South Carolina

Forest Science

Guide for Teachers

a special project of the
S.C. Forestry Commission
FOREWORD

The South Carolina Forest Science series is designed to provide middle school science teachers with supplementary or alternative lesson material dealing with forestry and related environmental subjects.

The Forestry Commission gratefully acknowledges the contributions of: Commissioner Charles Williams, for conceiving the idea and his leadership throughout the project; Principal Dr. Celestine Pringle, Science Department Chairperson Carolyn Greene, and the teaching staff of J. B. Beck Middle School for the pilot implementation; and Staff Forester Ken Cabe for writing and illustrating the lesson material.

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INTRODUCTION

This teacher's guide to seventh grade Forest Science is designed to help you present the basic tenets of managing the forest resource in South Carolina. The book contains six lessons which deal with scientific forest management, including natural science, environmental considerations, and applied genetics.

Each lesson includes factual information as well as italicized teaching suggestions, projects, and extensions. The margin of each page contains some helpful references and lots of room for notes you may wish to keep.

One teacher's resource kit is provided to the school. Material in this kit may be copied or used as reference as you teach the unit.

This book produced by the SC Forestry Commission. Editorial comments and suggestions are welcomed. Correspondence should be addressed to:

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LESSON 1: WHY DO WE NEED FORESTS?

This lesson is designed to lead students to understand what the forest means to humankind. It is important that they see the forest not only for its products, but also for the environmental benefits and intangible rewards it provides.

The day before beginning this lesson, ask the students to list everything they touch while at home that evening that is in some way derived from trees. Then take their lists and categorize the items as paper products, food products, identifiable wood material (furniture, boards, pencils, bats, etc.), and wood by-products like medicines, chemicals, and camera film.

You may wish to reinforce this project with Project Learning Tree Activity 33 in the manual for Grades K-6.

In addition to the products we use daily, the forest provides many benefits that most people fail to notice:

Water. Trees take up large quantities of water from the soil. Some is used in the photosynthetic process, some is used as a solvent to transport minerals and nutrients, but most is incorporated in the protoplasm of the tree cells. About 80-90% of a tree's bulk is water, leading some people to view the forest as a massive water storage facility.

About 95% of the water in a tree is recycled into the atmosphere through an evaporative process called transpiration. This occurs mostly from the leaves, and the transpiration rate is highest during hot afternoons in the growing season. The transpired water is constantly being replaced by water brought from the soil. When transpiration occurs more rapidly than water replacement, the tree will wilt.

Tie a plastic bag around the end of a leafy twig and leave it for 24 hours. Collect and measure the amount of water that accumulates. Try it on days when the weather is hot and sunny as well as during cool, cloudy weather. Compare the results.

Forests also affect the quality of water in our streams and lakes. The roots and the organic litter (dead leaves and needles) slow the runoff from rainfall and let the water soak into the soil. Without this buffering effect, soil can be carried by the runoff into streams, adversely affecting streamflow, water quality and aquatic life.
Show the class pictures of eroded, hilly farmland. Discuss the total environmental ramifications, including decreased water quality, fewer fish in the stream, and reduced productivity of the land. How does this affect the people who live in the area? How might it affect people who live miles away, especially downstream? What could the farmer have done to prevent it?


**Temperature modification.** Trees provide a buffer against winter winds, and moisture transpiration in the summer acts as natural air conditioning. Studies of tree-related temperature modification in urban environments have shown that well-placed trees can reduce heating and cooling bills up to 30%. One study by the Federal Energy Administration found that a large, vigorous, well-watered hardwood tree has a cooling capacity of 800,000 BTU’s per day. That’s the equivalent of 20 window air conditioning units running 20 hours a day!

Place a thermometer in the lower branches of a large, leafy tree and one in an exposed area. Compare the temperatures shown at both sites on a hot afternoon.
Air quality. A study reported in *General Climatology* showed 85% less air pollution within a forest than was measured just 300 feet from the forest edge. The basic photosynthetic equation shows how green plants convert water and carbon dioxide into sugars and release oxygen as a by-product:

$$6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$$

From this equation it's fairly obvious that plants take in a pollutant (carbon dioxide) and release pure oxygen into the air. Trees play a significant role in this process: South Carolina's forests, by some estimates, remove 240,000,000 tons of carbon dioxide from the air each year.

*Here's a fun exercise to put this in perspective for the students:*

*An elephant weighs about 5.5 tons. How many elephants are equivalent to the amount of carbon dioxide absorbed by SC forests? If an elephant is 10 feet long, how many miles of elephants would this be?*

**Answers:** 240,000,000 tons is about 4,363,636 elephants; there are 528 elephants per mile, so your parade would be 8,264 miles long. That's enough elephants to reach from Columbia to London and back again. (You can do the same thing with squirrels or rabbits, but the numbers get awfully big and it's a lot harder to get squirrels and rabbits to stay in line.)

Trees also help manage the amount of particulate matter picked up and carried by the wind. Vegetative windbreaks, consisting of several rows of trees, are utilized by farmers on the great plains to slow the force of the wind and prevent topsoil from being blown away. When dust or other particulate matter is picked up by the wind, forested areas buffer the wind speed so the material can settle back to earth.

Aesthetics. Aesthetic appeal is very subjective, but it can translate into things more quantitative. Here are some examples:

- Tourism is South Carolina's single biggest money-maker. Parks, camping areas, and tourist towns depend heavily on their appearance to attract tourists, and much of this appeal is based on trees and landscaping. (Trees can help set a mood for tourists. Developers at Myrtle Beach depend heavily on transplanted cabbage palmetto to provide a tropical look, encouraging tourists to stop there rather than go on to Florida.)
- Psychological studies have shown that trees and green space in and around the workplace have a positive impact on
worker productivity, job-related stress, and illness-related absenteeism. (The May, 1992 issue of *National Geographic Magazine* discusses the role of plants in therapy for the mentally ill and rehabilitation of criminals.)

- Noise reduction is a specific area where trees can improve people’s attitudes and enjoyment of where they live or work. A strip of trees 100 feet wide can reduce noise from a busy highway by 6-8 decibels, or about 10%. The human ear can detect a volume difference of about one decibel; according to OSHA, hearing can be damaged at volumes of about 85-90 decibels. Sounds in the 120-140 decibel range can actually be painful. The sound volume reduction provided by a buffer of trees can easily make the difference between noise that is tolerable and volumes that are dangerous.

- Visual screening has a great deal to do with our perception of sensory stimulation. A sewage lagoon that is hidden from view may still produce noxious odors, but it is not as annoying as if the lagoon were in full view.

- Property values and marketability of homes are influenced by the trees and landscaping. A study in New England revealed that trees increased residential property values by up to 20%. Urban foresters in South Carolina have reported that planting trees in barren yards can stimulate the sale of residential property; most real estate agents would agree that shaded, landscaped properties sell faster, especially in middle to upper price ranges.

*Conduct Project Learning Tree Activity 4 or 24 in the manual for Grades K-6.*
LESSON 2: FOREST DYNAMICS

Like any population of living things, a forest is always changing. In a forest, however, the change is so slow that most people don’t even recognize it. Sometimes this leads to the erroneous belief that a forest is a static entity, one that needs only protection to make it last forever.

The living, changing nature of forests makes them unique among our natural resources—they are renewable. They can be harvested, replenished, and harvested again forever. We don’t have to preserve forests; we must conserve and manage them so the flow of environmental and material benefits from the forest will never be interrupted. Understanding and applying how forests live, grow, and change are the keys to managing this resource.

Discuss the differences between conservation (wise use) and preservation (keeping safe). Many people tend to use the words interchangeably.

Ask if all forests should be managed. Are there situations where it would be advisable to leave some forestland untouched and let nature take its course? What would happen if all of South Carolina’s forests were handled this way?

The dynamics of change in a forest are a part of the natural order which may be modified but not arrested. All forests are inexorably moving toward a predetermined forest type. This is called the climax, and it is reached by a predictable series of steps called plant succession. In the Southeast, the climax forest type is one consisting primarily of oaks and hickories.

Plant succession can be observed in old fields which have been abandoned. During the first year the site will be dominated by grasses and some annual weeds. The second year sees the addition of perennial weeds and marks the advent of pine seedlings on the site. Hardwood sprouts also begin to appear during the second and third years, but the pines will assume dominance because they grow faster. Over a period of 12–20 years, many of the grasses and weeds will die out because of the shade produced by the pines. Most hardwoods are described as being shade tolerant and will survive as shrubs or small trees beneath the pine canopy.

The life span of southern pines is generally less than 200 years; most individuals within a population will die before they
As the pines succumb to natural causes, light is allowed to reach the forest floor. This stimulates the growth of the hardwoods which have survived, and they respond by growing to fill the places once occupied by the pines. Since pines are intolerant (cannot survive in shade), there are few young pines to compete with the hardwoods, and a predominantly hardwood forest, mostly oaks and hickories, is the result.

Locate a nearby vacant lot, abandoned field, or unused garden spot. Help the students decide what stage of plant succession is evident. Then discuss how you might be able to modify the succession process. What would happen if you burned the area with a hot fire? What would be the effect if all of one species was killed with herbicide? How would an epidemic of disease or insects which preyed on one species change the succession process?
LESSON 3: FOREST STANDS

This lesson introduces the idea that a tract of forestland may actually consist of many sub-forests, each needing individual treatment.

Because many forests have a variety of timber types, age classes, and soil types, it is practical to subdivide the forest into smaller units according to their management needs. These units are commonly called stands; a stand is usually identified by the species composition and general tree size, e.g., pine saplings, hardwood pulpwood, etc. In the case of hardwood stands, the type of site (bottomland, upland, swamp, cove, etc.) may preface the stand designation to further define it.

Distribute copies of the graphic “can you STAND it?” and ask the students to complete the exercise. They should produce something similar to the “can you STAND it?” teacher’s key.

When they are finished, discuss the results. What could explain the large body of young trees across the center of the map? (Area may have been clearcut and regenerated naturally; perhaps a wildfire burned the area.)

What conclusions might you draw about the block of young pines in the upper right corner? (Trees are regularly spaced and growing in rows, suggesting that they are planted. The fact that the block has straight-line edges supports the idea that humans have manipulated the area.)

Ask the students to look closely at the makeup of the pine stand in the lower right of the picture. Lead them to note that there are a few scattered large pines with groups of younger trees around them. (Perhaps someone cut most of the timber, leaving a few large seed trees to regenerate the area.)

What might happen if all the trees along the river were cut? (Erosion could occur, allowing sediment to go into the river; removing shade could raise water temperature to the point where aquatic life would be affected.)
Forest managers use aerial photographs, topographic maps, and field examination to develop forest type maps similar to the one in the student exercise. These maps provide a quick visual reference to the forest and often include codes or notations which describe stand conditions, management needs, etc. Development of type maps is one of the first steps in overall forest management planning.

In a real situation, stands would be delineated using a combination of scientific and practical criteria. Small stands may be incorporated into larger ones of a different type for convenience of management, or large homogenous stands may be divided to better distribute workloads, costs, and incomes. Such artificial division or combination may also be done to provide environmental or wildlife habitat benefits.

An aerial photo of your school site may be obtained from the County Assessor’s office for a small fee.
LESSON 4: SILVICULTURE

The science of forestry is based on understanding natural processes and using the same concepts to manage the forest for whatever benefits are desired. Applying these concepts is called silviculture from the Latin words *silva* (forest) and *cultura* (cultivation, husbandry). A good working definition of silviculture is "the art and science of managing a forest."

In some ways, forestry is like farming; it just takes a lot longer for the crop to mature. Like farming, there are many intermediate steps between the decision to grow trees and the harvest.

When a farmer sets out to grow a crop, the first decision he must make is what crop to grow. This will be based on a number of considerations: what crops are suitable for his land, what materials and services are available to support his effort, what markets are available, etc. He must also decide how to finance his operation, evaluate potential problems, and finally decide if his profit from the enterprise is worth the risk and expense.

Once the decision is made, the farmer begins to implement the plan. He must prepare the land, purchase and apply fertilizer, purchase and plant the seed, cultivate the crop, protect the plants from insects and diseases, irrigate and apply supplemental fertilizer if needed, monitor the progress of the crop, harvest it, and market the final product.

Like agriculture, silviculture consists of a number of individual activities. These individual activities are referred to as cultural practices. Many cultural practices may be involved over the life of the forest.

Getting a stand of trees established includes the cultural practices of site preparation and regeneration. Site preparation is anything needed to get the land ready for growing a new forest. It may be very simple like burning off brush and debris, or it may involve the use of heavy equipment to completely clear the land.

Regeneration is actually establishing new trees on the site. This may be done by planting tree seedlings, sowing tree seed, or making it possible for nature to regenerate the forest through natural seeding or sprouting.

Any crop must be cared for while it is growing, and trees are no exception. While it is usually impractical to fertilize,
irrigate, or cultivate a forest stand, the manager must insure that the trees are protected and that their basic growth requirements are met.

The forest must be protected from wildfire, insects, diseases, and the abuses of uncaring people. **Fire protection** may include establishing a system of permanent firebreaks around and through the forest stand. Prescribed burning (discussed later) is also an excellent fire protection measure in some pine stands.

**Insect and disease protection** is a bit more difficult; spraying an entire forest stand for insects is generally too expensive and trees can’t be immunized against disease. Since vigorous trees are much less susceptible to insect and disease attack, the best protection is to keep them growing well. If insect or disease attacks occur, the most practical treatment is to remove the affected trees.

Sometimes forest managers are confronted with problems caused by people. A lot of people have no understanding or respect for the forest, so they use the forest as a dumping ground for trash and household debris. Others may abuse the forest through unauthorized hunting, misuse of recreational vehicles, etc. This explains why many timber owners have had to block roads into their forests and post “No Trespassing” signs.

Many people might seriously doubt the judgment of a forest manager who intentionally sets fire to the woods. Actually, this can be an extremely effective cultural practice for southern pines if handled by professionals. Such professional burning is called **prescribed burning** because it is carefully planned and executed under exacting weather conditions to achieve a specific purpose. Some of the uses of prescribed fire in South Carolina are:

**Site preparation:** Sometimes fire is all that is needed to prepare land for planting or seeding. Prescribed burning may be very effective on sites with light brush, grass, or logging debris. Usually a fairly hot, fast-moving fire is prescribed. Burning can also be used to prepare the site for natural reseeding. The fire removes much of the organic litter on the forest floor, allowing seeds to fall directly on the soil.

**Disease control:** Fire may be prescribed to control brown-
spot needle disease in longleaf pine seedlings. A hot, fast-moving fire consumes the needles, killing the fungus that causes brown-spot disease. Since longleaf pine is extremely fire tolerant, the seedlings survive to produce new disease free needles.

**Brush control:** The presence of hardwood brush in pine stands can reduce the amount of water and soil nutrients available to the pines. A low-burning, low-intensity fire will kill the heat-sensitive brush back to the ground without harming the more fire tolerant pines. This process will have to be repeated every few years since the brush will sprout back from the roots.

**Wildfire hazard reduction:** As dead needles and twigs fall from trees, they decay and return nutrients to the soil. Frequently, pine stands produce this organic litter faster than it can decay, resulting in a buildup of highly flammable material on the forest floor. Carefully administered prescribed fire can be used to safely remove this excess, reducing the danger from damaging wildfire.

**Wildlife habitat improvement:** Early farmers knew that burning caused the woods to “green up” and frequently set fires to improve browse for their livestock. Tender, succulent hardwood sprouts and herbaceous seed-bearing plants proliferate after prescribed burning, thus improving the food supply for deer, rabbits, quail, songbirds, etc.

Some wise philosopher once observed that “nature abhors a vacuum.” In practical terms that means that any patch of ground usually grows as many plants as it can support. In the case of trees, the larger they grow, the fewer the land can support. If left alone, the overcrowding will take care of itself as less vigorous trees gradually die out. While the process is taking place, the entire stand grows slowly and the trees that die are simply wasted.

Forest managers can make this natural process more efficient by harvesting some of the trees periodically. A harvest designed to provide more room for trees to grow is called a thinning; a harvest which seeks to remove diseased, suppressed, and malformed trees is called an improvement cut. Most of the time these are combined so the harvest can serve both purposes.

When the manager selects trees for cutting, they are usually marked with two spots of paint. One spot is about eye level so the logger can easily locate the trees that are to be cut; the other is at the base of the tree, below where the logger will cut. This spot
remains on the stump, providing the manager a way to verify that only the selected trees have been harvested.

Thinnings and improvement cuts provide for the biological needs of the forest (available space, light, soil nutrients) as well as the needs of man. Since such harvests are usually scheduled when the trees are large enough to be useful, the landowner receives income and the forest products industry obtains raw material for manufacturing.

Make copies of the exercise "Too Many Trees" and have the students complete it. Discuss their choices. Is the forest still well-stocked? Do the remaining trees have plenty of room to grow?

Talk about the individual trees. Why should this one be cut? Why should that one be left? Students should be able to justify their decisions.

Assuming this is a pine forest (intolerant), most trees are probably about the same age. Should the small trees be cut? (Yes) Why? (Their growth may be stunted due to overcrowding or they may be of poor genetic quality. Either of these reasons could explain why they aren't as large as the others.)
LESSON 5: SILVICULTURAL SYSTEMS

This lesson provides a brief overview of the long-term planning for managing a forest stand. The descriptions of silvicultural systems are provided as general examples; many variations are possible within each system. Keep in mind that silviculture is both an art and a science, and different managers will take different approaches to any management scenario.

After the lesson material has been discussed in the classroom, arrange with a local forest industry, consulting forester, or the Forestry Commission for a field trip to see some of these practices in your area.

When a series of cultural practices are planned into the long-term management of a forest stand, the total program is called a silvicultural system. Planning a system depends on the objectives of the owner, the tree species involved, and the land itself. For example:

... High, rocky land in the mountains would not be suitable for growing bald cypress; deep swamp in the coastal plain will not support white pine.

... An owner whose primary objective is a rapid return on his investment might want to grow only pine pulpwood; another landowner whose objective is to produce high-quality, high-value sawlogs would plan to maintain his forest for a longer period.

... The practices of prescribed burning and regular thinning are appropriate in southern pine stands, but are not usually recommended for hardwood stands.

Since the regeneration of the stand is of such importance, silvicultural systems frequently take the name of the planned regeneration method. Three systems frequently used in South Carolina are the seed tree system, the artificial regeneration system, and the coppice system.

Seed Tree System: Used mostly in pine stands, this system involves a specialized program of timber harvesting and prescribed burning to imitate the natural pine regeneration process.

One of the first things a manager does is decide how long he wants to maintain the stand. This decision is based on the tree species, economics, and the owner’s objectives. The length of time between establishing the stand and the final harvest is called the rotation or rotation age.
In the early life of the stand, a seed tree system is just about the same as any other type of pine management. The stand will be protected from wildfire, insects, and disease; thinning/improvement cutting will be done; and prescribed burning will probably be conducted every 3-5 years.

About five years before the end of the rotation, prescribed burning is done more frequently. This keeps brush growth to a minimum and begins to expose patches of mineral soil on the forest floor, creating a good environment for seed to germinate and grow. On every acre, 10-12 of the very best trees are selected and clearly marked. These are the seed trees which will become the parents of the new forest.

When the rotation age is reached, all trees are harvested for market except for the seed trees. The seed produced by these remaining trees are scattered by the wind and begin to grow. When enough young pines are established to adequately restock the forest, the seed trees are harvested and the cycle begins again.

Project the graphic “Seed Trees?” onto a screen or reproduce it on the chalkboard. Ask the children to discuss which trees would obviously not make good seed trees (Numbers 2, 5, 7, 11, 13, and 15 seem to be good trees, but aren’t very tall. This may be because of some genetic weakness. Numbers 3, 8, and 10 are crooked and malformed.)

Ask the children to evaluate and compare the remaining
trees, then ask them to select the two trees best suited to reseed the area. (Numbers 4 and 12 will probably be the obvious choices.) What if Number 12 had a disease that would make it unsuitable? (Numbers 4 and 14 would still provide good seed coverage.)

Artificial Regeneration System: This system is also used most frequently in pine management. The basic cultural practices (protection, periodic harvesting, and prescribed burning) are similar to those described for the seed tree method. The big difference, once again, is in how the stand is regenerated.

Under the artificial regeneration system, when most of the trees are ready for harvest, the entire stand is cut. This is commonly called clearcutting. Some type of site preparation is usually needed following a clearcut. This may be done by prescribed burning to get rid of logging debris and brush, by herbicide to kill unwanted plants, or by clearing the land with heavy equipment. The site preparation method depends on the condition of the site and the planned method of regeneration.

When site preparation is complete, a new forest is established by planting tree seedlings or sowing seed across the land. In South Carolina, the most common method is planting seedlings because it allows the manager to control the spacing between trees. Another advantage is the option of planting genetically improved seedlings which grow faster and are more resistant to disease.

Ask the children when they think would be the best time of the year to plant trees. Most will probably say spring or summer.

People tend to think of planting as being done when the weather warms up in the spring. Unlike ornamental trees or
shrubs, forest tree seedlings are most frequently available as "bare root" plants. This means that they do not have a ball of soil around the root system. Because of this, forest plantings are generally done during the winter and early spring. This allows the seedling to become acclimated to its new environment before the growing season, reducing the biological shock of transplanting.

Arbor Day is observed in South Carolina on the first Friday in December, officially starting the tree planting season. Other states observe Arbor Day as late as April. Ask the children why a state like North Dakota or Michigan would not have Arbor Day during the winter. (The ground is frozen.)
Coppice System: By definition, a coppice is “a forest originating mainly from sprouts or root suckers rather than seed.” Most hardwood species in South Carolina sprout readily from cut stumps making this a viable means of regenerating hardwood stands.

When a hardwood tree is cut, dormant buds beneath the bark of the stump are stimulated. New sprouts grow from these buds, frequently resulting in a clump of new trees all coming from one stump. These new sprouts grow rapidly because they are still served by the large root system of the parent tree.

There are many variations of the coppice system. The most basic method is to simply clearcut a hardwood stand and allow nature to take its course. Another method is to clearcut and wait for sprouts to appear, then remove all but one healthy sprout from each stump. Others involve even more intensive management, including treating competing brush species with herbicide or clearcutting many small patches instead of the entire stand.

One method being practiced in South Carolina is the silvicultural clearcut. This involves a normal clearcut of all usable timber followed by another cutting that levels brush and any worthless timber remaining on the site. This method allows all sprouts equal access to sunlight. Given an even start, sprouts from the large timber stumps will grow more rapidly and quickly establish dominance over the brush.
LESSON 6: TREE IMPROVEMENT

In any population, there are always some individuals that are bigger, better, and stronger. Farmers recognized this long ago and made special efforts to gather seed from the very best plants to save for the next planting season. In modern times, hybridization of both plants and animals has helped farmers be more productive.

The same techniques that are used to produce improved agricultural plants are also being applied to forest trees. It is a much slower process, however, since trees take such a long time to mature.

An individual tree is the product of two important factors: its environment and its genetic makeup. Through silviculture, forest managers can exercise some control over the environment. Tree improvement concentrates on improving the genetic quality of trees.

The cells of each tree have bits of information that determine the exact characteristics of that individual. These bits of information are called genes, and are inherited from the parents. Some genes govern growth rate and mature size, some control whether a tree will be straight or crooked, some determine whether or not a tree can produce an abundance of seed, etc. It is the genetic makeup of a tree (called genotype) that tree improvement programs seek to understand and modify.

Unfortunately, genes are too small to see and identify, so tree improvement specialists have to work with observable characteristics called traits. Since traits are the outward manifestations of genes, it can be assumed that a tree has genes which correspond to these observed characteristics.

Most of the tree improvement work in South Carolina has been done with various species of pines. The general concept is the same for most trees, but this discussion will follow the tree improvement process in pines.

Pines have 24 chromosomes and an estimated 13 million genes. Breeding for a single trait may involve thirty or forty genes that exert some influence on the desired trait.

The first step in tree improvement is to identify the best individual trees that can be found growing in the wild. This is
done by visual evaluation of traits that are important to man's intended use of the species being studied. Straightness, height and diameter growth rate, absence of disease, branch angle and the overall appearance of the tree crown are among the traits prized in forest tree improvement programs.

When a tree is found that exhibits these desirable traits to a greater degree than others of the same age, it is said to be a superior phenotype. That simply means that its external, observable traits are better than its neighbors. Once a tree has passed this test, wood samples are tested to determine if the density of the wood and length of the wood fibers are acceptable. Only then may a tree be designated as a true superior tree.

The location of each superior tree in South Carolina is recorded. Trees are plainly marked with signs and painted bands so they will not be accidentally cut or damaged.

Some tree improvement could probably be gained by simply using the seed from a superior tree, but a single tree can only produce so much seed each year. In addition, it is very difficult for scientists to study individual trees scattered all over the countryside. To solve this problem, tree improvement specialists have devised a way to bring the superior tree from the forest to the laboratory. They take scions, or cuttings, from the superior tree and use them to produce exact genetic copies of the original one. This may be done by rooting the cutting, by tissue culture in a laboratory, or by grafting.

The most common method is grafting. In this method, the tops are cut from rooted seedlings and the scions are grafted in their place. Grafted seedlings, called ramets, are then planted in a seed orchard. (All the ramets produced from the same superior tree are called a clone.) Each tree in the orchard is carefully labeled to distinguish which superior tree clone it represents.

Since the scion material is from a mature tree, grafted trees are capable of producing seed right away. It only takes a few years for the trees to begin producing enough cones and pollen to make a full-scale breeding program worthwhile.
Pines produce both male flowers (staminate strobilli) and female flowers (ovulate strobilli) on the same tree. (These correspond to the stamen and pistil in true flowering plants.) The mature male flowers look like clusters of blue-purple worms; the female flowers look like tiny cones. Both types of flowers are usually produced near the tips of branches.

Have the students look for male and female flowers on pines in the early spring. You can tell when they are ripe by the greenish-yellow pine pollen that covers practically everything during the flowering season. Collect some pollen and look at it under a microscope.

As the female flowers mature, reinforced plastic bags are tied over them to prevent accidental pollination. When the male flowers are almost ripe, they are collected, labeled by parent tree (clone), and their pollen is extracted under controlled conditions. The pollen is then injected through the plastic bags, directly onto selected female flowers. This process is called controlled pollination.

The bags are removed after the pollination season, and the female flowers are labeled so the manager can keep track of both parents of the seed produced by that flower. Since a single orchard may contain thirty to forty clones, a large number of different crosses can be made in a single season.

Fertilization does not occur immediately after pollination. The flowers fertilized in the spring of one year will not become ripe seed-bearing cones until the fall of the next year. When the cones are ripe, they are collected and the seed is extracted. This seed is used to grow new trees for reforestation.

Not all crosses produce good offspring. The only way to know which are good and which are not is to plant the seed and evaluate the trees. The evaluation includes monitoring the growth rate, disease susceptibility, and general tree form. This process is called progeny testing, and usually takes from six to twelve years. The best crosses from the progeny test are used for continued breeding; those that don’t perform well are eliminated from the program.

For information on problems caused by plant pollen, you may contact:
Dr. Lawrence Weiner
1 Medical Park
Suite 200
Columbia, SC 29223
After one generation (or cycle) of breeding, tree improvement has resulted in trees that are 7-12% better overall. With increasing population and high demand for wood products, tree improvement is another way forest science serves the needs of people.

Depending on your location, a tree improvement specialist may be available to demonstrate grafting and controlled pollination for your class. If you are near a seed orchard, a tour could probably be arranged as well. To explore these possibilities, contact the Forestry Commission or one of the large timber companies near you.
RESOURCES

SC FORESTRY COMMISSION
LOCAL, DISTRICT, OR COLUMBIA HEADQUARTERS

US FOREST SERVICE
FRANCIS MARION NATIONAL FOREST
SUMTER NATIONAL FOREST
COLUMBIA HEADQUARTERS

CLEMSON EXTENSION SERVICE
LOCAL COUNTY AGENT'S OFFICE

SC WILDLIFE AND MARINE RESOURCES DEPARTMENT
LOCAL OR COLUMBIA HEADQUARTERS

FOREST INDUSTRY IN YOUR AREA

LOCAL CONSULTING FORESTERS

DEPARTMENT OF PARKS, RECREATION, AND TOURISM
LOCAL STATE PARK OR COLUMBIA OFFICE

IN THE TEACHER'S KIT . . .

GRAPHICS

CAN YOU STAND IT?
TOO MANY TREES
SEED TREES