GIANT SEQUOIA II UNIT

CONTENTS:

OBJECTIVES:

The student shall learn:

How to identify types of trees in the Sierra Nevada.
How to identify the giant sequoia, the world's largest living thing.
Basic historical and ecological information about the giant sequoia.
How and why the giant sequoia is protected.

MAJOR CONCEPTS:

~ Identification of the giant sequoia and other trees in the Sierra Nevada
~ Enemies of the giant sequoia
~ Optimum growth conditions of the giant sequoia
~ Logging history of the giant sequoia
~ Giant sequoia protection
~ Dendrochronology basics

MATERIALS PROVIDED:

~ Dichotomous Keys: Trees
~ How Many Trees? worksheets, laminated (Appendix A)
~ Expo markers
~ Lengths of rope/string (75 feet long)
~ Thinning the Forest role cards
~ Cones
~ Seed Survey recording sheet (Appendix C)
~ Pencils
~ Rulers
~ Tree interview question cards (Appendix D)
~ Blindfolds

SUPPLEMENTAL RESOURCES AVAILABLE:

"Trees, Shrubs and Flowers of the Redwood Region," Wilis, Linn, Jepson
"The Giant Sequoia of the Sierra Nevada," San Jose State University
"Redwoods," a teaching unit for upper elementary grades, Harriet Weaver
They Felled the Redwoods, Hank Johnston
Giant Sequoias, Harvey et al.

GIANT SEQUOIA - INTRODUCTION AND BASIC INFORMATION

For centuries the giant sequoias have inspired and awed those who have beheld them. Unfortunately, a great deal of error, distortion, and inconsistency has developed around these trees over time. Once the sequoia's existence and novel attributes became known, publicity was quick to follow. The vital statistics - age, height, and circumference - were in great demand but in short supply. The early visitors to the groves were considered authorities in spite of their limited knowledge, and their reports were both indisputable and highly published. This was true in spite of methods of measurement which ranged from lariat lengths, pacing, outstretched hands, or "by eye." However inaccurate, some of the older figures have been used over and over.

In this unit, we hope to present a clearer and more accurate view of the giant sequoias and their ecological inter-relationships. As research continues, much of the widely accepted information about the giant sequoias is being altered. This unit includes the most current information available and is taught in the Sherwood Forest portion of Calvin Crest, where there is evidence of logging mature sequoias as well as two large mature trees. It is hoped that the students who participate in this class will be inspired by the majesty and uniqueness of the giant sequoias.

"Walk in the Sequoia woods at any time of year
and you will say they are the most majestic on earth." John Muir

GIANT SEQUOIAS - THE LARGEST LIVING THING ON EARTH:
The giant sequoias are very special because they are among the oldest and largest living things on earth. The General Sherman Tree, found in Sequoia National Park, is the largest living thing on earth. It is 274.9 feet tall, has a circumference (4.5 ft. above the base) of 83.2 feet, a base circumference of 102.6 feet, and a volume of nearly 58,000 cubic feet. According to increment borings taken in 1965, the General Sherman Tree has an annual growth rate of almost a millimeter (1/125th inch) per year. This seemingly small amount of wood yields a yearly average of new wood production of about 40 cubic feet - or approximately the volume contained in a tree one foot in diameter and 50 feet tall.

The present distribution of the sequoia and its closest living relatives is small compared to what it was in the geological past. There are only 10 genera and 15 species of redwood in the entire world. Each species has a limited range.

In the redwood family the two trees most closely related to the giant sequoia are the coastal redwood and the dawn redwood. The coastal redwood (*Sequoia sempervirens*) grows along the northern California coastal mountain range. The dawn redwood (*Metasequoia*) is found in the mountain ranges of southwestern China. Its range is so remote and limited that it was unknown to science until 1944. The giant sequoia (*Sequoiadendren giganteum*) is found in isolated groves located along the western slopes of the Sierra Nevada.

NELDER GROVE:
Calvin Crest is fortunate to be located adjacent to Nelder Grove, one of only 75 giant sequoia groves left in the world. There are two large mature sequoias on the Calvin Crest grounds (Calvin Spire and the John Knox Tree). In addition to stands of young sequoias, several large stumps and abandoned trunk sections serve as reminders of the logging practices that occurred here 130 years ago.

Nelder Grove is named for John Nelder who spent the last 15 years of his life living in and working among the giant sequoias. Nelder left New Orleans in 1849 and headed to California in search for gold. By 1875 Nelder moved to the grove and built a log cabin on homesteaded land in the upper part of the grove.

In 1875 John Muir caught his first glimpse of the "Fresno Grove," as it was called, from atop Fresno Dome. From there he made his way down into the grove where he spent a week exploring and surveying its boundaries. While there he made the acquaintance of John Nelder who proudly showed him many of the grove's giants. Muir described John Nelder as "a fine, kind man, who in going into the woods has at last gone home; for he loves nature truly and realizes that these last shadowy days with scarce a glint of gold in them, are the best of all."

Late in the fall of 1889, a couple of stockmen were riding in the grove looking for stray cattle and found Nelder's cabin burned to the ground. Nelder had perished in the blaze.

His son Claudius inherited the property and three years later sold it to the Madera Flume and Trading Company. In 1900 the property was transferred to the Madera Sugar Pine Company from which it was acquired by the U.S. Forest Service in 1928 through a land exchange.

Some of the grove was logged by the California Lumber Company from 1874 to 1877. It was quite likely that during this period the sequoia on Calvin Crest's property and some of the smaller ones along the Shadow of the Giants Trail were logged. These logs were hauled on wagons pulled by oxen, horses, and mules to the mill at Gooseberry Flat located along Nelder Creek, downstream from Calvin Crest.

Much of the present Nelder Grove was logged between 1882 and 1892 by the Madera Flume and Trading Company who operated a mill in the grove at that time. At first they used oxen to pull wagons loaded with logs to the mill. About 1885 or 1886, they began to use greased two-pole (parallel) log chutes. Logs were dragged by mules down the greased chutes to the mill. Remnants of these chutes can still be seen in some places in Nelder Grove.

Most of the sequoias under eight feet in diameter were downed and sawn into lumber during this time. It appears that many of the larger giant sequoias were felled after the mill closed. This appears to be the case as many of the large sequoias felled blocked the chutes and wagon roads which had been used by the mill when it was in operation. The post makers used only the choice cuts of the tree nearest the stump. More than half the giant sequoias felled in Nelder Grove were used for shakes, posts, and grape stakes. Imagine being able to cut 3,000 fence posts from a single tree (enough to fence in an 8,000 acre ranch), plus some 650,000 shingles that could cover between 70 or 80 roofs! Evidence of this procedure can still be seen at several places in Nelder Grove.

There has been very little logging activity in the grove since 1928 when it became the property of the Federal Government. As a result, extensive areas of sequoia reproduction have become established. Most of the trees are 85 to 95 years old. They vary in height from 50 feet to at least 125 feet and in diameter from 10 inches to 7 feet. The majority of the youngest trees in Nelder Grove are about 40 years old now. Evidently, in the past 40 years, weather conditions, soil bed conditions and/or seed quality has not been right for seedling survival.

The giant sequoia is not considered an important lumber source. Many people are of the opinion that the real values of the sequoias are in their size, majestic beauty, longevity, and scarcity. Because of its limited occurrence the sequoia is considered a significant natural resource.

NEEDS OF THE GIANT SEQUOIA

Sequoia are considered a fire climax species which prefers an open, park-like setting as created by the repeated occurrence of fire. Under natural conditions, the sequoia need bare mineral soil, adequate soil moisture and mild temperatures to reproduce. Soils disturbed by logging in Nelder Grove have produced conditions favorable for sequoia seed germination. Seeds falling on thick forest litter seldom germinate, and if they do, the seed’s food supply is insufficient to sustain growth until the roots penetrate the litter layer to mineral soil. Other environmental disturbances such as fire are natural agents of seed bed preparation. Periodic fires are beneficial to sequoia for several reasons. Fires burn away forest floor litter which leaves optimum conditions for seed germination. Periodic fires reduce the potential hazard of a major wildfire which can occur more readily in an overcrowded, heavily littered forest, (forest floor litter, not human litter). Small periodic fires cause little damage to old-age sequoia, major wildfires can kill them. The heat from the small fires dries out the cones in the upper branches of the sequoias, allowing the seeds to be released and fall to the bare mineral soil that was prepared by the fire. Thereby continuing the lifecycle of the sequoias.

Optimum sites for favorable growth of giant sequoia occur on soils that are well drained and remain moist during much of the growing season. Groves are normally found near valley bottoms where water tables remain within a few feet of the surface until late summer. However, they are also found on mountain slopes and ridges where sub-surface runoff is within range of the sequoia's shallow-root system.

The root system of the giant sequoia is massive, sometimes extending outward radially more than 120 feet from the base of the tree. Apparently, the area of a sequoia's rooting zone varies with the availability of soil moisture. Lengthy roots are not necessary along drainage bottoms where sub-surface moisture flow may continue through most of the growing season. In such areas the roots may not extend more than 50 feet away from the trunk. In areas where the soil is well-drained the roots may commonly extend to a distance of 100 feet or more.

Sequoia seedlings have a main taproot which extends downward vertically in the soil, but this gradually disappears during the sapling stage to be replace by the massive system of lateral roots which may cover an acre or more. However, no matter how massive the system, the roots seldom penetrate more than four or five feet in depth.

Annual precipitation needs of the sequoia range from 45 to 60 inches per year. Much of this must occur as snow to ensure available moisture throughout spring and summer since California precipitation is primarily limited to the winter/spring seasons. Any changes in the water table can have a severe impact on the sequoia. Excessive moisture will weaken supporting soil, making the trees vulnerable to high winds. Insufficient moisture can cause stagnation in growth and ultimately death. The most frequent cause of sequoia seedling death is the drying of the soil downward below the maximum depth of the root system.

Under good conditions, giant sequoia are very fast growers. Factors which have the greatest effect on their growth rate are soil moisture, light, and competing vegetation. Because the sequoia is a relatively intolerant species, associated species such as white fir, incense cedar and sugar pine pose a threat to the survival of the sequoia seedlings and saplings. In undesirable light conditions fir and cedar have the ability to grow faster than the sequoia. When the competition for light and moisture is high among the various species, the less tolerant sequoia becomes choked out and eventually dies off.

The early stages of growth are the most critical for the giant sequoia. The reproductive requirements and sequence of subsequent events in its life cycle have only recently been extensively studied.

SEQUOIA REPRODUCTION

The reproductive sequence begins in mid to late winter, when the tiny male cones cover the outer branches of the upper branches. Clouds of golden pollen from these cones drift about on breezes staining the snow with a yellowish tint.

At the time of pollination, the female cone is only about the size of a grain of wheat. By the end of its first growing season the bright green cones are more than three-quarters their full size. Mature cones average only about 2.5 inches long by 1.75 inches in diameter. Each one produces an average of 200 seeds. Larger cones can produce over 300 seeds.

Unlike other conifers, sequoia cones can remain alive and growing for years. In a normal year 1,500 to 2,000 new cones might be produced. A large sequoia tree might be expected to contain about 11,000 cones at any given time of which about 7,000 would be green and growing. The remaining 4,000 would be opened, brown, and largely seedless. The age of a cone can be determined just as the age of a tree's trunk by counting the annual growth rings of the cone's stems. Usually a microscope is necessary to see the rings as they are often extremely narrow and difficult to distinguish.

Occasionally, in a very wet year with mild temperatures, there can be a great increase in cone production. In 1970 the Castro Tree in Sequoia-Kings Canyon National Park produced over 20,000 new cones. Very large specimens growing on favorable sites may bear more than 40,000 cones at one time while those on drier sites may have as few as 6,000.

An average mature giant sequoia may release up to 400,000 seeds per year. Dispersal of seeds takes a number of different forms. Cones may be cut by squirrels, damaged and dried out by beetle larvae activity, or broken off the tree by wind or snow. A high percentage of sequoia seeds are released by the activities of animals.

The chickaree, a small tree squirrel, inhabits many of the trees in the Sierran forests. Outside sequoia groves, the chickaree commonly feeds on the seeds of other conifers. In the sequoia groves it also feeds on the fleshy green scales of the younger sequoia cones, stripping the flesh from the outer portions of the scales. In the process, the seeds, too small to have much food value for the squirrel are dislodged and scattered over the ground.

In 1905 Walter Fry and John White recorded a single chickaree cutting approximately 12,000 cones which, when gathered up, filled 38 barley sacks and yielded 26 pounds of seeds - nearly 1,250,000 seeds! Another lone chickaree was observed cutting 538 green sequoia cones in 31 minutes. Once the cones are cut, the chickaree often stores them away for future food. They store hundreds or even thousands of cones in piles in wet or cool places.

Another important seed dispersal agent is a very small, long-horned wood boring beetle. The larvae of this beetle chew their way into the cone's interior to obtain nourishment from its tissues. In so doing they can sever the vascular system of the cone. The cone will gradually turn brown releasing its hold on the seeds and dispersal will follow. About one-quarter to one-third of the cones in an average tree are brown cones in which the beetle larvae have been active. If this is more or less representative for mature sequoias, this tiny insect deserves considerable credit for releasing the sequoia's seeds. In this symbiotic relationship (as is true with the chickaree), the tree's cones provide food and the beetle (or chickaree) causes the seeds to be released. Chickarees seem to prefer cones between two and five years old, while the beetle prefers cones four years or older so that there is little competition between these two species.

The tiny seeds resemble dry oatmeal flakes, with the embryo oriented along its long flat axis between two straw colored wings. Loose mineral soil provides the best situation for the germination of sequoia seeds. Disturbed soil is ideal as the tiny seeds are too light to readily bury themselves except where the soil is soft and readily crumbled. When lying on hard soil surfaces the seeds not only die quickly, but also seem to germinate poorly even when the soil is moist and the temperature optimal.

Experiments indicate that one-half full sunlight, (half sun and half shaded), is optimal for sequoia seed germination. The optimal burial depth, which seeds rarely exceed in normal circumstances, is about one-fourth inch.

Seedling survival is much more critical than germination. Seeds can remain viable under a wide range of conditions, but once the seedlings begin their growth, they cannot survive beyond a range of a narrow set of environmental conditions. As was mentioned earlier, the most frequent cause of sequoia seedling death is the drying of soil beyond the depth of the seedling's roots. Other major causes of death are heat canker, where the root tissues of the tree are damaged by high temperatures at the soil's surface, as well as burial by leaf and branch fall, and root fungi. Less common are insect, bird, and mammal depredation. Reduced light brought about by shading from the overhead canopy or downed debris may also be a significant mortality factor. Competition for resources, of course, plays a very important role in sequoia survival.

The oldest and largest sequoia began their lives 3,000 years - forty human lifetimes - ago when men were barely beginning to understand the meaning of civilization. Their massive, venerable character and their rarity impact us like no other living thing can.

It is our hope that this introduction to the giant sequoia will serve as a starting point for the students from which they can develop a lifetime of rewarding and respectful association with these truly incredible sentinels of the forest.

Giant Sequoia II Lesson Plan

The Trail

Do the introduction of the class at the Dining Hall. As you leave the Dining Hall, go down the stairway to the road between the Dining Hall and the basketball court. Proceed down the road and turn left at the dirt road that goes between the recreation field and Cedar Lodge (2-story building); stay on the dirt road that goes past Mountain View (girls cabin area). [Note: There are restrooms in the red laundry room building facing the lake. These are the last available restrooms on this trail.] Take the dirt road that goes left out on the dam next to the lake. About 75' out on the dam road you will take the trail downhill to your right towards Sherwood Forest. The trail will be marked from this point forward by blue trail markers with trees on them. The path is also noted by the small wooden bridge that crosses over the stream. Along this portion of trail, you will encounter posts #1-5. Once you are in Sherwood, head straight ahead to post #6 by the large Ponderosa Pine next to a wooden luggage platform. The trail continues on the road ahead and to your left, over a cement culvert, past an amphitheater area, wraps around the creek, behind the same amphitheater, across a small bridge, and up through a set of buildings back to the road, where you will run into the mature sequoia, the John Knox Tree. After the John Knox tree follow the dirt road down to the metal gate. To your left will be the Calvin Spire and the sequoia stumps mentioned in this unit. To return to camp, follow the dirt road back up to the trail.

Note: The water and power to Sherwood Forest are turned off for the majority of the year. The closest restroom to the trail is in the laundry room building above Mountain View Lounge.

Introduction Begin the class at the Dining Hall.

A. Ask the students if they have ever seen a giant sequoia before. If they have, ask them to describe their impressions of sequoias in their own words. (Some may have seen them before in places like Yosemite National Park or Sequoia/Kings Canyon National Parks.)
B. Have the group try to show how big they think the circumference of a mature sequoia might be by joining hands and forming a circle of an appropriate size. (If none of the class has ever seen a sequoia and has no idea of the size of the trees, get some predictions based on the name "Giant Sequoia.") Assure them they are in for a rare treat: today, there are only 75 groves of giant sequoias containing less than 60,000 mature trees. Giant sequoias can only be found on the western Sierra Nevada from Placer to Tulare County. If grouped together, these groves would cover less than half the surface of Lake Tahoe.
C. Tell students that they will be learning, not only about the giant sequoia, but also about the forest community with which it is associated.
D. Ask students to describe the weather and temperature that they experience at the dining hall. There is a thermometer on the outside wall of the dining hall on the deck side. Ask students to remember the temperature.
E. Tell students that this is a rare opportunity for them, as the giant sequoias only grow in the Sierra Nevadas. People travel from all over the world just to see these wonders of the forest.

Lesson #1: Tree Identification

Start walking down the road, take the left fork and follow the dirt road around the lake until turning right for the trail. Giant sequoias are a part of a large forest community called a “mixed coniferous forest.” The forest around sequoias is made up of cone-bearing trees (also known as conifers, or evergreen trees). In this class, students will learn to recognize 6 different species by observing each tree’s characteristics that make it different from the others.

Below you will find two possible activities to introduce the idea of using a dichotomous key. The dichotomous key allows you to answer a series of questions that eliminates possibilities until only the correct choice is left. As you walk along the trail, there are markers that will help you identify different types of trees using the dichotomous keys.

Introduction Activity Option #1

A. Direct the students to find something on the ground around them and pick it up (it may be a good reminder for students not to pick up scat).
B. Ask the students to find someone else who has an item similar to theirs in some way.
C. Have students share why they paired up. Students may have chosen to relate their items by type, color, size, texture, shape, etc.
D. Discuss with students the idea that plants can be identified by looking at their different features. Ask what kinds of things might vary from tree to tree. (Most helpful for identification are leaves/needles, bark, and seeds/cones.) Keep in mind that the size of the tree is not helpful for identifying trees, as a tree grows larger as it gets older.
E. Introduce the dichotomous key and continue along the trail to identify trees.

Introduction Activity Option #2

A. Have the students form a line, standing shoulder to shoulder, facing you.
B. Without saying the person’s name, pick out one student in your mind. Tell the students that the goal of the activity is to correctly identify which student you’re thinking of.
C. Have the students ask you yes or no questions one at a time. When you answer “yes” or “no,” students will be eliminated - no matter what is asked. When students are eliminated, they should come stand behind you. The most effective questions are the ones that eliminate the most possibilities. For example, a very effective first question is “is it a boy?,” because, no matter what the answer is, a sizeable number of students will be eliminated. An ineffective question might be “is it Juan?,” because only one student (assuming there is a Juan in the class) will be eliminated. If it happens to be Juan, it was simply a lucky guess.
D. Once the students have correctly identified the one student you were thinking of, discuss with students what kinds of questions they thought were most effective. Carry out the process again to see if their line of questioning improves.
E. Introduce the dichotomous key as a similar process (except that students will be answering the questions rather than asking them) and continue along the trail to identify trees.

As you continue along the trail, have students identify different types of trees at the markers using their dichotomous trees. You can use them as a class or split the students up into small groups to work together. You could also turn identification into a competition between teams - but be sure that students are using the keys, not just guessing. Below you will find basic information about each of the trees you will identify.

Note: there are sometimes ladybug beetles hibernating in the Sierra from November through April. Please be very careful to avoid crushing or stepping on them if you come across a grouping of them.

Post #2: Incense Cedar (Calocedrus decurrens)

A. The incense cedar's bright green scale-like needles lie in iron-flat sprays.
B. It has hard, orange-brown, deeply furrowed bark that comes off in large sheets when the tree dies. Have students feel the hard, furrowed bark. On young trees, the bark can be easily peeled.(Note that it was also used in Miwok construction)
C. Some younger trees look like they have been charred in a fire. This is a type of fungus called sooty fungus that is common on young cedar trunks and most cedar branches.
D. The incense cedar has a three-prong seed pod that looks like a duck bill.
E. The incense cedar is named for its fragrant needles and heartwood. Take a small number of green needles into your hand and crush them: have the students smell the crushed needles and describe what they smell.
F. Cedar wood has been used to make shingles, railroad ties, fence posts, siding, and pencils. The heartwood has been used to make chests.
G. Incense cedars and giant sequoias are often confused. Other than their differences in needles, bark, and cones, the shape of a young cedar is more triangular, as opposed to the spire-like silhouette of the sequoia.

Post #3: Black Oak (Quercus kelloggii)

A. The California black oak is the largest mountain oak in the west. The name comes from the blackish-grey bark that cover its sturdy, forked trunk and massive limbs. Have students feel the bark and compare the texture to the bark of the incense cedar.
B. The bright yellow-green leaves are distinctly lobed with each lobe having bristly tips. In the fall, they will range in color from tawny yellow to a rich golden brown yellow before falling to the ground. In the spring, tiny new leaves emerging from their buds are red and velvety.
C. In the winter, you may more easily notice large clumps of parasitic mistletoe growing on the branches of the black oak trees.
D. Many wildlife species eat its acorns, leaves, and young sprouts. Some species live in the branches or hollows in black oak trunks.
E. The Miwok collected black oak acorns as one of their main food sources. Today, the primary use for black oak is firewood. It is not suitable for lumber as it warps easily.

Post #4: White Fir (Abies concolor)

A. The white fir is named for its light grey bark that grows in small, light plates. Have the students feel the bark and compare to other trees you've seen today.
B. White firs have short, single needles and cones that grow upright on top of the branches, high in the tree. This is different from pine cones, which hang below the branches. (This is a good opportunity to discuss the difference between "pinecones" and other cones. Many people mistakenly use the word pinecone for cones from other species, such as firs.)
C. Early loggers considered white firs to be "weed trees" and did not cut them. Today they are used to make window frames, doors, shakes, shingles, and boxes.
D. Seeds of the white fir are a favorite food for the chickaree, or red squirrel. The squirrels cut cones to store away for winter. Those they miss fall to the ground and disintegrate in autumn.

Post #5 Sugar Pine (Pinus lambertiana)

A. Sugar pines can be identified by their short green needles in bunches of five. Needles are about 3 inches long. One helpful way for students to remember this is that the word "sugar" contains five letters.
B. Sugar pine cones are the largest cone in this area, and are typically 10-18 inches long.
C. Sugar pine bark has long, rectangular plates that fit together. Have students feel the bark and ask how it is similar to and different from the bark of other trees.
D. Early loggers in the Sierra Nevada called the sugar pine the "King of the Pines." The tallest known living sugar pine is in Yosemite National Park and is over 270 feet tall. Early settlers prized the even grained, soft white wood that doesn't warp or twist and resists rot for house timbers and shingles. Loggers still prefer sugar pine wood for projects like cabinets, doors, and window frames.

As you reach the end of the trail, it opens up to Sherwood Forest. Walk straight ahead to the large tree on the edge of the field next to the wooden platform.

Post #6: Ponderosa Pine (Pinus ponderosa)

A. Ponderosa needles are long (5"-9") and grow in bundles of three.
B. The bark of the mature ponderosa grows in large orange-brown plates that fit together like a jigsaw puzzle. Have students feel the bark. Encourage them to stick their nose between two plates and smell - ponderosa pines often smell like vanilla or butterscotch.
C. Ponderosa pine cones are approximately 4"-6" in length and are prickly to the touch.
D. One way to help students remember how to identify ponderosa pines is the "three P's" (to go with the P in ponderosa) - prickly pine cones, puzzle bark, and "perfect three" needles.
E. High grade ponderosa wood is used for doors, shakes, frames, and paneling. Low grade wood is used for boxes, rafters, joists, and railroad ties.
F. Ponderosa pines were named by botanist David Douglas for their "ponderous size."

Lesson #2: In Depth: Giant Sequoias

Follow the large trail to the left across the small stream (below the first grouping of buildings).

Post #7: Giant Sequoia (Sequoiadendron giganteum)

Young sequoias and cedars are often confused - as you explore the giant sequoia, have students compare its features to the incense cedar they saw earlier. There will be a stop later on the trail to compare two side by side.

Needles: In these young sequoias, the dark green, scale-like needles are bunched like awls and are prickly to the touch. The needles are rounded, as opposed to the iron-flat needles of the incense cedar.

Bark: Sequoia bark is cinnamon-colored and soft and spongy to the touch. Squirrels use it to line their nests. Have the students gently feel the bark (not strip the fibers and damage the tree) and compare it to other trees they've identified today.

The soft spongy bark of the sequoia can grow to be 15-18 inches thick and in rare cases, can grow up to 2 feet thick. It is more fire resistant than the bark of most trees and provides the sequoia with excellent protection. What kinds of things do we do to protect ourselves from the cold?

Cones and Seeds: Sequoia cones are egg-shaped, about the size of a chicken egg. Green cones have soft, fleshy scales and have only been on the ground for a short period of time (hours, days, or weeks). Reddish, brown, or dark cones have been on the ground for longer periods of time (months or years).

Mature cones average 2.5 inches long and 1.75 inches in diameter, and can remain on the tree for several years (the stems have countable rings much like the trunk of a tree). At any given time, one large sequoia can hold about 11,000 cones. (7,000 of which are green and growing, 4,000 of which are open, brown, and seedless). In a normal year, sequoias produce 1,500 - 2,000 new cones.

Tap two cones together or tap a cone on a rock or stump. The seeds are about the size of small oatmeal flakes - about 3,000 seeds weigh one ounce! Each cone holds 200-300 seeds.

Sequoias can drop up to 400,000 seeds/year, caused by squirrels, long-horned wood boring beetle larvae, wind, and snow. In it's lifetime, the sequoia will produce 60 million seeds. Only 3-4 of these seeds will grow to become trees of 100 years or older. Of those seeds that germinate, many will die from lack of water or sunlight in the first few years. Others will be eaten by birds, squirrels, gophers, or cut-worms.

Discuss how a sequoia seed and a computer chip are similar: both are able to store a large amount of information, both are very small for what they are able to accomplish.

At the end of this unit, you will find an activity called "The Sequoia Seed's Survival Search for Suitable Soil Survey." The materials are kept in a wooden cabinet near the John Knox Tree.

Shape: Young trees have a narrow, triangle spire-like shape. As they grow older, trees lose their lower limbs and the massive trunks of the mature trees support large gnarled limbs and a canopy of foliage. Before sequoias were protected, the wood was used for posts, rails, grape stakes, etc. More information about the history of sequoia logging can be found later in the unit.

Climate and Sequoias:

There is evidence of sequoias growing all over the world 130 million years ago, across North America and Europe, when the earth's climate was warmer. Today the giant sequoia is found in only about 75 small groves containing less than 60,000 mature trees. The groves are scattered from Placer County to Tulare County on the west side of the Sierra Nevada Mountains, where conditions remain favorable for growth and reproduction. If grouped together, the groves would cover less than half the surface area of Lake Tahoe.

Climate can be defined as "weather patterns that exist in an area over long periods of time." Ask the students to compare the climate here at Calvin Crest to their home. The middle elevations of the western slope of the Sierra Nevada have cooler temperatures and receive more precipitation than the central valley. (Average precipitation here is 45-60 inches - much of which comes as snow in November through April.) Temperatures here rarely drop as low as 0°F, which could kill young sequoias. Even when temperatures do drop this low, young sequoias are usually insulated against the cold by snow on the ground. In the summer, temperatures here rarely reach above 90°F, which helps minimize the loss of water by the trees. This will help students understand why there are no sequoia groves in the Central Valley.

Ask students if they can feel a difference in Sherwood Forest, then compare it to the Dining Hall. Have students look at the thermometer on the cabinet a little further down the trail and recall the temperature at the Dining Hall. The microclimate (climate in a small area) is different here than at the Dining Hall. Part of the reason for this is that there are more trees providing shade. Also, cool air is heavier than warm air and settles in low-lying areas. Because of the difference in microclimate, sequoias do not grow naturally near the dining hall, but grow very well here, a short distance away.

As you continue along the trail past the amphitheater area, you will walk under and past several pacific dogwood trees, which are beautiful throughout the year. In spring, it has large white blossoms. In summer, its bright green leaves filter the sunlight and cast a dappled shadow on the forest floor. Crimson leaves and clusters of shiny red seeds add warm color to a chilly autumn. No one knows for sure how the dogwood was named. It could have been Loggers named the tree "dog wood" because they were unhappy with the poor quality of the wood for timber. Or perhaps the name referred to the use of the bark as a care for mange in dogs.

Follow the trail straight ahead of you and watch for a sharp right turn.

Post #8: Wind and Water

During the winter of 1982-1983, flood waters of Nelder Creek washed the soil away from the roots of this young giant sequoia and it began to lean over the creek. Over the next 6-7 years, the trees roots were stressed to the breaking point as the weight of the tree gradually broke or pulled them from the ground, and it crashed to the earth. Water and wind are the principal natural enemies of the giant sequoia. If soil covering the root system is removed, the precarious balance of this giant tree will be upset, and winter winds will eventually send it toppling to the ground. (More information about the shallow roots can be found in the section titled "The John Knox Tree").

Fun Fact: After it had fallen, part of this sequoia trunk was used to make the Calvin Crest entrance sign.

Continue along the trail which will take you behind the same amphitheater as before, across a small footbridge, and up through a grouping of buildings. You will cross a large dirt road.

Post #9: Comparing Giant Sequoias and Incense Cedars

The large tree on your left is a giant sequoia. The slightly smaller tree about 20' to the right of the post is an incense cedar. Challenge students to correctly identify each tree, and review the differences between the two, outlined below:

	Giant Sequoia (Named for their large size)	**Incense Cedar** (Named for fragrant needles, heartwood)
Needles:	Dark green, round, prickly bunches	Bright green, iron flat sprays
Cones:	Egg shaped cone	Three-prong, duckbill seed pod
Bark:	Soft, spongy, cinnamon-colored	Hard, brown Young: peels, mature: furrowed
Shape:	Young: narrow, triangle-shape, Older: loses lower limbs.	Broader triangle shape
Wood Use:	[Formerly posts, rails, grape stakes, etc.]	Shingles, railroad ties, pencils. Heartwood: chests
Size:	Largest living things on earth Up to 30' diameter and 270' tall	Approx. 4'-5' in diameter, over 120' tall

The John Knox Tree

The John Knox tree is 50 feet to the left of post #9 and is surrounded by a split rail fence. This fence (and the one around the Calvin Spire, which you will see later) is there to protect the sequoia roots. Please keep students on the outside of the fence and prevent them from throwing objects at the tree.

Explain to the students why there is a fence around the tree. Giant sequoia seedlings have a taproot for the first few years of life, and it gradually disappears, leaving the tree to be supported only by its broad base and lateral roots. The root system of giant sequoia in valley bottoms near creeks probably do not need to extend more than 50 feet from the base of the tree and only rarely in an area with well-drained soil would the root system cover much more than an acre. The root system is unusually shallow, rarely extending more than 4-5 feet into the ground. If soil covering the root system is removed, the precarious balance of this giant tree will be upset, and winter winds will eventually send it toppling to the ground.

Sequoia cones are surprisingly small for a tree so huge. A mature tree produces 2,000 cones per year. Each cone contains 200 to 300 seeds. The seed is tiny - 3,000 seeds weigh an ounce - yet it took only one to produce this forest giant. Squirrels cut and store a large number of cones for their winter food supply. Here you can discuss the importance of the role animals fill in the dispersion of sequoia seeds as was described in the general information section. Point out that cone production can vary widely each year with one recorded instance of a single tree producing 20,000 green cones in a single year. With that many cones produced yearly and with each cone averaging 200 seeds, it would be perfectly natural to assume that a sequoia as large as this one should have thousands upon thousands of offspring surrounding it.

ACTIVITY #1 - How Many Trees?

Activity Overview

In this activity, students will examine plots of land of a predetermined size to graph information and answer questions regarding the number of trees of each species found in the given area.

Focus Questions

1. Which species of tree is the most abundant in this area of the forest?
2. Which species of tree is the least abundant in this area of the forest?
3. What are the 5 things a tree needs to grow?
4. Why do you think there are more of some species of trees, and less of other species?

Main Ideas

1. The most abundant trees in this part of the forest are the incense cedar, white fir, and the ponderosa pine.
2. The least abundant species are the giant sequoia

3. The 5 things all plants need to grow: water, sunlight, nutrients, carbon dioxide, and space.
4. Although all plants/trees need these 5 basic things, the different species need more or less of these elements in comparison to other species. For example: the giant sequoia needs more sunlight and water than the incense cedar or the white fir. Since this area is fairly shady (due to overgrowth from suppression of fire over the last 80 years) the giant sequoia seedlings die from lack of enough sunlight.

Activity Organizer

Objectives

By the end of this activity the students should be able to:

1. Tell which species of trees are most prevalent in this part of the forest.
2. Tell which species of trees are least prevalent in this part of the forest.
3. Describe the 5 things all plants need in order to grow to become a mature tree.
4. Explain what factors contribute to some species of trees being more abundant than others in this part of the forest.

Materials

1 sample bar graph
Four pieces of string or rope (75 feet long)
Student worksheets (Appendix A)
Tree identification cards
Pencils/Markers

Time Required 20-30 minutes

Location Near the John Knox Tree.

What To Do

1. Divide the students into four groups of nearly equal size.
2. Explain that the task of each group is to determine the number of trees over 1 foot tall (to make counting simpler) of each species in its plot and record this information on the graph. Display the example and explain how to use the graph.
3. Explain how students are to determine the boundaries of their plots.
    1. Lay the four strings/ropes down stretching outward from the tree in such a manner that they form a tee, or cross, with the tree at the intersection.
    2. Once the strings/ropes have been laid down have the students begin their census. Tell them to count only the trees in their plot over 1 foot tall. Leave them in place until all groups have completed counting trees, then pick up the strings/ropes.

4. Once all the trees have been counted, each group will determine the percentage of trees in their plot represented by each species. They will do so by using the following steps: (This work can be done on the back of the worksheet)
    1. Determine the total number of trees found in the plot by adding the numbers determined for each species together.
    2. Divide the number of trees of each species by the total number of trees in the plot, e.g. 25 white fir/50 total tree = .50 = 50%. Therefore, 50% of the trees in this example plot are white fir.
5. When all the groups have finished their graphs and calculations answer the following questions:
    1. Which species of tree was most abundant in each plot?
    2. Which species of tree was least common in each plot?
    3. What percent of the trees in each plot were white fir? Incense cedar? Giant sequoia?
    4. What was the total number of trees in all four plots? (Add each plot's total.)
    5. What was the total number of sequoia in all four plots?
    6. What percentage of the total number of trees were sequoia?
    7. Why do you suppose there were so few sequoia in the area in spite of the fact that a large giant sequoia is in the center of the study area and there are numerous sequoia cones on the forest floor?

As a group, brainstorm a list of factors that could possibly account for this phenomenon. Accept all suggestions. Have a student record them as they are given. Read the list aloud and have the group determine which they think are the three most likely factors.

Possible factors are:
1. Sequoia are intolerant of low light levels (they do not grow well in shady areas).
2. Sequoia seeds need mineral soil to germinate.
3. White fir and incense cedar are more shade tolerant and crowd out the sequoia.
4. Soil moisture/lack of moisture.
5. Poor seed viability.

Lesson #3: Fire and Sequoias

The Calvin Spire

As you head down the dirt road toward the metal gate, look up to your left in order to see the top of the Calvin Spire. The top 75' or so of the Calvin Spire is dead. It was possibly killed by lightning. Point it out to the students and let them know you will be discussing fire and sequoias soon. As you approach the tree, look up and see several branches are curved upward, competing to become the new crown. When the top of a conifer is killed, the upper branches curve upward to enable the tree to continue to grow in height. Several of these branches are larger than the entirety of nearby trees.

Size and Age Comparisons
The giant sequoia is the largest living thing in the world. Several other trees are taller and the Mexican tule cypress has a larger diameter. But no tree combines the height and great diameter of the sequoia. Look at the mature sequoia in front of you. How big do you think it is? How many toothpicks or rocking chairs or hockey sticks could be made out of it? This sequoia is ~270 feet tall and the circumference at the base is over 70 feet. It contains more than 100,000 board feet - enough to build ten five-room houses. The largest living sequoia is the General Sherman Tree. It is 274.9 feet tall, but has a base circumference of nearly 103 feet. It has enough wood to build 35 five-room houses.

Although it is the largest living thing on earth, the sequoia is not the oldest. Mature sequoias we see today are 2,000 to 3,000 years old. The oldest known sequoia lived 3,126 years. However, some bristlecone pines which grow east of the Sierra have been alive for 4,600 years. Recent calculations have indicated the need for revision to sequoia age estimates. The General Sherman Tree and the Grizzly Giant in Mariposa Grove in Yosemite are now believed to be 2,000-2,500 years old.The Calvin Spire is probably between 1,500 and 2,000 years old.

Fires
A mature sequoia is exposed to fire many times throughout its centuries of existence. Additionally, their tops are often struck by lightning because they are so tall, which is what likely happened to the Calvin Spire.

A 2,000 year old sequoia has probably been through nearly 100 forest fires. Forested areas will naturally experience fires at least once every 20 years due to lightning or other natural causes. Historically, fires would have been high-frequency low-intensity fires, meaning they happened more often but were not incredibly hot. Small saplings and debris on the forest floor would burn but larger trees would be unaffected. Periodic forest fires have blackened the trunks of most large trees. Because of their natural resistance, it used to be that few large sequoias died as a result of fire. Fires have been largely eliminated from this area for over 80 years. Without occasional fires, dead plant material accumulates on the forest floor and the forest is much more dense, which means there is more fuel to burn. Now, when there is a forest fire, is is a low-frequency, high-intensity burn, meaning it burns larger, longer, and hotter, eliminating most or all organic material in the burn area. The Railroad Fire in 2017 was a large, high-intensity fire in many places. At the time of writing this curriculum, it is uncertain how many of the large sequoias in Nelder Grove to the Northwest of Calvin Crest survived the blaze.

Often you can see burn scars in the bark, however new bark begins to grow back over the scar. This process is known as scrolling and is the tree’s way of healing itself. This is very similar to how the human body heals when we are injured. (We bleed, scab, then the skin begins to grow back over the wound, eventually leaving only a scar behind.)

Small fires can be extremely beneficial to the forest ecosystem, and especially to giant sequoias. Periodic small fires clear forests and make larger wildfires that kill sequoias less likely. When there is a great deal of debris on the forest floor, the lightweight seeds are unable to reach bare soil and start growing. After a fire has exposed bare mineral soil and the heat from the fires has dried up the cones causing them to release the seeds, they have a much greater chance of germination. Fire also eliminates many other trees and plants that compete with sequoia seedlings for moisture and sunlight.

ACTIVITY #2 - Thinning Overcrowded Forests

Activity Overview

Overcrowded forests are a significant factor in major wildfires. This activity will teach students about the spread of wildfire in overcrowded forests and how the risk can be mitigated through fuels management.

Focus Questions

1. What happens when an overcrowded forest catches on fire?
2. What happens to fire-resistant giant sequoias in a major wildfire?
3. What can be done about overcrowded forests?

Main Ideas

1. Because of fire suppression over the past 80 years, the forest has become cluttered. This makes it difficult for giant sequoia seeds to germinate, and it also increases the risk for a devastating wildfire.
2. Periodic fires are the main things that reduce the amount of forest litter in a healthy forest, however, since people have suppressed fire for so long, a fire now would be devastating. This leaves us with the question of what to do. The forest service has been implementing "controlled burns" throughout the Sierra Nevada for about 35 years. In controlled burns, people first go in and reduce the amount of forest litter, to ensure a "controllable" fire (cooler burning with less stuff to burn). One way to do this is to gather fallen wood, forest debris, and selected cut trees and burn them during the cold and wet season. Another way to do this would be to clear out most debris, remove it, and light a small ground fire in an area (again, carefully and during the appropriate season).

Activity Organizer

Objectives

By the end of this activity, students should be able to:

1. Explain what it means for a forest to be overcrowded and how it became that way.
2. Demonstrate an understanding of the causes and spread of wildfires.
3. Describe fuels management strategies and why it is important to keep forests healthy.

Materials
Role cards
Cones

Time Required
5-10 minutes

Location
Anywhere along the trail. Materials are stored in a wooden cabinet near the John Knox tree.

What to Do

1. Set out cones in a square shape in a small area (when standing inside the cones, students should be able to reach at least one or two other students). Direct students to stand anywhere inside the cones.
2. Tell students that you are about to give them a role card, and that they should read it to understand how either their species of tree, or other nature related object might respond in a wildfire.
3. After students have read their role cards, call out different types of trees/object and have students raise their hands if they are a particular type of tree (Giant Sequoia, White Fir, Incense Cedar, Sugar Pine, Ponderosa Pine, Black Oak, etc.).
4. Ask students, "Now that we have a better understanding of this particular forest that you represent, what do you think would happen if there were a fire in this area?"
5. Tell the students that you are now Mr./Ms. Lightning. When you touch a student on the shoulder, they will then touch the students around them and sit down. They should react as their role card dictates, (For example: Giant Sequoia needs to be touched 3 times before it sits down, where as White Fir sits down after 1 touch). The number of touches also dictates when the student can touch the other trees around them. Choose a student somewhere in the cone area and touch them on the shoulder.
6. Watch as "the forest" experiences fire. If you touch a giant sequoia, they won't burn right away, because sequoias are fire resistant (think of the Calvin Spire). If you touch any other tree they will reach out and touch the students that they can reach before sitting down, after receiving the amount of touches required on their card. Most role cards direct students to sit down if they are touched one time. If a Giant Sequoia is touched three times, it will crouch down, illustrating Sequoias' inability to withstand very hot fires.
7. Debrief with the students. Ask them what happened to the forest in this situation and why.
8. Tell the students about fuels management practices (the act of thinning forests and removing fuels so that a wildland fire will be less intense if it comes through). Ask them to stand up. Choose some students to "thin" from the forest. (Make sure you do this in such a way that students do not feel picked on.)
9. Choose another student to tap on the shoulder and watch what happens. Debrief. Do the activity as many times as needed to illustrate the main ideas of this activity. (Possible

scenarios include a lightning strike to a tree that can't reach other trees, and it's the only one to burn down, a lightning strike to a sequoia, a lightning strike that causes a fire to spread to a small area that can't reach other trees, etc.)

10. Not only are we illustrating how trees interact with one another during a fire but also how that in turn affects the other factors within the forest. Particularly with how much debris is on the forest floor from such things as the drought or the bark beetle epidemic. For example, rocks can become conductor for heat. An animal like a deer or some kind of bird would flee. That would not only displace the animals that flee but also place them into a neighboring ecosystem.

Lesson #4: Sequoia Logging History

Look around at the large sequoia stumps and fallen logs in the area. Logging in this area probably happened between the mid 1870s and the 1890s. We do not know why the Calvin Spire was spared by early loggers, while the other two large trees were cut.

Notice that the one closest to the Calvin Spire was cut so that it fell uphill past where the washstand sits between the two huts. You can walk back up to that log and see the growth rings. Remember that you're looking at the rings from about 120 feet up the tree. Ask the students to think about how trees grow upwards - there will be more tree rings in a cut at the base of a tree than in a cut further up the tree. In the smaller stump, you can see the rectangular notches that show where loggers put in spring boards to stand on so that they could cut the tree down.

Tannin

Move closer to one of these stumps. Feel the wood. The wood of this sequoia is as sound today as the day it fell and will probably be here hundreds of years from now. A high concentration of a chemical called tannin makes the wood resistant to decay, insect attack and disease. Compare the wood of the fallen sequoia to other fallen trees around, and note how much the others have decayed in comparison. The wood remaining here is heartwood, which has a relatively high concentration of tannin. The sapwood of fallen logs, without the tannin content of the heartwood, usually decays within a few years in moist conditions. One sequoia wood sample taken in the Giant Forest area of Sequoia National Park was calculated to have been dead for approximately 2,100 years, yet the wood was still sound.

Logging Waste

The remnants of logging in this area demonstrates the tremendous waste that occurred during this period in history. Pass out the laminated photographs of early logging in the Sierra. Have students share what his or her photograph shows according to the caption on the photo. These giant trees were cut down using axes and hand saws, and were hauled out of the woods using oxen, mules, and horses. The wood was used for fence posts, grape stakes, headgates on irrigation canals, shakes and shingles.

Point out the axe marks at the base of the log. This tree was cut down using only axes, and it probably took two men more than a week to finish the task. As you walk towards the end of the log, you can see that only about 40' of this 275' tall sequoia was used - the rest was wasted. (Be very careful around the barbed wire fence!) Notice the ditch which was dug and filled with small trees to cushion the falling giant so that it wouldn't shatter.

There are several factors that caused the waste of fallen sequoia wood. Invite the students to hypothesize why these sequoia logs were left behind, and then share the following with them:

1. The wood was very brittle and trees often shattered when they hit the ground. Because it was so brittle, it was unsuited for construction.
2. The downed trees were still so large that they were too difficult to move.
3. Only the lower portion of the tree below the large branches was used because the branches (knots) growing from the trunk were so large that they made the trunk wood unusable.
4. The broad base ("butt swell") of the sequoia made the very lowest part of the tree unusable. Note the stump next to the fallen giant. Men cutting this tree has to stand on spring boards (like scaffolding) to cut the tree off above the butt swell.
5. Greed, not wise conservation practices were the motivation behind cutting these very special trees.

Man's impact on the giant sequoia was negligible until the 19th century. Then loggers began to harvest the big trees. Entire sequoia groves were eliminated. Nelder Grove is unique because it was only partially logged. In this grove we can see full-sized sequoia growing among the stumps from past logging operations.

Because of improper logging practices and a greater understanding of how long it takes these giants to grow, it is now illegal to cut or remove giant sequoias.

John Muir said, "Walk in the sequoia woods at any time of year and you will say they are the most beautiful and majestic on earth." We hope that you have felt the beauty and majesty of the giant sequoias, and gained some insight into the complex life of the forest around you.

The following activities can be used to supplement this lesson, and can be completed at any time throughout the class.

ACTIVITY #3 - The Sequoia Seed's Survival Search for Suitable Soil Survey

Activity Overview

Sequoia seeds need disturbed, bare mineral soil to successfully germinate and grow. Students will measure the depth of forest litter to determine how deep a sequoia seedling would have to grow to reach the soil.

Focus Questions

1. Can a sequoia seed grow in the "forest litter," or does it need bare mineral soil (dirt)?
2. What is the average depth of the bare mineral soil (how far down do you have to dig before you get to dirt) in this part of the forest?
3. Does the current condition of the forest encourage or discourage sequoia seedlings growing here?
4. What things could reduce the amount of forest litter, and make the bare mineral soil more accessible to the seeds?

Main Ideas

1. Sequoia seeds need bare mineral soil in which to grow.
2. The students will discover that the "forest litter" is close to a foot deep in some areas (less in other areas, but still fairly deep throughout the forest.)
3. Because of fire suppression over the past 80 years, the forest has become cluttered, thereby making it a hard place for sequoia seeds to germinate and grow into mature trees. You will find very few young sequoias in the grove. (If you think you are finding a lot of giant sequoia seedlings, you many be confusing them with the incense cedars - there are many of these shade-tolerant trees throughout the forest.)
4. Periodic fires are the main things that reduce the amount of forest litter in a healthy forest, however, since people have suppressed fire in the grove for nearly 80 years, a fire now would be devastating. This leaves us with the question of what to do. The forest service has been implementing "controlled burns" throughout the Sierra Nevada for about 35 years. In controlled burns, they first go in and reduce the amount of forest litter, to insure a "controllable" fire (cooler burning with less stuff to burn).

Activity Organizer

Objectives

By the end of this activity, students should be able to:

1. Determine where in the forest a sequoia seedling would be likely to survive.
2. Explain what they could do to prepare a suitable site for a sequoia seedling.
3. Explain how nature prepares sites for the seedlings.
4. Describe what people have done to impede nature, and what is currently being done to rectify the current condition of the forest.

Materials

75 foot long piece of string
Pencil and recording sheet (Appendix C)
Sticks for digging
Rulers
Giant sequoia cone with seeds

Time Required
20-30 minutes

Location
Anywhere along the trail. Materials are stored in a wooden cabinet near the John Knox tree.

What to Do

1. Divide the students into groups of 2-3. Give one student the responsibility of being the recorder for the entire class. Each group is given a ruler and each group must find a stick or determine another suitable means for digging through the litter to the soil below. (e.g. bare hands.)
2. Lay out the 75-foot piece of string so that it lies in a straight line along the forest floor, but not along the trail.
3. Assign group locations along the entire length of the string so that all groups are evenly distributed.
4. Each group's task is to carefully dig through the forest litter until it reaches bare soil (dirt), measure the depth of the hole, and report its findings to the recorder.
5. When all the groups have reported their findings and these have been recorded, answer the following questions:
    1. Where was the forest litter the deepest? How deep?
    2. What was the average depth of the forest litter? The total of all depths? The number of holes dug?
    3. At which sites would sequoia seedlings least likely reach the soil?
    4. Which site had the best conditions for seedling survival? Why?
    5. Looking around the immediate area and taking into consideration the present condition of the forest, would you say that generally conditions are favorable or unfavorable for sequoia seedling survival? Why? What could be done to improve the conditions for sequoia seedling survival?

Use a sequoia cone to obtain a sequoia seed. Have the students plant it in the spot(s) that they determined would most likely enable survival. The seed should be buried no more than 1/4 inch deep and the soil should be loose, not hard packed.

Cover up all the other holes there were dug so that the forest looks like it did before your survey was taken. Don't forget the string. If you like, and time permits, you can conduct a second survey at a different location of your choosing farther down the trail.

ACTIVITY #4 - Tree Interview

Activity Overview

This is an exercise that will help the students summarize what they have learned in the class.

Focus Questions (to be asked of the tree)

1. What is your name?
2. How old are you?
3. What historical events were happening when you were sprouting?
4. Who are your relatives around here?
5. What are your enemies?
6. What neat things have happened to you in your life?
7. Who lives in your tree top?
8. Who lives at your ground level?
9. Who lives in your basement?

Main Ideas

1. Sequoiadendron gigantem is the scientific name, Giant Sequoia is the name we call them.
2. Some sequoias in the grove are close to 2,000 years old. This dates them to the days when Jesus was born, the height of the Roman Empire, and 1,500 years before Columbus arrived in America!
3. Enemies of the sequoia are:
    a. The overcrowded forest
    b. High winds
    c. Too much water
    d. Fires that burn too hot (due to excess forest litter)
4. There are over 140 species of insects, numerous species of birds, and chickarees that all depend on the sequoias for food and shelter.

Activity Organizer

By the end of this activity the students should be able to:

1. Identify the tree they interviewed by sight and name.
2. Express creative answers to the questions on the Tree Interview.
3. Share or discuss their responses with the other students.

Materials

Tree interview question sheets (Appendix D)

Time Required

10-15 minutes

Location
Anywhere along the trail where there are sequoias.

What to Do
Divide the students into groups of 2-3. Give one student the responsibility of being the recorder for their group. Each group is given a questionnaire. Assign each group a giant sequoia to interview. Encourage creativity in the students answers!

What is your name?
How old are you?
What historical events were happening when you were a seedling?
Who are you relatives around here?
Who are your enemies?
What neat things have happened to you?
Who lives in your tree top?
Who lives in your ground level?
Who lives in your basement?

ACTIVITY #5 - Meet A Tree

Have students do the "Meet A Tree" activity as follows:

Activity Overview
This is an activity that can be completed at any time on the trail and will help students familiarize themselves with the forest and with the characteristics of individual tree species.

Focus Questions
1. How are different trees unique?
2. What can I do to identify a specific tree?

Main Ideas
1. Each tree species is unique and has characteristics that help to identify it.
2. Like people are all different, trees are unique and can be distinguished from other trees.
3. We can use senses other than eyesight to identify trees.

Activity Organizer
By the end of this activity the students should be able to:
1. Identify "their tree" by using their senses.
2. Communicate an understanding of using senses other than sight to identify locations and objects.

Materials
Blindfolds

Time Required
10-15 minutes

Location
Anywhere on the trail. Be sure to pick a location that is relatively clear enough for blindfolded students to walk around safely.

What to Do
1. Divide the students into pairs. Give each pair a blindfold.
2. Direct the sighted students to lead their partner to a tree. Give the blindfolded students a few minutes to get to know their tree.
3. Have students return to where they started. Remove the blindfolds and have the students find their trees.
4. Have the partners trade roles and repeat the activity.
5. Discuss the ways that students got to know their tree and identified it after they were not blindfolded anymore. Review ways to identify different types of trees.

Appendix A: How Many Trees?

Complete the bar graph below by filling in one box for each tree you count on your study site.
Be sure to correctly identify each tree before filling in a box for it.

31							
30							
29							
28							
27							
26							
25							
24							
23							
22							
21							
20							
19							
18							
17							
16							
15							
14							
13							
12							
11							
10							
9							
8							
7							
6							
5							
4							
3							
2							
1							
#	**giant sequoia**	**incense cedar**	**ponderosa pine**	**white fir**	**sugar pine**	**dogwood**	**black oak**

Appendix B: Thinning Overcrowded Forests Example Card

[Front: **<u>Giant Sequoia</u>** [Back:] *3 Touches*

Appendix C:

The Sequoia Seed's Search for Suitable Soil Sites for Survival's Sake Survey

Depth of the hole to reach soil:

1. ___ inches
2. ___
3. ___
4. ___
5. ___
6. ___
7. ___
8. ___
9. ___
10. ___

___ total inches

Average depth of forest litter __________.
Average depth = total inches/# holes dug

The site that would be best for a sequoia seed to survive was site(s) # __________.

Was a seed planted? ___________.

Appendix D:

Tree Interview Questions

Ask the following questions of your tree. Be creative in thinking about how it might answer!

What is your name?
How old are you?
What historical events were happening
when you were a seedling?
Who are your relatives around here?
Who are your enemies?
What neat things have happened to you?
Who lives in your tree top?
Who lives in your ground level?
Who lives in your basement?

Appendix E: At a Glance: Giant Sequoia - - sequoiadendron giganteum

"Walk in the sequoia woods at any time of year and you will say that they are the most beautiful and majestic on earth."
John Muir

<u>Nelder Grove:</u>
- Named for John Nelder (Left New Orleans in 1849 gold rush, moved to grove in 1875, died in cabin fire, fall 1889.)
- John Muir visited "Fresno Grove" in 1875.
- Logging: California Lumber Company, 1874-1877; Madera Flume and Trading Company, 1882-1892
- 1928 Nelder Grove became property of the federal government in a land exchange, very little logging since then.
- Most sequoias in the grove are 85-95 years old, 50-125+ feet tall, 10in-7ft diameter.
- Most of youngest trees: 40 yrs old. (weather, conditions, soil bed conditions, seed quality = low seedling survival.)

Of 101 old growth sequoia, only 13 have no apparent fire scars.

<u>Sequoia Facts:</u>
- First sequoias: 130 million years ago, across North America and Europe (warmer climate)
- Today: **75 groves containing < 60,000 mature trees**, scattered west Sierra Nevada range (Placer to Tulare County) If grouped together, the groves would cover less than half the surface of Lake Tahoe
- **Largest living thing - combined height and diameter** (larger diameter - Mexican tule cypress, several taller)
  [On trail, one is 272 feet tall, base circumference 71 feet; board feet to build 17 5-room houses]
- **Age: 2,000 - 3,000 years**. Oldest known: 3,126 years. (older - bristlecone pine: 4,600 years)

<u>Two Closest Redwood Relatives:</u> [only 10 genera and 15 species of redwood in the world]
coastal redwood - Sequoia sempervirens (northern CA coastal range)
dawn redwood - Metasequoia (southwestern China)

<u>Largest Giant Sequoia:</u>
General Sherman, Sequoia National Park — Estimated 2,500 years old
Height: 274.9 ft — Volume: 52,500 cubic feet
Base Circumference: 102.6 ft
83.2 feet (4.5 ft above base)
According to increment borings, 1965:
Annual growth rate of almost a milimeter (1/125th inch) per year.
(Yearly wood production average of 40 cubic feet, or volume contained in a 50ft tall, 1 ft diameter tree)

<u>Plants Need:</u>	<u>Sequoias:</u>
Water	Require well-drained (but moist) soil. Groves usually found near valley bottoms where water tables remain within a few feet of the surface until summer. (Sometimes found on mountain slopes where sub-surface runoff is within range of the shallow root system.) Need 45-60 inches of precipitation/year.
Sunlight	Mild temperatures. One half full sunlight is optimal.
Nutrients	Seeds rarely germinate in littered soil - require loose, bare mineral soil, 1/4 in depth.
Space	Fire climax species: prefers an open, park-like setting created by repeated fires.
Carbon dioxide	

<u>Fire and Sequoias:</u> Small, periodic fires are beneficial to sequoias because:
1. Fires burn away forest floor litter, exposing bare mineral soil (optimum conditions for seed germination.)
2. Heat from small fires dries out cones in the upper branches, allowing the seeds to fall on bare soil.
3. Fires eliminate other trees and plants that compete for moisture and sunlight.
4. Periodic small fires eliminate the potential for large wildfires, which can kill sequoias.

Characteristics of a Sequoia:

Roots: 4-5 feet deep, one acre wide.

(Plaque: 2-3 acres and 8 feet deep.) [1 acre = 4840 sq yd = .756 football field]

Seedlings have a taproot that gradually disappears in favor of a large lateral root system.

Tannin: A chemical that makes the wood resistant to insects and decay. (One in Sequoia NP: dead 2,100 years)

Bark: 15-18 inches thick (can exceed 2 feet in isolated spots), more fire resistant: excellent protection.

Enemies of the Giant Sequoia:

Main enemies: **wind and water** - if soil covering the shallow roots is removed, winds will eventually prevail

Seedling death: drying of soil, heat canker, burial by leaves and branches, root fungi, insects, birds, mammals.

Sequoia Cones and Seeds:

Mid- to late- winter, male cones release pollen. Female cones: grain of wheat size.

Mature cones: average 2.5 inches long by 1.75 inches in diameter.

Can remain alive and growing for years (count rings on stems)

Cones hold 200-300 seeds. 3,000 seeds weigh one ounce.

One large sequoia: about 11,000 cones at any given time (7,000 green and growing, 4,000 open, brown, seedless.)

1,500-2,000 new cones produced in a normal year

Average: Up to 400,000 seeds/year released. (Squirrels, long-horned wood boring beetle larvae, wind, or snow.)

Lifetime: 60 million seeds produced (3-4 will become 100 year old trees)

	Giant Sequoia	**Incense Cedar**
		(Named for fragrant needles, heartwood)
Needles:	Dark green, round, prickly bunches	Bright green, iron flat sprays
Cones:	Egg shaped cone	Three-prong, duck bill seed pod
Bark:	Soft, spongy, cinnamon-colored	Hard, brown (young: peels, mature: furrowed)
Shape:	Young: narrow, triangle-shape, Older: loses lower limbs.	Broader triangle shape
Wood Use:	[Formerly posts, rails, grape stakes, etc.]	Shingles, railroad ties, pencils. Heartwood: chests

Other Common Trees on the Trail:

- Sugar Pine
    - Also known as the "King of the Pines"
    - Loggers prefer the soft, white wood for cabinets, doors, window frames, etc.
    - Short needles in groups of five
    - Cones typically 10-18 inches long

- White Fir
    - Early loggers considered them to be "weed trees" and did not cut them. (Today: window frames, doors, shakes, shingles, boxes)
    - Gray bark grows in small, light plates
    - Single needles, upright cones

- Ponderosa Pine
    - Named by David Douglas because of their ponderous size
    - High grade: for doors, shakes, frames, and paneling. Low grade: for boxes, rafters, joists, railroad ties
    - Long needles (5-9in) grow in bundles of three
    - Cones are prickly to the touch and 4-6 inches in length

Giant Sequoia II Trail Map