Section I
NATURAL HISTORY OF CONIFEROUS FORESTS AND WATERSHEDS

Chapter 1 of this section introduces **coniferous** forests. Chapter 2 introduces the concept of a **watershed**. The effect of geography and geology on California's coniferous forests and watersheds is the topic of Chapter 3. Chapter 4 reviews basic ecological principles, while Chapter 5 is about the **ecology** of coniferous forests. Chapter 6 introduces some of the major environmental concerns in our coniferous forest regions. Chapter 7 introduces some of the most common or most important organisms found in California's coniferous forests.

This is not intended to be a comprehensive or detailed summary of the science associated with studies of a complex ecosystem such as a coniferous forest and its associated watershed. It does provide basic background for teachers and others who may not have extensive backgrounds in forestry or forest ecology. Elementary students need not learn all of this information. However, teachers who have a good background in the natural history of the forest will be better able to take advantage of "teachable moments" while with students in parks and forests, as well as blend this forest information into other studies throughout the year.

The study of science enables students to understand how the world works, to appreciate nature's beauty, wonder, and importance, and to find one's place in the world. While learning vocabulary is not an end in itself, a working knowledge of scientific terms makes learning and communicating easier. Likewise, discovering the etymology of words facilitates understanding both scientific and non-scientific terms. Throughout *The Conifer Connection*, **bold** type emphasizes important vocabulary that will help clarify the information being reviewed. (See Appendix II for a glossary of terms, page 334.)

Use of Images in The Conifer Connection

Some images in *The Conifer Connection* are presented two-to-a-page, especially in Section II (page 105), Humans in the Coniferous Forest. Consider making overhead transparencies of those images and using them for instruction with the students.

Many images are smaller and illustrate points that teachers might want to point out while on a trip to a park or forest. When you do your pre-trip visit to the park, you might show those images to park personnel and ask where similar scenes might be found. The organisms illustrated in Chapter 7 of the Natural History section are provided as line drawings so that particular characteristics can be clearly shown. In addition, they can be easily photocopied if you want to enlarge them and make copies to use with students, as is suggested in some of the activities. Consider having students color the images. Color photographs of common forest organisms can be found in field guides, many of which are listed in Appendix V on page 350.

CHAPTER 1
The Coniferous Forest

In the western United States, the word "forest" typically brings to mind large stands of evergreen trees. The conifers, or cone-bearing trees, include pines, firs, Douglas-fir, redwoods, cedars and other trees that reproduce with cones or cone-like structures. They are classified as **gymnosperms**, which means "naked seeds," because the seeds are not enclosed by a fleshy fruit such as is found in flowering plants like oaks, maples, fruit trees and flowers, which are called **angiosperms.**

Conifers are sometimes referred to as **softwood** species. They are generally evergreen, meaning that they don't lose their leaves (needles) in the winter. Angiosperm trees are called **hardwoods**, and are sometimes evergreen (like the live oaks) and sometimes **deciduous**, losing their leaves in winter, like black oaks.

Most students are familiar with conifers as "Christmas trees." Conifers are important as sources of wood for home, deck, fence and furniture construction, paper pulp, and as landscaping. Coniferous forests provide recreation for millions of people in the form of camping, hiking, skiing, fishing, bird watching, boating, and hunting. They store or sequester carbon, helping reduce global warming. Conifers also help reduce erosion, and slow the runoff of water, thus helping provide a year-round supply of water.

Several common **species** of conifers found in California are described in Chapter 7, beginning on page 54. Major groups of conifers include:

Pines: The pines typically have needles that are enclosed by a sheath at their base and cones that hang down or grow close to the branch.

Firs: Firs have needles that leave scars on the twig when they fall off and their cones stand upright on the branches, falling apart and dropping scales while still on the tree.

Douglas-fir: Douglas-firs are not true firs. Their cones hang down from the limbs and fall from the tree intact, rather than disintegrating as true fir cones typically do.

Figure 1. Red fir cones.

Figure 2. Douglas-fir cone.

Cypresses, cedars, junipers and related trees: Most of these trees have scale-like leaves that grow close to the branchlet, as opposed to pines and firs in which the needles project out.

Redwoods: Both the coast redwood (*Sequoia sempervirens*) and the Giant Sequoia (*Sequoiadendron giganteum*) are related to the cypresses.

Figure 3. Cedar cones.

Teaching Idea

While being able to identify all of the plants and animals in an ecosystem is not as important as understanding their interactions and the ecology of the place, knowing the names of common organisms can help students feel connected to the area.

See the activity "Name That Plant" on page 189.

In some coniferous forest regions, fairly large areas are dominated by a single species of tree, while in many places one or two species of conifer are predominant, with other species of conifers and other trees mixed in. The makeup of the forest depends on many factors such as the availability of water, soil type, elevation and latitude (which are related to water and temperature), competition among various species, and fire or other disturbances such as logging, avalanches, erosion, or landslides.

Of course, a forest consists of much more than the dominant trees. Animals depend on plants for their food. Fungi and bacteria are found everywhere and play extremely important roles as decomposers and in various cycles. Chapter 7 provides information on some coniferous forest organisms.

Teaching Idea

The saying "Can't see the forest for the trees" means that one only sees the most obvious part of something, but not the whole picture. Discuss the saying with the students as you point out that trees are the most conspicuous part of a forest, but the forest consists of many other organisms and also non-living things such as soil, rocks, and water.

The living (**biotic**) parts of a forest depend on the non-living or **abiotic** parts. Climate, geology, hydrology, and other factors are important factors in every **ecosystem**. Chapter 4 (page 18) and Chapter 5 (page 41) of this section provide a review of basic ecological principles.

Conifer Anatomy

Conifers, like most other plants, have four main parts: reproductive bodies, leaves, roots, and stems.

Figure 4. Male white fir flowers or "cones."

Most conifers reproduce primarily with "cones." The woody structure that most people think of as a cone is the female reproductive body. The male cones produce copious amounts of pollen, are less conspicuous, and don't stay on the tree for long. The pollen fertilizes the ovule, which then develops into a seed. The seed often has a wing that enables the seed to be carried far from the parent tree, thus reducing competition for the germinating seedling. (The coast redwood also reproduces by stump sprouting.)

Figure 5. Pine seeds vary in size. Wings help reduce competition with the parent tree by facilitating distribution by the wind. Left to right: gray pine, Jeffrey pine, sugar pine seeds.

Figure 6. Sprouting pine seedling.

Teaching Idea

Collect some cones in early to mid-summer, before the seeds have fallen out or been eaten. Remove the seeds, including as many with the wings intact as possible. Have students predict what effect the wing will have on a falling seed. Then take the students and seeds outside and have students simultaneously drop seeds with and without wings. Discuss the species survival value of having seeds disperse away from the parent tree. Store seeds for future use. Also look for evidence of insects feeding on the seeds. (Big leaf maple seeds will also work well for this.)

The leaves of a conifer are needle-like or scale-like structures. The primary function of the leaves is **photosynthesis**, the process by which plants use light energy to convert water and carbon dioxide to carbohydrates and oxygen, which are used by plants (and animals) for **respiration**.

Most conifers are also evergreen; they don't shed their leaves in the winter. This gives them an advantage where the growing season is short because they can photosynthesize on clear winter days, and their leaves are already in place when the days lengthen (Allaby, 1999).

The needle-like leaves also help conifers conserve water by reducing water loss, because smaller leaves have less surface area for evaporation and transpiration. The needles are covered with a thick waxy covering called a **cuticle**, and also have a reduced number of **stomata** (singular: **stomate**), which are holes in leaves through which carbon dioxide is taken in and water and oxygen are given off.

In addition to anchoring the tree, roots absorb water and minerals from the soil. Most conifers have **tap roots**, but if the tree lives in the mountains, the tap root may not be able to penetrate far into the soil because the bedrock is so near to the surface. Instead, the roots seek out cracks in the rocks. As they grow, roots may enlarge the cracks, eventually causing pieces of rock to break away. Trees are thus part of the process of soil formation because they help break down rocks into smaller particles, as well as adding organic matter to the soil.

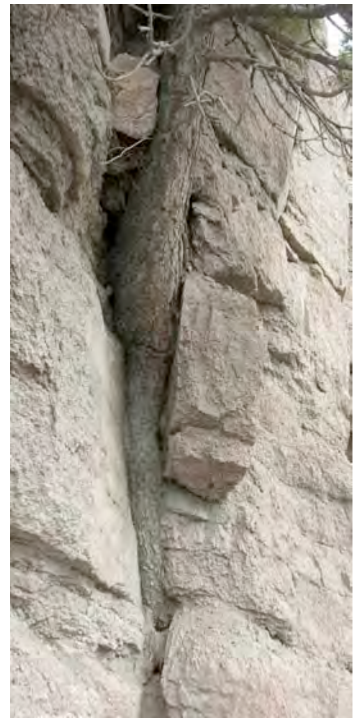


Figure 7. Mechanical breakdown of rock to smaller particles by roots.

Teaching Ideas

The actual absorbing of water and nutrients is done by tiny root structures called ***root hairs****. These structures are very delicate and easily damaged if they are stepped on or exposed to the drying effects of the air. Discuss the importance of staying on trails and not taking shortcuts across switchbacks so that tree roots are not damaged or exposed.*

Many parks have cordoned off "habitat restoration areas." Ask a park ranger or docent to discuss such areas when you visit a park.

The stem of a conifer is often referred to as the trunk, or **bole**, of the tree. The trunk supports the limbs which, in turn, support the leaves (needles) where they can capture sunlight for photosynthesis. As the tree grows, lower branches die due to lack of sunlight and then break off. This is called "**natural pruning**."

Water and nutrients are transported up from the roots and down from the leaves through the **vascular system**, which consists primarily of **xylem** and **phloem** cells produced by the **cambium** layer. The xylem moves water and minerals upward from the roots, while the phloem moves carbohydrates produced by the leaves to the other cells throughout the plant.

The living, active **sapwood** and the inactive **heartwood** make up the xylem. The phloem is just beneath the bark, and is sometimes considered to be part of the bark.

The xylem and phloem make up the wood that is used for lumber.

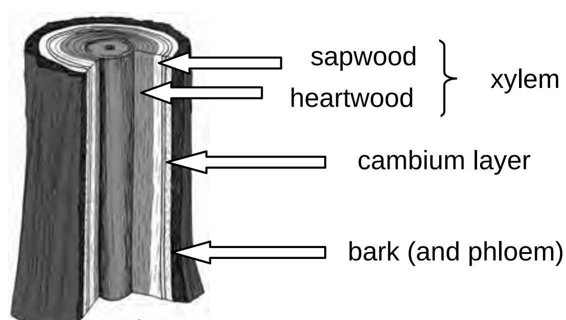


Figure 8.

Conifers are the largest trees in the world. Coast redwoods (*Sequoia sempervirens*) can reach heights of over 370', and trees over 300' tall with diameters of over 12' are common. A Douglas-fir (*Pseudotsuga menziesii*) in Oregon is about 329' tall, while one that once stood in Washington was reported to be 385' tall! The Giant

Sequoia (*Sequoiadendron giganteum*) are not as tall as the coast redwoods, but they are even more massive. The General Sherman tree, in Sequoia National Park, is about 275' tall and has a diameter at breast height of about 27' (Lanner, 1999).

Teaching Idea

*When measuring the size of trees, foresters measure the circumference at “breast height” (4.5'), and use that to calculate the diameter of the tree at breast height (**dbh**). (Actually, they use a special tape measure that does that calculation for them.) Using the diameter of the tree or log and its height or length, foresters estimate the volume of lumber that the tree or log can provide.*

Since circumference equals pi times the diameter, the diameter equals circumference divided by pi.

$$C = \pi \times d \qquad d = C \div \pi$$

Work with students to practice converting circumferences of circles to diameters. You can also work on rounding off and approximating. For example, have the students calculate the difference between using 3.14 for pi and using 3.1 or 3 when calculating diameters. Is the error greater if the circumference is greater?

E.g.,: If the circumference is 10', using 3.14 gives a diameter of about 3.18', while using 3 for pi yields a diameter of about 3.33', a difference of 0.15 ft.

If the circumference is 20', using 3.14 gives a diameter of about 6.37', while using 3 for pi yields a diameter of about 6.67', a difference of 0.3'.

See the activity “Making a Forester’s Diameter Tape” on page 186.

Teaching Idea

When in a grove of tall trees, ask the students to state some ideas about how the trees can get water up to the top leaves. Record their ideas and have students investigate this question.

CHAPTER 2
The Watershed

A **watershed** is the area from which water flows into a stream, lake, wetland or ocean. Watersheds are sometimes called **drainage basins** or **catchment areas**. As small streams flow into larger streams, watershed systems are formed. One watershed is separated from another by higher terrain that is the watershed boundary.

The importance of the watershed cannot be over emphasized. The ecological importance of water is obvious. Water is also economically important. In *Status of the Sierra Nevada: Summary of the Sierra Nevada Ecosystem Project Report*, it was estimated that water accounts for more than 60% of the financial value of the commodities and services of the Sierra Nevada ecosystem, making it the most valuable commodity (University of California, Davis, 1996).

Teaching Ideas

Many excellent resources are available for teaching about watersheds. Appendix III includes a table of water education resources.

Consider contacting the Water Education Foundation for the California Water Map and The California Water Story curriculum units, as well as information on workshops for Project WET: (916) 444-6240 or www.watereducation.org.

Many resources are also available from the California Department of Water Resources. (800) 272-8869 or http://www.dwr.water.ca.gov.

*Introduce the concept of a watershed when teaching the **water cycle**. Also introduce the terms **tributary** and **headwater**. (See the Glossary, page 334.)*

Use a state map to show how watersheds in the area to be visited and the students' home town(s) are connected to other watersheds. Point out that eventually the water from the watershed enters the ocean.

See the activities "The Case of the Runaway Topsoil" (page 173), "Washing a Watershed" (page 192) and "Water…Cycling" (page 318).

Streams carry suspended, floating, and dissolved materials with them as they join other streams in ever-growing drainage basins. Most watersheds ultimately empty into the ocean, so whatever the streams carry is eventually brought to the ocean. Thus, what happens in a coniferous forest far from the sea can have an impact on the ocean. Sometimes that impact is something as simple as plastic bottle caps or cigarette butts being carried to the sea where they can harm wildlife. Other effects such as dissolved minerals, or pesticides and herbicides applied to gardens, farms and forests are less obvious, but can have a great impact on the ocean ecosystem.

See the activity "From the Mountains to the Sea: Traveling Trash" on page 215.

While the streams of a watershed contain the visible water, much of the water sinks or percolates into the ground. The forest watershed thus acts much like a sponge, filtering the water and allowing it to enter the underground water system or **aquifer**. The aquifer releases its water throughout the year, thus providing the water supply for most of California.

Teaching Ideas

When teaching about acids and bases, also teach about acidic precipitation or "acid rain." Acids affect streams in several ways. When the acid rain enters the stream or lake, it can acidify the water to the point where aquatic organisms are killed. Acid rain falling on the land may dissolve metals or other harmful minerals and carry them to the stream or lake. Acidic precipitation has killed thousands of trees in some areas such as the northeast.

Have students investigate the California Water Plan. Have them find out the source of their local water supply.

Harvesting of trees affects water quality in many ways. Road construction, harvesting of trees, and the use of heavy equipment can all effect the forest ecosystems, including streams. Loss of shade along streams can lead to increased water temperature, and warmer water is able to hold less dissolved oxygen than cold water, which has an adverse effect on fish such as trout and salmon. Disturbed soil can erode into streams and bury fish spawning grounds. Removal of plants can increase runoff, resulting in flooding, but sometimes debris in streams can slow runoff or create pools (Mitchell, 1997). Because of the environmental impacts of timber harvesting, California has some of the most stringent timber harvesting regulations in the nation.

Teaching Idea

To illustrate that warm water is able to hold less dissolved gas than cold water, fill a bottle half full of cold water, cap it, and shake it vigorously for a few minutes to dissolve air in the water. Pour some of the cold water into a clear glass and let it sit in a warm room for several minutes. Students should observe bubbles forming as the dissolved air comes out of solution. Another way to demonstrate this is to simply heat some cold water in a pan. Bubbles will start to form long before the water reaches its boiling point.

To be ecologically healthy, a watershed must have healthy streams and adjoining lands. Because of their small size and small volume of water, streams at the headwaters are the most vulnerable to human disturbance, especially timber harvesting, road building, and grazing. All river systems in the United States have been degraded to a greater or lesser extent. While 10%–15% of terrestrial vertebrates are classified as rare to extinct, 33%–75% of aquatic species are classified as rare to extinct (Doppelt, 1993).

The streamside area is called the **riparian** zone. It contains elements of both aquatic and terrestrial ecosystems, and those systems influence and interact with each other.

The land contributes organic debris, nutrients, and sediments to the water. The water influences the riparian zone by elevating the water table, moderating temperature, increasing humidity, and by periodic flooding, which deposits sediments.

Riparian communities are very important in forest watersheds. Examples of the influence of the riparian zone include:

- The vegetation helps store water during dry times.
- The vegetated areas help reduce flooding by absorbing water.
- The vegetation filters runoff from the land, reducing silt and other pollution.
- Trees and larger shrubs provide shade, which cools the stream.
- Logs, roots, and low branches provide protection for fish and other animals.
- Logs and large branches in streams create pools and riffles and also trap sediment.
- Vegetation provides food for aquatic (and terrestrial) organisms.
- Vegetation provides habitat for birds and other wildlife.

(Murdoch et al. 2001)

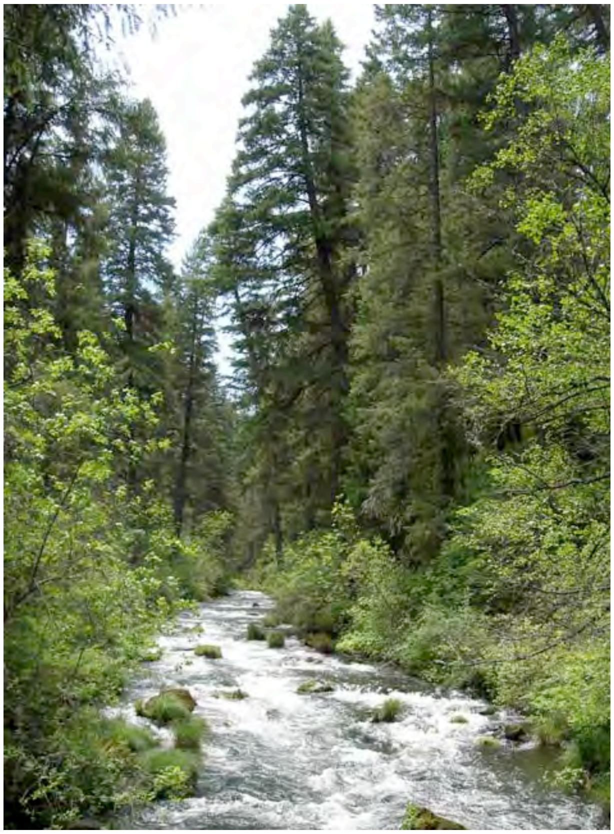


Figure 9. The riparian community often includes willows and alders, which provide shade and other benefits along the banks of streams.

Figure 10. "Large woody debris" helps form pools in streams, providing a variety of habitats.

Teaching Idea

Have students compare the leaves of riparian community trees such as cottonwood, willow, and alder with the conifers that live in drier areas. Discuss the idea that the conifers' reduced leaf size reduces water loss through transpiration.

See the activities "Transpiration" (page 315) and "Water…Cycling" (page 318).

Figure 11. Willow leaves and flowers.

Several excellent resources for teaching about watersheds are listed in Appendices III, (page 342) and V (page 350).

A book that may be of interest to younger students is *Follow the Water from Brook to Ocean*, by Arthur Dorros.

CHAPTER 3
Geography and Geology

Geography

Much of California's precipitation is brought by storms coming from the west. As the moist air moves eastward, it encounters mountain ranges such as the coast ranges, the Klamath, the Cascades, and the Sierra Nevada. As the moist air rises, it cools, and the water vapor condenses to form precipitation. As a result, most of the moisture of Pacific storms falls on the west side of the mountains. This "orographic precipitation" creates a **rain shadow effect** on the eastern side of the mountains. The Great Basin desert, the Nevada desert, and other deserts are formed by the rain shadow effect.

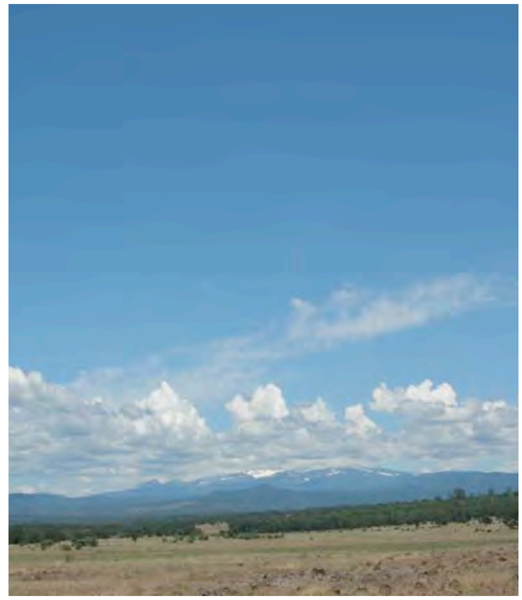


Figure 12. Rain clouds form as moist air rises and cools over the mountains.

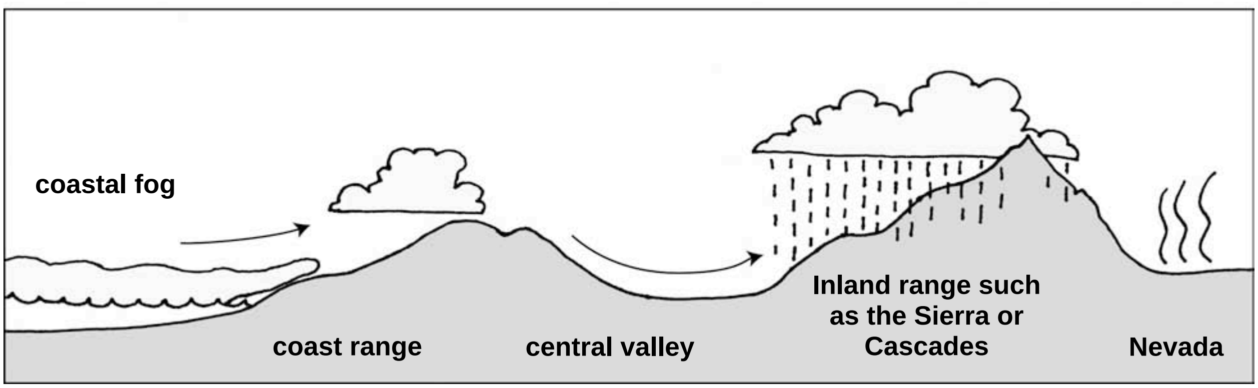


Figure 13. The rain shadow effect. As moist air rises on the west side of mountains, it cools and forms clouds. Precipitation falls mostly on the west side of the mountains in California. (Illustration by Faith Rumm)

California's coniferous forests form primarily on the western slopes. Since most of the moisture precipitates from the air at lower elevations, the higher regions, especially those above 5000' or 6000', receive less precipitation. Also, precipitation at a given elevation tends to be greater in the north. For example, Plumas County, at about 5000' elevation, receives about 90" of precipitation per year, while Mariposa County, about 130 miles to the south, also at about 5000', receives only about 55" (Storer et al., 2004).

The orientation of a slope to the sun can also affect the types of plants and animals that grow on it. For example, a north-facing slope may be relatively cool and support ponderosa pines and Steller's jays, while the warmer south-facing slope of the same valley may have gray pines and scrub jays (Storer et al., 2004).

Teaching Idea

Discuss the north/south facing slope differences with the students prior to your field trip. As you approach the mountains have them look for differences in the vegetation on the slopes. Alternatively, point out the differences and ask the students to develop theories to explain them.

Another important geographical effect is the inversion layer. Typically, air temperature decreases as altitude increases, and air pollution in rising warmer air is diluted and carried away. In large valleys or basins cool air may pool at night and become trapped by a warmer layer that forms over the cooler, polluted air during the day. In such cases, there may be very little mixing of polluted air. It is such an effect that results in the smog for which the Los Angeles Basin is famous. The ozone in the smog essentially bleaches the trees' chlorophyll, eventually weakening and killing the tree. Pine trees in the San Gabriel and San Bernardino ranges, the Tahoe Basin, and Yosemite Valley have been affected by automobile smog trapped by inversion layers (Little, 1995). Sometimes the air pollution in the Central Valley is carried up the western slope of the Sierra Nevada and affects trees in the river valleys (Schoenherr, 1992).

Geology

The geology of California's coniferous forests is much too varied to go into detail here, but students should be aware of the points that follow. For more detailed information on the geology of California, see the books by Hill, Schoenherr, and Storer, which are listed in Appendix V.

Students should understand that just as animals depend on plants for their food, land plants depend on soil for their nutrients.

Soils are a combination of minerals, water, air, and organic material. One indication of the importance of soil is the growth rates of coast redwoods growing in alluvial flats as compared to those growing in different soil types "upslope." In conjunction with the greater availability of water, the deeper, richer soils of the **alluvial floodplains** result in growth rates as much as 20 times that of redwoods growing in the thinner, drier soils on some hillsides.

The minerals come from the rocks, so to truly understand a place, one must know something of the rocks that contribute to the soil. See the section on abiotic factors (soil) in Chapter 4 (page 33).

Students should also understand how valleys are formed. Most valleys are formed by streams eroding away the rocks and soil over millions of years. Stream-formed valleys tend to be V-shaped. In the Sierra, however, many valleys were formed by glaciers moving slowly downhill. As they moved down the valleys, rocks became frozen into the glacial mass. The moving mass of ice and rock acted as a rasp, carving out the characteristic U-shaped valleys such as those seen in Yosemite.

Another important geological point is that minerals and rocks such as gold, limestone, marble and gravel are still being mined in California's mountains and forests, and that extraction of mineral resources has a huge impact on the environment.

CHAPTER 4
General Ecological Principles

What is Ecology?

Ecology is the study of an environment, the organisms that live in the environment, and their interactions. Some people use the term "ecology" to mean conservation or environmental protection. In *The Conifer Connection*, we will use the scientific meaning…the study of interactions and interconnectedness of organisms and their environment, including such factors as light, soil, water, and air.

Teaching Idea

When introducing the term "ecology," it might be useful to discuss the word roots of the term. "Eco-" comes from the Greek term for home, and "–ology" means "the study of." So, ecology is, literally, the study of our home. Looking at the earth as our home can be very helpful when discussing environmental concerns. Introducing the word roots can also be helpful when discussing other "ologies" such as biology, geology, zoology, etc. It is also good to encourage the proper and specific use of terms. People sometimes say they're "protecting the ecology." Do they really mean that they're protecting the study of the environment? Or do they mean that they're protecting the environment?

The physical (non-living) parts of the environment are called the **abiotic factors**. These include such things as temperature, light, humidity, soil nutrients, and substrate type. **Biotic factors** are those that result from living things and their interactions with each other. Some specific abiotic and biotic factors of coniferous forests will be discussed in this chapter.

Teaching Idea

An important part of ecological studies deals with how organisms meet their needs for energy, materials, water, etc. Have students list their own needs and how they are met. Discuss true "needs," which are few, as distinguished from "wants," which are usually many. Also discuss the prices that we pay, not just in terms of money, for satisfying our needs and wants.

Cycles and Interactions

There are many **cycles** in nature, and they are important to all organisms, including people. Described below are simplified versions of some of the important natural cycles and ways that organisms interact with their environment and with each other.

Unlike energy, matter (chemical substances…the "stuff" of which everything is made) remains in the environment in a "closed system." It is neither created nor destroyed except in very unusual (on Earth) circumstances. This **Law of Conservation of Matter** is a basic law of nature, and warrants discussion with the students. It gives us the basis for the need to recycle, explains why we can't just create new stuff from nothing, and explains why pollutants don't just "go away."

Figure 14. Puffball fungus. Other species are smooth.

One place where the Law of Conservation of Matter plays a role in the forest is in the **decomposition** of dead material. Bacteria, fungi, and other organisms “recycle” dead limbs, leaves, and organisms through the process of decomposition. Branches, tree tops, and other woody debris from logging are also used, decomposed, or burned. Burning simply changes the wood into smoke and ash, recycling the materials in another way.

Teaching Idea

One way to help students to remember the main organisms involved with decomposition is “F.B.I.”…fungi, bacteria, and invertebrates. (Some say that the “I” stands for insects, but other types of invertebrates are involved with decomposition in addition to insects.)

The Water Cycle

Energy from the sun causes water from the Earth’s surface to evaporate and enter the air as water vapor. As water vapor cools, it forms clouds. Further cooling results in precipitation as rain, snow, or hail.

Teaching Idea

Have students tell what happens when they exhale their warm, moist breath on a cold day, either into the air or onto a mirror or window. This condensed water is similar to a cloud or fog.

Depending on where precipitation falls, it may directly re-enter surface water systems such as lakes, streams, and oceans, or it may fall onto the ground. Surface water may flow downhill as runoff in a stream, soak into the ground (percolation or infiltration), or evaporate, starting the cycle again. A healthy forest has a rich soil with an abundance of organic material that absorbs and holds a lot of moisture.

See the activity “Water…Cycling” on page 318.

If water enters the ground, it may be absorbed by plants, join the underground water system (**aquifer**), or it may re-emerge as a spring.

Some of the water taken up by the roots is used in **photosynthesis** and some is expelled through pores (**stomata**) of the leaves by a process called **transpiration**.

Transpiration is water loss through the leaves of a plant, and it plays a very important role in the forest. Warm, dry air and wind increase water loss through transpiration.

Teaching Idea

When discussing transpiration, compare it to perspiration. Like perspiration, it affects the plant's temperature. It also helps move water and dissolved minerals upwards in the xylem.

See the activity "Transpiration" on page 315.

Students are often interested to find out that, during its existence on Earth, every bit of water that they drink has been used by thousands of other organisms. The water that they drink today, for example, may well have once been in a dinosaur's body. The same holds true for the other substances in our bodies.

The Oxygen/Carbon Dioxide Cycle, and Photosynthesis

Oxygen enters the air primarily through the process of photosynthesis. In photosynthesis, plants use **carbon dioxide** (CO_2) and water to produce complex molecules of sugars. In the process, oxygen is released into the environment as a byproduct. On land, this oxygen "waste product" enters the air. In aquatic environments it may be dissolved into the water as it is released by plants or it may be released as tiny bubbles.

Plants and other organisms use the sugars produced in photosynthesis as an energy source through the process of **respiration**. Respiration is a chemical process in which cells use oxygen and food such as sugars to release energy from the food, producing carbon dioxide and water in the process. (Students often confuse respiration, which is a <u>chemical</u> process, with breathing, which is the <u>physical</u> <u>act</u> of taking air in (inhaling) and exhaling waste from the lungs.)

Forests play a very important role in the production of the oxygen on which we all depend. When trees (or other plants) are replaced by buildings or pavement, less oxygen is produced. A vigorously growing forest produces a lot of oxygen. Not only does photosynthesis produce oxygen, but it also takes carbon dioxide out of the air. Carbon dioxide is a major **greenhouse gas** that is a significant factor in **global climate change** and the so-called **greenhouse effect**. Forests, therefore, not only replenish oxygen, but they also help remove carbon dioxide and sequester the carbon as wood.

See the activities "Global Warming" on page 267 and "Fantastic Photosynthesis" on page 284.

The Nitrogen Cycle

The element nitrogen makes up about 78% of the air that we breathe. Nitrogen is an important raw material for many chemicals that organisms need to live, including amino acids, which are building blocks for proteins, and nucleic acids, which form DNA. Most organisms, however, cannot use the nitrogen found in the air.

Some organisms, especially certain bacteria and some **lichens**, are able to use ("fix") atmospheric nitrogen to form simple compounds such as nitrates. One of the few trees having the ability to fix nitrogen is the red alder. Plants use the nitrates to form various more complex nitrogen-containing compounds. Animals, including people, rely on those plants and bacteria to store nitrogen in forms that they (we) can use.

Figure 15. Alder.

Nitrogen compounds form an important part of animals' waste products. They provide fertilizer that is used by plants both on land and in the water. Nitrogen is also important because it is a necessary component of proteins, which are such an essential group of chemicals that they are sometimes referred to as the building blocks of life.

When organisms die, the nitrogenous compounds, as well as the other chemicals found in their bodies, are returned to the environment through the process of decomposition. Decomposition is accomplished through the action of various fungi, bacteria, and invertebrates.

Teaching Idea

It is interesting to discuss what would happen if bacteria and fungi didn't decompose dead organisms. Students will quickly understand that un-decomposed bodies would accumulate. More importantly, perhaps, chemicals needed by living things would be tied up in the un-decomposed bodies, depriving living organisms of the nutrients that they need.

See the activity "Duff Dwellers" on page 212.

Energy

Most of the Earth's energy comes from the sun. Some of the sun's energy is reflected back into space by the atmosphere before it reaches the Earth. Other solar energy is absorbed by the atmosphere, oceans, and land, and is re-radiated into space as heat.

Of the energy that reaches the Earth's surface, some is reflected, some is absorbed as heat energy and then re-radiated, and some is used by plants in the process of photosynthesis. Most of the energy that is absorbed is radiated back out to space at night. The energy stored in chemicals by photosynthesis is returned to the environment when the organisms use the sugars produced by photosynthesis in the process of respiration, giving off heat to the environment in the process.

As a result of all of these processes, energy is said to “flow through” the environment, constantly coming to Earth and being re-radiated back out into space. This is called an **open system**, because energy enters and leaves. This is in contrast to matter, which is constantly recycled on earth through natural processes in a **closed system**. The vast majority of organisms on Earth depend on the sun for a constant supply of energy.

An important aspect of energy in an ecosystem is the temperature range produced by sunlight. Temperature and precipitation are major factors that determine where plants will grow.

Niches and Trophic Levels

Human communities have people who fill various roles, such as growing food, producing various products, cleaning up the waste, and providing a variety of other services. Natural communities also have a variety of organisms that fulfill a variety of roles. The roles or jobs of organisms are called their **niches**. A tree, for example provides food for some organisms. It also provides shade. Some animals, and even plants, live in and on trees. All such roles combine to describe an organism’s niche. One important part of an organism’s role is its **trophic level**, or its place in a **food chain**.

The basic group of organisms on which all others depend is the **producers**. It is the producers that use the process of photosynthesis to produce complex chemicals upon which life depends. The most obvious producers in the forest are the trees, but others, such as the ferns, mosses, and flowering plants, are also important.

Organisms that don’t photosynthesize, such as animals, are called **consumers** because they obtain their energy from the food that they eat or consume. Consumers can be further divided into several groups:

Herbivores mostly eat plant material. Examples include deer, squirrels, hummingbirds, and many insects.

Carnivores mostly feed on animals. Frogs, owls, bobcats and ticks are carnivores.

Omnivores eat both plants and animals. Bears and raccoons are examples. As a species, humans are also considered to be omnivores.

Scavengers (detritivores) feed on dead animals or plants. Examples include turkey vultures, crayfish, and California condors.

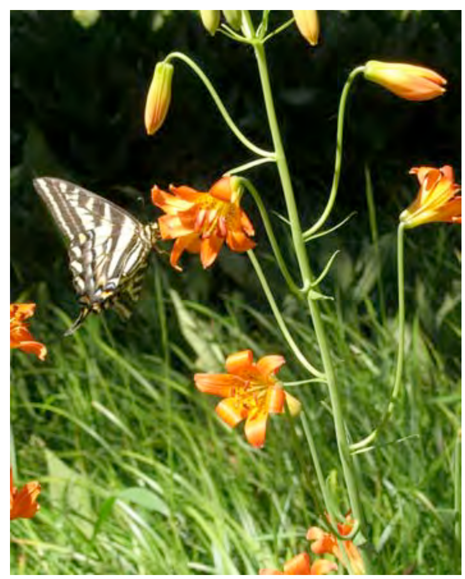


Figure 16. Swallow tail butterfly (consumer) feeding on nectar of *Lilium* (producer).

Another important group of consumers is the **decomposers**. These organisms, mostly fungi, bacteria, and invertebrates, consume dead organic matter and return the nutrients to the soil where the nutrients can then be used again by plants (producers).

It is important to remind students that all consumers, including people, depend on the plants (producers) that form the basis of the food chain.

Teaching Idea

Have students compare their human community to a natural community such as a forest. Compare the niches of organisms to the roles that people play in their community.

Food Chains and Food Webs

A **food chain** is a concept that ecologists find useful when studying ecosystems such as the coniferous forest. Basically, a food chain is intended to show which organisms feed on which other organisms. For example, an insect might feed on a fern in the forest. A frog might eat the insect, and the frog might be eaten by a garter snake. The garter snake might, in turn, be eaten by a hawk. When the hawk dies, its body would be consumed by bacteria and fungi as well as a variety of insects and worms. Each of these steps is considered to be a trophic level, or a step in a food chain.

Food chains are useful because they provide simplified illustrations of the relationships between various organisms. However, food chains are generally oversimplifications. The fern might have been fed upon by other types of insects, or deer, or other animals. The frog would eat a variety of insects, and the garter snake would eat other organisms, too. Although they are oversimplified, food chains can be useful in studying organisms.

A more realistic, but more complex, concept is that of the **food web**. A food web shows that most organisms eat, and are eaten by, a variety of organisms.

When people discuss or teach about food chains and food webs, they often don't emphasize the critical role of the decomposers. Without the decomposers, the raw materials needed by the producers would soon be locked up, or sequestered, in the bodies of dead organisms.

While not technically part of food chains and food webs, the physical parts of the environment, such as water, sunlight, and minerals, are also important in food chains and food webs.

The next page shows examples a food chain and a food web such as might be found in a coniferous forest.

Teaching Idea

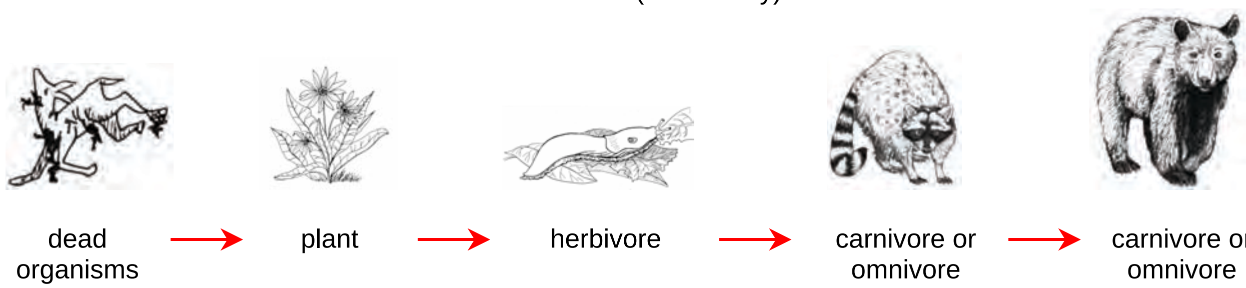
Use a transparency of the Food Chain/Food Web diagram (on page 24) when teaching about those concepts.

See the activities "We're All in This Together," page 194 and "Who's for Dinner?," page 199.

Figure 17

A Forest Food Chain

An arrow indicates an organism is eaten by another.
For example, grass → deer
(is eaten by)

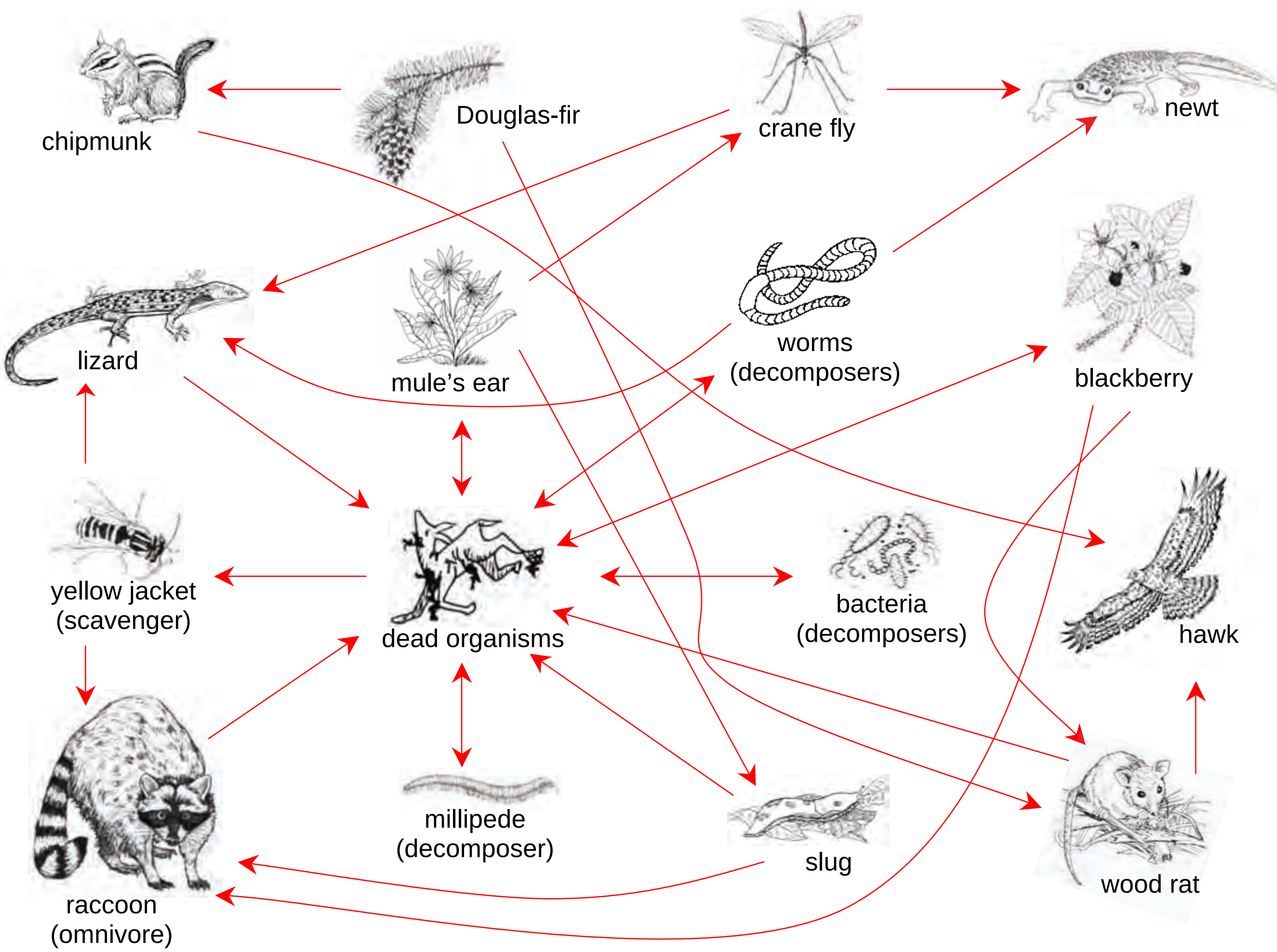


Products of decomposition provide nutrients used by plants.

Figure 18.

A Simplified Forest Food Web

Remember that the organisms depend on light (energy) from the sun, minerals and water. In this simplified food web, not all organisms or connections are drawn. Nutrients released by decomposers are used by plants



Populations

In the science of ecology, a group of individual organisms of the same species living in a defined area is considered to be a **population**. When an ecologist discusses a population, he or she will identify both the organism and the place. One might study the population of banana slugs on a fallen log, deer in and around a meadow, or Douglas-firs in a watershed.

The number of individuals in a population is limited by one or more factors in the environment. Depending on the organism, the factor might be available soil nutrients, water, sunlight, food, temperature, predators, or any of a number of other factors. Whatever limits a population is called the **limiting factor**. Thus, sunlight reaching the forest floor might be the limiting factor for low-growing plants, while moisture available in the summer might be a limiting factor for high altitude trees.

The number of a type of organism that can thrive in a habitat is determined by one or more limiting factors. **Carrying capacity** refers to how many of a particular organism can live in a place over a long period of time without causing damage to the environment. One could place several deer in a small meadow, but they may not do well if there are too many, *i.e.,* if the number exceeds the carrying capacity of the meadow. The carrying capacity for deer in a meadow is much lower than the same meadow's carrying capacity for mice or grasshoppers. If there are too many of an organism for the environment to sustain, the organisms are said to have exceeded the carrying capacity of that place.

Many students have heard of **overpopulation**. To an ecologist, overpopulation means exceeding the carrying capacity of a place, or exceeding the number of individuals that a place can support without harm to the environment. With regards to human population, one must consider not only how many people a place (a house, a town, a state, a continent, or the Earth) can support, but also the quality of life for the people (or other organisms). Of course, the Earth can support many more people living at a subsistence level than it can support at the level of resource use that we have in the United States. Even within the United States, some people use many more resources than others. It might be useful to discuss the quality of life vs. quantity, and whether we should be willing to consume less so that others can have enough to survive.

A discussion of carrying capacity can help students understand the importance of trying to minimize their negative impact on natural environments. It can also help them to understand that they can have positive impacts.

Teaching Idea

Discuss "wants" vs. "needs." Many things that most of us consider almost necessities (cell phones, cars, televisions, soda pop, meat, etc.) would be considered luxuries by much of the world's population. Discuss the idea of "living simply so that others may simply live."

The Pyramid of Numbers or Pyramid of Biomass

As one goes "up" a food chain, there is a decrease in both numbers and the total mass of the organisms (biomass). This is because organisms are not 100% efficient in converting food to body mass. Some of the food is converted to body mass, but much is lost as waste. A single grasshopper, mouse, deer, bear, or human will eat many times its weight in its lifetime.

In reality, most of the food that we eat is not added to our bodies, even though it may seem like it as we approach middle age! Most of the food that we take in is expelled from our bodies as solid waste (feces), liquid waste (urine and perspiration), or gaseous waste (CO_2 and water vapor in our breath). While the efficiency of conversion varies among organisms, an often-used approximation is 10%. Using that estimate, we can create a hypothetical **pyramid of numbers** or biomass like the one below.

An important consequence of this inefficiency is that the more steps there are in a food chain, the fewer top consumers (such as people) can exist in an area. A given amount of land can support more people if they eat plants such as corn, wheat, or rice than if the same amount of land is used to raise cattle for people to eat. Basically, the Earth can support more vegetarians than carnivores. For example, a field can support more mice or grasshoppers than lizards or foxes.

See the activity "The Higher the Fewer" page 182.

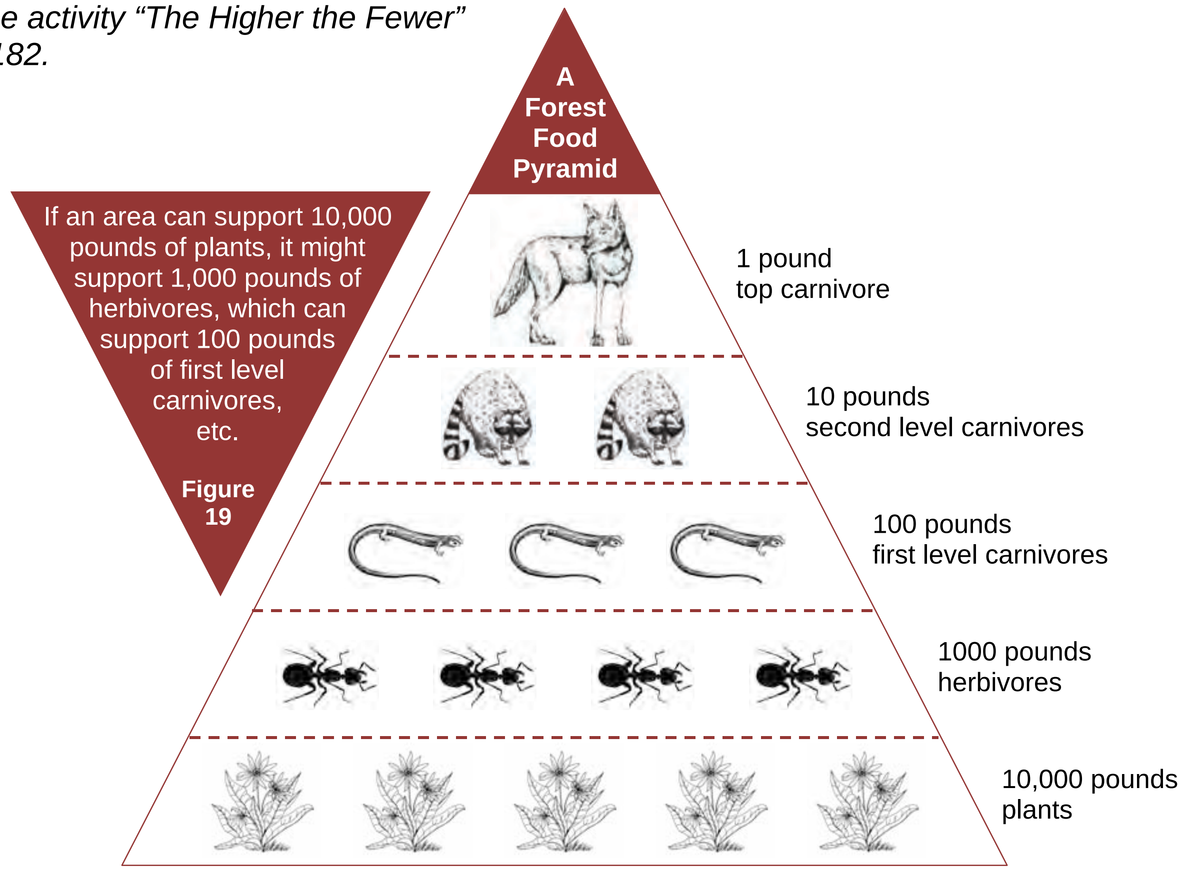


Figure 19

The food pyramid is based on abiotic factors such as soil nutrients, water, and sunlight. Decomposers return nutrients from dead organisms to the soil.

Habitat, Community, and Ecosystem

A **habitat** is a place where an organism lives. A **stand** of forest trees is a habitat, as is a clearing in the forest or a decomposing log. The forest is not a homogeneous environment. There are various **microhabitats** such as the shaded forest floor, rotting logs, streamside (**riparian**), sunny openings, dead trees (**snags)**, and others. Even a tree itself has microhabitats ranging from the bark at the base of the tree to the crotches of branches, to the top of the tree in the forest **canopy**. Each microhabitat will have its own set of organisms filling the various niches.

See the activity "Microhabitats" on page 298.

The forest itself can be viewed as having different vertical layers. The soil and the organisms that live in it provide the foundation on which the forest grows. On top of the soil is the **humus**, where leaves and other organic materials are decomposing. The top part of the humus is the **duff**, consisting of recently fallen leaves and twigs that have begun to decompose but are still recognizable as leaves. On top of the duff is the still more recently fallen **litter**.

Plants that live on other plants are called **epiphytes**. Sometimes large amounts of decaying leaf litter, wind-blown soil and other material can accumulate in level or hollowed-out areas high in the forest canopy. In areas where the canopy is dense, entire communities, including trees growing on trees, can exist far off the ground.

Beneath the litter, duff, and humus is, of course, the soil. The nature of the soil is an important factor for all plants.

Growing near the ground are the ground cover plants. Shrubs are larger plants. Small trees form the **understory**. The canopy consists of the top branches of the taller trees.

Forests can also be subdivided horizontally or laterally. Some organisms do best in the interior core of the forest, while others need to be near forest openings.

While some organisms are found throughout the forest, many live in specific layers or areas.

The edge of the forest, between forest and grassland, or between conifer forest and **hardwood** forest, provides a greater diversity of microhabitats and, therefore, has a greater diversity of organisms. The same is true for the edge of a stream, lake, or rocky outcropping. The area where two habitat or community types meet is called an **ecotone**, and it is an important area for organisms from both habitats. Organisms from both communities can be found in the ecotone.

In an old-growth forest, there are normally gaps in the canopy due to **treefall**. Treefall can be caused by many things such as wind, a landslide above a tree, slumping of soil down slope, root rot, or erosion of the bank of a stream. These gaps provide microhabitats that allow a greater diversity of both plants and animals than one would find in an even-aged forest. Similarly, streams provide habitat for the aquatic and riparian organisms as well as access for sunlight into the nearby forest. If timber lands are managed to maintain a diversity of microhabitats, they can maintain much of the species diversity found in a natural forest.

Some plants are **parasitic**. Mistletoe has chlorophyll and photosynthesizes, but it also obtains water and dissolved nutrients from the trees on which it grows, so it is called a "**hemiparasite**," meaning half-parasite.

Figures 20 (left) and 21 (right). Green mistletoe on black oak.

A less well known form of mistletoe is dwarf mistletoe, which is yellow-brown in color and is a true parasite. Infested branches often develop characteristic masses of bent branches called witch's brooms.

Mistletoe seeds are sticky and are spread by birds and other animals or by simply being passed from tree to tree when the berry bursts open. Mistletoe can kill its host trees, and large areas of forest may be infected, so sometimes infected trees are burned to keep it from doing too much damage in a forest.

Figure 22. "Witch's brooms" in gray pine, caused by dwarf mistletoe.

Figure 23. Dwarf mistletoe on Jeffrey pine.

See the activities "Creek Studies," page 207 "Duff Dwellers," page 212 and "Micro-hiking" page 233.

Each type of habitat is defined by a set of **abiotic** (non-living) and **biotic** (living) factors.

All of the organisms that live together in a habitat can be referred to as a **community**. A community is a group of interacting populations in a given geographic area. Just as our human communities have people that do different jobs, natural communities include organisms that make their living in different ways and depend on each other. A coniferous forest community would include the conifers and the various other plants, animals, fungi, lichens, and bacteria that live with them. Each member of the community has a particular role or niche. Any natural community will have a diversity of organisms, *i.e.,* it will have **biodiversity**. A community with the organisms that naturally occur there is said to have **biological integrity**, *i.e.,* it is a "natural" community.

When we combine the community of organisms with the habitat in which they live, we have an **ecosystem**. Within the ecosystem, the organisms interact with each other and with their physical environment. A community can be large, like a forest covering hundreds of acres and including many watersheds, or smaller, like a particular stand of trees on a hillside or on an alluvial flat along a river, or even very small, such as the community of organisms living in and on a fallen log, or in the upper branches of a tree.

Another thing to consider regarding forest communities is the spatial arrangement. One factor is the size of the "patch" of habitat. Some species will do fine if they have some logs under which to live. Others require large areas. Ten one-acre patches may not support any of a particular species of bird, while one ten-acre stand may support many birds of that species. **Fragmentation** of habitat is an important concern as forest land is logged or developed for other uses such as houses, shopping centers, and roads.

Communities are not static; they continually change over time. The sequence of change from one community to another is sometimes called **succession**. The idea of succession involves a series of progressive changes in the species structure of the community. Many textbooks describe succession as a gradual and continuous replacement of one group of plants and animals with another. It is, however, rarely as simple and linear as that. Changes in the physical environment tend to favor different species, so different species dominate at different times. Species from previous or later successional stages will usually be present at several stages.

See activity "The Only Constant is Change: Succession in Action" on page 235.

Succession on newly formed land (primary succession), such as a lava flow or bare rock, might proceed through stages like this: bare rock…lichens on the rock breaking it down and trapping nutrients…mosses or small grasses growing among the lichens…small **herbaceous** plants growing in the accumulating soil…small grasses…bushes and shrubs…shade intolerant trees…shade tolerant trees…forest.

Figure 24. Lichens and moss on a rock.

An example of succession occurs as a lake fills with sediments and becomes a shallow pond and then a marshy area. As sediments continue to accumulate, the marsh may become a grassy field. Bushes and shrubs may invade the field, eventually being replaced by forest trees.

In the forest, anything that creates bare soil can start a new successional process. Bare soil is commonly produced by landslides, falling trees, silt from floods, fires, clearing of land for homes or roads, or logging. The first plants that grow on the bare soil are called the **pioneer species**, and in the coniferous forest may include many species, including grasses, blackberries, poison oak, coyote brush, or others, including **exotic** (non-native) species.

Figure 25. As open water is filled in by soil and debris, a series of different plant types eventually transforms the lake to a meadow.

The series of communities in a successional sequence is called a **sere**, and each of the temporary communities is called a seral stage. Eventually, succession may slow down and a more or less steady state may be achieved. The “final” community is stable, tolerant of the environmental conditions that it imposes upon itself. This “final” stage has been called the **climax community**, but it is rarely, if ever, truly a final stage. While the late stages of succession are relatively stable and may last for a long time (hundreds or even thousands of years), they are not permanent. Nutrients may be tied up in vegetation, or fire, flood, landslide, or other event may set succession back. A more modern concept is that of a community reaching a state of dynamic equilibrium in which individual plants and animals are constantly dying and being replaced, resulting in a constantly changing community.

In some areas, old-growth forests of even-aged trees suggest that natural phenomena such as fires and landslides cleared swaths of the natural forest much like **clear-cut** logging does. Clear-cutting has been compared to natural processes such as fires, landslides, and treefall. In California, clear cuts are limited to 40 acres or less; landslides and treefall cause disturbance in a much smaller area, but fires often affect much larger areas.

Teaching Idea

Have students compare and contrast clear-cutting with fire with regards to their effect on the forest. How are they similar and how are they different? What happens to the materials in the tree when it is cut? When it is burned? What is the impact on other plants and animals? On the water and soil? On the air? How long does it take the forest to recover?

People

The role of people in the conifer forest is discussed in Section II, with emphasis on the timber industry. Conservation and environmental concerns are discussed in Chapter 6 of this section (page 46), and in Section II (page 132).

As California's population increases, more people want to build homes in the forests, either for permanent living or as vacation homes. In those areas, an important threat to the forests is from fragmentation of the forest as people purchase small parcels on which to build homes. Of course, to build homes, people cut trees for the building site, for roads, and to open up the area so that they can have sun for their swimming pool, deck, and lawn. This fragmentation has a great impact on wildlife.

While Section II deals with the human history of California's coniferous forests, it might be useful to discuss here some terminology as it relates to the ongoing concern about environmental issues in the forests.

Some of the terminology used to describe caring for the environment can be confusing. What is the difference between conservation, preservation, management, and stewardship of the land? In *The Conifer Connection*, we will use the terms as follows with regards to the forests:

Preservation: Managing the land so that it remains, as much as possible, in a more or less natural state as it was before Europeans came to California. (It should be noted that keeping fire and flood out of forests will not preserve the forests in a natural state, as both fire and flood are natural in various forests. How to maintain a forest in its current condition—or the condition that a park was in when the park was created—is an important issue.)

Conservation: The wise use of resources so that they provide the most good for the most people. Sometimes preservation might be the best use; sometimes harvesting of lumber might be the best use. (The dictionary definition of conservation is to "preserve from loss, waste, etc.; preservation." The definition used in *The Conifer Connection* is more commonly used in resource management fields such as forestry.)

Stewardship: Caring for the land or environment, protecting it from damage. (The University of California's Division of Agriculture and Natural Resources (ANR) has produced a "Forest Stewardship Series" of publications for forest landowners to help them with managing their lands. It covers many aspects of forest land management, and is useful for teachers who want to learn about forests and forest management. It is ANR publication number 8323. Go to http://andcatalog.ucdavis.edu).

Management: Making choices as to what happens to the forest, with specific goals in mind. A forest might be managed for recreational use, as an example of a pre-European old-growth forest, for research, or as a lumber-producing resource. A stand of trees might be managed to produce the maximum amount of timber in the short term, or to continue to produce timber over a long period of time, or to provide wildlife habitat. Management implies steps taken towards a goal, and usually includes aspects of preservation, conservation, and stewardship. Preservation, conservation, and stewardship are all forms of management.

Environmentalism: Environmentalism is another term that means different things to different people. What is an "environmentalist?" The foresters and scientists of the forest products industry would consider themselves to be environmentalists, as their job is to manage the forest lands so that they can grow more trees while complying with forest practice regulations.

Preservationists would consider themselves environmentalists because they are trying to preserve and protect the forest environment from human impact. Some use the term "environmentalist" in a negative manner, referring to those who have interfered with business interests or who have taken actions that threaten their livelihoods. In *The Conifer Connection*, I will use the term **environmentalism** to refer to concern for the environment and to environmentalists as those who share that concern.

Teaching Ideas

Have the students first discuss the meanings of the terms conservation, preservation, stewardship, and management. Then have them look up the dictionary definitions. Have them try to agree on definitions that will show the differences. Discuss word roots.

See the activity "Connie's Woods: Tough Choices" on page 262.

A few words about **old-growth** and related terms:

Terminology can be important and confusing, as is the case with the term "old-growth." To some, old-growth trees are those in an area that has never been logged. To others, the term implies a certain type of forest ecosystem; while others use the term to describe trees of a certain size or age. To many, old-growth forests are revered as places for spiritual renewal, while others see them as a potential but unavailable source of increasingly valuable lumber. One must also consider the difference between a stand of old-growth trees and an old-growth forest, which includes trees of varying species and ages.

Would a group of trees in an area where Native Americans felled trees using fire be considered old-growth? What about trees that are 180 years old or older, but growing in an area that was logged in 1830? And what about trees in a forest that has never been logged, but are only 10 years old and growing in an opening created by a fallen forest giant, fire, undercutting, flood or other causes? Are they old-growth?

In this guide, the term "old-growth" will refer to stands of trees that:

a. have not been logged, other than the occasional tree felled by Native Americans… relatively undisturbed by humans
b. include diverse ages, spacing, and sizes of trees, with a multi-level canopy… structurally complex
c. have large (for the site) and/or old (for the species) trees
d. have most of the understory consisting of shade-tolerant species
e. have downed logs on the floor and some **snags**, or standing dead trees

While some animal species can do fine in even-aged forests, the downed logs, snags, and canopies of old-growth communities provide habitats for many species that do not thrive in even-aged forests. Some timber companies intentionally leave snags and other woody debris to provide old-growth-like habitats; in fact, timber management plans may require that snags and other "wildlife trees" be left during logging operations.

In *The Conifer Connection*, **second-growth** refers to trees growing in an area where the old-growth forest has been logged once, and **third-growth** refers to trees growing where second growth forests have been logged. The term **young-growth** refers to any trees growing after the first cutting.

An excellent discussion of "old-growth forests" can be found in a "Science Update" brochure titled *New Findings About Old-Growth Forests*, available from the USFS Pacific Northwest Research Station (Rapp, 2003).

Ecological Factors

Factors that affect an ecological community are often divided into two categories—physical or abiotic, and biological or biotic factors. These divisions are not mutually exclusive, because the physical factors affect the biological and *vice-versa*.

Physical (Abiotic) Factors

<u>Moisture</u> is an important abiotic factor for all plants. While many conifers grow where there is abundant water, for some it is a limiting factor. Students may be surprised to learn that trees living in areas that experience a lot of winter snow actually have to deal with a shortage of water. While the water is frozen as snow, it is unavailable for plants to use. In addition, many mountain forests have soil that is so shallow that it is unable to absorb and hold much water for use during the spring and summer growing seasons.

Moisture and temperature often determine what types of plants (and, therefore, animals) can live in a place. Sometimes moisture determines not only the type of plants, but also how they grow. For example, ponderosa pine will grow in dense stands where there is adequate moisture. Where there is less moisture, they tend to grow in open stands with grass or low brush between the widely spaced trees, and where there is even less moisture, single trees may grow scattered on open range lands (McEvoy, 2004).

<u>Temperature</u> is an important factor, largely because of its impact on water. As noted above, frozen water is of little use to plants. Warm temperatures increase rates of evaporation and transpiration. Warm temperatures also increase the risk of fires.

<u>Light</u> is important, of course, for photosynthesis. Different plants have different tolerances for shade. Light (or lack of light) may be a limiting factor for a species' survival. It is also important because of its effect on growth rates. A tree growing in an open, well-lit area of the forest may grow ten or more times as fast as a tree struggling to grow in the shade of a dense forest canopy.

Anything that opens up the forest canopy can prompt a growth spurt. A large tree falling may provide a forest opening, as might a landslide, strong wind, or even a chainsaw. A study of tree rings can show when the tree's growth was **released**, resulting in more widely spaced rings. The added light also allows trees of less shade-tolerant species to grow. When a tree falls, it may move down slope, clearing a swath of vegetation and bringing debris to lower ground or creeks.

When a forest canopy closes in, more shade results in slower growth or **suppression**. In order to grow in the reduced light of a dense forest, plants must be shade-tolerant.

See the activities "Fence Post Studies" page 286 and "The Great Tree Cookie Mystery" page 176.

As a tree grows taller, the lower branches receive less light. Eventually, the lower branches die and break off, a process called **natural pruning**. One consequence of natural pruning is the absence of knots in wood formed after the branch falls. Knots are formed where limbs grow from trees and are surrounded by subsequent growth. Lumber without knots is called "clear," and it is much more valuable than wood with knots. Older trees generally have much more clear wood than do young-growth trees.

Natural pruning helps the tree survive fires because lower limbs are removed, preventing frequent naturally occurring low-intensity fires from reaching the branches in the canopy.

The tops of most plants tend to grow towards the light. This growth towards something is called a positive **tropism**, so most tree branches and tops tend to have a strong positive **phototropism**, or grow towards light. Sometimes trees growing in shady areas bend towards an open space such as a creek or other clearing. The roots of most plants have a strong positive **geotropism;** they grow downward. (Negative tropisms would, of course, be growing away from something.)

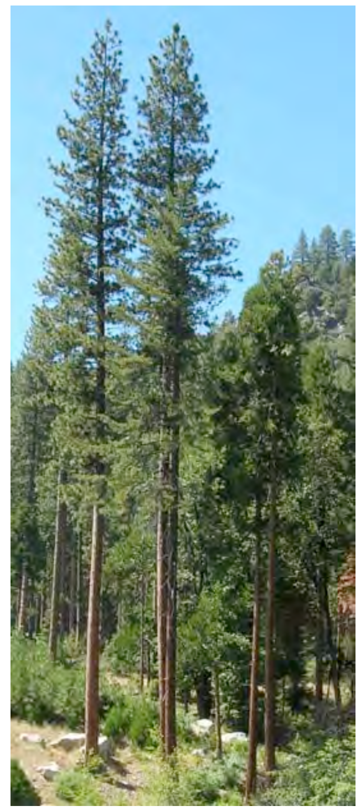


Figure 26. Natural pruning.

Wind is a factor in forest ecology for a variety of reasons. Some species of conifer such as the coast redwoods and giant Sequoia have shallow root systems for trees their size, but the roots are long and may even intertwine, providing additional support. When trees live in dense forest situations, the trees tend to shelter each other from strong winter winds. If some trees are removed by logging, landslide, or other means, the remaining trees may be susceptible to being knocked down by subsequent winds. This **windthrow** or **blowdown** can have a snowball effect as more trees are exposed to the winds.

Wind also increases evaporation and transpiration. It also aids in seed and pollen dispersal for many trees, including many conifers.

Soil is an extremely important abiotic factor in any terrestrial community. Soil provides mineral nutrients, holds moisture, and anchors the plants.

Water and light are important in determining what types of ecological communities occur in a place; soil is the main factor that determines a forest's productivity (McEvoy, 2004).

Soil texture is important because it can facilitate or hinder absorption and retention of moisture. Many conifers do well in a wide range of soil types, but do best where the soil is continuously moist and well aerated.

Soil chemistry can be very important. Without proper nutrients, tree growth will be stunted. An example of this is the "Pygmy Forest" of Mendocino cypresses, pines, rhododendrons, and other plants in Mendocino County. Soils in the Mendocino White Plains are very acidic, with a pH as low as 2.8. Mature trees may be less than 5' tall. Seeds from those trees grow to normal size when planted in normal soils, indicating that the stunting is due to the soil itself (Lanner, 1999).

Figure 27. 100 year-old Mendocino cypress trees (*Cupressus goveniana*) and lodgepole pines in the "pygmy forest" may be less than five ft. (1.5 m) tall.

Figure 28. Mendocino cypress trees in fertile soil may reach heights of over 100 feet (30 m). Note the person with light colored jacket near the base of the trees.

Soil structure is also important. Sandy or gravelly soil does not hold water well, and soil such as clay doesn't let water and air pass between the particles. Plants generally grow best in loamy soils with a variety of medium-sized soil particles and organic materials. This can be seen at the "Chaos Jumbles" area of Lassen National Park. In about 1650, the side of a mountain broke off, forming a huge rock avalanche. The larger particles settled out first. Trees growing in areas with large particles are a fraction of the size of trees of the same age and species growing in nearby areas where the particles are smaller. (See Figures 29 and 30 on page 36.)

Figures 29 (left) and 30 (right). The trees in these two pictures are of about the same age. The photo at the left is taken about a quarter of a mile from the photo on the right, which is in the Chaos Jumbles area of Lassen National Park.

For some species of conifer, successful reproduction by seeds depends on soil disturbance. On an undisturbed forest floor, the layer of needles and leaves may be too thick for the tiny seed to produce a root that can reach the soil, and the air spaces between the needles on the floor allow the developing young root to dry out. In nature, landslides, treefall, flooding, and fire expose the soil. Logging, with its concomitant soil disruption, can actually enhance the sprouting of some types of seedlings.

Sometimes a portion of a hillside slides or "slumps" downhill, resulting in a relatively flat-topped area where the slumping soil stops. This disturbed area, sometimes called a **slump-jumble** often provides a place where seedlings can gain a start, along with other colonizing early-successional plants.

When a tree falls, of course, the roots pull some of the soil with them, thus creating what is called a **root-pull pit**. This pit provides exposed soil for pioneer species or seedlings, as does the clump of soil attached to the root.

Flooding can be a major environmental factor, especially in the rainy north coast region. Redwoods often live on the alluvial flats, and they are more resistant to flood damage than other species such as Douglas-fir, alder, tanoak and others. Redwoods surviving a flood may eventually die, however, if the roots are unable to obtain oxygen because they are buried too deeply in sediments. However, many redwoods have the ability to send up new shoots through the newly deposited sediments, further enhancing their ability to survive flooding.

Fire is a very important factor in any forest. Some species, such as the coast redwood, are relatively resistant to damage by fire, while many of the plants competing with them are more susceptible to fire damage. The redwood's thick, fire resistant bark protects the living inner parts, and the wood has little resin. Thus, fire-adapted species such as the coast redwood may actually depend on fire to reduce competition from more shade-tolerant species. (Fire is discussed more beginning on page 42.)

See the activities "Anatomy of a Giant," page 167, "Fence Post Studies," page 286 and "The Great Tree Cookie Mystery," page 176.

Biological (Biotic) Factors

Reproduction in most species of conifers results from the germination of fertilized seeds. Unique among conifers, coast redwoods also frequently reproduce by sprouting from stumps or even from fallen branches.

Figure 31. Male ponderosa pine "cones."

Figure 32. Female lodgepole pine cone.

Conifers have both male and female cones on the same tree. Pollen is produced by a "male cone," which looks more like a tuft or brush than the familiar woody "female" cone. The fertilized seed grows in the female cone.

The male cone releases huge amounts of pollen which is carried by the wind to the female cone.

Most conifers produce seeds that have wings on them. The wings slow the seed's fall to the ground, helping to disperse the seeds so that they aren't competing with the parent tree for light, water, and soil nutrients.

If the seeds fall on accumulated forest leaf litter or duff, they may dry out and die or become infected by **damping-off fungus** before they can extend their roots to the soil. Seeds are also fed on by slugs, birds, rodents, rabbits, and nematodes (roundworms).

Seeds that fall on mineral soil, however, have a much better chance of germinating and surviving. Soil exposed by wildfire or deposited by flooding is often covered by forests of miniature trees. The soil exposed by a fallen tree's roots, a small landslide, or logging operations can provide a seed bed that also has ample sunlight.

As the tree grows, it reaches for the sunlight. Once it reaches the height of the forest canopy, the tree slows its vertical growth and adds more wood to its trunk or bole. Thus, a 200-year-old tree may be 250' tall with a diameter of 5', while a 400-year-old tree may be 275' with a diameter of only 7'. Timber companies seek an optimal growth rate and harvest cycle that produces the most wood in the shortest time.

Teaching Ideas

Discuss the large number of seeds produced by a single cone or tree each year, and have the students think about and discuss how many seeds would be produced by a tree in its lifetime. (Seed production is not constant throughout a tree's life, but it is easy to see that a tree producing several million seeds per year may produce a billion or more seeds in a lifetime of several hundred years.) For the species to survive in its current numbers, each tree only needs to successfully produce one other tree that reaches maturity.

Discuss the idea that some seeds may produce seedlings or young trees that are more likely to survive. Help the students come up with some characteristics or ***adaptations*** *that may give some seedlings an advantage in the struggle for survival. These might include faster growing roots or stems, chemicals that make them more resistant to fungus or distasteful to animals, or better resistance to drying out.*

Many students have heard of ***cloning****, which is sometimes used to produce trees with desired characteristics. Discuss its advantages and disadvantages.*

Discuss with the students what characteristics timber companies might desire. Examples include fast growth, straight trunks, horizontal branches (resulting in smaller knots), resistance to disease or insects, the ability to withstand drought, or others.

Have the students discuss the dangers of having a "crop" of trees all with the same characteristics, i.e., a ***monoculture****. (All of the trees—or wheat or cotton—will have the same good characteristics, but they will also all have the same "bad" characteristics; they will all be susceptible to the same diseases, environmental changes, etc.)*

Discuss how nature deals with this issue…mixing of genes through sexual reproduction, natural selection, and "survival of the fittest."

Then discuss how timber managers might deal with the problems of monoculture… leaving seed trees, stump sprouting producing a portion of the trees, planting a variety of ***clones****, or using* ***selective*** *harvesting.*

<u>Tree growth and form</u> are important to a tree's survival. Much of a conifer's shape comes from adaptations that enable it to compete for light needed for photosynthesis. Rapid growth in height may enable a tree to out-compete others when a clearing becomes available. Once a canopy forms, other trees may not do well in the shady understory, so competition for water and minerals is reduced.

As the tree grows taller and the canopy shades the base of the tree, the lower branches lose their usefulness and die. Loss of lower branches also helps protect the tree from fire, as frequent naturally occurring fires generally wouldn't reach branches that are 20' or more off the ground, and thick bark helps protect the base of the tree. Now that fires are suppressed in most areas, small trees, brush, and dead wood often accumulate on the forest floor, providing a "fire ladder" that carries fire up into the upper parts of the tree, making fires worse than they would be if allowed to clear out the forest floor fuel load every few years. Depending on the location, such fires may have occurred as frequently as every 7–10 years or so. (See pages 42–45 and 153.)

Wood growth below the level of the branches will be free of knots, which are caused by the growth of wood around a branch. This "clear" wood produces very valuable lumber, but the young-growth trees that provide most of the lumber today produce relatively little clear wood. Conversely, the huge trees cut in the early days of logging had a lot of clear wood, so much so that the tops of the trees, which contained branches and therefore knots, were often left in the woods.

Roots: Most plants have very fine **root hairs** that greatly increase the surface area of the root system and facilitate the absorption of water and minerals.

The coast redwood and some other conifers lack root hairs. Rather, they have a variety of strand-like fungi that grow on the roots and actually extend into the root cells. These fungi absorb water and nutrients and pass them on to the root cells. In turn, the fungi receive nutrients from the tree. This **mutualistic** association is called **mycorrhizae**.

Teaching Idea

The Save-the-Redwoods League has published a very interesting booklet titled Story Told by a Fallen Redwood, by Emanuel Fritz (1995). If possible, obtain copies of this booklet for students to study, and if you are in the Richardson Grove area in Mendocino County, visit the actual log about which the booklet is written.

Animal associations with the forest trees are important. Trees provide shelter and food, moderate the forest climate, affect water retention in the soil, and affect what other plants will grow in the forest.

Animals also affect the forest trees. Some species feed on the seeds, but in the process, they also help disburse the seeds. Wood rats, mice, deer, and elk feed on young seedlings and shoots. Elk and deer feeding on terminal shoots of young trees can suppress trees' growth or even kill them. Various animals, such as wood rats, squirrels, porcupines, and black bears, feed on the cambium layer beneath the bark. Black bears sometimes cause significant damage to seedlings planted in logged areas as they strip the bark and feed on the cambium layer, especially in the early spring when the sap is flowing. Bears seem to prefer saplings ranging from 6–12" in diameter, so they are of particular concern to timber companies. A tree can be killed if a foraging bear or porcupine eats so much of the vascular tissue that the tree cannot transport materials to and from the leaves, a process called **girdling** if it encircles the tree.

Insects are of particular importance. Sap produced by conifers provides some protection from insect attacks, and healthy trees generally survive mild insect infestations. Trees weakened by climate change, drought, or fire may not be able to fend off the insects, and the insects can sometimes do significant damage to a tree or a whole stand of trees.

Some theorize that climate change may be enabling more insects to survive the winter, thus increasing their damage to forests. In Wyoming, for example, historically about 80% of the mountain bark beetle larvae die over the winter. Wyoming's winters have been milder since 1994, and now less than 10% of the larvae die. In Alaska, spruce bark beetles have even been able to breed an extra generation in some years (Epstein and Tabor, 2003).

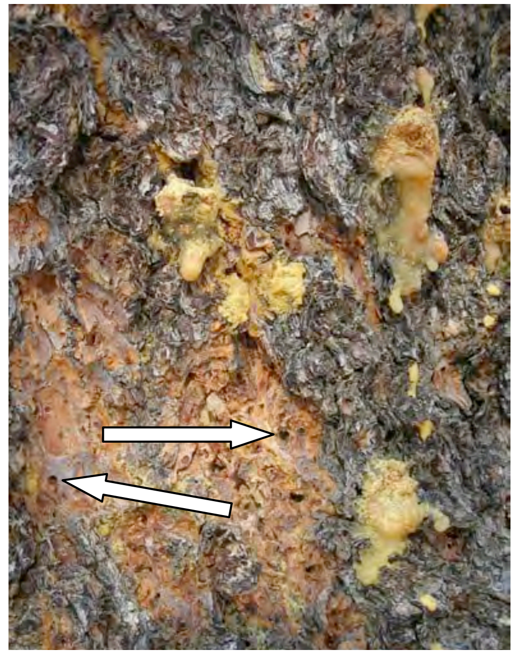


Figure 33.
Lodgepole pine that has been attacked by bark beetles. Note exit holes and sap.

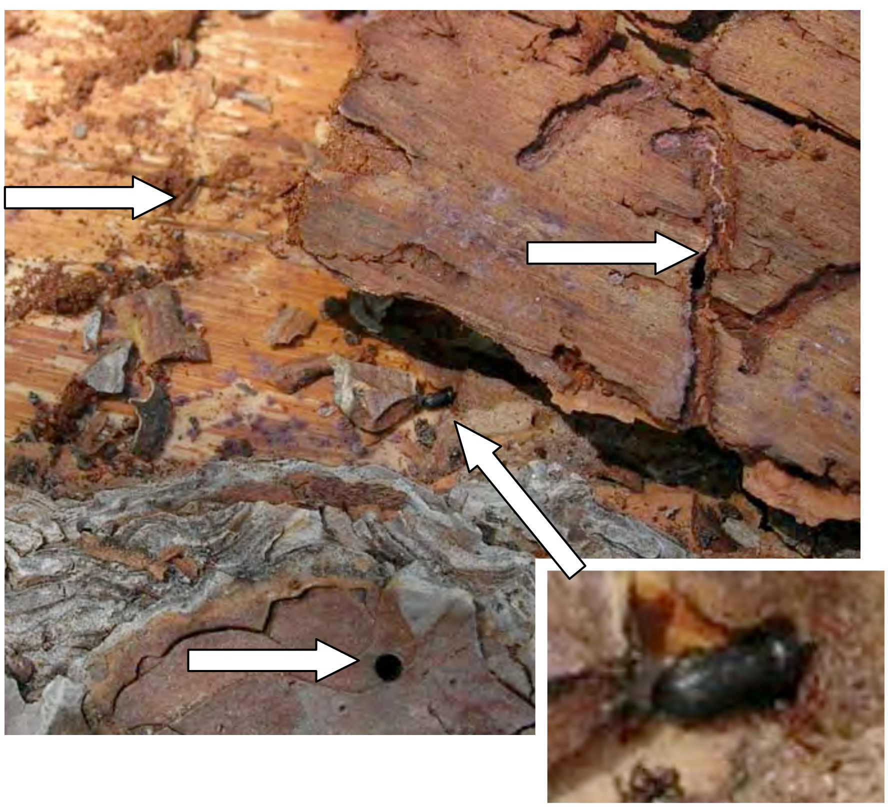


Figure 34. Evidence of bark beetles in a pine log. The bark at the bottom of the picture is in place on the log. Holes in the bark show where adult beetles exited.

In the upper right is a piece of bark that has been turned over, showing the tunnels made by the larvae as they fed on the inner bark.

Evidence is also apparent on the wood that was under the bark, shown in the upper left. As the beetles feed on the inner bark, they cut off the nutrient supply for the tree, eventually killing it.

A dead beetle is in the center of the picture (and inset).

CHAPTER 5
The Ecology of Coniferous Forests

Conifers are well adapted to the rigors of life in the mountains. They evolved in northern latitudes where water is scarce much of the year because it is frozen in the snow pack. Conifers' needle-like leaves help reduce water loss through their leaves (transpiration).

Climate, especially temperature and precipitation, is extremely important in determining what types of plants (and, therefore, animals) can live in a place. Often, the lowest temperature and minimum amount of precipitation are the limiting factors. As one goes up a mountain, temperatures and precipitation typically decline, especially above 6000 feed elevation. (While a snow pack may be deep, frozen water is unavailable to the plants, and spring runoff may quickly carry most of the water away.) Temperatures also tend to decline as one travels northward. As a result, plants found at an elevation of 5000' in the central Sierra Nevada may be found at an elevation of 4000' a few hundred miles north.

As one travels from low areas such as California's central valley to the high elevations in the mountains, they pass through a series of plant/animal communities. These communities are sometimes called **wildlife regions** or **life zones**. Such zones have much overlap, and seldom consist of a single species of tree. As one travels northward, mountain life zones tend to be found at lower elevations.

Life zones can be thought of as bands or **plant belts** on the sides of mountain ranges.

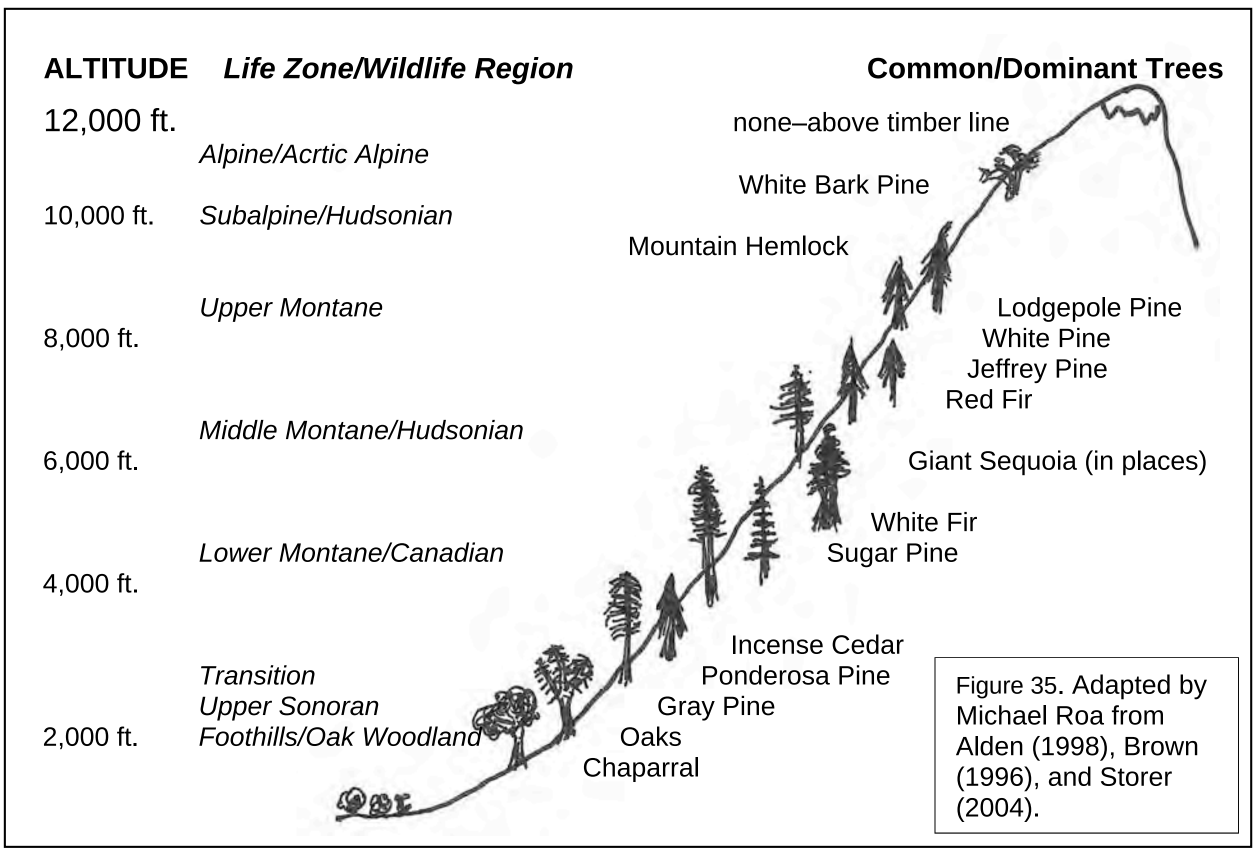


Figure 35. Adapted by Michael Roa from Alden (1998), Brown (1996), and Storer (2004).

For more detailed drawings of life zones, see *Sierra Nevada Natural History*, by Storer et al. (2004). Transects of the life zones at six different latitudes can be found on pages 4–5, and plant belts are drawn on the plate facing page 17 in that book.

Teaching Ideas

Prior to going to a coniferous forest with students, determine the altitude of the area that you will visit. Have the students locate the area on a California map.

While in the forest, have the students identify the main plant species of the area. Compare that information to the information on the profile on the previous page, noting that the profile is drawn for the central Sierra Nevada.

As you approach a mountain range such as the Sierra Nevada, help the students notice the changes in vegetation types as you gain elevation. Also, have them look for different vegetation types on north-facing and south-facing slopes.

See the activity "Rain Reasons" in the Project Learning Tree Pre K–8 Environmental Education Activity Guide. A California adaptation of this activity has been developed by the California Project Learning Tree. Go to: www.plt.org.

Fire and the Forest

Fire is a natural part of the coniferous forest's ecology. The plants and animals of the forest evolved with lightning-caused fires and have adaptations for survival. Lightning strikes caused literally hundreds of fires in California's forests annually before being suppressed in modern times (Johnston, 1998). See pages 154–155.

Native Americans used fire to modify their environment. They maintained grasslands by periodically setting fire to areas that were being colonized by shrubs and trees. Clearing brush and trees made travel easier, increased visibility, reduced the chances of ambush, improved hunting, and encouraged grasses and herbs that were valuable food sources (Johnston, 1998).

When gold was discovered, miners rushed to the foothills and mountains. While their campfires would occasionally escape to start fires, they also intentionally started brush fires to clear away brush that might hide gold-bearing rock and to clear space for living.

In the late 1800s, loggers employed slash and burn methods to clear underbrush and get rid of limbs and tops.

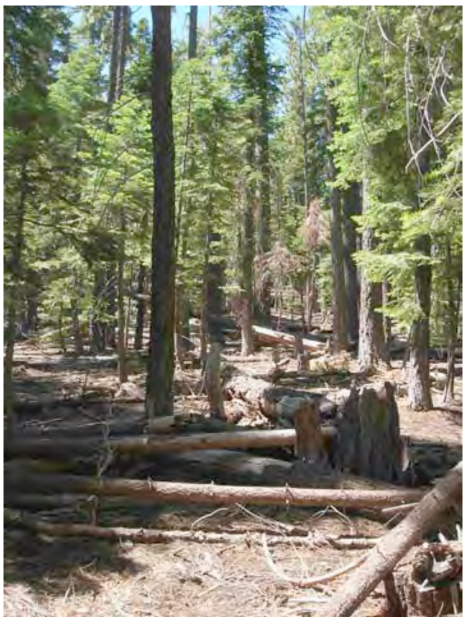
California's coniferous forests are adapted to frequent low-intensity fires. When the dead limbs and underbrush were burned every 5–15 years or so, the fires didn't get hot enough to kill mature trees with thick bark, and the flames didn't get high enough to reach the branches of the naturally pruned trees. Thus, the forests generally consisted of widely spaced mature trees.

Not only does excessive fire suppression result in fuel accumulation, but also crowding of trees increases competition for resources, including water, light, and minerals. Historically, Sierra forests averaged from 30 to 50 trees per acre. Now averages range from 300 to 1,000 trees per acre (Perry, 2007). See Figures 39 and 40 on page 45.

With fire, suppression came the growth of brush and young trees in the forest and the accumulation of fuel in the form of dead limbs and fallen trees.

Some species such as knobcone pines require the heat of a fire to cause their cones to open. Fire suppression thus reduces seed release and germination of seedlings. When (not if) a fire does burn through the forest, it may be too hot for survival of the seeds if there is a large accumulation of fuel (Storer et al., 2004).

By the early 1960s, some experiments with prescribed burning to remove the fuel load had shown that small fires benefit the forest in many ways. Prescribed burns are now common, and wildfires are often allowed to burn in order to prevent continued accumulation of fuel that would someday result in an even greater conflagration.



Figures 36 (left) and 37 (right), taken in 2010. Fuel accumulation at D.L Bliss State Park in an area that has not been treated with prescribed burning (Figure 36, left). The area in Figure 37 was treated with a prescribed burn in 2005, and is directly across the road from Figure 36.

Reducing the size and intensity of fires is not the only reason for encouraging and allowing periodic fires. Some species, such as the Giant Sequoia, need bare mineral soil for seed germination. Also, the Giant Sequoia does not reproduce well in its own shade. White firs, however, do. Since fire has been kept out of the Giant Sequoia groves, practically no Giant Sequoia seedlings have sprouted, but many white firs are growing in the groves (Johnston, 1998). Similarly, shade-tolerant white fir and incense cedar have replaced ponderosa pine and black oak in some areas (Johnston, 1994).

A hundred or more years of fire suppression have left much of our forest full of fuel just waiting for a fire. Fires that previously would have simply cleared out the underbrush may now burn hot enough to kill or weaken mature trees. Trees that are weakened by fire are susceptible to attacks by insects—what the fire doesn't kill, insects may.

Fuel accumulation in the forests is a challenging issue. Prescribed or controlled burns are expensive, and the public often objects to them. Manual removal of brush and fuel load is even more expensive. Recent research indicates that even differences in slope and local habitat characteristics require different treatments, further complicating forest management for fire as well as other factors. The alternative, however, is the inevitable burns that may prove disastrous to people's interests and to the forest (North et al., 2009).

Figure 38.
"Natural pruning" has removed the lower branches from this Jeffrey pine tree, which would help protect it from frequent low-burning fires. Fire suppression, however, has allowed fir and cedar trees to grow up underneath the pine, creating a "fire ladder" that might allow fire to reach the branches of the pine.

Teaching Idea: Resources

Fire in the Sierra Nevada Forests, by George Gruell, is a book of side-by-side photographs of various areas in the 1800s and early 1900s compared to the same sites in the 1990s. It includes a section on "agents of change" that discusses the effects of grazing, logging, mining, fire, and climate.

The Forest Foundation has a variety of resources for teachers and students posted on its Web site, including some dealing with fire: www.calforestfoundation.org.

Project Learning Tree has produced secondary modules designed for older students. The Changing Forest: Forest Ecology has an activity called "Fighting Fire With Fire" (Dobbins et al., 1996). *The module titled Exploring Environmental Issues: Focus on Risk includes an activity titled "Decision Making: Ecological Risk, Wildfires, and Natural Hazards"* (Iozzi et al., 1998).

The California PLT has compiled a list titled *Fire Ecology and Management Educational Resources: Books, Videos, Curriculum, and Websites*. Contact Kay Antunez de Mayolo at: Kay.Antunez@fire.ca.gov

The California Department of Forestry and Fire Protection (CalFIRE) has a variety of fire education materials available at www.fire.ca.gov. If you contact your nearest CalFIRE office they may be able to come to your class and/or provide free materials.

Some children's books include *The Book of Fire*, by William Cottrell, *The Charcoal Forest*, by Beth Peluso, and *Fire Race*, by Jonathan London. (See Appendix IV.)

The U.S. Department of Agriculture Forest Service also has fire education materials, including "FireWorks Curriculum" by Jane Smith and Nancy McMurray, go to www.fs.fed.us/rm or call (970) 498-1392. The regional USDA Forest Service office that deals with California is the Pacific Southwest Region office, in Vallejo, (707) 562-8737.

The Temperate Forest Foundation has a video titled *The Two Sides of Fire*, go to www.forestinfo.org or (530) 579-6762.

Figure 39.
Sugar pine and ponderosa pine in Plumas County in 1937, before extensive fire suppression measures were enacted.

Note the openness of the forest floor. Pioneers would have been able to drive their wagons through this forest.

Fires probably burned through this area every 10–30 years or so. The minimal accumulation of fuel would keep fires from getting too hot.

Natural pruning and fires would keep the low-burning fires from reaching the trees' branches, minimizing damage. (U.S. Forest Service photograph.)

Figure 40.
Pine and Fir trees in Lassen National Park in 2010.

Imagine trying to drive a covered wagon (or even a horse!) through this forest.

The accumulated fuel load on the ground would result in a very hot fire that would probably kill the trees, and "fire ladders" of fuel would enable the fire to reach the branches.

CHAPTER 6
Environmental Concerns…Conservation, Sustainable Management

The human population is increasing, technology is changing, people's expectations are changing, and the human impact on all ecosystems is increasing. Even Antarctica has been impacted by tourism and, apparently, by global warming and ozone depletion. Tropical rainforests are being logged for their wood and to clear land for other crops or cattle ranching, endangering many species of plants and animals even while the "ecotourism" business continues to grow. The fastest growing areas in the U.S. are in the southwest, where the water supply is far from adequate to meet the needs of the ever-increasing demand. Environmental concerns are important in the forested areas. Even though people have caused environmental problems, many people have become concerned and have taken steps to protect and conserve the environment.

Many human uses of forest lands are incompatible with maintaining a more or less natural ecosystem. By law, national forest lands are to be managed for "multiple uses," and those uses are often incompatible.

Teaching Ideas

See page 146 for a list of some times incompatible forest uses that students might investigate, discuss, and report on.

Project Learning Tree has some good information and suggestions for teaching about ethical issues: Go to www.plt.org. Then select "Resources" and scroll down to "Teaching Controversial Issues."

One value of field trips to natural areas such as coniferous parks or forests is the increased level of environmental awareness and concern that students can develop through exposure to interesting ecosystems. While it is important not to overwhelm students with bad news about the environment, it is also important that they become aware of environmental concerns. When teaching students about environmental issues, it is essential to also teach them about ways that problems can be addressed. An important part of that is to help them to understand that there are at least two sides to every issue, and that people have learned ways to minimize or reduce negative impacts on the environment. In some cases, people are working to help areas recover from previous damage or **legacy issues** such as poorly planned roads.

Students need to visit natural ecosystems to fully appreciate their beauty and importance. However, merely learning about the plants and animals is not enough. Students should come away with not only an appreciation, but also a desire and willingness to try to protect, improve, and conserve their environment. The teacher's example, not only while on a field trip, but especially in day-to-day classroom life, can be very powerful.

Discussions of "needs" vs. "wants" are important. So, too, is an understanding of the difference between quality and quantity. It is also important to help students realize the impact of population on the environment.

Teaching Idea

Several of Aesop's Fables can be useful in such understandings. Read (or have students read) and discuss such fables as:

- *The Lioness (Quality is more important than quantity.)*
- *The Two Frogs (Think before acting.)*
- *The Two Crabs (Example is the best teacher.)*
- *The Mule (Every truth has two sides.)*
- *The Goose with the Golden Eggs (Conserve resources for future use.)*
- *The Ant and the Grasshopper (Planning ahead and conservation are important.)*

Habitat Protection and Recovery

As increasing human population and park use puts more pressure on the environment, some species are threatened with extinction. Sometimes areas are closed to human use to protect endangered species or to allow an overused area to recover.

Figure 41.
Forest Service land closed for native plant restoration, near Lake Tahoe.

Figure 42.
Protection for Yellow Cress, an endangered plant in D.L. Bliss State Park near Lake Tahoe. The tubes in the sand contain young plants. (Photo by Alison Stanton)

Exotic Species

Endemic species are those that are native to an area. Nonnative or "exotic" species of plants and animals (**introduced species**) often become problems when they are introduced into new ecosystems. A major reason for this is that natural controls such as insects that feed on the invasive plants, or predatory insects that feed on other insects, are often absent. Without natural controls, invasive species can often out-compete native species (see page 83).

During and after the Civil War, shepherds brought millions of sheep to California's mountains. They set fires to clear predator-concealing underbrush, and to increase the growth of the grasses for the sheep. Even though John Muir spent some time as a shepherd in the Sierra, he saw the damage that the animals did to the meadows and forests, referring to them as "swarms of hoofed locusts" (Farquhar, 1965).

Many of our most harmful insect species are also introduced. Lack of natural predators sometimes results in outbreaks that seriously impact native species.

Over 3,000 species of nonnative plants have been introduced into the wildlands of the United States. About 400 of those are considered invasive, and it is estimated that invasive plants cover about 133 million acres in the U.S. It is further estimated that invasive plants take over an additional 1.7 million acres each year! (Rapp, 2005).

Even the removal of invasive plants or animals can be problematical, as the removal process may leave bare land or require trapping or poisoning.

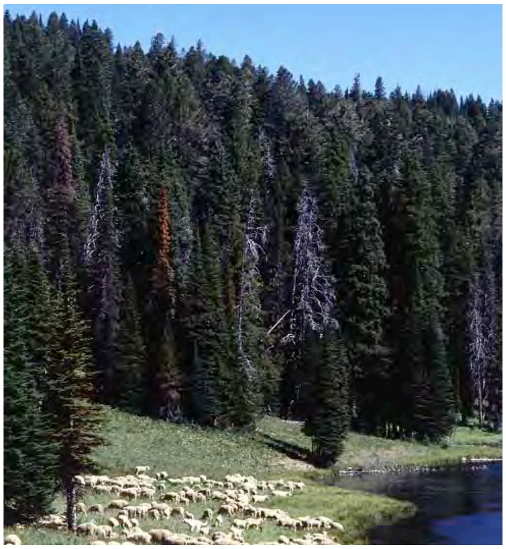


Figure 43. Sheep in the forest. (U.S. Forest Service photo.)

Figure 44. Scotch broom invading a stand of pine and cedar trees.

Examples of exotic plants that have become problems include various types of brooms and gorse, eucalyptus, a variety of thistles, and others.

White pine blister rust, which threatens several important species of pines, was introduced from Europe over 100 years ago.

Teaching Idea

Several organizations and agencies have produced brochures about local invasive species. Invite your local chapter of the California Native Plant Society, your local Resource Conservation District, or a representative of the U.S. Forest Service to talk to your class.

Contact the following. Ask about speakers, publications, and other resources:

California Department of Food and Agriculture: www.cdfa.ca.gov

California Invasive Plant Council: www.ca.-ipc.org

California State Parks: (916) 653-6725 (obtain the brochure titled Silent Threats)

El Dorado County Invasive Weeds Management Group: http://ceeldorado.ucdavis.edu/files/40826.pdf

Lake Tahoe Basin Weed Coordinating Group: http://tahoeinvasiveweeds.org/weeds

National Invasive Species Council: www.invasivespecies.gov

The Nature Conservancy: http://tncweeds.ucdavis.edu

Nevada or Placer County Agricultural Commissioner's Office (530) 273-2648 or (530) 885-3046

Tahoe Conservation District (530) 543-1501

The U.S. Department of Agriculture has a *Woodsy Owl Invasive Weeds Activity Kit* that may be useful with younger students. It is publication PA-1749.

The U.S. Bureau of Land Management and other groups have produced a poster called *Invasive Weeds: A Growing Pain*. It includes several suggestions for student activities and investigations. Contact the BLM Weed Team at (406) 255-2766.

Teaching Idea

The environmental issues listed in the table below can serve as topics for further discussion and research by students. The focus here is on environmental issues in parks. See pages 145-155 for more in-depth discussion of issues and concerns affecting forest lands. Prior to a trip to a forest or park, discuss some of these issues with students and have them ready to ask park staff or volunteers about the issues and that particular park or forest.

Environmental Issues of Parks in Coniferous Forest Areas

Environmental Issue	What's the problem?	What can I do about it?
Lack of environmental literacy and a land stewardship ethic in both the general population and legislators	Unless people both understand the environment and care about taking care of it and using it wisely, the environment will continue to deteriorate. Since there is no "free lunch," it takes an educated and caring populace to be willing to pay the price for environmental protection, whether it is protection of trees, reducing global climate change, or paying for improved sewage treatment.	Education is the key! Not only must the general population be educated, but also they must care enough about the environment to influence both legislators and industry. The public needs to understand the need to use resources wisely and conserve them for future generations.
Lack of information…lack of baseline data	Decisions with lasting implications are made daily. How can information be gathered and interpreted prior to making decisions? Should a given piece of property be acquired for park land, or would the money be better spent on something else? How can this endangered plant or animal be protected? Is this plant or animal truly endangered? Should it be added to the endangered species list? How many of these organisms live here, and how many do we want/need to have? What would be the social or economic impact of this decision? What is the best use of this area?	Students need to comprehend the importance of understanding an issue before making decisions, if possible. If there is a controversy, they need to be willing to understand both (or all) sides of the issue. Students can be encouraged to consider careers in science or social science that may help answer some of the questions associated with decisions about land use and planning.

Environmental Issue	What's the problem?	What can I do about it?
Urbanization/ development	Not only does development of forest areas break up the contiguous forest land, but also urban development brings such problems as water runoff from roads and buildings (as opposed to water percolating into the forest floor), loss of habitat for native species, and the introduction of exotic species, including dogs and cats. Another issue is an urban population that does not understand forest management practices.	Not only is it important to become politically savvy and involved, but also one must be willing to make personal choices with regards to such things as where one builds a home.
Limited funds	Funds for managing public lands are very limited. Should available money be used to acquire new land before it is logged or developed? Should it be used to purchase land, develop land, or protect and conserve land already in parks? If new land is to be purchased, which land should it be, should it be developed for public use, and if so, how?	It is important that taxpayers be willing to support the park system. Organizations such as the Save-the-Redwoods League and numerous "cooperating associations" raise funds to support the parks, too, and students and parents should be made aware of such groups.
Overcrowding in parks	Some parks, especially those near urban areas, face problems with overuse, primarily in the summer months. Too many visitors cause soil compaction, loss of the peace and quiet that people seek in parks, law enforcement problems, demands for more development, and other environmental issues.	Discussion of why there are rules and regulations in parks can make students more willing to stay on trails, not litter, and otherwise comply with the rules. People who do not visit parks are not very likely to support efforts to purchase more park land. Encouraging parents and others to visit parks can help create support for parks and the efforts of organizations such as the Save-the-Redwoods League and local cooperating associations.
Overdevelopment in parks, or inappropriate development	For parks, the problem isn't just how many people want to visit. Another issue is what kind of development should be allowed. How much land should be kept in a natural state, how much should be allocated for roads, buildings, sewage treatment, campsites, or trails? Different people, of course have different ideas about what parks should be and what kinds of development are appropriate.	It is important to discuss with students what kinds of values the parks provide, and to help them appreciate those things that can only be found in natural settings. Only by spending time in nature, can people appreciate and understand its value. Teachers can help students get beyond fears and discomfort to appreciate the natural world.

Environmental Issue	What's the problem?	What can I do about it?
Fragmentation of forest land	Some animals require large uninterrupted forest landscapes. For a variety of reasons, some forest tracts are becoming fragmented. Sometimes this results from roads passing through the forest, but more often, it comes from timber harvests or sales of parcels for development within the forest.	Becoming educated about local land use issues is important, but it is also important that people become politically involved. Land use planning and development must include protection of parklands and both commercial and public forests.
New park land?	Some maintain that more land should be added to the existing park systems. They maintain that additional land may be required to buffer current parkland, and that an increasing population will place ever more pressure on existing parks. Many parks, for example, have no campsites available on most summer weekends. Others point out that many parks are little used during the rainy season, and that when timber land is removed from production, not only are jobs lost, but so are taxes and payrolls that help local communities. Also, less timber available for lumber tends to drive up prices. Furthermore, modern timber companies actively manage the forests to try to prevent wildfires, erosion, and other problems. If they don't do that, the costs for doing so will have to come out of the state or federal budgets, leaving less money available for other needed park projects. If well-managed working forests are taken out of production for parks (or any other purpose), timber will need to be harvested elsewhere. Most other states and countries have lower standards of environmental protection than California.	If more park land is to be acquired, or even if the goal is just to maintain and protect current park land, taxpayers need to be willing to support the California Department of Parks and Recreation, the National Park Service, county park departments, and other similar agencies. People who don't experience the parks can't very well appreciate their importance. When teachers bring students to visit parks, it is important to help students understand that the parks need their support, and to encourage parents to visit and support the parks, too.
Pollution…air, water, solid waste, noise, light	With people come all sorts of pollution. School buses or cars that bring students to visit parks also bring air pollution and noise. Litter is an issue. How is sewage to be dealt with? Should lights be installed on trails, or would that ruin the after-dark park experience? Noise and light can disrupt animal behavior, including sleep and feeding.	Students need to understand that their actions have many consequences. Building a culture of caring and respect in the classroom can be extended to the field. Discussion of population issues can help students understand their impact on their environment. Students can develop attitudes and habits such as recycling and being willing to put up with some inconvenience for the sake of the environment.

Environmental Issue	What's the problem?	What can I do about it?
Invasive and exotic species	When people think of parks, they generally envision a natural setting with plants and animals that are native to the area. Many non-native (exotic) species have been introduced to the parks and forests, either intentionally or accidentally. Exotic species compete with, and often out-compete, native species for space and other resources. Since natural controls may be lacking for introduced species, they may become a significant problem. Many invasive species are difficult to kill or remove.	Learning to recognize introduced species and to understand the problems associated with them is the first step. This can be expanded to discussion of efforts to keep pests out of California and to check their spread within the state. Students can participate in studies of exotic species and in removal projects. They can help with programs to introduce native species.
Fires…or lack of fires	Obviously, fires burn plants in the forest. People sometimes forget that fires also can kill animals, and destroy animal habitat and food. Fire is, however, a natural part of the forest ecosystem. Some types of trees may depend on fires to reduce competition from less fire-resistant species. One problem is that fires have been kept out of the forests for so long, especially in stands that have never been logged, that there has been a buildup of fuel. This large fuel supply, if and when it burns, may be hot enough to damage or even kill trees that could have withstood smaller, more frequent, fires.	If fires are to be kept out of parks, some other way needs to be used to clear the understory and reduce accumulation of fuel that might turn a small fire into a conflagration. Students can participate in fuel reduction projects. Fuel reduction by hand is very expensive, as is prescribed or controlled burning to reduce fuel accumulation. In order for taxpayers to provide funding for such efforts, they must understand the need.
Erosion and siltation of creeks and rivers	Landslides and erosion deposit clay, silt, sand and pebbly sediments in creeks and rivers. Silt and clay reduce the ability of salmon and trout to spawn. Sediments can also fill up the stream channel and change the flow of the stream, possibly resulting in flooding or erosion of the stream banks where many of the largest trees grow. Undercutting of banks may topple streamside trees. While natural landslides contribute to siltation of streams, improperly built roads, especially where they cross streams, are an important problem. Modern road building techniques greatly reduce the sedimentation, but old "legacy" roads and stream crossings continue to produce sediments.	Students need to understand the importance of staying on designated trails, not taking shortcuts. This helps reduce erosion. Students can be involved in trail projects to reduce erosion or in tree planting or other re-vegetation efforts. Modern forest management practices include efforts to protect streams. Students can be encouraged to consider careers in forestry, civil engineering, or geology so that they can help develop and institute even better practices. Students can also be encouraged to become politically active so that appropriate laws and regulations are passed and enforced.

Environmental Issue	What's the problem?	What can I do about it?
Compaction of soil	When people walk or drive on soil, especially if it is wet, it may become compacted. Seeds may not be able go sprout in compacted soil. Soil compaction reduces the ability of both water and air to get into the soil. When water can't enter the soil, it runs off, causing erosion, while plants' roots are deprived of water. Roots also need air, and compacted soil may not allow enough air to reach the roots. Soil compaction may be a problem in parks and also in areas where heavy equipment drives on improperly designed roads.	In parks, people must learn to stay on designated trails and to respect boundaries such as fences and signs indicating "habitat recovery" areas. Students can be involved with trail re-routing and campsite relocation projects. They also need to learn about the impact of such things as mountain biking, off-road driving, and horses on trails.
Roads, stream crossings, and cut-over areas left over from earlier logging…"legacy issues"	Many parks include areas that were logged at one time. Earlier logging techniques sometimes provided little, if any, environmental protection. Some of the "legacy" roads, culverts, and cut-over areas continue to result in erosion or other problems years later.	Again, students can consider careers in the natural resource sector where they can work not only to protect ecosystems but also to correct mistakes of the past. Students can be encouraged to continue their education, formally or informally, so that they can become politically active. Students can participate in tree planting or other re-vegetation efforts, or in other restoration projects.
Demand for wood products	As the human population of the world, including California and the rest of the United States, continues to increase, so does the demand for products made from wood and other resources. As the demand for wood products increases, forest land becomes more valuable and the pressure to increase harvests grows. The United States Department of Agriculture's U.S. Forest Service holds huge tracts of forest lands in California and elsewhere. As the demand for forest products grows, pressure to log those lands increases. Also, potential park land not only becomes more scarce, but more expensive.	Making informed choices is a key. Sometimes wood products may be the best choice because it is a renewable resource. At other times, other materials may be preferable because they will last longer. We should remember "the 3 Rs: reduce, reuse, recycle." We can reduce our use of wood by selecting other resources, but we should keep in mind that those choices will have their own environmental consequences. We can reuse some wood. Many communities have wood recycling/reusing programs, and it may be possible to find used wood for sale.

CHAPTER 7
Organisms of the Coniferous Forest

The focus of this guide is on the coniferous forest, but to understand the forest, one must understand the ecosystem, including the organisms living in it and the surrounding environment or watershed. Chapter 7, therefore, includes some aquatic organisms found in the streams of coniferous forests. Obviously there is only enough space here to discuss a small fraction of the many organisms found in coniferous forests.

Teaching Idea

Invite people who make their livings or spend a lot of time in the forest to talk to your class. Possibilities include foresters, resource/timber company representatives, fishermen, park docents or naturalists, scientists, college science majors, etc.

What's in a Name?

When a child sees a new type of animal or plant, the first thing he or she usually wants to know is its name. This is true of adults, too, and it indicates a basic human desire to make a connection with an organism by knowing its name.

Most organisms have two names: the "common name" and the "scientific name." Our common name, for example, is "human," while our scientific name is *Homo sapiens*. There are advantages and disadvantages to both scientific and common names.

Common names are usually easier for us to understand—they're in our common language. They are often descriptive. A redwood tree does have red-colored wood. A striped skunk does have stripes, and a rough-skinned newt has rough skin. Common names can also be confusing or misleading. The California bay tree is also known as California laurel, bay-laurel, and pepperwood. Neither poison oak nor tanoak is an oak. Douglas-fir is more closely related to hemlock (genus *Tsuga*) than to firs (genus *Abies*), and the same tree is sometimes called Oregon pine…and it's not a pine either!

Another disadvantage of common names is that they differ in different places. In California, the lodgepole pine (*Pinus murrayana*) is sometimes called the tamarack pine. In the northwoods region from Minnesota to Newfoundland, a tamarack is a deciduous tree (*Larix laricina*), also called the Larch.

Also, different languages have different names for the same organism. Italians working in California's forests would call the raccoon <u>procione</u>, while the French would call the same animal <u>raton laveur</u>. A Swedish lumberjack would call it <u>sjubb</u>, while a German would call it <u>der Waschbar</u>. A Spanish missionary might talk about the <u>mapache</u>. Different Native American groups had different words for raccoon: in Pomo it's <u>kah-doos</u>, while the Coast Miwok would call the raccoon <u>hoo-ma-ka</u>. However, scientists from around the world would know the raccoon as *Procyon lotor*.

An advantage of a scientific name is that it has two parts, the genus name and the specific epithet, which combined make the **species** name. The genus of an organism indicates a group of organisms that are very similar (closely related evolutionarily) to each other. The species name indicates the particular (specific) kind of organism. The genus is written first and is a capitalized proper noun, followed by the species name, which is not capitalized and is usually an adjective. Both genus and species are italicized or underlined. For example, a common oak in northern California is the black oak, *Quercus kelloggii*. The closely related Oregon white oak is named *Quercus garryana*. The tanoak tree, which is not a true oak, is in a different genus, and its scientific name is *Lithocarpus densiflorus*. All oaks of the genus *Quercus* are more closely related to each other than they are to trees in the genus *Lithocarpus*.

Scientific names, on the other hand, may be hard to pronounce or remember, as they are typically derived from Latin or Greek words, or "Latinized" forms of other words. They are, however, generally descriptive of the organism. The coast redwood, for example, is named *Sequoia sempervirens*: "*Sequoia*" to honor the great Native American leader and "*sempervirens*" to recognize the tree's long life. Scientists all around the world know that *Sequoia sempervirens* is the coast redwood, and that all other types of trees, even the giant Sequoia redwood of the Sierra and dawn redwood of China, have different scientific names. The giant Sequoia, also called the Sierra redwood and big tree, is *Sequoiadendron giganteum*, and the dawn redwood is *Metasequoia glyptostroboides*.

See the activity "Name That Plant" on page 189.

Plants and animals were originally grouped or classified by observation of their physical structures. Some kinds of organisms from very different groups have similar looking and functioning structures. For example, bats and flying squirrels have "wings" that allow them to fly or glide through the air, much like birds. They aren't, of course, birds. Scientists have developed a variety of methods for grouping organisms according to how closely related they are evolutionarily. Not only are physical structures examined closely, but fossil evidence, genetic studies, blood chemistry, and DNA are used to try to obtain an accurate understanding of how organisms are related. This study of how organisms are related is called **taxonomy**, and taxonomists continue to clarify organisms' relationships to each other. Some of the scientific names in *The Conifer Connection* would have been different 30 years ago, and some may well change in the future as taxonomists learn more about the evolutionary relationships of organisms. Even contemporary authors may use different scientific names for the same organisms. For example, the scientific names used by Stebbins in the *Peterson Field Guide to Reptiles and Amphibians* (2003) sometimes differ from those used by Behler and King in their *Field Guide to North American Reptiles and Amphibians* (1979).

In this guide, I have tried to use the "valid" names as accepted in the Integrated Taxonomic Information System, www.itis.usda.gov or www.cbif.gc.ca/pls/itisca

Taxonomy

When I took high school biology in the 1960s, we were taught that living things could be divided into two "kingdoms" *Plantae* (plants) and *Animalia* (animals). Things that didn't fit into either category were called protists. Now, most taxonomists use five or six kingdoms:

1. *Archaebacteria*: ancient bacteria-like organisms; don't have a cell nucleus
2. *Eubacteria*: most bacteria; without a true cell nucleus or nuclear membrane; chemically different from *Archaebacteria*; important in decomposition
3. *Protista*: have a nucleus and membrane-bound organelles; includes algae
4. *Plantae*: green plants…mosses, ferns, grasses, flowering plants, conifers
5. *Fungi*: molds, mushrooms, yeasts
6. *Animalia*: animals

Each kingdom is divided into smaller groups of organisms. Within each subgroup, the organisms are more closely related to each other than they are to organisms in other groups. A kingdom has several phyla (singular: phylum). Each phylum has several classes, which typically have several orders, which usually have several families, which may have several genera (singular: genus). Most genera have several species.

The study of taxonomy is a constantly evolving science. Not only does it change as we find out more about organisms' evolutionary relationships and discover new organisms, but names of groups change, and not all taxonomists agree on every classification.

Here is a simplified classification of the bobcat, *Lynx rufus*:

KINGDOM — All living things are usually classified into the six kingdoms:					
Archaebacteria	*Eubacteria*	*Protista*	*Fungi*	*Plantae*	***Animalia***
PHYLUM — *Animalia* is divided into different phyla including among others:					
Porifera (sponges)	*Annelida* (earthworms)	*Mollusca* (snails/slugs)	*Arthropoda* (insects/spiders)	*Echinodermata* (sea stars/urchins)	***Chordata*** (fish/bird/mammals)
CLASS — The *Phylum Chordata* is divided into different classesincluding:					
Chondrichthyes (sharks/rays)	*Osteichthyes* (bony fish)	*Amphibia* (frogs/newts)	*Reptilia* (snakes/lizards)	*Aves* (birds)	***Mammalia*** (mice/cats/people)
ORDER — The class *Mammalia* is divided into different orders including:					
Marsupialia (opossums)	*Lagomorpha* (rabbits/hares)	*Rodentia* (mice/squirrels)	*Cetacea* (whales/porpoises)	*Artiodactyla* (deer/elk)	***Carnivora*** (skunks/cats/seals)
FAMILY — The order *Carnivora* is divided into different families including:					
Canidae (foxes/coyotes)	*Ursidae* (bears)	*Procyonidae* (raccoon/ringtail)	*Mustelidae* (weasels/minks/otters/skunks)	***Felidae*** (bobcat)	
GENUS — The family *Felidae* is divided into different genera including:					
Felis (mountain lion)	*Panthera* (lions/tigers)	***Lynx*** (lynx/bobcat)			
SPECIES/EPITHET — The genus *Lynx* has several species including:					
Lynx Canadensis (Canadian lynx)	***Lynx rufus*** (bobcat)				

Species

What's a "species?"

By "species," scientists typically mean organisms that are able to mate and produce fertile offspring. All kinds of domestic cats are able to mate and produce fertile offspring, and do so naturally; so all domestic cats are of the same species—*Felis domesticus.* An alley cat is the same species as a Siamese cat, as is a Persian cat. They can all successfully mate. The mountain lion (a.k.a. cougar, catamount, puma, or panther) is classified in the same genus as the domestic cat because they have many structural similarities. It is, of course, a different species—*Felis concolor.* Both *F. domesticus* and *F. concolor* have 30 teeth. Bobcats can't successfully mate with domestic cats and are different in other ways, such as the ratio of tail length to foot length and number of teeth (28), so they are classified as a different genus and species—*Lynx rufus.* The Canadian lynx is closely related to the bobcat. The Lynx also has 28 teeth, so it is classified in the same genus, but as a different species—*Lynx canadensis.* Bottom line: scientific names show how organisms are related to each other, and each kind of organism has its own unique scientific name that is the same anywhere in the world.

Names of species are generally given as a combination of the genus (capitalized and italicized) (*Lynx*) and the species name, which is italicized but not capitalized (*rufus*).

There is one kind of animal, the bobcat, that is named *Lynx rufus*.

Another way to look at the classification of the bobcat would be:

Kingdom: Animalia

Phylum: Chordata

Class: Mammalia

Order: Carnivora

Family: Felidae

Genus: *Lynx*

Species, epithet or trivial name: *rufus*

Scientific/species name: *Lynx rufus*

Some species are further divided into subspecies (also called varieties). The mule deer, or black-tailed deer, has several subspecies (ssp.). Some taxonomists recognize as many as nine. Among them are the California mule deer (*Odocoileus hemionus* ssp*. californicus*), Rocky Mountain mule deer (*Odocoileus hemionus* ssp*. hemionus*), Columbian mule deer (*Odocoileus hemionus* ssp*. columbianus*), and the southern mule deer (*Odocoileus hemionus* ssp*. fuliginatus*). The population of foxtail pine in northern California is classified as *Pinus balfouriana* ssp*. balfourina*, while those in the Sierra are classified as *Pinus balfouriana* ssp*. austrina*.

Some students enjoy learning about the etymology (origins) of words and word roots. Knowledge of word roots can be valuable in later education and elsewhere. A good source for science word roots is:

www.biology.ualberta.ca (Type "word roots" in the search box.)

Another good resource for word roots is the *Dictionary of Word Roots and Combining Forms*, by D.J. Borror (1988).

In *The Conifer Connection*, both common and scientific names of organisms will be used. If the student or teacher wishes to find out more about a particular organism, I suggest using the scientific name, as it will yield more precise information. Sometimes a common name applies to more than one species. In such cases I've indicated the genus name (capitalized and italicized), followed by "spp," to indicate more than one species. For example, there are several species of alder (genus *Alnus*) found in our coniferous forests, so I might refer to them collectively or as unspecified species as *Alnus* spp.

Adaptations for Survival

Why is there such a diversity of living things on Earth, or in a particular ecosystem such as a coniferous forest? What causes that diversity? The complexity of the chemical molecule named deoxyribonucleic acid (DNA), coupled with sexual reproduction and numbers of chromosomes results in a seemingly infinite variety of genetic combinations. Couple this with the mutations that change the DNA and chromosomes, and the possible variations are even greater. As a result of this variation and diversity, each individual organism is slightly different from the others. Most of the differences are insignificant. However, when there is competition for resources, some individuals may survive and others may not. Those with characteristics or **adaptations** that enable them to survive may pass on those adaptations to their offspring. Organisms that don't have such adaptations may not survive to reproduce, especially when competition is extreme.

Some adaptations are structural (wings, camouflage coloration), some are physiological (the ability to grow rapidly, production of chemicals that deter termites), while others are behavioral (migrating, competition for mates, tool making). When thinking about adaptations, it should be kept in mind that individual organisms **don't** develop genetic adaptations in order to survive. Those that, due to natural genetic variability, already have certain genetic adaptations may survive and reproduce, while those that don't have the necessary adaptations might not survive and reproduce. Thus, "good" adaptations are inherited from successful parents. And successful parents pass on their adaptations to their offspring, thus eventually altering the genetic makeup of the population. This is "natural selection."

Information on teaching about evolution can be found at: www.pbs.org.wgbh/evolution.

Teaching Idea

When I teach about the concept of adaptations, I try to emphasize the idea of diversity within a species being desirable with regard to the survival of the species. You can have "what if" discussions with your students…What if people with black hair can survive global warming better than those with blond hair? What if people with slow metabolisms survive better if there is a food shortage? Will people decide to grow black hair or change their metabolisms in order to survive? Obviously those who already have those genetically based adaptations will be the ones to survive and pass them on to their offspring. I refer to this *as "pre-adaptation," and emphasize that we can't predict which adaptations will be advantageous in the future, and we can't decide to develop genetic adaptations.*

This discussion can also be useful in encouraging tolerance and appreciation of diversity among the students, as well as the theories of Lamarck and Darwin.

Every habitat (and microhabitat) has conditions that make different adaptations advantageous. Adaptations that are useful in one environment might not be useful in another. In the organism descriptions on the following pages, I've tried to point out particularly interesting, unique, or important adaptations.

Teaching Idea

When at a forest site, discuss with the students the adaptations that plants and animals have that enable them to survive in that habitat. Point out that native species have lived there far longer than people have. What can we learn from them that might help us to survive?

A Few Words About Evolution

Some teachers are hesitant to teach about evolution, and this is understandable, as some parents reject the idea. The state of California, on the other hand, supports the teaching of evolution as a valid and important part of science education. It even uses evolution as a theme progressing through the grades, provides examples of court cases supporting education about evolution, and provides examples of evolution education in the 1990 *Science Framework for California Public Schools*.

One approach is to be clear that one is teaching evolution as a (very well supported) theory, and not require students to say that they accept or agree with the theory. The 2004 *California Science Framework* says that "…students should be made aware of the difference between *understanding*, which is the goal of education, and *subscribing* to ideas." If parents ask that their children not be taught about evolution, the child can be excused, but I recommend that you do so only after discussing it with the parent. You can point out that the child will need to understand evolution if they are to be able to counter the arguments that they will doubtless encounter later in life. Another reason that students should understand the theory of evolution is that questions about it may appear on various high school and college tests. You might point out that many scientists are also religious and have been able to reconcile their religion with evolution.

Examination and discussion of the great diversity of life in any particular habitat provides an excellent opportunity to discuss the diversity and competition that form the basis of the theory of natural selection.

Other Communities

The coniferous forest ecosystem includes not only forests, but also other communities such as ponds, streams, fields, and mixed forest that includes various oaks, Douglas-fir, madrone, and other trees. *The Conifer Connection* focuses on the forest communities, but includes some information about organisms from other communities.

Some Common or Important Organisms of the Coniferous Forest

This Chapter includes some organisms that forest visitors are likely to see. It also includes some common organisms that are important but not so likely to be seen, and other organisms that may be of interest to students. Coniferous forests vary in their flora and fauna depending on where they are located, so it is a good idea to check with the interpretive staff to obtain a local species list before visiting a park. The organisms described below are, of course, but a small fraction of those that one may see upon visiting a coniferous forest. I highly recommend bringing with you one or more of the guides listed in the Appendices. Among them are simple keys that students can use to identify many common plants and animals, as well as field guides that help with identification through the use of pictures.

Keep in mind, too, that simply memorizing names of organisms is probably not an important goal. However, knowing some organisms' names and their roles in the ecosystem will make a visit to the forest more interesting.

See "Name that Plant," page 189 and "Similar, But Not the Same!" page 251.

The Yosemite Association has published a series of easy-to-use "Field Cards" with illustrations and descriptions of many common species. Topics include trees, birds, flowers, and mammals. To obtain the cards, contact the Yosemite Association:

(209) 379-2648 www.yosemite.org

Bacteria (Kingdom Eubacteria)

Figure 45. Bacteria take many forms.

While many people equate bacteria with disease, these **microorganisms** play extremely important roles in all ecosystems. They provide food for many small organisms. Just as important is their role as recyclers of dead organisms through the process of decay or **decomposition**.

Teaching Idea

*Teach students to remember "F.B.I." (**F**ungi, **B**acteria, **I**nvertebrates) for the decomposers. (Some say that the "I" stands for insects, but there are other invertebrate decomposers such as worms and isopods (pill bugs or "roly-polies") that should not be forgotten.)*

Protists, Including Algae (Kingdom Protista)

Algae and other protists are generally found in streams and ponds. Algae range from microscopic to much larger, sometimes forming stringy masses along the edges of streams or ponds. They may also grow as a slimy coating on damp surfaces such as submerged rocks or logs.

Algae are **photosynthetic**, so they are classified as "producers" because they use energy from the sun to produce organic chemicals such as sugars, starches, and cellulose through the process of photosynthesis.

Oxygen is released as a by-product of photosynthesis. This oxygen may dissolve in the water, where it becomes available to aquatic organisms, or it may bubble out of the water and be released into the atmosphere. In fast-moving streams the splashing and tumbling of the water probably provides more oxygen than do algae or plants.

As producers, algae form the base of the aquatic **food pyramid** and are at the beginning of many aquatic **food chains**.

Kingdom Fungi

Many species of fungus live in coniferous forests. Most fungi are found on decaying logs or growing on the forest floor where they are important decomposers. Some can kill young trees if they get a start growing on them. Others form **mutualistic** associations in which both the fungus and plant benefit. The fungus obtains nutrients from the plant and the plant benefits because the fungus helps the roots absorb water and minerals.

Most fungi have an above ground portion and a root-like underground system of **mycelia**. Mycelia are not true roots because they don't have **vascular tissues**, *i.e.,* they don't have specialized cells for conducting water and minerals upward and food downward. (Plants have xylem and phloem cells to perform these functions.)

Caution

***Some fungi are edible. Others are deadly poison*.**

Do not let students eat forest mushrooms, even if you think they have found an edible species. If you (or the student) are wrong, consequences can be disastrous. Even if the mushroom is edible, students should be discouraged from killing or eating forest plants or fungi. And killing plants or fungi in a park is illegal! If students want to learn about edible fungi, they should contact a mycological society.

Most books call the giant Sequoia the largest living thing. Some people, though, consider the massive system of mycelia of some fungi to be a single organism, larger even than the General Sherman giant Sequoia tree!

Fly Amanita (*Amanita muscarina*)
Up to 5 in. (13 cm) tall and 5 in. cap diameter

The *Amanita* mushrooms can be very showy, with a red or orange cap and white spots. While attractive, some are deadly poisonous to humans (Alden et al., 1998). Some animals, however, are able to eat them.

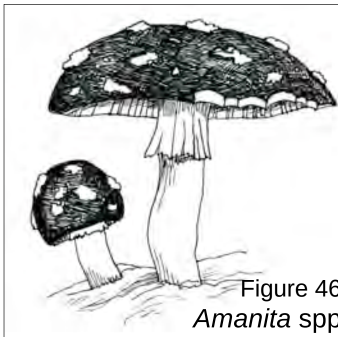


Figure 46. *Amanita* spp.

Common Puffball (*Lycoperdon perlatum*)
Up to 2 in. (5 cm) diameter

Figure 47. Common Puffball (*Lycoperdon perlatum*) Other types are smooth.

"Puffball" fungi develop their spores inside a protective wall. Immature puffballs may be moist, white and fleshy on the inside, while dry "mature" puffballs release millions of powdery dark colored spores when the fragile wall is broken (see Figure 14, page 19).

Shelf Fungus (Bracket Fungus or Conk) (*Ganoderma applanatum*)

Shelf fungi can be delicate and frilly or quite robust. They can be colorful or drab on top and creamy white underneath. They can be tiny, or up to 16" (40 cm) at their point of attachment to a log.

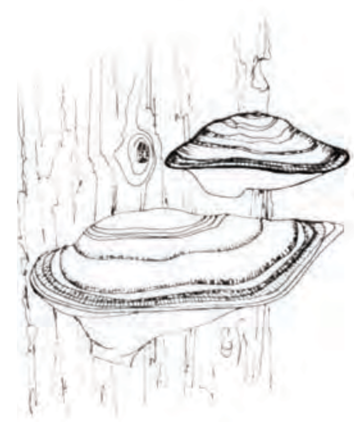


Figure 48. Shelf Fungus (*Ganoderma applanatum*)

Lichens

Lichens are actually two organisms, an alga and a fungus, living together in a mutualistic relationship. **Mutualism** is a **symbiotic** relationship in which both organisms benefit. The alga (or sometimes a blue-green bacterium) provides nutrients for the fungus through photosynthesis. The fungus provides a sheltered environment where the alga is protected from drying out (see page 29).

Most lichens grow very slowly. They often colonize bare rock surfaces and produce acids that help break down the rock into soil. They can also be very sensitive to air or water pollution, and are thus useful in assessing the impact of smog (Laws, 2007).

There are three growth forms of lichens:

Fruticose lichens are stringy, looking a bit like moss.

Crustose lichens grow close to rock or other surfaces, looking like spilled paint.

Foliose lichens look a bit "leafy," looking more like peeling paint.

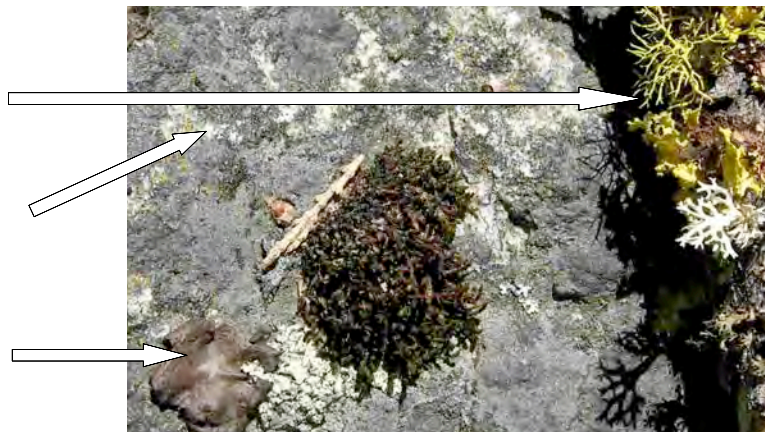


Figure 49. Several species of lichen on a rock and a branch in Calaveras Big Trees State Park, with a clump of moss to the left of center.

Wolf Lichen (*Letharia* spp.)
"Strings" to several inches from
a base about 1 in. (2.5 cm) across

This chartreuse colored stringy (fruticose) lichen is common on red fir and other conifers. It can be used to make a yellow-green dye, and contains an acid that was used in Europe to make a wolf poison (Laws, 2007).

Figure 50. Wolf Lichen (*Letharia* spp.)

Fire Ant Lichen (*Caloplaca ignea*)
To an in. (2.5 cm) or more across

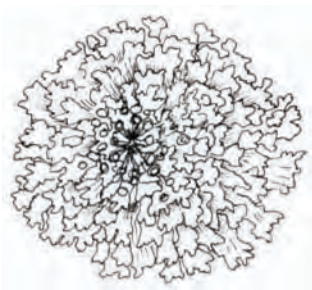


Figure 51. Fire Ant Lichen (*Caloplaca ignea*)

This red-orange lichen is found growing in a thin layer (crustose growth form) on rocks. Some types of lichens grow on rocks where bird droppings provide a source of nitrogen (Laws, 2007).

Crustose lichens are found in a rainbow of colors ranging from white and yellow to brown and black.

For more information on lichens, see the books by Purvis and Hale in Appendix IV.

Plants (Kingdom Plantae)

Hundreds of species of plants are found in coniferous forests. Excellent plant guides are available; many are well illustrated with color pictures and/or keys for identification. See Appendix IV and V, and check with the park for a list of plants that are most likely to be seen. As you help students identify plants, be sure to discuss their role in the forest.

Non-Vascular Plants

Non-vascular plants include mosses, liverworts, and hornworts. Since they do not have specialized **vascular tissues** to carry water and other materials, they are all fairly small plants that live in moist areas such as decaying logs in shady areas and on rocks along streams. In such places, they are among the first organisms in a succession sequence. In vascular plants, the vascular tissue provides support. The lack of support from vascular tissue is another limit on the size of non-vascular plants.

Mosses: Phylum Bryophyta
Various genera and species of mosses live in the cool, damp areas of coniferous forests. Look for the spore capsule on its stalk. Mosses reproduce with **spores**, as opposed to **seeds** (see Figure 49 on page 62).

Figure 52. Moss, including sporangia

Vascular Plants

Most of the familiar plants are vascular plants. Vascular plants have vascular tissues that carry water and other materials throughout the plants. The **xylem** generally carries water and minerals upward, while the **phloem** carries nutrients from the leaves to the rest of the plant. Vascular plants have true roots, stems, and leaves.

Teaching Idea

A memory aid for xylem and phloem:
Xylem carries fluid towards the sky.
Fluids flow down through the phloem.

Note: Typical heights (H) and diameters (D) are provided for many of the plants listed below. Different sources vary greatly in the dimensions that they list.

Horsetails: Phylum Equisetophyta, genus *Equisetum*
H: To 2 ft. (60 cm) or more

The horsetail, or scouring rush, is among the most primitive of vascular plants. The common name “horsetail” comes from its appearance, while “scouring rush” derives from its abrasive silica, which made it useful for scouring pots and pans. Some species of *Equisetum* have the stems surrounded by branches that stick out from the joints or nodes, while others look like a jointed spear.

Figure 53. Horsetail (*Equisetum* spp.)

Modern horsetails are very similar to giant species that lived during the time of the dinosaurs.

The tips of young plants were sometimes boiled like asparagus, and were used as a diuretic. Too much, however, can cause illness.

Ferns: Phylum Pteridophyta

Ferns are also primitive vascular plants. Unlike “higher” plants, ferns reproduce with **spores** rather than seeds. The spores are produced in **sporangia** on the undersides of the leaves. The sporangia are often clustered in a group called a **sorus** (pl: sori). Along with leaf shape, the location, shape, and distribution of the sporangia and sori are often used in identifying species of ferns. Several of the plant guides listed in the Appendices can be used to identify ferns.

Sword Fern: *Polystichum* spp.
Several fronds, from 2 to 4 ft. (0.7–1.2 m) in length, arise from a single base.

Figure 54. Sword Fern (*Polystichum* spp.)

Look for the projection from the base of the leaflet, which somewhat resembles the hilt (handle) of a sword.

Sword ferns are among the most common ferns in coniferous forests, sometimes forming dense clusters. They are relatively resistant to drought and do well in moist environments.

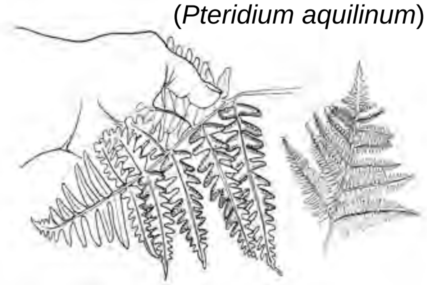
The tips of young leaves, called fiddleheads, can be boiled and eaten. To keep food clean, Native Americans sometimes laid fronds on the dirt floors of their cooking pits.

Caution

While the young fiddleheads can be eaten in limited quantities, large quantities, or older plants are toxic!

Bracken Fern: *Pteridium aquilinum*

Figure 55. Bracken Fern (*Pteridium aquilinum*)



The bracken fern is extremely wide-ranging, with many varieties living from the subarctic to tropical regions. Their triangular fronds, which may be up to 4' (1.2 m) long, are often highly branched.

Bracken may be found from shady, moist areas to relatively dry openings in the forest. The fronds die back in the winter.

Native Americans use the roots to create patterns in baskets.

Five-Finger Fern: *Adiantum pedatum*
H: To 2 ft. (0.7 m)

The five-finger fern isn't necessarily five-fingered…they may have more than five segments growing out from a central area of a single frond in a finger-like fashion. These ferns are often found growing from moist crevasses in rocks and along streams. The spores are hidden on the underside of the leaf's curled margin. The stem is black or very dark brown in color.

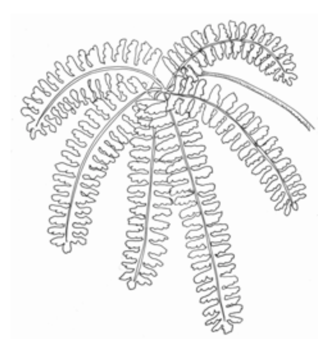


Figure 56. Five-Finger Fern (*Adiantum pedatum*)

Native Americans used (and still use) the five-finger fern in basketry.

California Maidenhair Fern (*Adiantum jordanii)*

The maidenhair fern is usually found on moist rocky outcroppings. The leaflets (**pinnae**) are rounded and grow from short stems along a 1–2 foot (0.3–0.7 m) dark colored central stem. The spores line the edge of the underside of the pinnae.

The dark stem was used by Native Americans, who pounded them to obtain long black strands for use in basket weaving.

Figure 57. Gold Back Fern (*Pentagramma triangularis*)

Gold (Golden) Back Fern (*Pentagramma triangularis*)

H: 4–6 in. (15 cm)

Often found in rocky areas. As the name implies, the back of the frond is covered with a gold-colored powder. People sometimes press the frond onto a piece of paper to make a print…But do not encourage students to pick fronds for this.

(In the illustration, the lower leaflets are turned to show the sporangia.)

Figure 58. Wood Fern (*Dryopteris arguta*)

Wood Fern (*Dryopteris arguta*)

H: To 3 ft. (1 m)

The wood fern often grows in open, relatively dry areas between 2000' and 5000' in elevation. The sori are C-shaped.

Angiosperms ("Flowering Plants")

Figure 59. Snow Plant (*Sarcodes sanguinea*)

Snow Plant (*Sarcodes sanguinea*)

H: To 15 in. (37 cm)

The red-colored snow plant and several other non-photosynthetic plants were once thought to be saprophytic, feeding on decomposing matter in the soil. It is now thought that they are parasitic on living soil fungi.

Other similar plants include Coralroot (*Corallorhiza* spp.), *Sugar Stick (Allotropa virgata*), *Pinedrops (Pterospora andromedea),* and Leafless Wintergreen (*Pyrola aphylla*) (Laws, 2007).

Figure 60. Fireweed (*Epilobium angustifolium*)

Fireweed (*Epilobium angustifolium*)
H: To 4 ft. (1.2 m)

Fireweed has pink flowers with four petals and often sprouts in nutrient rich soils after a fire.

Shooting Star (*Dodecantheon* spp.)
H: about 14–24 in. (35–60 cm)

Several species of these beautiful purple “reversed” flowers can be found in damp grassy areas.

Figure 61. Shooting Star (*Dodecantheon* spp.)

Figure 62. Mule's Ears (*Wyethia* spp.)

Mule’s Ears (*Wyethia* spp.)
H: 16 in. (45 cm)

Yellow flowers sprout among clusters of gray-green wooly leaves in this plant, which is commonly found in clearings. See Figure 41 on page 47.

Figure 63. Buckwheat (*Eriogonum* spp.)

Buckwheat (*Eriogonum spp.*)
H: 7 in. (18 cm)

Various species of buckwheat grow in dry areas, especially at higher elevations. They generally form a low mat of leaves, which reduces the impact of the wind on the stems and leaves. Buckwheat is often among the first plants to grow after a fire.

Mistletoe

Some species of mistletoe (such as *Phoradendron* spp.) are green and rely primarily on photosynthesis for their food, while obtaining water and minerals from a host plant. They are considered **hemiparasites**. Other species (such as dwarf mistletoe, *Arceuthobium* spp.) are true parasites, obtaining all of their nourishment from the host tree.

Different species of mistletoe live on different tree species. Seeds are spread by birds. See Figures 20–23 on page 28.

Figure 64. Green mistletoe's leaves are thick. Seeds are white and sticky.

Figure 65. Clusters of green mistletoe may be spotted in oak or other trees.

Woody Shrubs and Trees:

About sizes: Different reference books vary greatly in the sizes given for plants. The heights and other measurements such as leaf and cone lengths below are from *Trees and Shrubs of California*, by John Stuart and John Sawyer (2001).

Currants and Gooseberries (*Ribes* spp.)
H: 5 ft. (1.5 m)

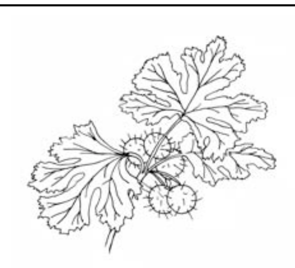


Figure 66. Currant (*Ribes* spp.)

These plants have pea-sized red or purple edible fruit. White pine blister rust forms red spots on their leaves.

Manzanita (*Arctostaphylos* spp.)
H: To over 15 ft. (4.5 m)

Figure 67. Manzanita (*Arctostaphylos* spp.)

"Manzanita" means "little apple" in Spanish, and the ripe fruit does look like a little apple. Native Americans sometimes ate the fruit either fresh or dried. The bark is smooth and dark red.

Madrone (*Arbutus menziesii)*
H: 25–130 ft. (8–40 m)   D: 1–3 ft. (30–90 cm)


Figure 68. Madrone (*Arbutus menziesii*)

Common in the mixed evergreen forests, especially on upper slopes. Madrone often grows from multiple trunks with twisted shapes formed as the branches reach for light. Smooth bark which peels off in the summer to reveal smooth light green wood, which later becomes a rich dark red-brown color.

The evergreen leaves have a thick waxy cuticle that helps prevent water loss. Madrones are well adapted for surviving fires and will readily stump sprout. Native Americans and early settlers used the leaves and berries as foods and medicines.

Willow (*Salix* spp.)
H: To 15 ft. (4.5 m)

Willows often indicate water near the surface and are commonly found along streams. Willow bark contains salicylic acid, which is the active ingredient in aspirin (see Figures 9 and 11 on page 15).

Figure 69. Willow (*Salix* spp.)


Scotch Broom (*Cytisus scoparius)*
H: To 10 ft. (3 m)

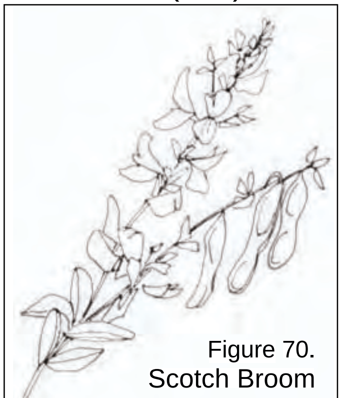


Figure 70. Scotch Broom (*Cytisus scoparius*)

Several types of "broom" can be found along roads and in fields in coniferous forests. Other types include the French Broom (*Genista monspessulana*) and Spanish Broom (*Spartium junceum*). The green stems account for much of the plant's photosynthesis.

Brooms are non-native, invasive species, rapidly displacing native plants, including plants that provide important food for wildlife. They also interfere with reforestation efforts after logging or a fire. They are strong competitors and often form dense pure stands, shading out native or desirable species (Bossard et al., 2000).

Seeds can remain viable in the soil for decades, forming "seed banks" that make eradication a multi-year endeavor (Moore, 1998). Foliage and seeds can be toxic to wildlife. They are also prone to hot-burning fires and can carry the fire to the canopy layer (Bossard et al., 2000) (see Figure 44 on page 48).

Common Gorse (*Ulex europaea*)
H: To 10 ft. (3 m)

Common gorse is an evergreen shrub with prickly stems and yellow pea-like flowers. It invades areas disturbed by grazing, fire, or logging. It doesn't spread as rapidly as the brooms, but once it becomes established, it tends to completely dominate an area and is extremely difficult to eradicate (Bossard et al., 2000).

Figure 71. Poison Oak (*Toxicodendron diversilobum*)

Poison Oak: *(Toxicodendron diversilobum)*
(formerly *Rhus diversiloba*)
Shrubs to 6.5 ft. (2 m); tree-like forms to 15 ft. (4.5 m) and vines that can climb more than 100 ft. (30 m)

Caution

To identify poison oak in the spring and summer, look for three leaves. The leaves may be nearly smooth-edged, or deeply lobed, hence the name "diversilobum." In the fall, the leaves turn red and fall off. Blackberry plants have spines; poison oak doesn't.

To identify poison oak in the winter, look for stems that are almost pencil-thick and taper very little until they get to the end.

The Native Americans were apparently not very much affected by the oils of poison oak and had many uses for it. They used the stems in basketry, and obtained a juice from them to create a dark dye. The juice was also used as medicine for a variety of ailments and in a tattooing process.

California Bay (California Laurel, Bay-Laurel, Pepperwood, Oregon Myrtle) (*Umbellularia californica)*
H: 30–80 ft. (9–24 m)   D: 1–3 ft. (1 m)

The long leaves are pointed at the tips and wedge-shaped at the base, and have a strong fragrance. They are leathery and dark green in color.

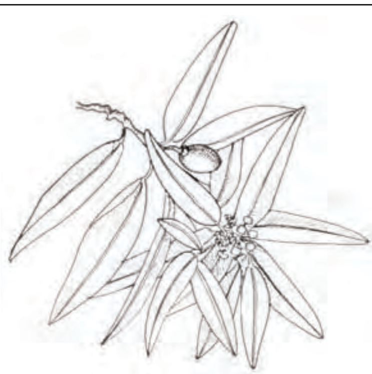


Figure 72. California Bay (*Umbellularia californica*)

The Native Americans used the leaves to cleanse wounds and cure headaches. The leaves were also used as a flea-repellant in their dwellings. The nuts were roasted to remove the bitter taste and eaten whole or ground into flour.

Today the leaves are dried and used as a spice which is similar to the more expensive European bay leaves. The wood is often used to make bowls and other fine wood products.

Big-leaf Maple (Big Leaved Maple) *(Acer macrophyllum)*
H: To 100 ft. (30 m)   D: To 3–4 ft. (1.2 m)

The bark of young trees is smooth and light gray-reddish in color. As the tree grows older, the bark darkens and becomes more rough. The leaves have a typical maple-leaf shape with deep notches. In the fall, they turn bright yellow or orange. The long, drooping clusters of yellow-green flowers produce double-winged fruits. Wings on the seeds enable them to be blown far from the parent tree as they fall to the ground, reducing competition between the seedling and the parent tree. The seeds may hang on the tree all winter and are an important winter food source for birds and other animals. Twigs are eaten by deer (Arno, 1973).

Figure 73. Big-leaf Maple (*Acer macrophyllum*)

Maple wood is used for making furniture, paneling, and veneer. A syrup can be made from the sap.

Quaking Aspen *(Populus tremuloides)*
H: 20–80 ft. (6–24 m)   D: 4–24 in. (10–60 cm)

This tree gets the “quaking” part of its name from the fluttering of the leaves in the wind. The leaves are similar to cottonwood, but rounder, with a flattened stem near the leaf, which results in the fluttering. Aspen often grow in groups of clones, with the trees connected by their roots. In the fall, the leaves turn to brilliant yellow and gold colors, with all members of a clonal group changing color at the same time (Laws, 2007).

Figure 74. Quaking Aspen (*Populus tremuloides*)

Cottonwood *(Populus spp.)*
H: To 100–125 ft. (30–38 m)   D: 1–3 ft. (30–90 cm)

Cottonwood trees generally indicate water near the surface. Their leaves are more pointed or heart-shaped than those of the quaking aspen. Seeds have cottony filaments (Alden and Heath, 1998).

Figure 75. Cottonwood (*Populus* spp.)

Alder: (*Alnus* spp.)
H: 50–100 ft. (15–30 m) tall D: To 2 ft. (0.6 m), occasionally to 4 ft. (1.2 m)


Figure 76. Red Alder (*Alnus rubra*)

The leaves of white alder have finely toothed edges, while red alder leaves are more coarsely toothed (have larger "teeth").

The bark is gray-white. The elongated male flowers, called catkins, release pollen in February and March. The female catkins are cone-like, to 1" in length, and resemble an elongated coast redwood cone.

Alders are one of the few trees that can use nitrogen from the atmosphere. They, like legumes, have nitrogen fixing bacteria in their roots. The bacteria capture nitrogen from the air and combine (or "fix") it with oxygen to form compounds that plants can use.

Alders need a fair amount of sunlight and moisture, so they usually grow along streams. They grow rapidly and can grow to 40' tall in a decade.

Native Americans used the red alder for basketry, with the roots used as a fiber and the inner bark used to produce an orange dye. The wood is used in furniture making. White alders are sometimes planted as ornamental trees (see Figure 15 on page 21).

Mountain Dogwood *(Cornus nuttalli)*
H: 10–40 ft. (3–12 m) D: 6–12 in. (15–30 cm)

The large (5 in.) "flowers" of this tree are actually white bracts that surround a cluster of tiny flowers. The true flowers form an inconspicuous button at the center of the flower-like bract. Dogwoods often grow in moist areas and along streams, often in the shade of other trees (Arno, 1973).


Figure 77. Mountain Dogwood (*Cornus nuttalli*)

Live Oak (*Quercus* spp.)
H: 15–75 ft. (4.5–23 m) (varies with species)
D: 1–5 ft. (30–150 cm) (varies with species)


Figure 78. Live Oak (Quercus spp.)

Many of the species of oak can hybridize with each other, sometimes making identification difficult. Male flowers develop in the spring and soon fall from the tree. The female flowers form acorns. Acorns provide important food for a variety of animals, including deer, bears, rodents, and birds. They also provided an important source of food for Native Americans.

Black Oak (*Quercus kelloggii)*
H: 30–80 ft. (9–24 m), occasionally 100 ft. (30 m)
D: 1–3 ft. (1 m), sometimes to 4 ft. (1.2 m)

The deeply lobed leaves have sharp points and are large, sometimes reaching almost 10" in length.

Most western oaks are evergreen; the black oak is deciduous. In many areas of California, the black oak's acorn was an important food source for Native Americans.


Figure 79. Black Oak (*Quercus kelloggii*)

Gymnosperms: Cone-bearing Trees

"Gymnosperm" means naked seed, which refers to the seeds of these trees being borne in cones without fleshy fruits (see Figures 5 and 6 on page 10).

Giant Sequoia (Sierra Redwood, Big Tree) (*Sequoiadendron giganteum)*
H: 225–275 ft. (69–84 m)   D: typically 10–20 ft. (3–6 m) up to 36 ft. (12 m)

- Needles: 0.25 in (6 mm) long, scale-like, sharp pointed, arranged in a spiral
- Cones: barrel or egg-shaped, 1.75–2.75 in. long (4.5–7 cm)
- Range: 2,700–8,800 ft. in about 75 groves in the western Sierra Nevada

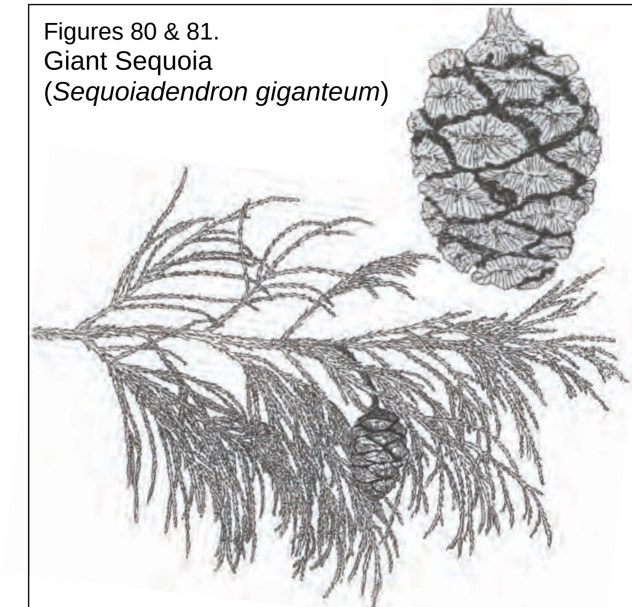
Often called the largest living things, these trees can get to 36 ft. (12 m) in diameter and nearly 300 ft. (90 m) tall (Laws, 2007). (Some consider fungi with extensive systems of mycelia to be more massive.) While not as tall as the coast redwood (*Sequoia sempervirens*), the giant sequoia can get to be larger in diameter. The General Sherman tree, in Sequoia National Park, has over 52,000 cubic feet of wood.

Giant Sequoia were logged commercially from about 1850–1950, but are now protected in their natural habitat. The insect—and fungus—resistant wood was used for fence posts and shingles, but the tree often shattered upon falling and so was not much used for lumber. Giant Sequoias are often planted as ornamental trees (Lanner, 2007 and Arno, 1973).

Cones often remain on the tree, closed, for many years. For seed distribution, the cones must dry out. Drying can be prompted by several factors, including ground fires, insects feeding on the cones' vascular tissues, squirrels feeding on seeds, or storms tearing off limbs with cones. A single tree may hold 30,000 or more cones (Lanner, 2007).

Giant Sequoias may live to be over 3000 years old. A main cause of death is falling due to loss of balance. Loss of a large limb, damage to roots, or damage due to fungus or fire at the base may cause the massive tree to become unbalanced. A heavy snowfall may then cause the tree to topple.

Figures 80 & 81.
Giant Sequoia
(*Sequoiadendron giganteum*)



Figures 82 & 83.
Coast Redwood
(*Sequoia sempervirens*)

(Figures 80-83. The individual cone drawings are approximately life size.)
(Drawings by Daniel J. Miller.)

Coast Redwood (*Sequoia sempervirens)*
H: 200–300 ft. (61–91 m), can grow to over 370 ft. (112 m)
D: usually 10–13 ft. (3.5–4.5 m), to 33 ft. (10 m) in alluvial flats

- Needles: linear, 0.75–1 in. (2–2.5 cm) long, arranged in flat sprays. (Leaves from the upper portion on the canopy and on cone-bearing branchlets are often more awl-like and closer to the twig.)
- Cones: barrel-shaped 0.75–1.25 in. (2–3 cm) long
- Range: coastal forest fog belt from southern Oregon to Monterey county

The thick, reddish brown bark is resistant to fire and to insect attack. The bark may be up to a foot thick, absorbs moisture readily, and is relatively free of resin, which contributes to its fire resistance.

Reproduction is often from sprouts that grow from lignotubers or basal burls that form at the base of the trunk. Redwoods form olive-sized cones that produce tiny seeds. For a variety of reasons, seeds often fail to grow. The male and female cones often hang in clusters and are found on the same tree.

Native Americans used the roots for fiber, and the wood as planks for canoes, building structures, and other uses.

Redwoods are distinguished from Douglas-firs by the cones, more fibrous bark with long parallel grooves, and leaves (needles), which grow flatter from green twigs.

Redwood Ed is a guide that is similar to *The Conifer Connection*, but it focuses on the Coast Redwood forests. It is available from California State Parks at www.parks.ca.gov/teachersguides and from the Stewards of the Coast and Redwoods.

Douglas-Fir (*Pseudotsuga menziesii*)
H: 125–200 ft. (38–61 m), sometimes to more than 300 ft. (90 m)
D: 24–60 in. (0.6–1.5 m)

- Needles: 0.5–1.5 in. (12–40 mm) long, flexible, arranged around stem, bottlebrush style
- Cones: 2–4 in. (5–10 cm), hanging downward. The 3-pointed bracts protrude from between the scales
- Range: to 7,200 ft., throughout much of the west.

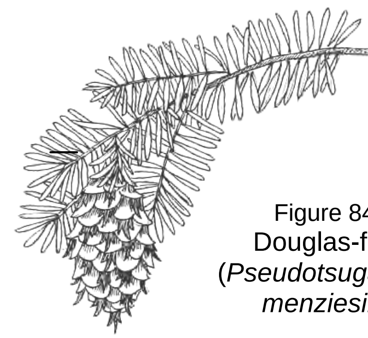


Figure 84. Douglas-fir (*Pseudotsuga menziesii*)

The Douglas-fir is not a true “fir,” hence the hyphenated name. (The genus for hemlock is *Tsuga*, and the Douglas-fir is more closely related to hemlocks than to true firs (Hence, *Pseudotsuga*)).

Needles can be used to make a vitamin C-rich tea.

“Doug-fir” is the major lumber-producing tree in North America (see Figure 2 on page 8).

Mountain Hemlock (*Tsuga mertensiana*)
H: 100 ft. (30 m)   D: 2–4 ft. (60–80 cm)

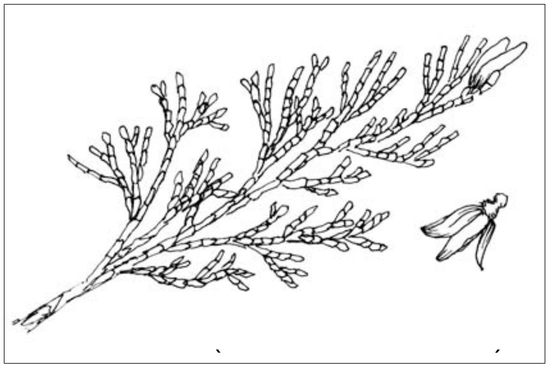
- Needles: 0.25–1 in. (6–25 mm) long, thick, triangular in cross section, blunt tipped
- Cones: 1–3 in. (2.5–7.5 cm) long, hang down
- Range: subalpine forests, 4,000–11,600 ft. elevation throughout the west

Mountain hemlock can often be identified from a distance by the drooping of the topmost branches.

Mountain hemlock seems to be expanding its range into subalpine meadows, perhaps due to global climate change (Lanner, 2007).

Figures 85-88. Mountain Hemlock (*Tsuga mertensiana*)

Incense-cedar (*Calocedrus decurrens)*
H: 80–150 ft. (24–46 m) D: 3–6 ft. (90–180 cm)



- Needles: scale-like, blunt, yellow-green, 0.25–0.75 in. (6–20 mm) in opposite, alternating pairs on twig
- Cones: leathery, cinnamon-brown in color 0.75–1.25 in. (20–31 mm), 2 scales
- Range: northern Oregon to Baja California, mixed coniferous forests to 9,700 ft.

The scale-like leaves are arranged in a flattened pattern. The cones are about an inch long and "winged."

The wood is used for fence boards, rustic paneling, shingles, and pencils. The thick bark helps make the tree fire-resistant. Early loggers scorned this tree because of the "worm holes" in its wood, but incense-cedar is now a valued lumber tree. The tannins and phenols in the wood not only give it a red color and pleasant odor, but repel insects and resist decay (Lanner, 2007) (see Figure 3 on page 8).

Sierra Juniper (Western Juniper) (*Juniperus occidentalis)*
H: 15–50 ft. (4.5–15 m) D: 1–3 ft. (30–90 cm)

- Needles: scale-like, grayish green to bluish green, arranged in whorls around twig
- Cones: berry-like, bluish-black on underside, lighter on top, 0.25–.38 in. (6–10 mm) in diameter
- Range: California and western Nevada

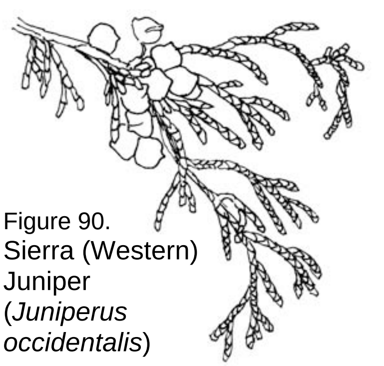


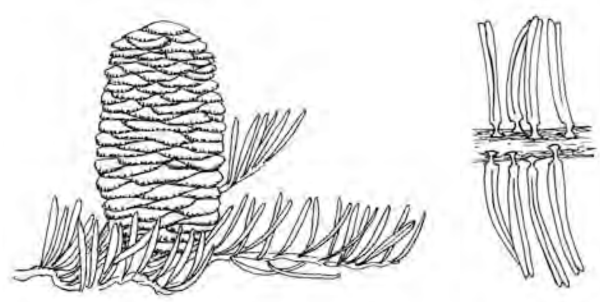
Figure 90. Sierra (Western) Juniper (*Juniperus occidentalis*)

Generally found at 4,000–10,000 feet elevation, the Sierra juniper often grows in rocky areas near lodgepole, Jeffrey and whitebark pines, mountain hemlock, and California red fir. These trees are often short and broad-crowned. The leaves are scale-like and protrude in different directions around the stem (which distinguishes it from incense cedar with its flattened arrangement) (Lanner, 2007).

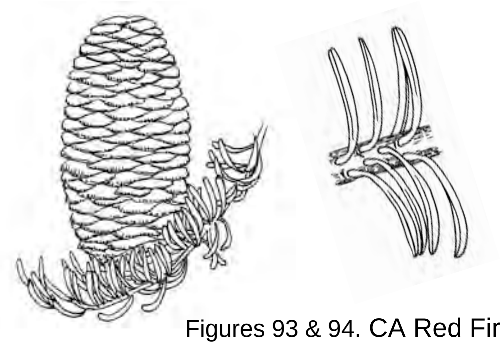
Trees may be spaced a mile or more apart, with seed distribution somewhat dependent on birds and mammals, and germination somewhat dependent on having passed through the digestive tract of an animal (Arno, 1973).

White Fir (*Abies concolor)*
H: 130–180 ft. (40–55 m)   D: 40–60 in. (1–1.5 m)

- Needles: 1.5–2.75 in. (4–7 cm) long, arranged in either flat or V-shaped sprays
- Whitish band on top, rounded tip, base of needle resembles suction cup
- Flattened (will not roll between the fingers)
- Cones: barrel-shaped, 3–5 in. (7.5–12.5 cm) long, held upright on branch
- Range: 3,000–10,000 ft. elevation in California; also grows in the Rocky Mountains



Figures 91 & 92. White Fir (*Abies concolor*)



Figures 93 & 94. CA Red Fir (*Abies magnifica*)

White fir is often found growing in a mixed-conifer forest with a variety of other conifers. White firs are susceptible to fire, but with the absence of fires in most forests today, they may replace pines or other conifers, including the Giant Sequoia, because the firs are more shade-tolerant (Lanner, 2007). They generally grow at lower elevations than the red fir (Arno, 1973). White fir is important for lumber and is also often used as a Christmas tree (see Figure 4 on page 9).

California Red Fir (Silvertip Fir) (*Abiesmagnifica*)
H: 150–180 ft. (45–55 m)   D: 4–5 ft. (1.2–1.5 m)

- Needles: 0.75–1.5 in. (2–4 cm) long. Base of needle tends to parallel the twig so that the needle resembles a hockey stick. They are triangular or square in cross section and can be rolled between the fingers.
- Cones: barrel-shaped, 6–9 in. (15–23 cm) long, held upright on branch, clustered near the top of the tree. The cones generally disintegrate on the tree, releasing their seeds in the fall and winter.
- Range: 4,000–9,000 ft. in Sierra, southern Cascades, Klamath Mountains, and northern Coast Ranges.

Red firs can grow in a mixed conifer forest with white fir or other conifers, or they can grow in nearly pure stands. The seeds provide an important food source for a variety of birds, rodents, and other animals (Lanner, 2007) (see Figure 1 on page 8).

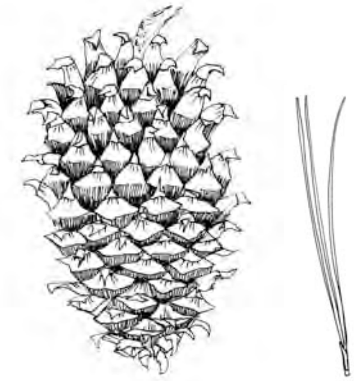
Pines and Firs: Pine tree needles are enclosed in a sheath at the base, and the cones hang down or are held close to the branch, as opposed to firs that have individual needles without sheaths, and cones held upright on the branch.

Coulter Pine (Bigcone Pine) (*Pinus coulteri)*

H: 30–85 ft. (9–26 m)   D: 12–30 in. (30–75 cm)

- Needles: bundles of 3, dark green to bluish green, 6–12 in. (15–30 cm) long
- Cones: to 14" in length, symmetrical
- Range: dry areas Contra Costa County to Baja, California, 500–7000 ft.

Coulter pine is renowned for its huge cone, one of which was measured at 20" in length and weighed eight pounds. They generally grow in coastal ranges in chaparral, oak woodlands, or lower elevation pine forests (Lanner, 2007).



Figures 95 & 96. Coulter Pine (*Pinus coulteri*)

Lodgepole Pine (tamarack pine, shore pine) *(Pinus contorta)*

H: 60–110 ft. (18–33 m)   D: 10–18 in. (25–45 cm)

- Needles: bundles of two, twisted, yellowish green, 1–3" (2.5–7.5 cm) long
- Cones: egg-shaped to spherical, 1.5–2" (4–5 cm) long
- Range: montane and subalpine forests from Washington to Baja California

The lodgepole pine is wide-ranging, with at least four recognized subspecies. One group lives on acidic soils in Mendocino County and forms a “pygmy forest” of trees only a few feet tall (Lanner, 2007) (see Figure 27 on page 35).

The common name comes from their use by Native Americans for lodges (teepees).

The larvae of a needle-miner moth have killed large numbers of lodgepole pines, but since this is a natural predator on the tree, there seems little threat that they will wipe out the species (Arno, 1973) (see Figure 32 on page 37).

Figures 97, 98, 99. Lodgepole Pine (*Pinus contorta*)

Monterey Pine (*Pinus radiata)*

H: 50–125 ft. (15–38 m)   D: 2–3 ft. (60–90 cm)

- Needles: bundles of three (sometimes two), dark green, 4–6 in. (10-15 cm) long
- Cones: asymmetrical, persistent, often in whorls of 3–5 on a branch
- Range: native to coastal central California, but planted widely throughout the world

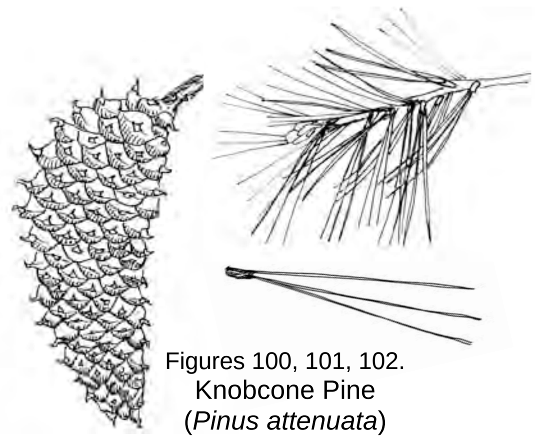
In its natural habitat, *Pinus radiata* is not a good lumber tree. But due to selective breeding and transplanting to other habitats, this fast-growing pine has become an important lumber and paper pulp tree in many areas of the world. In California, it is mainly grown as an ornamental tree.

The cones and needles look much like those of the knobcone pine (page 79).

Knobcone Pine *(Pinus attenuata)*
H: 20–40 ft. (6–12 m) D: 1–2 ft. (30–60 cm)

- Needles: bundles of three (sometimes two), yellow green, 3–6 in. (7.5–15 cm) long
- Cones: asymmetrical, persistent, often in whorls of 3–5 on a branch
- Range: throughout California in regions with poor soils

The knobcone pine is strongly dependent on fire for reproduction. The cones rarely open until a fire passes through the stand. When they get hot enough, the cones burst open, releasing thousands of pine seeds onto the earth even as it is still smoldering. The trees are short-lived and begin to die when about 50–60 years old. The species is thus dependent on periodic fires to release the seeds into a mineral rich ash in an area where the competition has been burned away.

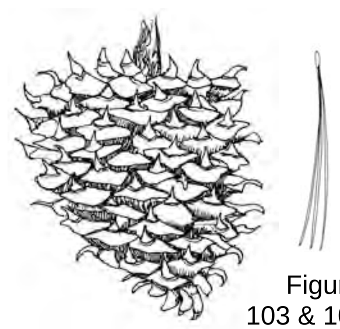


Figures 100, 101, 102.
Knobcone Pine
(*Pinus attenuata*)

Knobcone pines are very similar to the Monterey pine and hybridize with them in the Santa Cruz Mountains. Because their cones stay closed for so long, knobcone and Monterey pines are referred to as closed-cone pines.

Gray Pine (Foothill Pine, Ghost Pine) (*Pinus sabiniana*)
H: 40–80 ft. (12–24 m) D: 1–3 ft. (30–90 cm)

- Needles: bundles of three, grayish green, 7–17 in. (18–43 cm) long
- Cones: generally symmetrical, oblong to egg shaped, 6–10 in. (15–25 cm) long
- Range: foothill woodlands and chaparral areas throughout much of California from 100–7,000 ft elevation



Figures 103 & 104.
Gray Pine (*Pinus sabiniana*)

Figure105.
Gray Pine
(*Pinus sabiniana*)

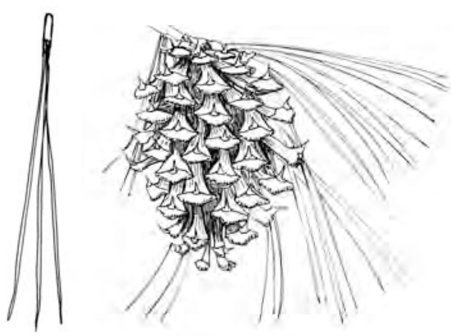
Relatively small and often with branching trunks, the gray pine has never been an important lumber tree. However, it provided fuel for the steam engines that drove much of California's gold mining in the Sierra Nevada.

The large nuts of the Gray pine provided a valuable food source to Native Americans.

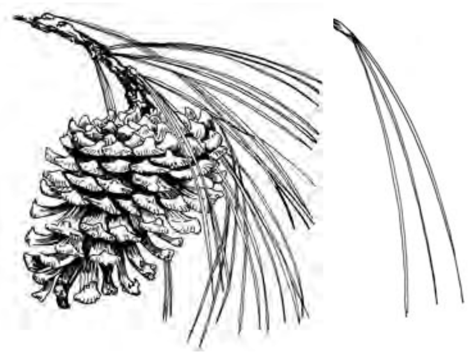
Ponderosa Pine *(Pinus ponderosa)*
H: 100–180 ft. (30–55 m)   D: 3–4 ft. (90–120 cm)

- Needles: bundles of three, green to yellowish green, 4–11 in. (10–28 cm) long
- Cones: egg-shaped to conical, deciduous, 3–6.5 in. (7.5–16 cm) long, slender spines that point outward (as opposed to the similar appearing Jeffrey Pine, which has spines that point inward, toward the center of the cone)
- Range: Throughout much of western North America. In California, from 500 ft. elevation in the Sacramento Valley to over 9,500 ft. in the Sierra Nevada

The Ponderosa pine does best where disturbances such as fires expose bare soil for seed germination and remove other plants that compete for sunlight and water. Fire suppression allows competing species to gain a foothold and results in the build up of fuels so that when a fire does get started it burns hotter and higher, possibly into the crowns of the trees (see Figure 31 on page 37, and Figure 39 on page 45).



Figures 106 & 107. Ponderosa Pine (*Pinus ponderosa*)



Figures 108 & 109. Jeffrey Pine (*Pinus jeffreyi*)

Jeffrey Pine *(Pinus jeffreyi)*
H: 80–140 ft. (24–43 m)   D: 3–4 ft. (90–120 cm)

- Needles: bundles of three, bluish green, 7.5–11 in. (19–28 cm) long
- Cones: egg-shaped to cylindrical, 5–10 in. (12.5–25 cm) long, deciduous
- Range: 200–10,000 ft. elevation, Cascades, Klamath Mountains, Sierra Nevada, Tehachapi, San Bernardino and other ranges

Similar in appearance to the Ponderosa, Jeffrey pine will even hybridize with it. Both are very important lumber trees, and are called “yellow pines” (see Figure 38 on page 44). Like Ponderosa pine, Jeffrey pine does best where frequent fires remove competition.

Ponderosa pine cones have spines that point outward, making them “prickly.” Jeffrey pine cones have spines that point downward. Some also say that Jeffrey pine bark smells like pineapple or vanilla.

Teaching Idea
*To distinguish between Ponderosa and Jeffrey Pine, remember: **P**rickly **P**onderosa and **G**entle **J**effrey (or My friend Jeff won’t hurt me.)*

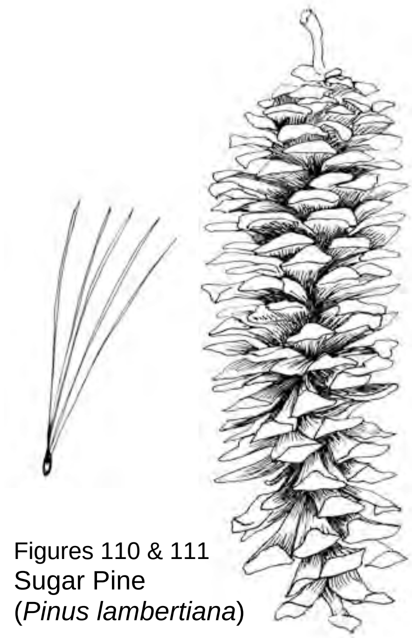
Sugar Pine *(Pinus lambertiana)*
H: 175–200 ft. (53–61 m) D: 3–5 ft. (90–150 cm)

- Needles: bundles of 5, dark green to bluish green, 2–4 in. (5–10 cm) long
- Cones: cylindrical, 10–24 in. (26–60 cm) long
- Range: north-central Oregon to Baja. In California, from 1,000–10,000 ft.

The sugar pine produces the longest cones of any pine, and the world's tallest pine is a 270 ft. tall sugar pine in Yosemite National Park (Stuart and Sawyer, 2001). The large cones can often be seen silhouetted against the sky in tall trees.

This magnificent tree is an important lumber tree. Sutter's mill, of gold rush fame, was built to mill sugar pine (Arno, 1973).

Sugar pine is especially susceptible to white pine blister rust (see Western White Pine, below) (Lanner, 2007).



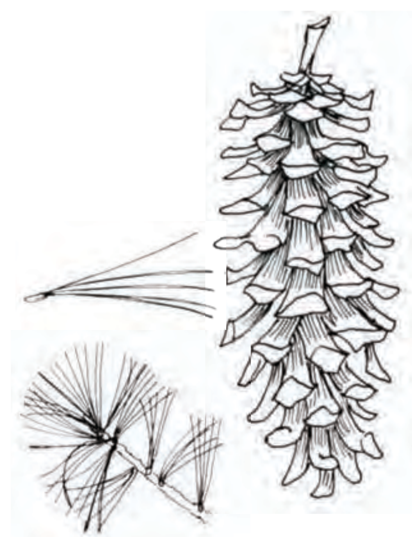
Figures 110 & 111
Sugar Pine
(*Pinus lambertiana*)

Western White Pine (Silver Pine, Mountain Pine) *(Pinus monticola)*
H: 120–180 ft. (37–55 m) D: 2–4 ft. (30–120 cm)

- Needles: bundles of five, bluish green, 2–4 in. (5–10 cm) long
- Cones: cylindrical, curved, 5–10 in. (12.5–25 cm) long
- Range: Montane and subalpine mountains from southern Sierra to the northwest and the Rocky Mountains. In California, mostly from 5,000–1,000 ft., but down to 500 ft. in Del Norte County.

The Western White pine generally grows in mixed conifer forests with lodgepole and Jeffrey pine, hemlock, and red fir, but it sometimes forms extensive stands.

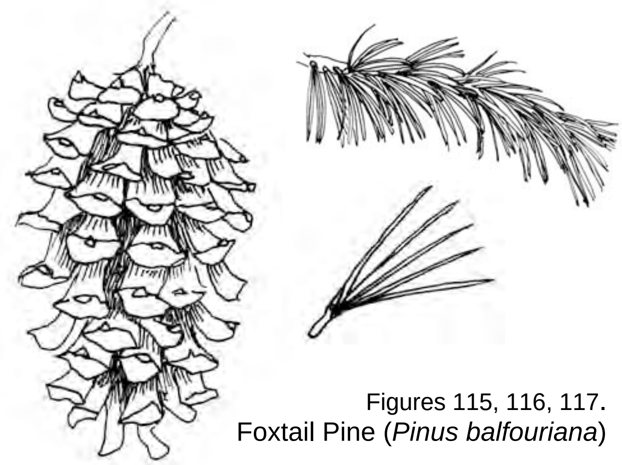
This pine is susceptible to white pine blister rust, which is caused by a fungus that requires alternate hosts of *Ribes* bushes such as currant and gooseberry, and pine trees. The disease was introduced from Europe, and foresters have been trying to develop resistant trees (Arno, 1973).



Figures 112, 113, 114.
Western White Pine
(*Pinus monticola*)

Foxtail Pine (*Pinus balfouriana*)
H: 30–60 ft. (9–18 m) D: to100 in. (2.5 m)

- Needles: bundles of five, sometimes four; 0.75–1.5 in. (20–40 mm) long
- Cones: egg shaped to barrel shaped, reddish brown, 3.5–5 in. (9–12.5 cm) long
- Range: near tree line (see below).



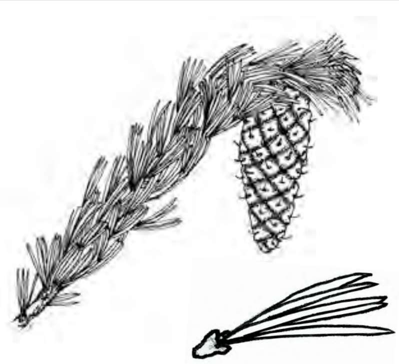
Figures 115, 116, 117. Foxtail Pine (*Pinus balfouriana*)

The foxtail pine is found in two areas separated by about 300 miles. One population is in the Klamath ranges in northern California, while the southern population is mostly in and near Kings Canyon and Sequoia national parks. They are found almost exclusively in California, with a small population a mile or so into Oregon.

Great Basin Bristlecone Pine (*Pinus longaeva*)
H: 30–40 ft. (9–12 m) D: 1–6 ft. (30 cm–1.8 m)

- Needles: bundles of five; 0.5–1.5 in. (12–40 mm) long
- Cones: egg shaped to barrel shaped, reddish brown, 2–5 in. (5–12.5 cm) long
- Range: Great Basin regions of California, Nevada, and Utah, 7,500–12,000 ft.

Figure 118. Great Basin Bristlecone Pine (*Pinus longaeva*)



Figures 119, 120. Great Basin Bristlecone Pine (*Pinus longaeva*)

Growing in the harsh conditions high in the White Mountains, the bristlecone pine is the oldest known living thing. Several have been found to be over 4,000 years old. The oldest known tree was cut down (!) in 1964. The initial ring count yielded an age of 4,844 years, but a subsequent count indicated that it was at least 4,862 year old when cut (Lanner, 1999).

Exotic Species

Nonnative or "exotic" species of plants and animals often become problems when they are introduced into new ecosystems. One reason for this is that their natural controls are often absent. Without natural controls, they can often out-compete native species.

Over 3,000 species of nonnative plants have been introduced into the wildlands of the U.S. About 400 of those are considered to be invasive, and invasive plants cover about 133 million acres in the U.S. It is estimated that invasive plants take over an additional 1.7 million acres each year! (Rapp, 2005).

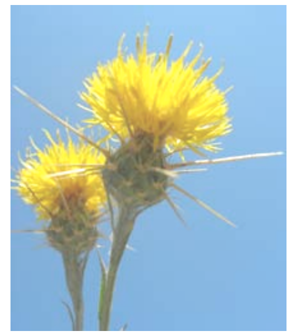


Figure 121. Star Thistle. *Centaurea* spp.

Exotic plants that have become problems include various brooms and gorse as noted above, eucalyptus, and a variety of thistles. White pine blister rust, which threatens several species of pine, was introduced from Europe. (See pages 47–49.)

Many of our most harmful insect species are also introduced.

Teaching Idea

Several organizations and agencies have produced brochures about local invasive species. Invite your local chapter of the California Native Plant Society, your local Resource Conservation District, or a representative of the U.S. Forest Service to talk to your class.

Go to the following Web sites:

California Invasive Plant Council: www.ca.-ipc.org
The Nature Conservancy: http://tncweeds.ucdavis.edu
California Department of Food and Agriculture: www.cdfa.ca.gov
National Invasive Species Council: www.invasivespecies.gov

Obtain copies of booklets such as:

Noxious Weeds of the Sierras: Nevada or Placer County Agricultural Commissioner's Office (530) 273-2648 or (530) 885-3046, respectively

Don't Plant a Pest: (Lake) Tahoe Conservation District (530) 543-1501

Selected Invasive Weeds of the Central Sierra Nevada: download color brochure at: http://ceeldorado.ucdavis.edu/files/40826.pdf

Silent Threats: Non-Native Species Invading Our Wildlands: California State Parks: (916) 653-6725

The U.S. Department of Agriculture has a *Woodsy Owl Invasive Weeds Activity Kit* that may be useful with younger students. It is publication PA-1749.

The U.S. Bureau of Land Management and other groups have produced a poster called Invasive Weeds: A Growing Pain. It includes several suggestions for student activities and investigations. Contact the BLM Weed Team at (406) 255-2766.

Animals (Kingdom *Animalia*)

Included here are some common types of animals that students might encounter in coniferous forests. Obviously there are many others. See the excellent field guides listed in the Appendices for identification and information about forest animals.

Invertebrates: Animals Without Backbones

Invertebrates are extremely important in any ecosystem, including coniferous forests. Many kinds of mites, spiders, worms, insects, and other invertebrates can be found in the soil, humus, and duff. Insects feed on animals and all parts of living plants; slugs, insect larvae, millipedes, and worms help decompose dead organisms. Flies, butterflies, and bees pollinate flowers. Mosquitoes and ticks feed on blood. Yellow jackets and scorpions sting. All provide food for other organisms.

While invertebrates are extremely important, most are small and students may not notice them. Watch for opportunities to point them out.

Teaching Idea

The scientific names of organisms can be used to teach word roots that will be very helpful to students as they learn new vocabulary. Word roots for some of the animals described below are provided.

Phylum Arthropoda

Word origins: The arthropods are animals that have jointed appendages such as legs, antennae, and mouth parts. "Arthro-" refers to joints…*Arthritis* is an inflammation of the joints. "-poda" refers to feet…A *podiatrist* is a foot doctor.

Class Insecta

Longhorned (round-headed) Wood-Boring Beetle (family Cerambycidae)
0.5–2 in. (1–5 cm) long

These beetles are often large and have long antennae. Most adults feed on flowers and lay their eggs in crevices in the bark of weakened or dying trees, or on freshly fallen or cut trees.

Their larvae often have round heads, and chew round tunnels in wood.

Woodpeckers are important predators of the larvae of these and short-horned wood borers.

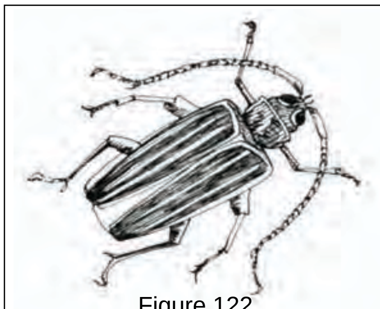


Figure 122.
Longhorned Wood Boring Beetle (family Cerambycidae)

Shorthorned (flat-headed, metallic) Wood-Boring Beetle (family Buprestidae)

0.5–1.25 in. (1–3 cm) long

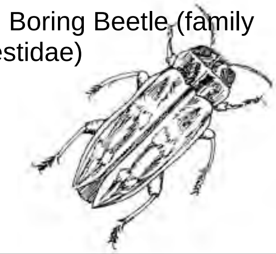
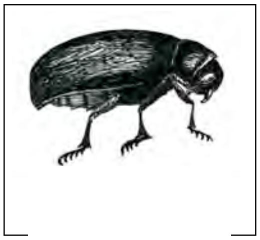


Figure 123. Shorthorned Wood Boring Beetle (family Buprestidae)

Shorthorned wood borer larvae often have flattened heads and chew tunnels that are oval in cross section in wood or under bark. Many do serious damage to trees, especially if the trees have already been weakened by fire, disease, or climate change.

Many are brightly colored with iridescent or shiny green, copper, and gold hues.



Bark or Engraver Beetles (family Scolytidae)

Figure 125. Galleries of bark beetle (bark removed).

0.25–0.5 in. (6–8 mm) long

These small cylindrical beetles feed on the inner bark or wood of trees. Both adults and larvae feed by excavating “galleries” of tunnels under the bark. The pattern, which varies to some degree according to the species of beetle, is created by larvae eating their way away from the brood gallery tunnel. These beetles cause major damage to many kinds of trees, including pines, Douglas-fir, spruce, and others. When trees are weakened by drought or fire, they may succumb to infestations. See Figures 33–34 on page 40.

Ten-lined June Beetle (family Scarabaeidae)

1 in. (2.5 cm) long

The ten-lined June beetle is a common scarab beetle. The larvae feed on roots. Like many other insects, they are often attracted to porch lights. The male’s feathery antennae help it locate females. Some scarab species feed on dung.

Figure 126. Ten-lined June Beetle (genus *Polyphilla*)

Teaching Ideas

Have students investigate ancient Egyptian beliefs about scarab beetles.

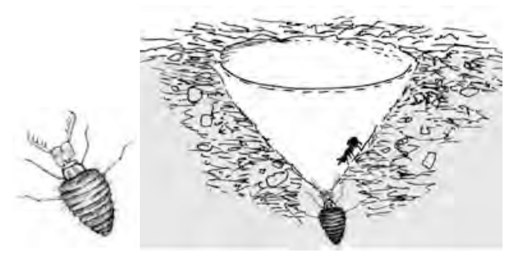
Many types of insects are attracted to lights, especially ultraviolet (“black”) lights. Hang a sheet and shine an ultraviolet light on it at night to see what types of insects are attracted.

Caution

Caution the students not to look directly at the light! It can harm their eyes.

Ant Lion (family Myrmeleontidae)
Larva: 0.5 in. (1 cm) long
adult: 1.25 in. (2.5 cm) long

Adult ant lions have membranous wings with visible veins.



Figures 127 (left) and 128 (right).
Ant lion larva or "doodle bug."

Figure 129.
Ant Lion adult
(family Myrmeleontidae)

The larva of the ant lion, sometimes called a "doodlebug," digs a cone-shaped pit in the sand, often at the base of a tree or rock where it is not likely to be stepped on.

If an ant blunders into the funnel, it slides down to the waiting jaws of the larva buried at the bottom of the pit.

Teaching Idea

Students can try feeding a doodlebug by dropping an ant into the funnel. They should watch for a stirring or "popping" at the bottom of the funnel when the ant lion larva grabs its prey.

Water Strider (Family Gerridae; *Gerris* spp.)
0.5–1 in. (1–2.5 cm) long

Students often mistakenly call this insect a "water spider." It is not a spider, but rather an insect of the order Hemiptera, which is the order of the "true bugs". They stride or walk on the surface of the water. Water striders feed on insects that fall to the surface of the water. There are both winged and wingless species.

Figure 130.
Water Strider
(family Gerridae,
Gerris spp.)

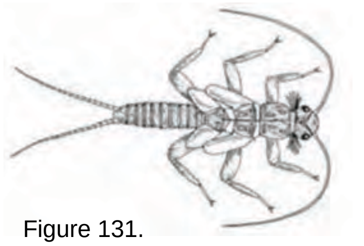


Figure 131.
Stone Fly (family Perlidae)
(Drawing courtesy of
Izaak Walton League)

Stone Fly (family Perlidae)
Larva: 0.75–1.25 in. (1.5–3 cm) long
Adult: 0.75–1.5 in. (1.5–4 cm) long

Stonefly larvae or nymphs are often found under rocks and logs in streams. They require cold, well-oxygenated water and are thus an indicator of a healthy stream.

Larvae usually have two "tails," while mayfly larvae usually have three, but there is variation.

Crane Fly (Family Tipulidae and others)
Adults: Up to 2 in. (5 cm) body length

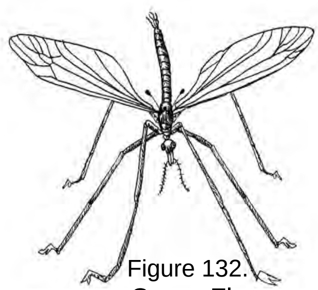


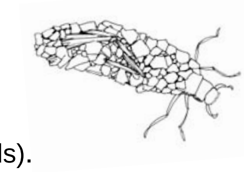
Figure 132.
Crane Fly

The crane flies resemble overgrown mosquitoes, but they don't bite. Crane flies are most commonly found in areas where there is abundant vegetation and it is fairly damp. Larvae may live in water or wet soil where they feed on decaying vegetative matter. Sometimes they are called "mosquito hawks," although the adults are not predaceous. The larvae of most species feed on plants, but the larvae of some species are predaceous.

Word Origins: True "flies", including crane flies, have two wings. The order name, Diptera, refers to the two (Di) wings (-ptera).

Caddisfly (various families including Limnephilidae, Bracdhycentridae, et al.)
Naiad/larva: 0.5–1.25 in. (1.5–3 cm) long Adult: 0.5–1 in. (1–2.5 cm) long




Figures 133 (left), 134 (middle), 135 (right). Caddisfly larvae (niads).
(133 courtesy of the Izaak Walton League; 134 and 135 by Faith Rumm)

Most immature caddisflies (called **naiads**) form a protective cocoon-like case in which they develop, although some species are "free-living." These cases may be made of twigs (Figure 133), sand grains (Figure 135), or even hollowed out sticks (Figure 134). Adults may be predators, filter feeders, or detritus feeders, which feed on material that has fallen to the stream bottom.


Figure 136.
Carpenter Ant
(family Formicidae,
Camponotus spp.

Carpenter Ant (family Formicidae; *Camponotus* spp.)
0.75–1 in. (1–2.5 cm) long

Carpenter ants are the largest ants in North America. Carpenter ants generally nest in logs and stumps, on which they feed. Most other types of ants nest in the ground.

Yellow Jacket (Family Vespidae, Genus *Vespula*)
0.75–1 in. (1–2.5 cm) long

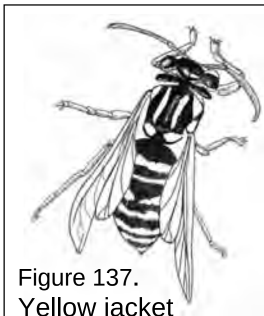


Figure 137. Yellow jacket (*Vespula* spp.)

Yellow jackets are very helpful in the forest, as they feed on any animals that might die. Yellow jackets are carnivorous wasps that build paper nests either in the ground or in trees. They can be very aggressive and should be left alone. Unlike honeybees, which die after stinging, yellow jackets can sting repeatedly.

Caution

If the children are eating lunch, yellow jackets might be quite persistent in trying to get to their food. Sometimes setting an open can of cat food a few yards from the lunch site can attract the yellow jackets away from the lunch area. Do not leave the cat food can behind.

Word origins: Bees, ants, and wasps are in the order Hymenoptera. “Hymen-“ refers to a membrane and “-ptera” refers to wings. The hymenoptera have membranous wings.

Tick (Class Arachnida, Subclass Acarina)
Ticks are arachnids, which puts them in the same class as spiders and mites. Ticks have four pairs of legs and resemble watermelon seeds when not engorged by a recent blood meal. Ticks are small (about 1/8" – less than 1/4" long) when not engorged, but they enlarge significantly as they feed on their host. Ticks wait on a bush or other plant until an animal brushes against it. They then drop onto the animal and bury their mouth parts in their host to feed.


Figure 138. A non-engorged tick

Wearing light colored clothing may facilitate spotting ticks before they attach themselves. After landing on a person, ticks often crawl until they come to a barrier such as a belt line, the top of the socks, or a sleeve. The tick may stop at the constriction and burrow its head at that point, so one should pay special attention to those areas. Insect repellants may help keep ticks off, and tucking shirts and pant legs in may help keep them off of skin.

Caution

Ticks carry several diseases, most notably Lyme disease, so it is important to remove them as soon as possible. They do NOT “screw themselves in,” so don’t try to “unscrew” them! The recommended method for removal is to use tweezers to grasp the animal as close to the skin as possible and gently but firmly pull it straight out. Hopefully, the tick will release its hold before the mouth parts break off. If parts remain after removing the body, use tweezers to remove as much as possible. The puncture wound should be treated with disinfectant.

Some people recommend saving the removed tick in a small jar of alcohol or in the freezer in case one develops symptoms of a disease and identification of the tick becomes important.

Parents should be notified to watch for any sign of infection, rash, or ill feeling. If symptoms develop, the child should see a doctor as soon as possible.

Black legged ticks or deer ticks are the transmitters of the bacterium that causes Lyme disease. The adults are tiny, about the size of a sesame seed, and the larvae are even smaller. Symptoms of Lyme disease vary greatly and include such diverse and common signs as fatigue, chills, fever, headache, muscle or joint aches, and swollen lymph nodes. A “bulls-eye” rash may develop in many cases, **but it doesn’t always appear.** Whether a rash appears or not, if a tick-bitten person displays any symptoms of Lyme disease, a doctor should be consulted as soon as possible.

Teaching Idea

Before going on a field trip, have students do some research on ticks and tick-borne diseases. A useful book is Outwitting Ticks, by Susan Hauser (2001). Internet searches can yield useful information and illustrations, including descriptions of tick-borne diseases. Local veterinarians or doctors may be willing to visit the class and discuss tick-borne diseases, prevention, and treatment.

Millipede (Phylum Arthropoda, Class Diplopoda)

Millipedes are sometimes mistakenly called “thousand-leggers.” While they have many legs, they don’t have a thousand. They are sometimes confused with centipedes but can be distinguished by having two legs per body segment and a more rounded body shape when viewed from the front.

Figure 139. Millipede. Note two pairs of legs per section, rounded body shape.

Millipedes serve an important role in the forest as they feed on dead matter and help return the nutrients to the soil through decomposition. While not poisonous, many millipedes can excrete a smelly fluid when threatened.

Word origins: “Milli-“ comes from the Latin for a thousand, and “-ped” refers to feet. A *mille*nnium is a thousand years, and a meter has a thousand *milli*meters. *Ped*estrians walk. The “di-“ in Diplopoda refers to the 2' or legs per segment. Again, “-pod” refers to feet.

Centipede (Phylum Arthropoda, Class Chilopoda)

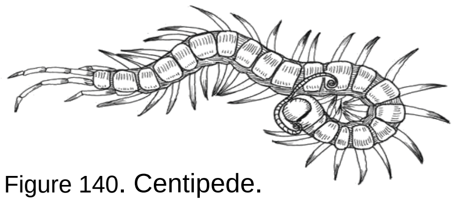


Figure 140. Centipede.
Note one pair of legs per segment.

Centipedes are sometimes called "hundred-leggers," but they don't have a hundred legs. To distinguish centipedes from millipedes, check the number of legs per body segment: centipedes have one pair of legs per segment while millipedes have two pairs. Also, centipedes generally are more flattened in cross section.

Caution

Unlike millipedes, centipedes are carnivores, using a poison claw near their mouth to kill their prey and also for defense. I have never known anybody to actually be "bitten" or stung by one, but it is best to advise students to use forceps, a leaf, a piece of paper, or other tool when picking up a centipede. This will also reduce the chance of injuring the animal.

Word origins: "Centi-" refers to a hundred; there are a hundred cents in a dollar and a hundred years in a century.

Fish

Salmon, and their relatives the trout and steelhead trout (which are rainbow trout that spend part of their lives at sea), are collectively referred to as "**salmonids**." The main distinguishing characteristic of salmonids is a small, flexible adipose fin on the back between the dorsal fin and the tail. They also have small scales. (As compared to perch, bass, and most other fish, which have relatively large scales.)

Salmonids may be seen in streams and rivers in coniferous forests and are important to both sport and commercial fisheries. Over-fishing, introduction of exotic species, and habitat destruction threaten some populations and even entire species of salmon.

Students should be aware that many lakes in the higher mountains do not have native or natural populations of trout (or of any fish). Years of planting trout for recreational fishing have introduced them into many high altitude lakes. As a result, amphibians such as the endangered mountain yellow-legged frog have been eliminated from up to 85% of the locations where they were found in the early 1900s (Rosenthal, 2003).

After laying and fertilizing eggs in shallow gravel "nests," called **redds**, adult salmon die. When salmon and bears were plentiful, the feeding bears helped transfer nutrients from the sea to the forest through their feces. After hatching, the young fish develop in streams as they make their way back to the ocean where they spend varying lengths of time growing to adult size. As adults, salmon return to freshwater streams, usually the same one where they hatched, to breed and complete the cycle.

A healthy salmonid stream has a variety of conditions. Fast moving water and ripples help oxygen dissolve in the water. Large rocks and woody debris, such as logs, help form deep, cool pools where salmonids can hide and seek shelter from warm water at the surface. Salmonids need cool, oxygen-rich waters, and destruction of streamside vegetation can cause a deadly increase in water temperatures. Gravelly bottoms are needed for egg-laying areas. Silt can bury potential nesting sites or smother eggs. These are main reasons why timber companies are required to leave “buffer zones” along fish-bearing streams.

Except for steelhead trout, which are a type of rainbow trout (*Oncorhynchus mykiss*), trout spend their entire lives in fresh water streams. Steelhead spend 1–3 years at sea before returning to fresh water to spawn. Rainbow trout are typically 6–8" (15–20 cm) long in small streams and may reach 16" (41 cm) and 1.5 pounds in rivers or lakes. Steelhead may reach 41" (1.1 m) in length and over 42 pounds (19.1 kg) in weight, but average 2.5–12 pounds (1.1–5.4 kg).

Figure 141. Salmon and young (smolt).

The Chinook or king salmon (*Oncorhynchus tshawytscha*)

The largest of the salmon in the west, reaching almost 6' in length and weighing as much as 135 pounds! The average is 10–15 pounds. They may travel hundreds of miles up rivers to spawn.

Populations of all types of salmon have decreased greatly since the 1940s, probably due to a combination of over-fishing, habitat degradation, and damming of rivers.

Salmon and trout were, and still are, a very important food source to Native American groups, especially in the north coast region.

Trout (*Oncorhynchus* spp.)
Length varies

Figure 142. Trout (*Oncorhynchus* spp.)

Several species of trout can be found in western coniferous forest streams and lakes. Native trout include Rainbow Trout and the Golden Trout, California’s official fish. Non-native species such as Eastern Brook and Brown Trout have been planted in many lakes and rivers that originally had native Rainbows or no trout. In some areas the native fish are threatened by either competition with introduced species or hybridization. Introduced fish also threaten to wipe out native amphibians such as the red-legged and yellow-legged frog.

Teaching Ideas

<u>Web of Water: Life in Redwood Creek</u>, by Maya Khosla (1997) is a very nicely illustrated book that tells the story of life in a healthy creek.

Invite parents, commercial fishermen, or people from a local fishing club or Trout Unlimited to speak to the class about protecting fish habitat.

Amphibians

Rough-skinned Newt (*Taricha granulosa*)
Body: 2–4 in. (5–10 cm) long

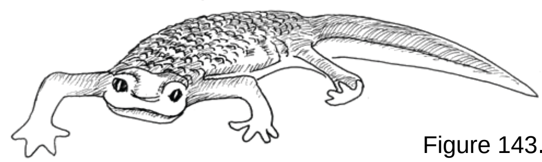


Figure 143.
Rough-Skinned Newt (*Taricha granulosa*)

Sometimes called mud puppy or water dog, this is one of the more commonly seen newts. Their upper surface is dark brown, while the underside is a bright orange. Glands in their skin secrete a poisonous chemical that repels most predators.

Caution

The poisonous chemicals can be found throughout the body, and newts can be highly toxic to most vertebrates, including people. Wash hands after handling a newt. In wet weather, they may wander far from streams.

California Slender Salamander (*Batrachoseps spp.)*
Body: 1.5–3 in. (4–8 cm) long

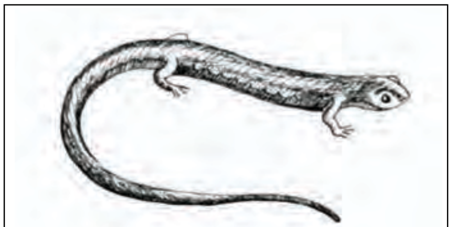


Figure 144. CA Slender Salamander (*Batrachoseps* spp.)

These salamanders have very long, slender bodies and short legs. They are often found under bark, rotting logs, or damp leaf litter.

Their short legs limit their ability to walk far, and several species have developed as populations have become isolated from each other.

Pacific Treefrog (*Pseudacris regilla*) (formerly *Hyla regilla*)
Body about 1–2 in. (3–6 cm)

The treefrog is often found (and heard) in bushes and small trees a considerable distance from water. The color varies from brownish-gray to black to red, to orange to bright green, and tends to resemble its habitat. It can change the shade or darkness of its skin color in a few minutes, changing from light to dark green, for example. The black eye stripe is an important identifying characteristic.

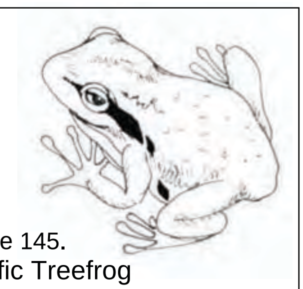


Figure 145.
Pacific Treefrog
(*Pseudacris regilla*)

The **bullfrog** (*Rana catesbeiana*) has been introduced into California from the east. It is an invasive species that has caused damage to populations of many native species such as other amphibians, salmon fry, and young trout.

Red-legged Frog (*Rana draytonii*)
Body about 5 in. (13 cm) long

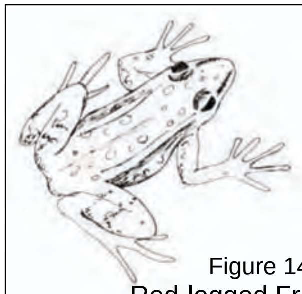


Figure 146. Red-legged Frog (*Rana draytonii*)

The red-legged frog prefers slow-moving water such as ponds or lakes, as opposed to the yellow-legged frog (*R. muscosa*), which prefers faster running water. Its name comes from the reddish coloring on the underside of the hind legs.

In much of its range, the population of the red-legged frog has been seriously reduced by habitat loss, pesticides, and competition with species such as the bullfrog, and predation by non-native fish, including some trout. In the late 1800s and early 1900s, it was an important source of frog legs for human consumption. They are considered a threatened species.

Toad (*Bufo* spp.)
3–5 in. (7–13 cm)

Toads can be distinguished from frogs by their warty skin. Toads have a gland near their eye that secretes a poison that potential predators find distasteful.

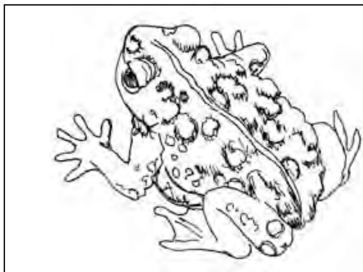


Figure 147. Toad (*Bufo* spp.)

Reptiles

Western Pond Turtle *(Actinemys marmorata)*
5–8 in. (12–20 cm)

This is the only native freshwater turtle in California. Look for it basking on logs or rocks near moving water, marshes, ponds, or lakes. In much of its range, the population is in serious decline due to habitat loss and use as a food source.


Figure 148. Western Skink (*Eumeces skiltonianus*)

Western Skink *(Eumeces skiltonianus)*
10 in. (25 cm)

Skinks have smooth scales. Young western skinks have a striking blue tail, while adults have a reddish tail and head. Their tails are very easily broken off. When broken off, they writhe for several minutes, which may distract a predator long enough for the skink to escape. Regenerating tails are also blue.

Caution

Caution students not to pick up skinks, lest they lose their tails and, therefore, lose an important means of defense.

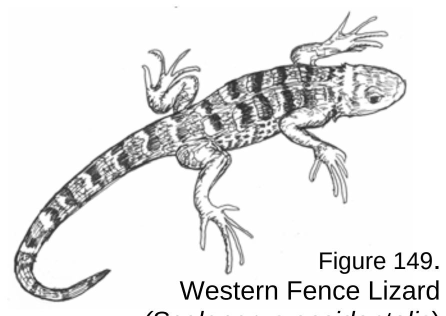


Figure 149.
Western Fence Lizard
(*Sceloporus occidentalis*)

Western Fence Lizard *(Sceloporus occidentalis)*
6–9 in. (15–22 cm) long

Sometimes called the "bluebelly lizard," this is a common lizard in warmer and drier areas such as gassy openings, rocky areas, wood piles, or old buildings. It is generally a grayish color with rough scales. Males have a dark blue belly; female bellies may be gray or light blue.

A protein in the blood of these lizards kills the bacterium that causes Lyme disease. (See *Lizards that Fight Lyme disease* in Appendix V.)

Alligator Lizard (*Elgaria* spp.)
8–13 in. long (20–33 cm)

Generally a lighter green-brown color than the fence lizard, with smoother scales. It is more commonly found in the forest itself than the fence lizard.

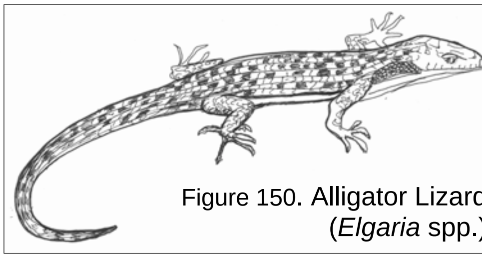


Figure 150. Alligator Lizard
(*Elgaria* spp.)

Caution

When captured, alligator lizards will often try to bite, and large specimens may bite hard enough to break the skin.

Ringneck Snake (*Diadophis punctatus*)
10–22 in. long (25–55 cm)

The upper body of this snake is a uniform blue-gray or dark gray color, with a yellow, orange, or red ring around the neck and a similar colored belly. These pretty snakes are usually found under leaves or other debris.

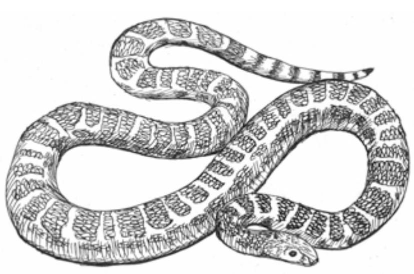


Figure 151. Gopher Snake
(*Pituophis catenifer*)

Gopher Snake (*Pituophis catenifer*)
Up to 6 ft. (1.8 m) in length

This well-camouflaged snake is common in woodland and grassy areas. Distinguish it from the rattlesnake by the head, which is narrower than the body. The gopher snake will sometimes vibrate its tail in dry grass or leaves, making a sound somewhat like a rattlesnake. These snakes help keep the rodent population in check.

Rattlesnake (*Crotalus* spp.)
Up to 5 ft. (1.5 m) in length

Caution

Rattlesnakes of various species can be found in coniferous forests, and children should be cautioned to look before stepping over logs, rocks, or small bushes.

Figure 152.
Rattlesnake (*Crotalus* spp.)

Walking, rather than running, will allow snakes to get out of the way, not to mention allowing children to see more.

Rattlesnakes' color ranges from gray to brownish to dark green, and they may look like gopher snakes. Distinguish them from gopher snakes by the shape of the head, which is triangular and wider than the body. Babies may have only a single "button" for a rattle and, therefore, may not be able to produce a warning rattling sound. Also, babies tend to inject all of their venom when they bite, whereas an adult often uses just a little for a first bite. Like gopher snakes, rattlesnakes help keep the rodent population in check.

Garter Snake (*Thamnophis* spp.)
Up to 4 ft. in length

Several species or subspecies of garter snakes can be found in coniferous forests. Most have light colored stripes running the length of the body. Some types are often found in and around water, while others prefer areas such as meadows, but not really dry areas. Some tend to strike out in self-defense, and they will often secrete a foul-smelling fluid if picked up.

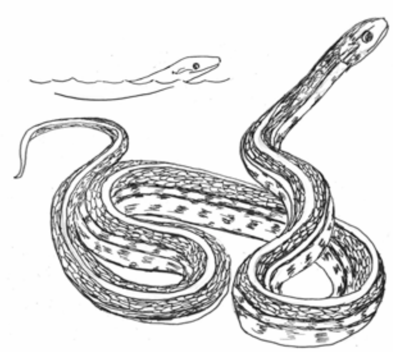


Figure 153. Garter Snake
(*Thamnophis* spp.)

Kingsnake (*Lampropeltis* spp.)
Up to 3.5 ft. (1m +)

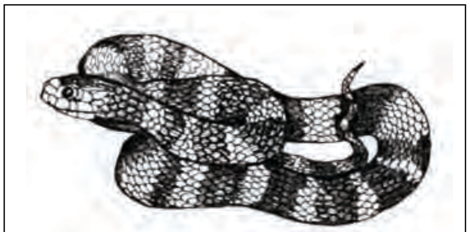


Figure 154. Kingsnake
(*Lampropeltis* spp.)

The dark bands range from dark brown to black.

King snakes feed on lizards, bird eggs, and other snakes, including rattlesnakes. They are constrictors and kill by squeezing their prey.

The California Mountain King Snake (*Lampropeltis zonata*) has red, white (or cream-colored), and black bands.

Birds

Birds are very important to the coniferous forest. They spread seeds, and their droppings fertilize the soil. They consume seeds, but also eat millions of potentially damaging insects. In one experiment, it was found that birds ate more than 80% of the budworm and tussock moth larvae on fir trees! Unfortunately, loss of habitat has resulted in significant declines in the populations of many pest-eating birds (Torgersen and Torgersen, 1995).

Acorn Woodpecker (*Melanerpes formicivorus*)
About 9 in. (23 cm) long

The acorn woodpecker is a striking black and white bird with a red cap and white patch on its outstretched wing. Common where there are oaks, these birds often store acorns by pecking storage holes in snags, bark, or even fence posts or walls of buildings. Such granary trees may be used for many years by a colony of acorn woodpeckers, which live in family groups of up to 16 birds. They also feed on insects during the spring and summer months (Fix and Bezener, 2000).

Figure 155. Acorn woodpecker (*Melanerpes formicivorus*)

Figure 156. Steller's Jay (*Cyanocitta stelleri*)

Steller's Jay (*Cyanocitta stelleri*)
11–13.5 in. (28–33 cm) long

These large blue birds with a dark gray-blue head are easily identified by the pointed crest on the head. Their natural food includes insects and conifer seeds. They can often be seen around picnic areas, noisily searching for scraps of food. Children should be discouraged from feeding them, as human food can be harmful to them. Steller's jays have been known to drive marbled murrelets from their nests by making a hawk-like call. The jays then feed on the young or the eggs. They are often mistakenly called "blue jays."

Northern Spotted Owl (*Strix occidentalis*)
Length/height to 16 in. (40 cm)   wingspan to 42 in. (1 m +)

There are at least four recognized subspecies. The northern spotted owl is apparently more common in northern California than in some other parts of its range. Considered a threatened species, it has been the subject of much controversy because its presence severely restricts logging due to protection afforded by the endangered species act. Yocom and Dasmann (1965) refer to it as "resident and fairly common in the (redwood) region," while Robbins et al. (1966) say that it is "rare." While some books say that it requires old growth forests, recent studies indicate that it is often found in older young-growth forests (Noss, 2000), even reported as commonly found in 30–40 year-old stands of redwoods (Diller, 1996). Spotted owls seem to need older trees and snags for nesting and may be found in younger stands either because of remnants of old trees left there, because of the rapid growth of some species, or because they enter the young-growth from surrounding stands of older trees and snags to forage for food.

A favorite prey for the spotted owl is the flying squirrel, but where the flying squirrel populations are low, they feed on the dusky-footed wood rat and voles. They also eat insects such as large beetles and crickets.

According to the *Field Guide to the Birds of North America* (National Geographic Society, 1999), there is some hybridizing between the spotted owl and the barred owl, *Strix varia*.

Figure 157. Northern Spotted Owl (*Strix occidentalis*)

Great horned owls and barred owls will feed on the spotted owls, and barred owls seem to be encroaching on the spotted owls' range from the east. Some stands of old growth (or at least a diversity of forest types) seem to provide corridors for spotted owl dispersal as they provide some protection from predation by other species (Noss, 2000).

Some biologists have developed the ability to imitate their call and have good success attracting the owls. Sometimes mice are used to attract the owls as the biologists complete their surveys prior to timber harvesting.

Information, pictures, range maps, and even sound recordings can be found on the Internet at: www.owling.com.

Figure 158. Turkey Vulture (*Cathartes aura*)

Turkey Vulture (*Cathartes aura*)
Length 26–32 in. (0.6–0.8 m)   Wing span to 6 ft. (2 m)

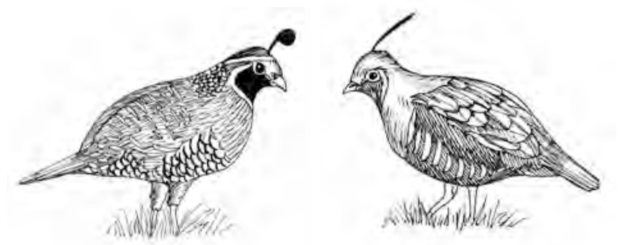
The tremendous wings of the turkey vulture enable it to soar high in the air while using its strong sense of smell to search for carrion. The naked head helps prevent infection from bacteria and parasites.

Figure 159. Red-tailed Hawk *(Buteo jamaicensis)*

Red-tailed Hawk (*Buteo jamaicensis*)
About 23 in. (58 cm) long   Wing span 55 in. (1.5 m)

This hawk can be seen throughout California. It often calls out in a shrill "scream" as it flies. (The call is often added to movie sound tracks.) The red tail color doesn't develop until the bird is mature.

Quail (Mountain and California)
Around 11 in. (28 cm) long



Figures 160 and 161. California Quail (left) and Mountain Quail (right) (family Phasianidae)

Family groups of quail may be spotted in the spring in brushy areas. Mountain Quail migrate to lower elevations in the winter, while California Quail do not migrate.

The California Quail is the State Bird of California.

Anna's Hummingbird (*Calypte anna*)
Length: 3.5–4 in. (8–0 cm)

A variety of hummingbirds can be found in and around coniferous forests. They generally migrate to lower elevations or warmer climates in the winter, but Anna's hummingbird stays in northern California during winter.

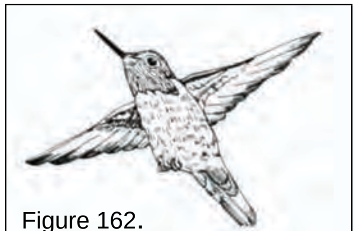
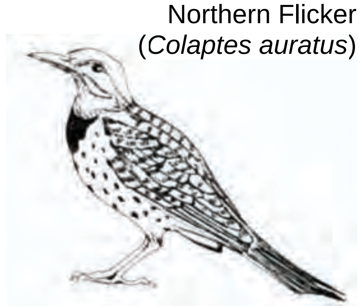


Figure 162. Anna's Hummingbird (*Calypte anna*)

Figure 163. Northern Flicker (*Colaptes auratus*)



Northern Flicker *(Calaptes auratus)*
Length: 13 in. (32 cm)

The Northern Flicker has two forms: the Red-shafted (with red wing and tail linings) and the Yellow-shafted (with yellow wing and tail linings). The Yellow-shafted form usually occurs east of the Rockies, but is not uncommon in northern California from September to April.

The bright red-orange feathers were used by Native Americans as decorations in head-dresses and clothing.

Common Raven (*Corvus corax*)
Length: 24 in. (60 cm) Wingspan: 50 in (1.25 m)

Ravens and their smaller relatives the crows are very intelligent and wide-spread birds. They will feed on almost anything, and will even harass Golden Eagles. Smaller birds of other species will often harass crows and ravens. Ravens figure prominently in Native American mythology.

Figure 164. Common Raven (*Carvus corax*)

Belted Kingfisher (*Ceryle alcyon*)
Length: 11–14 in. (28–35 cm)

Belted Kingfishers are found along rivers and lakes, often perched on a branch over the water. They can dive up to 2' into the water to catch a fish. They nest in tunnels that they dig in the river bank. Their call is a distinctive rattling sound.

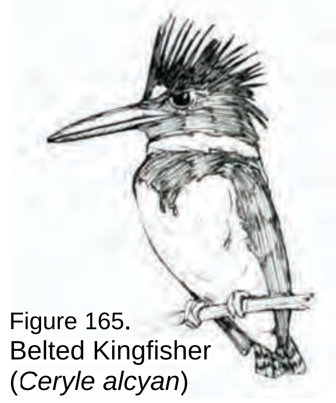


Figure 165. Belted Kingfisher (*Ceryle alcyan*)

Chickadee (*Poecile* spp.)
Length: around 5 in. (12 cm)

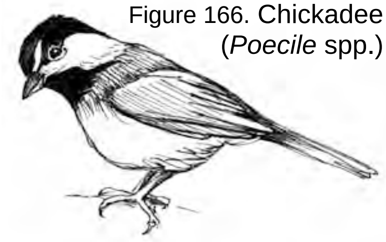


Figure 166. Chickadee (*Poecile* spp.)

A variety of chickadee species can be found in coniferous forests. They can be found even at high elevations feeding on small insects and seeds. The name comes from the sound of their calls.

Mammals

Opossum (*Didelphis marsupialis*)
Total length: 27–33 in. (0.6–0.8 m) Tail: 12–14 in. (30–35 cm)

The opossum is not native to California; it was introduced from the eastern part of North America. As a marsupial, it is more closely related to kangaroos and other marsupials of Central and South America, than to other North American mammals. While the opossum's tail is strong and prehensile, it is seldom actually used to hang from branches. "Possums" are slow moving and commonly killed by cars on the road. They are omnivorous, feeding on invertebrates, small invertebrates, plants, and carrion.

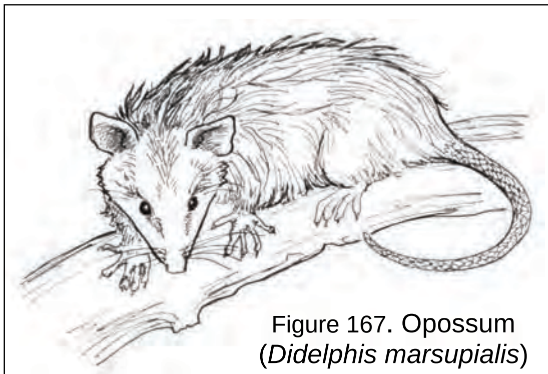


Figure 167. Opossum (*Didelphis marsupialis*)

Bats (Order Chiroptera)

Several species of bats are common in coniferous forests. They feed on insects, finding their prey by emitting high-frequency calls that are generally too high-pitched for people to hear. A few species emit lower frequency calls that humans can hear. They can often be seen at dusk, when they emerge from their nesting areas in rocky crags, trees, or even buildings. Common species include the big brown bat, which is about 4.5 in. long (11 cm), with a wing span of 13 in. (33 cm) and the little brown bat, which is 3.5 in. (9 cm) long, with a wing span of 10.5 in. (26 cm). Students should be cautioned not to pick up a bat if they find it. Bats are fairly common carriers of rabies.

Mice (various genera)

Length: 3–4 in. (7–10 cm) Tail: 2–4 in. (5–10 cm)

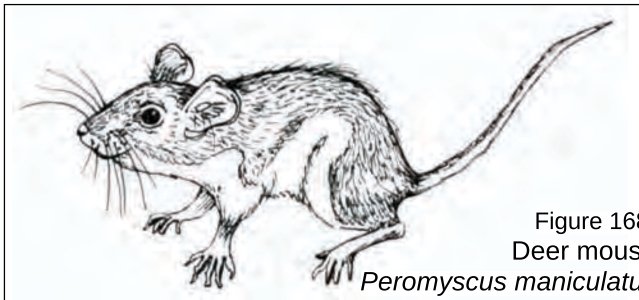


Figure 168. Deer mouse *Peromyscus maniculatus*

Several species of mouse are found in coniferous forests. The deer mouse (*Peromyscus maniculatus*) is the most wide spread.

Mice are quite adept at stealing food from backpacks or other storage.

Dusky-footed Wood Rat (*Neotoma fuscipes*)

Length: 13–19 in. (37–48 cm)
Tail length: 6.25–9 in. (16–23 cm)

The wood rat builds a nest of sticks, bark and plants, either on the ground or in trees, sometimes as much as 50' off the ground. Wood rats may use fire cavities or sprout clumps for nesting sites. These nests may be used for many generations and may be quite large. The nest may provide homes for many other animals. The dusky-footed wood rat is notorious for stashing a wide variety of objects in its nest, earning it the name “packrat.” They mostly feed on green plants, but may also eat seeds, fruits, nuts, and fungi. Where flying squirrels are scarce, wood rats are an important food source for the northern spotted owl.

Figure 169. Dusky-Footed Wood Rat (*Neotoma fuscipes*)

Figure 170. Douglas' Squirrel (*Tamiasciurus douglasii*)

Douglas' Squirrel (*Tamiasciurus douglasii*)
Length: 11–14 in. (28–35 cm)
Tail length: 3.72–6.25 in. (9–16 cm)

Sometimes called the chickaree, these noisy squirrels scold humans who dare enter their domain, chattering, stamping their feet and flicking their tails. They cut conifer cones, letting them fall to the ground, then collect them for storage in caches under fallen logs or beside tree stumps. When they consume the seeds from the cones, they often carry the cone(s) to a tree branch and drop the scales and cores, so you may locate the squirrels by looking for piles of recently discarded scales. They will also feed on green plants, young trees, berries, and mushrooms.

The similar-appearing Western Gray Squirrel, *Sciurus griseus*, is larger and grayer, having a lighter colored belly than the Douglas' Squirrel, which has a rust-colored belly.

Chipmunk (*Tamias* spp.)
Length: 4–5 in. (10–13 cm)   Tail: 2–4 in. (5–8 cm)

Stripes on the side of the face distinguish chipmunks from squirrels. Various species may build nests in burrows or tree cavities. Generally ground-dwelling, they feed on seeds, nuts, berries, and mushrooms. Chipmunks often learn to beg from humans, but children should be discouraged from feeding them because many human foods are not good for them, and they often get used to cars or pets, resulting in the death of many chipmunks.

Figure 171. Chipmunk (*Tamias* spp.)

According to Eder (2005), where several species of chipmunk inhabit the same area, the different species develop different calls.

Golden-mantled Ground Squirrel (*Spermophilus lateralis*)
Length: 7–11 in. (17–28 cm)   Tail: 3–4 in. (7–10 cm)

Distinguish from chipmunks by the lack of stripes on the side of the head. Rarely climbs trees as gray squirrels often do.

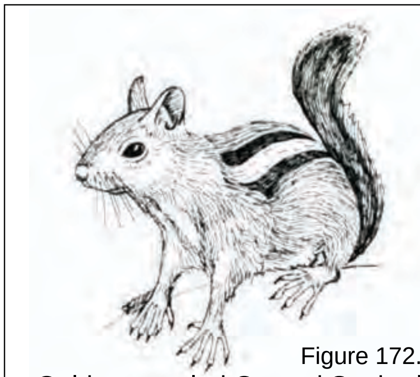


Figure 172. Golden-mantled Ground Squirrel (*Spermophilus lateralis*)

Red Fox (*Vulpes vulpes*)
Length: 2–3 ft. (0.6–0.9 m)

The red fox ranges in color from reddish to dark gray and silver. It can be distinguished from the gray fox by the black ear tips, black feet, and white-tipped tail.

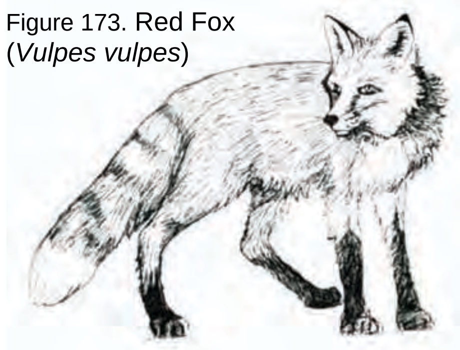


Figure 173. Red Fox (*Vulpes vulpes*)

Coyote (*Canis latrans*)
Length: 2.5–3.5 ft. (0.75–1 m)

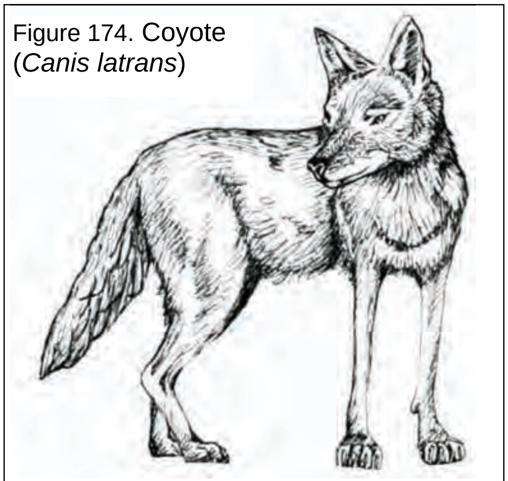


Figure 174. Coyote (*Canis latrans*)

Coyotes are grayish-brown in color. Like the gray fox, the tip of the tail is dark in color.

Coyotes and foxes are important predators on a variety of rodents.

Bobcat (*Lynx rufus*)
Length: 2–3 ft. (0.6–0.9 m) Tail: 4 in. (10 cm)

Bobcats are generally nocturnal, although they may occasionally be seen in the daytime, especially in areas where they have become accustomed to people.

They feed primarily on mammals and birds.

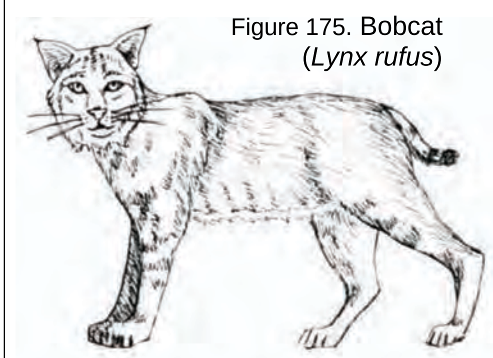


Figure 175. Bobcat (*Lynx rufus*)

Black Bear (*Ursus americanus*)
Length: 4.5–6 ft. (1.4–2 m) Shoulder height: 3–4 ft. (1–1.2 m)
Weight: 200–600 lb.

Figure 176. Black Bear (*Ursus americanus*)

The black bear's coat ranges from black to brown to honey colored. They are excellent climbers. Their dens are used mostly in the winter and may be in a cave, hollow tree, under a fallen log or any other protected area. They don't truly hibernate; rather, they enter state of reduced activity and may actually leave their dens on mild winter days.

While often thought of as being carnivores, bears are very omnivorous; up to 95% of their diet may be plant material. They can be problematic near human habitation, as they will raid garbage containers, cars, and food caches. They sometimes do damage to young trees as they strip the bark to feed on sweet sap in the spring.

Black bears are very intelligent and strong. They can smell and see food in cars and will often break windows to get at it. Food should never be stored in cars when in bear country. Backpackers should store food in "bear canisters." Hanging food at night sometimes works, but many bears have learned how to get at hanging food.

Striped Skunk (*Mephitis mephitis*)
Length: 13–18 in. (32–45 cm) Tail length: 8–14 in. (20–35 cm)

More often smelled than seen alive, the striped skunk is omnivorous, feeding on insects, bird eggs, amphibians, grains, green vegetation, fruits, berries, and many other foods, including road kill.

Skunks usually nest in underground burrows lined with dried leaves and grasses. They are generally nocturnal.

They can spray their famously smelly fluid about 20', and are accurate to about 10'.

Figure 177. Striped Skunk (*Mephitis mephitis*)

Raccoon (*Procyon lotor*)

Length: 26–38 in. (0.7–1 m)   Tail length: 7.5–16 in. (19–40 cm)

Weight: 12–31 lb.

Figure 178. Raccoon (*Procyon lotor*)

Raccoons often use hollow trees for their dens, but will also nest in rock crevices and even beneath buildings. They often become quite used to people and become pests at cabins, campsites, and garbage cans. They are generally nocturnal. In places where people live, they can be garden pests and will steal pet food left outside at night.

Raccoons often follow streams, and their hand-like footprints are among the most commonly seen. They often "wash" their food in water to remove bits of inedible material. The name "raccoon" is derived from the Algonquian name, which translates to "He scratches with his hands. The Latin scientific name *lotor,* means "washer" (Eder, 2005).

Mule Deer (Black-tailed Deer) (*Odocoileus hemionus*)

Length: 4.5–5.5 ft. (1.35–1.65 m)   Shoulder height: 35–41 in. (1 m–1.1 m)

Weight: 100–400 lb.

These animals range throughout western North America. There are several subspecies. They generally avoid the deep forest, preferring grassy meadows or mixed woodland. These animals have managed to adapt quite well to human invasion of their habitat, so much so that they are often garden pests and are frequently killed on the highways.

They often feed at dusk, dawn, and into the night. They can do damage to young trees, especially in the winter, but generally prefer grasses and shrubs. Look for deer tracks along creeks and rivers. Several subspecies are recognized.

Figure 179. Black-tailed Deer (*Odocoileus hemionus*)

Caution

Deer may become quite tame near parks, but children should be discouraged from feeding or attempting to pet them. Human food is generally not good for the animals, and they can (<u>and do</u>!) strike out surprisingly quickly with sharp hooves or antlers.