

A Training Manual

for Virginia Tree Stewards

4th Edition

Volunteers for the Community Forest



TREES VIRGINIA

Virginia's Urban Forest Council

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To make this edition current, the use of websites is embedded in the text. The 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. Copyright Pending Virginia Urban Forest Council 900 Natural Resources Drive Suite 800 Charlottesville, VA 22903 434-295-6401 <https://treesvirginia.org/>

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Introduction

Tree Stewards

Tree Stewards are trained community volunteers committed to promoting healthy urban and rural forests in Virginia. It is a grassroots effort and each Tree Steward group in Virginia is unique and has evolved to meet the needs of its community. Tree Stewards provide training classes, educational programs, and projects in their communities intended to increase public awareness of the value of trees while teaching about trees and tree care. With classroom training and hands-on practice, Tree Stewards are equipped to identify trees, counsel on tree selection, demonstrate proper tree planting and follow-up care, and guide removal of invasive plants that threaten trees. Tree stewards are passionate about planning for the long-term future of the urban forest.

Each person taking the Tree Steward training makes a commitment to return a specific number of volunteer hours contributing to local Tree Steward projects. Each community determines the number of hours, sets the standards for volunteer work, and decides the Tree Steward projects its volunteers will undertake. Tree Steward volunteers are a positive force for change in their communities. All Tree Steward projects are tailored to meet the needs of their communities. There are ten Tree Steward groups in Virginia.

Tree Steward Group	For More Information
Arlington/Alexandria Tree Stewards	www.treestewards.org
Charlottesville Area Tree Stewards	www.charlottesvilleareatreestewards.org
Fairfax County Tree Stewards	email: info@ffxtreestewards.org
Tree Fredericksburg Tree Stewards	www.treefredericksburg.org
Front Royal/Warren County Tree Stewards	www.treesfrontroyal.org
Greater Lynchburg Tree Stewards	www.lynchburgva.gov/lynchburg-tree-stewards
Harrisonburg Tree Stewards	https://www.harrisonburgva.gov/tree-stewards-harrisonburg
Tree Stewards of the Central Rappahannock Area	www.treestewardsofthecra.org
Richmond Tree Stewards	http://richmondtreestewards.org/
Roanoke Tree Stewards	www.roanoketreestewards.org

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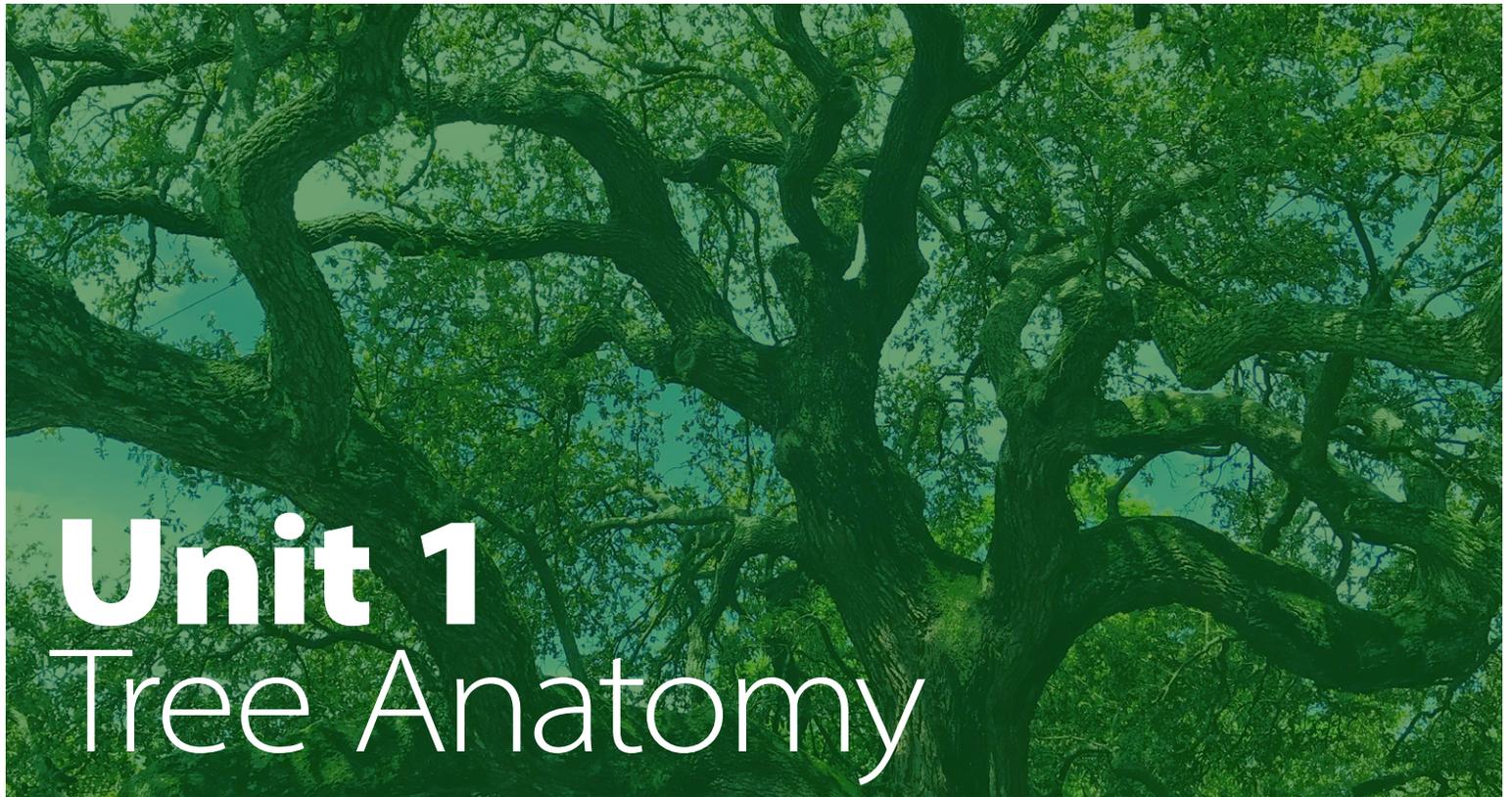
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Unit 1

Tree Anatomy

What is a Tree?

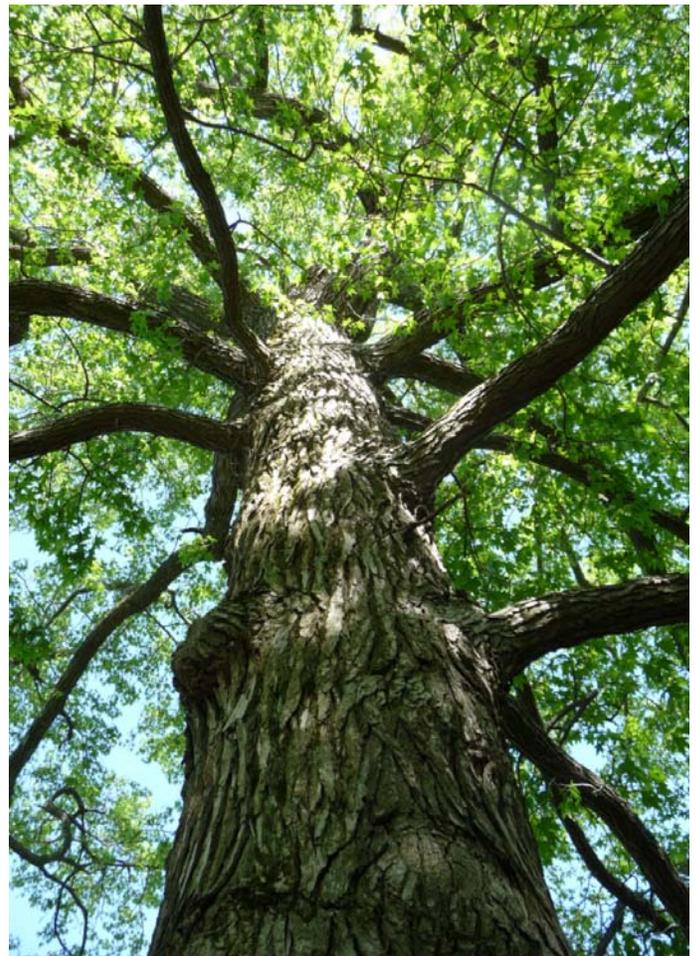
Trees are the tallest, largest, longest-lived freestanding organisms in the world. There are an estimated 100,000 species of trees across the world, making up about 25% of all living plant species.

They are compartmented 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 and interact with their environments can help you understand the effects of environmental stresses.

One of three types of woody perennial plants, (trees, shrubs, and vines), a tree must meet these criteria:

- Has the potential to grow to at least 15 feet tall at maturity.
- 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 (Self-supporting).



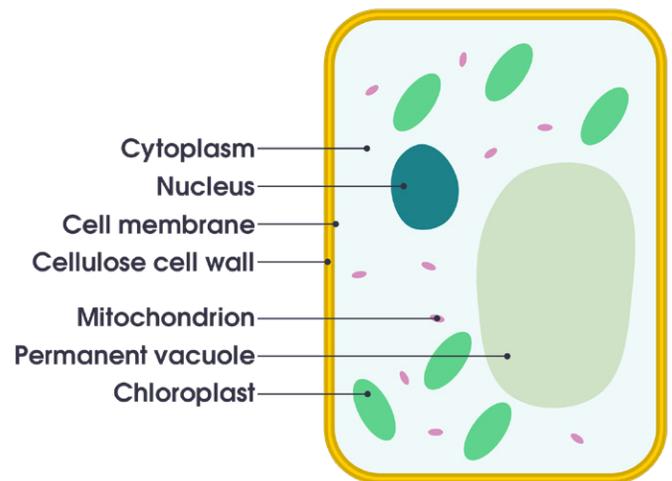
Microbiology of Trees

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 similar to ours to provide the tree with nutrition and energy for growth, maintenance, reproduction, and defense. To understand the nature of plants – trees in this case – we begin with a look at their cells.

Under a microscope, plant cells are square or rectangular, distinctly different from round animal cells. Surrounding the **cytoplasm**, the jelly-like living material of each cell, is a **membrane** that contains the cellular components just like animal cells. However, plant cells have an additional container called the **cell wall** that comprises layers of **cellulose** fibers. This cellulose 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.

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. In the cells of leaves and young stems are tiny structures called **chloroplasts**, which contain the green pigment **chlorophyll** that plays a key role in the energy-capturing process of **photosynthesis**. Also contained in living cells are **mitochondria**, which are tiny engines that release energy from the sugars in a process called **respiration** ([See more in unit 2](#)).

Trees contain many specialized cell types. As a tree grows, cells inside the trunk and branches (wood cells) 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.



Plant Cell. Image by domdomegg / CC BY (<https://creativecommons.org/licenses/by/4.0>)

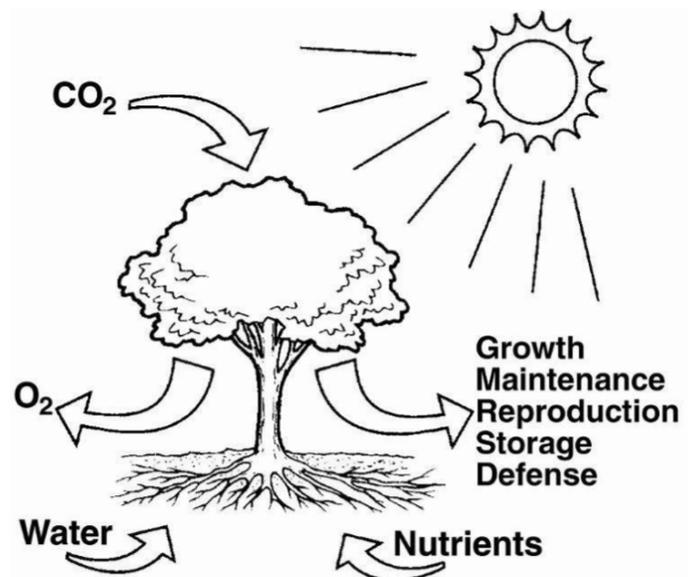


Image by International Society of Arboriculture, Bugwood.org

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.

How Trees Grow

Tree growth takes place only in the **meristem** tissue, specialized areas within the tree where cell division occurs. Trees get bigger in two ways. 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, branches, and structural roots of the tree. Here cell division forms the **secondary growth** of wood that gradually thickens the shoots and roots, allowing support for a tree's great weight and water transport up the tree. Every year a tree grows new living tissue on top of and to the outside of the previous year's tissue. New wood and new bark are produced annually.

Main Parts of a Tree

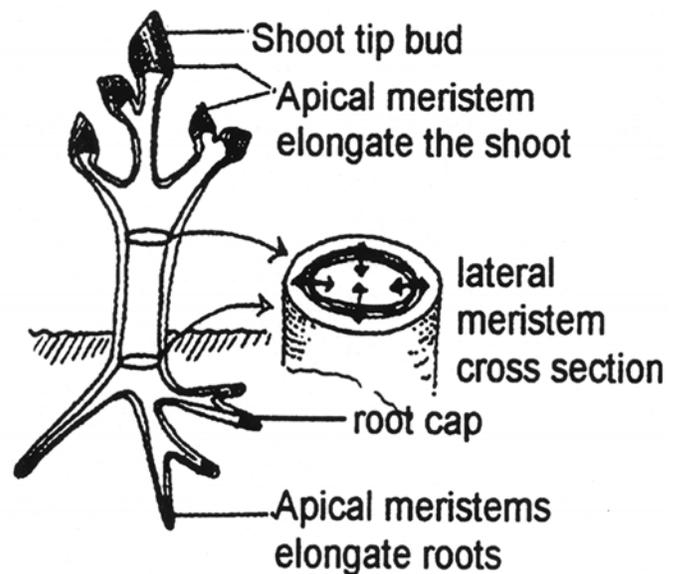
The body of a tree relies on two main systems. The underground root system anchors the tree and absorbs and transports water and nutrient resources. Above ground, the trunk and shoot system develops branches, leaves, flowers and fruit, providing energy, growth, and reproduction.

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.

Trunk & Branch System

Trees are usually distinguished from shrubs by having one main stem, called a trunk. The trunk divides into branches and smaller twigs that form the crown of the tree. The trunk elevates photosynthesizing leaves above other plants to compete for light. Branches and twigs spread out from the trunk to give as much sun and air exposure as possible to the leaves. The trunk and branches support the tree, but also move water and nutrients from the roots to the leaves and food around the tree to keep the parts alive. The trunk and branches are made up of the following layers of tissues involved in the support and transport functions:

MERISTEM TISSUES

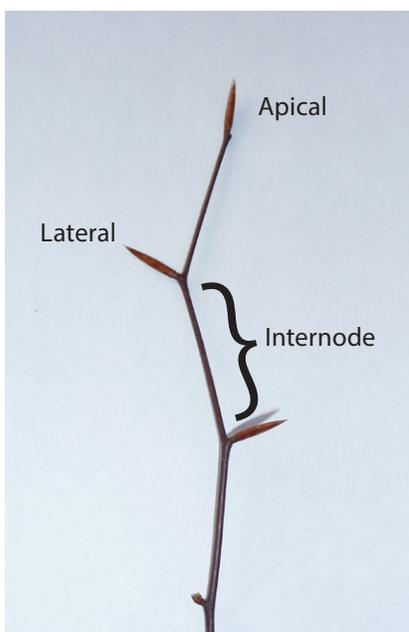


From the outside in:

- As the **outer bark** builds layers, it protects the tree from mechanical injury and insulates it from fire, extreme temperatures, water loss, and pests. Accumulated wax and compounds in these dead cells make the outer bark relatively waterproof and impenetrable by insects and diseases. 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.
- **Lenticels** are tiny openings that allow oxygen, carbon dioxide, and water vapor to enter and leave the tree. They occur on the trunk, branches, and roots.
- The **inner bark**, also called **phloem**, is the pipeline for transporting sugars 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 **vascular cambium** is the lateral 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.

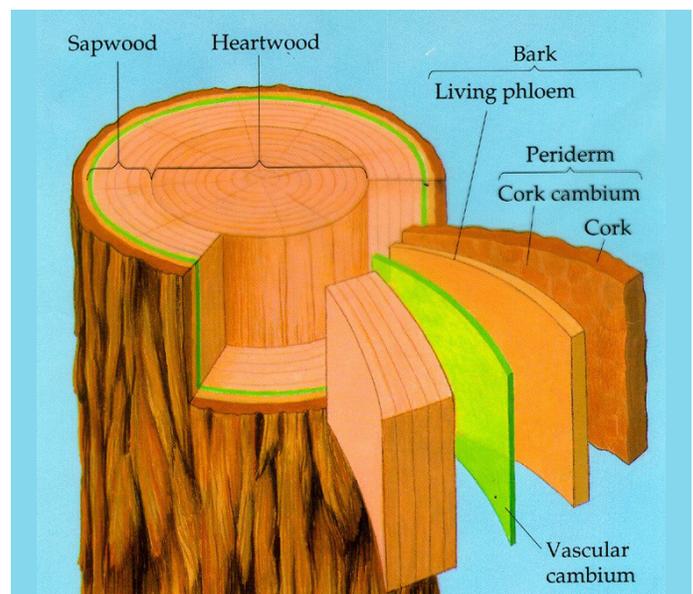
- The **sapwood**, or xylem, are the cells to the inside of the cambium providing an upward passageway for water and nutrients. These cells divide and lay down woody tissue to strengthen the stems and trunk. Xylem is the Greek word for wood. As new rings of sapwood are laid on top, older sapwood turns into heartwood.
- The **heartwood** forms the central tree support. This rigid, nonliving xylem tissue is filled with wax and chemicals to defend against decay. 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.
- Although most water, nutrient, and chemical transfers move upward and downward in a tree, some transfers also occur across the tree. Sap travels horizontally between the phloem and xylem through **rays**. Resembling wheel spokes, **rays** are thin sheets of living cells that are oriented horizontally rather than vertically like most of the wood cells. Rays complete the vascular system by linking the xylem and phloem systems. They also provide lateral strength by binding it all together. Rays also store sugars produced in photosynthesis and play a role in limiting the spread of decay.



American Beech twig.

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 & black cherry.



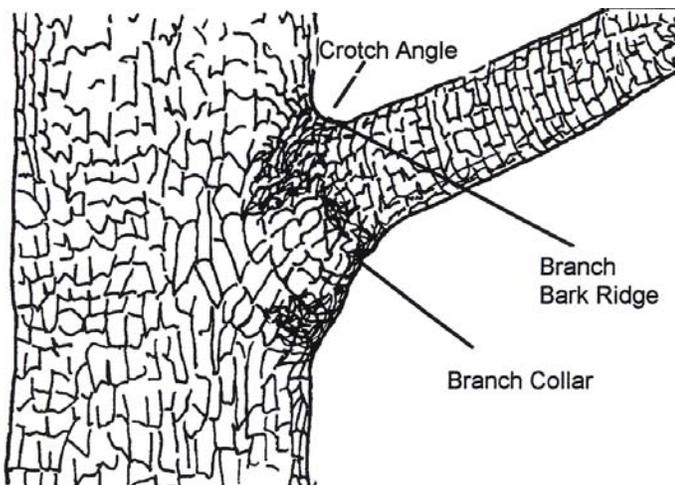
Examination of a twig will reveal enlarged **nodes** where buds, leaves, and flowers emerge. The stem area between the nodes is called the **internode**. As a twig grows each year, the terminal bud from the previous year leaves a scar where the scales surrounding the bud were attached. The distance between these annual bud scale scars shows 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 shoot elongation and height growth occurs from the terminal bud. If this bud is removed, production ceases of growth hormones that suppress the lateral, or sometimes dormant, buds along the stem and they begin to form new shoots.

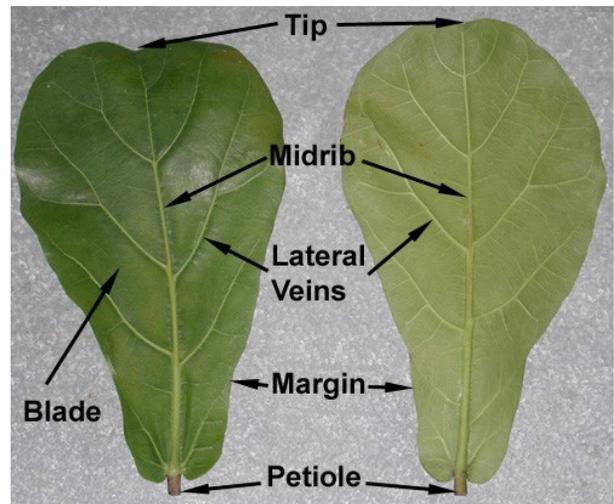
When normal buds are lost, trees may produce **adventitious buds** along their stems or from surface roots. Shoots from these buds can fill in areas left open when branches are lost to disease, damage, or pruning. They may also become undesirable **suckers** at the base of the tree or **watersprouts** on the branches. The presence of many adventitious shoots often indicates that the tree is under stress or signals other underlying problems. (See more unit 8).

Shoots Become Branches

Shoots that grow for multiple years transition from twigs to large branches. The attachment of a lateral branch to the trunk or its parent branch is strengthened by overlapping layers of wood between the two. These layers are visible as a bulge around the bottom of the branch attachment called the **branch collar**. These stronger tissues around the branch provide support. On top of the branch attachment, the wood layers compress each other rather than overlapping, creating a **branch bark ridge**. Weaker tissues form on the upper side, or crotch, of each branch. The angle of attachment is called the **crotch angle**. When this angle is narrow, the branch attachment is often weaker and prone to breaking.



One of the best ways to promote the importance of trees is through youth engagement. Project Learning Tree is a great resource for tree stewards looking for hands-on activities to do with the public during community events. Visit the following link to learn more – <https://www.dof.virginia.gov/edu/EE-Ideas-VDOF-PLT.pdf>



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 efficiently. **Chlorophyll** within the millions of **chloroplasts**, produces the characteristic green leaf color. Leaves are relatively thin, and all their photosynthetic 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**. A waxy coating over the epidermis called a **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 and sunscald can result. Leaves of some species also develop hair-like cells on the epidermis called trichomes, which further enhance tolerance of extremes in light, temperature, moisture, or pests.

Looking at the underside of a leaf under a microscope reveals tiny openings called **stomates**. They open and close to regulate gas exchange and **transpiration**, which is the passage of water vapor out of the leaf. The surrounding **guard cells** cause the stomates to open and close in response to environmental conditions: heat,



drought, air pollution, and darkness cause the guard cells to close stomates to prevent excess moisture loss.

Trees even have sun and shade leaves. Shade leaves are larger, thinner, and darker green due to concentrated chlorophyll. They also have fewer stomata than sun leaves and can work more efficiently at lower light intensities by having quicker stomata opening response time. However, they can be injured if suddenly exposed to high intensity light when overstory foliage is removed by storms or pruning. Alternatively, sun leaves work better in direct light and will not respond well when shaded.

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 monocots, such as palms, or ancient gymnosperms such as ginkgo trees. Net-veined leaves are common in the dicots, which include most hardwood trees.

Deciduous Trees

Deciduous trees shed their leaves each year in response to decreasing day length. Deciduous trees drop their leaves to conserve water and energy during the dark, cold winter when photosynthesis is less efficient. Prior to leaf drop, nutrients such as nitrogen and phosphorus are mobilized and stored by the tree for future use. During this “dormant” period, root growth continues as long as the soil is not frozen, and the tree survives on the food resources it has accumulated during the growing season.

In some climates, certain tree species shed leaves and go dormant in response to water scarcity or very high temperatures. To make things a bit more complicated, some deciduous tree species, like American Beech, like to hold on to their leaves until spring bud break also called **marcescence**.

Short days with cooler nights trigger the bright colors of fall foliage by ceasing chlorophyll production. The breakdown of chlorophyll allows other pigments within the leaf to appear. Reds and purples are chemical pigments called anthocyanins, while carotenoids create the bright yellows, oranges and reds. Carotenoids are present during the growing season, 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.

Evergreens

Evergreens hold their leaves for more than one year. While many have needles, some are broadleaf evergreens such as southern magnolia (*Magnolia grandiflora*) and



Ginkgo leaves in the fall.

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.

American holly (*Ilex opaca*). 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 foliage, but not all at once and not on the same seasonal cycles of deciduous species.

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 non-woody roots that branch.



Girdling roots and buried root collar of a nursery grown tree. See [Units 5 & 6](#) for more information.

The two main functions of roots are to take up water and nutrients and provide structural support for the tree. Other functions include food storage in the form of carbohydrates, producing hormones, and forming symbiotic relationships with soil microbes. The root system and canopy develop a dynamic, interdependent balance that affects tree health and stability. Too few roots will negatively impact how much water and nutrients get to the canopy. See [Unit 8](#) for more information on the negative impacts of root loss to construction. 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 large lateral branching roots. The roots comprising 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. These roots are long-lived and enlarge in girth by growth of the lateral meristem.
- **Absorbing roots** primarily function 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. These fine roots (typically 2 mm or less in diameter) can live anywhere from 1 week to 3 or 4 years depending on species and growing conditions.
- The first roots one would encounter are the **buttress roots** that 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**, do not contribute to or form their own branch hierarchy but rather grow downward to anchor and seek groundwater.

Root Growth

Roots have xylem and phloem. Structural roots also have primary and secondary growth similar to the aboveground portions of the tree. They form woody tissues and thick, protective outer coatings. Primary growth occurs in root tip meristems, elongating the root behind the protective root cap. Roots absorb water and nutrients from the soil and move them into the tree trunk, where they are further transported through the xylem 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 sugars, nutrients, 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 is very shallow and wide extending 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, fertilizers, and herbicides applied to the soil within a wide radius can harm root health and growth, directly affecting overall tree health. Because soil becomes denser and less oxygenated at greater depth, it is also physically difficult and energy expensive for roots to grow downward. However, some tree species develop very deep roots to access groundwater in arid ecosystems.

Roots are opportunistic. They will proliferate in soil spaces where water and nutrients are abundant and dwindle in spaces where they are scarce. Because certain nutrients are immobile in the soil or slow to replenish, roots must actively expand into new soil spaces to obtain adequate resources. The environment strongly influences the direction and extent of root growth in trees. Root damage is a major cause of decline, 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.

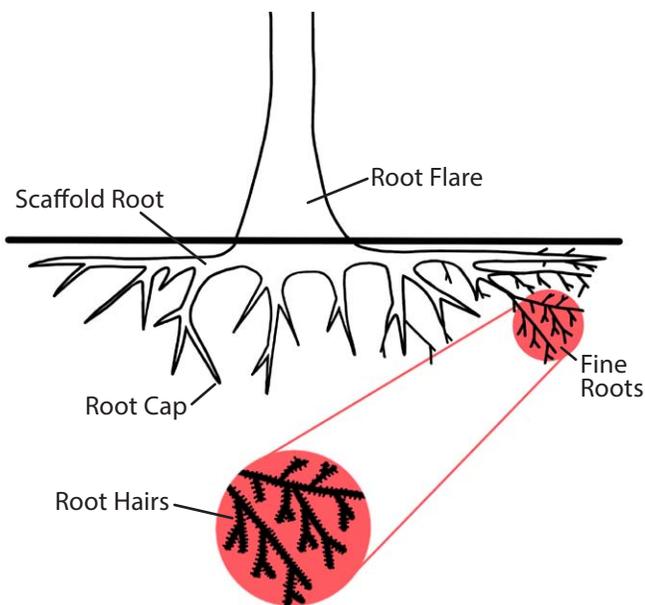


Illustration by Sarah Gugercin, Virginia Tech. Based on drawing from *Seeing Trees: A History of Street Trees in New York City and Berlin* by Sonja Dümpelmann



In trees with coarse- woody root systems, the roots are further divided into types based on their primary function and location. Photo by USDA Forest Service - Northeastern Area, Bugwood.org

Aids to Water and Nutrient Uptake

The root system grows and proliferates to obtain resources, but this growth is not limitless. There is a cost to producing and maintaining roots. In addition to being opportunistic, there are several ways tree roots increase their **surface area** to maximize potential for water and nutrient uptake.

Root hairs are outgrowths of roots cells near the root tip or apex. They anchor the tip of the root and help it grow forward through the soil and increase absorption. They may only live for a few hours, days or weeks and are replaced by new hairs as the root elongates.

Mycorrhizae (my-cor-ri-zae) are a symbiotic relationship between fungi and plant roots enabling the roots to better absorb nutrients and water in hard to reach places through fungal hyphae. The fungi can be found partly within the tree root (endo) or outside the root (ecto). The majority of mycorrhizae that associate with trees are ectomycorrhizal. This symbiotic relationship benefits the tree not only by increasing surface area of the root but also in creating a better connection to the soil particles. The mycorrhizae benefit by absorbing 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 mycorrhizal inoculants for improving tree health.

In another form of symbiosis, certain tree species develop **nodules** on the roots that contain bacteria (*Rhizobium* species) that can fix atmospheric nitrogen into an organic form that is usable by the tree. In exchange, the bacteria receive sugars and metabolites from the tree. Some examples are species in the Fabaceae or pea family (locust and redbud). These relationships are important for tree growth in disturbed environments where nitrogen is scarce and actually improved overall soil fertility for other plants.

Roots can also release exudates in the form of simple sugars, amino acids, organic acids or phenolics in response to nutrient deficiencies. These exudates influence the solubility of nutrients by changing the pH around the rhizosphere or directly affect soil microbes.

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.

Key Questions:

1. What two substances make wood stiff and durable?
2. What tissue is responsible for tree growth? Where is it found?
3. How can you determine where in a tree photosynthesis is taking place?
4. What do the phloem and xylem tissues do?
5. Where is the cambium? Why does this make bark injuries so important?
6. What can be learned from the annual growth rings of a tree?
7. What is the function of the root system of a tree? Of the shoot system?
8. Where on a twig will buds and new growth form?
9. What happens when the apical (terminal) bud is removed from a twig?
10. What structures support the weight of the tree canopy?
11. Can you locate the branch collar and branch bark ridge on a tree branch?
12. What functions, besides photosynthesis, occur in leaves?
13. What is the difference between a deciduous tree and an evergreen tree?
14. Where is the majority of a tree's root system located?
15. What is the difference between endo and ectomycorrhize?
16. Why is it important to understand a tree's needs, functions and the extent of its root system when planting?

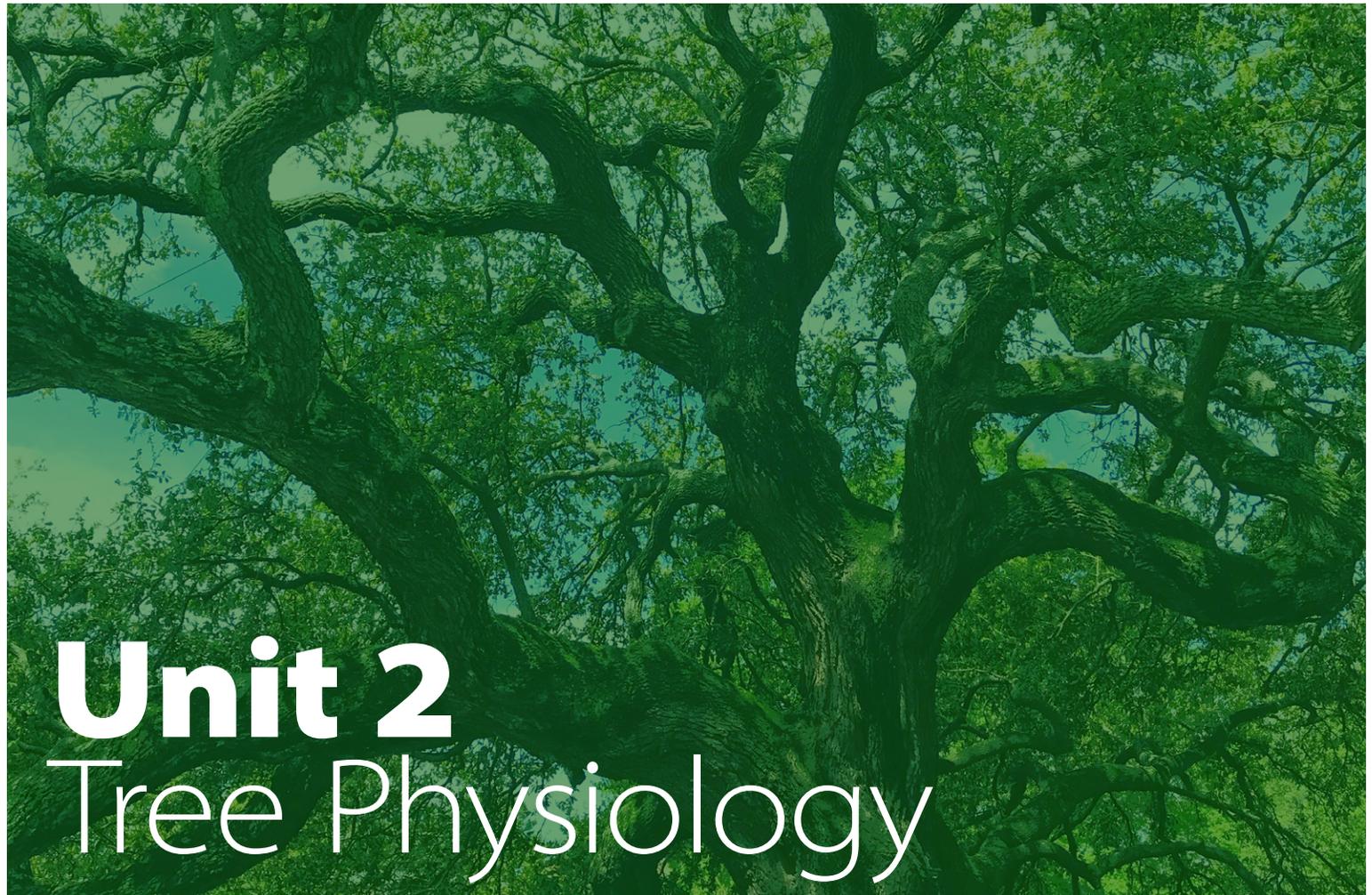
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Unit 2

Tree Physiology

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 nutrient supplement and does not feed the plant.

A microscope reveals rows of oval **chloroplasts** containing **chlorophyll** inside leaf cells. The light energy absorbed by the chlorophyll is used to split chemical bonds in water and carbon dioxide molecules and then form new bonds in carbohydrate molecules (starches and sugars) called **photosynthates**. Leaves look green because chlorophyll absorbs blue and red light and reflects green light back to our eyes.

Starches and sugars combine with minerals and elements to produce amino acids, fats, proteins and other compounds necessary for tree growth and development. 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 the chemical bonds in carbohydrate molecules. The released energy is used in biological processes such as growth. Respiration occurs in every living cell type in the tree where energy-demanding processes are occurring. Oxygen is absorbed for respiration through roots, **lenticels** and **stomates**. A tree will decline if its rate of respiration (food consumption) exceeds its photosynthesis (food creation). It is the same process that occurs in animal cells.

When a tree prematurely loses its leaves, it relies on stored energy reserves to grow 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 root respiration by preventing roots from absorbing oxygen. Without root respiration, there is no growth, nutrient uptake, or hormone synthesis, leading to tree decline.

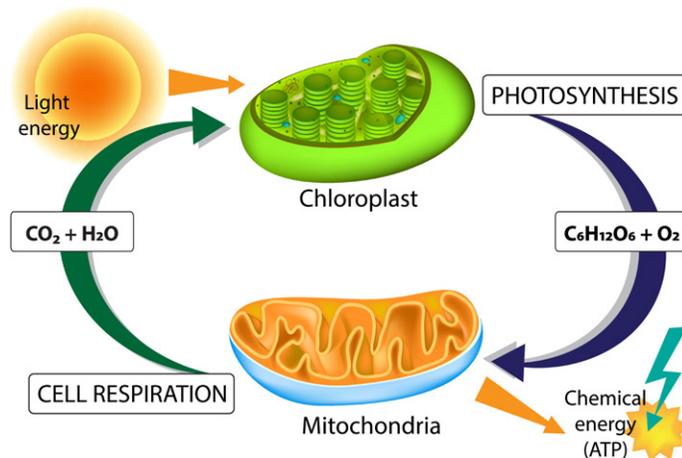


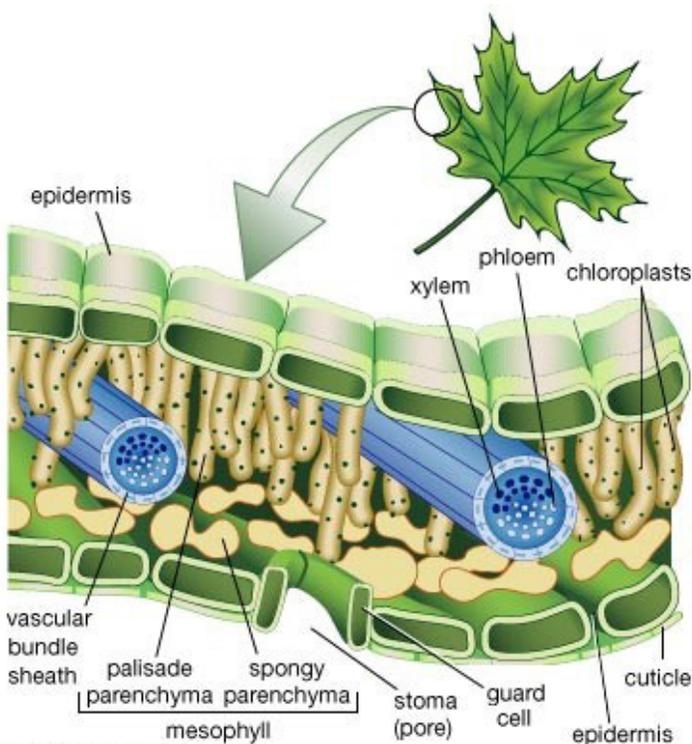
Illustration purchased from Adobe Stock.

Transpiration

While some water is used in photosynthesis, the majority of water transported through the tree exits the stomates without a metabolic role. In this way, the water is primarily acting as a transport system for soil nutrients and tree metabolites. The process of water moving through the tree is called **transpiration**. As water leaves the stomates, it changes from liquid to gaseous water vapor, which 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 pulls 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 than its roots absorb. This creates temporary turgor loss (wilting) of shoots and leaves, but turgor is regained overnight when stomates close and cells refill with water.



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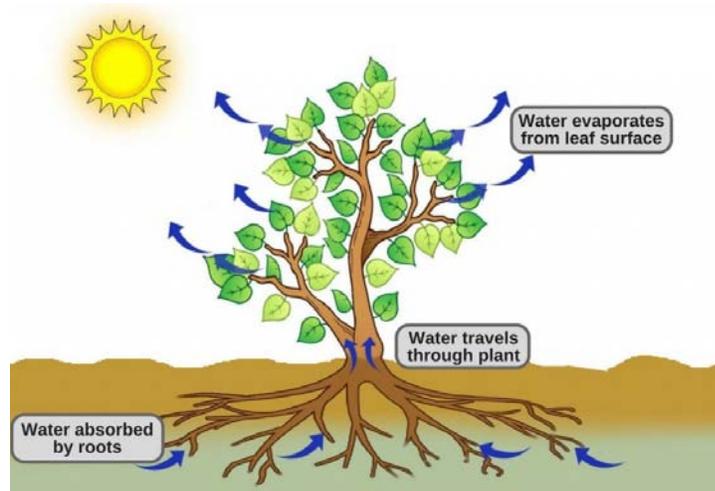
100 Feet or 5 Feet... Makes No Difference

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.

Osmosis

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 (potential) to areas of lower water concentration (potential).

Trees absorb water through their roots by osmosis. Roots generally have a lower water potential than the surrounding soil because carbohydrates and metabolites (solutes) are concentrated there, forcing water to move passively (no energy required) 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 pumped actively (energy required) 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 lower in sugar content, called **sinks**. Sinks are areas of the tree that use more energy than they produce. Most growing areas are sinks. Food energy continuously moves up and down the tree to be stored and used. Water and nutrients move laterally across the phloem, cambium, and xylem through **ray cells**.

Did You Know?

Adding minerals or sugars to water lowers its relative potential. Because of this, soils that have accumulated salt or mineral concentrations from de-icing and over-fertilization can actually pull water *out* of tree roots.

Growth Factors

A tree's genetics and its environment determine the rate at which it grows, its lifespan 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 coordinate and control aspects of growth such as flowering, fruit development, root development, and leaf formation and shedding. 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.

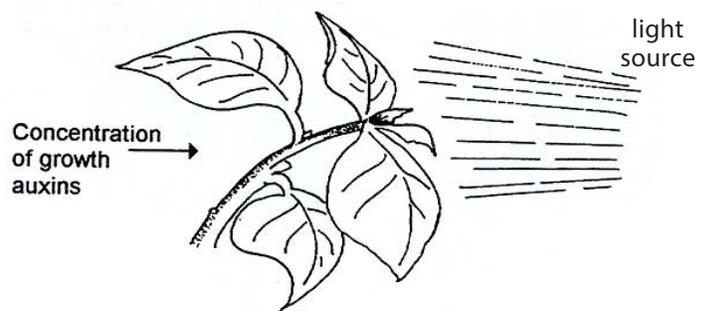
Auxins are hormones controlling plant growth. They are concentrated in **meristem** tissues at shoot and root tips. Apical meristem in the terminal bud produces strong concentrations of auxin that regulates the apical meristem in the lateral buds lower on the stem. If the terminal bud is removed, auxin flow to lateral buds is disrupted, liberating the lateral from inhibition and spurring lateral shoot growth. Commercial growers encourage rooting by dipping plant cuttings in synthetic auxins.

Hormone activity creates a tree's shape. In **apical dominance**, the growing terminal bud of a shoot produces auxins that suppress lateral buds and enable the terminal shoot (leader) to maintain apical control over lateral shoot (branch) development. **Excurret**- shaped trees, such as white pine, bald cypress or tulip tree, with dominant central leaders and a triangular form have strong apical control over lateral branches and codominant leaders.

Rounded, **decurent**- shaped trees, like oaks and maples, have terminal leaders with weaker apical dominance and therefore do not exert as much apical control over lateral branches. As a result, they may develop multiple codominant leaders and upright branches. Some decurrent species start their life in an excurret form, but transition to decurrent form as they age. Open-grown conditions also tend to favor a decurrent form in species with intermediate apical dominance.

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 *away from* 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.

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.



(left) Excurret shape- one dominant leader. (right) Decurrent shape- no dominant leader

Seasonal 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. Sugars stored in trunks and roots are mobilized and transported to the buds and leaves to fuel their 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 dormancy and cold tolerance. Roots never really go dormant and therefore can be damaged by temperatures below freezing. This especially affects trees in above-ground containers.

Tree growth is also controlled by external factors and internal controls. Tree growth requires a sufficient supply of light, nutrients, carbon dioxide, oxygen, water, and appropriate climate. These are external factors and the lack of one or more will slow growth. [Unit 4](#) describes the need for planting trees in an appropriate climate in more detail. Because a tree is made up of independent parts there are conflicts for limited resources. Different parts of the tree compete for resources and a balance has to be kept between growth of these parts to ensure long-term survival. For example, rapid height growth may leave a tree with no stored food for next year's new leaf or root growth.

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 in the same year.

Fortunately, the tree has a highly organized internal control system for allocating resources to growth, maintenance and reproduction by switching on and off different sinks at different times. The signal for this switching comes from external factors.

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 because soil water is abundant and air temperatures are mild, allowing rapid transpiration. 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 because soil water is scarce and air temperatures are high, requiring smaller wood pores to avoid dehydration. They 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.

There are differences in growth rings for hardwoods and conifers. The wood in conifers is composed of dead empty tubes called **tracheids**. Not only does water flow through them but since they make up roughly 90% of the tree,



they also hold it up. In hardwood trees the cell tubes are called **vessels** and they can also be further divided into ring- and diffuse-porous trees. In ring-porous trees, like ash, elm and oak, the earlywood is dominated by huge vessels, which contrast distinctly with the smaller latewood ones. In diffuse-porous trees, like maple, beech and poplar, the vessel sizes are more evenly distributed throughout the ring. This makes the ring less obvious if counting.

Trees have evolved to grow taller in competition for light. When a tree is young, the amount of wood grown per year increases as the canopy grows larger. In this juvenile state, growth rings are typically uniform and the volume of wood added makes the tree larger each year. The extra wood can carry extra water and nutrients to the developing canopy. As the tree reaches maturity, upward growth slows down to a nearly imperceptible annual pace due to the negative effect of gravity on transpiration at greater heights. Branches lower in the crown may retain much of their juvenile growth rate, causing the tree to become more broad in crown form as it matures. These changes in growth habit, along with scarcity of water and nutrients, result in progressively narrower growth rings once the tree matures. Chronic scarcity of water and nutrients, coupled with diminished growth and stress from diseases, pests, and injuries, lead to terminal **senescence** of the tree at the end of its lifespan. Indicators of senescence include shortened twig internodes, diminished foliage production and canopy size, and branch dieback.

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.

Did You Know?

Conifers tend to have more lignin and less cellulose than hardwoods.

How Long Do Trees Live?

Trees have 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. Tree species usually fall into two categories of life strategy: grow fast-die young and grow slow-live long. These strategies generally align with early-succession and late-succession habitat preferences. Early succession species grow rapidly to take advantage of abundant ephemeral resources (light, space, nutrients) following land disturbance. As such, they invest energy primarily in rapid growth rather than sturdy tissues and strong defense systems. In contrast, late succession species opt to grow slowly and develop sturdy tissues and strong defenses to better tolerate competition and resource scarcity. Therefore, early succession species often have lifespans measured in decades and late succession species measured in centuries. In urban areas, trees rarely achieve their biological maximum lifespan due to pollution, injury, and poor growing conditions.

Dicots vs. Monocots

Most trees are dicots. This means that they have two “seed leaves” in the seed. Leaves of dicots have veins that are branched. Monocots only have one “seed leaf” and have veins that are parallel to one another. The Palmaceae (Arecaeaceae) family which includes palms are monocots and not true trees. In fact, they are more closely related to grasses and lilies. Palms only have one apical meristem and no secondary growth and do not get wider as they grow older. 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.

Types of Trees

Trees are 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 fleshy coverings (fruit). Their seeds are exposed between the scales of cones; thus, they are often referred to as **conifers**.

Gymnosperms generally have un-showy 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.

Tree Reproduction

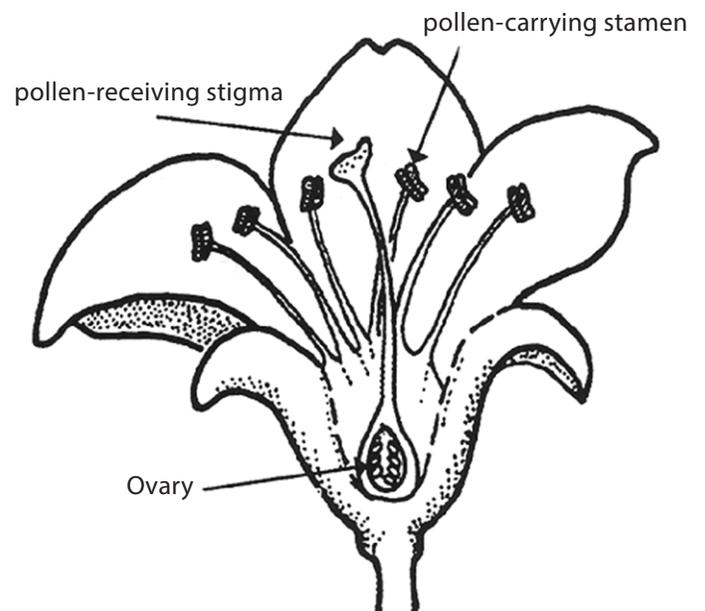
Dicot trees are further classified as gymnosperms (conifers and ginkgo) and angiosperms (flowering plants). Common broadleaf trees such as oaks and maples are angiosperms. Gymnosperms and angiosperms are both seed plants, but their reproductive structures differ. Gymnosperms have male cones that disperse sperm in pollen to the female cone where fertilization occurs for the development of seed. Angiosperms carry their sexual parts in flowers. 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.

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 a seed enclosed in a protective covering, commonly recognized as a nut or fleshy 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 ginkgo (*Ginkgo biloba*) trees, planting male trees will avoid unpleasant fruit. Unfortunately, determining the sex of dioecious trees is rarely possible until flowering or fruiting occur. In the case of hollies, planting female trees results in beautiful berries in the fall. Some trees have been purposefully bred to eliminate flower or fruit production in order to prevent problems with excess pollen or fruit litter in urban areas.



Gymnosperms include conifers and Ginkgos



The oldest trees, conifers, are wind-pollinated but flowering plants evolved to become insect-pollinated. Some flowering plants have reverted back to wind pollination. The table below describes the flowering dates, pollination method and fruit or cone type of many common species found in Virginia.

Common Name	Pollinator	Fruit/Cone Type
Alder	Wind	Woody cone with nuts
Apple	Insects	Pome
Ash	Wind	Samara
Beech	Wind	Nut
Cherry	Insects	Drupe
Elm	Wind	Samara
Holly	Insects (honey bees)	Drupe (3+ stones)
Maple	Wind & small insects	Samara
Oak	Wind	Nut
Poplar	Wind	Capsule
Viburnum	Insects	Drupe
Willow	Insects & Birds	Capsule
Juniper	Wind	Fleshy cone
Yew	Wind	Seed with Aril

Table reference: The Woody Plant Seed Manual - USDA Forest Service, Agriculture Handbook 727

Key Questions:

1. How do photosynthesis and respiration work together?
2. How does water move up from tree roots into the leaves?
3. How do roots absorb water?
4. What can happen when minerals or salts build up in tree root zones?
5. What parts of trees are generally energy sources? Energy sinks?
6. Why do roots grow down?
7. Why do shoots grow up?
8. What trees are wind versus insect pollinated?
9. What differentiates gymnosperms and angiosperms?
10. Which group produces cones?
11. When should the sex of a dioecious tree be of concern?
12. What controls tree growth?

Resources

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Unit 3

Environmental Factors Affecting Trees

Trees are highly evolved organisms with anatomical and physiological adaptations finely tuned to their growing environments. Regardless of ecosystem, trees are all influenced by a similar set of environmental factors that affect metabolism, growth, and reproduction. It is the unique combinations of these environmental factors that define ecosystem types and determine the genetic adaptability that tree species from particular ecosystems possess. In this unit, we will examine the primary environmental factors affecting trees in urban areas and discuss their implications for tree planting and management.

Light

Light is the key environmental factor affecting trees because it provides the energy to drive photosynthesis and fuel tree metabolism. The sun's rays are electromagnetic radiation with varying wavelengths. Trees are most responsive to light in the visible light spectrum and use mostly blue and red wavelengths to drive photosynthesis. Light quality can be affected by surfaces and structures that intercept

or reflect light around trees. For example, heavy shade from overstory vegetation or buildings diminishes the quality of the light for driving photosynthesis and may induce changes in the tree to gather more light (shade leaves) or to reach light (phototropism). In urban areas, glass, metal, and concrete can reflect sunshine upon trees and increase light intensity to stressful levels.

The amount of light also varies with the daylength. Long days of spring and summer provide greater light energy for trees to photosynthesize and store carbohydrates. Seasonal changes in daylength are sensed by trees using a specialized protein called phytochrome, which then signals photoperiodism responses such as flowering, fruiting, and leaf abscission. In urban areas, photoperiodism may be disrupted in sensitive tree species by high intensity lights that mask the length of day and night.

Tree species vary in their light needs based on the ecosystem where they evolved and their successional niche. Shade-intolerant trees tend to be early successional species that need high light intensity to thrive and cannot

effectively photosynthesize in low light conditions. Shade-tolerant trees tend to be late successional species that cannot tolerate long durations of high intensity light and will become stressed. Clearing overstory vegetation around shade-tolerant trees increasing light intensity to stressful levels. Likewise, planting shade intolerant trees in heavy shade may adversely affect growth and development. Many species are intermediate in their light demands and can acclimate to varying light conditions, which provides flexibility for where to plant the trees and how to manage surrounding vegetation.

Temperature

Air temperature is another source of sun energy that influences trees. All metabolic reactions inside trees have an optimum temperature range to operate correctly. Above freezing, metabolic reactions progress more rapidly as temperature rises. However, excessive heat damages enzymes and proteins inside trees and causes metabolic stress. In urban areas, trees may experience excessive heat in parking lots and along streets where asphalt absorbs and reradiates sunlight energy. Trees may also encounter excessive heat if situated next to exhaust vents or machinery operating at high temperatures. Tree species adapted to colder climates often do not thrive when planted in hot regions because the heat disrupts their metabolism and they become vulnerable to secondary stresses such as drought or pests.

At the other extreme, metabolic activity will slow as the temperature approaches freezing. In the dead of winter, very little metabolic activity is occurring in trees due to the absence of energy (warmth) to drive enzymes. When temperatures drop below freezing, trees may suffer anatomical injuries, depending on the adaptations that are inherent to the species. Cold-hardy trees modify their cell membranes and cytoplasm to avoid ice crystal formation that ruptures cells. Think of it as a combination of anti-freeze and freeze-drying. Tree species from tropical and sub-tropical climates lack these adaptations and will die when exposed to sub-freezing temperatures. Likewise, tree species from mild temperate climates cannot tolerate the extreme cold of northern latitudes because their adaptations are insufficient to protect them. In urban areas, trees may encounter abnormally low temperatures at higher elevations or in frost pockets that develop overnight when cold air settles in low spots or against impermeable structures.

Extreme cold in the middle of winter may cause branch and trunk injuries such as frost cracks and sunscald due to rapid fluctuations in wood temperatures that fracture wood fibers and kill vascular cambium. Late season frosts that occur after trees begin breaking dormancy may kill buds or newly emerging foliage, flowers, and stems. Marginally hardy tree species and low vigor trees seem to be more vulnerable to cold temperature injury. Therefore, use caution when selecting tree species and keep trees healthy through proper cultural practices.



Sunscald on a newly planted street tree.
Image by Matt Wolanski

Wind

Air flow around trees affects gas exchange, water loss, and stability of trees. The speed and persistence of wind depends upon major weather patterns and orientation of landscape features that funnel and deflect wind. Persistent windy conditions may exist in coastal areas, mountainous areas, and open areas around lakes and fields. In urban areas, large buildings and walls can accelerate wind beyond normal conditions. Extreme wind speeds may occur during hurricanes, tornadoes, thunderstorms, and winter weather. Trees may uproot or break during extreme winds, especially if the tree has existing defects such as cracks, decay, included bark or a compromised root system. Moderate winds can defoliate trees or exacerbate drought stress by increasing transpiration from the leaves. Trees growing in windy locations should be monitored closely during droughts because they will dry out more quickly and may need greater irrigation. Lack of wind can also be a problem for certain foliar diseases. Air currents do not circulate well in landscapes with dense vegetation, which means foliage is slow to dry out after rainstorms or overnight dew. This creates conditions where fungal diseases such as powdery mildew can proliferate. Trees prone to fungal diseases should be planted where air will circulate properly. Vegetation clearing and canopy thinning can also improve air circulation.

Soil

Soil is the substrate covering the Earth's surface that is a reservoir for water and nutrients and habitat for roots and associated organisms. Soil originates from the weathering of bedrock intermixed with decomposing organic matter and atmospheric gases.

The nature of the original rock – granite, sandstone, limestone, etc. – determines the basic mineral and nutrient 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.

Some soils have an **organic horizon (O)** on the surface which may be present in forests and other undisturbed locations.

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**, nematodes, earthworms, bacteria, fungi, insects, 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.

Under ideal circumstances, air and water make up about 25% each of the soil volume. The other 50% of soil volume is made up of solid matter. Of that 95% are inorganic components such as sand, silt, clay and gravel and 5% are organic.

Soil Texture

The bulk of the solid material in soil is a mixture of tiny mineral particles. These particles have unique characteristics based on their size and chemical composition. The basic particle types, in ascending size, are clay, silt, and sand. Most soils are a mixture of these particle sizes. Gravel (sizes greater than 2 mm) are not considered when determining texture, but are also part of the inorganic component of soils. We use the term soil texture to describe specific combinations of soil particles. The term texture refers to our ability to distinguish texture classes by rubbing and handling soil. Scientists distinguish between 12 different soil texture classes based on the percent composition of clay, silt, and sand. Each texture class has unique properties in relation to aeration, drainage, and nutrient retention.

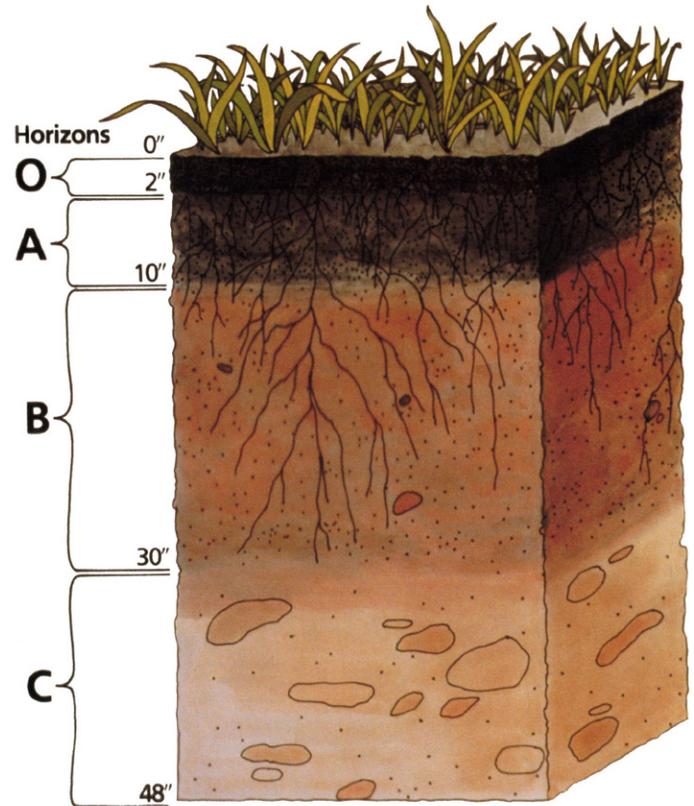
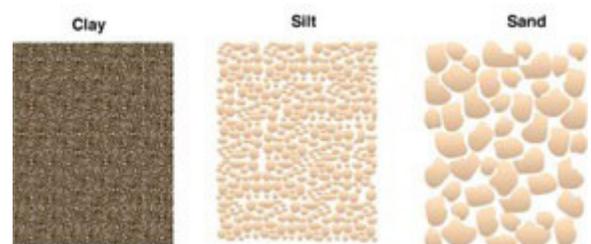


Image by USDA - NRCS

- **Sand** is relatively coarse (0.5 mm – 2 mm). Sand has good aeration and drainage potential due to its larger size but typically poor nutrient retention ability.
- **Silt** is finer (0.002mm – 0.5mm). Silt particles feel like flour and are intermediate in properties between sand and clay. However, it has high erosion potential.
- **Clay** is composed of the finest particles (less than 0.002 mm). Clay has high nutrient retention and water holding capacity but can have poor aeration and drainage. Clay is also easily prone to compaction.
- **Loam** is not a size of soil particles but a near equal mix of the three. This creates the ideal balance of properties and is ideal for plant growth.



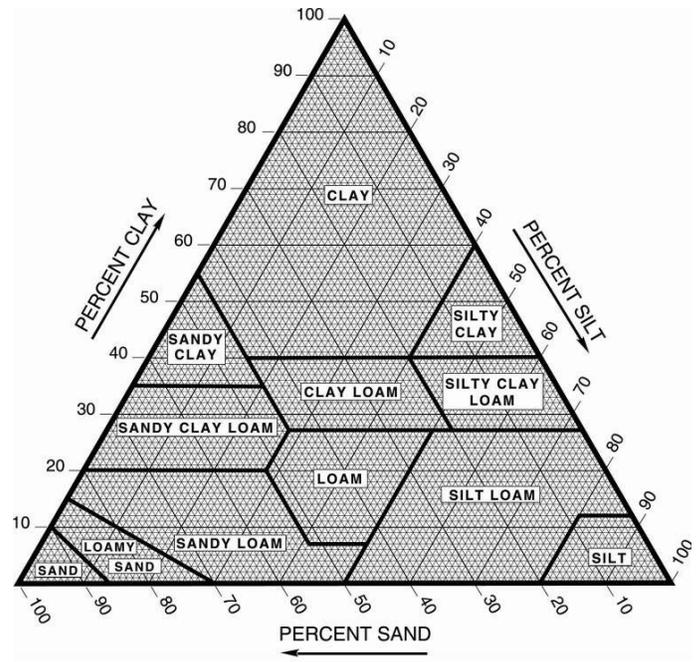
Sandy soils tend to be well drained and aerated and resistive to compaction, but do not hold water and nutrients well. Clayey and silty soils tend to have the opposite properties. For these reasons, a soil containing a blend of clay, silt, and sand (called loam texture) has the best balance of characteristics for productive tree growth and development. Loam is the common native topsoil (surface 6-12" of soil) throughout much of Virginia. However, topsoil is often absent or highly degraded in urban areas due to erosion and grading. More commonly we encounter soil that is predominantly clay and silt, which creates problems with soil drainage, aeration, and compaction.

The texture triangle can be used to estimate the percentages of sand, silt and clay and distinguish between different soil types. Texturing is a fun way to get your hands dirty and learn a little more about the physical properties of soil. Some tips for getting started are to the right.

Soil Organic Matter

The other component of soil solids is organic matter, decomposing plant and animal tissue. A healthy soil in Virginia typically contains 3-5% organic matter. The benefits of organic matter to trees are numerous. It provides food for a wide diversity of organisms that inhabit the soil. The activity and by-products of these organisms improve soil health. Their movements loosen and mix the soil and their excrements bind and stabilize the soil. Microbes are typically the final link in the food chain that break down highly decomposed organic matter into small molecules and elements that become nutrients available for tree uptake.

Urban soils are often deficient of organic matter due to erosion of rich topsoil and lack of organic matter replenishment from plants and animals. 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. As a result, the soil contains fewer nutrients and lacks good structure for root system function. 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 texture triangle. Image by International Society of Arboriculture, Bugwood.org

Determining Soil Texture

Tip 1: Wet the soil sample down and try to make a ribbon out of it. For every inch on the ribbon estimate 10% clay.

Tip 2: Roll two small balls of the same size of wetted soil. Use the spray bottle and break up the ball in the palm of your hand. The silt and clay will wash away leaving the sand. Use the second ball to estimate the percentage sand.

Tip 3: Once you have sand and clay percentages you can estimate the silt from the triangle or by subtracting the % clay and sand from 100%.

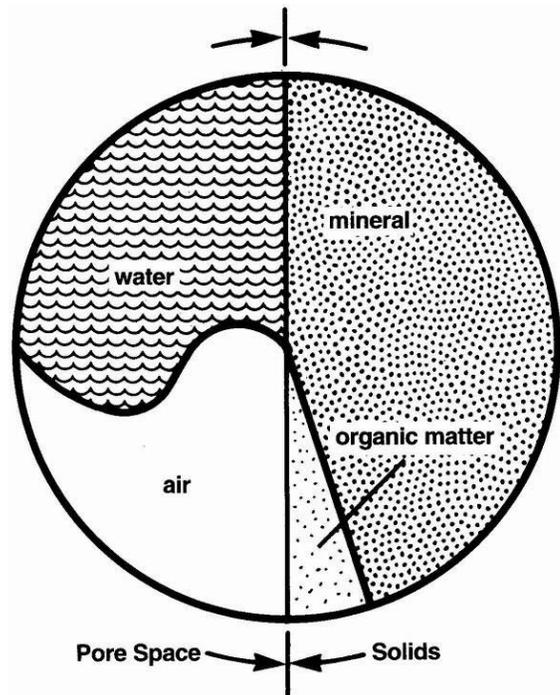
Soil Porosity

Soil particles clump together to form aggregates that pack together with small and large spaces between them. These spaces are called pores because they are the pathway of movement for liquids and gases. In a healthy soil, about half of the total volume is pore space, and there are a mix of small and large pores, called micropores and macropores. Water and air move rapidly through macropores, but slowly through micropores. However, water clings to the surface of micropores better, which is important for soil moisture retention during droughts. Macropores comprise most of the porosity in sandy soils, making them well-aerated, but vulnerable to drought. Micropores comprise most of the porosity in silty and clayey soils, making them prone to poor drainage and aeration. Loamy soil has a balanced mix of small and large pores, making them ideal for proper drainage, aeration, and moisture retention. Macropores are easily compressed into micropores when soil is compacted, so urban areas often have problems with low porosity, especially in clayey soils where particles are easily compressed and packed together.

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. Impaired soil has reduced waterflow, reduced nutrients and air space available to the roots and restricted drainage away from the roots. Soils that are compressed or that contain little organic matter, like sand, may allow leaching as rapid runoff carries nutrients away from the topsoil. The major causes of soil compaction are raindrop impact and mechanical pressure from machinery, wheels, hooves and feet. Mulch, leaf litter and/or strong root systems significantly reduces the compaction and erosion power of raindrops.

Soil pH

Soil **pH** is the relative acidity or alkalinity of the soil. A pH value of 7 is neutral, with lower values being acidic, and higher values being alkaline. Soil pH varies widely depending on the mineral types in the soil, organic matter content, weather, and management practices. Soil pH is a critical property of the soil because it dictates the availability of nutrients and activity of soil organisms. Most tree species evolved in ecosystems where organic matter accumulates in the soil and releases acids, making the soil mildly acidic (5.5 – 6.5). Therefore, many of the trees we cultivate in urban forests prefer a soil pH in this range. When pH moves outside this optimal range in either direction, nutrient deficiencies are likely to develop in the soil and impact tree health. In urban areas, we often encounter soils with elevated (alkaline) pH due to the abundance of concrete, which leaches calcium



Soil composition. Image by International Society of Arboriculture, Bugwood.org

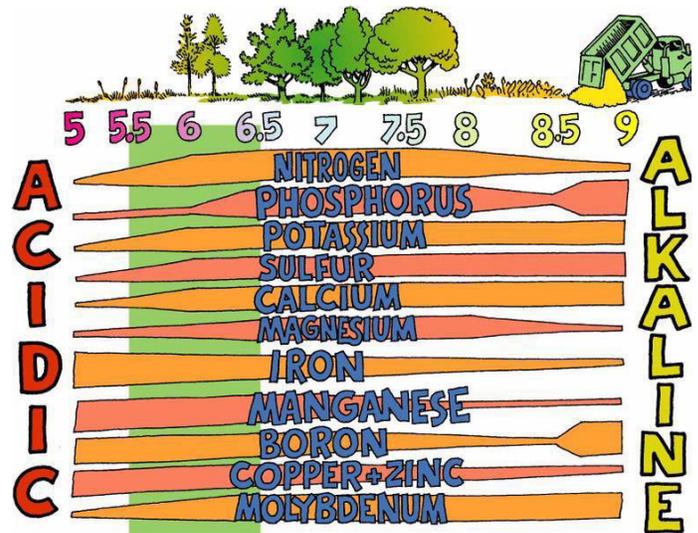
Did You Know?

Soils with a pH less than 7 are **acidic** and those above 7 are **alkaline**. The pH scale is logarithmic; each measurement unit 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.

and magnesium into nearby soil and raises the pH. Acid-loving tree species in alkaline urban soils often suffer deficiencies of iron, manganese, or phosphorus. Excessive acidity is rarely encountered in urban soils except for situations of industrial sulfur compound contamination or overuse of fertilizers or compost. Soil pH can be adjusted into a desirable range by applying amendments based on a soil test. However, some soils are highly resistant to pH changes and the adjustments may not persist. Therefore, it is best to select a tree species that can adapt to the existing soil pH.

Soil Fertility

Trees depend on soil nutrients in the form of essential elements in order to properly grow and develop. These essential elements are released into the soil by weathering of minerals and decomposition of organic matter. Nitrogen (N), phosphorus (P), and potassium (K) are the nutrients needed in large quantities for tree health and are called primary **macronutrients**. Secondary macronutrients include sulfur (S), calcium (Ca), and magnesium (Mg), which are needed in intermediate quantities. **Micronutrients** are needed by the tree, but in smaller amounts. These include: Copper (Cu), Iron (Fe), Manganese (Mn), Chlorine (Cl), Cobalt (Co), Molybdenum (Mo), Zinc (Zn), and Boron (B). Each nutrient plays a specific role in tree metabolism. Nitrogen is found in amino acids and helps build chlorophyll in the leaves. Phosphorus can be found in cell membranes and is part of the process that converts carbohydrates into energy. Potassium helps plants absorb water and create favorable concentration gradients. Deficiency of a nutrient may become evident as changes in the size, shape or color of leaves. Chlorosis is a yellowing of foliage commonly associated with nutrient deficiencies. A soil test can confirm which nutrients are deficient and provide recommendations on fertilizer application to correct the deficiencies.



Soil pH affects nutrient availability. Image by International Society of Arboriculture, Bugwood.org

Soil Salinity

Many chemical substances exist in the soil as charged particles called ions. Some of these may accumulate to excessive levels and disrupt the availability of essential elements or water uptake by roots. Elements commonly causing salinity problems are sodium, chlorine, carbonate, and bicarbonate. These elements may accumulate to toxic levels in urban soils due to heavy fertilizer application, deicing salts, coastal salt spray, saltwater intrusion, or contaminated irrigation. Trees experiencing salinity toxicity may have foliage burn due to dehydration or chlorosis due to calcium and magnesium deficiency. Excess salinity can be corrected by adjusting toxic inputs, watering the soil to leach salts, or applying gypsum to neutralize salts.

Soil Depth and Volume

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.

In urban areas, lateral spread of tree root systems is often limited by streets, sidewalks, building foundations, and



Tree failure following a strong storm. Restricted roots were not able to stabilize the tree. Image by Joseph OBrien, USDA Forest Service, Bugwood.org

utility vaults. As a result, the total volume of soil available to anchor the tree and store water and nutrients is limited. When soil volume is limited, trees may be unstable or suffer chronic drought stress. Large-maturing trees planted in restricted soil volumes are often stunted, unhealthy, and die prematurely. That means fewer trees and less canopy cover. Strategies for increasing soil volume are discussed in [Unit 6](#).

Water

Water is critical to photosynthesis, respiration, transpiration, and translocation. Without adequate water, tree metabolism is compromised, resulting in slower growth and reduced defense mechanisms. Extended drought or inadequate irrigation is a common cause of tree stress and mortality. Excessive water can also be a problem. Soil that does not properly drain becomes waterlogged, leading to oxygen depletion, which asphyxiates roots and creates favorable conditions for root diseases. Wet soil can also lead to uprooting of large trees when the soil becomes soft and slippery.

How Water Moves

When water falls onto the earth's surface, it enters the soil, and eventually flows into a body of water. 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.

Soil is a reservoir for water between precipitation events. The water percolates down through soil pores and accumulates in deep soil horizons saturated with water. Closer to the soil surface, water clings to soil particles in micropores (small soil pores, usually found within structural aggregates, with diameters less than 0.08 mm). After precipitation, once soil has drained its macropores (large soil pores, usually between aggregates, that are generally greater than 0.08 mm in diameter) and yet still retains water in micropores, it has reached **field capacity**. As time goes on, evaporation and root uptake deplete water from the micropores. Eventually the soil becomes so dry that it reaches the **permanent wilting point**. At that point, plants can no longer exert enough suction on the water to absorb it and the leaves then wilt. Soils vary in the amount of water they contain between field capacity and permanent wilting point, known as **plant available water**. Optimum surface soil moisture occurs when 50% of the pore spaces are filled with water. Sandy soils tend to have limited plant available water because the macropores drain readily and few micropores exist to hold water. Clayey soils likewise have limited available water because their abundance of micropores hold water strongly against root suction. Intermediate soils (silty and loamy) tend to have the greatest plant available water due to the mixture of large and small pores.

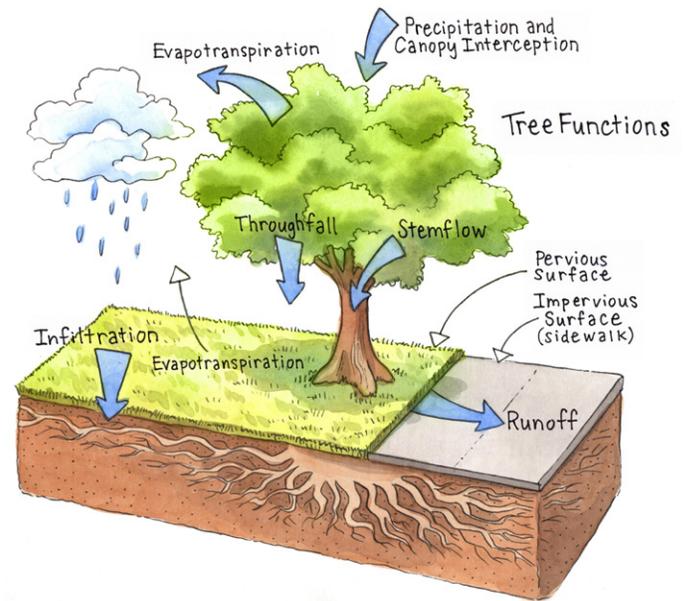
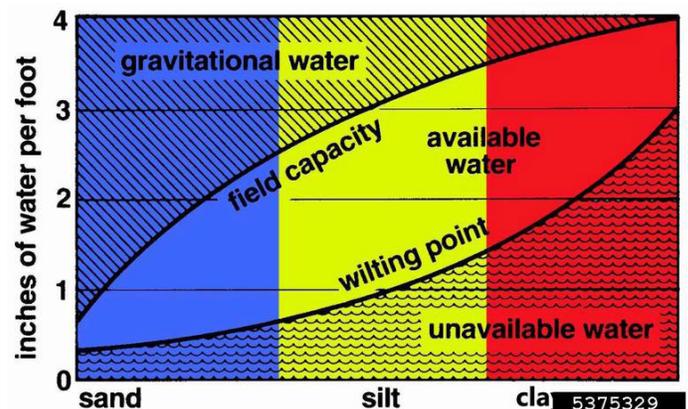


Illustration by Green Infrastructure Center Inc.

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.



Soil texture and water relationships. Image by International Society of Arboriculture, Bugwood.org

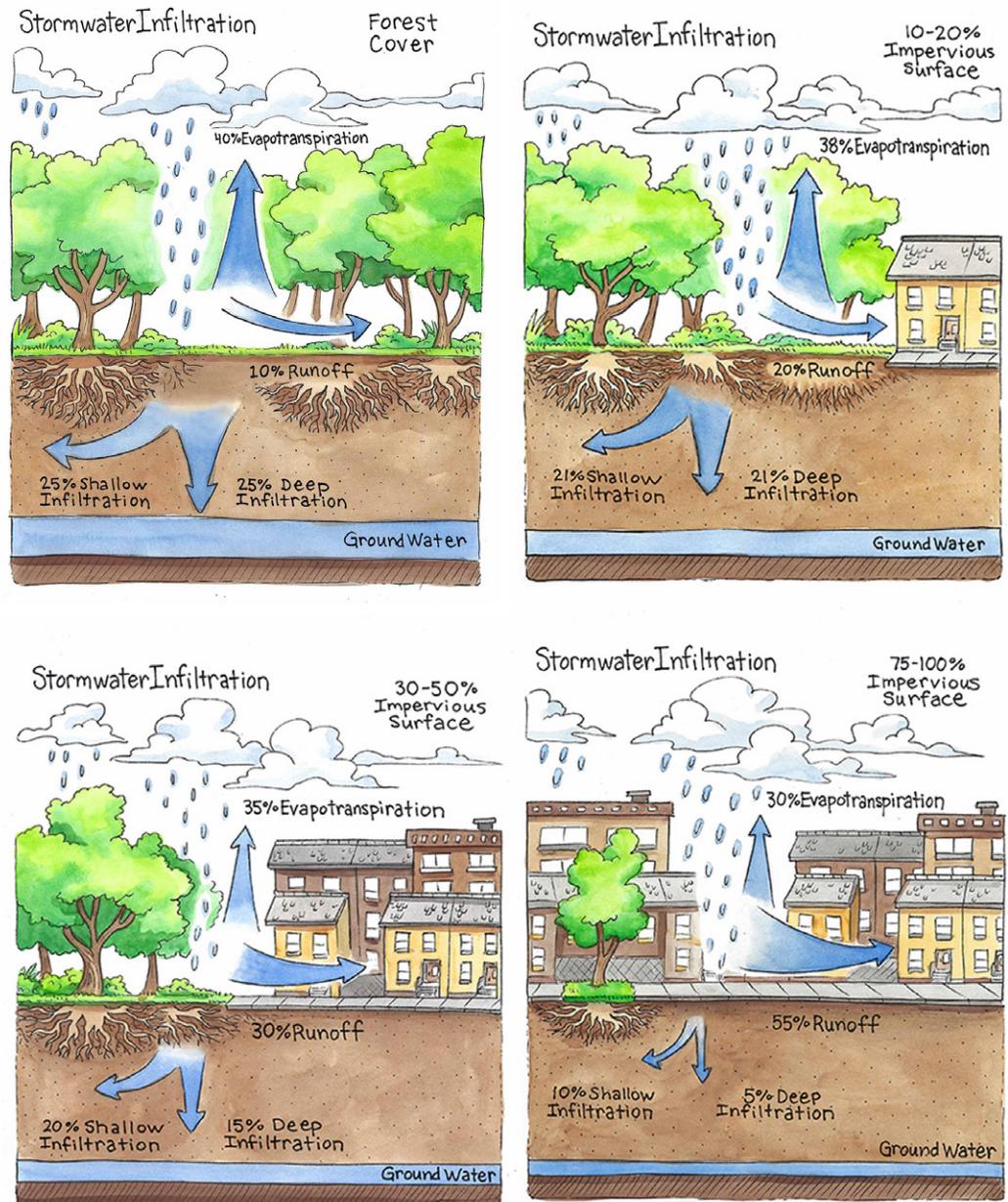
Water Management

In urban areas, drought conditions often occur because much of the precipitation falls upon impervious surfaces that keep water from infiltrating the soil. Water also has a hard time infiltrating soil that is compacted or lacks an organic ground cover (leaf litter or mulch). At the other extreme, urban soils may hold too much water because runoff is concentrated by roofs, pavement, and gutters or the soil is slow to drain due to compaction and high clay content. Drainage measures the rate and extent of water movement down through the soil. Drainage is affected by soil texture 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.

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

Tree species vary in their tolerance of drought and flooding. Irrigation of drought sensitive trees may be necessary during extended dry spells or for trees with confined or compromised root systems. Soil that has poor infiltration due to compaction or surface crusting can be improved by applying mulch or compost, which roughens the soil surface and encourages biological activity that improves porosity. Mulch also protects the soil from erosion, which could affect root anchorage and tree stability. Heavily compacted soil may require tilling to loosen the soil surface

prior to mulching. **Mechanical tillage** can be used on soil prior to planting and **air tillage** can be used around existing trees. Addressing excessive water or poor drainage is more challenging, especially around established trees. Options include diverting sources of runoff by adjusting downspouts or building berms and swales. In some cases, a drain tile may need to be installed below the soil surface. When planting new trees, be sure to first assess water flow and soil characteristics on the site so that species can be selected that will tolerate the moisture regimes.



Relationship between impervious cover and surface runoff. Illustration by Green Infrastructure Center Inc.

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 and Sedimentation** – Water that moves rapidly across the soil surface has the potential to cause significant erosion, resulting in the loss of topsoil and associated nutrients and depositing of sediment into waterbodies.
- **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. Examples include bald cypress, river birch and sycamore.

Trees, Water Quality and Riparian Buffers

Many urban rivers and streams have lost benefits for wildlife and passive recreation for people. Removal of streamside vegetation for land use changes and infrastructure has reduced the natural ability of streams to cleanse themselves. Local governments are faced with the challenge of planning riverfront re-development with residential, commercial and industrial sites for economic growth, while creating better river function for flood control. Also, 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 these 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.

In “the Woods”

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.

Once these soil pore spaces are filled, overland flow leads to increased stream flow.

Stream flow remains elevated for some time, dependent on the intensity of the rain event and other factors.

In “the City”

Heavy thundershowers quickly fill storm gutters and street gutters or ditches and they run with muddy water.

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.

This “lost” water causes flooding downstream, compounding the problems related to water management in urban areas.



Through planned reforestation urban **riparian forest buffers** are returning to some urban waterways. Remnants of riparian forest buffers are being enhanced to provide shade for passive recreation and habitat for terrestrial and in-stream wildlife. A riparian buffer can offset many of the effects of development because of the inherent benefits it provides. All of the benefits are dependent on sheet flow of surface water through the riparian buffer. Be cautious of piping around the buffer and concentrated flow paths.

Stormwater 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.

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.

Key Questions:

1. Why do tree species vary in their light demands?
2. What are some examples of stressful light conditions found in urban environments?
3. Explain how extreme urban heat predisposes trees to drought and pest stress.
4. Identify adaptations that trees possess to tolerate freezing temperatures.
5. Describe the circumstances where you might anticipate wind damage to trees.
6. What are the ideal proportions of mineral solids, organic matter, and pores in a healthy soil?
7. What are the sources of soil organic matter and how does it promote soil health?
8. Define soil compaction and explain how it alters soil characteristics favorable to tree growth.
9. Compare and contrast sandy, loamy, and clayey soils in terms of their drainage and water retention.
10. Why is pH a critical soil characteristic when selecting and cultivating trees in urban landscapes?
11. How does excess soil salinity adversely affect trees?
12. Explain how landscape trees improve water quality and control stormwater runoff in urban areas.
13. What is a riparian forest buffer?

Resources

- Drought, Heat & Trees Manual (2018). University of Georgia. Available at: <https://www.warnell.uga.edu/outreach/publications/individual/drought-heat-trees-learning-manual>
- Shade Management Beneath Trees (2018). University of Georgia. Available at: <https://www.warnell.uga.edu/outreach/publications/individual/shade-management-beneath-trees-0>
- Soil Health Manual Series Fact Sheets. Cornell University. Available at: <https://soilhealth.cals.cornell.edu/soil-health-manual-series/>
- Tennessee Riparian Forest Buffer Handbook. Available at: <https://www.tn.gov/content/dam/tn/agriculture/documents/forestry/UrbanRiparianBufferHandbook.pdf>
- Trees & Cold Temperatures (2017). University of Georgia. Available at: <https://www.warnell.uga.edu/outreach/publications/individual/trees-cold-temperatures>
- Trees Tame Stormwater Poster by the Arbor Day Foundation. Available at: <https://www.arborday.org/trees/stormwater.cfm>
- Water & Tree Health Manual (2018). University of Georgia. Available at: <https://www.warnell.uga.edu/outreach/publications/individual/water-tree-health-manual>
- Web Soil Survey by NRCS. Available at: <https://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/home/>
- Wind and Trees (2007). University of Florida. Available at: <https://hort.ifas.ufl.edu/woody/documents/FR173.pdf>
- Up by Roots by James Urban (2008). International Society of Arboriculture



Unit 4

Tree Identification

Tree stewards need to be able to ID trees so they can determine when/where/how to plant, when/how to prune, diagnose problems, etc. If you don't know what they are, you are really in the dark in trying to support them.

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, form 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 scientific names.

Scientific Name

A tree's scientific name identifies both the **genus** and **species** to which it belongs. Trees within the same genus (pl. genera) are closely related in evolutionary lineage and have many strong similarities. When identifying trees, consider the genus as the “general” group to which the tree belongs. For example, *Quercus* comprises oaks.



Magnolia grandiflora- southern magnolia

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 redcedar) 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 plane tree (platanoides: "like Platanus"). **Cultivars** (cultivated varieties) are distinct forms of a species that have been produced through careful breeding and selection and maintain their desirable characteristics during propagation. For instance, *Acer rubrum* 'Red Sunset' is a cultivar of red maple named for its bright red-orange fall color.

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. Some computer programs use multichotomous keys.

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 space or adequate water and nutrients will stunt leaf, trunk and canopy growth in trees that might normally grow much larger at maturity.

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!

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 imbricaria*).

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*).



Simple



Compound



Opposite



Alternate



Entire



Lobed

Leaves

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 stem is also recognizable.

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. Compound leaves are sometimes confused with simple leaves arranged in opposite or whorled form. The key to distinguishing these is to look for the axillary bud – a bud nestled between the base of the leaf and the stem. If there is a bud, it is a simple leaf. If there is no bud, then it is a compound leaf.

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.

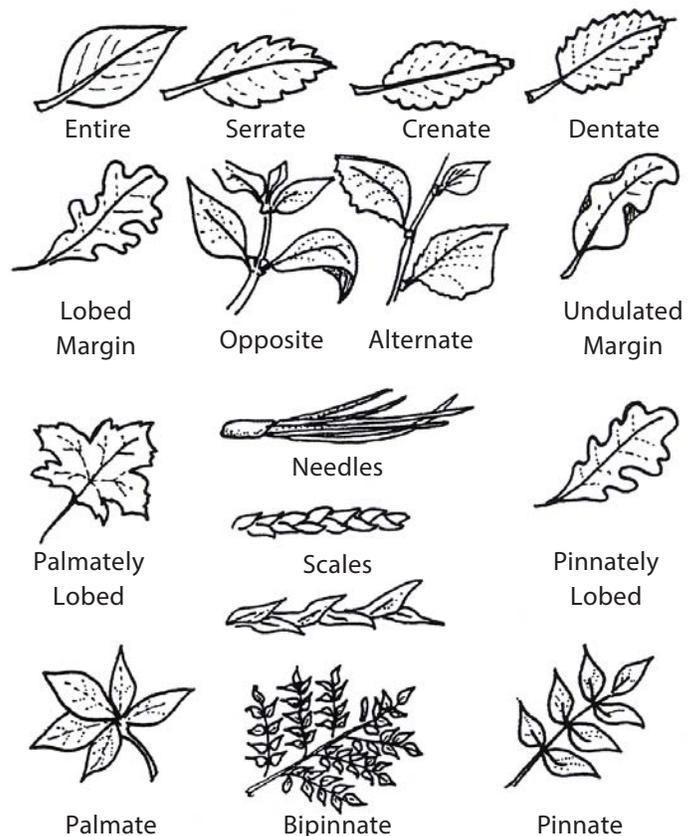
Identification of trees with needle-type foliage is made from the shape of the needles and the number and arrangement of the needles in bundles. Only pines have needles in bundles. As you become familiar with local trees, make notes on special characteristics that help you recognize them. Although leaf identification is one way to begin differentiating trees, learn to identify other characteristics as well. Remember that most deciduous trees will not be carrying trees in the 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://dendro.cnre.vt.edu/dendrology/factsheets.cfm>. Another reference to check for tree information is the *Manual of Woody Landscape Plants* by Michael A. Dirr, Department of Horticulture, University of Georgia.

Did You Know?

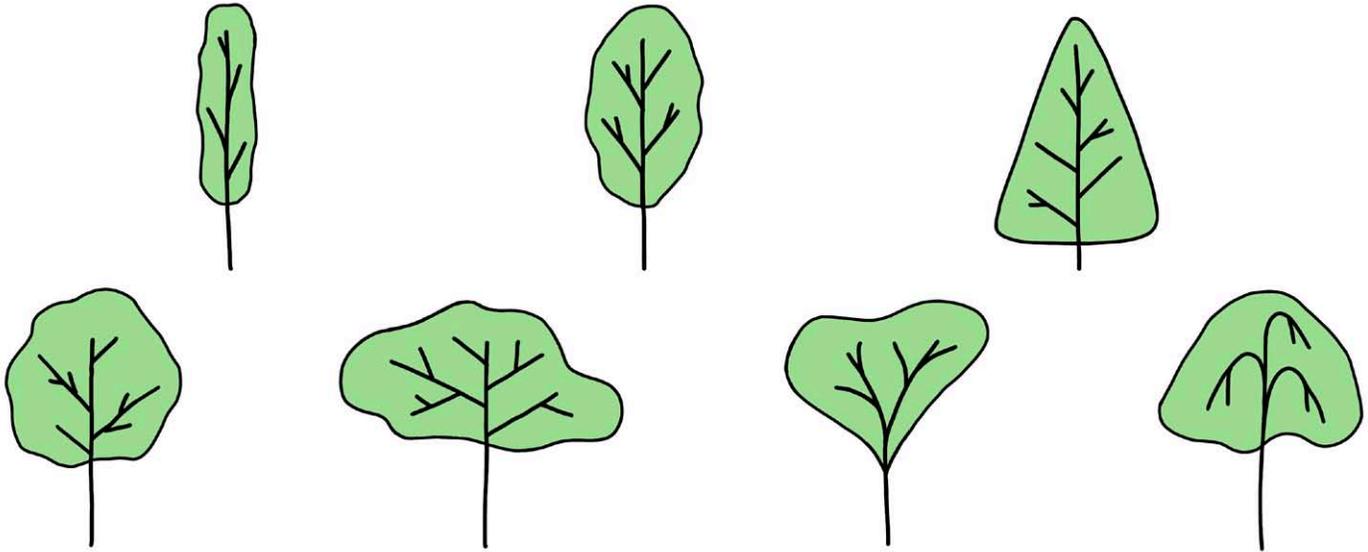
A good field guide includes clear information, illustrations or photographs of the leaves, bark, flowers or fruit, and sometimes autumn foliage. Always read the description carefully. Look for the subtle clues, such as leaf or twig hairs and bud arrangements. These reliably distinguish each tree species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



MADCap Horse:

Most common hardwood trees with *opposite branching* and leaf patterns can be remembered by the memory aid—MADCap Horse.

Maple • Ash • Dogwood • Caprifoliaceae • Horse-chestnut



Tree forms. Top: columnar, oval, and pyramidal. Bottom: round, spreading, vase and weeping. Illustration by Sarah Gugercin, Virginia Tech.

Tree Form and Structure

Tree form and structure can also help with identification. Some species have such distinctive form that they can be recognized by their overall shape and manner of growth (also known as growth habit). Tree form falls into seven basic categories: columnar, oval, pyramidal, rounded, spreading, vase-shaped, and weeping. A tree's form tendency is genetic, but other factors can affect growth including soil characteristics, wind, water, availability of light, and location.

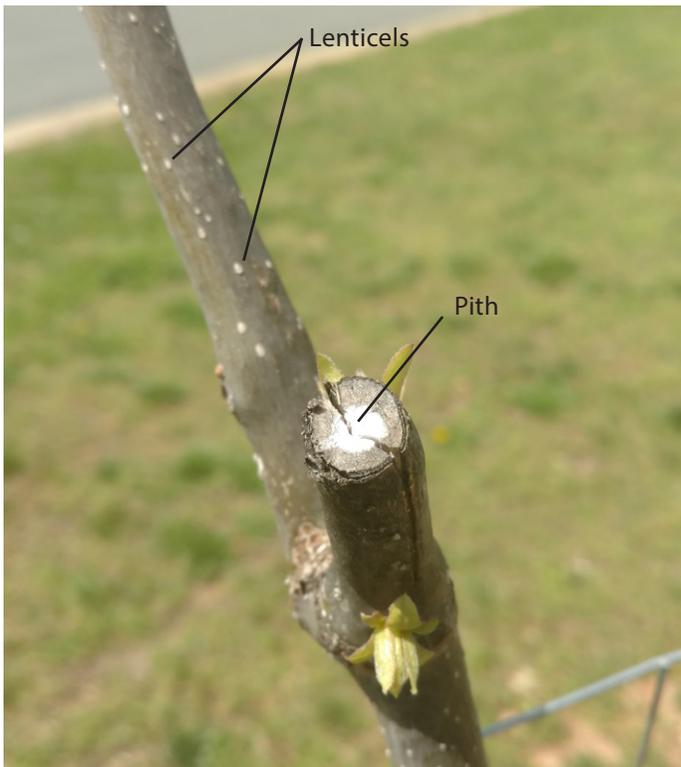
- **Columnar Form** – Columnar trees have a narrow, upright growth habit. The branches typically grow straight up instead of spreading sideways. The benefits of these trees include being able to fit in tight spaces and on small streets. Some examples include the 'Freeman' maple, 'Green Pillar' pin oak, 'Princeton Sentry' ginkgo, and Lombardy poplar.
- **Oval Form** – This form is narrow at the bottom, wide in the middle and narrow at the top. Some examples include sweetgum, blackgum or 'Washington' hawthorn.
- **Pyramidal Form** – This growth form is excurrent and looks cone shaped with triangular canopies. They usually cast ample shade when mature. Lower branches can droop. Some examples include spruce, hemlock, holly and bald cypress.
- **Rounded Form** – Rounded form is as the name implies, round and full like a sphere and is decurrent. Some examples include sycamore, several oak and maple species.
- **Spreading Form** – These trees have strong horizontal branches and seem wide. Some examples include dogwood, redbud, crabapple and Japanese maple.
- **Vase-shaped Form** – Vase-shaped trees have an inverted triangular shape. They work well near streets because they do not block the view of cars or people. Branches grow upright at a sharp angle from the trunk. Some common examples include elms and zelkova.
- **Weeping Form** – The branches of this form droop downward, typically having slender cascading branches. Weeping Willow is a well-known tree with this form but there are several weeping cultivars of cherries and maples also available.

Buds and Twigs

The shape, size, color, and texture of buds and twigs vary from species to species. Buds produce flowers and leaves and can be a great way to learn winter ID. Buds are either “scaly”– having a protective covering known as bud scales–or “naked”–lacking scales and having the developing leaves exposed and often look hairy. They are the resting stage of growth. *In many ID manuals twigs refer to the terminal portion of the branch that grew during the current year or preceding year.* Below are descriptions of the main parts of a twigs and buds.

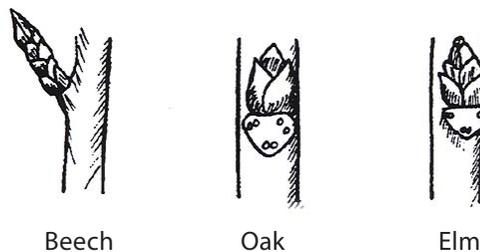


Terminal and lateral Buds on American Beech.



Lenticels and pith on Catalpa tree.

- **Terminal Bud** – The bud on the tip of every twig and is often larger than the lateral buds. **Apical dominance** inhibits the growth and development of lateral buds on the same stem, which is why terminal buds outgrow lateral ones. Some trees that can be easily identified by their terminal buds are tuliptree (duckbilled shaped) and oak (clustered buds).
- **Lateral Buds** – These buds are located on each side of the branch. Trees easily identified by a lateral bud are the American beech (cigar-shaped, scaled bud) and elm (off center buds over leaf scar).
- **Leaf Scar** – This is a scar where the leaf petiole was attached to the twig. When the leaf drops, a scar is left just under the bud. Some trees that are easily identified by the leaf scar include black walnut (3-lobed, monkey-faced), green ash (D-shaped) and white ash (U- shaped).
- **Bud Scar** – This scar results from the bud scales detaching from the twig when the terminal shoot elongates.
- **Lenticels** – Almost all trees have lenticels (pores that allow for gas exchange) but several trees are easy to identify due to visible lenticels on twigs and bark. Some examples include black cherry (long, narrow) and bigtooth aspen (diamond shaped).
- **Pith** – The pith is the spongy material in the inner core of the twig. Some trees easily identified by their pith are black walnut and butternut (chambered pith).



Common bud shapes.

Flowers and fruit

Tree flowers and fruit occur in a variety of shapes, sizes, colors and arrangements.

Tree flowers can be grouped into three broad categories:

Flower and fruit images by Virginia Tech Dendrology, Dr Dendro



Catkins – A dense cylinder of inconspicuous flowers (a spike). Examples include walnut, willow and hickory.



Clusters – Features many small flowers that occur in large branched groups. An example is an elderberry with its white flower clusters.



Solitary – Features a single flower. Some examples include dogwood and magnolia.

Tree fruits are the seed-bearing portion of the tree. Different tree fruits are identified below. They can either be found on the tree or be found on the ground.



Samara – A dry fruit (nut) surrounded by a papery tissue that is wing-like and enables wind to carry the seed. The fruit is indehiscent which does not split open to release the seed when ripe. Examples include white ash (single), sugar maple (double), tuliptree (aggregate).



Berry – A single fleshy fruit without a stone, typically contains several seeds. An example would include persimmon.



Pod – A dry fruit that splits on two sides. It is dehiscent. Examples include honeylocust and eastern redbud.



Nut – A large single hardened achene. They are indehiscent. Examples include Pignut hickory (husk) and White oak (acorn).



Achene – Single seeded dry fruit that does not open to release the seed. Examples include American sycamore and London plane



Drupe – A single fleshy fruit with a hard stone that contains one seed. Examples include black cherry and American holly.



Follicle – A dry fruit that splits only on one side. It is dehiscent. An example is a southern magnolia.



Pome – A fleshy fruit with thin skin. Seeds are contained in a chambered center of the fruit. Examples include common apple and pear.



Capsule – Dry fruit with most being dehiscent and split open to release the seeds within. Examples include Paulownia (oval) and sweetgum (gumballs).

Bark

Bark is the protective covering over the trunk and is created from cork cambium. Unlike deciduous leaves, bark, along with form, twigs and buds, can be used in the winter months to help with ID. There are a few broad categories for defining bark surface texture and patterns. These include smooth, lenticels, exfoliating, scaly, plated, and ridged. Different guides will describe and categorize bark differently and these selected categories are not all inclusive. It is important to note that there can be subtle to extreme variability within species, between mature versus young bark, and location and growth rate. All affect bark patterns and texture. Trees can also fit into multiple categories.

For example, black cherry and sycamore might have either smooth or scaly bark depending on age and growing environment.



Ridged – Elevated vertical crests divided by furrows (valleys between ridges) or fissures (cracks or crevices that are narrower than furrows). Ridges can intersect (ash) or be broken as in (red oak).



Smooth – Unbroken bark that is smooth and lacks ridges, furrows or other distinguishable features. Smooth bark is very common on younger trees but only some retain this bark type at maturity. A common example is American beech.



Scaly – Scales are roughly similar in size and usually small, thin and can be easily flaked off tree. An example is a black cherry.



Exfoliating – Bark that naturally peels away from the tree trunk either in large or small pieces and can either remain attached or detach from the trunk or branches with time and weather. Some examples include sycamore and shagbark hickory.



Plated – Plates on bark are usually relatively large, thicker and blockier than scales. An example is Shortleaf Pine.

Bark images by Virginia Tech Dendrology, Dr Dendro

Key Questions:

1. What two classification groups are used to make up a scientific name?
2. How do you use a dichotomous key?
3. Name some ways to ID trees during the winter?
4. List some examples of bark types and species examples?
5. List some examples of different fruit types and species examples?
6. How could you potentially ID a tree from a distance?

Resources

Dendrology Factsheets. Virginia Tech. Available at: <http://dendro.cnre.vt.edu/dendrology/factsheets.cfm>

Tree ID Apps: TreeSnap, and VTree

Bark: A Field Guide to Trees of the Northeast by M. Wojtech (2011). University Press of New England.

City Trees: ID Guide to Urban & Suburban Species by K.J. School (2011). Stackpole Books.

Common Native Shrubs and Woody Vines (2016). Virginia Department of Forestry. (.pdf available here: https://www.dof.virginia.gov/infopubs/Native-Shrub-ID-spreads_2016_pub.pdf)

Common Native Trees of Virginia (2020). Virginia Department of Forestry. (.pdf available here: https://www.dof.virginia.gov/infopubs/Native-Tree-ID_2020-spreads.pdf)

Eastern Trees by G.A. Petrides and J. Wehr (1998). Peterson Field Guides.

Identifying Trees by M.D. Williams (2007). Stackpole Books.

Nature Guide: Trees by T. Russell (2012). DK Nature Guide.

The Sibley Guide to Trees by D.A. Sibley (2009). Knopf.

Tree Finder by M. Theilgaard Watts (1991). Nature Study Guild Publishers.

What Tree is That? by the Arbor Day Foundation (2009). Arbor Day Foundation.

Winter Tree Finder by M. Theilgaard Watts (1991). Nature Study Guild Publishers.



Unit 5

Tree Selection

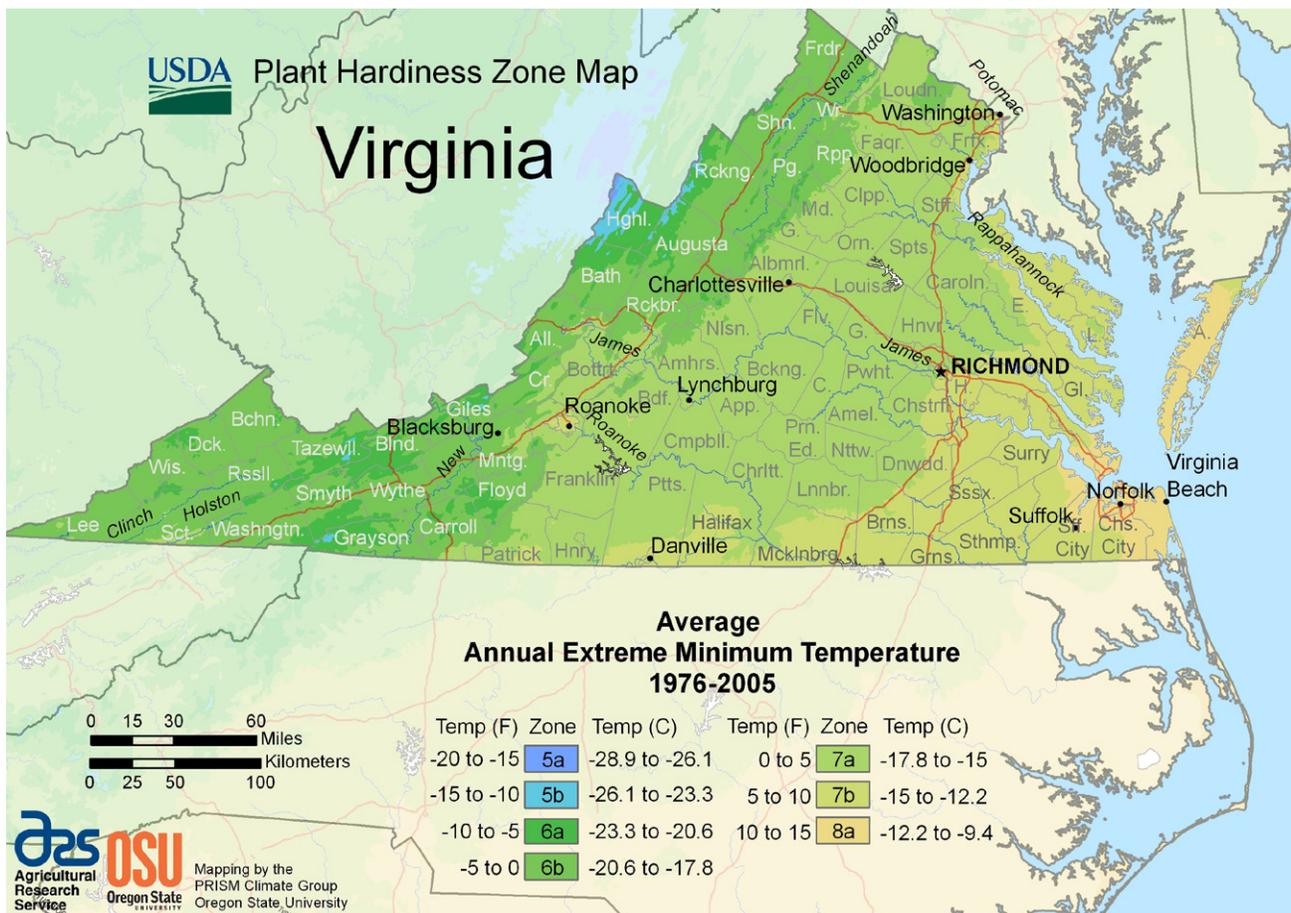
The choice of a tree species to plant and how a specimen should be cared for after planting depends upon many factors. Before selecting a tree, determine what the tree is expected to do. Will its main function be to provide shade or be an ornamental? Then get the right tree for the job. Remember that a tree is an investment of time and resources that we want to pay dividends, so choose carefully.

The Right Tree for the Right Place

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 just any available trees, do enough research and planning to ensure success. Taking a bit of time to plan before putting a tree in the ground will save money and headaches in the future. When choosing a tree, make sure to do a complete site evaluation to understand the conditions and ensure the best tree for the place chosen.



Tree planting demonstration in Carver Neighborhood with Richmond Tree stewards and VCU. Image by Wyatt Carpenter, VCU



USDA Plant Hardiness Zone. Image by PRISM Climate Group, Oregon State University

Hardiness Zones & Heat Tolerance

Some tree species possess the genetic 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 geographic areas that experience similar minimum temperatures annually and group them into zones. Most of Virginia is covered by zones 6 and 7, with some extreme cold (zone 5) in highlands of western Virginia and some mild cold (zone 8) in coastal areas.

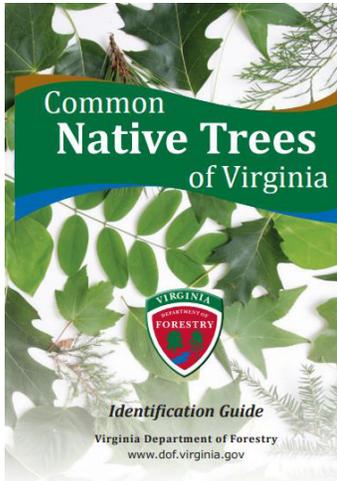
Heat tolerance is a plant's adaptability to high temperatures. A heat tolerance map shows high temperature zones across a region similar to a hardiness map. A collection of heat zone maps can be found at <http://www.gardeningplaces.com/heatzonemap>.

Native & 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 site such as a **tree pit**. There are no trees native to parking lots and tree pits.

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 known as **non-native invasives**. See [Unit 9](#) for more information on invasive species.



Common Native Trees of Virginia. Image by Virginia Department of Forestry

Microclimates Affect the Site

While a region can be defined in terms of general geography and environment, 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 shield a tree from wind or storm damage and allow a marginally hardy tree to survive. Arrangements of buildings can also create wind tunnels. 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 a 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 but 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.
- Concrete can impact pH and soil temperature in highly urbanized areas.
- 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 type 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.

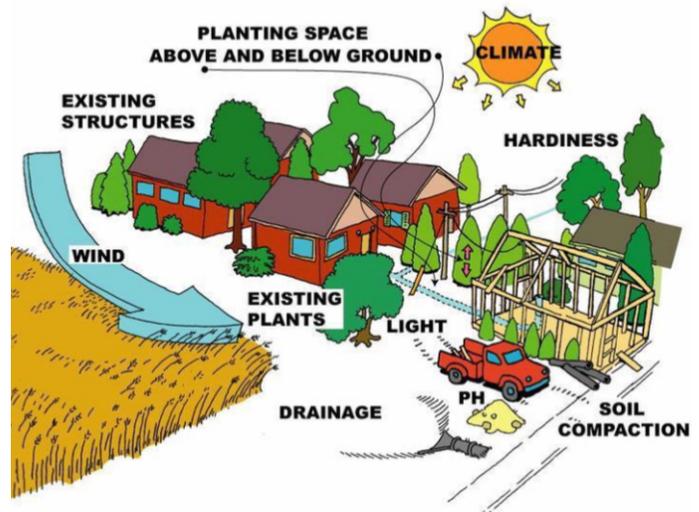


Site Evaluation

A site evaluation is the process of identifying and examining features and conditions in a landscape that will impact tree growth and landscape compatibility. Information from the site evaluation can then be used to create a planting plan. 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 site evaluation and planting plan should identify:

- characteristics of the soil, including texture, pH, and drainage
- exposure to sunlight and wind
- location of other trees, vegetation, and landscape features
- location of buildings, streets, sidewalks, and other hardscape features
- location of overhead and underground utilities
- known problems such as areas of poor drainage or construction fill
- source of undesirable view or noise for screen plantings
- access to site
- proposed location, spacing, and size of trees
- the scale (e.g., 1" = 25') of the drawing and the orientation (include a north arrow)

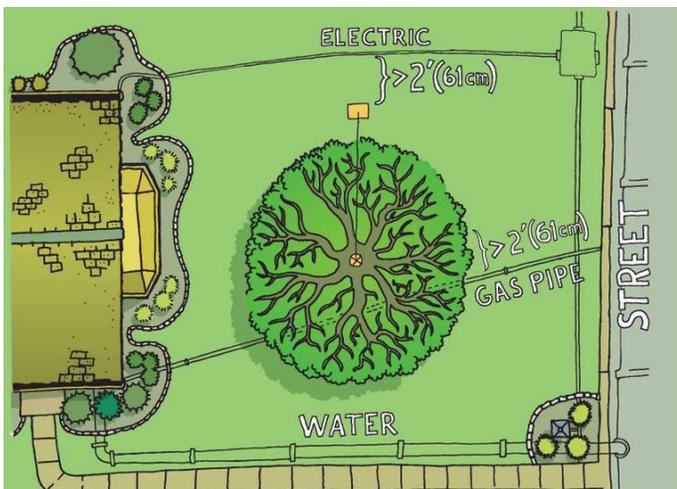


Factors to consider in the urban landscape. Image by International Society of Arboriculture, Bugwood.org

Cliffside Pocket Park - Final Conceptual Master Plan



Cliffside Pocket Park. Image by Community Design Assistance Center



Planning map for backyard. Image by International Society of Arboriculture, Bugwood.org

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. In addition to hardiness and adaptability, trees should be selected for size, foliage, flowers, fruit, debris – 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 **fastigate** cultivar is sometimes a good selection, such as “Armstrong” maple. See [Unit 4](#) for more information on tree form.

Propagation

Propagation is the process of growing new trees for planting into the landscape. Trees can be propagated both naturally and artificially. With natural propagation, trees follow their reproductive cycle and seeds are allowed to naturally disperse. With artificial propagation, people manipulate the reproductive cycle by selectively pollinating or germinating seeds collected from fruits. Trees can also be asexually reproduced (vegetatively) by rooted cuttings, grafting, or layering.

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.

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.

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 temperature. 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, which replicates animal digestion or physical weathering in the environment.

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 and securing 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.

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 growing medium 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 than seedlings.

Nursery stock with sturdy, compact root ball systems 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.



Chestnut Oak growing at the Virginia Department of Forestry’s bare-root nursery. Image by Virginia Department of Forestry



Fabric containers growing Longleaf Pine at a local Virginia nursery.

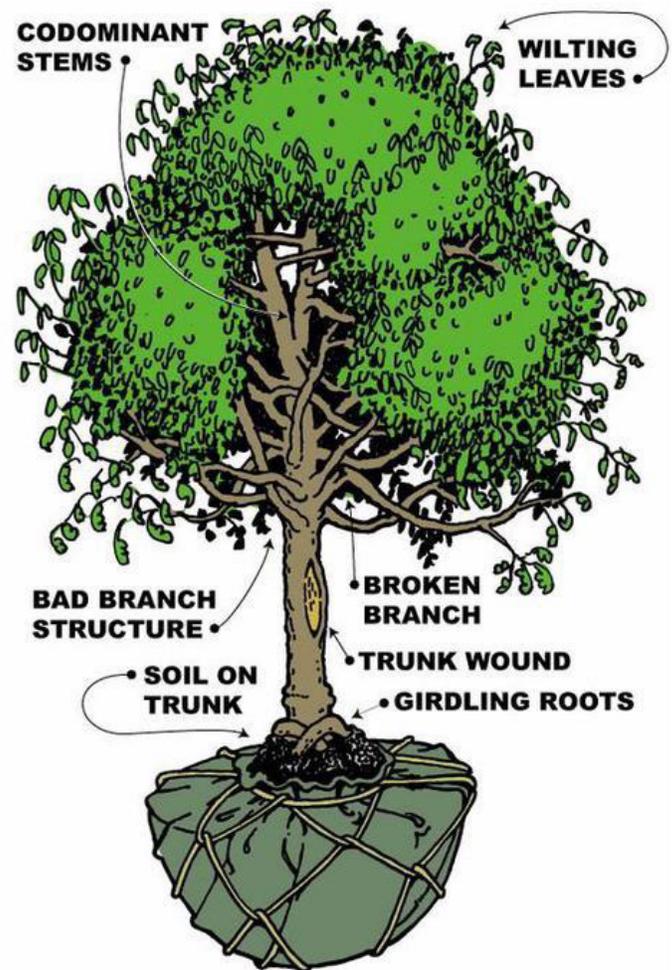
Purchasing Quality Trees

Trees may be purchased as bare-root, balled and burlapped or container-grown. See [Unit 6](#) for planting procedures.

- **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 soil or mulch 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 slow-release fertilizer.
- **Balled and burlapped** (B&B) trees have been dug from the field by a tree spade producing a root ball comprised of roots and soil. The root ball is wrapped in burlap and tied or wired closed. Keep the root ball moist because the tree is prone to drying out from loss of roots at spading.

Buying young trees from a reputable nursery rather than digging seedlings from the wild is preferred for ensuring good tree quality and planting success. Wild transplants typically have poor survival rates. Reject poor plant material even if it's from a reputable nursery. Make sure to find a quality nursery with a return policy for purchased trees that fail to thrive. 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 root ball or container is too small for the trunk caliper. The trunk should be well-tapered and appropriate caliper for the height of the tree.
- *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 and planted too deep.
- *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. Bring a probe to evaluate the root depth and root collar in the root ball or container.
- *Avoid stock with 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 stressors. Wilted, discolored twigs and leaves may indicate disease.



Bad nursery tree. Image by International Society of Arboriculture, Bugwood.org

Did You Know?

Larger trees take longer to recover versus smaller trees; approximately 1 year of recovery is needed for each inch of diameter after transplanting.

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 a unique plant type being commercially propagated for specific desirable traits that have been discovered either as natural mutations or purposefully created through breeding or genetic modification. 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* 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.

Choose the "Right Tree for the Right Place"

Determine the desired function for trees in the landscape.

Trees can be planted to provide shade and privacy, to screen out noise, to block pedestrian traffic, improve property values, reduce energy use, 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 significant troublesome "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.

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.

*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.*

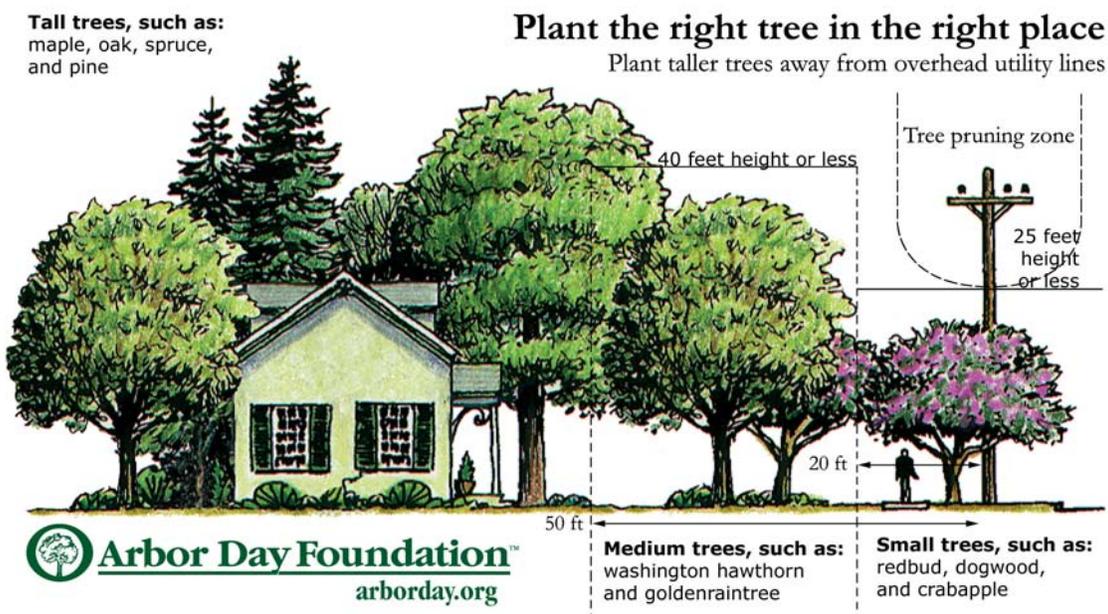


Image by the Arbor Day Foundation

A Checklist for Site Evaluation 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 known or anticipated diseases and pests, especially if the site is likely to be stressful and predispose trees to infections.
- *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 – Virginia 811!*
- *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. They can also adversely affect newly planted trees through competition and allelopathy (phytotoxic chemicals emitted to deter growth of neighboring plants).

Tree Steward Stories— Right Tree, Right Place

Written by Nora Palmatier, Tree Steward

"Arlington County has a program that turns the sour lemons of trees being cut down for new development into the lemonade of planting new trees. Developers who cannot meet the legal requirement to replace tree canopy on their sites must pay into the County's Tree Canopy Fund. This money is used to pay for the planting of saplings (usually 2" caliper native trees) on private property. Trees can go into single family yards, the grounds of condos and apartments, churches, and nonprofits. Our members are active in advertising the program and providing one on one education to homeowners and greens committees. Those requesting a tree can ask for a consultation and a Tree Steward will come out to discuss what tree species are a good choice in their particular space.

The Tree Canopy Fund offers about 7 species each year and Tree Stewards assist in making a simple info sheet about each species - the usual how tall, how wide (most important for our small yards), wet or dry preference, etc. New Tree Steward members accompany experienced Tree Stewards on a few visits for training as well as having this included in the class training. We have found that the consultation should start by asking the question "What is important to you from your tree?" Once we know if they love flowering trees, or hate having tree litter, or want shade over a picnic table, or want red leaves in the fall we can review the information chart with them for their choice.

One very important point is that we Tree Stewards are not to tell them what is the best tree choice— our role is to help them look at all the information and decide for themselves."

Key Questions:

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

Resources

Find a Plant | North Carolina Extension Gardener Plant Toolbox (2020). Available at: https://plants.ces.ncsu.edu/find_a_plant/

Native Plants for Conservation, Restoration, and Landscaping – Native Plant Finder (2020). Virginia

Department of Conservation and Recreation. Available at: <https://www.dcr.virginia.gov/natural-heritage/native-plants-finder>

Tree and Plant Selection (2020). The Morton Arboretum. Available at: <https://www.mortonarb.org/trees-plants/tree-and-plant-selection>

Tree City USA Bulletin Videos. Arbor Day Foundation. Available at: <https://www.arborday.org/trees/bulletins/bulletin-videos.cfm>

Tree Owner's Manual (2019). United States Department of Agriculture. Available at: https://www.fs.usda.gov/naspf/sites/default/files/tree_owners_manual_print_res.pdf

Tree & Stormwater Relationships Website. Available at: <http://treesandstormwater.org/>

Virginia Urban Street Tree Selector. Virginia Tech. Available at: <http://dendro.cnre.vt.edu/dendrology/treeselector.cfm>

Dirr's Encyclopedia of Trees and Shrubs by M.A. Dirr (2011). Timber Press.

The Tree Book by M.A. Dirr & K.S. Warren (2019). Timber Press.



Unit 6

Tree Planting and Care

Planting a tree correctly and following up with good initial maintenance is essential for a long healthy life. 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.

When to Plant

It is best to plant while the trees are dormant in late fall, winter or early spring. **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. It is better to plant some species in the spring including oaks, river birch, and blackgum because they are slow to develop roots when planted in fall, putting them at risk of winter mortality.

Evergreens should only be planted in early spring. Winter burn on evergreens is caused when air temperatures suddenly warm while the ground is frozen. The warm air causes the evergreen plant to transpire when it cannot get water from the frozen ground, causing the foliage to desiccate. In newly planted trees where the root system is already too small for the canopy, this problem is made worse.

The Planting Site

As covered in [Unit 5](#), the first step in good tree planting is selecting a good specimen of the right species. Having selected the Right Tree for the Right Place, it is time to prepare 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.

Mark the planting site and remove any vegetation, especially turf, from an area at least three to five times the diameter of the tree's root ball. This will eliminate competition with the young tree for water and nutrients.

Be aware of utility lines and always remember to call your utility company before you put the shovel to the soil. Keep in mind potential future hazards and nuisance risks the tree may pose. For instance, be situationally aware of sign clearance and traffic sight lines. Consider contacting the city traffic engineer or related department for information and approvals on street plantings.

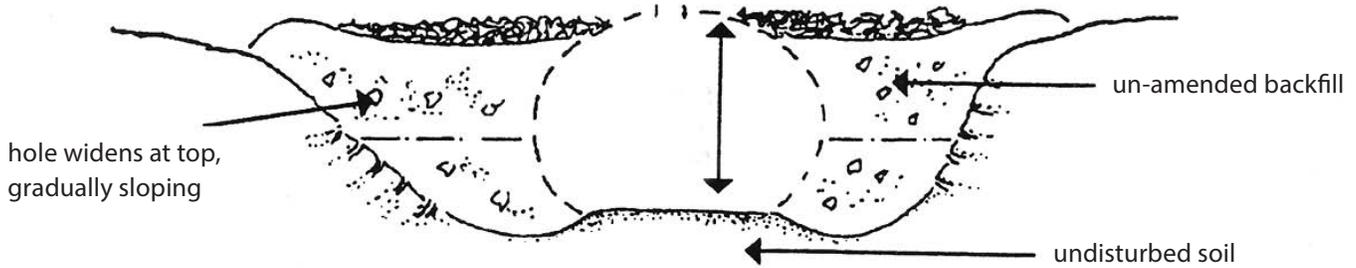


Diagram of a proper planting hole.

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. 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. Expose the root flare within the root ball by removing excess soil from the top. Then, in the middle of the prepared root zone, dig a hole deep enough so the root flare will be just at the surface of the surrounding soil. Roughen the sides of the hole to remove glazing caused by the shovel moving through the soil.
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.
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. 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 to give good contact between the root ball and the native soil and unhinder root elongation*
6. Backfill with soil excavated from the hole until it is about 3/4 full. Be sure to break up large soil clods and remove large stones so that roots proliferate in the backfill. Do not fill the hole with mulch, compost, gravel or other soil amendments. Research indicates that over amended soil in the planting hole disrupts drainage and 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 over the root collar or against the trunk base, which can cause problems with girdling roots or create infection points for pests and diseases.

Call before you dig!

Before digging, always contact Virginia 811 or “Miss Utility” at 811 countrywide. “Miss Utility” will locate and mark underground pipes and cables at no charge. *They will only mark public utilities; private utility markings will need to be contracted out to a private company.*

Root Washing Technique by Tree Fredericksburg Tree Stewards



Root washing before when soil media is still intact. Images by Trees Fredericksburg



Root washing after when root structure is exposed.



Fibrous roots freed from soil media.



The root ball is matted from residing in the pot for a long period time. Removing the matted roots will encourage new roots to grow out and away from the base of the tree, making it more stable and more likely to thrive.

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.

Did You Know?

The practice of root washing removes all of the soil or potting media from the root ball. Exposing the root structure will highlight any structural defects that need to be corrected or pruned before planting. Removing the soil or growing medium from the root ball will also eliminate conflicts with the native soil and help roots and water move out of the root ball into the surrounding soil. After the roots are washed, plant as you would a bare root tree. The tree will be much lighter with the soil removed and easier to lift/plant but do not let the roots dry out!

Planting Different Types of Stock

Bare-root – Gently prune away any dried, damaged and broken roots using a sharp tool. Many nurseries dip the roots of seedlings in hydrogel to prevent desiccation during shipping and handling. Concerns that the hydrogel may injure root membranes or alter water uptake may warrant rinsing hydrogel from the roots prior to transplanting. However, it is important not to damage the root system or allow the roots to dry out when removing hydrogel. 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 of 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 that excess soil. Remove as

much packaging – string, wire basket and burlap – from the root ball as practical before planting the tree.

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. *Caution:* Sometimes growing medium surrounding the tree in the container is above the root flare and the excess should be removed. Make the planting hole at least two to three times wider than the container. Remove the tree from the container before planting. Container-grown trees may show circling roots that should be straightened out to prevent later girdling and to encourage natural root growth. If large circling roots are severe, return the tree to the nursery for a replacement. Shaving the edges of root ball with a sharp shovel or other tool to remove small circling roots is a process called “squaring the circle.” Also shave the bottom to remove roots growing back up into the ball. Trees are constantly growing and shedding the fine absorbing roots that are lost in this process and root pruning will stimulate new root growth.

Roanoke Tree Steward Fall 2019 Project

The Roanoke Tree Stewards participated in a tree-planting project in a section of Roanoke lacking street trees. The project was a collaborative effort with the Roanoke Urban Forestry Department, the Southeast Neighborhood Association (I Heart SE) and non-profit organizations Trees Roanoke and Fitness for Good Roanoke (a local nonprofit that serves lonely and isolated individuals).

Tree Stewards worked with the City Arborist to learn the process for selecting and marking the site where the trees would be planted. Miss Utility was then called to mark the location of the utilities before the holes were dug. Trees Roanoke provided 21 redbud and crab apple trees for planting in the “tree lawn” (area between the sidewalk and street curb) along a two block section of 8th Street, SE. (These bare root trees were selected from the gravel bed maintained by the City on the morning they were planted.) The Roanoke



Urban Forester approved the site and a member of the City of Roanoke Tree Crew dug holes for the trees with a backhoe. Members of I Heart SE and Fitness for Good Roanoke worked in teams to plant the trees while Roanoke Tree Stewards joined each team to ensure each tree was planted properly. This is an example of how the Roanoke Tree Stewards use collaboration, partnership and public education to fulfill their mission.

Tree Steward Stories– Richmond Tree Steward Missouri Gravel Beds

In an effort to increase the root systems of bare root seedlings of native species, three gravel beds were constructed by Richmond Tree Steward volunteers. The project came to fruition as part of Tree Stewards' partnership with the Enrichmond Foundation and thanks to a grant from the Virginia Department of Forestry for building a demonstration gravel bed.

Why a community gravel bed?

- Improve the plants overall health and survival rate by developing the fibrous root system. This improves plant health and reduces transplant shock.
- Ability to use bare root stock. Bare root stock is generally more available in the spring, but spring is not the best planting season. If we acquire bare root trees in spring and allow them to develop fibrous roots in gravel bed over the summer, they have healthy root systems in the fall—the best planting season.
- Increases species availability. Usually there are more species available for purchase as bare root stock than in containerized or balled and burlap stock. As a result of better diversity, we reduce exposure to insects and disease in our urban forest.
- To save money! Bare root stock costs significantly less than balled and burlap or container trees.
- Labor and cost savings at transplant time. Without the added weight from the root ball we don't need special equipment for planting.

Trees developed in our gravel bed are planted on Belle Isle in the James River Park System as part of native habitat restoration. We included gravel bed trees in our Community Roots Tree giveaway in 2017 and have scores of seedlings on order for our homeowner giveaway and for restoration planting in 2018.

For additional information on the Missouri Gravel beds and the Richmond Tree Stewards, please visit this website: <http://richmondtreestewards.org/projects/gravel-beds/>



Gravel beds with new plants and irrigation. Image courtesy of Richmond Tree Stewards



Actively growing roots after 3 months in the gravel beds. Image courtesy of Richmond Tree Stewards

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** and **reaction wood** toward its base. Because staking costs time and money, and can potentially harm the tree when improperly installed or maintained, staking should only be installed when there is substantial concern for tree stability. Some situations where staking is appropriate: heavy wind, steep hillsides, tall trees, dense crowns, or heavy site use by people. Here are some guidelines for staking:

- On trees that may be unstable, set two or three 4- to 6-foot stakes (depending on the height of the tree) firmly into the ground. Don't drive them through the root ball.
- Install guy lines or a wide, smooth and flexible strap that are just tight enough to prevent excessive movement of the root system and loose enough to permit some trunk swaying. Guy lines should be padded or have rounded or soft edges that will not cut the bark. Guy lines or straps should be loose enough around the trunk of the tree to allow for some trunk expansion.
- Remove staking materials once the root system has firmly established to keep the tree upright. To determine if the guy lines can be removed use the "wobble test." Grasp the trunk at 3/4ths its height and bend it 2"-4" in all directions. Observe the root collar for movement. If it is stable, then roots are well anchored and staking can be removed. If it shifts in the soil, retain stakes and allow roots to continue developing. Smaller nursery stock that is well tended can typically have stakes removed after one growing season. Large nursery stock, slow-growing species, or difficult sites may require staking for several growing seasons. The key is to periodically inspect and adjust staking so that it does not cause injury. Failure to remove guy lines can eventually strangle expanding tree trunks and reduce structural root growth.
- In school yards or heavily trafficked areas you may want to place stakes around trees even without guy lines. The purpose of the stakes in this case are to protect the tree and root zone from trampling by school children and other pedestrians.



Example of tree staking in the City of Fredericksburg. Image by Tree Fredericksburg

Did You Know? Tree Staking

Your shoulder can explain why trees sometimes need to be staked. Your shoulder is a ball and socket joint. The humerus, the bone between your shoulder and elbow, has a rounded knob that fits into a socket in your shoulder. The knob is attached to the bone, so when you move your arm, the knob moves in the socket. A tree with its root ball is like the humerus and its knob, with the ground forming the socket. When the tree moves the root ball moves in the ground. When trees are planted bare root and the roots are spread out like a disc around the base of the tree, it is much harder to move the roots in the soil when the tree moves and the tree usually does not need to be staked.

Did You Know? The Wiggle Test

The purpose of staking and guying your tree is to keep the root ball stable in the ground until roots can establish outside the root ball. Use the wiggle test to determine if the guys are ready to come off.

Hold the tree by the trunk at 3/4ths of its height and gently wiggle the tree. If the trunk flexes and the base of the tree and soil around do not move, the tree passes the test and the guy lines can be removed. If the base and soil move, the tree fails and the guy lines should remain.



Image by Harry Gleeson, Town of Buchanan

Pruning on the day of planting should be restricted to dead, diseased and broken branches *only*. Note any structural issue like co-dominant leaders or rubbing branches and fix them after the tree becomes established, typically one year per inch caliper at planting. Most newly planted trees have compromised root systems and need all the existing canopy to make sugars for root growth and reestablish a balance between the roots and shoots.

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. More information on pruning is provided in [Unit 7](#).

Fertilizer should NOT be applied at planting. Contrary to traditional practice, research recommends against it. Good aeration and adequate moisture are far more important for establishing sturdy root systems and overcoming transplant shock. If your soil analysis indicates that fertilizer will be needed to remedy a nutrient deficiency, the first application should be made in the *second* season after planting.

Fertilizing a tree or any plant in the absence of a scientific soil test is malpractice!

Mycorrhizal Fungi additives have not been found to improve tree transplanting success beyond proper planting technique and good mulching and irrigation practices. These organisms are ubiquitous in the environment and generally replenish themselves on the tree shortly after transplanting. Highly disturbed or contaminated soil may benefit from additives, but typical planting conditions do not warrant their use.

Specifics on Urban Street Tree Plantings

Urban street trees have a difficult life as they must deal with air pollution, infrequent watering, limited space for roots and possible trunk damage by pedestrians, animals, and car doors. Ensuring that street trees are planted correctly and with sufficient amounts of soil is one of the most critical aspects of urban street tree survival.

Trees require 1 to 2 cubic feet of soil per square foot of canopy spread at mature size. Conventional tree pits, often referred to as “tree coffins”, generally provide about 120 cubic feet, which would support about a 10-foot diameter canopy. When given the chance to live and grow in the appropriate quantity of healthy soil, trees can handle a lot of negative environmental factors, grow larger, and live longer. In recent years, the techniques listed below have been used to improve the soil conditions for street trees and other confined environments.

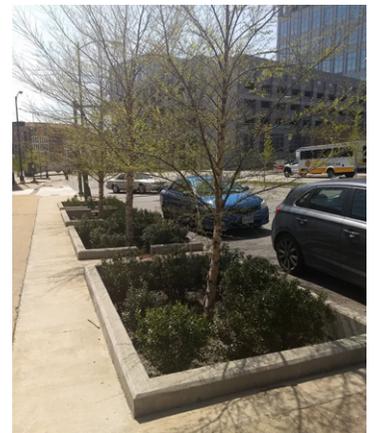


Photo of an urban street tree planting in Richmond VA.

Open planting strips are the simplest and (usually) the cheapest approach to provide adequate soil volume. A planting strip 6 feet wide, 3 feet deep and 55 feet long will provide about 1,000 cubic feet of soil for tree roots. The advantages are many-fold, including reduced

impervious cover, and full access for the tree to soil, water and nutrients. This is appropriate for residential areas, but is typically not preferred in heavy commercial areas, where benches, fire hydrants, sidewalks, street lights, utilities, and access to parking are both desired and required.

Continuous soil panels under sidewalks are essentially a reinforced sidewalk cantilevered over a continuous planting strip. This allows uncompacted soil to live in harmony with a sidewalk reinforced by steel rods, which are placed before pouring concrete. This technique has been used in many projects, and no issues have been found with sidewalk cracking. What limits this technique is the width of the area you can bridge with these steel rods. Once you get past 6 feet in width, the steel rods lose the capacity to support the sidewalk and whatever may be on top of it.

Structural cells were inspired by gothic cathedrals, where the weight of heavy concrete rooves is supported by columns and transferred to the compacted foundation. These products look like large open plastic crates that carry the weight of the sidewalk down along vertical pillars through the uncompacted soil to a compacted base. Trees can be planted and grow in the uncompacted soil filling the structural cells. The support components of the cells occupy about 10% of the space, so a 1,000 cubic foot pit would provide about 900 cubic feet of soil for the tree. This technique is fairly advanced, and requires expert installation. Depending on installation, air and water infiltration can be a limitation to this technology. There are also concerns about adding more plastic to our environment and maintenance when working with under-pavement utilities.

Structural soils are a different technology, which focuses on the composition of the base supporting the sidewalk. Sidewalks and other hardscape need a compacted base for support, typically gravel. Structural soils blend large washed gravel (to eliminate small particles) and top soil that can be compacted to support the hardscape and still leave soil filled void spaces for tree roots. Structural soils are typically 80% gravel and 20% top soil by volume. This means a 1,000 cubic foot tree pit would provide 200 cubic feet of soil for trees. There is currently significant debate about the effectiveness of this technology, and Tree Stewards should monitor research on this before recommending it in their jurisdiction.

Deer Protection

Deer protection is needed in suburban and ex-urban areas where hunting pressure is low. Deer damage trees by browsing on foliage and twigs and by rubbing antlers on the trunk to remove the velvet. Deer browse will reach about 4-6 feet above ground and deer will strip all branches and leaves up to this height. For seedlings and smaller stock, this can mean the entire tree. Male deer rub on trunks and branches up to 3 inches in diameter to remove velvet from their antlers. Young trees need to be protected until at least half of their canopy is above 4 feet; and trunks and lower branches at least 3 inches at breast height. Protection usually takes the form of a fence or trunk guard, but spray-on repellents can also be effective to deter browsing. Over-abundance of deer not only impacts transplanted trees, but also degrades habitat quality for other wildlife and creates hazards for people by vehicle collisions and disease transmission. Therefore, herd management is also important to environmental quality and sustainability.

Tree tubes are preformed tubes, usually made of plastic that can be slipped over newly planted seedlings or whips. Tubes should be shipped as tubes, not flattened. They should have a minimum diameter of 3 inches and a minimum height of 4 feet. The top edge should be flared out to prevent cutting of young bark as the tree emerges and sways. Green color allows maximum penetration of photosynthetic light and helps the tube blend in with the background. They should be perforated to allow the tube to split as the tree expands. Stakes should be 1 inch by 1 inch wooden, preferably untreated oak or black locust. Bird



Tree tubes protect young hardwood tree seedlings from hungry wildlife at Powhatan State Park.

nets should be installed to prevent birds from getting trapped in the shelter. These should be pulled down until they leave a circle 1 to 1.5 inches in diameter to prevent trapping and damaging the tree leader as it emerges. Tree tubes may not be appropriate for shrubs.



Silverbell protected with mesh and stakes from deer on the VDOF headquarters grounds.

Cages made of woven wire or plastic can be used for larger stock that cannot be slipped into tree shelters. Cages are either premade or constructed in the field and consist of a wire or plastic mesh attached to one or more rot resistant wooden stakes. The mesh should be firmly attached to the stake(s) and at least 4 feet tall. The cage should remain in place until the tree is safe from browse and rub. Tomato cages are not usually adequate to protect trees from deer; they are not tall enough and openings are too large to prevent deer from browsing the plant.

Maintenance for Young Trees – Year One

Watering is about the only maintenance trees need during the first year, assuming they have been properly mulched and staked at planting. The crown and roots of newly planted trees are out of water balance, with the crown needing more water than the existing root system can supply with normal soil moisture. To compensate for this, newly planted trees will need watering until they become established. The table below from the University of Florida Extension Service (<https://hort.ifas.ufl.edu/woody/planting.shtml>) show establishment times and watering needs of newly planted trees.

Max. Trunk diameter (inches)	USDA Plant Hardiness Zone					
	5	6	7	8	9	10
	to ensure establishment, trees should be irrigated for this many months:					
1	12	10	7	5	3	3
2	24	20	15	10	6	6
3	36	30	16	16	9	9
4	48	39	21	21	12	12

Maximum recommended tree size at planting depends on climate and how long trees can be irrigated after planting. For example, if irrigation can be provided for six months after planting in USDA hardiness zone 9, maximum trunk diameter at planting is two inches. With seven months' irrigation, maximum trunk diameter for planting in zone 5 would be about one inch.

Recall that trees use water for transpiration, photosynthesis, and transport of dissolved nutrients and sugar. During the growing season, rates of transpiration and photosynthesis are high and water demand is greatest. But even in dormancy trees are moving some sugar and nutrients to maintain life functions, so they still need water. The table below, from the same site, shows the irrigation needs of newly planted trees.

Size of nursery stock	Irrigation schedule for vigor 1,3	Irrigation schedule for survival 2,3,4
< 2 inch caliper	Daily for 2 weeks; every other day for 2 months; weekly until established.	Twice weekly for 2-3 months
2-4 inch caliper	Daily for 1 month; every other day for 3 months; weekly until established.	Twice weekly for 3-4 months
> 4 inch caliper	Daily for 6 weeks; every other day for 5 months; weekly until established.	Twice weekly for 4-5 months

- 1.) Delete daily irrigation when planting in winter or when planting in cool climates. Irrigation frequency can be reduced slightly (e.g. 2-3 times each week instead of every other day) when planting hardened-off, field-grown trees that were root-pruned during production. Establishment takes 3 (hardiness zones 10-11) to 4 (hardiness zones 8-9) to 8 (hardiness zones 6-8) to 12 (hardiness zones 2-5) months per inch trunk caliper. Never apply irrigation if the soil is saturated.
2. Irrigation frequency can be reduced slightly (e.g. to once or twice each week) when planting hardened-off, field-grown trees that were root-pruned during production.
3. At each irrigation, apply 1-2 gallons (cool climates) or 2-3 gallons (warmest climates) per inch trunk caliper to the root ball. Apply it in a manner so all water soaks into the root ball. Do not water if root ball is wet/saturated on the irrigation day.
4. Trees take much longer to establish than regularly irrigated trees. Irrigate in drought the following summer.

These guidelines are based on the following research: Beeson and Gilman 1992; Gilman et al. 1994; Gilman and Beeson 1996; Gilman et al. 1996; Gilman 2001; Gilman et al. 2002; Harris and Gilman 1993; Watson and Himelick 1982.

As can be seen from the blue table, watering newly planted trees can be a significant commitment of time and resources that should be taken into account when selecting planting stock. When resources are scarce, it is best to plant smaller stock that will establish quickly with minimal care. Remember even drought tolerant species do not become drought tolerant until they are established in the landscape.

Young Tree Maintenance – Year Two and Beyond

Water recently planted trees according to the guidelines above until they are established in the landscape. Established trees may need supplemental watering during extended dry periods.

When a moisture gauge or inspection indicate that the top few inches of soil are dry, it is time to water established trees. Watering should be in the form of a deep soaking, with the objective of wetting the entire depth of the root system and refilling the deep reservoir, not to just replenish surface soil moisture.



Did You Know? Reaction Wood and Taper

When cambium is physically stressed by stretching (tension) or squeezing (compression) it has a bio-chemical response that causes it to grow more wood fiber. When trees sway in the breeze, it is like when you do arm curls with a weight. The sway causes the tree to bend near the base and the cambium here experiences a cycle of tension and compression. The response is to grow additional wood fiber here to strengthen the tree. The added fiber creates the taper of the tree. Similarly when the tree is wounded the cambium becomes stressed and reacts by forming reaction wood. Hidden hollows are often revealed when the tree grows reaction wood to compensate for decayed wood.

Mulching is an important supplement to watering. Proper mulching will help infiltrate water, reduce soil moisture evaporation, reduce soil temperature, suppress weeds, feed the soil ecosystem, and improve soil structure. Wood mulch is also a vital resource for ectomycorrhizal fungi. Given this, it is easy to understand why proper mulching is critical to tree health.

Proper mulching starts with proper mulch. There are a number of products both organic and inorganic that are sold as mulch. Ironically, the best mulch is usually free – arborist chips fresh off the truck. The next best are coarse shredded wood and undecomposed leaves. Finely shredded, bark and inorganic mulches should be avoided. Fine mulches can interlock and form mats that will shed water rather than infiltrate it and interfere with oxygen exchange with the soil beneath. Bark is full of waxy substances and shed water rather than absorbing it; this means they will tend to float away or reduce infiltration. Inorganic mulches such as stone or crushed brick may help with water infiltration and soil erosion, but will not decompose to replenish soil nutrients; and rubber will leach heavy metals as it decomposes.

Mulch should be applied to as wide an area as possible. Mulch should never touch the base of the tree. Green wood chips should be applied at 4 to 6 inches; partially decomposed wood mulch should be 3 to 4 inches deep and other mulches 2 to 3 inches deep.

Organic mulch will need to be periodically refreshed, with the frequency depending on rate of decomposition. Do not remove the old mulch. Add new mulch on top to bring the depth to the amount suggested above. Leaves should be allowed to lay on top of wood mulch in the fall, but do not add more from other parts of the yard (in turf areas just mow over them and let them be.) 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 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.

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. 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.

Under-Tree Planting of annual ornamentals and bedding plants within the dripline of trees that necessitate constant disturbance of the soil should be discouraged. Shrubs and other perennial plants that do not require continual maintenance can be planted under trees and is encouraged. Trees evolved in forests along with shrubs, perennial wild flowers and self-seeding annual plants. Recent research has indicated that mimicking this horizontal diversity in our landscapes with native plants creates superior habitat for beneficial insects, including pest predators. Perennial ground covers provide many of the same benefits as mulch and are sometimes referred to as living mulches. Replacing turf under trees with native shrubs and wildflowers is also a good way to manage storm water and to keep string trimmers and lawn mowers away from trees.

Trees and Turf do not get along. Maintenance practices for turf can also harm trees. Higher soil pH created for turf reduces the availability of some nutrients, especially iron, that are critical to trees. Summer watering of cool season turf creates warm, moist conditions that are favorable to pathogenic fungi. Summer and fall turf fertilizer applications can

"Volcano" mulching is a very bad practice. This involves making a deep pile of mulch around the base of the tree. This can soften and weaken the tree bark and create pathways for pathogens. Fungal mats can also form within the pile that prevent water and air from reaching the soils and roots below.



Volcano mulching. Image by Tim Maywalt.

cause new growth that is susceptible to pests (summer) or freeze (fall). Pushing or driving mowers over the lawn repeatedly can further compact soils, making tree root growth difficult. Compacted soils can force trees to grow large roots near the soil surface where they can be cut by lawn mowers.

Tree Steward Stories– Tree Fredericksburg Tree Stewards

Through a grant, Tree Fredericksburg Tree Stewards teamed up with the City of Fredericksburg Department of Public Works to put together this information sheet for citizens. This document was sent out to all residents in the area with the hopes of promoting the importance of proper mulching. Visit the Tree Fredericksburg website for additional information and other great ideas! <https://treefredericksburg.org/>



Proper Mulching = Healthy Safe Trees



All living things need oxygen. One way trees absorb oxygen is through their roots. Too much mulch can smother the tree's ability to take in oxygen through roots and can lead to disease and death. It is important to have the root flare showing at the base of the tree, as this is the point at which tree tissue changes structure. Tissue above the root flare is trunk tissue and not made to be kept wet. Tissue below the root flare should be developing roots and taking in nutrients for the tree through the root system. Mulch should be less than 3 inches deep.



There are small breathing holes (lenticels) in the tree trunk that take in oxygen. If the trunk has mulch piled against it all the time, the trunk will stay wet and the lenticels won't be able to breathe. Similar to getting water in your lungs, the tree will become sick and unable to function. After 10 or 15 years, the tree can rot all the way through and fall over in a storm on your car or house. For a safer tree, keep mulch at least 4-5 inches away from the trunk.



Other things to know.

- Trees grown in mulch will grow twice as fast and be twice as healthy as trees grown in grass. Grass steals nutrients before tree roots can get to them.
- Mulch to the width of the crown of the tree. Shrubs, grass, flowers, or extra soil placed under the tree all rob the tree of oxygen and nutrients and stress the tree.
- **VERY IMPORTANT!** When planting – place the root flare at or above the soil level.
- Shredded hardwood mulch forms a thick mat and repels water. Use pine bark mini-nuggets or Virginia Fines mulch.
- Trees can easily drown in hard clay. Use a moisture meter to check before watering the tree (available for under \$10 at big box stores). Better to water deeper and less frequently.
- Remove the old mulch first before adding new mulch, too much mulch smothers the tree.



www.fredericksburgva.gov/1219/Trees

www.treefredericksburg.org

November 2019

Fertilize Established trees are generally fertilized in the very early spring to make the additional nutrients available during the ensuing growing season. Fertilizing late in the fall can encourage a flush of tender new growth that may 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, due to lack of organic matter replenishment or constricted soil volume, correct fertilizing may help the problem, but always confirm with a soil test first. Fertilizer will not make up for compacted soil or poor drainage or control infestations of pests and diseases. Trees under severe stress from other causes are unlikely to respond to fertilizer application. 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.

Virginia Tech has a Soil Testing Lab that samples can be sent to for analysis. Soil test kits and forms can be found at any extension office and most soil and water conservation district offices. Note: The Virginia Tech lab report does not include Nitrogen. You can pay extra for soluble salts and organic matter analyses to be included onto your routine report. For more information <https://www.soiltest.vt.edu/>. Private labs can do other assessments if deemed necessary.

Monitor for Problems, Pests, And Diseases

by looking for distress signs and symptoms. Then seek help from local experts. When problems are spotted early, effective solutions can usually be found. This topic is discussed more in [Unit 8](#).

If something changes in the tree's crown – yellowing, wilting, widespread feeding, unseasonal leaf drop, darkened or wilting shoots and leaves – these are signs of disease or stress. Watch for frass, oozing sap, and other signs of insects, rodents, and other pests. Fungus growing from the bark or unusual swelling can be signs 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;” problems that show up in the crown often start at the roots.

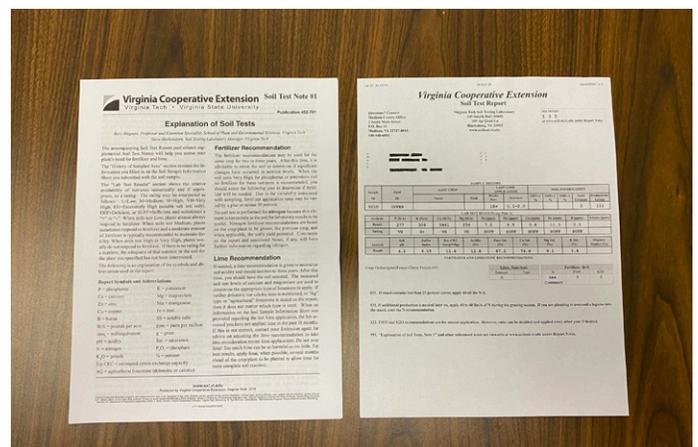
County Extension offices accept samples from trees for diagnostic examination. In addition, your group may be able to locate ISA-certified arborists willing to assist in diagnosing problems. Many Virginia Department of Forestry field staff are certified arborists and will help as well. If

How to Sample Soil

Use a clean bucket and trowel. Take one half cup samples from depths of 1 to 12 inches from 5 to 10 spots in the area where the tree is or will be growing and mix them well in the bucket. Use the mix in the bucket to fill the sample container sent to the lab.



A full soil sample box correctly labeled from Virginia Cooperative Extension.



Soil test report with supplemental information from Virginia Cooperative Extension.

examination cannot take place on the site, take a sample or a picture of the damaged material to the designated office. Samples should include both diseased and healthy tissue.

Using Pesticides, Herbicides, and Fertilizer

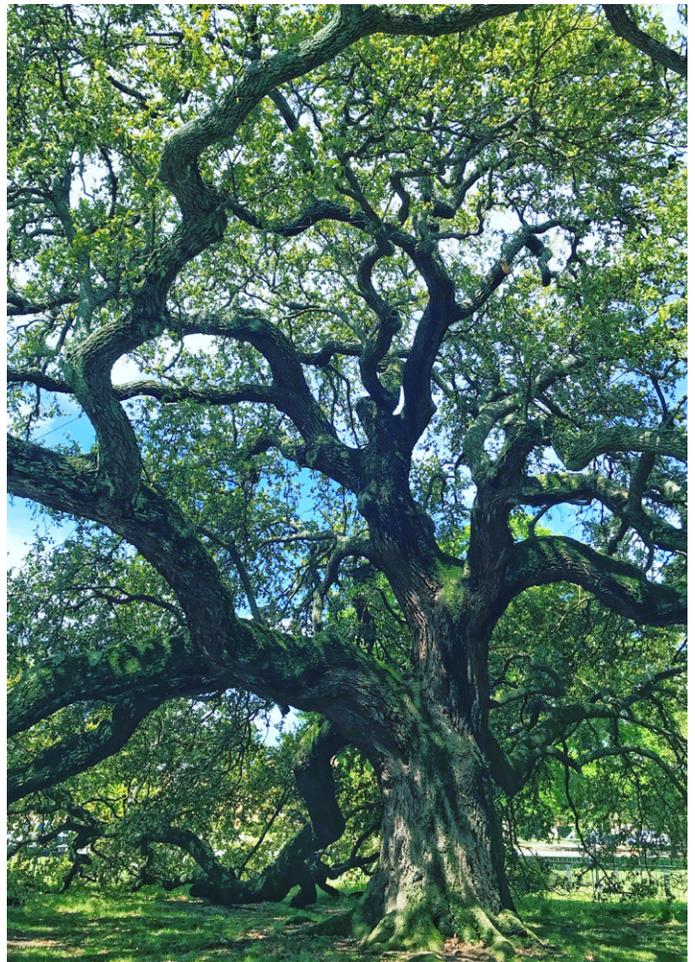
Many tree problems can be managed simply if noticed early. Improving the planting site, pruning away an infected branch, remedying water deficiencies – even blasting destructive insects away with a water hose spray may solve some problems. However, if the problem is severe, consult a professional for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

Volunteers shall not use nor make specific recommendations for chemicals or fertilizer in public areas or on private property other than their own. Only professionals who have obtained the proper pesticide and fertilizer training, and certification can legally undertake such measures. Volunteers may make general statements that chemicals or fertilizers could be useful and refer landowners to a certified professional for specific treatment recommendations and applications. See <http://www.vdacs.virginia.gov/plant-in-dustry-services-certified-fertilizer-applicator-training.shtml> for Certified Fertilizer Applicator Program and <http://www.vdacs.virginia.gov/pesticide-applicator-certification.shtml> for Certified Pesticide Applicator Information.

Mature Tree Care

Trees are an investment and older trees have large and complex structures to maintain. Having an effective maintenance program is the key to caring for a mature tree. Most mature trees in urban areas die from repeated stress. The process has been studied in oaks and is called Oak Decline Syndrome, but decline can occur in all species and follows similar patterns. Trees may be predisposed to decline and death by soil compaction, inadequate soil volume, construction damage or even age. Trees that are predisposed to decline may be hit by repeated stressors, like flooding, drought, defoliation, or extreme heat, which can cause the tree to deplete its stored energy supplies. In this stressed and depleted state, it can no longer fight off endemic pests and pathogens, finally resulting in its death. In this situation it is difficult to point at a specific cause of death other than the tree's inability to cope with all of the stress it faced. The best we can do is provide the best growing conditions we can and deal with the stressors as we are able.

Mulching as wide an area as possible is the best tool we have to create good growing conditions for the tree and make it as resilient as possible to stress. Mulching can reduce compaction, moderate soil



The Emancipation Oak is located on the grounds of Hampton University in Hampton, VA. In 1863, the Black community gathered under this tree to hear the first Southern reading of President Lincoln's Emancipation Proclamation.

temperature and reduce competition or injury from the turf or lawn care equipment. Having a large mulch ring around a mature tree will also increase organic matter in the soil and decrease water loss. Avoid placing mulch right against the trunk as it can cause decay.

Watering when the subsoil feels dry to the touch. Deep watering during drought will restore the soil moisture reservoir and prevent water stress. Be aware that over watering can saturate the soil and create oxygen stress. Watering needs for any species will vary based on weather conditions, location, exposure and time of year.

Fertilizing when nutrient deficiencies are evident based on foliage color, canopy density, and twig elongation. Large trees may not have adequate root zones or organic matter inputs to meet their nutrient needs. Apply fertilizers based on soil test results.

Regular Monitoring to observe and report sudden changes in the tree's health before biotic (pest, disease) or abiotic (drought, soil compaction) factors become too serious allows time for a caregiver to respond. Some key items to look for: adequate bud, leaf formation or twig elongation, dead branches, crown dieback, pest activity, new wounds, fungus on the tree or in the soil around the tree, and/or worsening decay.

Consult a Professional for more significant issues such as pruning, fertilization, pest management, and even removal. While Tree Stewards may observe pruning needs in a mature tree, working in large trees is dangerous so it is important to call in a professional who is trained for that work. Also, an expert can help with a timely diagnosis if a serious problem emerges. To find an arborist see the International Society of Arboriculture website and you can search by city and state. See <https://www.treesaregood.org/findanarborist> or <https://goodtreecare.com/> for more details.



An arborist climbing a tree to prune.

Key Questions:

1. What is the most common cause of poor tree health?
2. At what depth should trees be planted?
3. What is the most common mistake when digging a tree-planting hole?
4. Describe the perfect planting site.
5. When are the best times to plant trees in Virginia?
6. Describe the bare-rooting technique.
7. What is the most important follow-up activity after planting trees?
8. When should a tree be fertilized?
9. What are some tips for mature tree care?

Resources

Healthy Trees Healthy Cities: Planting (2015). Available at: <https://www.youtube.com/watch?v=wvMqCcm3ZJ4>

Healthy Trees Healthy Cities: Pruning (2015). Available at: <https://www.youtube.com/watch?v=M1wVL5InBxM>

iTree Tools. Available at: <https://www.itreetools.org/>

Planting Trees in Landscapes (2020). University of Florida. Available at: <https://hort.ifas.ufl.edu/woody/planting.shtml>

Planting Trees (2017). Virginia Cooperative Extension. Available at: <https://www.pubs.ext.vt.edu/426/426-702/426-702.html>

Tree Care Resources. International Society of Arboriculture. Available at: <https://www.treesaregood.org/>

ANSI A300 Standards & Best Management Practices Part 6 – Planting & Transplanting (2012). Tree Care Industry Association.

The Practical Science of Planting Trees by G. Watson and E.B. Himelick (2013). International Society of Arboriculture.



Unit 7

Tree Pruning

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 live branches. An unhealthy tree may not be able to tolerate loss of foliage and pruning wounds. If dead or dying limbs are present, try to determine the cause. Handle pruning carefully, using correct cuts and proper, sharp tools.

The primary consideration in pruning must be safety—both as a matter of pruning practices and pruning objectives. Pruning is potentially dangerous for those doing the pruning, so safety precautions must be taken. But pruning is also critical to keeping people and property safe from tree hazards. Pruning should be used to remove unsound or poorly positioned limbs and thus to prevent personal injury or damage to nearby property. These priorities apply to trees of all ages.

Before any pruning, check the following:

- What species of tree is being pruned?
- What is its natural form?
- 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

- Potential Hazards – dead wood, branches that interfere with vehicle or pedestrian visibility, branches that threaten structures or activity areas
- Tree Health – branches that are dead or damaged may harbor pests or attract disease infections
- Tree Structure – poor branch spacing and branch attachments in young trees can cause serious problems at maturity

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 species 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 can this be prevented? Planting an appropriate species with a mature height that would not require this type of pruning.

Tree Health

Look for **girdling roots**, **watersprouts**, **suckers** and declining branches. 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.

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.

Make sure that crossing, rubbing and poorly spaced 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.

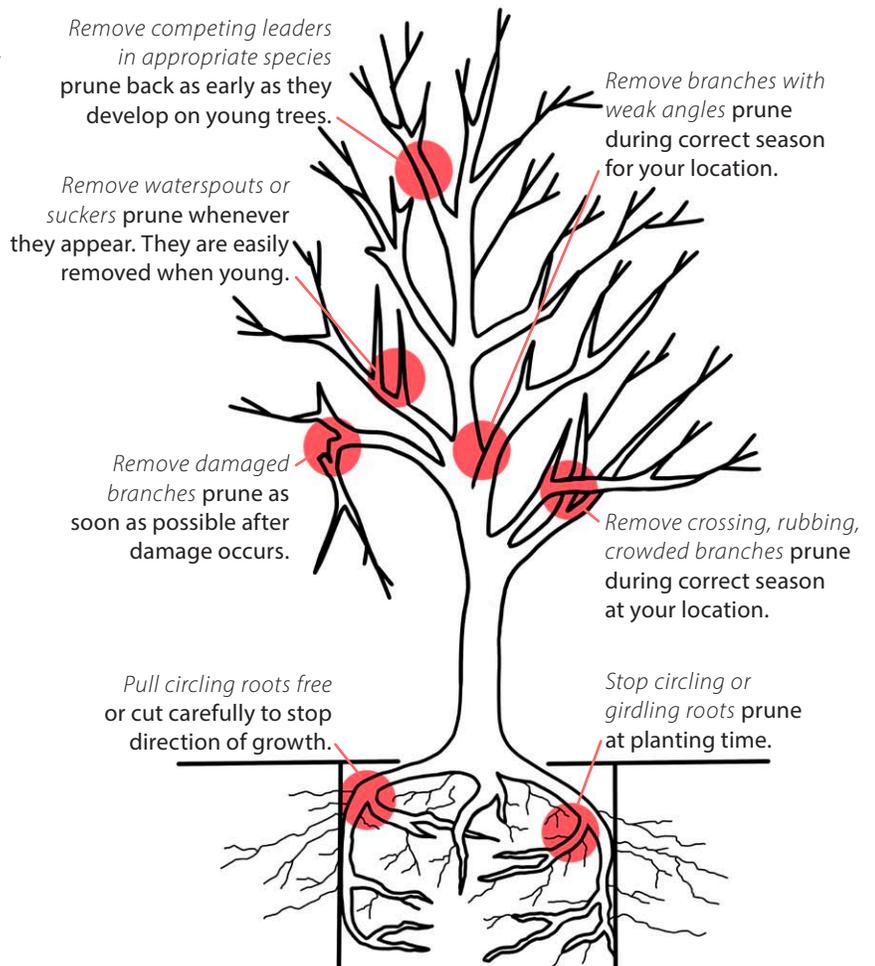


Illustration by Sarah Gugercin, Virginia Tech. Drawing based on three illustrations used in previous version of the Virginia Tree Steward Manual.

Tree Structure

Too often, the eventual size of tree is not considered when planting. Some tree species are unsuitable for some planting locations 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. 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
- When pruning, it is important to remember how trees grow and the structure of the species being pruned. 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.



Image by Charlottesville Area Tree Stewards

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 leaders**. Subordination is restricting the size and growth rate of a leader by selectively pruning to reduce its twig and leaf area.
- Prune out branches with **included bark** that weakens the branch 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.
- Visible **girdling roots** should be cut to encourage outward growth.

For the first three to four years after planting, leave as many of the lateral branches as possible, even if they appear lower on the trunk than will be desirable later. Sometimes these retained branches should be subordinated so they do not become large in relation to the trunk. These young leafy branches are important in adding to the trunk's girth and protect the trunk as it begins to develop. Lower 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.

Did You Know?

Pruning should remove no more living branches than necessary to achieve the pruning objective. A common rule of thumb is to not exceed more than 25% canopy removal, but discretion may set the limit higher or lower depending on the tree.

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 pines, or a rounded, spreading shape, such as seen in maples. A tree with weak apical dominance will tend to develop multiple 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 exceed half the diameter of the trunk or parent branch that support them have a greater potential to fail and sustain a larger wound when removed. subordinate large-diameter branches to control their growth rate so the attachment is stronger and eventual pruning wounds are smaller.
- Narrow **crotch angles** with included bark may be more likely to break under wind stress or ice/snow load, especially when the relative size of the branches is similar. However, some species have a columnar habit (tall, slim form) with narrow crotch angles that are structurally strong.
- Branches exist to spread leaves or needles out for maximum sunlight and air exposure. Growth that is too dense increases competition for light.

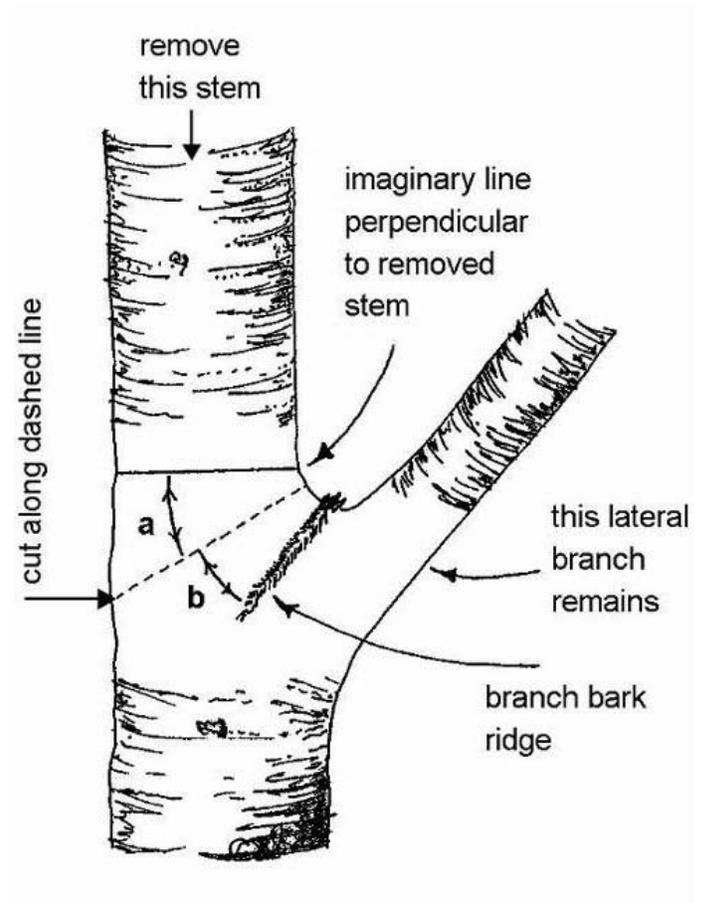


Wide crowns are common in older trees.

Proper 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. Also avoid cutting into the **branch bark ridge**. Direct growth of young branches by pruning them 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.

Reduction cut – shortens the limb to a smaller lateral branch at least 1/3 the diameter of the branch being removed. Shortening by reduction to a lateral branch removes excess tissue that might attract pests and allows the lateral to assume the dominant role formerly held by the part being pruned off.



Reduction cut. Image by International Society of Arboriculture, Bugwood.org

Traditional Pruning Practices

- **Crown cleaning** is the selective removal of dead, diseased, or defective branches for safety, sanitation, and aesthetic purposes.
- **Crown thinning** is the selective removal of live branches in the periphery and interior of the crown to reduce crown density for air, light, visibility, and branch spacing. Thinning does not significantly alter the size or shape of the crown and may incorporate both branch removal and branch reduction cuts. Excessive thinning, particularly in crown interior may adversely affect branch symmetry and induce suckering.
- **Crown raising** is selective removal or reduction of lower branches to improve clearance, visibility, or tree shape. After the pruning, a healthy crown should be at least 2/3 of the tree's overall height. Excessive raising may induce trunk cracks, sunscald, and inhibit trunk taper. Raising is usually done in cities to provide clearance and visibility for vehicles, pedestrians, buildings, traffic signals, etc. This practice is sometimes called "limbing up."
- **Crown reduction** is selective removal or reduction of branches to reduce the height and/or canopy spread. Proper pruning cuts must be used to prevent stem decay and excessive sprouting. Shortening branches with heading cuts rather than reduction cuts is harmful to the tree and is called "topping."
- **Structural pruning** is used in younger trees to develop a dominant leader and strong branch arrangement specific to the species.
- **Restoration pruning** is used on trees that have been damaged from storms or mechanical methods.

Branch Collar

The **branch collar** is the area at the base of a branch where it grows out from the trunk or parent branch. It contains a double layer of wood (see photo of crepe myrtle with obvious branch collar); One layer forms on the branch each year and another layer grows over it from its source - the trunk or parent branch. This double layer of wood provides the great strength that is needed to support the branch as it grows larger over the years. Although in some trees the branch collar is not visible, it can usually be found after finding the **branch bark ridge**. The branch bark ridge is caused by the squeezing of tissue located where the trunk meets the branch (known as the 'crotch').

The branch collar is important to the tree not only for providing mechanical strength, but also because it contains chemical and physical properties that limit the spread of decay if the branch is damaged or removed. It is also referred to as the **branch protection zone** because of these properties.

Pruning cuts need to be made just outside the branch collar. This is to avoid undermining this area's ability to protect the tree from the spread of decay. See photos of the 2-cut and 3-cut methods on the following page.

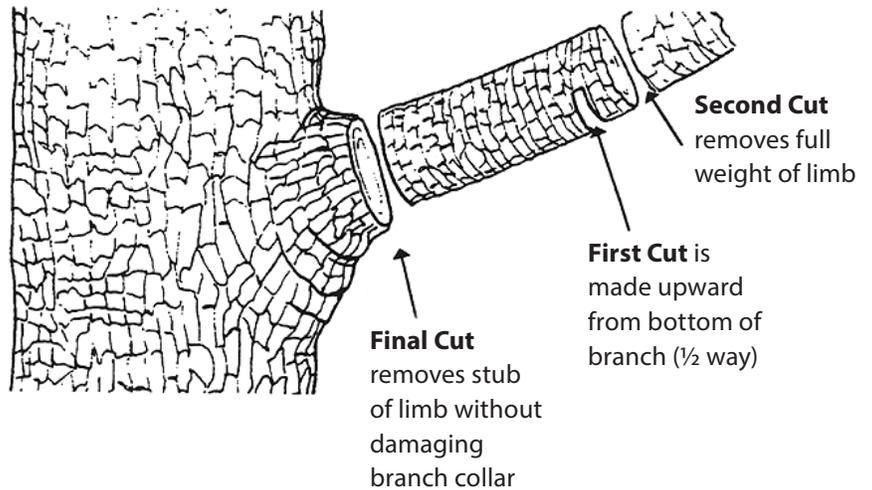


Image by Charlottesville Area Tree Stewards

Specialized pruning practices should only be used after consulting the ANSI A300 National Standards regarding pruning. It is recommended to contact a certified arborist for additional guidance. Another great website to learn more about pruning and find a arborist is at the following link—<https://www.treesaregood.org/treeowner/pruningyourtrees>

Pruning Large Branches

Depending on the size of the tool's jaws, it may be possible to prune branches up to two inches in diameter with loppers. But when branch diameter is too big to comfortably, safely, and accurately remove with loppers, a saw is needed. For almost all pruning done with a saw, a single cut to remove a branch is likely to leave a wound that is difficult for the tree to seal. This is because when cutting downward with a saw into a branch, as the blade penetrates over half way through it, the branch will break from its own weight. This results in bark stripping off the underside of the branch and excessively damaging the trunk or parent branch. Usually, two or three cuts will be needed to remove a single large branch without stripping bark, splintering the branch or trapping the saw blade.



The **three cut method** is an industry standard pruning method.

- Moving outward a few inches from the branch's source (the trunk or another branch), the *first cut* is made from the bottom of the branch upward, deep enough to cut all the way through the bottom bark, but not deep enough to trap the blade.
- The *second cut* is made about an inch or two outward from the undercut and is made from the top down, all the way through the branch, cutting it off and reducing most of the branch's weight.
- The *third cut* removes the stub that is left as a result of the first two cuts. This cut is made like the typical **removal cut**, just outside the branch collar.

For branches that are large enough to require a saw, but small enough to easily control, the **two cut method** may be used.

- In this method, the two cuts are made in the normal location - just outside the branch bark collar, but the *first cut* is made from the bottom of the branch upward. The blade should cut all the way through the bottom bark, but not deep enough to trap the blade. Its purpose is to ensure that the bark does not strip during the second cut.
- The *second cut* is made from the top down, just outside the branch bark collar, joining the undercut.

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 seal and 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 crotches.
- Remove branches with weak V-shaped crotches and 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.
- Avoid excessively thinning lateral branches from the crown interior.
- Remove girdling roots.
- Remove suckers and watersprouts.
- Use crown reduction pruning only when absolutely necessary. For example, when repairing storm damage.

“Pruning” Practices That Hurt Trees

The following practices are harmful to trees and should be avoided:

- **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.
- **Flush cuts** injure the branch collar and can result in serious decay of the trunk.
- **Rip cuts** damage branch collar and trunk tissue. Use the three-cut method to avoid bark ripping.
- **Heading cut** reduces a stem or branch back to an internode, bud, or small lateral branch. Heading to an internode is not acceptable for shortening branches, only for storm damage restoration. Heading to a bud or small lateral branch is acceptable for fruit production or structural pruning of young trees.
- **Lion’s tailing** occurs when trees are stripped of their interior foliage and branches, leaving only a small amount of new growth at the end of the branch.

Avoid making the cut too far out from the branch bark collar, leaving a stub. 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.



Topping of a Crepe Myrtle tree (process sometimes called ‘Crepe Murder’)



Oak trees topped along a neighborhood street



Flush cut inhibited the tree from sealing the wound and rot is present in the trunk. Image by Luana Vargas, Desert Botanical Garden, Bugwood.org

When to prune

Standard practice recommends pruning **deciduous** trees when they are dormant. It is also easier to see the structure of the branches. Dormant season pruning may prevent excess sap residue at the wound from attracting disease-carrying pests. Seasonal disease outbreaks or susceptibility should be considered for each tree species.

See the Virginia Cooperative Extension Service website for the best pruning time: <https://www.pubs.ext.vt.edu/>. Pruning can be conducted at any time for dead, damaged or diseased branches. Excess foliage growth, including suckers and watersprouts, can be pruned off throughout the year. Look for underlying health problems and possible causes for these growth habits.

Basic Tools & Tool Maintenance

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!

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.

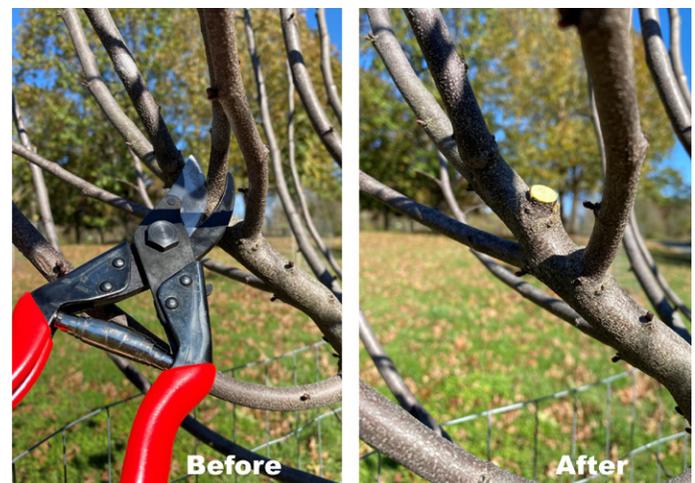


Using a pruning saw for two cut method on a branch that is too large to be pruned with a bypass pruner. Image by Tim Maywalt.

- **Hand pruners** can be used to cut very small branches ($\frac{1}{2}$ " diameter or less).
- **Loppers** are long-handled pruners used to cut branches $\frac{1}{2}$ to $1\frac{1}{2}$ " 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 $1\frac{1}{2}$ " diameter), but may leave ragged-edged pruning wounds on thin-barked trees.
- **Pole pruners** are bypass blade instruments on an extendable pole to allow cutting higher branches without getting on a ladder.
- **Pole saws** are pruning saws on an extendable pole.

Pruning shears or hedge clippers are not recommended for general 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. Shearing is a specialty pruning best reserved for formal landscapes under intensive maintenance regimes.

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.



Before and after structural pruning using a standard bypass pruner.

Cleaning and Disinfection

Clean blades make better cuts. After using pruning tools, clean them. A clean tool is a safer tool, and they need to be cleaned before disinfection to ensure that the disinfectant can reach all parts of the tool. Disinfecting tool blades is important to prevent the transmission of disease pathogens from one cut to the next. Recommended disinfecting solutions are ethyl or isopropyl alcohol, and household cleaners, such as Lysol, Pine-Sol or Listerine. After cleaning them, dip tools into the solution or use a spray bottle and soak the entire cutting blade. Bleach is not recommended as it is an oxidizing agent and can damage the steel on pruners, as well as skin and clothing.

Maintaining and Storing Tools

After cleaning and disinfecting, spray tools with a light oil, coating the blade and other metal parts to prevent rust and to lubricate joints and moving parts. Any good, light oil will suffice, such as Fluid Film, WD-40, Break-Free, etc. Most hand pruners, loppers, and folding saws have a screw or bolt that holds the blades together or to the handle. With use, blades may loosen and need to be tightened with the appropriate tool. Always store your bladed tools in a dry area, as even high humidity can cause rust.

Sharpening

A sharp tool is a safer tool! Less effort is required to cut through branches when tools are sharp, cutting takes less energy and cuts are easier for the tree to seal.



Tool sharpening. Image by Charlottesville Area Tree Stewards

Files are good for sharpening axes, hatchets, and other thick bladed tools. But most files are too coarse to effectively sharpen the thin, fine blades of hand pruners and loppers. These require a stone or a diamond hone.

Sharpening stones are usually inexpensive and come in a variety of grits from extra coarse to medium to fine to extra fine. Each of these grits has its own purpose. A badly chipped or very dull blade might require a number of stones to efficiently sharpen the blade. A coarse stone might be used only to remove nicks, while a medium grit stone will be needed to start the sharpening process. Sharpening stones must always be used with some kind of lubricant (oil or water) to float the steel grindings away from the stone's surface.

Diamond hones are preferred sharpeners by many people for numerous reasons, including speed of sharpening and longevity of the diamond surface. Another advantage of diamond over stone is diamond hones don't require a lubricant – they can be used dry. They work faster with a lubricant though (usually water). As with stones, diamond hones come in a variety of grits, and different degrees of dullness of a blade may require multiple hones to reach acceptable sharpness.

Be sure to consult your tool's maintenance manual for sharpening and maintenance suggestions.

Wounding a Tree

Trees may suffer damage from a wide range of pests, diseases, natural events, and human activities. For example, 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. Damage to tree bark can take decades to seal and replenish. Trees can live after sustaining substantial damage to the interior wood or to areas of the bark as long as the injury or disease does not spread to living cambium tissues. Structurally, however, these trees may be weakened if their wood does not resist decay well. 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 guy wires cause much damage to trees in urban areas.



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. Image by Eric Wiseman, Virginia Tech

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 compartmental 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 decay spread above and below the wound by plugging xylem vessels or trachieds. Wall 2 slows inward spread by depositing chemicals in **late wood** cells of older growth rings. 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 walls 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

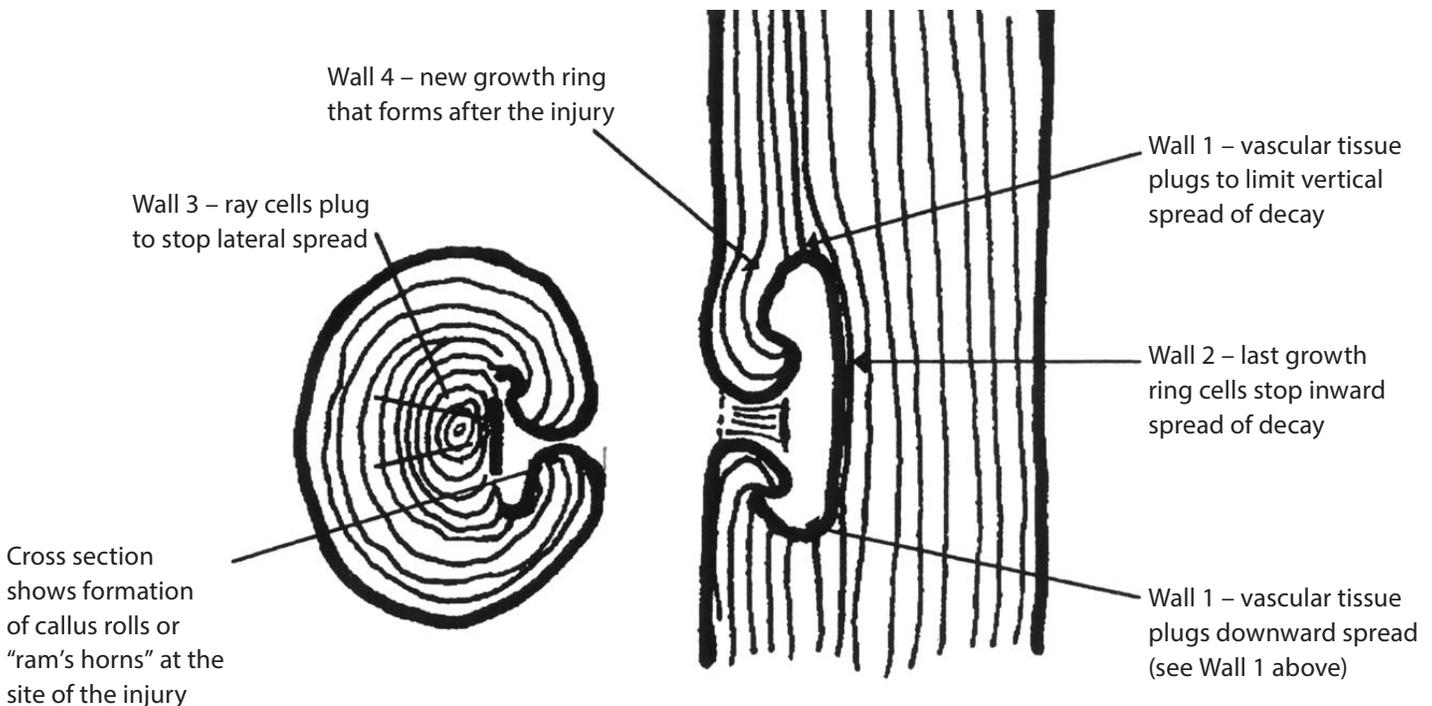
of the new cambium or if some canker-causing fungus restricts the development of the new growth ring. Sealing off the damage may require more than one growth cycle.

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.

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.

CODIT Diagram



Hazard Trees— Pruning for Safety

Every tree owner should learn to recognize the following 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 soil 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. Fencing can be used to exclude people from under the tree where falling branches may harm them.
- 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 to reinforce weakened or defective parts – consult a professional for this.
- Refer to a specialist and hire a Tree Risk Assessment Qualification (**TRAQ**) qualified arborist
- Remove the tree.



Callery pear is an example of a tree that should not be planted because of its poor form.

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:

1. What does CODIT stand for?
2. How do trees counteract bark damage?
3. Name eight symptoms or conditions that may indicate an unsafe/hazard tree.
4. What is the No. 1 thing to remember about pruning any tree?
5. What five questions should be answered before deciding to prune?
6. What are suckers and watersprouts?
7. What style of pruning tool is best?
8. Describe or draw the three-cut method.
9. What function does the branch collar serve for the tree?

Resources

A Guide to Successful Pruning, Deciduous Tree Pruning Calendar (2009). Virginia Cooperative Extension. Available at: <https://www.pubs.ext.vt.edu/430/430-460/430-460.html>

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Unit 8

Tree Problems & Diagnosis

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. It is also important to understand several common **abiotic** and **biotic** factors that can also affect growth and survival discussed in more detail on the following pages.



Spiral of decline. Image by Jason Sharman, Vitalitree, Bugwood.org

HOW TO KILL A TREE

Few residential trees die of "old age." Mechanical damage and improper tree care kill more trees than any pests or disease. **AVOID** making these harmful mistakes and consider hiring a certified arborist to perform advanced tree care.



- 1 "Top" your tree to encourage weak watersprouts
- 2 Leave codominant leaders with included bark that split during winds and storms
- 3 Plant close to house or obstacle to reduce adequate growing space
- 4 Leave "stubs" when pruning to promote branch decay
- 5 Leave crossing branches when pruning to rub bark wounds
- 6 Ignore pests, diseases, and nutrient deficiencies
- 7 Nail or attach items to tree to damage bark and girdle branches
- 8 Encourage pests by leaving broken branches on the tree
- 9 Coat pruning cuts with paint or sealer to slow wound closure
- 10 Cut large branches flush with the trunk to increase decay
- 11 Damage roots and trunk with lawn equipment
- 12 Spray herbicides on turf that accidentally poison tree
- 13 Cut through roots when digging trenches
- 14 Encourage rot and hinder tree growth by leaving wrap on trunk
- 15 Leave tree staked until guy wire girdles trunk
- 16 Pile mulch against the trunk to encourage rodent damage and bark rot
- 17 Prevent water and nutrients from reaching the roots by covering the soil with a plastic weed barrier
- 18 Leave root ball twine on to girdle the trunk
- 19 Leave wire basket in place to girdle roots
- 20 Leave on treated or synthetic burlap to prevent root growth
- 21 Leave circling roots that will strangle the tree
- 22 Dig planting hole too narrow and overamend backfill to discourage proper root spread
- 23 Dig hole too deep to smother the trunk flare and drown the roots
- 24 Drown the roots by over-irrigating your lawn

Bonnie Appleton's How to Kill a Tree Poster was revised in 2019 and is a great resource to show people all the different abiotic ways trees decline and die.

Major Urban Site Problems

Limited Space for Root Growth – *Causes:* **compacted soil**, insufficient soil volume, 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, nutrients, and oxygen to thrive and withstand drought and pests.

Impermeable Surfaces – *Causes:* surrounding asphalt or concrete. *Effects:* reduced air and water to the root zone; polluted water; 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.

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

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.

Soil and Water Contamination – *Causes:* road salt, over-fertilization, 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.

Soil Erosion – *Causes:* trees planted too high in “planter” areas, soil covering root ball is allowed to erode away. *Effects:* exposed surface roots, desiccation of roots.

Construction – *Causes:* heavy equipment, foot traffic, stockpiling, grading *Effects:* compacted soil, increased debris, disrupted soil structure, increased likelihood of mechanical injury to bark and cutting of roots. Negative effect on soil quality, physical harm to trees.



Can this tree be saved?

Heat – *Causes:* reflection from pavement, asphalt, cars and buildings. *Effects:* increased dehydration, sunscald on leaves and bark, and stunted growth.

Physical Damage – *Causes:* vehicles, lawn mowers, string trimmers, installation and removal of holiday lights, vehicle accidents. *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.

Waste – *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.

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.

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 vines and die as they are smothered and strangled. (See [Unit 9](#) for additional information on invasive plants).

Incorrect Planting – *Causes:* Planting a tree too deep or shallow, leaving girdling roots, and failure to remove tree wraps or supporting wiring. *Effects:* stress and gradual death of the tree.

Most of these are abiotic problems. Trees can be injured by both abiotic and biotic agents, but the International Society of Arboriculture estimates that up to 90% of tree problems 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 it 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.



Physical damage—a support system left on longer than the tree needs results in girdling and decline. Image by Eric Wiseman, Virginia Tech



English Ivy climbing up a tree will compete for nutrients and sunlight.



Tree planted too shallow exposes delicate roots to risk of mechanical and structural damage. Image by Eric Wiseman, Virginia Tech

Tree Disorders

Tree disorders are not always fatal. When a disorder causes stress, the tree may still be within the realm of recovery, either on its own or with the help of treatment. The key is that the stress must be mitigated in order to prevent mortality. Treatment is not always necessary to alleviate stress and disorders. 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. If a disorder causes the stress to exceed a tree's tolerance level, then the tree may enter terminal decline from which it will not recover, either through natural processes or treatment interventions. For this reason, it is important to recognize early symptoms of stress and diagnose the cause of the disorder so that treatment can be undertaken as necessary. Diagnosing tree disorders can be extremely difficult and many symptoms overlap between different pests and diseases, so contacting a professional is recommended.

Abiotic vs. Biotic Factors

Causes of tree disorders can be classified as either abiotic or biotic. Abiotic or nonliving agents include environmental, physical, and other non-biological factors. Some examples include soil compaction, water and nutritional deficiencies, temperature extremes and mechanical injury. Biotic or living agents can include bacteria, fungi, viruses, insects, mites, nematodes, vertebrates, etc. Symptoms of abiotic and biotic agents can look similar and often are difficult to diagnose.



Woodpecker damage is a common example of a biotic tree factor

Common Abiotic Symptoms & Causes

Defoliation – *Symptom:* loss of foliage during an irregular time of year *Potential Causes:* herbicide exposure or sudden extreme drop in temperature, drought, overwatering, high temperatures and also many biotic causes.

Fine Root Discoloration – *Symptom:* black or grey fine roots, smell of decomposition *Potential Causes:* poor soil aeration or overwatering

Leaf Chlorosis – *Symptom:* yellowing of the leaf *Potential Causes:* nutritional deficiencies primarily nitrogen, phosphorus, iron, and manganese (can also be caused by biotic agents)

Did You Know?

Along with checking for proper root structure, it is also important to check for proper root health. When selecting a tree from the nursery, check that the roots are white and spongy. This indicates the roots are healthy and actively growing.

Leaf Necrosis – *Symptom:* death of part of all of the leaf *Potential Causes:* salt, herbicide exposure, lack of water, temperature extremes, excessive sun exposure (can also be caused by biotic agents)

Leaf or Shoot Wilting – *Symptom:* drooping, loss of rigidity *Potential Causes:* overwatering or under-watering or drought (can also be caused by biotic agents)

Stunted Growth – *Symptom:* reduction in growth rate *Potential Causes:* soil compaction, nutritional deficiencies, incorrect planting, heat stress, herbicide drift

Trunk Swelling – *Symptom:* increased localized growth or enlarged areas *Potential Causes:* girdling roots, mechanical injury, tree wraps, ties or tags left on tree

Many abiotic disorders are due to soil issues, nutritional deficiencies, water problems, and mechanical injury. Therefore, it is important to understanding the basics of soil and water management ([Unit 3](#)) and how trees respond to injury ([Unit 7](#)). More details about injury from construction are provided on the next page.



Chlorosis in a maple leaf. Image by Jason Sharman, Vitalitree, Bugwood.org

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



Construction damage. Image by Andrew Koeser, International Society of Arboriculture, Bugwood.org

to trees and routinely results in tree decline and even death. Most conflicts over trees are not intentional. Many of them result from lack of knowledge, lack of planning, or poor communication. The good news is that conflicts between trees and construction can usually be avoided, or mutually agreeable solutions can often be reached. 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, nutrients, and oxygen.
- A tree's ability to remain upright may be compromised, especially when buttress 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 may be difficult for a tree to compartmentalize.
- As resulting decay advances, it can weaken a tree's ability to resist and respond to other stresses.

Symptoms of Tree Stress Triggered by Construction

- Shorter internode growth on twigs
- Smaller leaves
- Thinner crown foliage
- Leaf scorch
- Leaf wilting
- Early defoliation
- Watersprouts or suckers
- Heavy seeding
- Branch dieback
- Physical damage from equipment (decay on older wounds)
- Wood borers & other stress-related pests



Tree at a construction site. Image by Eric Wiseman, Virginia Tech

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, while also giving desirable trees the best chance for survival.

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 support systems 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 or chisel, 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 damaged 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 or four years to show up. See <https://www.pubs.ext.vt.edu/430/430-210/430-210.html> for "24 Ways to Kill a Tree" by Dr. Bonnie Appleton.

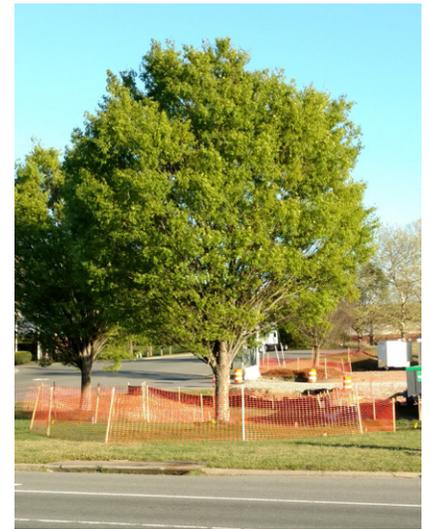
What Communities Can Do

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.

Minimize Construction 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 disturbance of native soils.

Special trees deserve special attention to protect their critical root zone (CRZ). The size of the CRZ is proportionate to the size of the trunk and crown. A common guideline is that the CRZ is 1' in radius per 1" of trunk diameter. So a 20" diameter tree would have a CRZ with radius 20' (diameter 40'). Older trees, low vigor trees, and sensitive species require a larger CRZ. Before construction

begins, sturdy fencing and signage should be constructed around the perimeter of the CRZ to create a tree protection zone (TPZ). The TPZ should be placed off-limits to all traffic, grading, material storage, and dumping for the duration of the project. 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: <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.530.9304&rep=rep1&type=pdf>.



Root Protection Zone fenced off to dripline during construction. Note: Metal fencing would be better protection than this construction fence.

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. Other examples include rain barrels.

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.

Native Biotic Pests and Diseases

Biotic or living agents can include bacteria, fungi, viruses, insects, mites, nematodes, vertebrates, etc. Few organisms found in or around trees are pests. Most are simply using the tree for habitat and many of them improve tree health by controlling pests and recycling organic matter. Organisms become pests when they compete with, feed on or infect desirable plants. Some of their symptoms may be similar to abiotic conditions.

Common Diseases

Below are some examples of common diseases found in Virginia. This is not a comprehensive list but a starting point for common problems for diagnostic purposes. These diseases are also generalized. For example, multiple types of root rot and galls infect several species of trees.

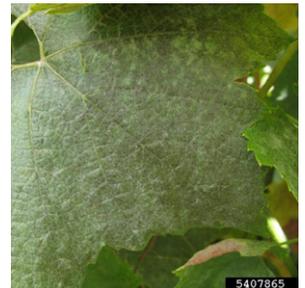
Anthracnose – Results from various fungi that causes noticeable dry looking spots of various colors (tan, brown, black) or irregular dead areas on leaves or twigs. It can cause foliage to become distorted and an infected plant can defoliate. Some susceptible hosts include dogwood, American chestnut, sycamore, and oak. It typically occurs after wet spring weather.



Dogwood Anthracnose. Image by John Hartman, University of Kentucky, Bugwood.org

Planting the right tree in the right place is the best solution to anthracnose. Pruning out infected twigs over the winter can prevent anthracnose from spreading. Fungicides can also be applied and have shown effective on some species.

Powdery Mildew – White patches on leaves caused by fungi that looks powdery. Some hosts include rose, sycamore, viburnum and hydrangea. Infected leaves can prematurely drop and twigs can become distorted on some hosts. Spores spread by the wind and favor warm days with cool nights. Also use resistant cultivars, appropriate sun exposure and the use of fungicides and good air control.



Powdery Mildew. Image by Julia Beale, University of Kentucky, Bugwood.org

Sooty Mold – Sucking insects feeding on tree sap excrete honeydew, which accumulates on vegetation below. Sooty mold are fungi that grow upon the honeydew, creating a darkened crust upon surfaces. They are generally harmless to the tree. It is more of an aesthetic problem. However, it can be an indicator of major pest issues that need to be addressed. Fungicides should not be used on sooty mold but insecticidal soaps, horticultural oils, and other products may work to control the sucking insects.



Sooty Mold. Image by Joseph O'Brien, USDA Forest Service, Bugwood.org

Cankers – Cankers are sunken lesions made up of dead tissue on a branch or trunk. They can be caused by sunscald as well as by fungi or other microorganisms. Some cankers are short-term and others long-term infections. Long-term infections can girdle and kill limbs on the tree with time. Cankers may also lead to sapwood decay in trunks and branches. Solutions include planting resistant cultivars, pruning dead or dying branches, and avoiding mechanical injuries.



Thousand Cankers Disease. Image by Whitney Cranshaw, Colorado State University, Bugwood.org

Galls – Swollen, tumor-looking growths on the leaves, branches, trunk, or roots. Caused by either fungi, bacteria, or insects. The majority of galls are an aesthetic issue, but pruning out diseased or damaged growths on the tree will help. Some host trees include elm, cherry, maple, and oak.



Gall Wasp. Image by Steven Katovich, Bugwood.org

Root Rot – Causes infected roots to die and typically caused by a fungus. They are often brown or black in color, soggy looking and smell of decomposition. Observed symptoms include wilting foliage and discolored leaves because water and nutrients cannot reach the crown. Cultural care is the most important solution to this problem.



Phytophthora Root Rot. Image by Edward L. Barnard, Florida Department of Agriculture and Consumer Services, Bugwood.org

Giving a tree too much water can cause root rot. Planting a tree that is not well adapted in poorly drained and compacted soils can cause the problem. Fungicidal products can work to control disease organisms.

Fire Blight – Common to the Rose family, fire blight is caused by bacteria that infects new growth from the flowers during the spring. Wilting, blackening of shoots, blossoms or fruit give the tree a scorched appearance. Cankers can form on tissue and prolonged infections can kill some trees. Pruning diseased branches back to healthy tissue can help manage this disease. Applying bactericides during blossoming can reduce spread.



Fire Blight. Image by Jason Sharman, Vitaltree, Bugwood.org

Common Arthropod Pests

Aphids (Aphididae Family) – small soft-bodied insects that suck plant juices also known as plant lice. They are pear shaped (larger at the end than the head). Feeding causes leaves to wilt and curl and severe infestations will kill the tree. Aphids produce honeydew, which can cause sooty mold discussed above. Spray with warm soapy water or prune infected areas to help manage infestations.



Aphids. Image by Jim Baker, North Carolina Forest Service, Bugwood.org

Bagworm (*Thyridopteryx ephemeraeformis*) – Native to the United States, this pest damages evergreens. They spend most of their life cycle in a spindle-shaped bag covered in needles from the host plant. Heavy infestations will defoliate the tree and bag attachment can cause abnormal growth. Picking the bags off the tree and disposing them offsite will help with the infestation. Insecticides specific to caterpillars will also control them if applied early in the growth stage.



Bagworm. Image by William Fountain, University of Kentucky, Bugwood.org

Bark Beetles (Scolytidae Family) – Tunneling into the phloem from bark beetles causes significant tree damage. They typically attack weakened, dead or dying trees. Prevention, by keeping trees in a state of vigorous growth and/or applying bark or systemic insecticides in anticipation of an attack, is the only effective way to avoid bark beetle damage.



Bark beetle damage. Image by Roger Anderson, Duke University, Bugwood.org

Eastern Tent Caterpillar (*Malacosoma americanum*) – A native defoliator pest. Eastern tent caterpillars can nearly defoliate a tree if in large numbers but most trees will recover. However, repeated defoliation can stress the tree. The silken nests, build in the crotches of limbs, can become large and an eyesore. Host trees include cherry and apple. On small trees it is possible to remove the large masses of caterpillars in nests by pruning out or removing by hand. Insecticides can be applied as a spot treatment, but it is not practical on a large scale.



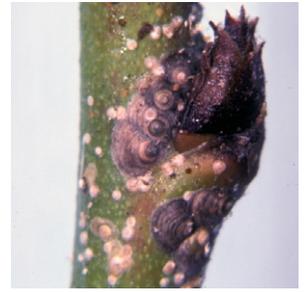
Eastern tent caterpillar. Image by Steven Katovich, Bugwood.org

Fall Webworm (*Hyphantria cunea*) – Also a tent making pest but tents are formed on the outer portions of the tree's branches. Mature larvae are yellow and hairy. Pruning infested foliage is possible. Insecticides can be applied early in the infestation, but it is not practical on a large scale.



Fall Webworm. Image by Linda Haugan, USDA Forest Service, Bugwood.org

Scale (Armored Diaspididae Family; Soft Coccidae Family) – Scale feed by sucking plant juices. Armored scales have a waxy outer covering that acts like a shield that females live under to feed and reproduce. Soft scales have a smooth rubbery outer covering that cannot be separated from their body. Severe infestations will cause a tree's leaves to yellow and drop and can kill young trees. Chronic infestations significantly reduce tree vitality and make them vulnerable to other stresses. Some scale species can be controlled by scrubbing infested branches with a brush and mild detergent solution, but this is only practical for small trees. Insecticidal soaps, systemic treatments, growth regulators, or foliar insecticidal sprays are also effective treatment options.



Scale. Image by USDA Agricultural Research Service, Bugwood.org

Degree Day Monitoring

Insect activity and growth rate depends on temperature. Measuring temperature over time will provide a time scale, called degree-days. Insects are cold-blooded and understanding degree-days can help measure insect growth or development in response to daily temperatures. Degree-day totals, lower threshold temperatures (temperature below which development stops) and upper development threshold (temperature at which the rate of growth starts to decrease) have been determined for many pests in the landscape. These numbers can be looked up for any pest and used to properly time treatments to coincide with harmful pest activity.

The averaging method used to calculate the number of degree-days is below:

$$\text{Degree-days points} = \left[\frac{(\text{max temp} + \text{min temp})}{2} \right] - \text{base temp}$$

For example, on May 14, 1998 in Albemarle County, VA, maximum daily temperature and minimum daily temperatures were 70 and 52° F, respectively. Using 50° F for the lower development threshold for Southern Pine Beetle, degree days accumulated were $(70 + 52)/2 - 50 = 11$ DD. Therefore, on May 14, 11 degree-days were accumulated for Southern Pine Beetle.

What's Wrong with My Tree?

Answering "what is wrong?" is a process, much like a detective would use. 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 *be objective*. Don't look for a quick answer. Many pests, pathogens, environmental stresses, and even human events can cause tree problems. The second important quality is *practice*. No one learns to be a good tree diagnostician overnight or by reading one unit in a book.

The Diagnostic Process

Look for any abnormalities. Don't make snap judgments, just look. Talk to people. Become familiar with the site 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.
- **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. Look for signs and symptoms when attempting to identify a tree disorder.

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
- Lean

Signs show actual evidence of the damaging agent itself, such as **conks** or fruiting bodies or 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.

Top to Bottom Diagnosis

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.

- **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.



Dieback. Image by Jason Sherman, Vitalitree, Bugwood.org

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



Defoliation. Image by Karla Salp, Washington State Department of Agriculture, Bugwood.org

- **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.



Flagging. Image by James Solomon, USDA Forest Service, Bugwood.org

- **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 **internode length** and abnormal leaf



Decline.

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 many years.

- **Chlorosis** is a general yellowing of leaf tissue due to a lack of **chlorophyll**. Interveinal 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.



Chlorosis. Image by Jason Sherman, Vitalitree, Bugwood.org

- **Wilting** can be easily observed as leaves that are limp or droopy due to dehydration, resulting from lack of soil moisture, root damage, or vascular damage.



Wilt. Image by USDA Forest Service, Bugwood.org

- **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 nutrient deficiency.



Leaf Necrosis. Image by Gerald Holmes, Cal Poly San Luis Obispo, Bugwood.org

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, insect **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.



Canker. Image by Elizabeth Bush, Virginia Tech, Bugwood.org

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, topping, excessive pruning.



Watersprouts. Image by Alex Shigo, Shigo & Trees, Assoc., Bugwood.org

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



Suckers. Image by Rob Flynn, Bugwood.org

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



Fruiting bodies. Image by Robert L. Anderson, USDA Forest Service, Bugwood.org

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. If you can find the root flare, determine it is level with the grade. Check for girdling roots. Soil pH, texture, moisture and compaction all can affect a root’s ability to function and thrive. Any abnormal conditions should be noted.



TIP:

Proper tree identification is essential to diagnosing a tree problem.

If you aren’t familiar with trees in your area, buy a good field guide from a local bookstore or order *Common Native Trees of Virginia* from the Virginia Department of Forestry at <http://dof.virginia.gov/tree/index.htm>.

Collecting Samples

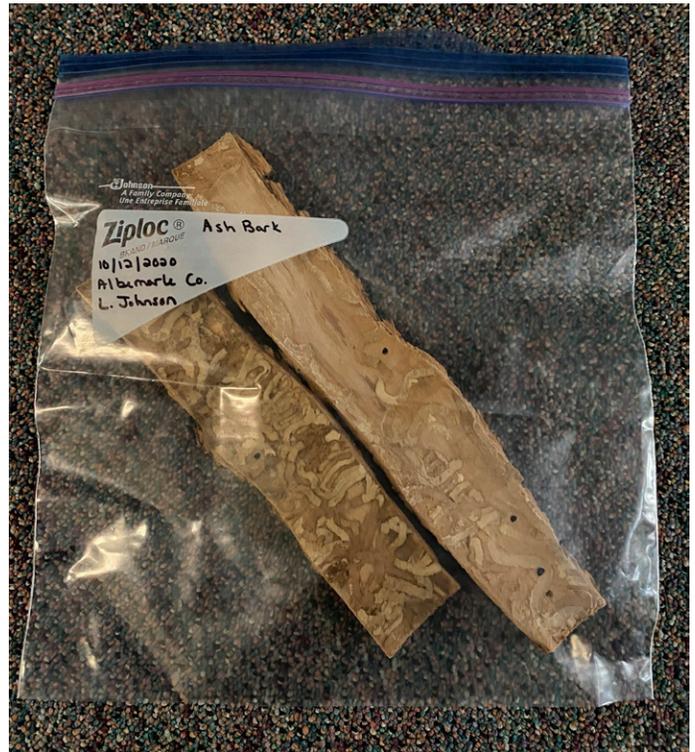
Tissue samples can help identify a sign or symptom of a plant disorder whether caused by disease, insect, nutrient, cultural or herbicide problems. Success depends on collecting adequate samples and recording a good description of the situation.

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

- 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.
- 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.
- Contact local extension office for advice.



Spotted Lanternfly (referenced more in [Unit 9](#)) in sample collection vials.



Ash bark sample with specific details such as date, county and collector written on bag.

Example Tree Inspection Form

Date: _____ Volunteer name: _____

Tree Species: _____

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

Years since planting (if known): _____

Estimated height: _____ Estimated diameter: _____

Location of the tree:

Overall appearance of the tree:

Problems noticed:

Referrals:

Actions taken at the site:

Follow-up:

Initials: _____ Date: _____

Key Questions:

1. What is the most important consideration in examining a tree?
2. If the signs/symptoms of a disorder are present, is the tree necessarily in decline? Explain your answer.
3. What are some symptoms of disorder in the crown?
4. What are some symptoms of disorder on the trunk and stem?
5. List two reasons to collect tree-related specimens during a site visit.
6. Name two sources of soil contaminants.
7. How does soil compaction harm trees?
8. If rainwater cannot infiltrate the soil surface, what problems can result?
9. What practices can help minimize impervious surfaces and otherwise slow rainwater runoff from developed areas?
10. What part of a tree is usually injured during construction?
11. What are five signs that a tree is under stress because of construction damage?
12. What is the number one goal in treating construction damaged trees?
13. What is a utility's primary requirement where trees are involved?
14. Name three types of tree and utility conflicts.
15. What is the cheapest and most effective way to address tree and utility conflicts?
16. What advice should a Tree Steward offer to a homeowner?
17. What is topsoil?
18. What are some problems that can occur belowground in the roots?
19. How do mycorrhizal fungi benefit tree root systems?

20. How does soil structure affect trees?

21. What causes leaching?

Resources

Signs and Symptoms of Branches and Bole (2020). Bugwoodwiki. Available at: https://wiki.bugwood.org/IPED:Signs_and_symptoms_of_branches_and_bole

Signs and Symptoms of Foliage and Twigs (2020). Bugwoodwiki. Available at: https://wiki.bugwood.org/IPED:Signs_and_symptoms_of_foliage_and_twigs

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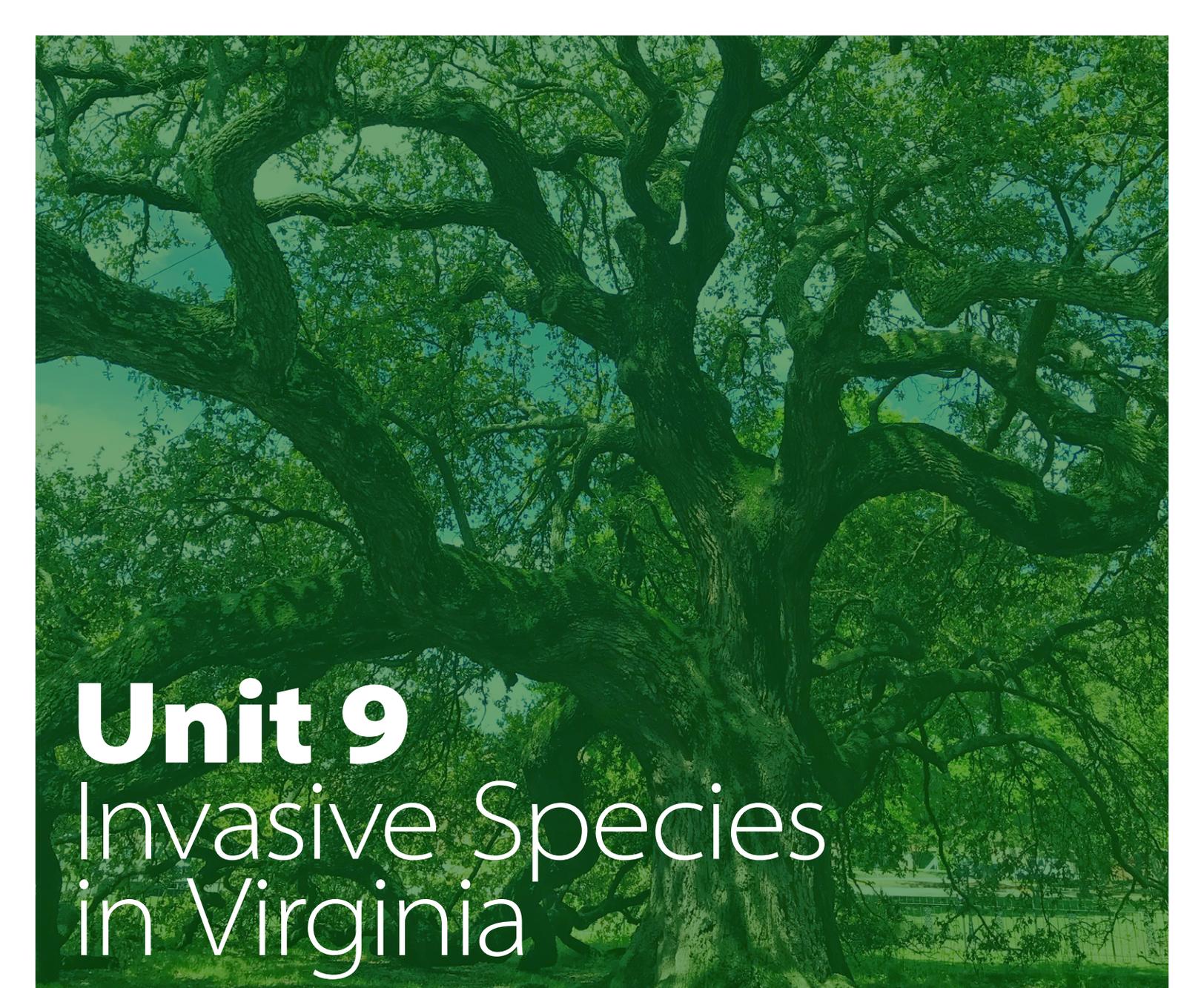
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ANSI A300 Standards & Best Management Practices Part 10 – IPM (2012). Tree Care Industry Association.

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Unit 9

Invasive Species in Virginia

Invasive species are non-native plants or animals that are introduced, either intentionally or unintentionally, into an area outside their natural range, and cause environmental and/or economic harm. While many non-natives such as wheat are beneficial to society, invasives cause harm by displacing native species, disrupting ecosystem processes, reducing biodiversity and wildlife habitat, or reducing productivity of crops. Often, because they do not have natural enemies, they can spread quickly. Invasive species are recognized as one of the leading threats to biodiversity and impose enormous costs to the forestry industry as well as others. This unit will highlight some of the more common invasive plants and tree pests found throughout the Commonwealth and what can be done about them.

The Virginia Department of Conservation and Recreation maintains a list of invasive plants found <http://www.dcr.virginia.gov/natural-heritage/invspdflist>. The Southeast Exotic Pest Council also maintains a comprehensive database with photos. <https://www.se-eppc.org/index.cfm>.

To report sightings of invasives:
Use this online mapping and reporting tool: <http://eddmaps.org>.

Download this smartphone app: MAEDN, Mid-Atlantic Early Detection Network.

Major Invasive Plants of Virginia

Oriental Bittersweet

(*Celastrus orbiculatus*)

- Climbing perennial vine
- Seeds are attractive to birds
- Spreads readily through underground roots
- Native to Asia
- Smothers and uproots plants it is clinging to with weight as it grows



Garlic Mustard

(*Alliaria petiolata*)

- Biennial or winter annual herb
- Introduced from Europe
- Spreads by seed and can self-pollinate rapidly
- Found along forest trails and riverbanks
- Allelopathic characteristics inhibit growth of native plants



Image by Rob Routledge, Sault College, Bugwood.org

Mile-A-Minute

(*Persicaria perfoliata*)

- Grows up to 6 inches per day creating dense mats
- Native to India and Eastern Asia
- Herbaceous annual vine
- Triangular shaped leaves contain recurved barbs



Image by Richard Gardner, Bugwood.org

English Ivy

(*Hedera helix*)

- Evergreen climbing perennial vine
- Spreads by runners and seeds and birds
- Carrier of bacterial leaf scorch (*Xylella fastidiosa*)
- Native to Europe and East Asia



Image by Andy Mabbett / CC BY-SA

Ailanthus

(*Ailanthus altissima*)

- Commonly known as Tree of Heaven
- Open grown trees can reach 70 – 80 ft at maturity
- Native of China
- Produces millions of seeds in a lifetime
- Pinnately compound, occurs in clumps and prolifically sprouts
- Out-competes and displaces natives



Image by Chuck Barger, University of Georgia, Bugwood.org

Japanese Honeysuckle

(*Lonicera japonica*)

- Semi-evergreen perennial vine
- Opposite leaves and fragrant flowers
- Native East Asia
- Commonly invades distributed areas, forests and roadsides



Autumn Olive

(*Elaeagnus umbellata*)

- Deciduous shrub
- Mature height 20 ft
- Native of Asia
- Produces millions of seeds in a lifetime that are easily spread by birds
- Underside of leaves silvery
- Creates dense shade that hinders the growth of natives



Image by Chris Evans, University of Illinois, Bugwood.org

Kudzu

(*Pueraria montana*)

- Climbing perennial vine
- Native to Asia
- Spreads through runners and roots at nodes to form new vines
- Can grow at 1 ft per day
- Suffocates and crowds out native plants



Image by Kerry Britton, USDA Forest Service, Bugwood.org

Multiflora Rose

(*Rosa multiflora*)

- Multi-stem perennial shrub with thorns
- Mature height 15 ft
- Native to Asia
- Rose hips spread readily by birds and remain on shrub through winter
- Grows in thickets and displaces native vegetation



Chinese Privet

(*Ligustrum sinense*)

- Evergreen shrub
- Mature height 20 ft
- Opposite leaves
- Native Europe and Asia
- Birds spread seeds and it also root sprouts
- Displaces native vegetation and grows in thickets



Japanese Stiltgrass

(*Microstegium vimineum*)

- Sprawling annual grass
- Very shade tolerant and creates continuous carpet on forest floor
- Native to Asia
- Silvery line at center of blade
- Displaces native vegetation and suppresses forest regeneration



Waveleaf Grass (*Oplismenus undulatifolius*)

- Sprawling perennial grass
- Very shade tolerant and creates continuous carpet on forest floor
- Rippled waves across leaf blade
- Native to Asia
- Displaces native vegetation and suppresses forest regeneration



Image by Kerrie L. Kyde, Maryland Department of Natural Resources, Bugwood.org

Chinese Wisteria

(*Wisteria sinensis*)

- Native to China, currently sold in U.S. garden centers
- Vine that climbs and winds around native plants, shading them out
- Attractive lavender flowers in the spring
- Prefers full sun; can be found along roadsides, forest edges and right-of-ways



Image by Chris Evans, University of Illinois, Bugwood.org

Callery Pear

(*Pyrus calleryana*)

- Native to China
- Widely planted in ornamental settings
- Fruits are round and eaten by birds
- Often invade roadsides, pastures, hedgerows and untended land
- Long lived seedbank
- Weak branch structure poses hazard
- Bradford Pear was the original introduction



Image by Tim Maywalt

Porcelain Berry

(*Ampelopsis brevipedunculata*)

- Native to Asia
- Perennial vine can climb 50 ft or more
- Smothers native plants, weight topples trees
- Leaves can be confused with wild grape
- Grape-like fruit are dappled blue and white



Image by Tim Maywalt

Management of Invasive Plants

Managing invasive plant infestations is challenging, but a great place to start is in your own community or back yard. Developing a plan of attack and breaking up the task by cutting treatment areas into smaller more manageable sections is a great place to start. Next, decide on a control option, either mechanical or chemical, based on need. The best control option for a particular invasive plant depends on the species characteristics and preferred growing conditions. Understanding the biology and ecology of the targeted invasive can help you choose the best control options and put together a solid management plan.

Mechanical Control

These procedures do not introduce chemicals into the environment and do not require a Certified Pesticide Applicator license. However, because you are manually removing invasives by hand or with hand tools, it can be extremely labor intensive. This method also creates a lot of site disturbance, and if not repeated frequently or followed up with chemical control, the treatment site can be reinvaded quickly.

Important note: Make sure you can identify poison ivy and be on the lookout when using a mechanical control method.



Mechanical cutting back bittersweet at the stump will disrupt seed. This can be paired with chemical control methods discussed below.

Did You Know?

It is very simple to remove English ivy from a tree. Cut the ivy at the bottom around the entire trunk of the tree taking out a piece at least three inches long so the vine can't reseal. If using an herbicide, apply it to the cut stump. *Any ivy above the cut will die off on its own and fall out of the tree.* Leave vines above the cut alone. Pulling them can damage the tree and cause injury.

Mow/Cut – Mowing or cutting invasive plants at ground level. This technique can disrupt seed production and the plant's ability to photosynthesize, but requires the area to be treated frequently because most invasives will sprout readily from the root system. In order to be effective, mowing should be done repeatedly until the seedbed and invasive plants' root systems are exhausted.

Pull/Dig – Pulling plants by hand or digging is another option for controlling invasive species (either herbaceous or small woody). It is important to get as much of the root system as possible during removal because leaving roots can restart an infestation. For larger woody trees, something like a Weed Wrench can be helpful and reduces back strain. Doing this form of control when the soil is moist, such as after a rainstorm, will allow the roots to be removed more easily.

Suffocate – Suffocating small ground level plants can be an effective treatment for small areas like your yard. Using cardboard or thick plastic sheeting over the infestation area will kill everything under the material. Overlap the materials and put weights down or cover with mulch to keep the material in place. Plastic is better for harder to treat invasives, but cardboard deteriorates and becomes mulch for the new plantings. Make sure to seed the treatment area with natives once the material is removed or invasives will seed back in.

Chemical Control

Herbicides can be an extremely effective tool to control invasive plants if used properly. In Virginia, you are not required to be a Certified Pesticide Applicator when using herbicides on your own property. However, all governmental agencies are subject to the provisions of the Virginia Pesticide Control Act. Certification and recordkeeping requirements apply to government employees and any volunteers authorized to make pesticide applications for a governmental agency. There is an exemption for only forestry applicators specified below.

2VAC5-685-60. Persons Exempt from Certification.

6. Forestry applicators standing on the ground who apply general use herbicides for forest vegetation control and tree thinning under the direct on-site supervision of a certified commercial applicator. One certified commercial applicator shall be present for every eight forestry applicators and be within voice contact of and no more than 200 feet from such applicators;

In these specific forestry scenarios, the Certified Applicator is responsible for the actions of those working and must be *physically present on the property upon which the pesticide is being applied, and in constant visual contact with the person applying the pesticide.* Read the labels and follow directions precisely for both environmental and personal safety. The label is the law.

For more information and if you are interested in becoming a Certified Pesticide Applicator see the Virginia Department of Agriculture and Consumer Service (VDACS) website (<https://www.vdacs.virginia.gov/pesticides.shtml>).

Foliar Spray – Directly spraying foliage with herbicide is a great control option for many invasive plants. Treatment can either be done as a spot treatment on a small scale using a backpack sprayer or on a large scale to treat monocultures. It is important to follow the instructions on the product label and conduct the treatment when the plants are actively growing. Target plants should be thoroughly wetted with the herbicide when there is no rain in the forecast for the next 24 to 48 hours.

Cut Stump/Hack and Squirt – Cut stump may be the most common combined mechanical/chemical technique since it can be used for vines, bushes and small trees up to about three inches in diameter. Cut stems close to the ground leaving a flat surface to apply the herbicide. Using a brush, sponge applicator, drip or spray bottle, apply a small amount of high-concentration herbicide to the cut end as soon as possible after cutting, before the cut end seals. For

larger stems, including mature trees, use the hack and squirt technique. Using a hatchet or ax, make a series of cuts into the tree leaving a couple inches between each cut all around the trunk or stem, then spray or drip herbicide into each cut. It can be helpful to add dye to the herbicide solution to mark the treated surfaces preventing reapplication.

The Virginia Department of Forestry has developed a guide organized by invasive plant type listing time of year to treat them, control methods, herbicide concentrations when chemical treatment is specified and notes to ensure effective treatment. It can be found at https://www.dof.virginia.gov/infopubs/_forestry-topics/FT0031_Nonnative-Invasive-Plant-Species-Control-Treatments_pub.pdf

Major Invasive Insect Pests in Virginia

Many of the invasive insect pests found in Virginia can only be treated by a professional with a Virginia Certified Pesticide Applicator license. As tree stewards, it is important to be able to recognize and identify these pests for educational and safety concerns. Please contact a local professional arborist for treatment options.

Emerald Ash Borer (*Agrilus planipennis*) – Invasive insect known for the golden green color of the adults. Host plants include all species of ash (*Fraxinus*). The white segmented larvae feed in the cambium producing galleries that girdle the tree with time. When exiting the tree during the spring, adults produce a D-shaped hole commonly used for identification. Blonding on the trees occurs as woodpeckers find the insects under the bark. A soil drench or systemic injection are potential treatment options.



left: EAB larva feeding below the bark of an ash tree. The galleries made by the larva will eventually kill the tree. right: Adult EAB next to galleries

Gypsy Moth (*Lymantria dispar*) – Introduced from Europe, host plants include oaks, linden and willow, but in high populations they will defoliate many other plants. Mature larvae have rows of blue dots on the front and red on the back. They feed at night and crawl down the trunk during the day to hide. Foliar insecticides or growth regulators can be applied on a large scale to control pest spread. Individuals can destroy egg masses or put up barriers on the trunk to control the crawling caterpillars.



left-top: Gypsy Moth adults. Image by USDA APHIS PPQ, Bugwood.org
 left-bottom: Gypsy Moth larvae. Image by Karla Salp, Washington State Department of Agriculture, Bugwood.org
 right: Egg masses on a tree trunk.

Hemlock Woolly Adelgid (*Adelges tsugae*) – Invasive pest introduced from Asia. Adults are brown to red in color and oval shaped. The white tufts that cover their bodies and resemble snowfall on the branches of the trees commonly identify crawlers. They are sapsuckers and can cause needles to drop prematurely, killing the tree after a few years of infestation. Horticulture oils sprayed on the foliage or systemic insecticides in a soil drench are effective for treatment of this pest.



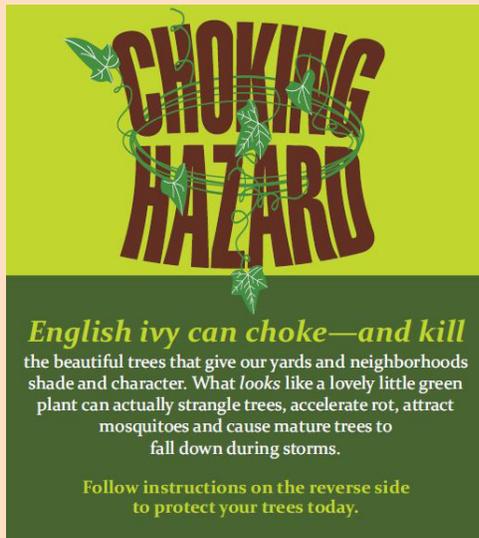
Spotted Lanternfly (*Lycorma delicatula*) – This pest is associated with over 70 different plant species, including fruit trees, ornamental trees, herbs, vines, agricultural crops and various hardwoods, especially the invasive tree species “tree-of-heaven” (*Ailanthus altissima*). The spotted lanternfly feeds by sucking sap from the stems, branches and trunks of trees, which creates weeping wounds. The insect then excretes honeydew, which promotes the growth of sooty mold. Sooty mold is dark in color and can damage the plant by blocking sunlight and preventing photosynthesis. Feeding by the spotted lanternfly can cause foliage wilting, branch dieback, and reduced fruit yield. The most important management strategy is to take measures to stop the spread of this insect. Always inspect vehicles, goods, and your clothes before leaving an infested area. This is required if you are exiting a quarantine zone. Early nymphs crawl up and down tree trunks and can be controlled with sticky bands in the late spring/ early summer. Egg masses should be scraped into alcohol or destroyed by smashing or burning. This pest prefers tree-of-heaven, and host removal can also be beneficial. Finally, contact and/or systemic chemical control may be used when spotted lanternfly is abundant.



left: Sooty mold caused by spotted lanternfly
 right-top: Adult spotted lanternfly
 right-bottom: Spotted lanternfly egg masses on bark

Tree Steward Stories—Arlington/ Alexandria Tree Stewards

Volunteers have been working to teach citizens in their localities how to remove English ivy and save their trees. The Tree Stewards set out equipped with education materials to share with homeowners, have slide presentations to give at civic associations, and materials for exhibit booths at farmers markets and festivals. Visit their website campaign link to learn more and download the 2-sided mini poster below: <https://treestewards.org/take-ivy-off-trees/>



Ivy is a threat to the trees of Northern Virginia. Thankfully, it is a beatable one.

Old tree-lined streets, neighborhood parks, shaded decks and secret gardens add comfort and character to our lives. These places are special because of the incredible trees that provide the privacy, shade and character that we cherish so much.

Our trees add value to our properties and quality to our lives. That is why we've invested so much time and money into landscaping, nurturing and maintaining our trees and gardens. The investment is worth it. Unfortunately, English ivy is a threat to that investment.

Protect your trees, landscaping investments and home by cutting ivy away from your trees. Follow these simple steps, as recommended by arborists and horticulturists:



- 1 Use garden clippers to cut ivy at the bottom around the entire trunk of all infested trees.



- 2 Pull all ivy vines out of the ground around the base of the tree, making a 3-foot "life-saver ring" around the tree. This will protect the tree from future infestations.



- 3 Once cut, leave ivy on the tree. Do not pull it off because that could harm the tree. Ivy will gradually blend into the tree bark after it is cut.

Sponsored by The Commonwealth and Arlington Regional Master Naturalists as part of a grant from The Tree Company Fund.



Dangers of English Ivy

- 1 English ivy can strangle trees. Ivy adds significant weight, which cause mature trees to fall down in storms and strong winds.
- 2 Once ivy is in the tree tops, it can block necessary sunlight from the tree's leaves or needles. Dense ivy cover competes with the tree for nutrients and water.
- 3 Thick ivy growth can accelerate rot by holding in moisture, which can also attract mosquitoes.

Learn how to remove ivy from your trees by visiting www.TreeStewards.org or www.ARMN.org

Key Questions:

1. List some common invasive plants found in your part of the state? Where can you find a list of invasive plants found in Virginia?
2. What method should you consider first when trying to control invasive plants? List of some common invasive insects found in your part of the state?
3. What does the damage look like on an ash tree infested with Emerald Ash Borer?
4. Name some common characteristics of spotted lanternfly?

Resources

A Field Guide for the Identification of Invasive Plants in Southern Forests (2010). USDA Forest Service. <https://www.srs.fs.usda.gov/pubs/35292>

A Management Guide for Invasive Plants in Southern Forests (2013). USDA Forest Service. <https://www.srs.fs.usda.gov/pubs/36915>

Invasive Plant Species of Virginia (2020). Virginia Department of Conservation and Recreation. Available at: <https://www.dcr.virginia.gov/natural-heritage/invspinfo>

Invasive Species (2020). USDA Forest Service. Available at: https://www.nrs.fs.fed.us/disturbance/invasive_species/

Plants Search. Forest Health, Southern Regional Extension Forestry. Available at: <http://southernforesthealth.net/plants/>

Insects That Feed on Trees and Shrubs by W.T. Johnson and H.H. Lyon (1991). Comstock Book.

Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide by S.H. Dreisrath (2004). University of California Agriculture & Natural Resources.



Unit 10

Trees & People in the Community

Urban Forestry

Urban Forestry 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 Ecosystem

The impact upon trees in an urban setting is far-reaching as the early part of this unit 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 ecosystem, 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.

How To Start a Tree Steward Group

If the area you live in does not have a Tree Steward group already in place, consider starting your very own! An independent Tree Steward group can be established by developing an Organizational Document (essentially a plan for organizing a group and expectations for its basic structure) and a training class. Below are a few different steps to help you get started.

- Explore the level of interest in your area and consider contacting your local Extension Agent to get their perspective on level of interest and how they can help.
- Contact Trees Virginia through their website and notify the current Tree Steward Board member, letting them know your interest in forming an organization.
- Collaborate with an existing Tree Steward group for advice and guidance. Established Tree Steward groups can be very helpful to start-up groups. The Tree Steward Board member of Trees Virginia can help with information and with facilitating assistance from established Tree Steward groups.
- Tree Stewards need to be trained to an appropriate level of knowledge and ability about trees and tree care. Concurrent with the organizational elements of a new group, a training class needs to be developed. Models for training classes have been

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.

Did You Know?

There is also a Tree Steward training opportunity associated with the Master Gardener program offered through Virginia Cooperative Extension. To be an Extension Master Gardener Tree Steward, one must first be an Extension Master Gardener volunteer before taking this specialized training.

These groups include:

- Loudoun County Master Gardeners Tree Stewards
- Peninsula Master Gardeners Tree Stewards
- Virginia Beach Master Gardeners Tree Stewards

established by existing Tree Steward groups which can be the basis for a new group's training class.

- The new Tree Steward Group can be a nonprofit organization without pursuing 501 (c)3 status, although there are definite benefits to establishing an organization as a registered nonprofit. It is advisable to have an attorney to assist with filing to become a registered 501(c)3 organization. As part of this process, By Laws will need to be developed. The Organizational Document can form the basis from which By Laws are derived.

Tree Steward Stories—Charlottesville Area Tree Stewards:

The Founding of Charlottesville Area Tree Stewards

Content Contributed by: Martha Orton, CATS Member & Trees Virginia Tree Board Member

Charlottesville Area Tree Stewards evolved out of Tree Steward training classes conducted in 2003 and 2004 by Peter Warren and Adam Downing of Virginia Cooperative Extension. Several years later, in 2007 and with their support, Jacki Vawter and other graduates of these previous classes began to develop a training class and also the beginnings of an ongoing organization. Paul Revell, Urban and Community Forestry Coordinator, Virginia Department of Forestry, was particularly helpful in supporting the efforts of the organization in its early stages, offering the training room at VDOF for classes and providing contact information for other Tree Steward groups and appropriate presenters.

The small group of Charlottesville members, seven at that time, also met with Lynchburg Tree Stewards, who were very welcoming and supportive, providing useful information and tools and showing some of their projects. The next step was to develop a training class to recruit and train more members. This first class was offered in spring of 2008 and included presenters from Blue Ridge Community College, VCE, VDOF, Lynchburg Tree Stewards, and

Front Royal Tree Stewards. The class had been limited to 30 participants and 30 enrolled.

On the basis of growing numbers, the original seven members moved forward to developing a Tree Steward organization with a mission statement and goals. Officers, term limits and responsibilities were determined, along with three basic committees: Education, Projects, and Communication. When the Organizational Document was approved by the general membership in July 2008 this became the basis for the By Laws. As the organization grew and evolved, consideration was given to the appropriateness of applying to the IRS for Federal 501(c)3 nonprofit status. A member who was an attorney, Cynthia Foulke, volunteered to assist in this process. The application was successful and having this formal nonprofit status has enabled the organization to receive grants which require 501(c)3 status.

Charlottesville Area Tree Stewards has grown to become an energetic organization of 149 members with numerous projects and activities, including a strong educational emphasis.



left: CATS potting up seedlings at their nursery at the VDOF headquarters
center: Planting in Greenleaf Park
right: CATS and UVA student volunteers participate in a workday at The Grove in McIntire Park
Photos courtesy of the Charlottesville Area Tree Stewards.

Advocacy

Are you passionate about trees? Are you willing to talk about that passion with others? If so, you're already an advocate. Growing a healthy urban forest involves more than tree planting and regular maintenance. The urban forest needs people to speak for the trees and hold elected officials accountable.

When it comes to advocacy (i.e., wanting to influence legislators at the local, state, and national level), it's essentially the same thing: You have an opinion, and you want to share it.

If you don't know your legislators, the best way to become an effective advocate is to develop a working relationship with them *before* you need something. A good approach is to introduce yourself and offer your assistance with any tree-related issues to local, state and federal.

You should be able to determine your local representative on your locality's website. For your state and federal officials, visit the Virginia General Assembly's website at <https://viriniageneralassembly.gov/> and click on *Who's My Legislator*. Enter your home address, and the system will display your State Delegate, State Senator, your U.S. Congressional Representative, and your two U.S. Senators.

Advocating brings awareness of the environmental, social, and economic benefits of the urban forest. Being a voice in your community by attending city or town council meetings, serving on a local tree board, or just inviting the media out for events you are hosting brings issues facing the urban forest in the forefront.

We must plan for the future and advocate for trees if we are to have a healthy urban canopy.



RTS educational booth at a public event. Photo courtesy of the Richmond Tree Stewards

Writing a Letter

Contact/communication with elected officials should be respectful. Make sure to include your name and address in a prominent place. Keep letters short, to the point and no more than 1 typed page. Be specific and address one main issue at the beginning of your letter. Also, do your research ahead of time. Make sure the letter is factual, avoid emotional arguments, and try to tie in the legislator's interest, background and/ or committee assignments. If you are writing about a specific bill, either in support of or opposed, please say so directly in the letter and include the bill's title and number.

Letters should be addressed as follows:

The Honorable _____ [Elected Official's Name]

_____ [Elected Official's Office, e.g., _____ City Council or Board of Supervisors] Virginia House of Delegates, Senate of Virginia, U.S. House of Representatives, U.S. Senate]

Address
City/State/Zip

Dear _____ [Elected Official's Title, e.g., Councilman/woman, Supervisor, Delegate, Senator, Representative, or Senator, Last Name].

Visiting an Elected Official

When visiting the elected official, make sure to make an appointment. Just like with writing a letter, do your research and make sure your arguments in favor or against a bill are factual. Keep your arguments concise but positive and prep documents to support your position to leave behind.

Address him/her as you would in the salutation of the letter, e.g., Senator _____, Supervisor _____, Delegate _____, etc. A firm handshake and friendly demeanor also make an impression. Also, thank the legislator for considering your position and for his or her time. It is also nice to follow up with a thank you note and reiterate your position.

Most importantly, *don't wait to start the process*. Attend a Town Hall meeting as soon as possible because you have to lay the groundwork now to reap the benefits later. Also, you're your local tree commission or board that helps make tree decisions in your community. Good luck!

Additional Tips and Tricks

- Stay informed on the issues in your community
- Leverage your efforts by partnering with other groups with similar goals
- Be ready by having a well-crafted, inspirational message that can be given to the right people at the right time. It is all relationships
- Invite your elected officials to come to your events
- Update local officials frequently with newsletters or presentations
- Prep some short-term and long-term goals, identify steps and prioritize these goals to help guide your group and help you reach you them
- Talk to your neighbors if you are concerned about the loss of tree where you live
- Join commissions or committees related to trees
- Highlight the benefits of trees at your HOA, school or civic group.
- Most importantly, do not be afraid to speak on behalf of trees whenever you have an opportunity to do so. The more people we educate the more advocates we have.

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 Representative, 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, Master Naturalists, Garden Clubs, Native Plant Societies and other local groups whose members volunteer to beautify the community with trees, restore riparian buffers, greenways and trails, 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 canopy in the city of Lynchburg

Tree Steward Stories—Front Royal/Warren County Tree Stewards Royal Shenandoah Greenway

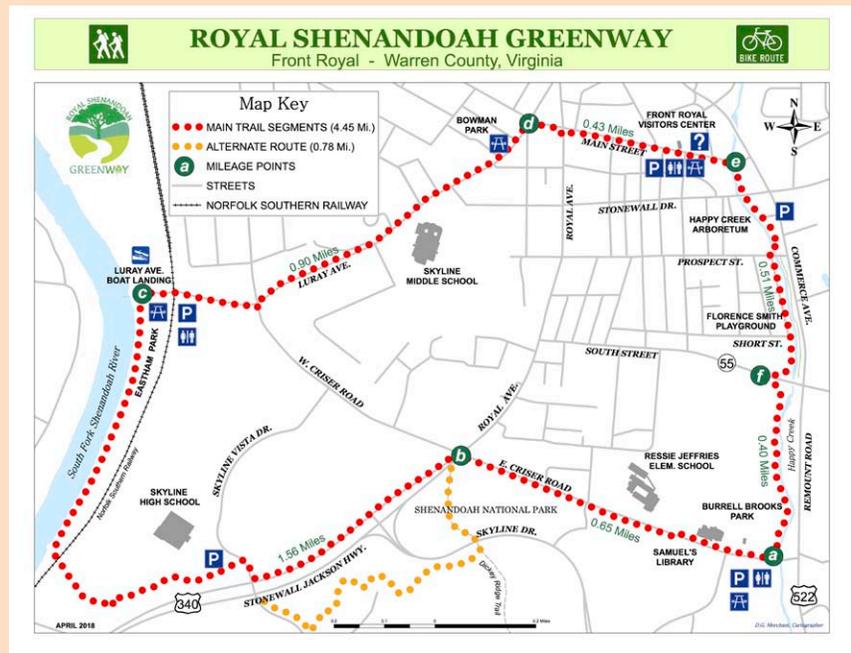
Written by Jim Huttar

Years ago at our annual Tree Stewards retreat we decided to see if we could spearhead a shelved Greenway development. We first got Virginia Tech to develop a four-and-a-half-mile trail on paper. We then presented this to both the Town and County officials since it would run through both entities. There is much to see along the Royal Shenandoah Greenway.

There is an arboretum replete with a variety of labeled trees and shrubs that the Tree Stewards maintain. A stroll along the South Fork of the Shenandoah, is sublime with spring bluebells providing bright and restful color. The Town has installed two kiosks – one in the Arboretum and the second, funded by the Beautification Committee, at the Visitors Center – providing information about tree care and current events. The Trees Stewards maintain these kiosks. The Royal Shenandoah Greenway is a trail for hikers, bikers, walkers, and baby strollers. But it is greater than the sum of its parts. Many organizations, public and private, and individuals have contributed financially to its creation.

It is a living vibrant confirmation of the spirit that makes our community such a wonderful place to live.

For more information on the Royal Shenandoah Greenway, visit the Front Royal/Warren County Tree Stewards Website—<https://treesfrontroyal.org/>



Virginia Urban Forest Council

The 1990 Farm Bill authorized the USDA Forest Service to provide financial support to states for urban forestry and mandated all states receiving support create an urban forest council to facilitate urban forestry.

The Virginia Urban Forest Council (Trees Virginia) 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: <https://treesvirginia.org/>.



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 2017, Virginia has 56 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. Trees stewards may have an opportunity to serve on their tree board.

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. To learn more about the Tree City USA program, go to <https://www.arborday.org/programs/treecityusa/>.

Celebrating Arbor Day

Arbor Day was first held in Nebraska on April 10th 1872. It was founded by J. Sterling Morton who was a newspaper editor and advocated for tree planting in his articles and editorials. Arbor Day is celebrated all across the United States today and provides an opportunity for Tree Stewards to connect with city staff, elected officials, and the general community. In Virginia, Arbor Day is held on the last Friday in April.

It is also a great place to meet potential new Tree Stewards, put up display tables or give out educational information about trees and Tree Steward training opportunities. Make it fun and include some educational activities for children and adults alike such as arts and crafts, mulching, tree giveaway, tree ID, etc.

Tree Campus Higher Education

The Arbor Day Foundation and Toyota sponsor Tree Campus Higher Education. This program recognizes college and university



campuses that meet five standards to promote healthy trees and student involvement. The program was started in 2008, when 29 colleges and universities were recognized as the first Tree Campus USA communities. As of 2020, Virginia has 10 Tree Campus Higher Education colleges and universities.

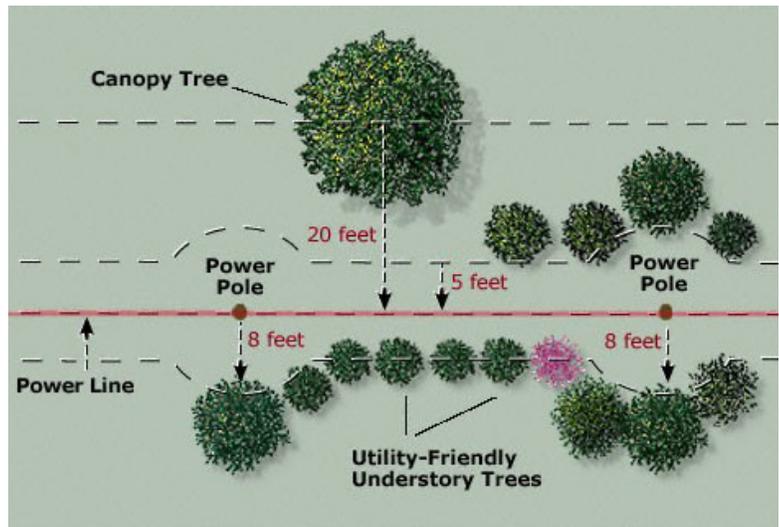
To learn more, go to <https://www.arborday.org/programs/treecampususa/>.

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.
- Plant the right tree near the powerlines
- Work with the utility to remove incorrect and plant correct species

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 should you plant away from utility lines? Plant canopy trees (>25 feet) at least 20 feet from power lines. Within 5 feet of power lines and within 8 feet of power poles, plant only small trees (<20 feet). Image by Robert O'Brien.



Planting an appropriate species with a mature height that would not require this type of pruning.

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 event.

Prevention

The cheapest and most effective approach to tree-versus-utility issues is to manage trees along utility **easements**. 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 Ordinances

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 created by the Department of Forest Resources and Environmental Conservation at Virginia Tech University. See <http://vtod.frec.vt.edu/>. Tree ordinances are usually administered by the Tree Commissions or Tree Boards. According to Arlington County's website, 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."

Heritage Trees

Heritage trees are individual trees that have exceptional aesthetic, historical and/or cultural value. They usually have stories to tell if a person can find the voice that speaks for them. They may be recognized by their age, species, unique features or outstanding size or association with an important event or person. A heritage program can be used by a community to recognize and celebrate grand and beautiful trees. Once a program is enacted and trees designated, a Heritage Tree enjoys a higher level of protection.

There is enabling legislation in the Code of Virginia stating how communities can officially designate a Heritage Tree and the resulting responsibilities.

Code of Virginia: <https://law.lis.virginia.gov/vacode/title10.1/chapter11/section10.1-1127.1/>

This code covers heritage, memorial, specimen and street trees. Definitions are below.

Heritage tree – means any tree that has been individually designated by the local governing body to have notable historic or cultural interest.

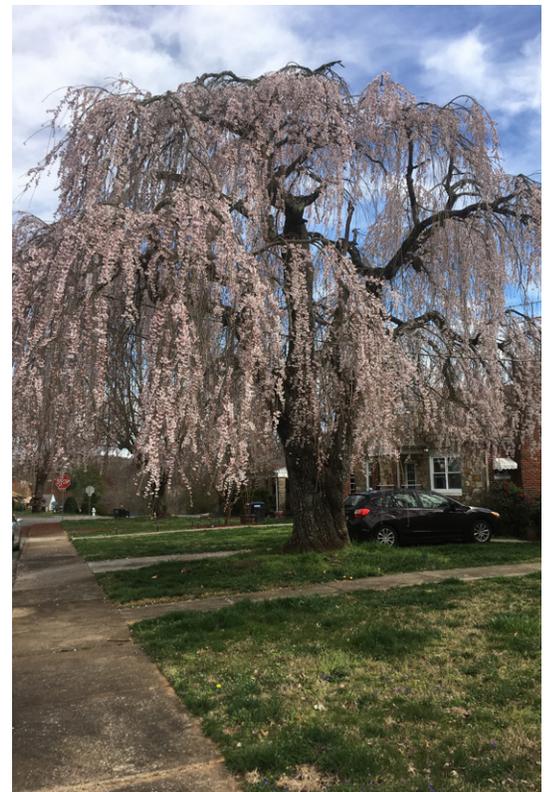
Memorial tree – means any tree that has been individually designated by the local governing body to be a special commemorating memorial.

Specimen tree – means any tree that has been individually designated by the local governing body to be notable by virtue of its outstanding size and quality for its particular species.

Street tree – means any tree that has been individually designated by the local governing body and which grows in the street right-of-way or on private property as authorized by the owner and placed or planted there by the local government.

From the Tree Preservation Ordinance from Arlington County

"...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..."



Weeping Cherry Heritage Tree in the City of Lynchburg
Image by Sarah Hagan

Some examples of heritage tree programs are below:

Alexandria:

Map and guide of Champion and Notable Trees
https://www.google.com/maps/d/viewer?mid=1gEM-F3Wb6GpWRqOYD3hCWBSn37_4&hl=en_US&ll=38.82033041664288%2C-77.17445048652655&z=11

Arlington:

Local ordinance giving extra protection to Heritage Trees <https://environment.arlingtonva.us/trees/trees-shrubs-%20ordinance/>

Lynchburg:

Local tree steward group and heritage tree program started in 1995 <https://www.lynchburgva.gov/lynchburg-tree-stewards>

Williamsburg:

Examples of a city heritage tree program <https://www.williamsburgva.gov/government/department-i-z/public-works-and-utilities/heritage-tree-program>

Virginia Big Tree Program

Established in 1970, the Virginia Big Tree Program (<https://bigtree.cnre.vt.edu>) began as a partnership between the Virginia Forestry Association and Virginia Cooperative Extension 4-H to encourage youth education and participation in natural resources. Since then, the program has grown to involve naturalists and outdoor enthusiasts of all ages and backgrounds. The mission of the program is to promote the care and appreciation of trees – big and small. This is accomplished by program staff and volunteers who discover, document, and curate the largest trees found in the state.

Led by the Department of Forest Resources and Environmental Conservation at Virginia Tech (along with Virginia Cooperative Extension), the big tree program maintains a register of the largest specimens of over 300 native, non-native, and naturalized tree species. The register is publicly available through a searchable database (<https://bigtree.cnre.vt.edu/search.cfm>) and includes information about each tree's size, location, and unique characteristics. Trees must be recertified every 10 years to maintain their eligibility for the register. Nominations for big trees are accepted from the public through the program website (<https://bigtree.cnre>).

Tree Steward Stories— Heritage Trees

Written by Robin Hanes

Notabletrees.org draws attention to wonderful trees in the Charlottesville area. There have been several times when we find trees that end up in consideration for state champions. We recognize the most well-known and specimen trees as Landmark Trees on Arbor Day. Having a small sign on them offers no legal protection, but the public recognizes them and a disturbance like cutting them down is unlikely.

We had a test of this concept during the 2016 Arbor Day event. We chose the Pin Oak on McIntire Road in front of the County Offices. Construction was going on where the local sewage authority was replacing large sewage pipes along McIntire Rd., heading toward the tree. After a lot of communications, they sent word on Arbor Day, that the line would curve away from the tree.



April 2016 Dedication of the Pin Oak as a Landmark Tree in Charlottesville. Photo courtesy of Notabletrees.org

[vt.edu/report.html](https://bigtree.cnre.vt.edu/report.html)). Tree stewards can nominate trees in their neighborhoods as well as volunteer to recertify trees already in the register. It is a wonderful opportunity to get outdoors, engage the body and mind, and contribute important data that helps us understand the maximum sizes that tree species can attain.

Trees are ranked in the big tree register using a scoring system that incorporates measurements of trunk circumference, tree height, and crown spread. The big tree score based on a point system is calculated using the following formula:

$$\text{Big Tree Score} = \text{trunk circumference (in.)} + \text{height (ft.)} + \frac{1}{4} \text{ average tree crown spread (ft.)}$$

Note that only 1/4-point is awarded for each foot of crown spread

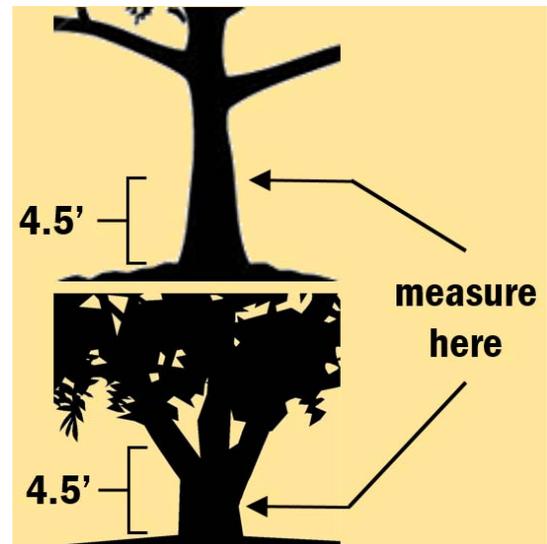
Measuring Tree Circumference – measure the distance in inches around the trunk of the tree at 4.5 feet above ground level. A cloth or fiberglass reel tape is a good measuring tool for this.

Note that adjustments must be made to the height of this measurement if the trunk has an unusual growth habit.

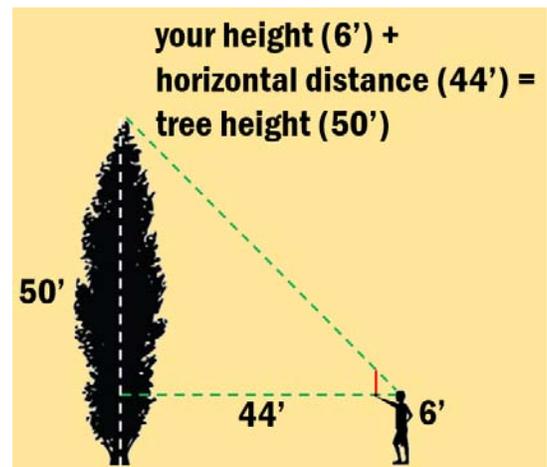
Measuring Tree Height – measure the vertical distance in feet between the trunk base and top-most live branch. The “stick trick” shown below can be used to estimate tree height and determine whether a tree is a contender; however, the program will only accept height measurements taken with a clinometer or laser hypsometer. Program staff can assist you with obtaining one of these tools or put you in contact with someone who has one.

Measuring Average Crown Spread – first measure the maximum crown spread (greatest distance between any two points along the perimeter of the crown). Then turn perpendicular to this measurement and measure the widest crown spread in the other direction. Neither of these measurements has to go through the trunk. Calculate the average of these two measurements. These must be true horizontal measurements, and adjustments in measurement technique must be made if the tree is on steep terrain.

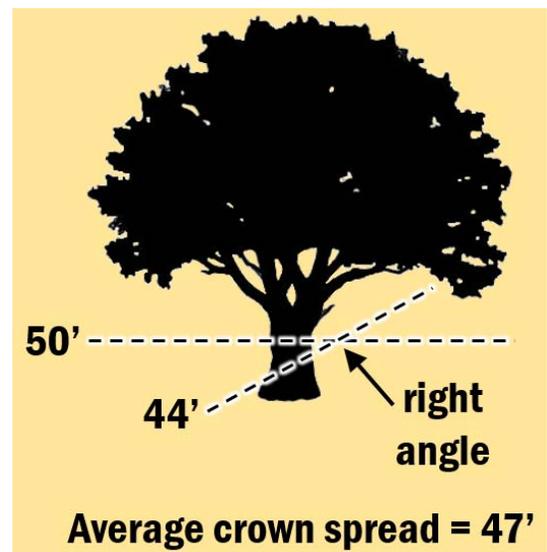
A detailed pictorial guide to the measurement and scoring system can be found at <https://bigtree.cnre.vt.edu/measure.cfm>. Also available online is a field data collection form that you can print and use as a guide to collect the appropriate information when you visit a tree (<https://bigtree.cnre.vt.edu/documents/NominationForm.pdf>). For more information about the program, please contact the staff liaison at 540-231-7671 or vabigtree@vt.edu.



Measuring trunk circumference



Measuring tree height



Measuring crown spread

Saving Space for Trees

Space is an issue of concern when growing the next generation of heritage or champion trees. Many of the designated [Big Trees of Virginia](#) are no longer in our cities and towns but on rural private land.

These champions exist because they had the luck to grow where they didn't get cut down. Try to think of your favorite big tree in your town or neighborhood and picture the space above and below ground it had to grow. When planting a new tree are you considering the size and space it will actually need to grow to maturity? Soil quality and site conditions including access to water have an influence on how large a tree will grow.

Under ideal conditions, every tree would have the opportunity to grow into a champion. However, more often than not, and especially in urban areas this is not the case. According to James Urban, a tree growing in 1,000 cubic feet of soil will reach about 16" in diameter and have a 32' canopy. Planning for adequate space is often where the problem starts. Considering adequate space in the initial planning phase of site development is essential for growing healthy trees. If left to the end, only the leftover space will be available leading to many of the tree problems we have in urban areas today.



Mature Willow Oak that has grown out of its planting space in a Richmond, VA neighborhood.

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 often change 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 A Limb 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. It may not be removed by the adjacent private property owner without consent of the local government.

- If the encroaching tree is owned by a private landowner, it is best to work out a solution one-on-one in an amicable manner. Property owners retain the right to remove offensive branches or roots up to the property line, but may not do so if the health or stability of the tree could be jeopardized. Trees that straddle property lines are jointly owned by the adjoining properties and may not be removed without consent of all property owners.

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:

1. What are some ways you can work to save trees in your community?
2. What is the Big Tree Program?
3. How might a tree become damaged by construction activities?
4. What are heritage trees?

Resources

Green Cities: Good Health (2018). University of Washington. Available as: <http://depts.washington.edu/hhwb/>

Human Dimensions of Urban Forestry and Urban Greening. University of Washington. Available as: <http://www.naturewithin.info/index.html>

Trees and the Law. Arbor Day Foundation. Available as: <https://www.arborday.org/trees/bulletins/documents/049-summary.pdf> or on website at <https://www.arborday.org/trees/bulletins/resources/049.cfm>

Virginia Big Trees. Virginia Tech. Available as: <https://bigtree.cnre.vt.edu/>

Virginia Tree Ordinance Database. Virginia Tech. Available as: <http://vtod.frec.vt.edu/index.html>

Seeing Trees: A History of Street Trees in New York City and Berlin by Sonja Dümpelmann.

Agencies and Organizations Interested in Trees

International Society of Arboriculture – <https://www.isa-arbor.com/>

National Arbor Day Foundation – <https://www.arborday.org/>

Virginia Cooperative Extension – <https://www.ext.vt.edu/>

Virginia Cooperative Extension Publications – <https://pubs.ext.vt.edu/>

Virginia Department of Forestry – <https://www.dof.virginia.gov/>

Virginia Native Plant Society – <https://vnps.org/index.htm>

Virginia Tech Urban Forestry Program: <https://www.urbanforestry.frec.vt.edu>

Virginia Urban Forest Council – <https://treesvirginia.org/>

U.S. Department of Agriculture Forest Service – <https://www.fs.usda.gov/>



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

achene – a small, dry one seeded fruit

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

air tillage – preparation of the soil by using an air tool without damaging large structural roots. alkaline – having a pH higher than 7

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

amino acids – organic compounds that combine to form proteins

anatomy – the structure and composition of the plant

angiosperm – plant with seeds protected by a fruit or nut

anthocyanin – a blue, violet or red pigment found in plants

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

berry – a fleshy fruit without a stone

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 bud scales

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

carotenoids – a yellow, orange and/or red pigment found in plants

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

catkins – small, petal-less flowers that hang like string from some trees. The flower clusters are usually all male or all female.

capsule – a membrane that encloses seeds

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

columnar form – tall, narrow and upright branches/growth habit

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

cork cambium – lateral meristem that produces cork to protect the roots and stems of a plant

croch 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 habit of crown; no main vertical leader in mature tree

defoliate – to lose leaves

dehiscent – the splitting or opening of a plant structure to release seed

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

drupe – a fleshy fruit with a thin skin and a central stone containing the seed

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

ectomycorrhizae – 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

exudates – a substance secreted by a plant

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 capacity – the amount of soil moisture or water content held in the soil after excess water has drained and downward movement has decreased. Also known as the available water capacity.

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

follicle – a dry, single chambered fruit that opens only on one side to release seed

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

indehiscent – seeds do not open at maturity; rely on predation or decomposition to release seeds

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

marcescence – is the retention of dead plant organs such as leaves that normally are shed

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

mechanical tillage – preparation of soil by mechanical agitation of various types, such as digging, stirring, and overturning.

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

nodule – swelling on a root of a plant that contains bacteria

nut – a fruit composed of a hard shell with a seed inside

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

organic acids – assist in the metabolism of plant materials

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

phenolic – compounds produced by the plant in response to stress

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

pod – a case that holds the seeds of a plant

pome – fleshy fruit that contains a central core holding seeds

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

pyramidal form – wider at the bottom, becoming narrower and tapering to a point at the top

range – geographic area where a plant occurs naturally

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

reaction wood – 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 apex – small tip of the root where growth and development starts

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

root hair – microscopic outgrowths from main root that aid in absorbing water and nutrients

rounded form – growth in a cylindrical shape

rhizosphere – small region surrounding the roots that act as a microbiome; important for nutrient uptake

samara – type of dry fruit with a seed surrounded by a papery tissue

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)

senescence – the process of aging brought on by shorter day length and low temperatures

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

spreading form – open, irregular shape that may be wider than it is tall

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

surface area – encompasses the total outermost layer of something

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

taper – reduced thickness towards one end

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

taxonomy – classification and naming of organisms

terminal bud – primary growing point at the tip of a stem or branch

tree physiology – the study of how trees grow

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

tracheids – cells in the xylem that transport water throughout the plant

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

vase-shaped form – trees with upright branches arching shape that is widest at the top

venation – pattern of veins in a leaf

water holding capacity – amount of water that a given soil can hold

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

wilting point – defined as the minimum amount of water in the soil that the plant requires not to wilt

xylem – water-conducting tissue