Student Page
Lesson 7

Basic Tree Biology[17]

Introduction

Plants are complex organisms that differ greatly in structure. While studying plants, you may discover trees, shrubs, flowering herbs, mosses, lichens and ferns, all of which share some common characteristics.

A **tree** is usually the tallest organism in the ecosystem (usually greater than 20 feet at maturity) and usually has a single stem, which is also known as the trunk. **Shrubs**, on the other hand, generally have multiple stems and relatively short statures.

A tree is a long-lived species. Some species live 1,000 years or more, so they must be able to meet the most severe conditions for long periods of time, including cold and hot temperatures, high winds, drought, rain and fire.

Trees cannot move to a new location if they do not like where they are located, so they must be well adapted to their site in order to thrive. A variety of factors including climate, geology and topography (the shape of the land) determine the tree species found in an ecosystem.

Trees serve many useful purposes to humans such as providing food, shelter, clothing, fuel, clean air, clean water, shade and medicine. Trees also provide food and shelter for many other living organisms such as squirrels, woodpeckers, insects, fungi, lichens and other plants.

Fun Facts

- Oregon's most common tree is the Douglas-fir, which is also the state tree. West of the Cascades, if you guessed that any evergreen tree you see is Douglas-fir, you would be right eight out of 10 times.
- The largest tree in Oregon is a 329-foot-tall Douglas-fir located in Coos County's Brummet Creek. It is taller than a 28-story building!
- The oldest tree in Oregon may be a limber pine on Cusick Mountain in Wallowa County, estimated to be between 1,600 and 2,000 years old.

[17] Source: *Exploration of Oregon Forests: Module 2 – Tree Biology.* Developed by Julie Woodward based on the Oregon State University Forestry Extension's *Basic Forestry Shortcourse.*

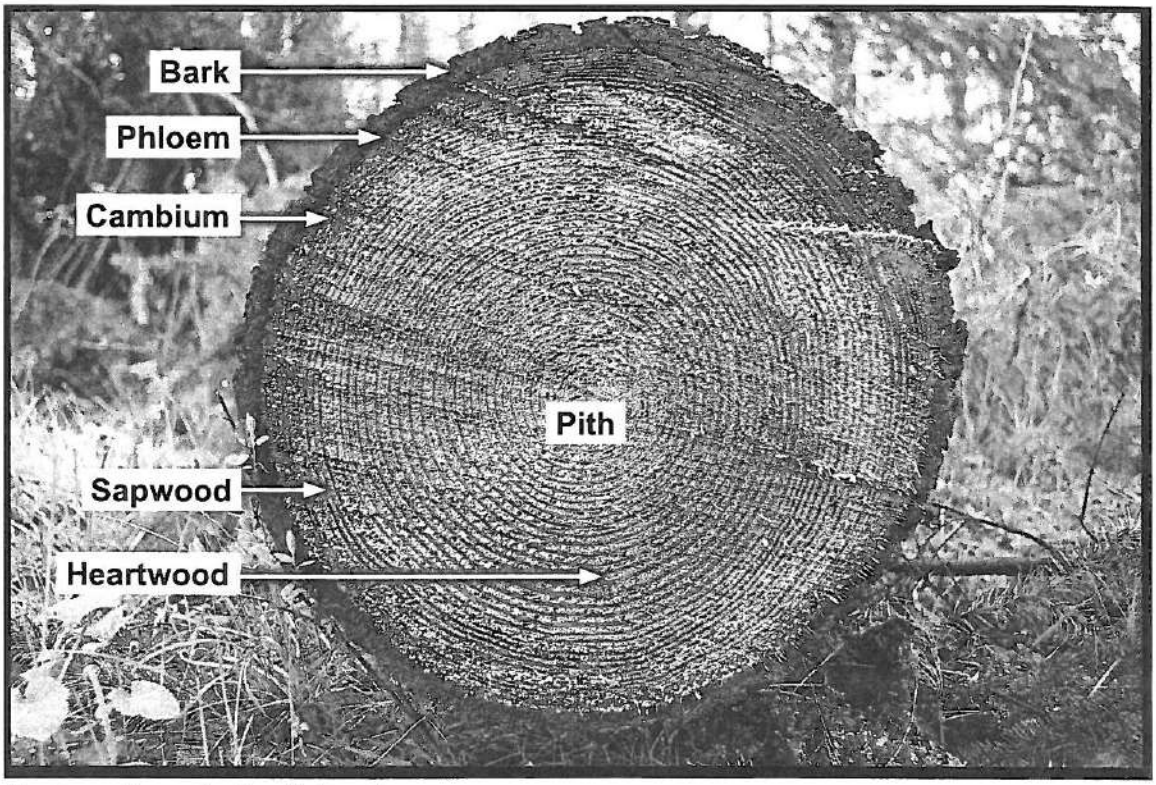
Tree Structures and Their Functions

Trees have specialized parts that enable them to meet their basic needs. The following are a few of these parts:

- **Leaves**. Leaves capture sunlight and produce food in a process called photosynthesis. They are an important component of the tree's transport system, releasing water to the air and drawing in carbon dioxide.
- **Branches**. Branches support the leaves and extend them into sunlit areas. They transport water and nutrients to leaves, and nutrients from leaves to the rest of the tree.
- **Stem.** The stem, or trunk, holds the tree's branches high above competing vegetation and transports food and water.
- **Woody roots.** Woody roots secure the tree to the soil and transport water and nutrients.
- **Fine roots.** Fine roots are responsible for much of the tree's uptake of water and nutrients.

A tree's stem, or trunk, also contains several layers, each of which serves different functions. Moving from the outside of the trunk toward the inside, you will find these layers:

- **Bark.** Bark provides the outer covering of a tree, which can be very thick (Douglas-fir) or thin (western hemlock). Bark protects against fire, disease, extreme temperatures and mechanical damage.
- **Phloem.** Phloem is a layer of living tissue just inside the protective outer bark. Phloem serves as the primary mechanism by which food is transported within the tree, and it is a favorite treat for bears in the spring.
- **Cambium.** Cambium is composed of living cells that actively divide and result in diameter growth. Cells on the outside of the cambium become phloem, while those on the inside become xylem.
- **Sapwood (xylem).** Sapwood, or xylem, is recently formed cells capable of water transport. They serve as the primary mechanism by which water and nutrients are moved from the roots to the leaves.
- **Heartwood (xylem).** Heartwood, also a form of xylem, is the nonfunctioning wood cells that used to be sapwood. They no longer transport water but still provide support. They may have a distinctive color and enhanced decay resistance depending on species and age. The heartwood is the part that shows annual rings. These are produced when the sapwood cells grow rapidly in the spring and are followed by the slower-growing, denser cells of summerwood. The main function of heartwood is to support the tree.
- **Pith.** Pith is found in the center core of the tree trunk and is made of air-filled cells with a distinctive dark color. The pith is a remnant of the first year's growth in the tree, and its main function is to store nutrients.



Cross section of a tree's trunk.

Leaf Functions

Leaves release oxygen into the atmosphere through small holes called **stomata**, which are usually located on the underside of the leaf. They can open and close to control movement of water and air. When they are open, water vapor escapes and carbon dioxide (CO_2) can enter the leaf. If there is a drought or high summer temperatures, the tree may close its stomata to conserve water. A lack of carbon in the leaf then limits photosynthesis. Drought-adapted species have found ways to keep stomata open even when water in the soil is limited.

Photosynthesis

Photosynthesis is a natural process by which green trees and plants use energy from the sun to transform water, carbon dioxide and minerals into organic compounds for their growth. Photosynthesis begins when green plants absorb water through roots and carry it to needles or leaves. At the same time, needles and leaves absorb carbon dioxide from the air. The carbon dioxide then flows to plant cells called chloroplasts, which contain chlorophyll. Chlorophyll uses sunlight as energy to transform carbon dioxide and water into oxygen and carbon-based compounds such as glucose (sugar). These carbon-based compounds provide energy as well as the building blocks for growth and tissue repair. As the plant grows, it releases oxygen into the atmosphere.

The elements needed for photosynthesis to take place:

- sunlight
- carbon dioxide (CO_2)
- nutrient-rich water from the soil

Photosynthesis produces sugars, which are needed for many things. Since it can only produce a limited amount of food, a tree must budget the sugars created through photosynthesis to satisfy the following priorities:

- Root growth
- Reproduction (flowers, cones, etc.)
- Growth so the tree can compete with other vegetation for light and maintain strength
- Food storage to help with spring growth and maintain the tree when photosynthesis is not possible
- Defensive compounds, which protect the tree against insects, rot and disease. If a tree is weak and not producing enough sugars, then it is more likely to be a target for disease-causing germs, or pathogens.

If sunlight, CO_2, water or nutrients are limited, then photosynthesis is reduced and not as much food is produced.

Tree Growth

Trees grow both in height and diameter. We call this primary growth and secondary growth, respectively. Primary growth starts at the top, or tip, of the tree and branches. Primary growth results in more leaf area, height and increased access to sunlight. Secondary growth increases the diameter of the stem or trunk, branches and roots. Secondary growth provides support to increase the numbers of leaves or needles.

Root growth and shoot growth occur at different times of the year. In the winter in the Pacific Northwest, we plant trees because this is when they are most fully dormant and least likely to become stressed by transplanting.

Trees respond directly to light, water, nutrients, humidity, temperature and other physical factors in the ecosystem. When these conditions are sufficient for a particular species, tree height and diameter may significantly increase with age. Drought, severe heat, early frost and other physical stresses, as well as interactions with other organisms, can slow tree growth. Each year, a tree increases in diameter as the cambium divides and a ring of xylem cells is laid down.

Close examination of a tree's cross section reveals that each ring is made of two bands. The first band is a lighter-colored area of large, thin-walled cells (springwood). The second band is a darker-colored area of small, dense, heavy-walled cells (summerwood). By counting these rings outward from the center, it is possible to determine the age of a tree. In the tropical regions of the world, there is not a definite growing season. Therefore, determining the age of a tropical tree is more difficult.

Annual rings result from defined seasons of growth and dormancy. Most trees in North America have annual rings. Annual rings vary in width, and the width of tree rings tells the story of the growth conditions of a tree. Wider rings usually indicate a fast growth rate. If a tree is stressed by less-than-optimal conditions in its environment, tree rings are often narrow.

Fun Fact

Dendrochronology is the study of growth rings. Using dendrochronology, a scientist can estimate climate variation and other past events through the comparison of successive annual growth rings. Tree ring analysis provides insights into a variety of abiotic and biotic factors such as climate, disease, disturbance, management activity, competition and forest productivity. Using this information in conjunction with observations from the rest of the ecosystem, researchers can hypothesize about the causes of changes in tree growth.

Broadleaf vs. Conifer

Trees are generally classified as either broadleaf (or deciduous) trees or conifers.

Broadleaf trees usually have wide, flat leaves and bear seeds inside fruits, nuts or flowers. Most broadleaf trees are deciduous – that is, they drop their leaves in winter – but a few are evergreen. All broadleaf trees are referred to as hardwoods because their wood generally is harder than that of conifers. That's because, unlike conifers, they don't photosynthesize in the winter months. A few, however, such as cottonwoods and balsa, have very soft wood.

Conifers have needlelike or scalelike leaves and usually bear seeds inside woody cones. Conifers are often called evergreens because most hold their leaves all year long. There are, however, some deciduous conifers, such as the larch, that drop their leaves in winter. All conifers are also called softwoods because their wood is relatively soft when compared with that of broadleaf (hardwood) trees.

Tree Reproduction

There are two processes by which trees reproduce: seed reproduction and vegetative reproduction (sprouting, suckering and layering). Broadleaf trees usually sprout profusely from cut stems, or by sending up shoots from underground roots (suckering), or when lower branches of a tree touch the ground and the branch tips become covered and eventually a new tree grows from the branch tips (layering).

Conifer trees typically reproduce by seed production. For example, pine seeds are produced on the scales of the carpellate (female), cones. In the spring, the pine produces clusters of staminate pollen-bearing cones, or strobili. Upon ripening, they disperse their pollen and fall to the ground. Female cones are produced on the tree at about the same time and are usually greater in number and located on the outside of the crown. Once the female cones have been pollinated, they grow rapidly with developing seeds. Most pines require two years for the seeds to mature. At that time, the cone dries out, the scales open up, and the winged seeds are dispersed (usually by wind). In general, about 85 percent of the seeds fall within 125 feet of the parent tree.

Summary

A tree is the tallest organism in the ecosystem and usually has a single stem, which is also known as the trunk. Shrubs, on the other hand, generally have multiple stems and are relatively short. A tree is a long-lived species that must be well adapted to its site in order to prosper. Trees serve many useful purposes such as providing food, shelter, clothing, fuel and medicine.

Through the use of specialized parts, a tree provides itself with its basic biological requirements. The following are a few of these parts: leaves, branches, the stem, woody roots and fine roots. A tree cross section highlights additional specialized parts of a tree: bark, cambium, phloem, xylem and heartwood.

Trees can actually clean water by absorbing contaminated water through their roots and releasing clean water through their leaves. In addition, leaves release oxygen into the atmosphere through small vapor holes called stomata, which are located on the undersides of leaves. They open and close to control movement of water and air. Chlorophyll in leaves

converts sunlight to energy that plants use to produce food. This process is known as photosynthesis.

Trees grow both in height (primary growth) and diameter (secondary growth). Root and shoot growth occurs at different times of the year. Trees respond directly to light, water, nutrients, humidity, temperature and other physical factors in the ecosystem. Annual rings are created by defined seasons of growth and dormancy. Most trees in North America have annual rings. Tropical trees generally do not have annual rings, because there is no dormant season.

Trees can be divided into two main categories: broadleaf and conifer. Broadleaf trees are often referred to as hardwoods, because their wood is generally harder than conifers (softwoods). Broadleaf trees reproduce by seeds inside fruits, nuts, or flowers and typically drop their leaves in winter. Conifers reproduce with seeds in woody cones and hold their needles all year long.