you use a dichotomous key?

What is a special consideration when handling bare-root seedlings?

What types of characteristics are used to identify trees? Which ones can be used year-round?

When should the sex of a dioecious tree be of concern?

Photo by Robert Llewellyn, Sugar maple (*Acer saccharum*)

Trees in the Community – Unit 5

Trees in a natural forest do not require constant care and maintenance to survive. Forest trees establish themselves in natural areas where they are not dependent on people. Why do urban trees need additional care to survive?

Urban trees lack the shelter of the forest. Despite the competition for light and nutrients, young trees flourish in woodland environments. They are protected from strong winds, heat and sunscald. The ground is not disturbed and organic materials accumulate and cycle back into the soil. Undisturbed, trees grow steadily into their mature stature.

Urban trees struggle to grow against almost insurmountable odds.

Although the majestic old shade trees lining the streets of many communities appear to be monuments of strength and endurance, in reality the environment places numerous stresses on them.

Stress greatly affects newly planted and young trees as communities grow and development changes local environments.

To assist trees in the community, it is important to understand the growth and survival odds each tree is up against.

URBAN SITE PROBLEMS

LIMITED SPACE FOR ROOT GROWTH – Causes: **compacted soil**, buried debris, underground installation of pipes and utility lines, roots cut through to accommodate sidewalks and curbs, small planting area in medians or planting islands. Effects: stunted roots unable to take up enough water and oxygen to withstand drought.

IMPERMEABLE SURFACES – Causes: surrounding asphalt or concrete. Effects: reduced air and water to the root zone; higher soil temperatures which can damage roots.

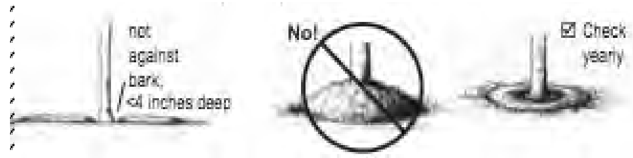
POOR SOIL QUALITY – Causes: soil compaction, lack of organic matter, removal of **topsoil**, disrupted **soil structure**, poor **drainage**. Effects: stunted root development, roots deprived of nutrients, water and oxygen.

HIGH SOIL PH – Causes: buried mortar and concrete rubble and **leaching** from building foundations and sidewalks. Effects: essential minerals like iron, manganese and zinc are less soluble and therefore unavailable for uptake by roots.

Can this tree be saved?

SOIL AND WATER CONTAMINATION – Causes: road salt, overfertilization, detergents used to clean storefronts and sidewalks draining into planting areas, gas and oil runoff from roads and parking lots, routine “trashing” of planted areas. Effects: poisoned trees; salt buildup in soil pulls water from roots.

OVERMULCHING – Causes: mulch piled several inches thick and pushed up against the trunk looking like a “mulch volcano.” Effects: damage to base of tree, surface-feeding roots damaged by either smothering or exposure.



SOIL EROSION – Causes: trees planted too high in "planter" areas, soil covering root ball is allowed to erode away. Effects: exposed surface roots.

CONSTRUCTION – Causes: negative effect on soil quality, physical harm to trees. Effects: compacted soil, increased debris, disrupted soil structure, increased likelihood of mechanical injury to bark and cutting of roots.

HEAT – Causes: reflection from pavement, asphalt, cars and buildings. Effects: increased dehydration during drought, sunscald on leaves and bark.

PHYSICAL DAMAGE – Causes: injuries by car doors, lawn mowers, string trimmers, installation and removal of holiday lights, vehicle accidents, nearby construction. Effects: broken branches, bark abrasions, cuts and girdling.

VANDALISM – Causes: lack of values and protection for urban trees. Effects: broken branches, trunk damage, broken and uprooted saplings.

WASTES – Causes: frequent dog-walking in planting areas, dumping unwanted materials into planted areas. Effects: contamination of surrounding soils.

AIR POLLUTION – Causes: vehicle exhaust, dust, ozone, industrial pollutants. Effects: weakened trees, early foliage drop; water may become acidic.

IVY GROWING ON TREE

NON-NATIVE INVASIVE PLANTS – Causes: Planting of invasive vines such as English Ivy and other plants that escape gardens and compete with native species. Effects: trees weakened by competition for sunlight, water and nutrients; trees break apart from weight of ivy and die as they are smothered.

COMPACTION – Causes: mechanical compaction from machinery and/or excessive foot traffic. Effects: eliminates space for water and oxygen, thereby destroying the soil structure.

OVERCULTIVATION – Causes: planting annual bedding plants or other displays directly under urban trees, chemicals used on nearby ornamentals. Effects: root zones damaged, excessive fertilizer contaminates soil, injury from implements, trunk damage or broken branches.

STORM AND WEATHER DAMAGE – Causes: isolated, solitary trees in parking lots or open areas lack protection from wind or ice and snow accumulation. Effects: broken branches, trunk damage, uprooted trees.

URBAN FORESTRY

No Tree Steward manual would be complete without mention of “urban forestry.” It is a relatively recent concept of the last few decades even though a city ordinance in the 1700s required homeowners to plant trees outside their homes in Philadelphia. Our interest in having trees near where we live is evident in personal stories, Arbor Day events, the Tree City USA program and implementation of tree ordinances or legislation that contributes to planting and caring for trees on public lands.

Urban forestry is defined as the management and care of trees in a municipality. Whether the municipality is a village, town, county or city, people and trees co-exist. No matter whether a population is small or large, a community’s approach to the management of trees is urban forestry. It is the size of the locale that may determine whether the term used is urban or community forestry. The subtitle of this manual is “Volunteers for the Community Forest” with the intention of addressing communities small and large in Virginia. Generally speaking, the literature most often uses the urban forestry term.

Urban Forest Ecosystems

The impact upon trees in an urban setting is far-reaching as the early part of this chapter reported. People and nature often work against the survival of trees. Yet there are numerous opportunities to deal with real world problems for trees. If we think of all the trees in an urban setting as an important element in the ecosytem, then we may view the urban forest as an asset to be protected and nurtured, not a liability.

The relationship or interaction between people and the urban forest can be healthy in terms of ecology and economics. One example would be building a development of new homes while preserving existing trees and planting more trees rather than clearing woodlands for houses and having no plans for trees. More real estate and housing developers are conscious of this sustainable practice today than in years past.

Other sustainable practices can serve the interests of both people and trees.

Do This	Avoid This
Preserve more open spaces.	Build without consideration to open spaces.
Use porous materials for walkways.	Pave surfaces for all walkways.
Use tree shade effectively.	Rely upon air conditioning to cool.
Use best management practices when planting and caring for trees.	Overuse pesticides and prune trees indiscriminately.

Urban Forestry Partnerships

The key to having a healthy and sustainable urban forest in a community of any size is the development of partnerships. Residents, businesses and governments may work jointly to advance the management of the urban forest because they share a common cause or goal. For example, a group of citizens may want a woodland trail connecting a local school with a local park. Who are the stakeholders for such a project? Who would want to make the trail happen? Finding the key players for the trail may be easy if the community is dedicated to “green” projects, if it fully involves its citizens in the planning stages of projects, if it has committed volunteer groups, and if its citizens have elected officials and agency employees who support an attitude of collaboration and demonstrate environmental integrity.

Partners for the urban forest should include a Department of Parks and Recreation or a Department of Public Works, agencies within which an urban forester will likely work. Many municipal arborists are urban foresters and work with civic groups and volunteers. They are usually an International Society of Arboriculture (ISA) certified arborist responsible for the selection, planting and care of public trees. An urban forester knows relevant ordinances and their enforcement regarding trees in the community.

Volunteer partners for the urban forest may include Tree Commissioners or Tree Board members, Tree Stewards, Master Gardeners, and other local groups whose members volunteer to beautify the community with trees, restore riparian buffers, eradicate invasive plants, and teach about trees and tree care.

Other partners interested in maintaining and improving the urban forest and who see trees as an asset are business owners, tree care companies, plant centers or nurseries, residential and business developers, utility companies, public safety officials, first responders, and land trust organizations.

Tree Ordinance

Many urban communities have tree ordinances. Such ordinances are useful although not essential for urban forestry projects. A tree ordinance is one of four criteria required to become a Tree City USA. The example of a tree ordinance to the right is from Arlington County. The full ordinance may be viewed on the Virginia Tree Ordinance Database sponsored by the Department of Forestry at Virginia Tech University. See www.cnr.vt.edu/vtod/wwwmain.html.

Arlington County
Tree Preservation Ordinance

There is hereby established a Tree Preservation Ordinance to ensure that the tree cover within Arlington County's boundaries is maintained and improved in order to protect the health, safety, and welfare of County citizens and the general public, to safeguard the ecological and aesthetic environment necessary to a community, to preserve, protect, and enhance valuable natural resources, and to conserve properties and their values.

Tree ordinances are usually administered by Tree Commissions or Tree Boards. According to Arlington County's Web site, the Arlington Urban Forest Commission "was established to bring together the expertise of existing special interest groups and other citizens and organizations with an interest in issues affecting Arlington's existing and future urban forest."

Virginia Urban Forest Council

In 1990 federal urban forestry legislation mandated all states to create urban forest councils.

The Virginia Urban Forest Council was formed as a result of the legislation. Since 1991, the VUFC has built an interdisciplinary membership representing the professions and groups that make up the urban forest constituency in Virginia. VUFC is registered as a non-profit organization, partners with the Urban and Community Forestry Program of Virginia's Department of Forestry, and sponsors workshops and seminars on urban forestry issues. VUFC is also responsible for developing this manual which has been used to train Tree Stewards throughout the state. The mini grant program for Virginia Tree Steward groups is sponsored by VUFC. Also known as "Trees Virginia," VUFC has a Web site: www.treesvirginia.org.

How can tree steward volunteers offset these many problems?

- Learn about and care for trees. They are a beautiful and living part of our community.

- Share knowledge of tree care with other community members.

TREE CITY USA

There are communities in the country that participate in the Tree City USA program of The Arbor Day Foundation. This program is supported by the National Association of State Foresters and the USDA Forest Service Urban and Community Forestry Program. As of 2008, Virginia has 54 Tree City USA communities. Forty-nine percent of Virginia's population lives in a Tree City USA.

Every community, regardless of size, may be recognized as a Tree City USA when meeting four standards established by The Arbor Day Foundation and the National Association of State Foresters.

1. A Tree Board or Department
2. A Tree Care Ordinance
3. A Community Forestry Program with an annual budget of at least $2 per capita
4. A public Arbor Day Observance and Proclamation

When communities apply to become a Tree City USA, they are taking steps toward an annual, systematic management of their tree resources. Reaching such recognition will affect a community's public image for its citizens and visitors. A Tree City USA sends the message that the quality of life and a sense of pride are important to this community. It encourages better care of community trees and increases public awareness of the many benefits of urban forestry practice.

To maintain the Tree City USA award, a community must submit an application for Recertification each year because the award is in recognition of work during the calendar year. The City of Falls Church was Virginia's first Tree City USA in 1978. It continues to maintain that status today. To learn more about the Tree City USA program, go to www.arborday.org/programs/treeCityUSA/index.cfm.

TREE CAMPUS USA

The Arbor Day Foundation and Toyota sponsor Tree Campus USA. This program recognizes college and university campuses that meet five standards to promote healthy trees and student involvement. Begun in 2008, 29 colleges and universities were recognized as the first Tree Campus USA communities. To learn more, go to www.arborday.org/programs/treeCampusUSA.

Photo by Robert Llewellyn, Ginkgo (*Ginkgo biloba*)

Key Questions:

Discuss the five potential soil problems that make urban sites less than ideal for trees.

Explain why a "mulch volcano" is a problem for a tree.

Discuss at least five human activities common in urban areas that can damage or create stress for trees.

Soils and Water – Unit 6

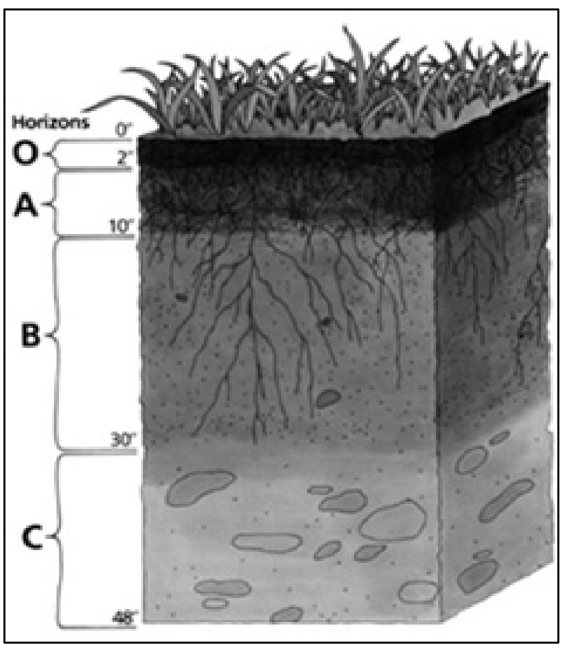
Soil forms when bedrock decomposes on the surface. Decomposition is caused by weathering, the breakdown of rock by wind, water, extreme temperatures and the growth of natural organisms, such as lichen. As the rock begins to decompose, plant roots and natural chemical interactions speed the breakdown.

The nature of the original rock – granite, sandstone, limestone, etc. – determines the basic mineral content of the soil it forms. Moving down from the surface, soil is described in cross section as having layers or **horizons**, each one with a different composition and texture.

- The **A Horizon**, the layer at the top of the soil, is partly formed by decomposing plant materials and contains many living organisms, such as **mycorrhizae** (my-cor-ri-zae), nematodes, earthworms, and grubs. The ideal surface soil (Horizon A) has a content ratio of 45% mineral, 25% air, 25% water and 5% organic material.

- The **B Horizon** is a mix of material from the A Horizon and soil particles from underlying parent rock. Together, these two layers are referred to as **topsoil**.

- The **C Horizon** is the substratum or parent material of soil. Some soils have an organic horizon (**O**) on the surface which may be present in forests and other undisturbed locations.



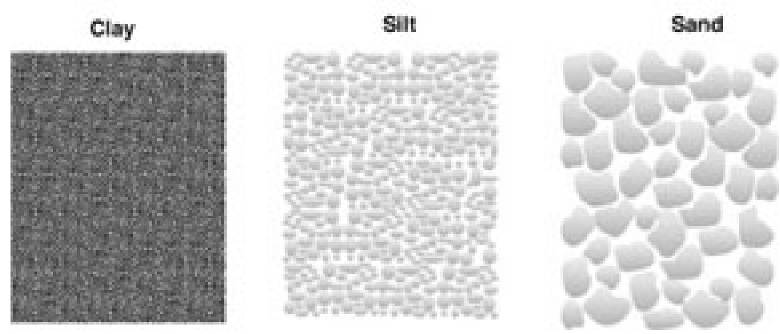
Many urban trees grow on sites where the topsoil, which contains most of the nutrients they need, has been stripped away during construction. In addition, grass clippings and leaves are removed without being allowed to decompose naturally into organic material that would release needed nutrients into the soil.

CHARACTERISTICS OF SOIL

How well air, water and dissolved minerals move through soil is determined by the particle size and the structure of the soil. **Soil structure** is determined by the shape of the aggregates and the size of the resulting air spaces or **pores** between particles.

The channels formed by these pores are also the avenues for growth as tree roots search for air and water. In turn, decomposing roots leave enlarged channels for increased air and water flow through the soil.

Soil can also be described by its primary **texture** or size of particles.
- Sand is relatively coarse.
- Silt is finer.
- Clay is composed of the finest particles.



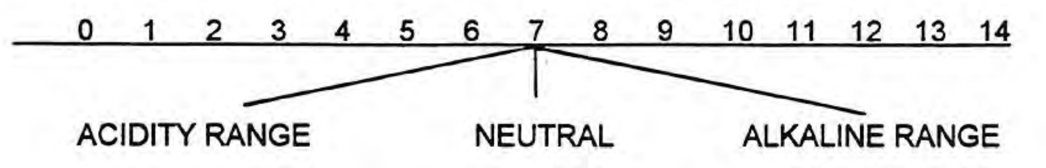
Drainage – Tree health is affected by how much water the soil holds and how quickly water drains away. Waterlogged soil will suffocate tree roots. If water drains out of the soil too quickly, dehydration and wilting occur. Optimum surface soil moisture occurs when 50% of the pore spaces are filled with water.

Drainage measures the rate and extent of water movement down through the soil. Drainage is affected by soil content and structure. The slope of the landscape can determine the rate and direction of water drainage. Upland areas tend to drain into low-lying areas, which may become saturated with runoff water.

Compaction – Drainage is dramatically reduced by soil compaction, which reduces the spaces between soil particles through which water can move. Impaired soil has reduced water flow, reduced nutrients available to the roots and restricted drainage away from the roots. Soils that are too tight or that contain little organic matter, like sand, may allow **leaching** as rapid runoff carries nutrients away from the topsoil.

Organic Matter – Adding fertilizer to soils makes up for missing nitrogen and minerals. It does not adequately replace the important organic matter in natural topsoil or change the texture of the soil. Mulch can slowly add organic matter back into the soil. Organic matter also may be worked into a site before trees are planted, but it is important to keep tilling and soil disruption away from established trees.

Soil pH – One characteristic of soils that can be monitored and changed is the pH. The **pH** measures the relative acidity/alkalinity of the soil. Soil pH influences what organisms are present and what minerals are available. At different acidity levels, organisms may not be able to live and certain minerals may form insoluble compounds that can't be absorbed by roots. Although pH requirements vary with different species, most trees grow well in a pH range of 6.5 to 6.8.



Did You Know?

*Soils with a pH less than 7 are **acidic** and those above 7 are **alkaline**. The pH scale is logarithmic; each measurement is a ten-fold increase. A pH reading of 6 means the soil is ten times more acidic than 7 and a pH reading of 5 means the soil is 100 times more acidic.*

Contact your local county Virginia Cooperative Extension office for soil test information.

EFFECTIVE DEPTH

Tree roots are able to reach maximum growth in deep, well-drained soils. Deep soils hold more nutrients and water available for root growth. Trees growing in very shallow soils not only suffer from limited soil productivity, but also have less mechanical support because of reduced growth of **sinker roots**. With a restricted root system, a tree growing in shallow soil is more frequently uprooted and blown over in severe weather.

MYCORRHIZAL SYMBIOSIS

Tree leaves provide the tree with nutritional carbohydrates. The root system absorbs minerals. Several types of soil fungi, mycorrhizae, actually help the root system absorb minerals and water. Some mycorrhizae grow into the roots without causing damage. Others grow on the outer surface of the roots. Although most are not seen, some may be spotted by their reproductive structures, i.e., mushrooms.

The symbiotic relationship between the roots and the mycorrhizae benefits both the tree and the soil fungi. The mycorrhizae absorb sugars, amino acids and nutrients from the tree roots. Through their own life processes they break down minerals and decaying organic matter in the soil into forms the host tree can use.

The presence of beneficial mycorrhizal fungi is particularly important to trees enduring drought or nutrient-poor sites. Research is ongoing into the effectiveness of commercial soil mycorrhizae inoculations.

STRUCTURAL SOIL SUPPORTING TREE GROWTH AND PAVEMENT

Trees along streets and in parking lots often have to deal with soils beneath pavement that were compacted to support vehicles. **Structural soils** were designed to meet the needs of street trees for air, water and soil while at the same time providing the support needed for pavement with vehicles. It is this load-bearing ability that defines structural soils and differentiates them from other types of soils. Structural soil is composed of rock and soil mixed in specific proportions.

Did You Know?
Evaporation occurs when there is a "free" water surface and it involves a change from the liquid to the vapor state. The rate of evaporation depends on the energy available (heat or wind) and the continued supply of water at the surface. The rate of evaporation slows as humidity rises.

WATER MANAGEMENT

Trees cannot thrive without adequate water and may eventually die as a result of insufficient moisture. On the other hand, too much water makes it impossible for a tree's roots to do their job and thus can also weaken or kill the tree. Water in motion can cause erosion and endanger trees. In short, the relationship between trees and water is anything but simple.

HOW WATER MOVES

When water falls onto the earth's surface, it enters the soil, drops into a body of water or runs off. A variety of factors work in tandem to determine how much water infiltrates the soil surface and how much stands on top of the soil or runs off.

In an ideal situation, water **infiltrates** the soil under any leaf litter that is present, and then percolates or moves down through the soil.

There are many significant differences between undisturbed wild landscapes and urban landscapes. Perhaps the most important difference is a significant increase in the amount of surface runoff. **Soil compaction**, paved and roofed surfaces, loss of native soils and litter layer, removal of native vegetation and disruption of the natural **drainage** patterns create the need for water management.

According to the Environmental Protection Agency (EPA), a city block can generate nine times more runoff than a wooded area the same size. Obviously, developed areas employ a variety of methods (gutters, storm drains, settling ponds, etc.) to "manage" water as it runs onto our streets. However, the need to manage water starts well before it reaches streets and streams and should involve more than moving water rapidly off-site.

WATER ISSUES IN DEVELOPED AREAS

- **Water loss** – If water is prevented from infiltrating the soil and is forced to move rapidly off-site, the landowner (public or private) may need to irrigate to make up for this lost water.

- **Erosion** – Water that moves rapidly across the soil surface has the potential to cause significant erosion, resulting in the loss of topsoil and associated nutrients.

- **Flooding** – Plantings in low-lying or flat areas on which rainwater collects may exhibit stress because of soil saturation. This can be mitigated to some degree by selecting plants that are flood-tolerant.

POLLUTION

Water that flows off of lawns and impervious surfaces such as parking lots often carries high concentrations of pollutants such as nitrites, salts and oils.

- These materials are likely to enter streams, where they cause significant damage to aquatic habitat, to the organisms living there and potentially to humans dependent on public drinking water.

- Increased stream flow resulting from less soil infiltration and more runoff can cause erosion within the streambed. Once this type of erosion starts, the stream will cut deeper and deeper into the soil until a new equilibrium is reached. This process results in high levels of sedimentation downstream, which severely impairs the aquatic ecosystem.

- Increases in overland flow into streams will increase peak flows and cause more frequent flooding. When overland flow occurs over sun-heated pavement, the temperature of water entering streams will be elevated. This higher temperature harms many species of aquatic organisms.

Trees help mitigate these problems by intercepting rainfall via their leaf canopy and helping water move into the soil, thus reducing runoff. In the process, trees absorb water and minerals (dissolved in water) from the soil. Trees also help cleanse and filter the water.

SOIL COMPACTION

Generally, soils with smaller particles, such as clay, are more easily compressed or **compacted.** Compression results in a reduction of pore space with the packing of particles, and the breakdown of soil aggregates occurs. The major causes of soil compaction are raindrop impact and mechanical pressure from machinery, wheels, hooves and feet.

It is easy for most people to envision mechanical pressure causing soil compaction. While we don't often think of raindrops as a cause, they can be a significant cause of erosion when landing on bare soil.

- Lower intensity rains consist of smaller drops having slower terminal velocity and thus less erosive force.
- Higher intensity rains consist of larger drops having faster terminal velocity capable of significant sediment detachment.

HOW IT HAPPENS

Heavy rain on bare soil detaches fine soil particles that are then picked up by the water. These particles tend to plug the infiltrating surface as the water enters the soil, thus resulting in soil compaction (filling of soil pores), overland flow and erosion. Mulch, leaf litter and/or strong vegetation significantly reduces the compaction and erosion power of raindrops.

RUNOFF

Water does not stay put. How and where it moves depends on the local environment. Water may infiltrate the soil into an aquifer and eventually to a stream. Alternatively, it may run over the soil surface before meeting a stream. The source of this water can be snowmelt, rainfall or excessive irrigation. The urban environment typically experiences a significant increase in runoff following precipitation events. One of the biggest differences between runoff occurring in undisturbed sites and that occurring in urban areas is related to timing.

COMPARING WATER MOVEMENT IN UNDISTURBED VS. DEVELOPED AREA

In "the Woods"	In "the City"
• In an undisturbed site there is typically a lag between the start of a rain event and the increase in runoff because soils are not compacted and so have more storage space for water.	• Heavy thundershowers quickly fill storm gutters and street gutters or ditches and they run with muddy water.
• Once these spaces are filled, overland flow leads to increased stream flow.	• Shortly after most storm events, this overland flow ceases. This means that a large amount of water that would, under more natural conditions, recharge the soils is lost from the site and moves rapidly into surface drainage systems.
• Stream flow remains elevated for some time, dependent on the intensity of the rain event and other factors.	• This "lost" water causes flooding downstream, compounding the problems related to water management in urban areas.

Of course, this is a simplistic description of a complex system and the number, intensity and timing of storm events affect the response time. In contrast to the undisturbed site, runoff in an urban area typically occurs very rapidly when it rains. This is why more flash flooding occurs in urban areas.

WHAT COMMUNITIES CAN DO

In a perfect world we would be able to develop our community landscape in such a way that soils would not be compacted, impervious surfaces would be at a minimum, and the native soils and vegetation would be disturbed only minimally. The reality is often far different.

MINIMUM IMPACT

One of the most significant issues is what to do about compacted soils. People planning a new home may be able to work with their contractor to minimize the removal of vegetation, the area impacted by heavy machinery, the extent of grading and the removal of native soils.

Special trees deserve special attention to protect their root zone with a sturdy fence. The size of a root protection zone (RPZ) is roughly based on tree size. For more information, go to *Protecting Trees from Construction Damage: A Homeowner's Guide*, a publication from Minnesota Cooperative Extension which can be accessed on line at: http://www.extension.umn.edu/distribution/housingandclothing/DK6135.html

RETROFITTING

Unfortunately, once soils are compacted, they recover very slowly – as in decades and centuries. Re-establishment of vegetation helps the process along, especially replanting trees because of their large root systems. Organic mulch such as wood chips helps speed the recovery of compacted soils as the organic matter works its way down into the soil over time.

VEGETATION AND MULCH

Mulching bare soil or establishing vegetation on it can minimize erosion. This increases the amount of water that can stay on-site long enough to soak in. Mulch reduces evaporation and reduces compaction and erosion. Mulching also helps control weeds and undergrowth. Lawns benefit from removal of thatch and aeration which can also encourage water movement to the roots of the turf.

RAINWATER HARVESTING

Consider rain “harvesting.” This can be done by directing downspouts and gutters to drain over the lawn, into plant beds or even into “rain gardens” where the water will be retained long enough to soak into the soil rather than immediately running off-site.

POROUS SURFACES

Using porous surfaces for walkways, driveways and patios can improve retention of water. Mulched paths, brick or flagstone, gravel and pervious concrete are options. Minimize impervious surfaces and maintain the natural grade to the extent possible.

GROUNDCOVER PLANTINGS

Groundcovers may be the best answer for steep slopes. Barriers that slow the water down without creating a cascade effect help increase the amount of water that penetrates the soil on slopes.

The topic of community water management is rapidly developing and these are only a few suggestions to improve the water patterns in the landscape.

Key Questions:

What is topsoil?

How does soil structure affect trees?

What causes leaching?

Name two sources of soil contaminants.

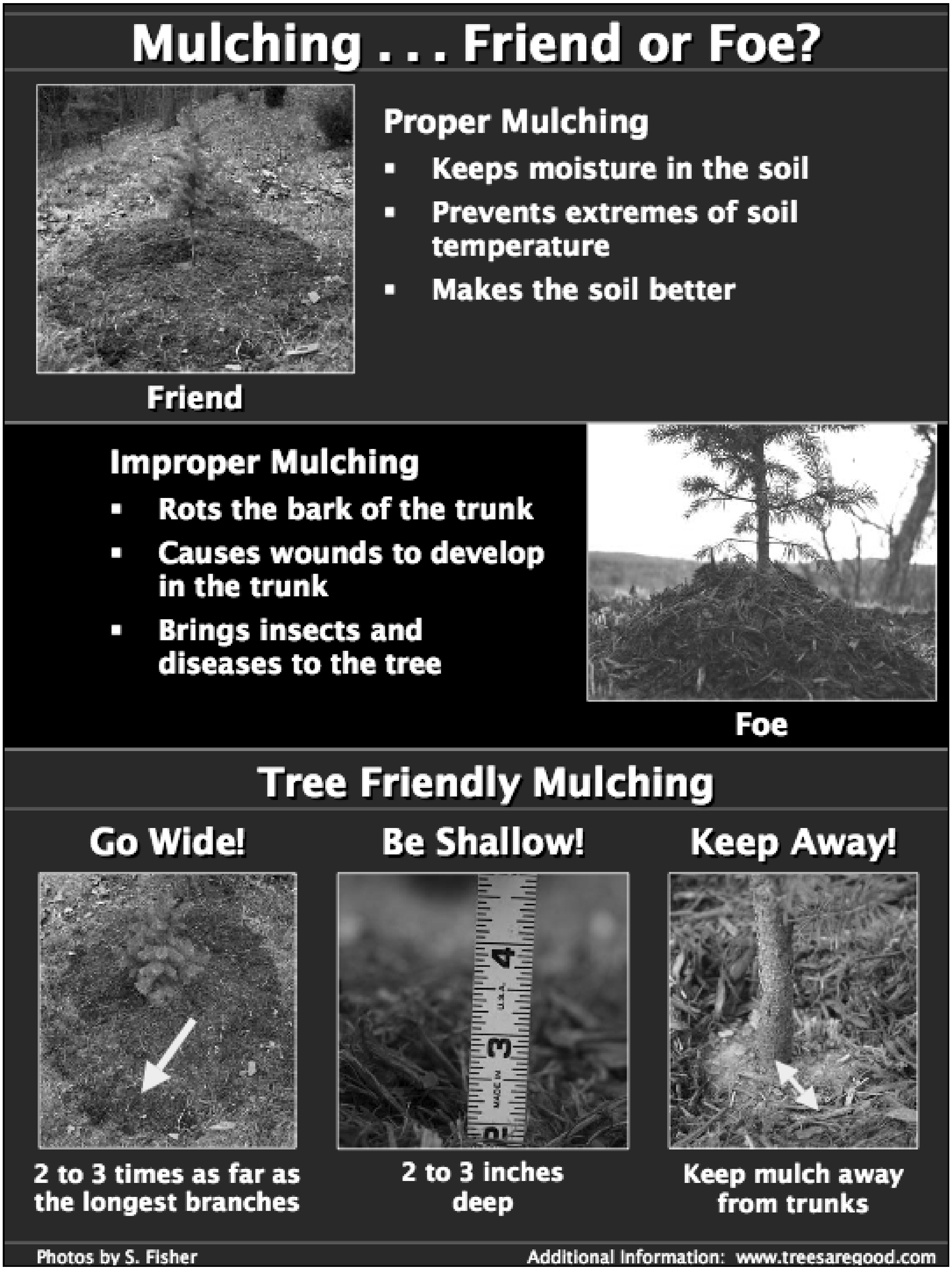
How do mycorrhizal fungi benefit tree root systems?

How does soil compaction harm trees?

If rainwater cannot infiltrate the soil surface, what problems can result?

What practices can help minimize impervious surfaces and otherwise slow rainwater runoff from developed areas?

Photo by Robert Llewellyn, Southern red oak (*Quercus falcata*)



Poster created by Front Royal Tree Stewards

Tree Selection – Unit 7

The choice of a tree to plant and how that species should be cared for depend upon many factors. Before selecting one, determine what the tree is expected to do. Will its main function be to provide shade or be an ornamental? Then get the right tree for the job. Remember that a tree is an investment that provides many benefits.

THE RIGHT TREE FOR THE RIGHT SITE

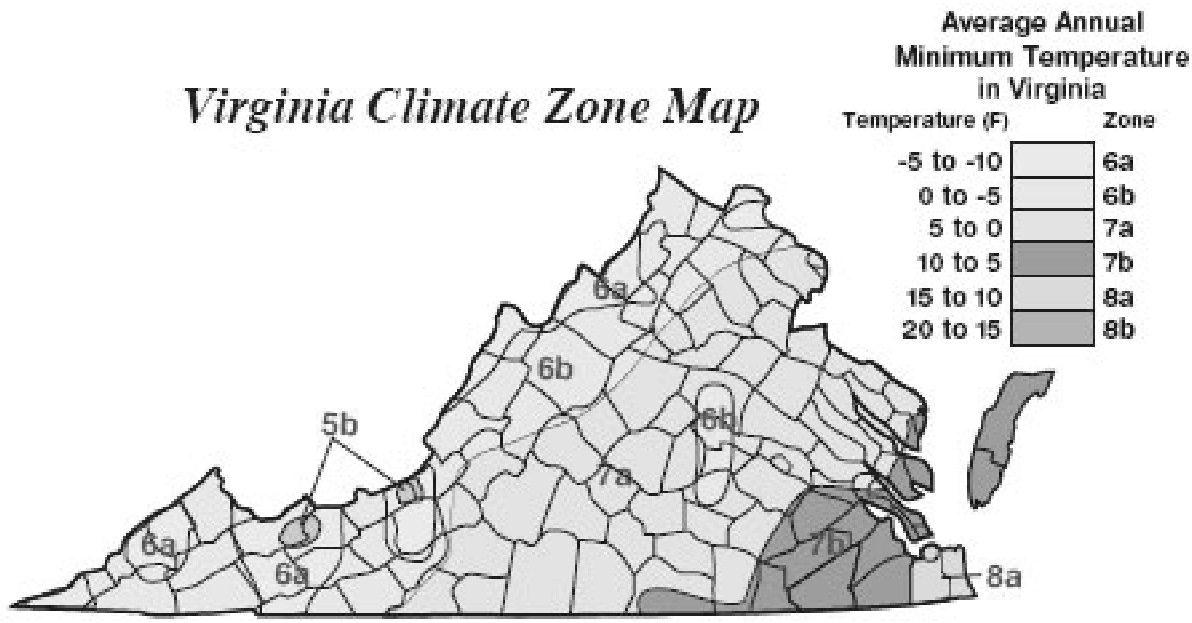
Many trees planted each year by well-meaning homeowners and community workers will never flourish because they are hopelessly unsuited for the conditions in which they are placed. Before rushing in to plant any available trees, do enough research and planning to ensure success. When choosing a tree, make sure to do a complete site evaluation to ensure the best tree for the site chosen.

HARDINESS ZONES AND HEAT TOLERANCE

Some tree species inherit the ability to live in many locations and climates. Tree researchers measure a species' **adaptability** by the different situations in which it grows well.

The geographic locations and environmental conditions where a tree species is found growing naturally constitute its **range**.

One of the factors limiting the range of tree species is **hardiness**. Hardiness is generally used to indicate a plant's ability to survive low temperatures. Hardiness maps show temperature ranges across a region as colored or patterned zones.



Heat tolerance is generally used to indicate a plant's adaptability to high temperatures. A heat tolerance map shows temperature ranges across a region as colored or patterned zones. Trees may attempt to adjust or acclimate to a new or adverse environment. See the American Horticulture Society's Web site at www.AHS.com for a Heat Zone Map.

NATIVE AND NON-NATIVE TREES

Native tree species are found growing naturally within a geographic region. In some cases, Virginia native trees may no longer be adaptable to an area because of construction and development or other changes. For example, though a white flowering dogwood is native to Virginia, it is not suitable to plant in full sun or in a highly urbanized area in a **tree pit**.

Efforts are being made in many areas to plant or replant native trees. Remember that any tree species will be native not only to a geographic location but also to a natural environment. Check to see if the species being considered grows naturally in riparian, upland or mountainous areas. A good resource for information about Virginia native trees is found in the *Common Native Trees of Virginia* by the Virginia Department of Forestry.

Non-native species, in contrast, are those that have been "imported" to the region. Non-native species include those native to other lands. Many of these trees have become popular because of various tolerances or physical traits. Non-native species are often portrayed as "bad," but they are sometimes more tolerant of urban soils.

In some areas, introduced species are taking over habitats, reducing the number of native, naturally growing species. These aggressive species are called **non-native invasives**.

MICROCLIMATES AFFECT THE SITE

While a region can be defined in terms of general geography and environment – for example, Zone 6 mountains, Zone 7 piedmont – specific environmental conditions can vary widely across an area smaller than an acre.

An exposed site is one where the tree will not be sheltered from the elements, by other plantings or buildings. A protected site may be blocked from wind or storm damage and allow a marginally hardy tree to survive. These small but significant changes in the overall environment create **microclimates** that can increase or lessen a tree's chance of survival.

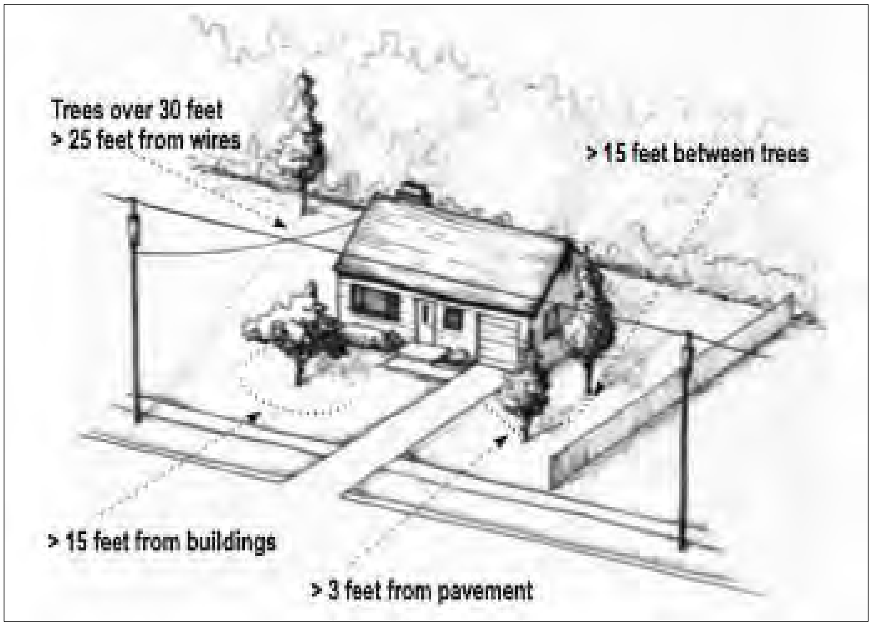
The temperature, wind exposure, soil drainage, acidity and light level of any planting site can change dramatically depending on buildings, streets and other trees in the area.

- A tree may be sheltered from wind by a nearby building or not receive enough sunlight, air circulation or root space to grow well.
- Marginally hardy trees may get enough warmth from nearby structures to survive cold weather.
- Cold air sinks to the bottom of slopes, which become "frost pockets." Have you noticed how long snow remains on more north-facing slopes? North-, east-, west- or south-facing slopes have different climates that affect plants growing there.
- Water runoff may keep high slopes well drained and overly dry while flooding lower elevations. **Soil texture** and content change **drainage**, as does **compaction** from construction.

Carefully examine the specific site and map out any microclimates and their causes. Selecting species tolerant of a site's specific conditions will greatly enhance the trees' chances of survival.

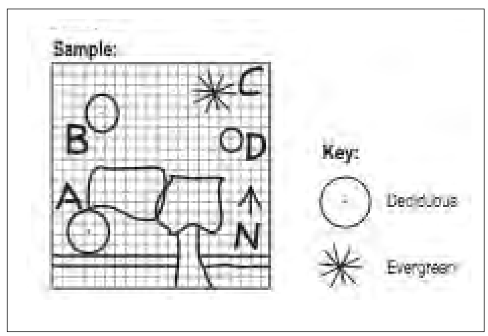
SITE EVALUATION

While considering possible plantings for a neighborhood or community, use a project or site plan to help evaluate and organize competing ideas. This plan can be a simple sketch that represents the site and the proposed tree locations. A site plan does not require artistic ability. Its function is to help assess the area and choose optimum planting locations. The plan should contain the following information:



- the scale (e.g., 1” = 25’) of the drawing and the orientation (include a north arrow)
- location of buildings, streets, sidewalks and other “hardscape”
- location of other plantings, trees and other “landscape”
- location of overhead and underground utilities*

Sample Site Plans



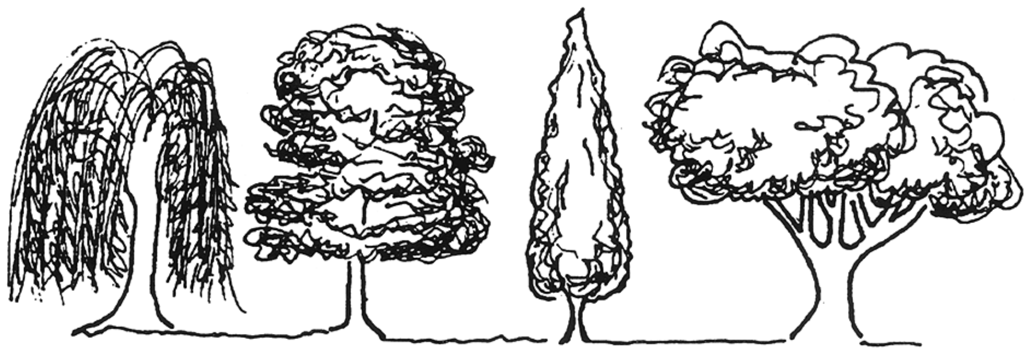
- known problems such as areas of poor drainage or construction fill
- access to site
- source of undesirable view or noise for screening plantings

ADDITIONAL SITE CONSIDERATIONS

Consider the “personality” of the selected site. Planting arrangements should enhance the overall landscape. Many street-side plantings are formal landscapes with trees planted in evenly spaced rows. These plantings give a feeling of order and predictability. Parks are areas for relaxation. They achieve an informal landscape by randomly spacing mixed groups of trees and shrubs. Wildlife habitat landscaping requires trees and shrubs that produce fruit, nuts and berries.

Caution!
It is not recommended to plant an entire site/park/community with just one species, a ***monoculture,*** *because this increases the potential for insect and disease problems to spread and destroy the whole planting.*

In addition to hardiness and adaptability, trees should be selected for size, foliage, flowers – even the form that will most enhance the chosen site. Within most tree species, **cultivars** can be found that have been bred to have special characteristics. In narrow urban spaces, a columnar or fastigiate cultivar is sometimes a good selection, such as Armstrong maple.



Weeping Full-Crowned Columnar Spreading

In addition to making sure that planted trees will do well at the selected site, make sure that the trees will not become nuisances or hazards as they grow larger. Here are some other planning considerations:

- Re-check all utility installations (above and below ground) including electrical, cable and telephone lines, water lines and sewers. Will branches and roots from the fully grown trees interfere with any of these?

*** Call before you dig!**

Before digging, always contact “Miss Utility”at 811 countrywide. “Miss Utility” will locate and mark underground pipes and cables at no charge.

- Make sure that the full-sized trees will not eventually block the view of traffic or obstruct municipal and commercial signs. Check with the city traffic engineer or related department for information and approvals on street plantings.

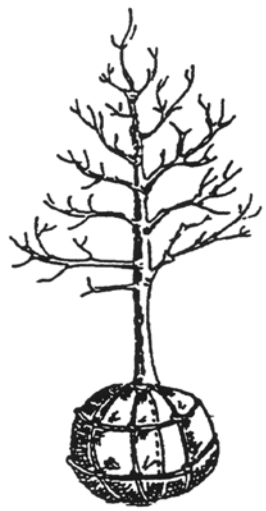
BUYING QUALITY TREES

Trees may be purchased as bare-root, balled and burlapped or container-grown.

- **Bare-root** seedlings are dug and shipped without any soil during fall and winter. Remember that they must be protected from drying and should be “heeled in” to a temporary bed if they will not be planted for several days. Best rule of thumb: Plant as soon as possible and keep them moist and cool.

- **Container-grown** plants should have been in the container for one season (at least three months), but not long enough to become root-bound or to develop circling roots. Container trees can be held for some time before planting as long as they are watered and supplied with a general timed-release fertilizer.

Container-Grown Tree



Balled & Burlapped Tree

- **Balled and burlapped** (B&B) trees have been dug from the field by lifting a root ball of roots and soil. The root ball is wrapped in burlap and tied or wired closed. Keep the root ball moist.

Buy planting stock from a reliable nursery rather than digging young trees or seedlings from the wild. Wild transplants typically have poor survival rates. Reject poor plant material even if it's from a certified nursery. The following checklist will help in selecting stock that will grow well after planting:

- **Look for well-formed, vigorous trees.** Nursery stock should be free of weeds, diseases and insect pests. Bark on young trees should be uniform. The trunk of the tree should be fairly straight and centered in the root ball or container. Check to see if the trunk caliper is too small for the container or the height of the tree and the foliage.

- **Check the trees for obvious signs of damage** such as broken branches or bark abrasions. Do not buy young trees with damaged trunks. Damaged, discolored or peeling bark may indicate pests or diseases. Make sure the tree has not been transplanted into a large pot but at a lower depth

- **Examine the roots.** It is important to examine the roots of container plants. Root growth should be dense and roots should be healthy. Do not buy trees with dark colored and decayed roots or with dried and withered roots. Trees held too long in undersized containers have circling, girdling roots. If the root ball has already been wrapped in burlap and tied or wired, make sure that the ball is solid and moist.

- **Avoid stock with heavy base suckering.** Select young trees with strong, single trunks and a well-defined leader unless a multi-stemmed species is desired.

- **Branching should be evenly distributed** on the top 2/3 of the trunk. Look for good branch spacing and open **crotch angles**. Avoid stock that has been severely pruned back (topped) or that shows a lot of spindly, upright branch growth.

- **Examine the bark and foliage for obvious signs of disease.** If foliage is present, check for healthy shoots, buds and leaves. During foliage seasons, dropping or yellowing leaves may indicate that the young tree has been under-watered or exposed to other stresses. Wilted, discolored twigs and leaves may indicate disease.

TYPES OF NURSERY STOCK

Nursery plants are often described as varieties or cultivars. Sometimes geographic separation or other conditions cause a group within a species to develop with different, distinct morphological characteristics (size, leaf shape, flower characteristics, etc.). This type of naturally occurring, unique inheritance is called a **variety** in the nursery trade.

A **cultivated variety** or **cultivar** is one being commercially propagated for specific, naturally occurring desirable traits. Cultivars will not reproduce true in the wild. In catalogs, varieties are indicated by the abbreviation “var.” Cultivars are shown by a name in single quotation marks (most cultivars in the nursery trade are given commercial names) or by the abbreviation “cv.”

Some newly developed cultivars are protected by “plant patents” that license all reproduction rights to the developer for 20 years. The Plant Variety Protection Act, effective in 1970, covers new hybrids produced from seed. These measures prevent newly developed plants from being reproduced without express permission. This protection allows plant breeders to receive the profits from plants they develop and encourages continued plant development work.

A CHECKLIST FOR SITE ASSESSMENT AND TREE SELECTION

Closely examine the conditions at each site. Every site has specific assets and/or limitations that will profoundly affect the health of any tree planted there. Use the following questions as a guideline for assessing a site:

- **How much space is available for root and canopy spread?** Small spaces require small trees. No amount of maintenance pruning will make up for planting a tree that will grow too large for its location. No tree grows to maturity with inadequate root space.

- **How much shade or sun will trees receive at this location?** Some trees grow best in shade and wilt or scorch in hot sunlight. Others will not tolerate heavy shade from buildings or other plantings.

- **Is the site unusually dry or wet? Does it drain well?** Select trees tolerant to drought or wet soils.

- **Does a soil test reveal acid or alkaline soil?** Trees should be selected to tolerate existing **pH** levels.

- **How polluted is the air in this area?** Plantings along busy commercial thoroughfares endure intense levels of automobile exhaust gases and heat.

- **What diseases and/or pests appear to be present already?** Select trees resistant to existing problems.

- **Are there overhead or underground utility lines, sewers or other service lines crossing the site?** Check reference lists for trees recommended to plant under utility wires. Always call the city utility office to check on unseen lines and make sure plantings will not interfere with rights of way. Plant at least 20 feet from the nearest electric line. And remember: CALL MISS UTILITY!

- **What are public easements?** An **easement** is not a piece of property. It is someone's right to use a certain part of someone else's property for limited purposes such as drainage, utility distribution or access. Land under a "utility and drainage easement" is not city property. In such a case, the easement trees are private trees, but a city or utility company may have authority to remove or severely prune easement trees.

- **What trees and other woody plants are already growing here?** Existing plants can offer valuable clues about site conditions.

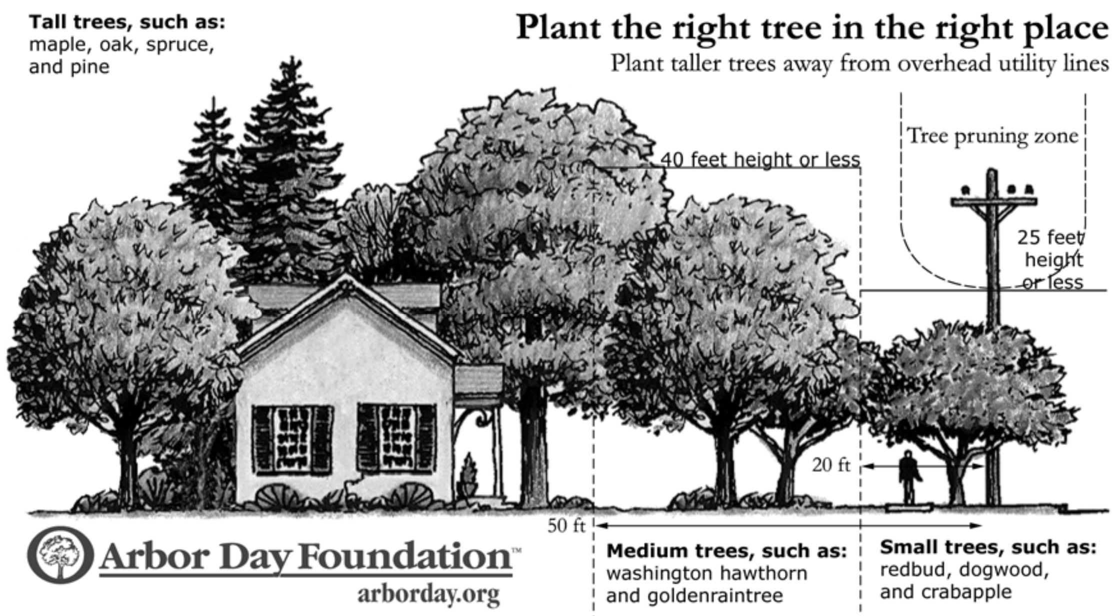
CHOOSE THE “RIGHT TREE FOR THE RIGHT PLACE”

- **Determine the desired function for trees at this location.** Trees can be planted to provide shade and privacy, to screen out noise, to block pedestrian traffic, or to provide a visual show of flowers, berries or foliage. **Deciduous** trees provide the best summer shade, but **evergreens** will provide better year-round wind, privacy or noise screening. Block pedestrian traffic by planting trees with thorns, spiny foliage or dense growth. Street-side plantings should use trees that are structurally strong, relatively pest-free, pollution-tolerant, and without “litter.”

- **Evaluate possible tree species for the best match to the site conditions and intended function.** Tree research and evaluation have provided excellent lists of trees that are genetically adapted to certain conditions. One such list is in the resources section of this manual.

- **Select the best tree for the site.** Cross-referencing tree lists narrows possible choices. For example, *Acer campestre* (hedge maple) appears on reference lists of trees tolerant of salt, adaptable to drought conditions and alkaline soil, and suitable for planting under utility lines.

- **Make sure the selected species is tolerant of the existing conditions**. A local forester, ISA-certified arborist or Extension agent, among other professionals, can be consulted.



Key Questions:

What are some steps to establish the right tree on a site?
List four possible functions of trees on a given site.
What is a tree's range?
A tree's ability to adjust to adverse circumstances is its____________________.
List four factors that can affect the microclimate of a possible planting site.
What is a non-native invasive?
List three considerations for selecting trees for street plantings.

Right Tree, Right Place, Right at Home!

A Checklist for Locating Shade Trees in Your Yard

Distances based on medium to large canopy shade tree such as American elm, river birch, and black gum (tupelo).

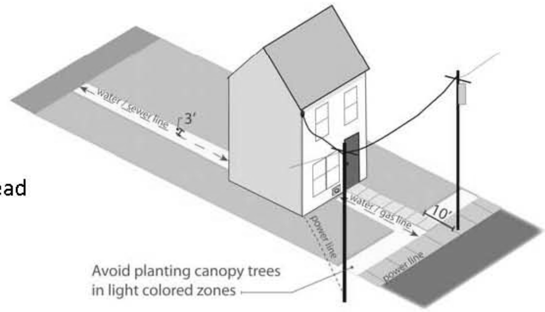
Locate and stay clear of utilities

___ Call Miss Utility (1-800-257-7777) to have your underground utility lines marked

___ Plant at least 10 feet from main overhead utility wires on street or alley

___ Avoid planting directly underneath smaller overhead wires that connect to your home or building

___ Plant at least 3 feet from buried utilities. The edge of the planting hole must be at least 18 inches from marked utilities. (DC law)



Plan for the tree's mature size

Give trees room to grow by planting minimum distances from other objects:

___ Plant at least 10 feet from a building

___ Plant at least 3 feet from sidewalks, driveways, patios, and fences

___ Plant at least 20 feet from other large trees

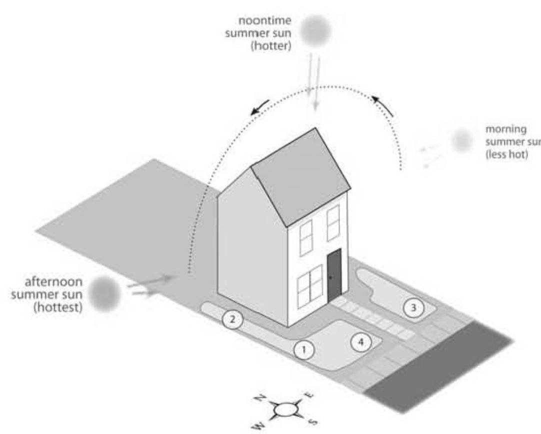
___ Plant at least 10 feet from small trees

Plant for shade

Lower your cooling costs by planting trees to shade summer sun.

___ Prioritize your tree planting with the sun's direction to maximize shade by planting on the 1)southwestern and 2)western sides of your home.

___ Planting on the 3)southeastern and 4)southern sides will help shade your home from morning sun.



Casey Trees
WASHINGTON DC

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Tree Planting and Tree Care – Unit 8

Planting a tree correctly and following up with good initial maintenance are *essential*. A healthy plant will survive disease, pests, drought and other stresses of its environment. The most common cause of poor tree health is poor planting: too deep, too shallow, or in too small an area. The objective is to plant the tree so that the **root flare** at the bottom of the trunk is at or slightly above the surrounding ground level.

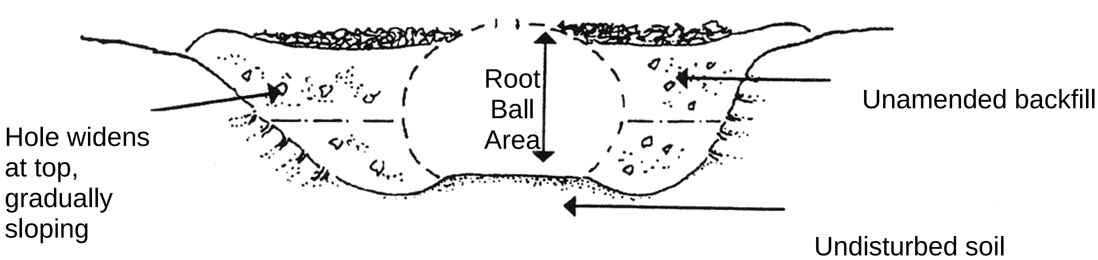
THE PLANTING SITE

Remember that the root system of a tree grows out much farther than the canopy. The roots of young trees must be able to spread out into the surrounding soil to find water, oxygen and nutrients. The health of the root system determines the health of the shoot system. Grow healthy roots for a healthy tree.

CREATING THE PERFECT PLANTING SITE

Mark the planting site and remove any vegetation, including turf, from an area three to five times the diameter of the tree's root ball.

1. Create a root zone, not just a hole. Break up the soil 8 to 10 inches deep – but no deeper than the root ball – in a space two to three times as wide as the root ball.



A well-made planting hole

   The objective is to de-compact the soil so new roots can spread out into the surrounding soil and create a strong base for the tree. This becomes especially important in times of drought, flooding and storms.

2. Examine the sides of the root ball or use a probe to locate the roots within the root ball. Then, in the middle of the prepared root zone, dig a hole deep enough so the main roots will be just below the surrounding soil.

Circling roots become girdling roots.

3. Gently prune away any dried, damaged and broken roots from **bare-root** trees. Pot-bound **container-grown** trees may show circling roots that should be cut through or straightened out to prevent later **girdling** and to encourage natural root growth. If circling roots are severe, return the tree to the nursery for a replacement. Check visible roots on **balled and burlapped trees** and lightly prune any obvious broken, damaged ends or circling roots. **Do not overprune roots!**

4. Install the young tree at the same soil depth that it has been growing or slightly higher. A slight rise in the center of the hole will keep water from "pooling" in the bottom of the hole. The depth from the top of this small mound to the surface of the ground should be no greater than the depth of the root ball while allowing the root flare to be at or slightly above the surrounding ground level. **Do not plant the tree too deeply!**

5. When moving a tree, always pick it up by the root ball, binding strings or container – NOT by the trunk. Turn the tree to the desired position and then set it in place. Remove all the ties and roll the burlap and other ball-wrapping materials away from the top half of the root ball. If possible, remove all packaging materials. This encourages good contact between the soil of the root ball and the surrounding soil. If the root ball is wrapped in natural burlap, the burlap can be left in the hole where it will gradually decompose. If the burlap is not natural, REMOVE it completely!

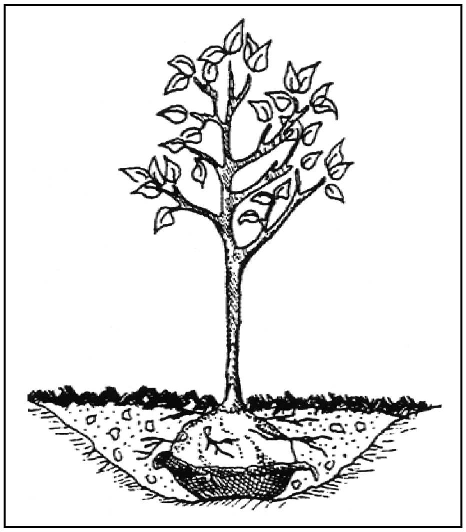
6. Backfill with soil excavated from the hole until it is about 3/4 full. Do not fill the hole with mulch, compost, gravel or other soil amendments. Research indicates that overamended soil in the planting hole discourages roots from growing into the surrounding soil.

7. Add water and allow the soil in the hole to settle. Finish backfilling around the root ball. Use the water to float out air pockets that can cause the roots to dry out and the soil to sink. Make sure that soil fill does not cover the root flare.

8. Firm and level the soil, but don't re-compact it solidly.

9. Don't replace sod over the root zone or in the hole.

10. Mulch takes the place of the natural layer of leaf litter found on the forest floor, and it greatly benefits the tree. Mulch should be made of a coarsely chopped organic material like chipped or shredded hardwood or shredded pine bark, and



should be applied 2 - 4 inches deep. Never pile mulch around the base of the tree. Mulch should never touch the tree.

Why such intense preparation? Moving and transplanting trees "shocks" their root systems and damages the delicate absorbing roots that supply water and nutrients. The success of re-establishing root growth and function determines the eventual success of the tree. Optimum site preparation makes it easier for the roots to grow and spread out. Remember that tree roots grow far more widely than deeply.

If labor and resources do not allow establishing a perfect planting site, try to follow as many of the suggestions as possible. Where site preparation is limited, make sure the actual planting excavation is wide: two to three times the diameter of the root ball and not too deep.

PLANTING DIFFERENT TYPES OF STOCK

- **Bare-root** – Dig a shallow planting hole no deeper than the roots will be when they are spread out. Make the hole wider than the root system to allow for spreading. When planting large bare-root stock, backfill with native soil while watering simultaneously, creating a slurry or mud that covers all of the roots.

- **Balled and burlapped** – When moving a tree, always pick it up by the root ball or binding strings and NOT by the trunk! Make the diameter of the planting hole at least two to three times wider than the root ball. ***Caution***: Sometimes soil surrounding the tree under the burlap is above the root flare. Remove the excess soil. Trees burlapped and encased in wire baskets should have at least the top two lateral wires cut and removed after being placed in the planting hole. Roll down burlap to the lower portion of the root ball to allow plenty of room for root growth. Cut and remove most of the burlap.

- **Container-grown** – When moving a tree, always pick it up by the container and NOT by the trunk! Dig the planting hole the same depth as the tree is growing in the container. Make the planting hole at least two to three times wider than the container. Remove the tree from the container before planting. Container-grown

See http://pubs.ext.vt.edu/426/426-702/426-702.pdf for a VCE publication on planting trees.

See http://www.dof.virginia.gov/mgt/resources/pub-hardwood-planting-guide.pdf for a VA DOF publication titled Hardwood Planting Guide.

trees may show circling roots that should be cut through or straightened out to prevent later girdling and to encourage natural root growth. If circling roots are severe, return the tree to the nursery for a replacement. Sometimes soil surrounding the tree in the container is <u>above</u> the natural root flare of the tree. Remove the excess soil.

EVERY PLANTING SITE MUST BE ASSESSED INDIVIDUALLY AND ADJUSTED ACCORDINGLY.

What soil composition and structure, drainage, location and other factors must be accommodated?

<u>Do not</u> plant bedding plants, other ornamentals or turf around a newly planted tree. The soil around trees should be left as undisturbed as possible to protect delicate roots near the surface.

EARLY MAINTENANCE FOR A GOOD START

STAKING is a controversial subject. There is much disagreement about whether it should be done at all, and if so how and with what materials. The goal of staking is to hold the root ball still so that new roots can become established in the surrounding soil, but to allow the trunk to sway a little, promoting good taper toward its base. Here are some guidelines for staking:

- On trees that may be unstable during strong winds, set two or three 5- to 8-foot stakes (depending on the height of the tree) firmly into the ground. Don't drive them through the root ball.

- Install padded supports that are just tight enough to prevent the tree from tipping and low enough on the trunk to permit some swaying.

- Remove all supports one year after planting. Failure to remove these supports can eventually strangle expanding tree trunks. The initial site assessment should help evaluate if the wind exposure requires any tree support.

PRUNING damaged branches should be done as soon as the damage is noticed. A new tree needs time to become established, so major pruning should not be performed until about a year after planting.

Once the tree is established, the **crown** can be evaluated for rubbing branches, crossing branches, **watersprouts** or other problems. Any offending branches can then be pruned. Do not remove more than 15% of a young tree's crown in any one season.

Recent research indicates that the old custom of removing 1/3 of top growth at planting to "compensate" for root loss when transplanting makes it more difficult for the young tree to recover. At transplanting, the tiny absorbing roots are often damaged, but the correct solution is to make sure that the tree receives ample water during the recovery period, NOT to decrease foliage. See Chapter 9 for more information on pruning.

FERTILIZER is not necessary at planting. Contrary to traditional practice, research recommends against it. Good aeration and adequate moisture are far more important for establishing sturdy root systems. If your soil analysis indicates that fertilizer will be needed, the first application should be made in the <u>second</u> season after planting.

PLANTING TIME is best in early spring or fall. **Deciduous** trees planted in the fall, after the heat of summer diminishes, have several months to re-establish their root system and often emerge healthier the next spring than those transplanted in the heat of summer. Planted very early in the spring, while still dormant, trees begin establishing a root system.

WATERING – Regardless of the season, newly planted trees need to be watered regularly. Do not assume that there will be adequate rainfall to care for newly planted trees. If the soil does not feel cool and moist, give the root zone a good soaking. Deep slow watering less often is better than many shallow waterings.

Many trees planted in our neighborhoods and communities now desperately need professionally directed care. By monitoring these trees and taking care of their needs, volunteers help keep trees healthy. The care given to the urban forest today will help create the beauty enjoyed tomorrow.

All public forest tree care should be undertaken cooperatively and with the appropriate municipal agencies and property owners. This program has been developed to educate and encourage many different parts of the community – municipal agencies, local professionals, civic groups and individual volunteers – to work together for the betterment of the community forest.

TREE NEEDS

WATER – All trees need supplemental watering during extended dry periods. Don't try to water an entire city of trees, but give special care to new plantings.

Adequate rainfall is <u>at least</u> one inch of rainfall every week to ten days. A rain gauge will record actual rainfall. Remember that not all sites in an area receive the same amount of rain, especially during summer's scattered showers. The casual observer will generally overestimate rainfall. Although adequate water is critical to survival and new root growth, excess water accumulation in the planting hole is a leading cause of transplant death. Watering must be appropriate for soil type and drainage.

Young Katsura (*Cercidiphyllum japonicum*) Tree in Autumn

Trees in sidewalk planters do not receive normal rainwater soaking down through the ground. Ideally, these trees should receive water weekly from automated irrigation equipped with rain sensors to avoid wasteful, inefficient water use (twice weekly in hot months). Try to supply an average of 20 gallons of water per tree at each watering.

MULCH – Piling mulch around the base of trees has, unfortunately, been gaining in popularity. Overmulching and allowing mulch to rest against the tree bark and root flare are among the most common causes for urban tree decline and premature death.

Mulch can help maintain soil moisture and protect against overheating in planting areas surrounded by concrete and asphalt, but make sure that any mulch used is organic. Keep it away from contact with the trunk bark and root flare.

Mulch gradually deteriorates. Mulch cover should remain at 3-4 inches. Check under mulching to make sure that rodents or other pests have not moved in. When this occurs, remove the existing mulch. Maintaining a good mulch cover makes weeding easier and discourages landscape maintenance workers from using string trimmers and mowers close to the trunk.

MAINTAIN SOIL LEVEL – Check street-side and container trees and replace soil eroded from the tree base. Soil in planters may gradually erode and settle out. Make sure that added soil does not exceed the planting level of the tree. Soil level should never exceed the root flare, that trunk-root interface where the trunk diameter flares out into the root system.

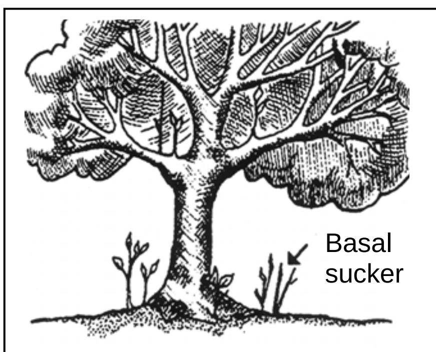
Although soil around trees should normally remain undisturbed, soil in planting **pits** can become hardened and impervious to water. Tree planting pits can be improved by gently loosening the soil surface with a hand cultivator or trowel, being careful to disturb as few roots as possible. Remember that delicate feeder roots are growing close to the surface. Mulch should be applied over the loosened soil. There is evidence that planter trees kept mulched and weeded are less likely to be "trashed" with careless littering.

Due to compaction, roots of a street tree are growing at soil surface

For standard in-ground tree plantings, it is also important to check soil level to make sure it has not been mounded up around the base of the tree. If soil and mulch have raised the surface level above the root flare, rake the area gently until the soil spreads away from the tree. Soil mounding is frequently the result of adding soil to create under-tree plantings of ground covers or flowering plants.

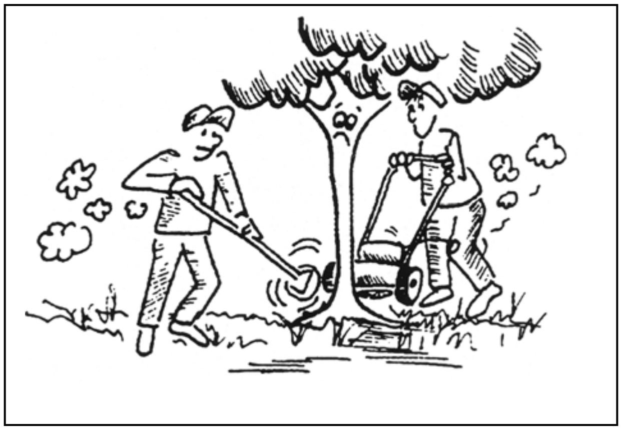
DISCOURAGE UNDER-TREE PLANTINGS – Planting ornamentals and annual bedding plants within the dripline of trees necessitates constant disturbance of the soil. As much as 90% of the tree’s root system is within the top foot or two of soil, with most of the delicate absorbing roots just below the surface. Digging and planting in this area should be discouraged.

PRUNE – Damaged branches should be removed as soon as possible. Do not do any extreme pruning or try to remove large damaged branches. These types of problems should be inventoried and referred to the proper professionals.



Monitor development of **suckers** and **watersprouts**, which should be pruned throughout the year as soon as they develop. Do not use herbicides to discourage suckering. Maintenance herbicides applied to the base of established trees can be taken up through any basal suckers and injure the tree. Do not use herbicides on young or newly planted trees.

If trees are well established and suckering is not present, herbicides can provide weed and grass control without the physical damage caused by mowers and string trimmers.



Mowers and string trimmers used to remove grass and weeds at a tree's base can cause extensive mechanical damage to the trunk and root flare area. This is especially harmful to the thin bark of young trees.

Make sure that crossing, rubbing and poorly placed branches are removed while they are still manageable. Thinning dense growth within the canopy will improve air and light access and reduce the tree's wind resistance during storms.

Proper pruning is both a skill and an art. It takes thorough instruction and careful practice to develop pruning skills. The best way to start pruning is under the watchful eye of someone knowledgeable. Volunteers should never engage in heavy pruning. If it appears that pruning of large branches is required, find out what city agency or professionals can handle the problem. Prune only with adequate supervision and prior approval.

MONITOR FOR PROBLEMS, PESTS AND DISEASES – Look for distress signs and symptoms, and then seek help from local experts. When problems are spotted early, effective solutions can usually be found.

If something changes in the tree's foliage – yellowing, wilting, holes and chewed edges, unseasonable leaf drop, darkened or wilting shoots and leaves – prune off a small sample and take it to the Cooperative Extension office. The U.S. Forest Service, ISA-certified arborists and other horticulture professionals may also be able to assist in identification and to recommend treatments.

Watch for insects, rodents and other pests. Fungus growing from the bark can be a sign of unseen decay. Loose bark and oozing sap or constant bark excavation by insect-eating birds indicates pests.

Remember to check the tree "from head to toe." The problems that show up in the foliage often start at the roots.

FERTILIZE – Do not fertilize trees with nitrogen at planting or during the first year of growth. Established trees are generally fertilized in the very early spring to make the additional nutrients available during the primary growing season. Fertilizing late in the fall can encourage a flush of tender new growth that will freeze. This will not happen if fertilizer is applied after leaf drop. Fertilizing should follow the natural growing patterns of a tree. To enhance growth, fertilize once a year following soil test recommendations.

If a tree shows signs of inadequate nutrition, as with many cramped or container tree plantings, correct fertilizing may help the problem. Fertilizer will not make up for compacted soil or poor drainage or remove infestations of pests and diseases. Trees that are under severe stress should not be fertilized. Correct the underlying problems first.

Any fertilizer and supplements to urban forest trees should be applied in accordance with the recommendations of soil test results and after obtaining necessary permissions.

PREVENTIVE MEASURES

The International Society of Arboriculture estimates that up to 90% of the problems encountered are not caused by living agents, such as pests or pathogens, but result from environmental stresses, mechanical injuries, planting the wrong species for a given site, or from improper planting.

Even if pests and pathogens are invading the tree, the ISA warns that this may be a symptom of an underlying problem that is weakening the tree and making it susceptible to attack. Often the best preventive measures for pests and diseases involve improving the site and related environmental factors to invigorate the tree.

All tree plantings are improved by selecting trees with known resistance to diseases and insects. Select trees that best fit conditions at the chosen location such as trees that have proven successful to that particular area of Virginia.

If environmental problems occur, select tree species that either do well under those conditions or have demonstrated adaptability to adverse circumstances. Ginkgo (*Ginkgo biloba*), for example, shows good resistance to city pollution, as does Chinese elm (*Ulmus parvifolia*).

Many tree problems originate from incorrect planting. Planting a tree too deeply is the number one planting mistake. Constricted root balls, girdling roots that gradually strangle the tree, and confining planting holes will stress young trees and result in later problems. Gradual death of the leaves may be a sign that the roots have been improperly planted. Failure to remove tree wraps and support wiring results in trunk girdling that wounds the cambium layer and kills the tree.

USING PESTICIDES AND HERBICIDES

Many tree problems can be managed simply if noticed early. Improving the planting site, pruning away an infected branch, remedying nutritional and water deficiencies – even blasting destructive insects away with a hose spray may solve some immediate problems. However, if the problem is severe, consult a professional for more information.

Volunteers should not use chemicals in public areas or on private property other than their own. Only professionals who have obtained the proper pesticide training and certification can legally undertake such measures.

GETTING MORE INFORMATION

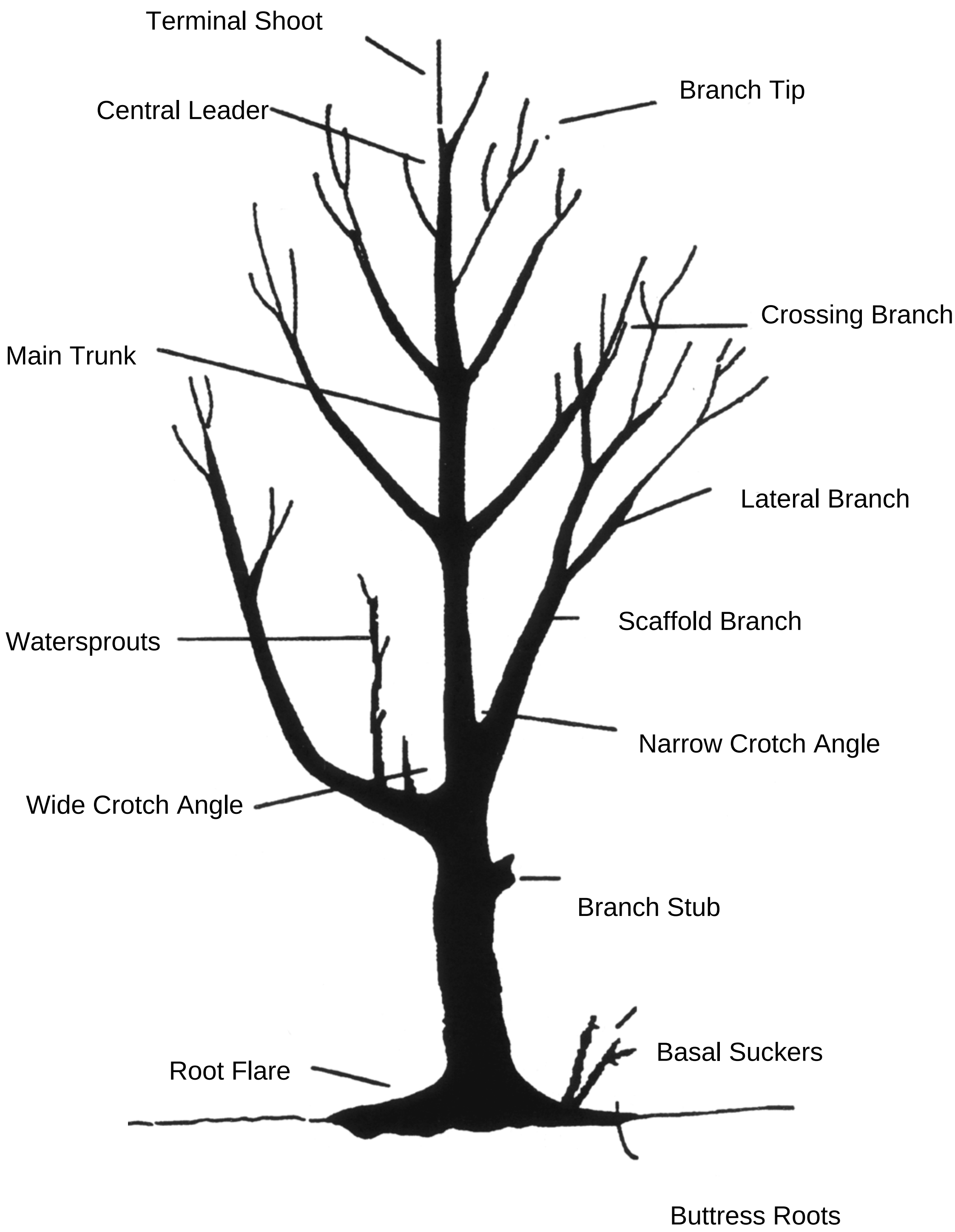
County Extension offices accept samples from trees for diagnostic examination. In addition, your group may be able to locate ISA-certified arborists willing to assist in diagnosing problems. If examination cannot take place on the site, take a sample or a picture of the damaged material to the designated office.

If a sample must be mailed to the lab, take care that the specimen is fresh and carefully wrapped in paper within a box. Samples mailed in envelopes arrive crushed and unusable. Bagging fresh material in plastic seals moisture and may cause rot. Identify the tree species and write out a clear description of observations of the tree and its surroundings. A color photograph may be helpful if it clearly shows the damage or pest in question.

Make sure that the outside of the package indicates that a sample is enclosed. Be sure to check the specific address of the agent or laboratory so that the sample is delivered promptly.

Key Questions:

What is the most common cause of poor tree health?
At what depth should trees be planted?
What is the most common mistake when digging a tree-planting hole?
Describe the perfect planting site.
When are the best times to plant trees in Virginia?
What is the most important follow-up activity after planting trees?
When should a tree be fertilized?



KNOW THE TREE
(adapted from a drawing provided byJohn March, Virginia Tree Stewards)

Photo by Robert Llewellyn, Ginkgo (*Gingko biloba*)

Tree Pruning – Unit 9

All pruning cuts are an injury to the tree. Pruning should only be undertaken when there is a clear need to meet specific objectives and should follow careful procedures.

Always make sure that there is a specific reason for pruning. Trees do not automatically need to be pruned. Check the tree's overall health carefully before undertaking pruning of living branches. A stressed tree may not be able to compensate for pruning damage. If dead or dying limbs are present, try to determine the cause. Handle pruning carefully, using correct cuts and proper tools.

BEFORE ANY PRUNING, CHECK THE FOLLOWING:

- Has permission been obtained to work on the tree(s)?
- Has the reason for the problem been determined?
- Is there an underlying health problem that needs to be addressed?
- Is there a clear need or reason for the pruning?
- Will the health of the tree support pruning?
- Have participating volunteers been properly trained with hands-on practice?
- Keep a record of work done as an important part of maintaining the community forest.

PRUNING PRIORITIES

The primary consideration in pruning must be safety. Pruning should be used to remove unsound or ill-placed limbs and thus to prevent personal injury or damage to nearby property. These priorities apply to trees of all ages.

FIRST PRIORITIES

- Potential Hazards – dead wood, branches that interfere with vehicle or pedestrian visibility
- Tree Health – branches that are cracked, diseased, insect-damaged or declining; *maintain strict pruner sanitation*
- Tree Structure – improve the branch structure of young trees

Potential hazards – A hazard is a condition that may cause injury or damage to people or property. Prune to avoid potential hazards from incorrect growth or damage before they develop. When you see potential hazards created by large limbs or branches, especially those near power lines, contact the municipal agency or utility responsible.

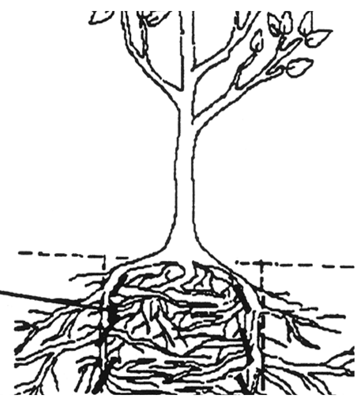
In many situations, hazards develop as a result of poor selection. Choose the right tree for the site. Pruning is a harmful way to control size. It is much better to select trees of an appropriate mature size and habit when planting a site rather than using pruning to limit growth.

🡐 How could this be prevented? Plant the tree farther from the house.

Tree Health – Look for **girdling roots**, **watersprouts** and limbs of poor structure. Favor branches that contribute to a strong structure. Removing dead, damaged and diseased branches may prevent the development and spread of pathogens and pests. If disease is suspected, get professional advice before pruning. Disinfect all pruning tools between cuts when working with any wood that could be carrying pests or pathogens.

Stop circling or girdling roots – prune at planting time.

Pull circling roots free or cut carefully to stop direction of growth

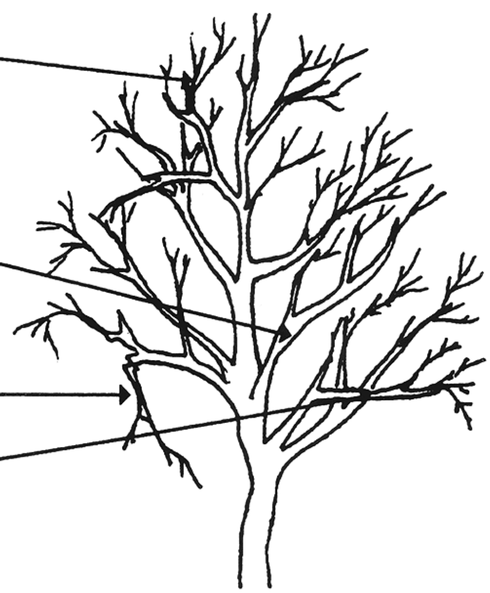


Remove competing leaders in appropriate species – prune back as early as they develop on young trees.

Remove branches with weak angles – prune during correct season for your location.

Remove damaged branches – prune as soon as possible after damage occurs.

Remove crossing, rubbing, crowded branches – prune during correct season for your location.



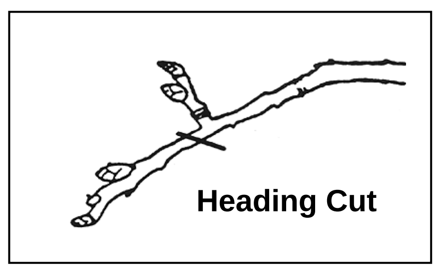
Remove watersprouts and suckers – prune whenever they appear.

Watersprouts are easily removed when young.

TREE STRUCTURE

Too often, the eventual size of tree is <u>not</u> considered when planting. Some tree species are unsuitable for urban and suburban plantings because of mature height, canopy spread or root buttressing that exceeds the existing space. The result of poor choices is seen in trees topped and/or cut away for power line or traffic access.

- Many tree problems can be prevented by correctly pruning young trees during the first few years after planting. Prune to create a stable structure.
- **Thinning cuts** remove branches at their point of attachment to the trunk or another branch. Thinning cuts can reduce tree size, but may also stimulate overall shoot growth, which may result in suckering.
- Remember that pruning cannot be used to compensate for planting too large a tree for its location. EDUCATE homeowners and landscapers to select tree species approved for planting under utility lines and other restricted locations.



- Direct growth by pruning young branches back to the next lateral bud or stem. Make these **heading cuts** on a 45° slant away from the bud or stem and at ¼ to ½ inch from the bud. Do not cut into the node or leave a blunt stubbed stem.

- Visible **girdling roots** should be cut to encourage outward growth.

When pruning, it is important to remember how trees grow. There is often an illusion that trees grow up from the base, like a blade of grass. On the contrary, a branch will remain at the height at which it originally formed. Prune for overall development of the above-ground system by managing growth of the **scaffold branches** supporting the foliage canopy.

YOUNG TREE PRUNING

Many tree problems can be prevented by correctly pruning young trees during the first few years after planting.

- Start by pruning out dead wood and damaged branches.
- **Subordinate** or eliminate **codominant leader**s.
- Prune out branches with **included bark** that disappears down into the crotch.
- Prune out limbs that are crossed or rubbing, growing back toward the center of the crown, or interfering with better branches nearby.
- Don’t worry if the tree appears somewhat lopsided for a time after pruning. A healthy, vigorous tree will quickly fill in gaps in its crown and grow stem wood that straightens out minor crooks and bends.

Did You Know?
Generally, no more than 15% of the crown – but never more than 25% -- should be removed at any one time, depending upon the age and condition of the tree.

For the first three to four years after transplanting, leave as many of the lateral branches as possible, even if they appear lower on the trunk than will be desirable later. These young leafy branches are important in adding to the tree’s girth and protect the trunk as it begins to develop. These branches can be removed gradually as the trunk and scaffold branches develop.

It is not uncommon for urban trees to lose some of the lower branches because of vandalism and other physical injuries.

Ideally, main **scaffold branches** should be well spaced vertically and radially on the trunk. Remove poorly placed scaffold branches with hand pruners when the tree is young and branches are small. This allows desirable branches to grow unimpeded.

NATURAL TREE SHAPE

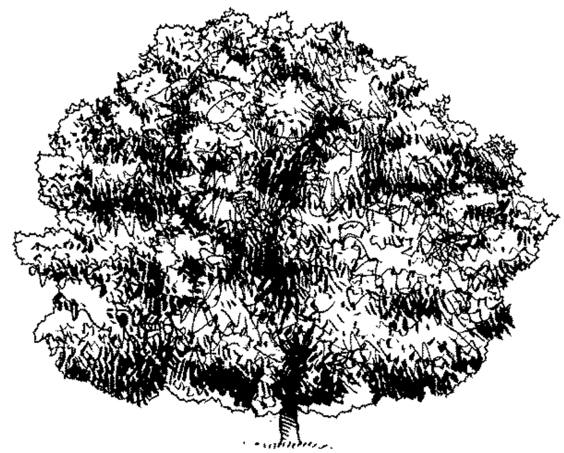
Crown shape is determined by inherited patterns of **apical dominance**. Check the typical growth pattern for each tree species to determine its natural tendency, whether a strong central **leader**, such as is seen in pine trees, or a rounded, spreading shape. A tree with weak apical dominance will tend to develop mulitple leaders.

In most trees, remove or subordinate branches competing with the leader. Allowing two leaders to develop can result in weak crotch angles, included bark and split trees.

Conversely, removing all leader(s) by incorrect hedge-style pruning produces multiple-stemmed, shrubby trees.

The weight-bearing strength of scaffold branches is a function of their attachment to the tree's trunk.

- Branches that are greater than half the size of the parent branch/trunk have a greater potential to fail.
- Narrow **crotch angles** may be more likely to break under wind stress or ice/snow load. However, some species have a columnar habit (tall, slim form) with narrow crotch angles that are structurally strong.



Wide crowns are common in older deciduous trees.

Branches exist to spread leaves or needles out for maximum sunlight and air exposure. Growth that is too dense increases competition for light.

PRUNING BASICS

Proper care of trees is critical to their continued health and beauty, and pruning is a key element of this work. Here are some basic concepts.

PRUNING CUTS

- **Branch removal cut** -- when removing a larger branch, prune so that the final cut runs just outside the **branch collar** without damaging it.
- **Reduction cut** -- shortens the limb to a smaller lateral branch at least 1/3 the diameter of the branch being removed.
- **Heading cut** – see Page 9-3; cut made between branches or nodes.

Pruning to lateral branches allows these branches to assume the dominant role formerly held by the part being pruned off.

PRUNING METHODS

- **Crown cleaning** is the removal of dead and diseased branches only.
- **Crown thinning** is the selective removal of branches in the interest of safety, health,

appearance or usefulness.

- **Crown raising** is selective removal or pruning of lower branches. After the pruning, a healthy crown should be at least 2/3 of the tree's overall height. This is usually done in cities to provide clearance and visibility for vehicles, pedestrians, buildings, traffic signals, etc. This practice is erroneously sometimes called “limbing up.”

- **Crown reduction** means selective removal of branches to a lateral to reduce the height and/or canopy spread. Crown reduction should be accomplished with reduction cuts, not heading cuts. This is not the same as “topping.”

- **Structural pruning** is used in younger trees to develop strong branch arrangement specific to the species.

- **Restoration pruning** is used on trees that have been damaged from storms or mechanical methods.

BRANCH COLLAR

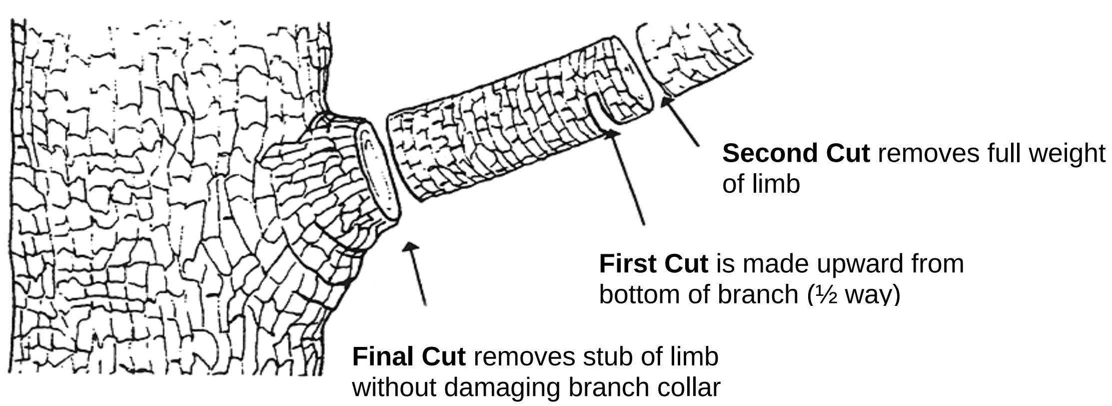
As stems grow larger, the tissue at the base of the branch builds up to form the ***branch collar***, a bulge surrounding the branch. In the crotch, this tissue is squeezed by the expanding diameter of the trunk to form a ***branch bark ridge***.

All pruning cuts are made <u>outside</u> the branch collar. This ***natural target pruning*** reflects the natural ways that trees attempt to seal off damaged branches by creating a barrier at the branch collar. (See CODIT in Unit 1.) The branch collar tissues have the ability to mechanically and chemically ward off pathogens from decay or disease and insect attack. Removing this tissue makes the tree more susceptible to future problems.

MAKING THE CUTS

To prune living branches, it is important to prevent the bark from tearing below the pruning cut. Use the three-cut method to ensure a proper cut.

Prune dead branches with a pruning cut just outside the living wood – cut only dead wood. Support large dead branches to prevent human injury. Use the **three-cut method**. Dead branches can be removed any time of the year.



GOOD PRUNING PRACTICES

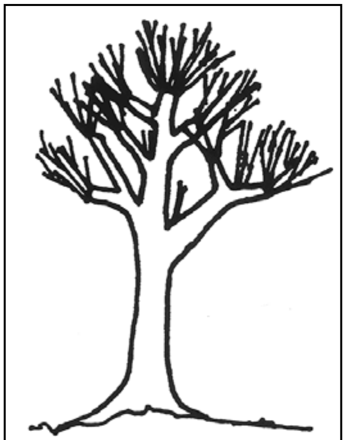
Remember, all pruning cuts in living wood are wounds. The larger the wound, the more difficult it is for the tree to prevent decay. Have a good reason for every cut – especially if the wound will be larger than two inches in diameter. Here are some simple rules to follow:

- Assess how a tree will be pruned from the top down.
- Try to retain branches with strong U-shaped angles of attachment.
- Remove branches with weak V-shaped angles of attachment and/or **included bark**, preferably when they are still small.
- Ideally, branches should be evenly spaced up the trunk of a young tree. Remove or subordinate branches that are poorly spaced.
- Generally do not remove more than 15% of the crown – but never more than 25% -- at one time. If you must remove more, do it over several years.
- Maintain branches on the upper 2/3 of a tree's total height.
- Remove basal and trunk sprouts.
- Use crown reduction pruning only when absolutely necessary.

"PRUNING" PRACTICES THAT HURT TREES

The following practices are harmful to trees and should be avoided or used only as a last resort:

- **Topping** is cutting the large **scaffold** branches between lateral branches to reduce crown size. This produces numerous, weak watersprouts. Such sprouts are weakly attached to the stem and grow from a stub that is likely to die back. If topping seems to be the only remedy for a problem, it is preferable to remove the tree and replace it with one better suited to the site.



A Topped Tree

- Failure to use the three-cut method often causes unnecessary injury and bark ripping.
- Flush cuts injure the branch collar and can result in serious decay.
- Stub cuts are incorrect cuts that leave an undesirable short length of a branch after the cut is made. Stub cuts delay wound closure, provide entry for fungi that may kill

the **cambium**, and create cankers or wood decay.

- It is no longer recommended to coat pruning cuts or other wounds with tree dressing or paint. The wound should be allowed to seal naturally.

CONIFERS AND PRUNING

Coniferous trees as a group require little pruning other than removing damaged or diseased limbs.

- **Conifers** such as pines have an inactive inner or central branch area. No new growth forms when limbs are pruned back to this area.

- New shoots on whorl-branched conifers, called candles, can be pinched back by hand to half their length each spring to encourage dense growth.

- Young conifers with **codominant leaders** should be pruned to the largest central leader.

- Any pruning on random branched conifers, such as cedars and junipers, should be in early spring to allow new growth to fill the void.

WHEN TO PRUNE

Standard practice recommends pruning **deciduous** trees when they are dormant. Dormant season pruning may prevent excess sap residue at the wound from attracting disease-carrying pests. An advantage to early spring pruning is more rapid callus formation that speeds wound closure. Pruning deciduous or **evergreen** trees in the late fall can encourage new foliage growth that may still be tender and suffer when freezing weather arrives.

Seasonal disease outbreaks or susceptibility should be considered for each tree species. See the Virginia Cooperative Extension Service website for the best pruning time: www.pubs.ext.vt.edu.

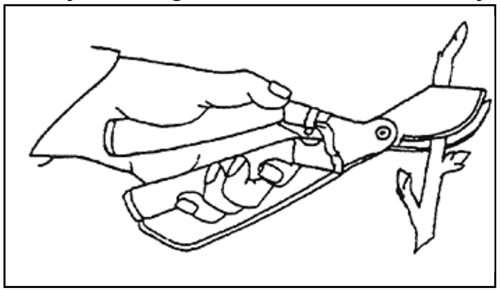
Excess foliage growth, including suckers and watersprouts, can be pruned off throughout the year. Look for underlying health problems and possible causes.

CORRECT TOOLS

Using the correct tool makes pruning easier and reduces damage to the tree. Never “force” pruning cuts with pruners too small or with dull saws. Most maintenance pruning cuts can be made with hand tools, although occasionally chain saws are required to remove large damaged limbs. Rely on professionals if power equipment is necessary!

BASIC PRUNING TOOLS

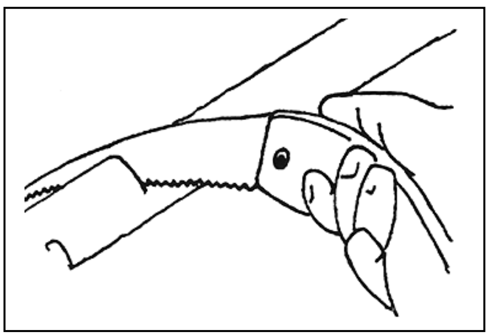
Many cutting tools come in two styles of cutting action, bypass or anvil. The bypass style has two curved blades that overlap slightly with a scissors-type cut. The anvil style uses a single straight, sharpened blade that cuts directly against a flat lower plate (not a blade).



Because the anvil style will crush stems rather than providing a clean cut, the bypass style is strongly recommended. Always use sharp tools and be careful.

- *Hand pruners* can be used to cut very small branches (1/2" diameter or less).

- *Loppers* are long-handled pruners used to cut branches 1/2 to 1 ½" diameter.



- *Pruning saws* are used to remove sturdier branches over 1” in diameter. Make sure that saw blades are sharp, replacing when necessary. Pruning saws come in a variety of shapes, sizes and tooth types. A finely toothed, curved saw can be used to remove smaller branches. A narrow bladed saw with a well-tapered point is useful for narrow crotches. A coarsely toothed saw moves more quickly through larger branch cuts (greater than 1 ½" diameter).

- *Pole pruners* are bypass blade instruments on an extendable pole to allow cutting higher branches without getting on a ladder.

Pruning shears or hedge clippers are <u>not</u> recommended for use on trees because they cause poor growth patterns. It is detrimental to tree health to have all leaf growth crowded to a flat, sheared surface.

Pruning trees is a thoughtful process of evaluating and shaping the canopy branch by branch. Planting appropriate trees for each site and providing consistent maintenance pruning for young trees eliminate many problems seen in neglected adult trees.

Safety First!
Special emphasis should be placed on pruning safely:

- *Have a first-aid kit handy.*
- *Use locking blades.*
- *Be vigilant when using telescopic pole pruners.*
- *Wear eye protection.*
- *Stay out of the street when possible.*
- *Be aware of traffic.*
- *Watch out for the public.*

Key Questions:

What is the No. 1 thing to remember about pruning any tree?
What five questions should be answered before deciding to prune?
What are suckers and watersprouts?
What style of pruning tool is best?
Describe or draw the three-cut method.
What function does the branch collar serve for the tree?

Photo by Kevin Sigmon

Tree Problems – Unit 10

WHAT'S WRONG WITH MY TREE?

Answering "what is wrong?" is a process, much like being a detective. The aim is to make observations, gather facts and work with experts. It requires using a systematic process to determine an explanation for the tree problem.

Tree Stewards provide education to the community, which includes explaining the need to consult professionals such as arborists and Extension agents. At times, Tree Stewards are asked to help gather information about specific tree problems.

Two qualities are important. One is to <u>be objective</u>. Don't look for a quick answer. There are too many pests, pathogens, environmental stresses and even human events that can cause tree problems. The second important quality is <u>practice</u>. No one learns to be a good tree inspector overnight or by reading one chapter in a book.

THE EVALUATION PROCESS

Look for any abnormalities. Don't make snap judgments, just look. Talk to people. Become familiar with the tree and its surroundings. Look at the tree from different angles. Take your time. The process should be simple but thorough so you can report to an arborist or other responsible party.

- **Observe Site Surroundings** – The inspection starts the moment you arrive at the tree. Approach the site with an open mind, and observe the surrounding area. Look to see if other trees and plants appear normal. Are there signs of any past or present land disturbances, weather damage or other environmental changes?

- **Identify Plant** – What kind of tree is it? Each tree species has its own set of characteristics and responses that can help determine if it is healthy or not. What does normal growth for this species look like? Compare the tree with other similar species in the area. For more tree identification assistance, check with Extension resources or local experts or refer to publications and technical materials.

TIP:
If you aren't familiar with trees in your area, buy a good field guide from a local bookstore or order <u>Common Native Trees of Virginia</u> from the Virginia Department of Forestry at <u>www.dof.virginia.gov</u>.

- **Look for Signs and Symptoms** – A **disorder** occurs when a tree has an ailment, or if there is a disruption of its normal health and behavior. When a tree has a disorder, it will normally display one or more visible clues. There are two dimensions to recognizing tree disorders.
    - **Signs** show actual evidence of the damaging agent itself, such as **conks** or fruiting bodies, and insects.
    - **Symptoms** indicate changes in a plant's normal appearance, growth or function that are the result of a damaging agent. Examples of tree symptoms include a reduction in shoot growth, smaller leaf size, discolored leaves and dieback. Some symptoms can be the result of two or more damaging agents.

UNDERSTANDING CAUSE AND EFFECT

Causes of tree disorders can be classified as either abiotic or biotic. **Abiotic** plant disorders are caused by nonliving factors that affect the ability of living organisms to survive in an environment. Examples of an abiotic disorder include **soil compaction**, mechanical damage, fire and excess fill material. **Biotic** tree disorders are caused by living organisms. Examples include fungi, bacteria, insects and vertebrates.

Woodpecker Damage

Tree disorders can be reversible, or the tree may be beyond recovery. When a disorder causes stress**,** the tree is still within its normal operating ranges.

Though the signs or symptoms of a disorder may be present, these may actually indicate that the tree's normal defensive mechanisms have been initiated to counteract the problem. Under normal circumstances and/or treatment, a tree under stress may recover.

If a disorder causes the stress to exceed a tree's natural ability to recover, the next phase is death for either the affected part of the tree or the entire tree.

Tree crowns exhibit any number of symptoms that may be helpful.

TOP TO BOTTOM

CROWN – There are many ways to perform a detailed and thorough tree examination. One method is from top to bottom, starting at the crown and working downward. An advantage to examining the crown first is that a foliage symptom can often signal a disorder in another part of the tree. When examining the crown, look from enough angles and distances to give a complete perspective. Use good binoculars.

Tree crowns exhibit any number of symptoms that may be helpful.

Is the Tree SAFE?

The overriding priority during any tree examination should be: Is the tree safe? A tree is unsafe if a defect or condition would threaten a "target" if the tree or part of the tree fell. A target is something of value, such as people, structures or other property. A symptom of a disorder with potential risk of tree failure should be reported to authorities. Here are seven key symptoms that may indicate an unsafe tree.

- *Defective Roots*
- *Multiple Trunks*
- *Weak Branch Attachment*
- *Cavities and Decay*
- *Cracks*
- *Hangers and Suspended Branches*
- *Dead wood*

- **Dieback** usually signifies a death sequence under way in specific portions of the tree, often in the outer tips and working its way inward. Dieback does not necessarily indicate that a tree is dying. In fact, the sequence frequently stops when the tree regains equilibrium in its life processes. Any number of disorders can cause tree dieback.

- **Defoliation** is the premature loss of foliage caused by some agent, usually an insect pest. Other causes include nutrient deficiency, disease, air pollution, herbicide injury and wind.

- **Flagging** occurs when leaves on some, but not all, branches begin to wilt and turn brown while still hanging on the tree. Any number of disorders can cause flagging.

- **Decline** is a more serious symptom. This results from a chronic disorder. Old age is one common cause, but mixtures of abiotic and biotic disorders can have the same result. Symptoms of decline include dieback, reduced growth, reduced **internodes** and abnormal leaf color. At best, it may be possible to stabilize the tree or delay its decline. Depending on the species and the factors involved, the time between decline and death can be as short as a few days or as long as years.

- **Chlorosis** is a general yellowing of leaf tissue due to a lack of **chlorophyll**. Inter-veinal chlorosis is a yellowing of tissue between normal green veins. Possible causes of chlorosis include insects, disease, poor drainage, damaged roots, compacted roots, air pollution, high alkalinity and nutrient deficiencies.

- **Wilting** can be easily observed as limp or drooping leaves that eventually change color before dying. Causes include too much or too little water, insects, diseases, excess fertilizer, air pollution and girdling.

- **Leaf Necrosis** includes a variety of conditions in which portions of the leaf are dead. The affected areas are usually brown, dry and withered. Typical causes of leaf necrosis can be drought, abrupt change in temperature and element deficiency.

TRUNK AND STEMS – Examine the bark on the trunk and main branches. A magnifying glass may be helpful. Bark that sloughs off easily may expose internal problems, such as rot. Rot and **decay** are symptoms of pathogens that have digested cell wall components. Look for signs that might include conks or fruiting bodies of fungi, leaf frass, emergence holes or discarded skins. If decay is found, try to determine how far it has spread. Common symptoms are open wounds, cankers growing on the stem, and smooth bark surfaces separated by a seam indicating where the tree's new growth sealed an older wound.

- **Cankers** are localized dead areas in the wood surrounded by healthy tissue and/or bark. This is often caused by fungi. The infection can sometimes spread to healthy tissue. When healthy wood grows over a canker, it creates a recognizable sunken area on the stem's surface. A **lesion** is visible evidence of injury or disease that resulted in an abnormal change or structure of the affected tree part.

- **Watersprouts** (also called epicormic shoots) emerge from dormant buds along branches and stems. Some tree species will form watersprouts when a shaded branch or stem is "suddenly" exposed to increased sunlight. Normally, this is not a disorder. On the other hand, watersprouts can indicate the tree is under stress. Reasons may include defoliation, crown damage, drought or old age.

Watersprouts are weak shoots that emerge from dormant buds.

- **Suckers** can grow from the tree's root some distance away from the stem. This usually indicates stress. If a tree is a **cultivar**, suckers having different characteristics from the tree canopy may form at the base of the tree from the rootstock.

Suckers on a sycamore

ROOTS – This is the most important part of a tree to examine since most urban tree problems are the result of a root disorder. Roots also pose the greatest challenge during a tree inspection because they are underground. A good root inspection begins with an understanding of where roots grow. Roots typically develop within inches of the surface. Because roots can extend far from the trunk, check the surrounding area.

- **Above-ground signs and symptoms** can indicate a root disorder. Above-ground **conks** or fungal fruiting bodies may indicate a root wound and decay.

- **Abiotic activities**, such as construction, may have severed or otherwise damaged roots. Where minor soil excavation is possible, expose a small area of the trunk **cambium** below the ground level to see if the tissue is a normal color. If possible, also check the soil for moisture levels, normal color and any unusual odors.

- **Improper planting or plant selection** may be the problem on younger trees. Try to gently rock the plant back and forth. If it pivots or pulls up the ground, the roots are not fully anchored.

- **Other root disorders** may be soil-related. Soil **pH**, texture, moisture and compaction all can affect a root's ability to function and thrive. Any abnormal conditions should be noted.

INVASIVE ENGLISH IVY

It is important to keep English ivy and other **invasive plants** away from trees. Trees covered by English ivy are weakened and eventually die as the ivy spreads over the crowns. Even if invasive vines are kept off the trunk, their presence above the roots can damage the tree's health. Like grass, invasive plants compete with trees for water and nutrients.

REMOVAL OF IVY

First, check for poison ivy.

To remove English ivy, cut the ivy "trunks" or vines all the way around the tree at about eye level. Clippers work well for the smaller vines and for exposing the vines themselves. The vines attach to the bark with aerial roots. It is recommended that the vines above the cut dry for a season before pulling it off the bark. If you MUST remove the ivy before allowing it to dry for a season, then as the vines are cut, begin to peel them down from the bark, one at a time if possible. Folding them back sometimes makes it possible to snip off the branches on the bottom of the peeled sections. Work down the trunk to the base of the tree. With persistence and great care, they can usually be peeled away without damaging or removing bark.

Vines a half-inch in diameter or larger cut more easily with a small hand saw. Again, persistence is in order since the growing vines seem to "fuse" with one another when they overlap, creating a strong bond and larger vines.

If ivy grows around the base of the tree, remove it at least 3-5 feet from the trunk. Dispose of the vines properly because they will grow in a compost pile.

COLLECTING SAMPLES

Tissue samples can help identify a sign or symptom of a plant disorder whether caused by disease, insect, nutrient, cultural or herbicide problems. Success depends on collecting adequate samples and recording a good description of the situation.

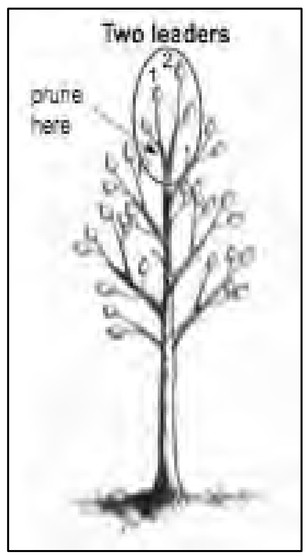
When collecting a plant sample for identification, try to obtain as many tree features as possible, such as leaves, branches with buds and flowering or fruiting parts.

- Preserve samples by placing them inside plastic bags.
- Samples should be kept cool until they can be identified later.
- If they are to be sent away, place them in a padded envelope or box and mail as soon as possible.

Collect plenty of plant material, keep it fresh, and include as many stages of the problem as is possible.

- Package specimens as soon as they are collected
- Leaves or foliage segments should be placed in a large sealed plastic bag. Do not enclose leaf specimens in moist or wet paper towels.
- Fleshy fruits should be wrapped in several layers of dry newspaper.
- Insect samples can be collected in plastic or glass vials. Try to get more than one insect specimen. Include plant damage caused by insects and healthy, undamaged parts.

HAZARD TREES – PRUNING FOR SAFETY



Every tree owner should learn to recognize potential tree hazards. Consult a professional tree expert for large scale work.

Be alert for:

- Trees in contact with or near power lines!
- Weak tree structures, especially trunks or branches with **included bark** or **codominant leaders**. Is the tree a tall, spindly loner left behind after construction? These are weak in high winds.
- "Hangers" – branches that have partially broken free but have not fallen
- Cracks or splits in the trunk, branches or branch attachments

- A "lodged" tree supported by other trees nearby
- A "leaner" whose roots are tearing from the ground, or whose top is not growing straight up
- Root damage from construction, trenching, grade change (cut or fill), mower injury, pavement repair, etc. Are roots exposed? Is the **root flare** covered with dirt or mulch? Do the roots show signs of disease, decay or other deterioration?
- Severe pruning or **topping**
- Dieback of leaves, twigs and branches
- Signs of decay: rotten places or cavities in trunk or branch wood, mushrooms or conks on the trunk or branches, or soil over the root system

SOLUTIONS TO HAZARDOUS TREE SITUATIONS

- Move potential "targets" – objects that might be damaged or attract people to spend time under a defective tree.
- Prune the tree and keep it healthy by watering and fertilization. Consult a professional for assistance with large scale work.
- Cable or brace the tree – consult a professional for this.
- Remove the tree.

NOTE: No one maintenance step alone will save a tree. To guarantee the continuing health of trees in your neighborhood or community, practice all these tree care techniques. Find other classes and learn more about tree care. Work with trained professionals to learn up-to-date tree care practices.

Key Questions:

What is the most important consideration in examining a tree?

If the signs/symptoms of a disorder are present, is the tree necessarily in decline? Explain your answer.

Name eight symptoms or conditions that may indicate an unsafe/hazard tree.

What are some symptoms of disorder in the crown?

What are some symptoms of disorder on the trunk and stem?

List two reasons to collect tree-related specimens during a site visit.

TREE INSPECTION

Date: ______________________________

Volunteer name: ______________________________

Tree Species: ______________________________

Tree I.D. # (if community inventory maintained): ________________

Location of Tree: ______________________________

____

____

Estimated height: ____________________

Estimated diameter: ____________________

Years since planting (if known): ____________

Overall appearance of tree:

____

____

____

Problems noticed:

____

____

____

Referrals:

____

____

____

Actions taken at the site:

____

____

____

Follow-up:

____

____

____

____

____

Initials: ____________ **Date:** ________________

Trees and People – Unit 11

Most conflicts over trees are not intentional. Many of them result from lack of knowledge, lack of planning and poor communications. The good news is that conflicts between trees and people can usually be avoided, or mutually agreeable solutions can often be reached.

TREES AND CONSTRUCTION

As our state's population grows, so will the demand for more residential, commercial and retail development. Local governments are also under pressure to meet requirements and expectations for municipal services and infrastructure. Most construction, however, is harmful to trees and routinely results in tree decline and even death.

Though it is impossible to prevent all construction-related damage to trees, it is feasible to minimize it.

HOW TREES ARE DAMAGED

Almost all construction activities harm trees. The number one reason a tree declines or dies during construction is root damage.

- Site grading, excavation and trenching for utilities and drainage are common causes of physical damage to roots.
- Roots are damaged by **soil compaction**, waste and chemical spills, and the laying of impervious pavement.
- A damaged root system loses its ability to perform life functions such as absorbing essential water, elements and oxygen.
- A tree's ability to remain upright may be compromised, especially when support and bracing roots are severed.

Construction damage is not limited to roots. Damage also can occur above ground.

- The most common type is wounding of the stem and **crown**. Equipment is the primary cause.
- Bumping, scraping or ripping through a tree's bark creates injuries that are conducive to decay-causing organisms.
- As this decay advances, it can weaken a tree's ability to resist and respond to other stresses.

HOW TO AVOID TREE DAMAGE

A knowledgeable tree professional can be part of the project team and help prevent damage to trees during construction. Trees should be considered during all four phases of development: planning, design, actual construction and post-construction maintenance.

Tree Stewards can educate the community about saving trees by considering them during the planning and construction process. Armed with this knowledge, a developer or homeowner can then make decisions that meet construction project goals but also give desirable trees the best chance for survival.

Symptoms of Tree Stress Triggered by Construction

- *Shorter shoot growth*
- *Smaller leaves*
- *Thinner crown foliage*
- *Leaf scorch*
- *Wilting*
- *Early defoliation*
- *Watersprouts or suckers*
- *Heavy seeding*
- *Dieback*
- *Physical damage from equipment (decay on older wounds)*
- *Wood borers & other stress-related pests*
- *Death*

HOW TO TREAT TREE DAMAGE

If a tree is damaged during construction, treat the injury as soon as possible. First, visually inspect the whole tree from the roots to the crown. Regardless of the injury, safety is the number one goal. If there is a serious safety risk, the tree may need to be removed. Other options include removing an unsafe branch, pruning to reduce the tree's weight, or installing artificial support such as cabling, bracing or guy wires.

There are other treatment options for construction-related injuries if the tree doesn't pose a safety risk. Here are three common examples.

- Broken, torn or split branches should be pruned.

- Loose bark around a damaged trunk or branch should be removed carefully through a process called **bark tracing**. Ragged bark edges surrounding the wound can be cut away with a sharp knife, but be careful not to cut through any intact wood or bark tissue.

- If there is root damage or a drainage change, steps must be taken to improve the tree's water management. Mulching is an effective treatment to help conserve moisture and create better soil conditions. Irrigation can help some trees, especially during long summer dry periods.

Despite such measures, construction damage may prove to be too much strain for a tree. No amount of corrective action will help. When this happens, the construction damage sets in motion a spiraling decline that ultimately results in tree death. Typical **symptoms** include extensive and progressive **dieback**, drying wood and indications of serious **decay**. As trees endure this level of stress, they can become more susceptible to other pests and conditions, which can be the ultimate cause of death. Damage from construction is usually a slow, insidious process that may take three to four years to show up.

See http://pubs.ext.vt.edu/430/430-210/430-210.html for “24 Ways to Kill a Tree” by Dr. Bonnie Appleton.

TREES AND UTILITIES

Communities have high expectations for safe and reliable electrical service.

Utilities spend millions of dollars each year keeping their lines operational for their customers. Yet, unplanned interruptions in electrical service occur and contact with trees is one of the main causes.

- Trees may grow into utility lines.

- New utility lines may be placed too close to trees.

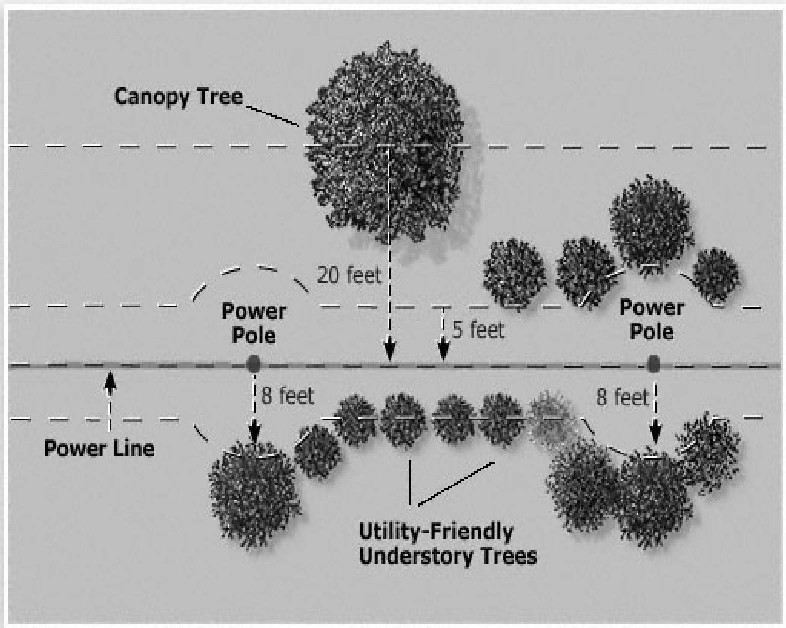
- Trenching may destroy important roots.

- Improper pruning may distort a tree’s shape and create unsafe conditions.

In any conflict between tree and utility, the goal should be to seek resolutions to maintain both the tree and safe, reliable energy service.

How Far You Should Plant From Utility Lines

- Plant canopy trees (25 feet and larger) at least 20 feet from power lines.
- Plant only small trees (20 feet and smaller) within 5 feet of power lines, and within 8 feet of power poles.



PREVENTION

The cheapest and most effective approach to tree-versus-utility issues is to manage trees along utility **easements** to prevent problems. Tree Stewards can help by educating the public about planting the right tree in the right place. Only tree species that are compatible to the site and the surrounding utility lines should be planted.

TREE LINE USA

Just as communities and campuses may be recognized for attention to trees and best tree practices, public and private utility companies in the country that demonstrate practices that protect and enhance America's urban forests may be recognized. The Arbor Day Foundation in cooperation with the National Association of State Foresters has established standards to promote best practices in utility arboriculture and public education. To receive the Tree Line USA award, utilities will follow industry standards for pruning, planting, removals and trenching and tunneling near trees. The utility will ensure that its employees and contract workers are trained in best practices, and will sponsor and participate in a tree planting and public education program. To learn more, go to www.arborday.org/programs/treelineusa.

TREES AND THE LAW

Many tree-and-people conflicts can be resolved with a better understanding of how laws apply to trees. Cities and private property owners have responsibilities and rights.

Local laws and procedures regarding trees can change often and are subject to different interpretations. Tree Stewards should tell residents to contact a lawyer for legal advice and never offer legal advice themselves. Remember that the role of the Tree Steward is community education, not refereeing.

WHEN LIMBS AND/OR ROOTS GROW ONTO ANOTHER PROPERTY

As trees grow, branches and roots may encroach onto another's property. Most homeowners usually do not mind the added shade and beauty, but for others it may create a problem. There are several ways to address this.

- If the tree is owned by the local government, ask the city to prune or remove the tree. Most cities and counties in Virginia have a person or process to handle these requests and will be glad to work with the affected property owner.

- If the overhanging tree is owned by a private landowner, it is best to work out a solution one-on-one in an amicable manner.

If further help is needed, involve the neighborhood association. There may be covenants, conditions and restrictions that apply. If a tree appears to be on a boundary line and it is unclear who owns it, advise the parties to contact a lawyer.

KEY QUESTIONS:
What part of a tree is usually injured during construction?
What are five signs that a tree is under stress because of construction damage?
What is the number one goal in treating construction damaged trees?
What is a utility's primary requirement where trees are involved?
Name three types of tree and utility conflicts.
What is the cheapest and most effective way to address tree and utility conflicts?
What advice should a Tree Steward offer to a homeowner?

GLOSSARY

abiotic – plant disorders caused by nonliving factors

absorbing root – extracts water and nutrients from the soil for structural roots to carry to rest of tree

A Horizon – organic-rich layer at the top of soil

adaptability – genetic ability of a plant to adjust to different environments

acidic – having a pH less than 7

acclimation – process by which organisms adapt to a different environment

adventitious bud – replacement for lost normal buds along stems or surface of roots; see also **watersprout** and **sucker**

alkaline – having a pH higher than 7

alternate – having one leaf per node and leaves in alternating positions on the stem

anatomy – the structure and composition of the plant

angiosperm – plant with seeds protected by a fruit or nut

annual growth ring – ring of xylem visible in cross section of tree trunk

apical dominance – terminal bud inhibits the growth and development of lateral buds on the same stem

apical meristem – undifferentiated tissue producing elongation (growth) at tips of roots or shoots

arboriculture – the study of trees and other plants

asexual reproduction – creating new plants through vegetative means such as stem cuttings, root cuttings, tissue culture and grafting

auxins – plant hormones that regulate many plant activities, such as growth

B&B – abbreviation for balled and burlapped (see below)

balled and burlapped – plant dug for transplant with root system and surrounding soil wrapped in burlap for moving

bare-root – plant dug for transplanting with soil removed from roots

bark – protective covering over branches and stem, created from cork cambium

barrier zone – new wood layer around **reaction zone** to prevent outward spread of damage from injury; see **compartmentalization**

basal sucker – undesirable shoot arising from the roots or root flare

bark tracing – remedial removal of loose bark resulting from injury

binomial nomenclature – scientific naming system that uses the genus and species epithet of the plant for identification; Latin designations

B Horizon – mixture of organic material from the A Horizon and soils from the underlying parent rock

biotic agent – living agent, such as an insect, that causes damage to plants

branch bark ridge – areas of a tree's crotch where the growth and development of the branch against the trunk (or another branch) pushes the bark into a ridge

branch collar – raised ridge surrounding the area where a branch joins another branch or trunk, created by overlapping xylem tissue

broad leaf – tree with flat, thin leaves rather than needles

broad-spectrum herbicide – general-formula herbicide that kills both grasses (monocots) and broadleaf plants (dicots)

bud – meristematic tissues that will become a new shoot

buttress roots – roots at the base of the trunk; see **root flare**

cambium – layer of meristematic cells that divide and specialize into the phloem and xylem, creating an increase in diameter of the tree

canker – localized dead areas in the wood surrounded by healthy tissue and/or bark, often caused by fungi

canopy – branches and foliage of the tree supported by the scaffold branches

cell wall – outer covering of plant cells formed by successive layers of cellulose fibers

cellulose – fibers laid down around a plant's cell membrane; increasing fiber layers create a slightly rigid cell wall

chemical factors – contamination from herbicides, fertilizers, salts and other outside agents

classification – identifying plants according to their taxonomic groups

chloroplasts – specialized bodies within plant cells that carry chlorophyll; sites of photosynthesis

chlorophyll – green pigment in plant cells; absorbs light energy for photosynthesis

chlorosis – general yellowing of leaves because of lack of chlorophyll

coarse-rooted system – one of two main root systems; system of most trees in Virginia; large and small woody and nonwoody roots that branch; see **fibrous root system**

CODIT – Compartmentalization of Decay in Trees; see **compartmentalization**

codominant leader – occurs when the primary vertical branch of the tree forks or another lateral branch produces a competitive vertical; results in strongly forked trees

compacted soil – see **soil compaction**

compartmentalization – model of tree adaptation to wounding proposed by Dr. Alex Shigo in which trees seal off damage by constructing “walls” to prevent spread of decay

compound leaf – leaf composed of a number of smaller leaflets

conifer – cone-bearing tree

conk – a fibrous but sometimes fleshy fruiting body of a wood-rotting fungus

container-grown – nursery-produced tree that has been transplanted into a container and grown one season before transplanting

contaminants – chemicals or other pollutants

crotch angle – angle of attachment where a branch forms from the trunk or another branch

crown – the leaves and branches from the lowest branch to the top of the tree

crown cleaning – pruning to remove only dead and/or diseased limbs

crown raising – selective pruning to remove or reduce lower branches, often to improve clearance or visibility

crown reduction – selective pruning of branches to a lateral to reduce crown height or canopy spread; NOT the same as **topping**

crown thinning – selective removal of branches for health, safety, appearance or usefulness

cultivar – a cultivated variety of a plant which is propagated not from seed but from vegetative matter, such as plant tissue.

cuticle – waxy layer outside the epidermis of a leaf

cutting – asexual propagation method involving rooting a shoot that has been cut from a parent plant

cytoplasm – jelly-like living material of each cell

damage pattern – physical areas and time frame in which damage occurs

decay – obvious symptom of pathogen damage

deciduous – trees and shrubs that lose their leaves in the fall

decurrent – rounded growth habitat of crown; no main vertical leader in mature tree

defoliate – to lose leaves

dichotomous key – identification process using either/or choices to determine the correct species based on matching traits

dieback – death of specific portions of the crown but not all of it

dioecious – plant with unisexual flowers with each sex confined to a separate plant

directional pruning – each pruning cut is made so that the lateral branch left below the cut will grow in an acceptable direction

disorder – an ailment or any other disruption of a tree's normal health and behavior

dormant – state of reduced physiological activity

drainage – rate and extent of water moving down through soil, determined by soil structure and content

dripline – outer boundaries of a tree's canopy

early wood cells – larger, lighter color cells of annual growth ring

easement – legal right of utility, local government or other party to somehow use or cross someone else's property

ecotomycorrhizae – beneficial fungi that colonize the outside surfaces of plant roots

endomycorrhizae – beneficial fungi that colonize within the tissues of plant roots

entire – smooth leaf margin (without serration or lobes)

environmental factor –light, moisture, temperature and other external factors that affect the growth of a tree

epidermis – top and bottom surfaces of leaf blade

essential elements – minerals essential to the normal growth and development of plants

evergreens – trees that hold their leaves more than one year

excurrent – crown develops with a strong leader; pyramidal growth form

exotic – a plant that is not native to the area in which it is growing

fibrous root system – one of two main root systems; common in palms and grasses; develops dense network of fine lateral roots; see **coarse-rooted system**

field guide – reference book with simple keys to identifying plants

flagging – condition in which some leaves wilt and turn brown but not all; they stay on tree

foliage – leaves of the tree

genotype – inherited genetic traits

genus – taxonomic group of species having similar genetic traits

girdling roots – roots growing in a circular pattern resulting from limited space; if not treated, the roots will constrict the flow of water and nutrients to the tree

grafting – asexual propagation method involves taking dormant scion cuttings or buds from the desired tree and inserting or binding them to a chosen rootstock; often used to produce dwarf trees

gravitropism – growth response to gravity (shoot response negative, root response positive)

guard cells – pair of cells that regulate the opening and closing of stomata (leaf pore openings)

gymnosperm – plants that produce unprotected seeds between the scales of a cone

habit – normal growth form

hardiness – ability of a plant to survive low temperatures (may also imply ability to survive other stresses)

hardwood – trees whose cells are additionally stiffened by the presence of lignin in the cell walls

heading cuts – cutting small branches back to buds or lateral branches to direct future growth

heart roots – **(**see **striker roots)**

heartwood – inner area of the tree composed of older, nonfunctional xylem tissue

herbarium – a reference collection of plants

herbicide – chemicals formulated to kill plants

horizon – designated layer of materials within a soil profile

included bark – bark pinched between two branches or between a branch and the trunk, preventing formation of a branch bark ridge

inner bark – short-lived phloem through which food travels from leaves to the rest of the tree; eventually becomes part of outer bark

internode – area of stem between (not including) two successive nodes

invasive exotics or **invasive non-natives** – introduced plant species that have the capacity to overrun areas where they are established

lateral meristem – designated the cambium layer

lateral bud – vegetative bud on the side of a stem

lateral root – side-branching root that grows horizontally

late wood cells – smaller, darker cells of annual growth ring

layering – gently bending shoots to the ground and covering with soil until they root; not normally used to propagate trees

leaching – tendency of elements to wash down through the soil

leader – primary terminal shoot or trunk of a tree

leaf blade – large flattened surface that absorbs sunlight

leaf necrosis – parts of leaf die; causes vary

leaf scar – mark left on twig after leaf falls

lenticels – openings in bark to allow exchange of gases

lesion – abnormality on bark or branch; visible symptom of a wound or injury

lignin – materials accumulated in the cell walls of some trees that lend additional stiffening to the cells

macropores – larger spaces between soil particles

mechanical injury – physical damage from impact, wind or other nonliving factors

meristems – areas of undifferentiated tissues where cell division (growth) takes place

microclimate – areas where the overall climate is altered by landforms, buildings or other factors that affect the temperature, drainage or other parts of the environment

micropores – smaller spaces between soil particles

monoculture – consisting of one variety or species; vulnerable to disease or pests

monoecious – having both sexes on the same plant

morphology – form or shape

mycorrhizae – fungi that form a symbiotic association with plant roots

native – a plant that grows naturally in an area, not cultivated or introduced from another region

natural target pruning – pruning method that follows the natural protective methods of the tree; limbs are removed without damage to the branch collar

natural variation – differences in plant morphology or growth habit that arise from naturally occurring genetic differences

node – slightly enlarged portion of a stem where leaves and buds arise

opposite – leaves situated two at each node, positioned across from each other on the stem

osmosis – diffusion of water through a semi-permeable membrane (cell to cell) from a region of higher water potential to a region of lower water potential

outer bark – external layer of dead cells full of wax that protect the tree from various environmental hazards; eventually cracks and sloughs off as new layers develop underneath it; thickness varies by species

pathogens – disease-causing agents

pathological – related to disease

pests – living agents, such as insects, that carry diseases or cause other damage to trees

petiole – stalk of a leaf

pH – measure of acidity or alkalinity

pith – core of smaller branches

phenotype – physical traits

phloem – food-conducting tissues of the tree

photoperiod – length of daylight required for certain developmental processes of plants such as growth and flowering to occur

photosynthate – carbohydrate (compound containing carbon and water) created during photosynthesis

photosynthesis – chemical process used by chlorophyll-carrying plants in which light energy is used to form organic compounds from water and carbon dioxide

phototropism – growth response of plants toward light

pore – air space between particles in soil

porosity – total pore space in a soil

primary growth – elongation of shoots and roots resulting from cell division at apical meristems

primary meristem – apical meristem occurring at the tip of shoots or roots

protected site – site blocked from wind or severe weather by the presence of other trees, buildings or other formations

protoplasm – the living material within cells

pruning saw – saws designated specifically for use in removing tree limbs; saw shapes and tooth configurations vary according to intended use

range – geographic area where a plant occurs naturally

ray cells – tissues that extend radially across the xylem and phloem of a tree

reaction zone – reaction of tree tissue to contain the damage from a wound or injury; see **compartmentalization**

respiration – energy-releasing process in which carbohydrates are combined with oxygen

restoration pruning – used to repair mechanical or storm damage

root cap – protective tissue at the tip of a root

root flare – widened area where the tree trunk spreads out into the root system; sometimes also called root collar

sapwood – outer wood that actively transports water and minerals

scaffold branches/limbs – major branches shaping the canopy

scarification – scratching or otherwise wearing through a tough seed coat so growth can begin

secondary growth – growth in cambium that increases diameter

selective herbicide – chemical formulation that kills a specific group of plants such as grasses (monocots) or broadleaf plants (dicots)

signs – evidence of an agent causing damage to a tree, such as spores or mushrooms; see also **symptom**

simple leaf – single leaf

sink – plant part that uses more energy than it produces

sinker roots – grow downward from primary, secondary and tertiary roots as root anchors; do not contribute to or form their own branch hierarchy

site clearance – distance away from utility rights-of-way, roads and other obstructions

site plan – a sketch showing the conditions, environment and factors of a specific site

soil analysis – laboratory analysis to determine pH and mineral composition of soil

soil compaction – reduction of total pore space in a soil, resulting in restricted plant root growth, poor drainage and reduced available oxygen

soil profile – vertical section through a soil, showing depth of horizons

soil structure – arrangement of soil particles

soil texture – particle size of soil

source – plant part that produces **photosynthates** (carbohydrates)

species – groups of related organisms that can produce offspring

staking – practice of externally supporting a newly planted tree; controversial and best used where strong winds are a factor

stomata or stomates – small pores on leaves and stems through which gases are exchanged

stratification – refrigerating seeds to simulate a natural cold cycle and allow growth to begin

striker roots – primary roots radiate from the root plate (buttress roots) and form branches of their own; also called **heart roots**

structural pruning – species-specific pruning of young trees to develop strong branch arrangement

structural roots – support the tree, transport water and nutrients, and store starches during dormancy

structural soil – rock and soil mixed in specific ratios to allow street tree roots to grow outward but also allow the soil to support pavement

subordinate – to remove lateral branches or the terminal portion of the parent branch to slow growth of the parent branch

sucker – undesirable shoot arising from the roots or root flare

symptom – changes in a plant's growth, function or appearance caused by a damaging agent; see also **signs**

taproot – central vertical root present in some young trees; growth is generally checked by development of other roots

taxonomy – classification and naming of organisms

thinning – selective removal of unwanted branches and limbs to provide air penetration into the crown of a tree and to lighten weight of branches

tolerance – adaptability to environmental conditions and other stresses

topping – reducing tree size by cutting back to stubs or laterals, resulting in heavy growth of undersized shoots

topsoil – uppermost layers of soil; A Horizon and B Horizon combined

transpiration – loss of water as vapor through leaf openings

transpirational pull – the process by which water is pulled from the roots up the tree as a result of loss of water vapor through the leaves

transplanting – planting in a new location

tree pit – an open space in a sidewalk suitable for planting a tree

trenching – construction activity that damages tree roots

tropism – a response to a stimulus; see **geotropism**, **phototropism**

variety – members of a plant species that show a distinct difference and that will breed true to that difference

vascular tissue – tissue that conducts water and/or nutrients; xylem and phloem

venation – pattern of veins in a leaf

watersprout – secondary upright shoot arising from the trunk, branches or roots; such shoots forming from roots are also called **basal suckers**

whorled – leaves form at several points on a node and surround the stem

wilting – loss of turgidity and subsequent drooping of leaves and stems

xylem – water-conducting tissue

Internet Resources

Tree Identification

- Tree identification, fact sheets on about 800 species of trees, and other tree information from the dendrology homepage at Virginia Tech

  http://www.cnr.vt.edu/DENDRO/DENDROLOGY/main.htm

- Fact sheets on 680 more trees

  http://hort.ifas.ufl.edu/trees/

- How to identify a tree

  http://www.cnr.vt.edu/dendro/forsite/Idtree.htm

- Identifying leaves

  http://www.fw.vt.edu/dendro/forsite/key/intro.htm

- Tree families with common and scientific names

  http://www.dof.virginia.gov/mgt/resources/familes-genera-of-trees.pdf

- USDA Forest Service Silvics of North America Manual
  (Vol. 1 - Conifers, and Vol. 2 - Hardwoods)

  http://na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm

Tree Selection

- Information to help you select a tree (height and spread, soil and sun requirements, leaves and fruit, history, wildlife habitat, and more)

  http://www.arbordayfoundation.org/trees/treeguide/

Tree Care: General Care

- How to plant a tree

  http://www.pubs.ext.vt.edu/426/426-702/426-702.html

- How to prune a tree: the basics

  http://www.pubs.ext.vt.edu/430/430-455/430-455.html

- A library of articles on taking care of trees

  http://www.treelink.org/linx/?navSubCatRef=46

- Tree care articles from the International Society of Arboriculture

  http://www.treesaregood.com/

- Why not to top trees

  http://www.pubs.ext.vt.edu/430/430-458/430-458.html

- How to tell if a tree has defects

  http://www.na.fs.fed.us/spfo/pubs/howtos/ht_haz/ht_haz.htm

Tree Care: Pruning

Deciduous Trees

- How to prune deciduous trees

  http://www.pubs.ext.vt.edu/430/430-456/430-456.html

- When to prune a deciduous tree: pruning calendar

  http://www.pubs.ext.vt.edu/430/430-460/430-460.html

Evergreen Trees

- How to prune evergreen trees

  http://www.pubs.ext.vt.edu/430/430-457/430-457.html

- When to prune an evergreen tree: pruning calendar

  http://www.pubs.ext.vt.edu/430/430-461/430-461.html

Shrubs

- How to prune shrubs

  http://www.pubs.ext.vt.edu/430/430-459/430-459.html

- When to prune shrubs: pruning calendar

  http://www.pubs.ext.vt.edu/430/430-462/430-462.html

Tree Problems

- How to diagnose a tree problem and identify controls using the Integrated Pest Management Site in Virginia Tech's Department of Pathology, Physiology and Weed Science

  http://ppwsipm.contentsrvr.net/

- How to determine a tree problem by viewing images from Virginia Tech's Department of Plant Pathology, Physiology and Weed Science

  http://ppwsidlab.contentsrvr.net/plant.vesh

- Description of the Emerald Ash Borer Street Tree Project from Virginia Tech and Virginia Department of Forestry

  http://www.cnr.vt.edu/urbanforestry/EABStreetTrees/index.html

- A series of free webinars from the Emerald Ash Borer University. Registration required.

  http://www.emeraldashborer.info/eab_university.cfm

Special Tree Topics

- Alien and invasive plants

  http://www.nps.gov/plants/alien/

- Virginia Big Tree Program

  http://www.cnr.vt.edu/4h/bigtree

Agencies and Organizations Interested in Trees

- International Society of Arboriculture

  http://www.isa-arbor.com/home.aspx

- National Arbor Day Foundation

  http://www.arbordayfoundation.org/

- Virginia Cooperative Extension

  http://www.ext.vt.edu/

- Virginia Cooperative Extension Publications

  http://pubs.ext.vt.edu/

- Virginia Department of Forestry

  http://www.dof.virginia.gov/index.shtml

- Virginia Native Plant Society

  http://www.vnps.org/index.htm

- Virginia Tech College of Natural Resources

  http://www.cnr.vt.edu/

- Virginia Tech Department of Forestry

  http://www.cnr.vt.edu/forestry/

- Virginia Urban Forest Council

  http://www.treesvirginia.org/

- Virginia Department of Forestry: Urban and Community Forestry

  http://www.dof.virginia.gov/urban/index.shtml

- U.S. Department of Agriculture Forest Service

  http://www.fs.fed.us/

Arboretums

Blue Ridge Community College Arboretum

http://www.brcc.edu/arboretum/

State Arboretum of Virginia: Blandy Experimental Farm

http://www.virginia.edu/blandy/

U.S. National Arboretum

http://www.usna.usda.gov/

Internet resources compiled by John Cannon, Front Royal/Warren County Tree Steward, 2009

Bibliography

Dirr, Michael. *Dirr's Hardy Trees and Shrubs: An Illustrated Encyclopedia*. Portland, OR: Timber Press, 1997.

Dirr, Michael. *Manual of Woody Landscape Plants*, Third Edition. Champaign, IL: Stipes Publishing Company, 2009.

Gilman, Edward F. *An Illustrated Guide to Pruning*, Second Edition. NY: Delmar, 2002.

Hugo, N. R. and J. Kirwan. Photography by R. Llewellyn. *Remarkable Trees of Virginia*. Earlysville, VA: Albemarle Books, 2008.

Johnson, W. and H. Lyon. *Insects That Feed on Trees and Shrubs,* Second Revised Edition. Ithaca, NY: Cornell University Press, 1991.

Shigo, Alex L. *Modern Arboriculture*. Durham, NH: Shigo & Trees Associates, 1991.

Sibley, David Allen. *The Sibley Guide to Trees.* NY: Alfred A. Knopf, 2009.

Sinclare, W. H. Lyon, and W. Johnson. *Diseases of Trees and Shrubs*, Second Edition. Ithaca, NY: Cornell University Press, 2005.

Urban, James. *Up by Roots*. Champaign, IL: International Society of Arboriculture, 2008.

Virginia Department of Forestry. *Common Native Trees of Virginia: Tree Identification Guide*. Charlottesville, VA: Virginia Department of Forestry, 2007.

Photo and Image Credits

Casey Trees, Washington, D.C., www.caseytrees.org..................................Pages 7-10.

Henne, Maud. Tree Steward, Charlottesville, VA. .... Pages iii, 2-8, and 3-6.

Llewellyn, Robert. Charlottesville, VA.   Photos from *Remarkable Trees of Virginia*, by Nancy R. Hugo and Jeff Kirwan. Photography by Robert Llewellyn. Earlysville, VA: Albemarle Books, 2008. ....Pages 4-8, 6-9, 8-12, and 11-6.

Merriam-Webster's Collegiate® Encyclopedia. Used by permission of the publisher. Merriam-Webster, Inc. www.merriam-webster.com ....Pages 3-2.

O'Brien, Robert. Robert O'Brien Design, Austin, TX, www.treeguides.com ....Page 11-4.

Sigmon, Kevin. City Arborist, Abingdon, VA...........................Pages 5-4, 9-10, and 11-3.

Seals, Louise. Tree Steward, Richmond, VA. ....Pages 5-2, 8-2, 8-7, and 10-4.

Vawter, Jacki. Tree Steward, Charlottesville, VA. ....Pages 5-3, 8-6, and 10-2.