Parts of a Tree

Roots

- A tree's root system pulls nutrients and water from the soil and carries it to the trunk for distribution through the tree. A tree that grows tall and thick like a redwood needs a root system that grows thick and deep to anchor it. Trees that grow in desert climates tend to have long, tendril-like roots that stay near the surface of the soil to catch rain more easily. Roots tend to grow to the size and depth needed to adapt to water levels in the soil. When a seedling forms, a taproot grows straight down and sub-roots grow off it. As the tree develops, a number of central taproots grow and the root system becomes a fibrous root system with many branches supporting and feeding the tree.

Trunk

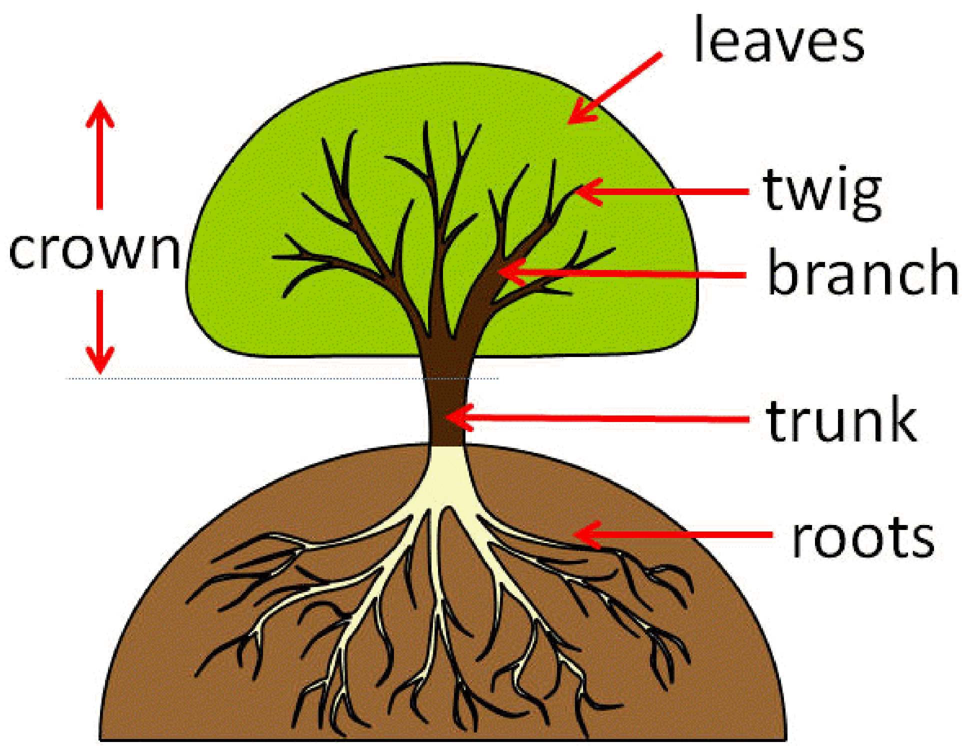
- Once the water and minerals pass through the roots and reach the trunk, they're carried up through the outer layers of the tree just below the bark. The trunk doesn't just transport water and minerals up from the ground, it also carries sugars from the leaves down to the roots to support and feed the root system. The trunk is the central support system for everything that happens in the tree. It's also the part of the tree that's harvested for lumber and to make paper.

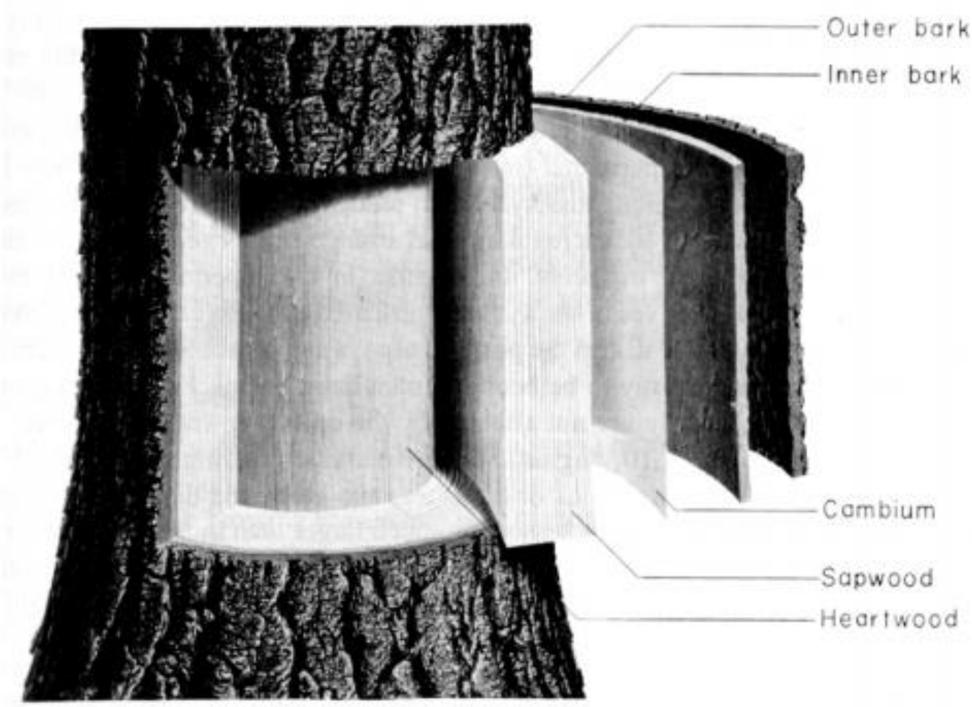
The four layers

- Within the trunk there are four layers. Starting from the center there's heartwood, xylem (sapwood), cambium and phloem (inner bark). The heartwood is a hard core of old xylem layers that have died and become compressed by the newer outer layers. The xylem is also called sapwood and carries water and minerals up the trunk. The cambium is a thin layer where new cells develop to either become xylem, phloem or more cambium. A cambium layer is turned into xylem once per year and this creates an annual ring around the trunk. Just outside the cambium, the phloem (inner bark) transports sugars from the leaves down to the roots and as it dies, it forms the bark.

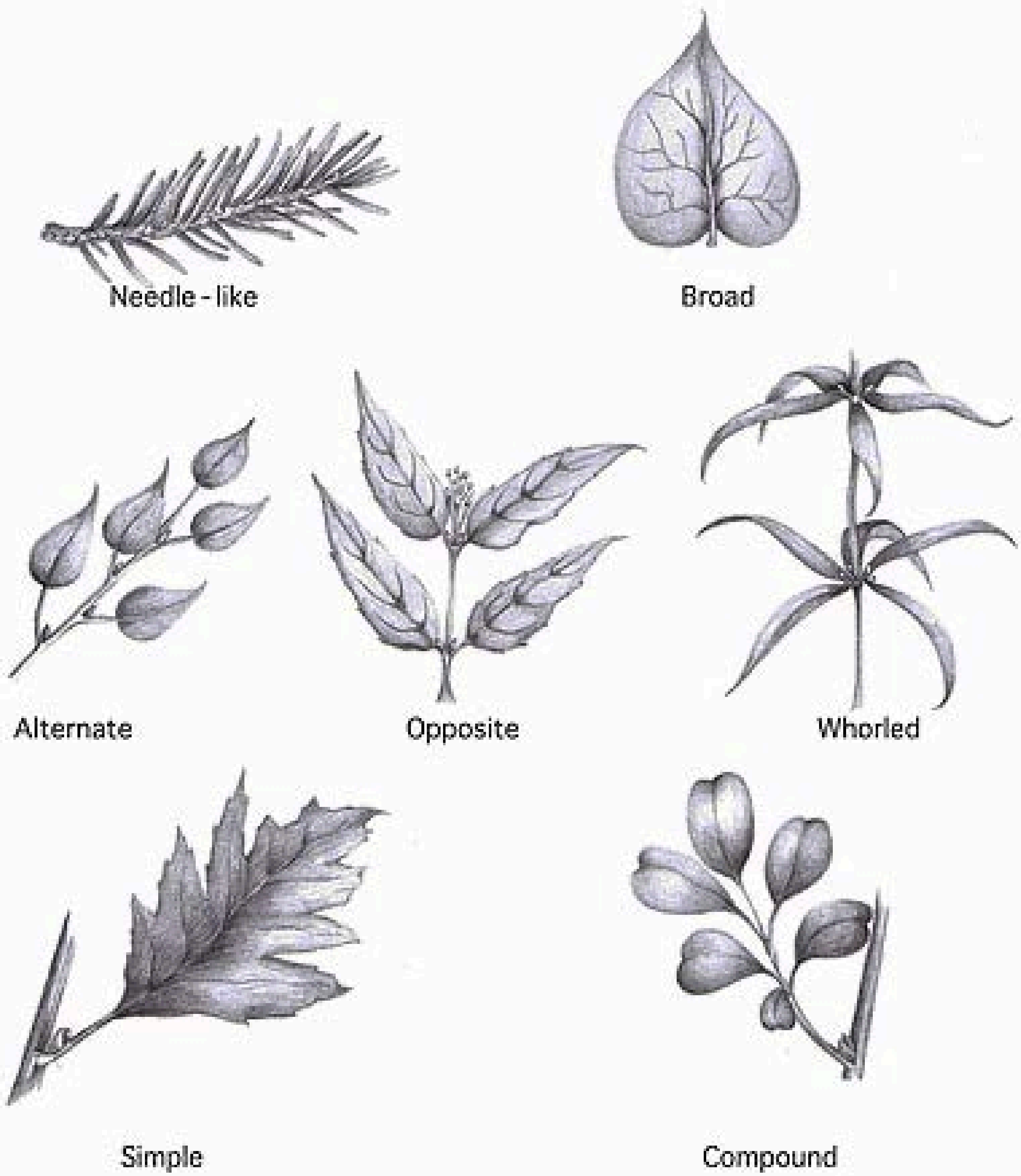
Crown

- Above the trunk is the crown. The crown is all the branches and leaves on the tree. The crown is the powerhouse of the tree. The leaves take in sunlight which reacts with the green chlorophyll to transform light into sugars. The process is called photosynthesis and the byproduct is oxygen released into the air. Photosynthesis occurs whether the leaves are broad and flat like a simple leaf or thin and pointed like needles. Leaves vary widely, but they all perform photosynthesis to feed the tree. Not only does the crown produce the sugars the tree needs to survive, it also filters dust from the air and protects the soil below from excessive erosion from rainfall.


leaves
twig
crown
branch
trunk
roots


Outer bark
Inner bark
Cambium
Sapwood
Heartwood

LEAF



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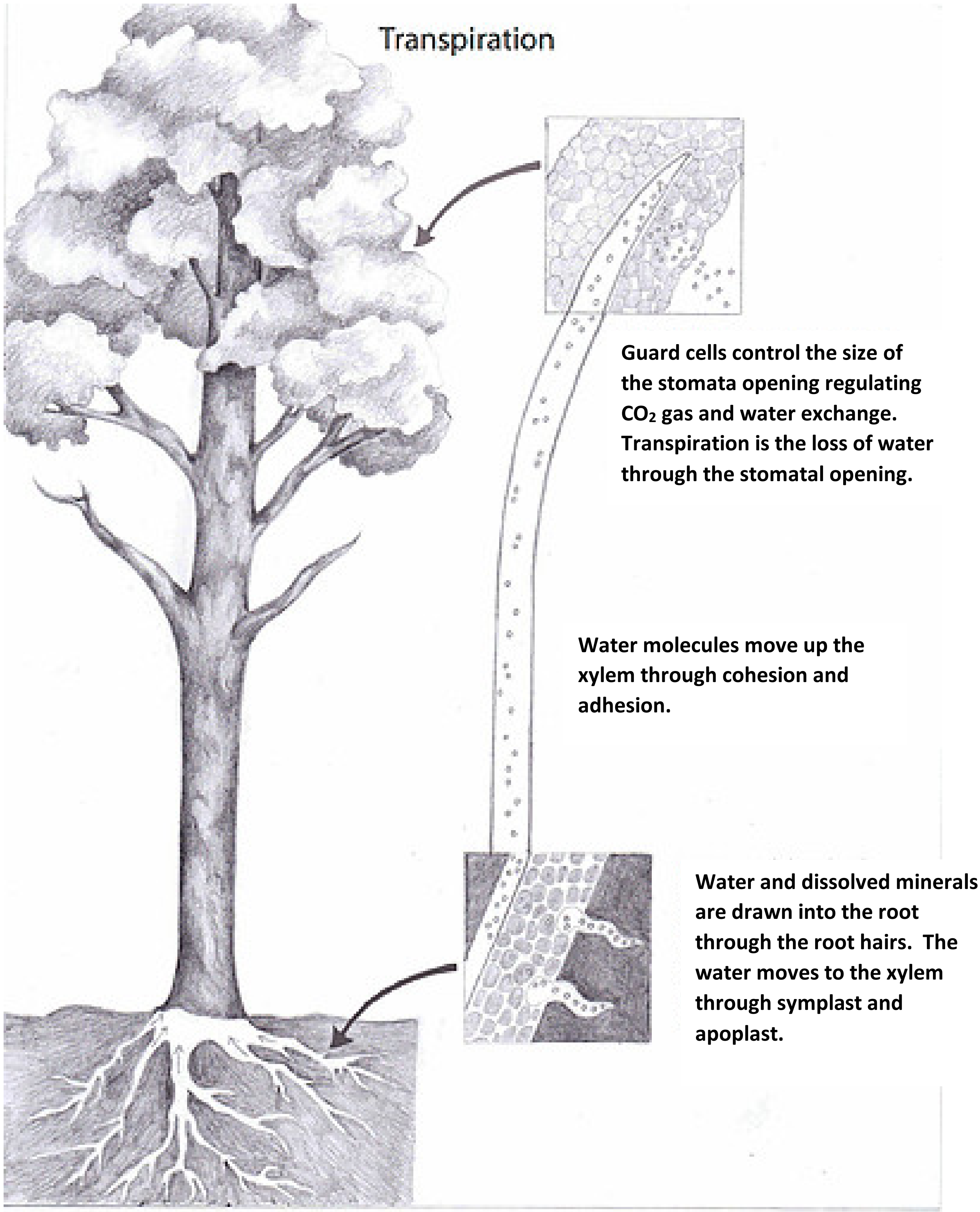

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STAND DESCRIPTION
Concepts and Definitions

Through the course of every profession a particular language, terminology, or jargon is developed. The concepts and definitions listed below are part of those which make up the jargon of forestry.

I. TERMINOLOGY OF FORESTS AND STANDS

An important concept often misunderstood in forestry is the difference and utility of the terms forest and stand. Remember that the stand is the unit which is of interest in silviculture. The forester practices silviculture on stands, not on forests. The following terms and definitions will serve to clarify the concept of stands as used by silviculturists.

1. Forest – A plant association predominantly of trees or other woody vegetation, a collection of stands.

2. Stand – An aggregation of trees or other growth occupying a specific area and sufficiently uniform in species composition, size, age, arrangement, and condition as to be distinguished from the forest or other growth on adjoining areas.

3. Stand Species Composition – The composition of stands is conceived of as being either pure or mixed. These are defined as:

   (a) Pure Stand – A stand in which at least 80% of the trees in the main canopy are of single species.

   (b) Mixed Stand – A stand in which less than 80% of the trees in the canopy are of a single species.

4. Stand Density – The density of stocking expressed in number of trees, basal area, volume, or other criteria, on a per-acre basis. In addition, stocking is further modified and defined as:

   (a) Fully stocked stands – Stands in which all the growing space is effectively occupied but which still have ample room for development of the crop trees.

   (b) Overstocked stands – Stands in which the growing space is so completely utilized that growth has slowed down and many trees, including dominants, are being suppressed.

   (c) Understocked stands – Stands in which the growing space is not effectively occupied by crop trees.

5. Stand Form – Stands are usefully described and considered from the standpoint of the age classes of which they are composed. Generally, two stand forms are recognized. These are:

(a) Even-aged stands – Stands in which there exists relatively small age differences between individual trees.

(b) Uneven-aged stands – Stands in which there exists relatively large age differences between individual trees. At least 3 age classes are present. A similar term is all-aged stand.

6. Stand Origin – Stands may be classified by origin; whether from seed or sprouts and suckers, or a combination of the two. Also descriptive of origin are natural or planted, and virgin or second growth.

II. TERMINOLOGY FOR INDIVIDUAL TREES

The previous concepts and terms apply in a general sense to stands and are useful in the description thereof. However, to adequately describe stands, it is necessary to employ terms which are descriptive of some characteristic of the individual trees within the stand. Some of the more common ones are given in the following:

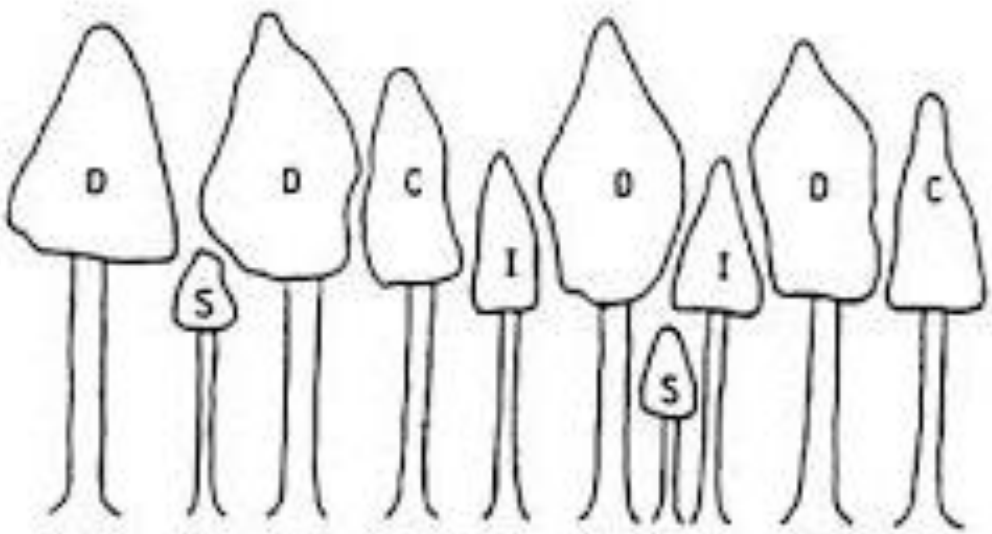
1. Tree Size Classification – The timber species are conveniently designated by certain size classes through their life development. They are:

(a) Seedling – from germination to 2 inches d.b.h.
(b) Sapling – from 2 to 4 inches d.b.h.
(c) Pole - from 4 to 12 inches d.b.h.
(d) Standard – from 12 to 24 inches d.b.h.
(e) Veteran – over 24 inches d.b.h.

2. Crown Classification - Trees in even-aged stands are classed on the basis of crown position in the canopy by a simple method which has long been standard procedure. These four classes are:

(a) Dominant – Trees with crowns extending above the general level of the crown cover and receiving full light from above and partly from the side; larger than the average trees in the stand, and with crowns well developed but possibly somewhat crowded on the sides.

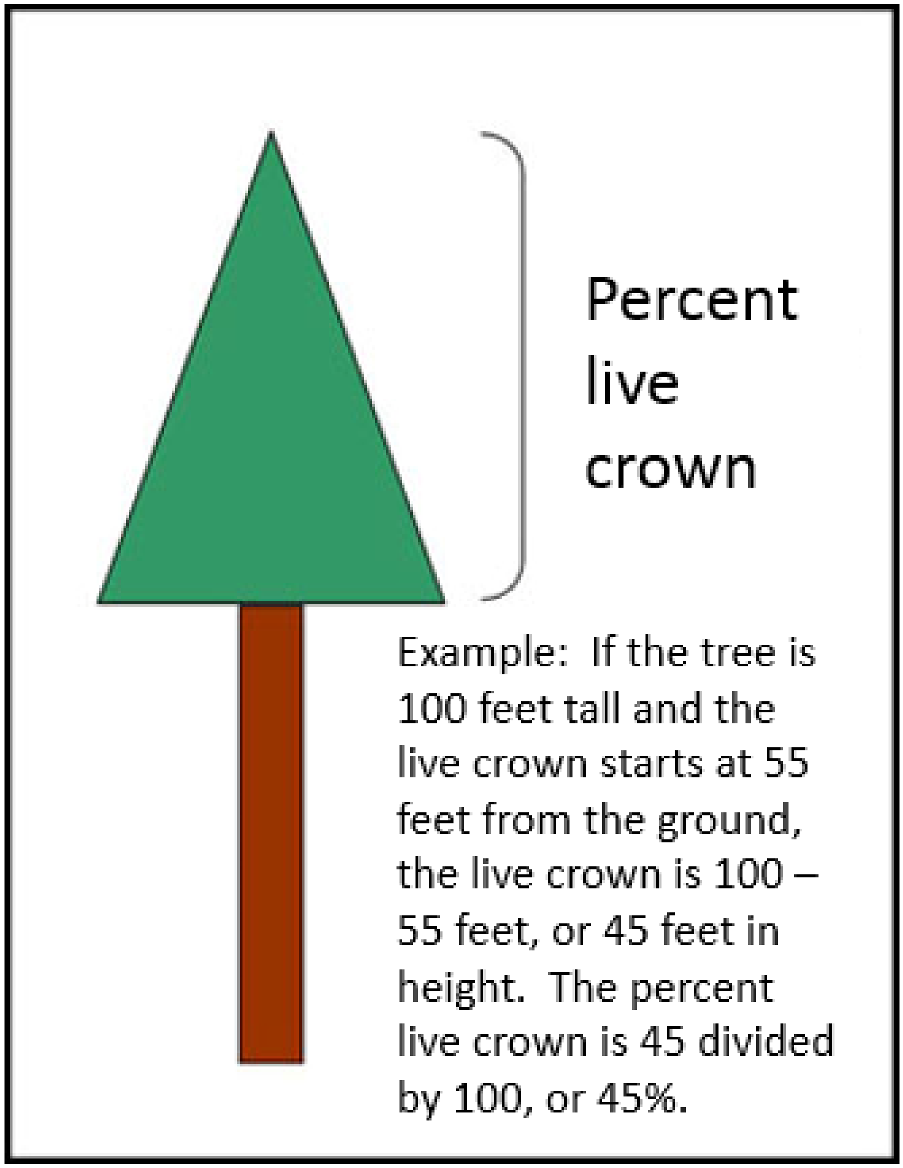
(b) Codominant – Trees with crowns forming the general level of the crown cover and receiving full light from above but comparatively little from the sides; usually with medium sized crowns more or less crowded on the sides.
(c) Intermediate – Trees shorter than those in the two preceding classes, but with crowns either below or extending into the crown cover framed by the codominant and dominant trees, receiving a little direct light from above, but none from the sides, usually with small crowns considerably crowded on the sides.
(d) Suppressed – Trees with crowns entirely below the general level of the crown cover receiving no direct light either from above or from the sides.



3. Tolerance – This is an important concept in silviculture which is generally defined as the ability or capacity of a tree to develop and grow in the shade of and in competition with other trees. Species are generally ranked by the broad classification of being either tolerant or intolerant.

4. Site Class or Site Quality – This is an additional concept of classification used freely by silviculturists when considering stands. It is defined as a designation of the relative production capacity or quality of a site (location or place). The volume or the average height of dominant and codominant trees at a given age is usually used as standard for classification.

5. Crown Percent – This is a descriptive tree term and is simply the percentage of crown length compared to total height.



ECOSYSTEMS AND FOREST ECOLOGY

The term ***ecosystem*** describes a community of ***organisms*** interacting with each other and their physical environment. ***Forest ecology*** is the study of the complex interactions between the ***organic*** and ***inorganic*** elements of a forest ecosystem. An ecosystem consists of the living and dead organisms— ranging from the smallest bacteria and algae to the largest birds and mammals— and the inorganic material contained in the soil, water, and air of a particular area. An ecosystem can vary in scale from a backyard to a ***watershed*** as large as the Chesapeake Bay, the Colorado River Basin, or the Amazon River Basin. Microecosystems, such as a decaying log, are often found within a larger ecosystem, such as a mature forest.

Producers, Consumers, Decomposers

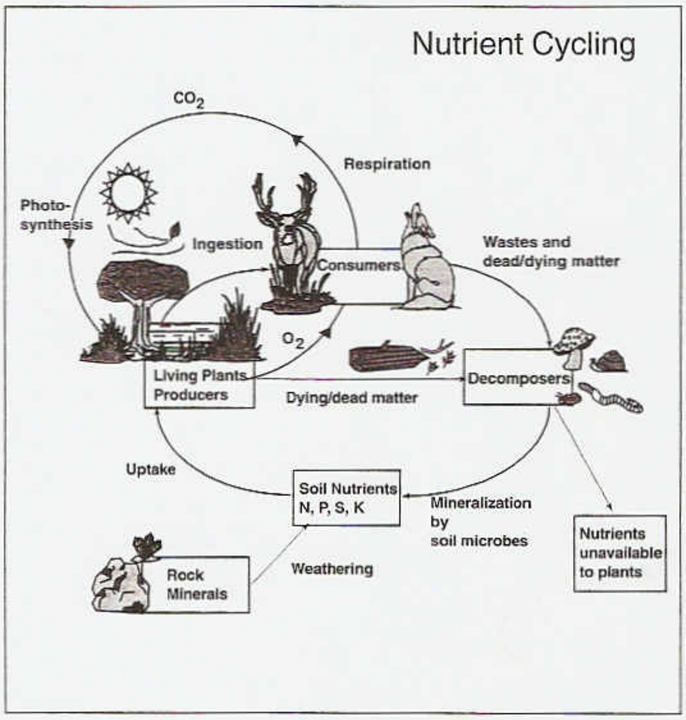
An ecosystem is characterized by its "interdependence," in which every organism depends on every other living and nonliving element of the system. The living components of an ecosystem include ***producers*** (green plants, along with some bacteria, that manufacture their own food from simple inorganic compounds and energy obtained from sunlight, or chemical energy in the case of bacteria); ***consumers*** (organisms that eat plants or animals); and ***decomposers*** (bacteria, fungi, insects, or other organisms that break down organic material into basic elements and compounds). The nonliving components include the soil, water, and climate. The transfer of food energy from organisms in one nutritional level to those in another is referred to as a ***food chain***. For example, a green plant may be consumed by a leaf-eating insect, and the insect, in turn, by an insect-eating bird. The ***food web*** is a complex and interlocking series of food chains.

Nutrient Cycles

The two processes that drive ecosystem structure and dynamics are the flow of energy and the movement of nutrients through the system. Nutrient cycles are critical features of a forest ecosystem. Life, growth, and reproductive cycles of organisms in any ecosystem need nutrients, such as nitrogen(N), phosphorus(P), carbon(C), potassium(K) and sulfur(S). Nutrient cycles provide self-regenerating supplies of these life-supporting materials that are necessary for forest animal and plant populations to live, grow, and reproduce.

Trees absorb nutrients from the soil by taking in nutrient-laden water through their roots and transporting the nutrients to ***xylem*** cells in their trunk, branches, and leaves. When leaves or needles fall and decay, they return nutrients to the soil. As organic materials accumulate on the forest floor, their mass decomposes into the soil and air, and the nutrient cycle begins again.

It is worth noting that decomposition is slower in colder regions where nutrients tend to accumulate in dead organic matter before being broken down, resulting in a longer nutrient cycle. In contrast, the climate in warm, moist regions of the world, such as tropical rain forests, provides conditions in which nutrients are rapidly released from dead organic matter. Thus, the nutrient cycle is accelerated.



PHOTOSYNTHESIS

The nuclear reactions that occur within the sun are responsible for almost all life on Earth through the generation and emission of the broad spectrum of wavelengths in sunlight. About 2 percent of the radiation we receive from the sun supports the process of photosynthesis; the rest warms the soil, the organisms, and the atmosphere. In photosynthesis, plants use the energy of sunlight to convert carbon dioxide (CO_2) and water (H_2O) into oxygen (O_2) and carbohydrates (predominantly sugar and starch). Certain elements (principally nitrogen, phosphorus, iron, magnesium, and sulfur) are required in the structure and function of photosynthetic systems.

Chemistry of Photosynthesis

Many parts of a tree are involved in photosynthesis. Minerals absorbed by tree roots are carried by water to the leaves where they participate in forming chlorophyll (the green pigment in leaves). Photons, the elementary particles of light, pass into the leaves and are absorbed by chlorophyll. The photochemical reaction that results creates sufficient energy to break water molecules apart into hydrogen (H) and oxygen (O_2). The oxygen from the broken water molecule is released into the atmosphere through the leaf. The hydrogen combines with carbon compounds derived from airborne carbon dioxide (CO_2) to form the carbohydrates that the plant uses as food (chemical energy), along with the rest of the H_2O.

In its most simple form, the equation for photosynthesis is:

Chlorophyll (in the presence of light)

$6CO_2$	+	$12H_2O$	→	$C_6H_{12}O_6$	+	$6O_2$	+	$6H_2O$
carbon dioxide		water		glucose		oxygen		water

Absence of Light

Without sufficient sunlight, photosynthesis slows down or halts. In conditions other than those triggered by normal seasonal changes, such as when a plant does not receive sufficient light, the plant will not be able to manufacture enough food, and it will die.

A Time of Transition

Seasonal changes result from the angle of the Earth's axis and the Earth's movement around the sun. When the Northern Hemisphere starts to angle away from the sun and receives less-direct rays, fall begins and is marked with shorter and cooler days. (In the Southern Hemisphere, just the opposite is occurring.) The changing angle of sunlight triggers a variety of biological changes in many organisms throughout Earth's ecosystems. For example, during fall in the Northern Hemisphere, the changes range from animal hibernation to diminished photochemical-based food production and the induction of dormancy in many plants, including trees.

Deciduous Trees and Winter Dormancy

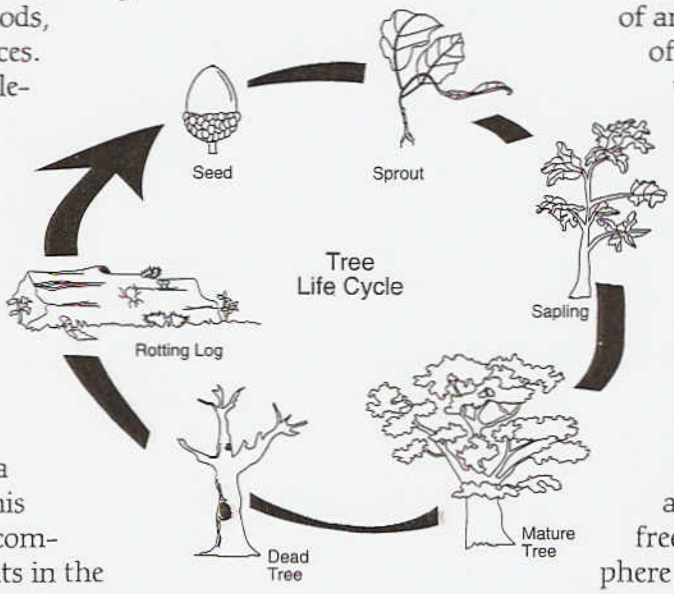
Within the forest ecosystem, colder temperatures and shorter days trigger responses in many ***deciduous*** trees. Cells die at the base of each leaf stalk and a layer of cork begins to form. This cork barrier keeps water and nutrients from traveling to the leaf, causing the leaf's attachment to the twig to weaken. Chlorophyll, the green pigment in the leaves, starts to break down and exposes other leaf pigments, notably xanthophylls (which are yellow) and carotenoids (which are yellow and orange). The formation of anthocyanins, the source of scarlet and purple pigmentation, is triggered by cooler temperatures. (Some of these accessory pigments help plants convert a wide range of light wavelengths into energy, which is passed on to the chlorophyll.) The blending of these remaining leaf pigments produces the many colors we see in autumn leaves. Eventually, the leaf detaches from the tree and falls to the ground. Without its leaves, the tree is less likely to suffer damage from freezing temperatures and strong winds. But without leaves, photosynthesis halts. These trees will remain dormant in the winter until the longer days and warmer weather of the spring trigger new leaves to grow.

A TREE'S LIFE CYCLE

Trees have life cycles that include birth, growth, injury, disease, aging, and death. As trees go through their life cycles, their physical form and their role in the ecosystem changes. By looking at the growth rings of a tree, one can learn about past influences on tree growth, such as fire, drought, or disease, and about changes in environmental conditions. By taking a core sample, one can observe growth rings in a living tree. Core sampling allows scientists, researchers, and foresters to examine growth rings with a minimum of damage to the tree. Fresh-cut logs or cleanly cut stumps can also yield growth ring data. By observing a seedling or sapling as it grows to maturity, one can learn even more about the life cycle of trees.

Seeds or Sprouts?

Most trees begin as seeds although some, such as eucalyptus, beech, willows, and redwoods, may reproduce vegetatively by sprouting from the roots of a parent tree or from the stump or injured portion of a predecessor. Many trees, along with most herbaceous plants and shrubs, are classified as ***angiosperms***. Angiosperms produce flowers and protect their seeds inside fruit. Angiosperms are usually pollinated by insects or other animals. Maples, oaks, and all other broadleafed trees are angiosperms. In contrast, ***gymnosperms*** have "naked" seeds, meaning that the seeds are not enclosed in fruit. Most gymnosperms produce their seeds on cone scales that are pollinated by the wind. The most common types of gymnosperms are the conifers or conebearing trees, such as redwoods, firs, pines, and spruces. Such trees bear needle-like leaves.



The Struggle to Survive

If a seed lands in a site with favorable light, soil, temperature, moisture, and nutrient conditions, it will germinate and grow into a seedling. To grow, this seedling must then compete with other plants in the area, as well as survive browsing by plant-eating animals. To ensure that at least some seeds will become mature members of the forest community, plants produce many more seeds than can possibly survive.

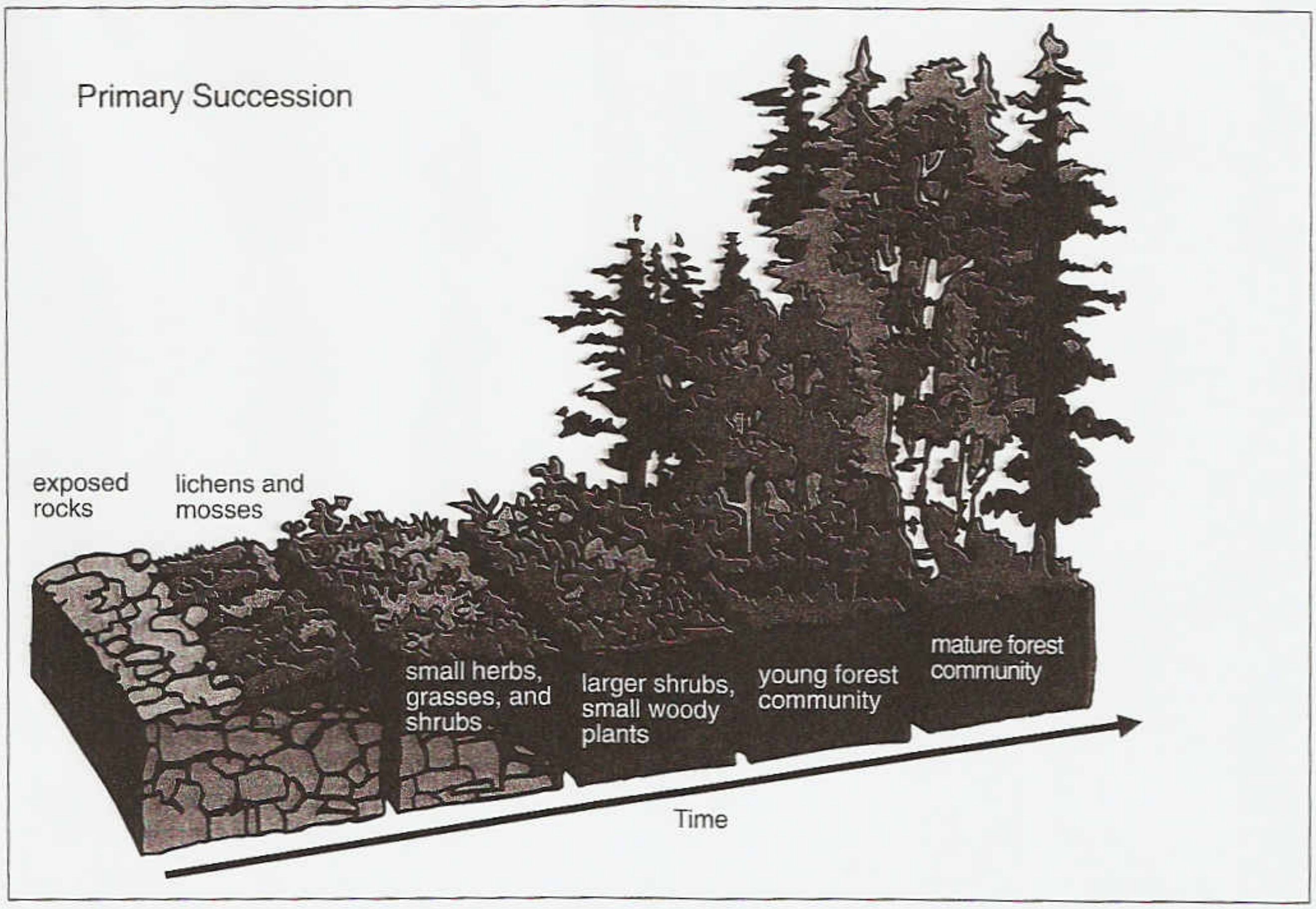
Making the Most of Growth Opportunities

As part of the ***understory***, young trees must compete with other trees and plants for sunlight and other resources, such as nutrients in the soil, water, and space for roots. All trees need light, but certain species may require more, or less, than others. In dense forests, small trees must wait for many years for a larger tree to fall and create an opening in the ***canopy*** into which they can grow. Trees that can exist in the understory are called shade-tolerant. Hemlocks are one example of shade-tolerant trees. Trees that are not shade-tolerant (Douglas fir, for example) require full sunlight from the very beginning stages of their lives. Some species are shade-tolerant as seedlings but become less shade-tolerant as they age. The length of time it takes a tree to reach maturity depends on the species of tree and the environmental opportunities that are present during its life. Trees are considered mature when they can reproduce.

Connections

Trees play different roles in the forest community depending on their age, size, and species. Their leaves, bark, seeds, fruit, nuts, and roots provide food for many kinds of animals and microbes. Trees offer roosts, shade, and shelter to many living creatures. Trees can become hosts for many organisms including harmless lichens or harmful plants such as mistletoe, which feeds on the host tree's sap. In some instances, one species of tree can actually be beneficial to other species. The root system of the red alder can "fix," or transfer, free nitrogen from the atmosphere and can deposit nitrogen compounds into the soil. It adds to the nitrogen pool in the forest soil in much the same way direct applications of nitrogen-rich fertilizers enrich a lawn.

The health of a forest ecosystem affects the local topography and the local, regional, and even continental weather. The roots of trees and other plants not only transport water and nutrients, but also hold soil in place. Where forests



grow and mature, water drainage and storage capacity are optimized, erosion is reduced, and surface winds are moderated. In addition, moisture generated by healthy trees contributes to atmospheric conditions conducive to rainfall many miles away.

When a Tree Falls in a Forest

Like all living things, trees are subject to disease and injury. Trees weakened by injury and disease die, fall, and are broken down by decomposers, such as insects, fungi, and bacteria. Through the decomposition process, trees return their nutrients and other elements to the soil to be recycled through the forest ecosystem.

ECOLOGICAL SUCCESSION

Ecological succession is the gradual change in plant and animal communities over time. ***Primary succession*** begins in areas with no true soil. Examples include rock or mud exposed by a retreating glacier, a sand dune, or those areas that have been affected by forces such as volcanic eruptions or landslides. As primary succession proceeds, minerals dissolved from rocks, along with organic material derived from decomposed plants and animals, begin to accumulate as soil. Sometimes it takes hundreds or thousands of years to build up soil where none existed. The first plants to grow at barren sites are called ***pioneer species***. Lichens, algae, mosses, and ferns are typical pioneer species. Not coincidentally, these organisms are among the longest surviving land plant species. Over time, rock weathers and releases minerals. Lichens and then moss cover the exposed rock. Soon small seeds carried by animals or blown by wind take root in the moist bed of vegetation. Small shrubs and plants become established. Eventually, if conditions are right, a healthy plant community will be established.

Secondary succession occurs on landscapes where the natural vegetation has been removed or destroyed but the soil remains intact. It can be considered an extension of primary succession or the soil-building phase. Examples of areas that undergo secondary succession are abandoned fields or pastures and burned, blown down, or cleared forests. Because soil is already present, secondary succession may follow a pattern slightly different from primary succession. Grass may establish first, followed by herbaceous and small woody plants, then shrubs and trees.

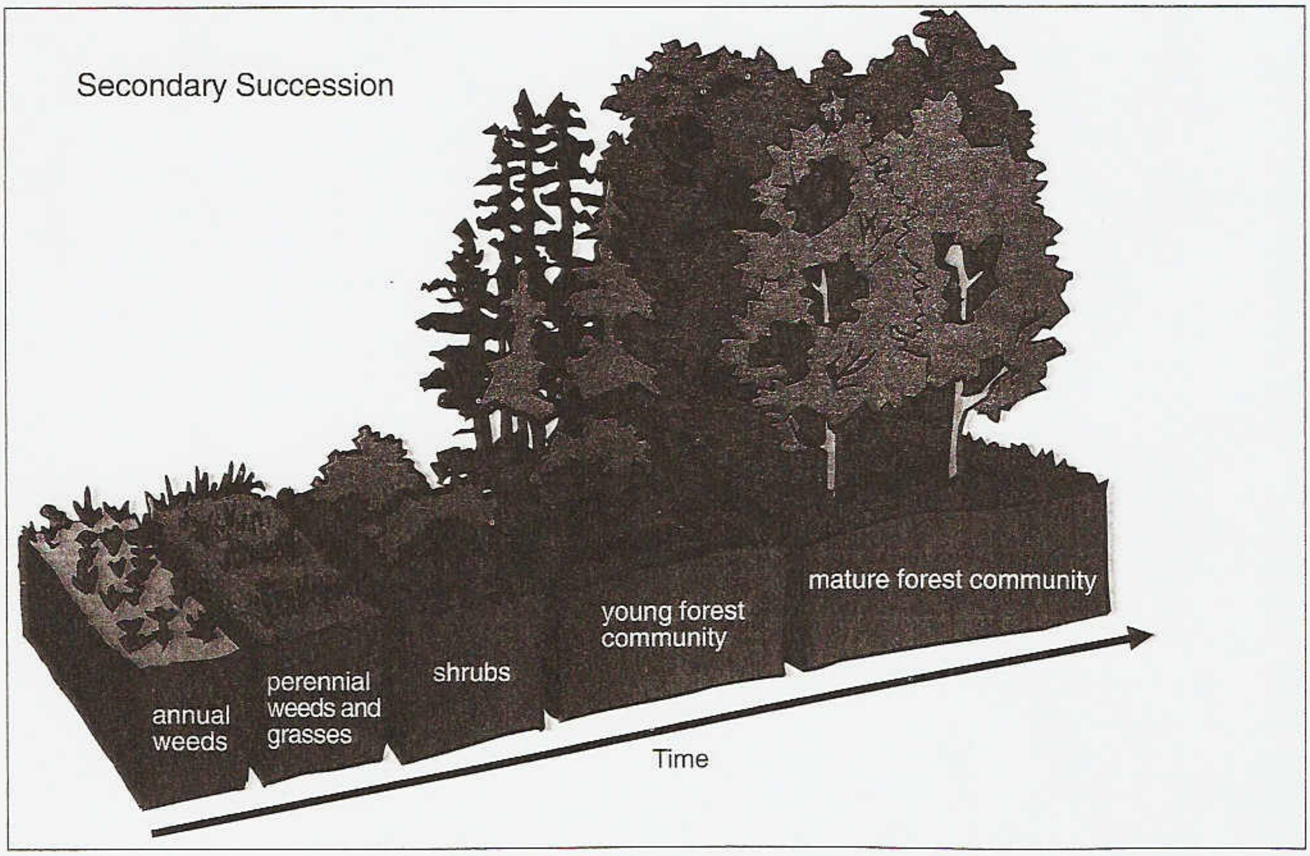
Examples of secondary succession can be found throughout the eastern United States, where most of the original forest cover was cut for timber or cleared for agriculture by European settlers and Native Americans. When the fields and pastures were abandoned, native plants slowly began to recolonize. Today in many areas, new forests are growing where the old fields and earlier woodlands used to be.

The Progress of Succession

In the absence of disturbances, a forest naturally progresses through a series of successional stages. Each stage is characterized by the dominance of certain species. For example, successional stages might include: herb, shrub and seedling; grasses and shade-intolerant trees; and shade-tolerant trees.

Pioneer species (for instance, Douglas fir, poplar, and pine) are usually sun loving and rapidly colonize a site where their seeds can germinate directly in mineral-rich soil (on the site of an abandoned farm, for example). Because these trees cannot tolerate shade and cannot germinate in deep forest litter, they are generally not found reproducing underneath their own canopy. But a species such as the hemlock, which is shade-tolerant and can reproduce and persist underneath a full canopy, will eventually overtake the pioneer species altogether. Therefore, it represents the next successional step. A forest has reached maturity when it is in a state of near equilibrium with its environment. In other words, the forest community is stable except for almost imperceptible changes that may occur, as compared to the earlier rapid stages of succession.

The term ***climax stage*** has been used in the past to describe the final stage of plant or animal succession, when conditions have been stable long enough to provide a semipermanent mix of species. But even climax stages are sometimes only relatively stable. Because they can grow to be hundreds of years old, West Coast redwoods were once thought to be a climax species. Ecologists now believe redwood forests, if they do not experience periodic disturbances, such as fire or windstorm, eventually give way to forests of hemlocks, which thrive in the shade of the redwoods. However, should the hemlock forest burn, a redwood forest is likely to grow back in its place, because the redwood's thick bark can withstand the intense heat that destroys other species.



Natural Patterns of Succession

The evolution of a forest ecosystem is often interrupted by natural and human-made disturbances, ranging from lightning fires, wind, volcanic eruptions, disease, and insect infestations to logging, farming, road-building, careless or arson-started fires, and urban expansion. One of the most powerful and enduring influences on forest succession is fire. Fire can be regarded as a natural process operating as a catalyst of change in an ecosystem. Ashes that remain after wildfires provide nutrients for trees, grasses, and other vegetation and aid in the decomposition of organic material into nutrients. Fire influences the types of trees and vegetation in a stand by favoring species adapted to endure the heat of a fire. For example, ponderosa pine, Douglas fir, and giant sequoia have thick bark that provides insulation from the heat of flames. Fire helps with seed distribution for some species; a number of pine species have cones that open only from excessive heat, like that from a fire. Fire is also a major instrument in decomposition and nutrient recycling.

Other natural factors affecting succession are (a) defoliating insects and wood-boring beetles that interfere with a forest's energy flow by prematurely removing leaves from trees or causing tree mortality; (b) diseases and blights that can spread regionally; (c) severe storms, such as the hurricanes and thunderstorms on the southern and eastern coasts of North America; and (d) volcanic eruptions such as Mount Saint Helens. Those storms can blow down large, mature trees, thereby opening up the forest canopy and providing new growth opportunities for a diversity of species that require direct sunlight.

The Human Factor

Human intervention is the other major factor affecting forest succession. Human activities modify the natural environment, whether by accident or by design. Farmers purposefully alter succession when they continually plow and harvest a field, allowing one stage of vegetation to dominate. Natural resource managers alter the course of succession when they ignite fires or permit naturally occurring fires to burn under very specific conditions. Managers do this to prevent the buildup of too much understory brush, which could lead to a catastrophic wildfire. Careless campers can change the course of succession by causing wildfires. City dwellers affect succession by allowing abandoned lots, neglected lawns, and poorly managed parks to serve as sites for successional species of plants. The first species of secondary succession to grow in human-disturbed areas are often grasses and herbaceous plants.

FOREST TYPES AND INTERACTIONS

Why is the swamp tupelo tree the dominant tree in the slack-water ponds of the southeast coastal plains, while it is absent from the scenic wetlands of South Dakota? For the same reason the two species of redwoods known as sequoias, (*Sequoia sempervirens* and *Sequoia gigantea*), survive in mutually isolated areas; the former is found only on the fogbound northern coasts of California and Oregon, while the latter is found in the high Sierra Nevada mountains between 5,000 and 8,000 feet (1,524 and 2,438 meters) in elevation.

A tree species has a complex set of habitat requirements that foresters often call the four factors of site. These are climate, location, soil composition, and animal interactions. Taken together, these factors form the forest habitat, not only for the trees themselves, but also for every living organism associated with them. These associations can be symbiotic, forming a relationship in which one organism or both can benefit from the actions or characteristics of the other. For example, oak trees provide food (acorns) for squirrels, who then store the acorns by burying them. This action provides an opportunity for acorns to germinate and grow into oak trees. Or the associations may be competitive, where one organism thrives at the expense of another. Shade-tolerant hemlocks grow well in the shadows of Douglas firs and will, if left unharmed by fire, eventually overtake and replace the firs as the dominant species. Whether the associations are symbiotic or competitive, the rise or decline of one tree species upon which certain organisms depend may signal a commensurate rise or decline of another tree species and may thus change the life cycles of living organisms that depend on those species.

BIOLOGICAL DIVERSITY

Biological diversity within a forest refers to the full range of living organisms that inhabit a particular forest ecosystem. Biological diversity includes the microorganisms in the soil; the grasses and plants that make up the ground cover; the invertebrates, reptiles, amphibians, birds, and mammals that make the forest their home; and the trees themselves. The scope of the diversity depends on the variety and number of tree species within the forest. A pine plantation is less biologically diverse than a tropical rain forest with many species of trees. A pine plantation is an example of a *monoculture*, a system dominated primarily by one plant species.

The diversity within and among our forests allows us to enjoy and use them for many different purposes. Every person in the world depends on the diversity of forests. From forests, we obtain more than 5,000 commercial products, such as firewood, lumber, paper, medicines, turpentine, charcoal, fruits, and nuts. People enjoy forests for their recreational activities, for their aesthetic value, and for their psychological "get-aways" from everyday stress.

INTRODUCTION OF EXOTIC SPECIES

Sometimes nonnative, or ***exotic***, species upset balanced ecosystems. In some regions, exotics may be especially aggressive and prolific. Often, their new habitats lack the predators and parasites that helped keep their populations in balance in their native lands. Exotic species include pests such as Dutch elm disease fungus, plants such as the kudzu vine, and insects such as the gypsy moth. Even the seemingly harmless cottontail rabbit can devastate an ecosystem, as it did when it was introduced in Australia. On the other side of the ecological equation, certain nonnative species can have a positive effect when introduced to a new environment. For example, Scotch pine, a species not native to North America, does very well in soils deficient in potash (potassium carbonate, an important mineral for many trees). The Adirondack Mountain sand plains were "farmed out" and nutrients depleted by the mid-20th century. Where few other trees would grow, the Scotch pine took hold and provided a solid economical crop in a region otherwise barren of agricultural possibilities.

RESOURCE MANAGEMENT

By studying forest ecology, students will be better able to understand the complexity involved in decisions regarding our environment. Today, land managers are taking a more holistic view of resource management. Managing forests for human uses (for example, harvesting for timber or maintaining opportunities for recreation) is integrated with protecting an ecosystem's structure and function. The time scale facing forest managers requires long-term planning: a forest harvested for timber, or lost to fire or disease, cannot be regenerated any faster than the trees will grow, whether left to nature or humans to manage. That time scale means the diverse animal and plant populations that depend on a forest must be considered whenever decisions are being made about forest use. In addition, the effects of a forest on local, regional, and even global environments are very real and must be included in the forest management equation. Taking all these elements together, responsible management of a forest is actually management of an ecosystem in which the future of every element in the system—both living and non-living—depends on carefully considering the future of every other element.

Wherever a forest exists, the interrelationships among all its living and nonliving elements have broad-ranging effects on other ecosystems. Responsible forest management accounts for the broad scope of forest life while determining the best uses of the forest for the long-term benefits of society and nature. By encouraging your students to consider the global implications of forest management, you will help them expand their knowledge not only of their own local environment, but also of the world's forests.