ADVANCING IN FORESTRY
4-H FOREST RESOURCES ADVANCED GUIDE
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CHAPTER 1

Forest Stewardship
An Introduction

Benefits of the Forest
In a cold, moving stream, a brook trout darts back to its hiding place beneath the roots of a bankside tree. A nearby angler ties a fly to a fishing line and gracefully arches it onto the surface of the water. After several casts, he is finally rewarded with a sharp tug of the line. As the late spring snow melts into the stream, the angler lands the brightly colored brook trout. After admiring the fish for a quick moment, he gently removes the hook from the side of the trout’s mouth and releases the fish back into the clear, clean water.

Forests can be managed for a wide variety of benefits including watershed protection, recreation, aesthetics (beauty), biodiversity, forage, and timber. A small area of forest may not always provide all of these benefits, but a large area of forest often does. Being a steward of the land means balancing the various demands on and capabilities of the forest.

Watershed Management
Water is one of the most important products of a forest. In mountainous areas of the western United States, more than 90 percent of the water supply originates in forests. Nationwide, more than 60 percent of the water found in streams, ponds, and lakes originates in forested watersheds. Forest management practices can affect both the quantity and quality of water flowing from forested areas.

Forests produce less overland flow (water that flows over the ground surface) than nonforest areas. This is because leaves, both living and fallen, intercept rain and snow. Much of this precipitation evaporates back into the atmosphere, so less water reaches the ground.

In areas that receive large amounts of snow, trees shade the ground and slow the rate of snow melt. By delaying snow melt, forests moderate stream flows longer into the summer.
Forests also help water remain clear and pure by lessening soil erosion. Fallen leaves and twigs help prevent water from running over the forest floor, allowing more water to soak into the ground. Tree roots also hold soil in place. Trees are especially important along stream banks, where rapidly moving water can loosen and wash away soil. Trees and other “riparian” (streamside) vegetation absorb nutrients before they reach streams and rivers.

**Timber Harvesting and Watersheds**

Because forests play such a big role in water movement, changes we make in the landscape also change water quantity and quality. Timber harvesting, especially clearcutting, may increase stream flow for a year or two. Without trees, more precipitation reaches the ground. Snow also melts more quickly in the spring because the sun shines brightly on it. This extra water enters rivers and can erode soil along stream banks. Eroded soil, called sediment, is a serious form of pollution.

Improperly constructed logging roads and log skid trails can increase sediment from harvested areas. Soil erosion on logging roads can be minimized by:

- keeping the road as level as possible (less than a 10-percent slope)
- diverting water from the roads with deflectors, culverts, water bars (shallow ditches), and broad-based dips (water diversion depressions across the road)
- seeding the roads to grass after logging is finished
- minimizing the number of stream crossings (roads should cross streams at a 90-degree angle)
- avoiding springs, seeps, wetlands, poor drainage areas, rock outcrops, and ledges

In the drawing at right, indicate whether you think each scene shows sound watershed management practices. (Answers on page 12.)
Soil erosion is more likely to be a problem on steep terrain than on level terrain. All timber harvesting operations in Pennsylvania are required by law to have a completed erosion and sedimentation prevention plan on site. These plans contain information on the activities the harvester will perform to prevent erosion from occurring. Implementing this plan will minimize the amount of sediment that ends up in a waterway. Stiff penalties exist if unacceptable amounts of sediment get into a stream or other water course.

**Why Manage Your Water?**
Water production is one of the most important uses of the forest. Forests must be managed properly to ensure an abundant, clear supply of water. Without proper management, our water supply can suffer. But how does this affect you?

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### Household Usage
An average person in the United States uses the following amounts of water:
- **Shower**—30–60 gallons/shower
- **Bath**—30 gallons/bath
- **Brushing teeth**—2 gallons/time
- **Flush toilet**—6–8 gallons/flush
- **Washing machine**—30–50 gallons/wash
- **Food preparation/cleanup**—10–20 gallons per time

### Food Production
Farm animals and plants use approximately the following amounts:
- **Horse, dry cow, beef animal**—12 gallons/day
- **Milking cow**—35 gallons/day
- **Hog**—4 gallons/day
- **100 chickens**—4 gallons/day
- **Corn**—54 gallons/plant/season
- **Potato**—25 gallons/plant/season
- **Tomato**—35 gallons/plant/season

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### Ways to Conserve Water At Your Home
Here are ways you can conserve water. Spread the word!
- **Turn off the water when shaving or brushing your teeth.**
- **Fix leaky faucets, which can lose 50 to 100 gallons a day.**
- **Put a weighted plastic bottle in your toilet tank, to use less water per flush.**
- **Install a water-saving shower head, which cuts shower flow in half.**
- **Mulch your garden! This will help the soil retain water, so you’ll need to water less often.**
Recreation Management

Recreation is a “product” of the forest just as lumber, wildlife, and clean water are forest products. The forest provides many recreational opportunities that enrich our lives. How would the activities you enjoy be affected if there were no forests?

Managing outdoor recreation in forests has become more complex as greater numbers of people participate in outdoor activities and compete for the same space. To properly mix activities in a given area of forest, forest recreation planners design space for both people and resources. In some cases, activities must be separated. For example, snowmobiling often is separated from skiing and hiking so that noise does not interfere with the solitude that others may seek.

The following is a list of recreational activities that people enjoy. Place an “X” beside the activities that you would consider appropriate for forests.

- Golfing
- Downhill skiing
- Boating
- Hiking
- Snowmobiling
- Fishing
- Hunting
- All-terrain biking
- Canoeing
- Berry picking
- Camping
- Target shooting
- Tennis
- Picnicking
- Football
- Nature study
- Horseback riding
- Soccer
- Baseball
- Orienteering
- Swimming
- Bicycling
- Basketball
- Skating
- Archery
- Cross-country skiing
- Playgrounds

(Answers on page 12.)
**Wildlife Management**

Wildlife management is the management of wild animal populations and their habitats. Wildlife play an essential role in forest ecosystems and in the food chain that links plants and animals (including humans).

A forester can increase or decrease an animal’s population by changing its habitat. Timber harvesting may improve habitat for some wildlife species while damaging habitat for other species. After a mature hardwood stand has been harvested and regenerated, white-tailed deer find ideal forage among new tree seedlings. Pileated woodpeckers, however, require a mature forest for cover. When planning a timber harvest, forest managers must consider carefully the types and requirements of wildlife present.

An important concept to wildlife managers is **carrying capacity**, the number of animals of a given species that an area can support without degrading the habitat. When a species’ population exceeds the carrying capacity, damage to both the animal and the forest can occur. Animals weakened by malnutrition become more susceptible to diseases. Trees and regeneration (tree seedlings and sprouts) may be damaged by overbrowsing as the animals compete for limited food. In many areas of Pennsylvania, white-tailed deer can cause forest regeneration failure by eating most of the young seedlings and sprouts.

When analyzing the types of wildlife present in a forest, wildlife managers consider the forest’s successional stages. Some animals prefer early successional stages such as aspen and birch regeneration, especially for their forage. Other animals cannot find cover, food, or nesting sites in newly harvested areas, and move into older tree stands.

Foresters and wildlife managers set priorities for wildlife species management. These priorities often are based on the current population of the animal and whether the animal is endangered or threatened. In certain areas of the forest, a specific animal species will be given careful consideration when planning a harvest. The forester will strive to reduce the negative effects of timber harvesting on this species. For some animals, this means that dead trees will be left as snags for homes, nesting, or forage. To maximize the availability of forest edges where many animals like to forage, clearcuts may be broken into smaller cuts with undisturbed forest between them. Old-growth forests may be left intact to preserve animal species that need the older trees for cover and forage.

In many cases, woodland owners manage for **specialists**, wildlife species that require a specific habitat, instead of **generalists**, wildlife species that do well in a wide variety of habitats.
Improving A Forest’s Edge
Many species of wildlife use “edge” habitat for nesting, feeding, and traveling. This is the habitat found on the boundary between two distinctly different successional stages, such as at the border of a field and a forested area. Edges between forests and fields are used by species typically found in either habitat; they also provide the primary habitat for some species. Predators often are attracted to forest edges because an abundance of prey can be found there.

Forest edge improvement often is carried out to increase the available food and cover along these boundaries by providing a variety of vegetation types and layers, from the shortest herbaceous vegetation to the tallest trees. Multiple vegetation layers provide more places where wildlife can obtain food and find nesting, resting, or escape cover. Several methods are used to enhance forest edge habitat, including planting, letting natural succession occur, and cutting. Adding brush piles and nest boxes also will improve the habitat along a forest edge.

Check These Species Out
All of the wildlife species listed below use forest edge habitat. Using a field guide or other reference book, mark those typically found within the forest with an “F,” those typically found in open fields with an “O,” and species that prefer forest edges as their primary habitat with an “E.” (Answers on page 12.)

___ field sparrow
___ indigo bunting
___ wild turkey
___ porcupine
___ eastern cottontail
___ raccoon

A gradual edge provides protective cover for many wildlife species.
Cultural Resources

The forests of Pennsylvania played a major role in the development of the state’s industry. In the late 1800s and early 1900s, Pennsylvania was the country’s leading producer of lumber, and Williamsport was the production capital. Millions of board feet of logs were rafted down the Susquehanna River to Williamsport where numerous mills sawed them into lumber. At one time, Pennsylvania was the leading leather-producing state. Tannic acid used to tan leather (which makes it supple and last longer), came from the bark of eastern hemlock. After the bark was removed from hemlock logs, they were cut into lumber as well. Because hemlock was so important to early Pennsylvania, it was designated the state tree.

Charcoal also was made from Pennsylvania hardwoods at this time. This charcoal was important to the iron industry. Charcoal was made by piling wood into a cone shape in a forest clearing near where the wood had been cut. The pile was covered with soil so very little oxygen would get to the wood, and then the wood was set on fire. When the charcoal was ready, the soil was removed and the charcoal was hauled off. Evidence of these charcoal-making areas can be found in Pennsylvania woodlots today.

Other resources of historical importance can be found in the forests of Pennsylvania. In some areas, old oil wells can be found. Stone walls are common throughout the woods, as are foundations from old homesteads. Much of our present-day forests have grown up on land that once was farmland and pasture. Native American artifacts also can be found. These resources need special attention and sometimes protection in the management of Pennsylvania’s forests. They can be important links between the past and the present.
**Career Considerations**
A recreation manager oversees the natural resources that make an area popular. The manager coordinates trail building and upkeep, information services (maps and signs), building construction and upkeep, and use of the area. Recreation managers can be found in national, state, and local parks and forests. A four-year degree, with emphasis on forestry or recreation management, generally is required.

**Tree-vial Pursuit**
Pennsylvania has 186 native tree species, 288 shrub species, 64 native mammal species, 278 native birds, and more than 150 kinds of fish!

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**4-H Wildlife Projects**
If you are interested in wildlife, consider participating in the 4-H wildlife projects *Wildlife Is All Around Us*, *Endangered Wildlife*, or the *Wildlife Habitat Evaluation Project*.

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**CHALLENGE!**
You are Lynn Hans, a forest manager for the Hemlock State Forest. You recently learned from the state office that Kate Clementine Rocksrd, a local philanthropist, has died and left the Hemlock State Forest 10,000 acres of forest land adjoining Big Falls Lake. You are in charge of preparing a management plan for this area.

The local snowmobile clubs are lobbying your office to establish 67 miles of snowmobile trails in this new land. These trails would cross six small undeveloped lakes and two rivers, and would run through bald eagle nesting areas. The trails also would be routed through prime elk habitat.

A cross-country skiers’ group, led by local activists Susan and John Block, wants to prohibit all motorized vehicles, including snowmobiles, from this area. Group members point out that the acreage is pristine and undeveloped. They do, however, want to develop 42 miles of cross-county ski trails on the land.

The local chapter of a national conservation group wants to set aside the area as a wildlife sanctuary, arguing that the area is environmentally sensitive and home to important animals like the bald eagle and elk.

Tom Grey, a local resort owner, wants to open the area to boaters and anglers, and wants Hemlock State Forest to stock the lakes with trout and build roads, docks, and boat accesses on the lakes.

Local loggers led by Art Marthey, mayor of a nearby town, want authorization to harvest approximately 6,700 acres of northern hardwood stands. They point out that this would boost the economy in towns surrounding the Hemlock State Forest.

How will you manage this land? What type of:

- recreation management plan will you draft?
- wildlife management plan will you draft?
- overall usage plan will you draft?

Who will benefit from your plan? Who will not benefit? Will you be able to make everyone happy?
Yearning to Learn

Additional Activities

In the following activities, remember the basic rules of conservation. Do not unnecessarily damage or destroy the plants and animals you are studying. Leave all ecosystems undamaged. Have a positive impact on the forest.

Observe the amount of sediment in a flowing stream. Using a large glass jar, collect water away from the bank just above the stream bottom. Do not disturb the bottom of the stream or the bank; this would cause more sediment to get into your jar than the stream normally carries. Allow the sediment to settle for about 48 hours without disturbing the jar. Using a ruler, measure and record the depth of the sediment. Do this experiment at least twice, collecting at least one sample during the spring and one later in the summer. Compare your measurements. Which sample has the most sediment? If there is a difference, how can you explain it?

Look at a map of a forested recreation area (park or forest) with which you are familiar to see how recreation facilities have been located or designed. As you look at the map, answer the following questions:

• What conflicts might occur between motorized and nonmotorized trail activities? How might they be minimized?

• Why are camping and picnicking areas located where they are? What natural and cultural resources are located nearby?

• What rules are there for visitors? What is the purpose for each? How do visitors learn about the rules?

Visit a local forested recreation area to participate in a forest recreation activity with your leader, other 4-H members, or your family. As you participate, look at ways in which the facilities have been designed to make them easy and safe for people to use. What types of signs and maps are in place to assist people? What rules are posted to ensure that visitors have a safe, enjoyable experience? What trees, plants, or other natural features make this area a desirable place to visit? Are the trails and other facilities handicap accessible? If possible, talk to the park or forest manager to see what is involved in managing the facility.

Visit a beaver dam. Look for signs of beaver activity—fallen logs on the shore, beaver prints, and, of course, the beaver dam itself. Quietly observe the area for a few hours and see if you are lucky enough to spot any beavers at work! What would happen to the beavers if their habitat changed—for instance, if the pond dried up? What would happen if their source of food—aspen, cherry, and other trees nearby—were removed?

Plant a landscape for wildlife. Plant flowers that will attract hummingbirds and butterflies, for example, or plant trees and shrubs that will attract birds. Observe the animals using your landscape. Make a detailed drawing of your landscape, and record the number of birds and other wildlife that use your area during a two-hour period. Also note any seasonal variations in wildlife use that may occur. It may take a number of years for your plants to become established enough for wildlife to really use them. Remember that you are planning for the future!

Build nest boxes for birds of your choice and put them in your yard or neighborhood. Woodworking for Wildlife, available through the Pennsylvania Game Commission, is a good resource for nesting box plans.

If you really enjoy wildlife, you might want to participate in Wildlife Habitat Judging, held each spring.

Search a wooded area for signs of past human activity or other land uses. List these signs and speculate how or why each one ended up there.
Tips for Making a Three-sided Display

• Use material such as cardboard, foamboard, or thin plywood. Posterboard is not sturdy.
• The display’s dimensions when opened should not exceed 12 inches deep by 18 inches wide by 22 inches high.
• Use hinges or thick tape to attach the sections to each other.
• Paint or cover the background with paper, cloth, or adhesive paper.

Prepare a three-sided display on the life of a wild animal species found in your area. Include pictures of the animal and a range map showing where it can be found. State whether the animal is abundant, threatened, or endangered. (This information is available from the Pennsylvania Game Commission.) Include a description of the animal’s habitat requirements.

Put together a display that depicts some aspect of the history of Pennsylvania forests. The display can be based on the lumber industry or on some other factor that has affected the forests that we have today. Use drawings, old photos, and if possible, photos of the same area today.

Answers

Watershed Management Practices (from page 4)
A=No
B=Yes
C=No
D=Yes

Recreation Management Quiz (from page 6)
All of these recreational activities can be provided in a managed forest.

Check These Species Out (from page 8)

_ O_ field sparrow
_ E_ indigo bunting
_ F_ wild turkey
_ F_ porcupine
_ E_ eastern cottontail
_ E_ raccoon
Silviculture is the practice of manipulating a forest, following ecologic and economic principles, to reach desired objectives. It involves managing the establishment, species composition, and quality of a forest. Silviculture enables a forester to produce wood products, improve wildlife habitat, enhance recreational opportunities, control soil erosion, and maintain water quality.

Foresters must understand a plant’s interactions with its environment (forest ecology) to practice silviculture. Some specific silvicultural activities include:

- harvesting trees
- regenerating trees (growing new trees)
- choosing the best tree species for a site
- pruning trees
- fertilizing trees
- controlling pests
- thinning a dense stand of trees
- other activities that improve a forest or maintain it in a productive, healthy condition

Silvicultural practices often deal with large areas of forest, rather than specific trees. However, a forest rarely is homogeneous (having the same composition throughout). For this reason, foresters commonly divide a forest into stands. A stand is an area of forest land that has similar tree species composition, tree age, site conditions, and history throughout. In a pure stand, at least 90 percent of the predominant trees are of a single species. A mixed stand has more than one predominant tree species. A stand can be small in area (less than an acre) or cover many acres.

Stands can be even-aged or uneven-aged. When trees all are approximately the same age, the stand is called even-aged. Trees in even-aged stands...
often are about the same size, but are not always. In many natural mixed stands, tree diameters often vary greatly, even though the trees are of similar ages. Trees in even-aged stands commonly are shade-intolerant species that have originated on a disturbed site. They also might be a tree plantation. Uneven-aged stands have at least three distinct age classes, but commonly have many. (All trees within an age class originate from a single event, e.g., a planting or fire.) Trees in uneven-aged stands vary widely in size.

**Tree Classifications**

In a forest stand, especially an uneven-aged stand, individual tree crowns occupy different levels in the canopy. The position of a tree crown affects how well a tree grows relative to its closest competitors. Trees that get the most sunlight generally grow fastest.

Silviculturists classify trees in even-aged stands based upon five different crown levels.

- **Dominant** trees have crowns that rise above the general canopy level. They get full sunlight from above and on all sides.

- **Codominant** trees make up the average canopy level. Their crowns receive overhead light, but dominant trees restrict some of the sunlight on their sides.

- **Intermediate** trees occupy a position underneath the dominants and codominants below the general crown canopy. They receive sunlight from above but no direct light from the sides.

- **Suppressed** trees receive no overhead sunlight. They usually are slow-growing and weakened. Sometimes very shade-tolerant trees exist in this class.

- **Dead** trees.

**Label The Trees**

\[
\begin{align*}
DO &= \textit{Dominant} \\
C &= \textit{Codominant} \\
I &= \textit{Intermediate} \\
S &= \textit{Suppressed} \\
D &= \textit{Dead}
\end{align*}
\]

(Answers on page 21.)
Methods of Harvest and Regeneration

Much of silviculture involves harvesting and growing new trees. The harvest method for a stand depends on economics (some methods of harvest are more expensive than others), the ecological requirements of the trees to be regenerated, and the landowner’s objectives. Harvest methods that produce even-aged stands are clearcutting, seed-tree, and shelterwood. These are very different from the selection method, which produces uneven-aged stands.

CLEARCUTTING

In clearcutting, loggers cut all the trees in a stand, creating an open area. Clearcutting refers only to situations in which a forest is allowed to regrow on the site. When trees are cut to convert land to agriculture or development, the process is called land clearing or deforestation.

After a clearcutting, trees can regenerate in several ways. They may grow naturally from seedlings and seeds already on the site before the harvest, from seed that blows onto the site, from stump sprouts, or from root suckers. Forest managers may reforest clearcut areas artificially by planting seedlings or cuttings, or by direct seeding. Artificial reforestation is much more common in the western and southern United States than it is in Pennsylvania. Clearcutting favors regrowth of tree species that are shade-intolerant. It produces even-aged stands.

SEED-TREE

This method of harvest is similar to clearcutting except that foresters mark a few scattered trees for loggers to leave. These trees supply additional seed to the harvested area. These “seed trees” are the healthiest dominants and codominants of a stand, and are species that are not susceptible to windthrow (being blown down by wind). Planting or direct seeding usually is not required, since the seed trees supply seeds to regenerate the stand.

The seed-tree method works best with tree species such as ash that produce a large amount of wind-disseminated seed. It produces even-aged stands.

SHELTERWOOD

In the shelterwood method of harvest, loggers harvest a stand in two or more cuts. The first cut is called the seed cut; it removes enough of the trees to allow light to reach the ground and enable seedlings to grow. Trees remaining supply seed and protect the area from too much light and high soil temperatures. In a process called the removal cut, the seed trees are harvested five to ten years after new seedlings have started to grow. The young seedlings then receive all the light they need for rapid growth. The shelterwood method produces even-aged stands.

SELECTION

The selection method of harvest produces uneven-aged stands. In this method, foresters designate individual trees or groups of trees throughout the stand for harvest. Large-diameter, high-quality trees and smaller trees that are crowded usually are chosen for harvest. Undesirable species, trees with poor form, damaged trees, and diseased or insect-infested trees are harvested. New seedlings or sprouts then grow in openings created by removing larger trees. Stands managed with the selection method can be cut every ten years or so, as young trees grow to acceptable size. Shade-tolerant tree species such as basswood and sugar maple can be managed successfully using this method.

HIGH GRADING

High grading is a term used to describe any harvesting method that removes only the most valuable timber trees and leaves less valuable trees for future harvests. Two common forms of high grading are selective cutting and diameter-limit cutting.

Selective cutting arbitrarily selects the higher-value, fastest-growing individuals or species. Selective cutting is a vaguely defined term that has little meaning. It often is used to mask high grading.

The Society of American Foresters defines selective cutting as “a type of exploitation cutting that removes only certain species (a) above a certain size [and] (b) of high value. Known silvicultural
requirements and/or sustained yields [are] being wholly or largely ignored or [are] impossible to fulfill.” [Terminology of Forest Science Technology, Practice, and Products, Ford-Robertson, F. C. (Ed.), 1971.]

This misleading term—selective cutting—refers to a practice that has no basis in scientific forestry. There is no indication of how and why the trees are selected or what the objective of the cutting is. Inappropriate use of terms like “selective cutting” leads to misunderstandings among foresters, loggers, and woodland owners. “Selective cutting” also should not be confused with the selection method; they are not the same! Selection is a regeneration method designed to create or perpetuate an uneven-aged stand or forest.

Diameter-limit cutting is another common form of high grading, and is the most common method used to harvest timber in Pennsylvania. This practice can degrade the forest and reduce its future value for timber and other benefits. In diameter-limit cutting, trees harvested are selected solely on the basis of their diameter—without regard for other values or the remaining forest. All marketable or commercial trees above the limit are cut, while those below the limit are left as the remaining stand. Without any other controls, diameter-limit cutting likely will eliminate trees with superior genetic potential and damage nontimber values.

These two types of harvesting methods should be avoided. By using proper harvesting methods, foresters can renew the forest and provide quality products and other benefits far into the future.

High grading removes the most valuable timber trees, and often leaves less valuable and damaged trees for the future forest.
Prescribing a Treatment

Foresters often prescribe special treatments for individual stands. These treatments are aimed at improving the quality and quantity of wood that eventually will be harvested from the stand, or at accomplishing another resource objective.

Often, intermediate cuttings are made between regeneration harvests. The purpose is not to prepare a stand to grow new trees, but to improve the conditions for the trees that currently are growing.

An improvement cut, often called TSI (for timber stand improvement) removes undesirable tree species, damaged trees, and trees with poor form. A thinning removes trees in dense even-aged stands to permit the remaining trees to grow faster.

Crop tree management is a technique used to favor the best trees in the stand and give them room to grow. A forester or landowner will go through a stand and select the very best trees or trees that meet a specific objective and mark them. Then only those trees directly competing with the crop trees are cut. Crop trees should be chosen from dominant and codominant trees. Crop tree management should be done when the trees in the stand are generally between 4 to 12 inches in diameter at breast height (dbh).

Pruning is the careful removal of a tree’s lower limbs to reduce the number and size of knots in the wood and thus increase its value. Because of the high labor cost, only high-value tree species such as black walnut are pruned in forests. Trees usually are pruned when they are three to six inches in diameter. Trees in urban or community areas sometimes are pruned to look more attractive and maintain health.

Sanitation involves removal of insect- or disease-infested trees to prevent the spread of the infestation to healthy trees.

A salvage cut involves harvesting insect-ridden, diseased, or fire-damaged trees for wood products before they completely lose their economic value. For example, pines killed by bark beetles usually are harvested the following season.

Mark an “x” on trees you would remove in timber stand improvement.

Remember to remove poorly shaped trees and improve the spacing of existing trees. How many trees did you mark?

(Answers on page 21.)
**Fertilization** may increase tree growth where there is plenty of soil moisture but few soil nutrients. Fertilization seldom is economical but may be appropriate where foresters manage trees intensively on short rotations or for specific products.

**Herbicides** are used to control weeds and other plants when seedlings are being established. This treatment is called *release*—the new seedlings are being “released” from competing vegetation. Foresters also use herbicides in some forests to control brush and kill competing trees, grasses, and ferns.

**Regeneration protection** often is needed to ensure that new seedlings and sprouts are not damaged and destroyed by wildlife. Sometimes, rodents and rabbits can feed on regeneration and kill some of the young seedlings. In most forest areas of Pennsylvania, the biggest threat to regenerating trees is excessive deer browsing. In areas where white-tail deer populations have approached or exceeded the carrying capacity, little or no regeneration of desirable tree species occurs because the deer have eaten most of the regeneration. In such areas, electric or tall fences are often constructed around the harvest area to exclude deer. In areas where deer are excluded, a sufficient number of seedlings and sprouts grow to successfully regenerate the area.

Silvicultural methods to improve the growth or quality of a forest continually are being developed and refined. New combinations of treatments also are being tested. Long-term research and evaluations help to advance the art and science of silviculture.

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Fencing is often used to protect regenerating trees after a timber harvest.
Biodiversity
An important consideration for foresters practicing silviculture is how different silvicultural practices will affect biodiversity. Simply put, biodiversity means the richness or variety of animal, plant, and other life in a given area. It encompasses not only the species themselves and their genetics, but also the complex interactions formed among the species and their communities and ecosystems. Sometimes, silvicultural activities must be modified to protect or enhance the biodiversity in a stand or forest.

Career Considerations
A logger harvests timber that foresters have marked for cutting. Loggers must operate their businesses efficiently to return a profit. They must know how to purchase timber, design access roads, sell logs, comply with forest management plans, and operate heavy equipment, all while performing basic business tasks. A college education is not necessary, but technical training with a solid business background will help a logger succeed.

EnviroQuotes
“We have not inherited the earth from our fathers; instead, we have borrowed it from our children.”
—Unknown

You are Ima G. Forester, forest supervisor for the U.S. Forest Service in Big Pine National Forest in the western United States. You work and live in Little Fork, the town surrounded by Big Pine National Forest.

You recently approved a plan for increased harvesting of Douglas-fir, ponderosa pine and western redcedar. This makes the local forest products industries, loggers, mill workers, shopkeepers, and townsfolk of Little Fork very happy, since they will profit financially from the action.

However, a local resident says that the planned harvest volume for the Big Pine is too great. He is concerned that the red-backed sap slurper, a rare nongame bird that nests in the Douglas-fir and western redcedar of the Big Pine, will be eradicated by the increase in logging. He obtains a court injunction to prevent you, the forest supervisor, from increasing the harvest.

Meanwhile, the folks in Little Fork are getting anxious to see the harvesting begin. They argue that without the increased volume of logging, the town will be forced to shut down its two mills, and that the local economy will collapse.

The Little Fork newspaper and national news media reporters rush to your office to interview you. What is your stand? Will you fight the court injunction and argue on behalf of the increased harvest volume, or will you concede that wildlife such as the red-backed sap slurper may be harmed by harvesting? Why? Is there a way to make everyone happy?
**Yearning to Learn**

*Additional Activities*

In the following activities, remember the basic rules of conservation. Do not unnecessarily damage or destroy the plants and animals you are studying. Leave all ecosystems undamaged. Have a positive impact on the forest.

**Classify trees in a local woods,** using the tree crown classification. Observe which trees in an area are dominant, which are codominant, etc. How do the trees appear to you? What species are common in the dominant and codominant classifications?

**Count seeds.** Build tree box seed traps out of cardboard boxes, about 3 feet on each side. Cover the traps with large-holed mesh wire. Place the traps 10, 30, and 50 feet from the base of a large-crowned, open-grown tree during the period in which seeds fall (usually during summer and autumn). Every two or three days, count and record the number of seeds in each trap. Answer the following questions:

- Which trap collected the most seed?
- Which trap collected the least seed?
- How would you explain this difference?
- What would these results mean for a large clearcut area?

**Visit a recently clearcut area.** Record the number of seedlings or sprouts on four 1/100-acre circular plots (11.78-foot radius). At the same time, count the number of stems of competing shrubs and other competing trees (beech brush and striped maple, for example) on the same plot. To estimate the number of seedlings and sprouts per acre, count the total number on the four plots, divide by four, and then multiply by 100. Discuss why you do or don’t believe the cut area is being regenerated successfully. What signs of wildlife do you see? Check with the responsible forester and find out what plans have been made to ensure regeneration on the site.

**Conduct a short interview** with a professional forester about his or her work. Ask about the types of silvicultural prescriptions the forester makes and the objective to be accomplished with each prescription. Prepare a short article or presentation about your interview.

**Consider participating in 4-H forestry judging.** This event is held in the spring, and high scorers may be chosen to participate in the national judging event held in the summer. A good understanding of silviculture will help in this event. More information on 4-H Forestry Judging can be found in Chapter 6.
Science or Roundup Projects

Complete one of the following:

Make a poster of a forest showing dominant, codominant, intermediate, suppressed, and dead trees. Show how a tree’s position in the canopy affects its growth. Label each tree with the correct classification.

Search the newspaper for three weeks looking for articles concerning silvicultural treatments being carried out somewhere. Collect these articles in a scrapbook and clearly label them, indicating the practice described in the article. Share and discuss these articles with your class or club.

Make an exhibit of one of the harvesting and regeneration methods. Be sure to explain the method.

Make a model, draw pictures, or take photographs of four types of stand treatments. Note the species you are showing for each method.

Answers
Label the Trees (from page 14)
A=S
B=DO
C=D
D=I
E=C

Selection Cut Exercise (from page 17)
Forests provide many essential products, including wood. Americans use more wood annually than all other industrial materials combined. Our private, state, and national forests provide us with much of the wood we use, but we also import wood from other countries. The United States is the largest importer of wood in the world.

Wood products are made from renewable resources. Although environmental disturbances are associated with harvesting wood, they often are shorter and less invasive than those that accompany other resource-gathering activities such as mining and oil drilling.
**Harvesting Trees**

Wood is obtained from forests through timber harvesting. The first step in timber harvesting is the designation, by a forester, of specific stands and trees for cutting. From there, timber harvesting involves:

1. designing and building a system of access roads and trails;
2. **felling** (cutting) the trees using chain saws or mechanized equipment called feller/bunchers;
3. removing the tree’s limbs (**limbing**) and cutting the stem into appropriate lengths (**bucking**), either in the woods or at the landing (the collection point);
4. moving the trees (called skidding or yarding) to a log landing (area where logs are collected to be loaded) using skidders, bulldozers, horses, or even helicopters in rugged or environmentally sensitive areas;
5. loading logs onto trucks using a loader;
6. if paper or fuel is the desired product, chipping the logs into small pieces at the landing or mill using a machine called a chipper, then loading chips onto a truck;
7. hauling logs or chips to a mill.

Timber harvesting is a dangerous occupation. Through training and experience, loggers learn to operate machinery safely and to use necessary safety equipment such as a hard hat and chain saw chaps.

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**Don’t Be Just Another...Casualty!**

Today’s loggers take chain saw and logging safety very seriously. Technological enhancements in saw design (such as chain breaks and safety chains), personal safety clothing and protective equipment, improved recommended cutting techniques, and hazard recognition training all have helped to greatly lower the number of accidents and injuries in this profession. However, a large number of accidents occur annually among “occasional” chain saw users. This includes people who cut firewood for themselves or who own a chain saw for pruning or felling trees around their yard. If you or someone you know will someday operate a chain saw, think about this:

The fundamental idea behind working safely is always to put yourself and others at minimum risk!

The following precautions are a good starting point for all current and future chain saw users:

- Read and study the chain saw owner’s manual that comes with every saw.
- Keep chain saws maintained and in top condition.
- Wear recommended personal protective equipment and clothing for chain saw use. This includes a safety shirt and safety chaps (both constructed of an approved saw-resistant material), a hard hat with hearing and eye protection, and chain saw-resistant boots and gloves.
- Follow proper felling techniques when cutting down trees. These usually are outlined in the owner’s manual, but courses that teach these techniques also are available.
- Most importantly, learn to recognize potential hazards. These may include dead trees, broken hanging branches, “hung” trees (cut or dead trees leaning into another tree) or even small trees bent over under a fallen tree (called “springpoles”).

**ALWAYS THINK SAFETY!**
**ALWAYS WORK SAFELY!**
**ALWAYS BE SAFE!**
Processing Wood
After timber is harvested and transported to the mill, it undergoes primary processing. During this phase, the log is made into basic products such as fuelwood, lumber, pulp, veneer, particleboard, paper, hardboard, insulation board, plywood, or medium-density fiberboard.

Secondary processing occurs when the primary products are converted into more specific products. Furniture, windows, pallets, baseball bats, cabinets, and toys are examples of these products.

The Story of Lumber
Although more than 1,000 species of trees grow in the United States, most lumber made today comes from relatively few of these species. Approximately three-quarters of the wood we use comes from softwood (conifer) species such as pine, hemlock, spruce, and fir. Buildings often are constructed with softwood lumber. Ninety-five percent of our homes are wood frame construction. Hardwood lumber, such as black cherry, oak, maple, and ash is used mainly for cabinets, furniture, flooring, and tool handles, although some hardwood lumber is used in construction.

Sawmills process logs into lumber. Today, sawmills often are highly automated, but the process of making lumber remains simple.

Logs being made into lumber typically first pass through a metal detector that “scans” the log for metal such as nails or bits of old fencing. The logs then go through a debarker, which mechanically removes much of the bark. They are then rolled one at a time onto a vise-like machine called a carriage. The carriage holds the log in place while the headsaw cuts off the curved sides of the log. The remaining log is called a cant. A rip saw then will cut the rectangular cant into boards. A conveyor carries the boards to an edger, which saws them into desired widths. Trimmer saws next cut the boards into desired lengths. Mills use the small leftover pieces of wood as fuel or for making chips. The bark often is sold as mulch for landscape purposes.
The edged and trimmed boards then move along another conveyor belt where workers grade them according to wood quality. This lumber then is seasoned, or dried, either outside or in an oven-like structure called a kiln. Finally, the dried rough lumber passes through a planer (a set of rotating knives), which gives it a smooth, finished surface. Finished hardwood lumber is graded again before it is shipped to stores and lumberyards.

**Products From Wood**

You probably recognize most of the wood materials used in home, farm, and industrial construction as products of the forest. But did you know wood also provides clothing (rayon), wood plastics, photographic film, charcoal, insulation, and fireworks? Even turpentine, surgical gloves, and the blades for giant wind generators are products of the forest.

Put an “X” by the items below that you think contain wood or are wood products. (Answers on page 35.)

- cellophane
- erasers
- race car tires
- cattle feed additives
- newspaper
- ceiling tiles
- ceramic vases
- paint resins
- *National Geographic* magazine
- table tennis paddles

Wood is a remarkable feat of natural engineering. It can be stronger than steel of equal weight, yet under certain circumstances, it can be tied into a knot. The structure and properties of wood help determine its uses. These properties are a function of tree species, growth rate, and tree (stem) form.
Baseball Bats

Baseball bats are made from straight white ash trees. White ash wood, which is shock resistant, strong, and relatively light, is perfect for the demands made on a good baseball bat. Some of the best white ash for bats is grown in the forests of northern Pennsylvania. Bats made from Pennsylvania white ash are used by little leaguers and major leaguers alike. When you watch a major league baseball game, it is likely that many of the bats being used came from Pennsylvania-grown trees!

Only the straightest ash, free of knots, can be used for baseball bats. After the trees have been felled, the logs are hauled to the mill. There, they are cut into 39-inch lengths and split with a hydraulic wood splitter. Sometimes a landowner will cut and split his or her own logs and haul the splits to the mill. The splits then are placed on a lathe, where large knife blades quickly turn the split into a 39-inch-long “round.” The rounds then are graded for defects such as knots, cracks, grain, and color. Bats for the professional baseball leagues must be free of defect, white in color, and have from 4 to 17 growth rings per inch. Rounds that don’t meet these specifications are made into little league, softball, and store bats.

After grading, the rounds are placed into kilns where they are dried to the correct moisture content. Next, the rounds are placed on a “tracer” lathe. Computers contain all the dimensions for each bat model. This information then is transferred to the lathe where the round is spun and the knives form the bat to the required specifications for that particular model.

After a light sanding, the trademark is burned in and the bat is finished with a coat of paint or clear lacquer. The bat then is ready for you to hit that home run.
**Paper Maker**

We each use more than 700 pounds of paper and paperboard per year. In fact, this book—like most others—is made from a mixture of wood fibers, water, and chemicals called **pulp**. Before wood is made into pulp, the bark must be removed from the logs. At the mill, grinders take the bark off the logs, or jets of water blast it away. Mills turn wood into pulp in one of two ways:

- mechanically, using a method such as the groundwood process, whereby wood is pressed against a grindstone and the fibers are ground off into water;
- chemically, “digesting” the wood with a sulfate or sulfite process.

A single pulp-making operation may combine methods to take advantage of the best features of each. Mechanical pulping, for instance, gives high fiber yields (up to 95 percent) but requires a lot of energy and produces relatively weak, easily yellowed paper. Pulp made from the chemical process has a much lower fiber yield (40 to 50 percent). No matter which pulping process is used, the pulp must be washed and screened before it can be made into paper.

If the pulp is to be used for whitened papers like writing or book papers, it is bleached. The pulp then goes through a washer and is sprayed with water as it revolves on large drums. Next, it goes into the beater, which rubs and frays the fibers until they are more flexible. For the finer grades of paper, a sizing solution (starch or glue) is added to seal pores. Color also may be added at this point.

The pulp is suspended in water and fed onto a broad wire screen that drains off part of the water. It then moves through roller presses that squeeze out more water. Pulp is dried by winding it through heated drums, then chilled steel rollers to smooth it and give it uniform thickness. The resulting finished paper is wound into large rolls.
Recycle It!

Recycling is an age-old idea. Because goods were scarce in early America, settlers carefully reused and recycled items. Quilts were made from bits of old clothes, and corn husks were turned into mattresses. Even nature recycles. Microorganisms break down dead material on the forest floor into nutrients, which in turn feed future generations of trees. These trees eventually become dead material. And so the cycle continues.

Interest in recycling has increased for several reasons, including landfill limitations, import costs, environmental concerns, and favorable production costs associated with recycling. Despite what you may think, paper does not break down rapidly in a landfill. Since newsprint is by far the major U.S. paper import (accounting for 47 percent of all imported paper), substantial efforts are being made to recycle this product to reduce imports. Currently, about 40 percent of U.S. newsprint paper is produced from recycled newspapers.

Recycling paper involves three different activities:

• collecting the recyclable materials (from curbside, paper drives, specially designated containers, drop-off locations, etc.);

• preparing (sorting) these materials for appropriate markets; and

• recycling the materials by manufacturing new products.

When different kinds of papers are mixed, the higher-grade papers (like photocopy paper) are downgraded by the large amounts of lower-grade papers (like newsprint). To avoid this, it is necessary to separate waste paper by grades before recycling. Newspapers and cardboard can be recycled into newsprint and egg cartons. Typing and note papers become shoeboxes and tar paper. Photocopy paper can be made into high-quality paper, paper plates and cups, and tissues.
Paper Making Revisited

The process of turning waste paper into a new paper product is different from the process of making paper from wood. Waste paper is brought to the mill, where it then is repulped by mixing it in water and beating it with a machine called a hydropulper. This procedure separates fibers from unusable material, forming fiber-and-water sludge. Plastics and other unusable solids are filtered out, and this sludge then is thickened. The sludge is mixed with water, air is added, and any ink that remains floats to the surface as foam. The foam then is vacuumed from the sludge mixture. Sometimes, the pulp must be bleached with chemicals to give it whiteness and brightness. The de-inked mix, consisting of 4 percent fiber and 96 percent water, then is run through a paper machine.

It takes less energy to produce some paper products from recyclable papers than from timber. These savings result from reduced energy needs in the process and from not having to cut and transport wood. They can be offset, however, by the energy (mostly fossil fuels) needed to collect, transport, and de-ink the waste paper.
Other Wood Products

**Hardwood veneer** is one of the most valuable wood products from Pennsylvania forests. Only the straightest, largest, and most defect-free logs are used to make veneer. The bark is removed from these “veneer” logs, and then they are heated in high-humidity chambers. After they have been heated, the veneer is sliced by a large, sharp knife into long, thin strips from 4 to 10 inches wide. These strips can be put together to form thin “panels.” These veneer panels often are glued onto poorer-quality wood products. Doors very often have a veneer covering over a less-expensive core stock.

**Particleboard** is made of small pieces of wood bonded with resin and hot-pressed into panels. Manufacturing is carefully controlled to produce strength and durability. Particleboard can be made into hundreds of products. Although boards made of any type of wood particle are correctly termed particleboard, some are marketed under a name that describes the specific type of particle used, such as waferboard or oriented-strand board (OSB).

Particleboard is made in a variety of sizes and thicknesses to meet end-product requirements. Furniture cores are made from particleboard, and these in turn are overlaid with veneer. Particleboard also is used widely in covering building roofs, floors, and walls.

Wood can also be reduced to individual fibers and then formed into a mat to produce **hardboard, medium-density fiberboard,** and **insulation board.** Hardboard is a medium- to high-density product used in furniture, wall paneling, doors, siding, signs, and roofing material. Truck doors, roof panels, car rear-window decks, and even dashboards are made from molded hardboard. Hardboard is different from other fiber products because it requires very little resin (glue) in its manufacture, but relies instead on lignin, the natural binding material in wood.

Medium-density fiberboard uses synthetic resin instead of lignin to bond fibers together. It is used for panels, doors, and table tops. Insulation board, a low-density product, is used for acoustical ceiling tile.

These are only a few of the many shapes wood takes as it is modified to meet our needs. Other wood products include posts, poles and pilings, mine timbers, railroad ties, shingles and shakes, cooperage (barrels), lath, matches, toothpicks, excelsior (used as packing and stuffing material), and turpentine.
Christmas Trees

Christmas trees are another product of the forest and farm. The first commercial sale of Christmas trees occurred in New York City in the late 1700s. Today, Americans buy more than 35 million trees a year. More than half of the states in the U.S. produce Christmas trees as a crop. Most Christmas tree operations are small family farms with less than 40 acres of trees. For many growers, Christmas tree farming is a part-time occupation.

Pennsylvania Christmas tree growers harvest a variety of different species of trees, including Scots and eastern white pine; balsam, white, and Fraser fir; Douglas-fir; and white, Colorado blue, and Norway spruce.

Suitable land, money, knowledge, and time are key ingredients in a successful Christmas tree operation. Most trees take from seven to twelve years to grow to marketable size for use as Christmas trees. During that period, the grower constantly must be involved with the operation. The grower must clear the site and prepare it for planting; control weeds, by mowing or by using herbicides; shear trees to develop a desirable shape; and watch for insect and disease problems. The grower must be a businessperson, locating buyers for the Christmas trees. At harvest time, the trees must be cut, bundled, and shipped to the buyers. Many growers sell some trees directly to the consumer either already cut or as “cut-your-own.” New trees must be planted to replace those cut.
Sugar Maples: The Art of Making Maple Syrup

Maple syrup and maple sugar are strictly North American forest products, made from the sap of maple trees. Sugar maple trees provide three-quarters of the sap used. Hobbyists and sugar producers also may use red maple and black maple to produce syrup, but sugar and black maple have the highest sugar content. Sugar maples occur mainly in southeastern Canada and in the northeastern United States as far west as Minnesota. Quebec accounts for more than 75 percent of the world’s production of maple syrup products.

For many sugarbush (maple syrup operation) owners today, making maple syrup is a hobby; for others, syrup is a major cash crop. Since the maple syrup season occurs in late winter and early spring, it rarely competes with other farm work.

In the summer, the leaves of the maple tree make sugars and starches through the process of photosynthesis. These are stored as starches in the roots in the late summer and fall. In the late winter and early spring, a tree converts stored starch to sugar. The sap that is collected contains some of this sugar. The best sap flows, or “runs,” occur when temperatures dip to below freezing at night and rise above freezing in the daytime. The best producing trees are those with the largest crowns.

A sugar maker taps a maple tree by drilling a small hole in the trunk and inserting a spile, or tap, into the wood. A bucket, bag, or tubing is attached to this tap, and the sap drips out of the tree into the container or tube. As the containers fill, they are collected and the sap is poured into a tank or other storage device before it is processed into syrup. If tubing is used, a series of tubes run from tree to tree and move sap downhill into a collector tank. An evaporator is used to boil the sap, reducing water content and converting it to maple syrup. When it first comes from the tree, maple sap is a clear liquid with a faintly sweet taste. Boiling concentrates sugars and produces chemical reactions that give maple syrup its special flavor and amber color. Maple syrup is a natural food product containing no additives or preservatives.

The amount of sap needed to make a gallon of syrup varies with the sweetness of (percent of sugar in) the sap. The sugar content of maple sap ranges from less than 1 percent to more than 10 percent, but averages 1 to 3 percent. Maple syrup is about 66 percent sugar. For trees with a 2-percent sugar content, nearly 43 gallons of sap are needed to make 1 gallon of syrup! A taphole may yield about 1 quart of syrup each year.

For more information see Maple Syrup Production for the Beginner, by Anni Davenport and Lewis Staats, available through your county extension office.
Career Considerations
A wood scientist studies the structure and use of wood to improve wood products. A wood scientist may study how to dry wood to prevent warping and cracking; develop preservatives that protect wood from decay, insects, or fire; or develop a new process for converting wood into lumber, paper, or plywood. A four-year college degree with a major in forest products or wood technology can help you enter this field.

EnviroQuotes
“Like winds and sunsets, wild things were taken for granted until progress began to do away with them. Now we face the question whether a still higher standard of living is worth its cost in things natural, wild, and free. . . . We of the minority see a law of diminishing returns in progress; our opponents do not.” Aldo Leopold, from a foreword to A Sand County Almanac: And Sketches Here and There. Oxford University Press, Inc., 1977.

Tree-vial Pursuit
The typical consumer uses a 100-foot tree every year. If you are 18 years old, you’ve used up 18 such trees in your lifetime!
Good morning! You are Globe Al Consumer, a typical student at Plasticide High. This morning an announcement on the radio informs you that, due to environmental considerations, the government has banned the use of all wood products.

“So what?” you yawn, as you get ready for school. You reach for your favorite banana yellow rayon shirt. (The shirt manufacturer chose rayon because of its colorfast properties.) But wait! Rayon is a wood product. So now you decide to (choose your favorite from the following list):

- put on your gray wool sweater with the ketchup stain.
- borrow a polyester blue flowered shirt from your big sister/brother.
- decide to wear your white cotton pajama top (the one with the picture of the homeless puppy with the big brown eyes) to school.

Your clothing problem temporarily solved, you run to grab a bite of breakfast. But wait! Your breakfast cereal contains aspen particulate (the “fiber” part of the cereal). You choose instead:

- to eat that last bit of pineapple pizza from last night’s dinner. (But don’t cut it on the countertop—the counter is a wood product.)
- to eat the leftover chocolate cookies your little sister made. (She accidentally used Worcestershire sauce instead of vanilla, which is a good thing, since artificial vanilla also is a wood product.)
- to skip breakfast. After all, you’ll have a 15-minute break in just six hours, and you probably can grab a pack of Cheezees—if the store still sells them, that is. (The packaging—yes, it’s a wood product.)

Your breakfast dilemma solved, you now face the big test: how to get to Plasticide High, four miles away, in less than two minutes. (You overslept, and besides, there was that wood products thing to deal with.) You do the following:

- decide not to use your mom’s Honda Prelude, since rayon, a wood product, lines the radial steel tires.
- give up on the thought of taking the bus, because your bus pass is paper.
- start walking. But you have to avoid the roads and walkways, since they contain particulate wood products, in the Portland cement.

### Yearning to Learn

#### Additional Activities

In the following activities, remember the basic rules of conservation. Do not unnecessarily damage or destroy the plants and animals you are studying. Leave all ecosystems undamaged. Have a positive impact on the forest.

1. **List the items in your home** that come from the forest. List them under the headings of Solid Wood Products (lumber, furniture, plywood, fuelwood, posts, etc.), Wood Fiber Products (paper, fiber/particleboard, cardboard, etc.), and Miscellaneous Products (maple syrup, turpentine, fruits, nuts, etc.).

2. **Visit a sawmill, paper mill, plywood plant, or other wood product plant.** Write a brief report on your visit and present it to your club or class. Describe the different machines you saw, how they worked, and what species of trees were used.

3. **Visit a Christmas tree farm** and interview the owner. Questions could include:
   - What type of trees do you grow?
   - How many years does it take before the trees can be harvested?
• What is your biggest insect/disease/pest problem?
• How do you market your trees?

Write an article about your visit, including quotes from the interview. Submit this article to your school or town newspaper.

Visit a local maple syrup operation. After your visit, write a brief description of the operation, including the number of taps used and where the syrup is sold. Include information on the other maple products the producer makes.

Science or Roundup Projects

Complete one of the following:

Visit a wood processing plant (sawmill, paper mill, etc.) and take pictures (if allowed) or sketch the process. Or, build a model of machinery used in a primary or secondary process. Mount pictures on a three-sided display board, or build the model on a plywood or other sturdy base. Be sure to include appropriate labels.

Collect samples of wood from at least ten different tree species in your area. Each sample should be a straight section of a branch at least 1-1/2 inches in diameter and 7 inches long, and should include the bark. Smooth the cut surface with sandpaper, and apply several coats of linseed oil or varnish. Mount the wood samples on a piece of plywood or lumber. (Insert two wood screws from the back to attach each sample.) Beneath each specimen, write or type the name of the sample and at least two uses for that type of wood.

Collect twigs from seven tree species used as Christmas trees in Pennsylvania. Prepare a display with these samples (properly identified) and a photograph of each tree.

Visit an active Christmas tree farm and talk with the owner (or volunteer to help with the operation). Prepare a display or book of photographs showing important operations in Christmas tree production (planting, shearing, protecting from insects, harvesting, and marketing).

Set up a display using photographs or models of a commercial maple syrup operation, from tapping the trees to packaging the finished product. For contrast, show a hobbyist’s operation or historical methods of making maple syrup.

Tap a maple tree and make syrup on your own. You may have a suitable tree in your yard, or you may know relatives or friends who own a small woodlot. Using photographs or a model, demonstrate the project from start to finish. Keep track of the costs of your production. Be sure to include a small sample of the syrup with your Roundup or fair entry.

Answers

Wood Products Quiz (from page 25)
All of the items are wood products.

Sugar Maple Quiz (from page 33)
Most sap: B
Least sap: E or A, which is a conifer
Tree Pests

The forest is home to an abundant diversity of organisms, including insects. Many insects play important roles in a forest ecosystem. The dark, shiny ground beetle preys on the gypsy moth, a serious pest of the forest. Other insects serve as food for wildlife, or as pollinators. Some insects, however, cause tremendous damage to a forest. They reduce the growth rate of trees, transmit disease, weaken trees so they are more susceptible to attack by other insects or diseases, or even kill trees. The study of forest insects is forest entomology.

Forest pathology is the study of tree diseases and tree mortality. Diseases that strike trees cause damage that ranges from mild to very severe. On commercial forest lands, the U.S. Forest Service estimated that almost half as much timber was lost in one year to disease as was harvested. (This total included lost wood production as well as dead trees.) In many of our towns and cities, Dutch elm disease has killed thousands of American elms. The American chestnut once was the major hardwood timber species in eastern forests, but chestnut blight, a disease introduced from Asia, has killed almost every tree. To minimize damage to forests, forest managers must be able to identify and understand the insect pests and diseases that attack trees.

Sprouts from American chestnut tree roots continue to grow, only to be killed by chestnut blight before they can reach maturity.
Entomology Up Close

One way to classify insects is by the damage they cause. Each insect species has a preferred part of the tree on which it feeds. Some insects eat leaves; others suck juice from the leaves, eat buds, bore through the bark and wood, or feed on seeds.

**Defoliators** eat a tree’s leaves or needles. Heavy infestations of these insects can strip the leaves from entire stands of trees. Without leaves or needles, trees cannot make the sugar they need to grow. Most deciduous trees can survive one year of defoliation, although their growth rate will slow. Several years of defoliation generally will kill them. Conifers can be killed by just one year of defoliation.

Some insects, such as gypsy moths, eat entire leaves. Gypsy moth caterpillars prefer oak leaves, especially white oaks, but will eat leaves of many different hardwoods. During outbreaks, these insects can defoliate an entire hardwood forest. Other insects eat all of the leaf except the veins. Some insects **skeletonize** or **mine** a leaf by digging between the upper and lower leaf surfaces or eating all but the upper surface, leaving only a thin layer of cells. Because a skeletonized leaf still can photosynthesize, albeit at a reduced level, skeletonizers cause less damage than do complete leaf eaters.

**Sapsucking** insects draw sap and plant juices from trees using their hollow, strawlike mouth parts. They feed on needles, leaves, shoots, or stems. The pear thrips is a small (less than 2 mm long) insect that is particularly fond of sugar maple. The adults suck juices from leaves that are in the bud or just expanding in the spring. Leaves fed upon by thrips have a crinkled appearance and generally are smaller. Although this feeding does not kill the tree, it does reduce the ability of damaged leaves to make sugars. This insect is of particular concern to maple syrup producers. In heavy infestations, sapsuckering insects also can kill the tree.
Bark boring insects are very damaging to forests. These insects feed on the cambium and inner bark of a tree, disrupting the transport of water and nutrients. Many bark borers attack only trees weakened from disease or drought. The bronze birch borer, a greenish-bronze beetle, attacks birch and poplar trees when they are weakened by drought or other conditions. Trees attacked by bark borers have small holes in the bark where adult beetles have exited.

Some bark boring insects carry tree disease. Dutch elm disease is spread by the smaller European elm bark beetle, which carries disease spores on its mouthparts and feeds in elm twig crotches. Insects that carry a disease are called vectors of the disease.

Match the illustrations of insect damage to the type of insect that caused it, using this list. Some types may be used more than once or not at all.

(Answers on page 47.)

- sapsucker
- gall maker
- bark borer
- defoliator
- skeletonizer
- cone insect
- shoot borer
- twig borer
Terminal and shoot boring insects infest the tips and shoots of small trees, primarily in the forest or in tree plantations. Their feeding can damage the shape and growth rate of the tree. Eastern white pine often is damaged by the white pine weevil.

Twig borers or girdlers can kill or weaken small trees by feeding on the main stem. They occasionally are important pests. The cottonwood twig borer stunts young trees and seriously affects their economic value.

Cone and seed insects damage seed crops. Some insects invade cones to make galleries (tunnels where eggs are laid). Others use the seeds as food. These insects are of economic importance mainly in seed orchards and commercial nut trees (e.g., pecan and walnut). They also destroy seeds that might have been food for wildlife. Acorn weevils can destroy much of the acorn crop that otherwise would be eaten by squirrels, deer, and birds or grow into new oak trees.

Gall makers affect tree growth by stimulating a tree to grow abnormally, forming a lump of tree tissue called a gall. Galls vary in shape and can appear on leaves, buds, stems, or roots. Gall makers are not especially harmful to forest ecosystems, but they can be serious pests on ornamental and Christmas trees.
**Insect Management**

How can forest managers control harmful insects? Foresters concentrate their efforts on:

- **suppression**—controlling existing insect populations; and
- **prevention**—preventing insect outbreaks.

**SUPPRESSING INSECT EPIDEMICS**

Foresters suppress insect epidemics using a variety of methods. These include biological control, chemicals, sanitation, and mechanical control.

**Biological control** reduces populations by the introduction of natural predators, competitors, or diseases. Introduced predators attack the unwanted insects. Biological controls can be “specific” to the pest, destroying that insect without harming others.

**Chemicals** called insecticides were used extensively in the past to control forest insects. Insecticides can provide a quick response in the face of insect epidemics. Insecticides are regulated carefully and must be used properly to avoid damaging other forest organisms. Some insecticides function almost as a disease. A caterpillar that feeds on a leaf sprayed with an insecticide called “Bt” will ingest the Bt bacteria, become sick, and die shortly afterward. These insecticides are safer than traditional chemicals because they rarely harm other “nontarget” organisms; however, they often are slightly less effective. Behavioral chemicals send signals that confuse insects so that they will not reproduce, or will gather in chemical traps.

**Sanitation** involves harvesting insect-infested trees. Loggers may remove the infested trees from the forest and sell the wood to a mill, where it is made into products. Sanitation procedures are aimed at removing the insects from an area, so that they can’t infest healthy trees.

**Mechanical procedures** for controlling insects include cutting down, chipping, peeling, or burning infested trees to destroy insect habitat. Wood produced by these methods seldom is used commercially.

During the 1930s, NPV virus, a biological control, was used to combat a major outbreak of the European spruce sawfly in Canada. The NPV virus quickly reduced the epidemic and saved the white spruces.

**PREVENTING INSECT EPIDEMICS**

Foresters focus on two methods of preventing insect epidemics—regulation and silviculture. In preventing insect epidemics, forest managers are thinking ahead about the types of potential insect problems a forest may have.

**Regulatory controls** include laws that prohibit the transport and entry of insect pests. Quarantines prohibit the movement of infested material into an area, whereas containment policies prevent movement of insects or infested material out of an area.

**Silvicultural controls** reduce insect populations through stand management practices that create favorable growing conditions for trees. Healthy trees are more likely to be unattractive to some pests and to recover more quickly if pest damage occurs.

Using all of these measures appropriately is known as **Integrated Pest Management**, referred to as “IPM” for short.
Pathology Up Close
To understand how to control tree diseases and mortality, we need to know their causes. Forest pathologists classify diseases and mortality as either biotic (caused by a living organism) or abiotic (caused by something that is not alive). The chart below lists the major biotic and abiotic agents of tree disease and mortality.

Diagnosing tree diseases and finding causes of mortality is a specialized job. Just as a physician is uniquely qualified to diagnose human ailments, a forest pathologist is educated and trained in the science of diagnosing tree disease and mortality. Pathologists look for disease signs and symptoms, which suggest different diseases.

### Biotic Agents
- Fungi (plural of fungus)
- Bacteria: one-celled microorganisms
- Viruses
- Seed plants: mistletoes and dwarf mistletoes

### Abiotic Agents
- Temperature and light: too hot, cold, shady, or sunny
- Moisture: too much or not enough
- Nutritional deficiencies: not enough nitrogen, phosphorus, potassium, or other elements
- Air pollution: sulfur dioxide, ozone, etc.
- Salt: from de-icing salt used on roads in winter
- Mechanical damage: construction, lightning, animals, lawn mowers, weed “eaters,” careless harvesting
- Herbicide damage
- Wind, ice

In many areas of Pennsylvania, sugar and red maples are suffering from “decline.” This condition is the gradual decline in vigor of a tree, which often leads to its death. The exact cause is not known, but poor site conditions, root fungi, drought, and acid deposition are suspected factors.
Biotic Agents of Tree Disease

FUNGI
As many as 100,000 different species of fungi may exist. Most don’t cause tree diseases, but the diseases that fungi do cause are more numerous and serious than the diseases caused by any other biotic agent. Fungi attack various parts of the tree, including the leaves, branches, trunk, and roots.

Fungi often appear as soft, fleshy fruiting bodies called mushrooms. Woody mushrooms growing on living or dead trees are conks. Conks are obvious signs that fungi are present, but fungal strands (called hyphae), which function as “roots,” may extend for many feet beyond these fruiting bodies.

Fungi cause by far the largest numbers of forest diseases. These diseases are grouped by the part of the plant that is infected, or the type of infection, as follows:

- Root diseases
- Rust diseases
- Leaf diseases
- Decay in living trees
- Vascular wilt diseases
- Decay in wood products
- Canker diseases

Fungal diseases include some severe pathogens. Dutch elm disease and oak wilt (vascular wilt diseases) essentially clog vessels and prevent water and nutrients from reaching the leaves, and sugars from reaching the roots and other parts of the tree. White pine blister rust (a rust disease), is a complicated disease that has an “alternate host.” Most rust diseases don’t directly infect the target tree species; instead, they first must infect a different plant species and then infect the tree from the alternate host. Chestnut blight (a canker disease) causes a canker, or visible wound, that destroys the tree’s vascular tissues, preventing the movement of water, nutrients, and sugars at the infected areas. These diseases kill many trees.

Other fungal diseases don’t kill trees, but instead damage their wood products. Fungal wood product decay can reduce the volume or value of fuelwood, pulpwood, and stored lumber, and can reduce the structural soundness of wood in buildings, homes, and even boats.

BACTERIA
Bacteria are small microorganisms consisting of one cell. They cause many serious tree diseases, especially on fruit and nut trees, but their effect on forests is minor. Bacterial symptoms include galls. Some bacterial galls kill young trees by disrupting the water and nutrient flow through the tree’s stem (called girdling). Others may endure and grow for many years without killing a branch or the tree. Bacteria causes wetwood disease in elm, which affects the aesthetic value of this tree.

VIRUSES
Viral diseases generally are not found on forest trees; however, phloem necrosis, a virus, can affect American elms. Infected trees usually die within a year or two.

NEMATODES
Nematodes (small or microscopic wormlike animals) can occur on the roots of forest trees, although the specific damage they cause is not fully understood. Root-knot nematodes, dagger

Fungi reproduce by spores. Some species can produce up to 30 billion spores, which are carried thousands of miles by the wind.
nematodes, and other members of this parasitic group infect forest trees throughout the United States, particularly in the South.

**SEED PLANTS**
Diseases caused by parasitic seed plants such as mistletoe and dwarf mistletoe can seriously harm trees. Mistletoes are plants that live on tree branches, primarily those of hardwoods such as oak. These plants often cause swelling on the branch where the plant is located, and branches beyond the mistletoe plant often die. The effect on the entire tree generally is minimal.

Dwarf mistletoe is similar to mistletoe but generally lacks the leaves of true mistletoe. Dwarf mistletoe is most common on western conifers such as pine, fir, and spruce. This plant can cause serious damage by reducing vigor and growth rate. If it infects the trunk, this infection can seriously reduce the quality of the log and can become a weak point that could break in high winds. Dwarf mistletoe commonly causes swelling of branches at the infection point and, in some tree species, leads to the formation of “witches brooms,” which appear as a very heavy accumulation of shoots and branches that look like a broom.

**Controlling Tree Diseases**
Since tree diseases often are very difficult to diagnose, it isn’t always possible to prevent a disease from killing a tree or stand of trees. When an outbreak of a specific disease such as oak wilt threatens, however, foresters try to manage and suppress the disease using control measures similar to those employed for insect epidemics. Foresters suppress the disease outbreak with sanitation and mechanical procedures to ensure that it does not expand beyond the first group of infected trees. Chemical control measures also can be used to combat diseases. Chemicals sometimes are used to give individual trees resistance to a disease—American elms, for instance, may be injected with chemicals to help them fight off Dutch elm disease. Chemical control, in most cases, is too expensive to use under normal forest conditions.

Foresters focus much of their disease prevention effort on silvicultural controls. As much as possible, they try to optimize a forest’s growing conditions so that it will not be susceptible to tree diseases in the first place. For example, foresters do not cut or prune oak trees in May and June, knowing that this is the period during which oaks are susceptible to infection by oak wilt. Regulatory controls, including quarantine and containment, also help prevent the spread of disease to and through a forest.

An American elm in decline with Dutch elm disease. Note the dead sections of the crown.
**Abiotic Agents of Tree Mortality**

All trees and plants require five items in the correct amounts for optimal growth. They are:

- sunlight
- temperature
- carbon dioxide
- water
- nutrients

If one or more of these items is not available in sufficient quantities, a tree’s health may be harmed as severely as it would be by a biotic disease. If these items are available in excess, the tree also may be harmed. For example, a drought can weaken trees, making them more susceptible to insects. On the other hand, a tree subjected to flooding or puddling also can be stressed or killed.

**Temperature and nutrients** are other factors that help or inhibit a tree’s growth. Temperature extremes, either hot or cold, can weaken or kill trees and seedlings. Nutrient concentrations that are too low or too high also can harm trees.

**Air pollution**—for example, toxic gases or acid rain—is another abiotic agent that can stress a forest. Urban trees in particular may experience slowed growth due to high carbon monoxide, sulfur dioxide, hydrogen fluoride, and ozone levels. Some tree species are more resistant to air pollution than others, and city foresters keep this in mind when selecting species to reforest urban parks and boulevards.

**Chemical damage** from salt used to de-ice roads can cause tree dieback and mortality. This agent can be combated by minimizing the use of de-icing salt or by planting resistant trees along highways where de-icing salt use is high.

**Mechanical damage**—direct physical damage to the tree—is a problem in construction areas and occasionally in forest environments. It can injure roots, bark, or treetops, inhibiting the tree’s ability to photosynthesize. Damage from home, sewer line, and road construction all contribute to decline of shade tree populations in many urban areas.

**Wind** can cause serious damage to trees, especially species that have shallow root systems or trees that are growing on shallow or wet soils, which inhibit root growth. High winds can break branches and tops of trees. Trees damaged in this way are more susceptible to disease and insect attacks. Trees with shallow root systems can be blown over. This is called **windfall** or **windthrow**.

**Ice storms**, especially in the fall or early spring, can damage trees. Heavy ice can cause branches and stems to bend, break, or crack. These trees then are more susceptible to other biotic agents. Trees damaged by ice often become unusable as forest products; however, they can become valuable for wildlife habitat.
Career Considerations
A forest entomologist is an expert on forest insect identification and control, whereas a forest pathologist specializes in tree diseases. Both kinds of professionals often find employment in a state or federal agency, or sometimes in a pest-control firm. These specialties require at least a four-year college degree in entomology or pathology, with an advanced degree or degrees preferred.

EnviroQuotes
“Even if it could be proven that a certain species had no utility for us or our descendants, and that it could be plucked from its ecosystem at no cost, we should still be obliged to protect it for its sake and our own.” G. Jon Roush, writing in The Nature Conservancy Magazine, November/December 1989.

Tree-vial Pursuit
A piece of dead or dying elm branch the size of a small fireplace log can produce up to 1,800 bark beetles. Imagine how many beetles an entire dying elm tree can produce!

You are Stu Marmot, an urban forester for the growing metropolis of Tree Corners. You just received a phone call from Mr. Tenner, whose red pine is not doing too well. In fact, the tree has grown very little in the three years since it was planted. You agree to go out and look at the tree.

When you arrive at Mr. Tenner’s house, he is pouring a bucket of bluish water on the red pine, and is ordering the tree to grow. You correctly surmise that the blue water is a fertilizer mix. You also note that the tree is growing on the north side of the house, near a large overhang that provides continuous shade.

Mr. Tenner greets you heartily. He says, “I don’t know what I’m doing wrong. I watered the darn thing every day throughout the drought.” (You note that the tree is standing in a puddle of water.) “I fertilize it regularly. I don’t let the kids play around the tree, because I know that will compact the soil and hurt the oxygen supply. So, what does my tree have?”

What might be wrong with Mr. Tenner’s tree? List the symptoms and their possible causes. What advice would you give Mr. Tenner? (Hint: you might want to focus on the abiotic agents of tree mortality to diagnose this tree’s problems.)

Yearning to Learn
Additional Activities
In the following activities, remember the basic rules of conservation. Do not unnecessarily damage or destroy the plants and animals you are studying. Leave all ecosystems undamaged. Have a positive impact on the forest.

For more information on insects, try the Catch The Bug 4-H entomology project. Check with your 4-H agent or leader for more information on this project.
Survey insect damage in your neighborhood, park, or nearby forest. Watch for insect-caused problems such as borer or bark beetle damage, partially eaten leaves or needles, and damage caused by sapsucking insects or birds or cone borers. Record each type of damage you see, the tree species on which you observe it, and whether or not you see an insect cause the damage.

Gently pull apart a rotting log and look for insects. Draw or collect a sample of each type of insect you find. Use an insect book to help identify your insects. Why were the insects living in the rotting log?

Cut the stem from a fresh, full-grown mushroom and place the mushroom cap flat side down on a piece of white paper. Cover the cap with a drinking glass or jar to eliminate air currents. After a few hours, lift the glass and the mushroom cap and you will see a spore print on the paper. The white lines show where the mushroom rested and the colored lines are the mushroom spores. Spores may be brown, white, black, pink, yellow, or rust colored. Spore prints are used to identify mushrooms. An identification book that gives spore colors for different mushrooms can help you identify the mushroom. Remember, you should never eat wild mushrooms unless you are absolutely sure of what they are. Many mushrooms are very poisonous!

Investigate a tree disease such as oak wilt, chestnut blight, white pine blister rust, Dutch elm disease, or nectria canker. Learn what tree species the disease attacks, how it damages the tree, and how (or whether) the disease can be controlled.

Participate in 4-H forestry judging. Participants in this event need to be able to identify insects (or the damage they cause) and tree diseases and symptoms. This event is held in the spring, and high scorers can represent Pennsylvania at the national event in the summer. Forestry judging is explained in more detail in Chapter 6.

Science or Roundup Projects

Complete one of the following:

Prepare a display about a harmful forest insect. Include drawings or photos of the insect’s life cycle; information about the damage it does; and a sample of one of the tree species that the insect harms (oak leaf for gypsy moth, aspen leaves for forest tent caterpillar, white birch bark for the bronze birch borer, etc.). Include a description of possible suppression methods. Use a three-sided display board for effective presentation.

Prepare a display about a beneficial forest insect. Include drawings, pictures, or photographs of the insect’s life cycle; information about the benefits it provides; and a sample of one of the tree species the insect helps.

Collect at least eight forest insects from at least two insect orders (you will need a book on entomology to find the correct order for the insects). Label each insect with the date of collection and species of trees in the area where you collected it. Instructions for collecting and displaying insects can be found in Catch the Bug, Pennsylvania’s 4-H entomology project book.

Choose one tree disease and illustrate its life cycle. Discuss the agent of the disease, how it infects a tree, the results of infection, how it passes from one tree to another, and how it can be controlled. Some diseases to consider are oak wilt, white pine blister rust, nectria canker, and Dutch elm disease.

Collect photos of diseased or dying urban trees. Find examples of at least six different diseases or causes of mortality (biotic and/or abiotic). Identify the tree species and the type of agent that is infecting or killing that tree. You may need to work with your county service forester, Penn State Cooperative Extension forester, or other knowledgeable person to help you find these diseased trees.
Collect at least six different conks or fungi from trees. Identify the fungi and the tree species they are infecting. Research and illustrate the life cycle of one of these diseases on a poster board.

Make a display showing at least six different causes of disease/mortality in urban trees. These causes can include abiotic as well as biotic agents. Use photographs or drawings of actual trees, and list some preventive measures (e.g., to prevent the death of pines lining a freeway, limit application of de-icing salts in the winter).

**Answers**

Insect Match (from page 38)
A=gall maker
B=defoliator
C=bark borer
D=bark borer
E=cone insect
F=skeletonizer
In 1988, fires raged through Yellowstone National Park in Wyoming. Scores of fire fighters from the U.S. Forest Service, state forestry agencies, and even the U.S. Army battled blazes. The fires burned close to a million acres in and around the park. Although this is more than half the total land area of Yellowstone Park, the damage was not as severe as this figure indicates, since the fire burned in a mosaic pattern and left much of the “burned” area untouched or only lightly burned.

How do fires as catastrophic as this get started? How could forest managers prevent these fires? Are fires bad or good for the forest? The answers to these questions require a basic understanding of fire behavior.

The Fire Triangle
Fire is a chemical reaction that requires three main ingredients:

- fuel (carbon)
- oxygen
- heat

These three ingredients make up the fire triangle. If any one is not present, a fire will not burn.

Fuel generally is available in ample quantities in the forest. Fuel must contain carbon, which comes from living or dead plant materials (organic matter). Trees and branches lying on the ground are a major source of fuel in a forest. Such fuel can accumulate gradually as trees in the stand die. Fuel also can build up in large amounts after catastrophic events, such as insect infestations or disease. Trees and branches left on the ground after a logging operation can become fuel too. In Yellowstone, an insect infestation (pine bark beetle) in the early 1980s killed many trees, providing a buildup of fuel.

Oxygen is present in the air. As oxygen is used up by fire, it is replenished quickly by wind.

Heat is needed to start and maintain a fire. Heat can be supplied by nature through lightning. People also supply a heat source through misuse of matches, campfires, trash fires, and cigarettes. Logging equipment, trains, and automobile exhaust systems also can supply a heat source for fire. Once fire has started, it provides its own heat source as it spreads.
The three types of forest fires are surface, crown, and ground fires.

**Surface fires** burn twigs, needles, leaves, branches, and underbrush on the forest floor. They rarely kill large trees directly, but they do kill seedlings and young saplings. Surface fires are the most common type of forest fire in the eastern and southern United States, especially in hardwood forests. Fires in the eastern forests occur in dry periods in the spring and fall when the leaves are not on the trees and there is no fuel “ladder” between the surface and tree crowns. In addition, the leaves of hardwood trees are not as combustible as are the needles of conifers.

**Crown fires** are the most spectacular. They occur when high winds and dry materials make conditions right for rapid fire spread. Surface fires move into the tree crowns, often by climbing a fuel “ladder.” These fires can spread rapidly from crown to crown, and surface fires often follow right behind them. Crown fires produce tremendous heat, often causing extensive damage to trees. Crown fires usually occur in conifer forests (e.g., pine, spruce, and Douglas-fir) and are most common in the western United States.

**Ground fires,** although not as visible as crown fires or surface fires, can damage the soil. Ground fires burn in soils high in organic matter (e.g., peat, leaves, and tree roots) and can burn beneath the litter layer. They burn very slowly but generate a large amount of heat, usually killing all the trees in their path. Ground fires are common in northern forests, especially in peat soils.

Identify the type of forest fire depicted in each illustration.
(Answers on page 57.)
Fire Control

Once a fire starts, fire fighters control it by “breaking” one leg of the fire triangle. This means that one of the necessary ingredients for maintaining fire—fuel, oxygen, or heat—must be eliminated.

To break the fuel leg, a fire fighter might:
- build a fire line by removing all fuel down to the bare soil in a band in front of the advancing fire. This can be done with hand tools such as shovels or fire rakes, or with bulldozers and other heavy equipment.
- light a backfire. A backfire is a fire deliberately set by fire fighters that burns all the fuel backward toward the fire. This stops the advancing fire by eliminating fuel in its path.

To break the oxygen leg, a fire fighter might:
- cover burning fuel with soil, using hand tools or bulldozers

To break the heat leg, a fire fighter might:
- soak high-value buildings with water or with a water/foam mixture. Water absorbs heat and prevents the fuel from heating up to the temperature at which it will burn.
- dump fire retardant on the fire from an airplane. A retardant will raise the temperature required to ignite the fuel.
- in the case of ground fires, inject water into the ground to cool the fuel.
- separate fuels and break them apart to diffuse the heat.
- cut down and break apart tall, burning, dead trees to remove a source of airborne sparks.
Fire Prevention
Foresters have one other important method of breaking the fire triangle. They use fire prevention measures to “attack” the fire before it starts.

Fire Prevention Fundamentals
• Education can be more powerful than a bulldozer in fighting forest fires. Spread the word about fire safety measures.
• If a woodland is larger than 20 acres, construct some trails or roads to break it into smaller units and provide better access to all areas.
• Avoid or prohibit all open burning during the spring and fall dry spells.

Fire Weather
Weather is the major factor affecting the fire triangle. In the Yellowstone fire, dry, windy weather conditions contributed to the fire’s ferocity.

High temperatures and dry air lower the amount of moisture in fuels, making them ignite and burn more easily. In the Yellowstone fire, fuels had a 2-percent moisture content, an extremely low reading.

Wind also contributes to fire. Strong winds help dry out forest fuels. After a fire has started, winds bring in new oxygen to replace that which the fire has used. The wind also helps a fire spread by pushing it. In Yellowstone, winds were gusting 50 to 70 miles per hour, with steady winds of 40 miles per hour.

Storms affect the likelihood of fire, too. Lightning can cause fires when it strikes trees or dry grass. Fewer fires occur in years with abundant rainfall than in dry years. During wet years, plants remain green and do not ignite or burn well. In 1988, Yellowstone was experiencing its worst drought in 120 years of recorded weather history.

Can you decide the fire danger based on these weather reports? Mark an “H” for high, and an “L” for low. (Answers on page 57.)
Fire—Friend or Enemy?

Fire plays an important role in shaping the composition of forests. Fires that occurred more than a century ago affect the appearance of our forests and prairies today. Many of the aspen and jack pine forests in the Lake States today are the direct result of forest fires 20 to 100 years ago. On the Allegheny Plateau in Pennsylvania, oak stands appear to be the result of fires set by Native Americans to clear the land for agriculture.

Fire that is not controlled or managed properly creates problems. It can not only kill trees, but also damage them in other ways. Trees that survive a major fire may be scarred, creating an entry point for insects and diseases. When weakened by fire, trees are less able to withstand insect or disease attacks.

Still, fires perform several needed functions in forests, so foresters speak of “fire management” as well as “fire prevention.” If we were to eliminate all fires from a forest, fuels would build up, and eventually a very disastrous fire could take place. This happened in Yellowstone in 1988.

Foresters often set surface fires to help reduce the amount of fuel present and thus prevent major fires. In the southern United States, foresters set fires every two or three years to reduce unwanted understory vegetation in pine forests and to control tree diseases. In the West, fires are set in recently logged areas to remove debris and prepare the site for replanting.

Fire helps some tree species reproduce. Jack pine, for example, has serotinous cones, which don’t open and release their seeds until they are exposed to a heat source such as fire. Fire helps other seeds to germinate by killing competing vegetation and removing dry litter on the soil surface, exposing moist mineral soil.
Fires also improve the habitat for some wildlife. Fires create forest openings and maintain and rejuvenate shrubs for wildlife food and shelter.

The changes brought by fire are not always bad. The Yellowstone fires blackened land, killed trees, and altered habitat for certain animals. But the forest is a renewable resource. These charred, blackened areas are developing into meadows and regenerating their lodgepole pine and aspen stands. The habitats that were altered will be replaced gradually by new habitats for wildlife. Yellowstone is undergoing a renewal, a birth occurring over the next 100 years.

**Wildlife and Forest Fires**

Forest fires affect more than just trees; they also drastically alter the habitat for wildlife species. Many species such as elk, deer, and birds are able to move out of the way when fires rage. Other species such as mice, groundhogs, and even snakes seek protection underground if they can find a hole. Only a few species are too slow to avoid rapidly moving forest fires; porcupines are one such animal. Fish and other aquatic life often are spared from fires, but their habitat can be altered after a forest fire. Increased light that reaches the surface of streams and waterways after a fire can raise the water temperature. After a forest fire has burned through an area, most forest wildlife species seek food and cover elsewhere until the burned area begins to regrow new vegetation.

Some wildlife species need fires to maintain or create critical habitat. For example, the Kirkland’s warbler is found in jack pine forests of the Lake States. Jack pine forests are best created through forest fires that provide favorable conditions for jack pine regeneration.
Career Considerations
A forest fire fighter is trained specifically to suppress fires. Often, the fire fighter is a forester or forest technician. The fire fighter can expect long days and long nights of work during fire season. Fighting a forest fire requires speed, endurance, alertness, good physical condition, and knowledge of fire behavior. A fire fighter digs fire lines, chases hot spots, uses water packs or hoses, and wields chain saws in the battle against blazes. The work is hard, but very exciting. A two-year or four-year forestry degree is a good background for entering this field.

EnviroQuotes
“But the main thing is, folks just hate to see the park change. They think it’s being ruined. People have a tendency to want things as they are, but in nature nothing stays as it is…. Nature is hollering, ‘I’m getting ready to start over!’ We’d like to shout, ‘No! Not now! We’re not ready for you!’ But that ain’t the way it works, folks…” John Krebs, a fire behavior analyst, on the 1988 Yellowstone fire in *Journal of Forestry*, December, 1989.

Tree-vial Pursuit
More than $145 million was spent to suppress the Yellowstone area fires in 1988.
You’re J. Gold Flash, a homeowner in the hills of Santa Monica, California. Your six-year-old home is constructed of ponderosa pine logs with cedar shake roofing. You have placed your home carefully so that you are surrounded by towering pines on all sides. Your landscape is natural—you don’t mow the grass or weeds, and you let pine needles and branches stay where they fall. You do not prune tree branches, and several lay softly touching your roof. You have cut and neatly stacked a two-year supply of firewood next to your home, ready to fuel your hand-crafted stone fireplace. Because you value your privacy, you don’t display your name or address at the end of your driveway. The driveway itself is a narrow, winding, single lane—the better to keep trespassers out.

You’ve just heard on the radio that a nearby fire is burning out of control, threatening your home and those in your neighborhood. The radio warns that you have approximately four hours to evacuate, and that you can safely spend three hours trying to save your home.

To save your home, what leg of the fire triangle should you concentrate on breaking? What specific action could you take? What could you have done six years ago when you were constructing your home to make it safer?
Yearning to Learn
Additional Activities
In the following activities, remember the basic rules of conservation. Do not unnecessarily damage or destroy the plants and animals you are studying. Leave all ecosystems undamaged. Have a positive impact on the forest.

Take part in a fire prevention campaign in your community through your school or 4-H club. Wildfires burn not only forests, but also homes and other buildings. Prepare a plan for this campaign. Give a demonstration on fire prevention to your group using charts, posters, slides, or film.

Burn some forest debris, under a leader’s or parent’s supervision. In a charcoal grill or campfire ring, try to ignite and burn:
- green (wet) pine needles
- dead (dry) pine needles
- green leaves
- brown, dead leaves
- peat
- rocks
- other forest debris

Observe how different fuels burn, and whether all forest fuels can be ignited easily.

Make a poster to teach fire education or safety to the public. The poster should be colorful and should emphasize a fire safety issue. Your poster should concentrate on fire sources and prevention, (e.g., using spark arresters on chain saws in forested areas) or fuels (e.g., how to reduce burnable fuels in home, yard, and camping areas).

Science or Roundup Projects
Complete one of the following:

Prepare a display showing correct uses of fire to improve a forest. The display should contain at least three photographs or drawings of these activities, and should be mounted on a three-sided display board. Each picture should be captioned appropriately.

Prepare a display showing low- and high-fire-hazard forest areas (use photos or drawings). Show four methods of preventing or controlling fires and how each method affects a leg of the fire triangle. Use either a three-dimensional display mounted on plywood or in a box, or a three-sided display panel.

Prepare a display showing the results of the burning forest debris activity in Yearning to Learn. Use photos or drawings to tell what happened.

Make a poster to teach a concept of fire safety, as suggested above in Yearning to Learn. The poster should measure approximately 18 by 36 inches.

Make a historical display of fire activity in your area. Using photos or evidence of fire such as burned bark (fire scars), diagram the history of fire in your town or surrounding area. Your local historical society, library, and bureau of forestry office may be able to help you with the information on past forest fires.

Make a display that shows how fire may affect a forest ecosystem. Show how it may affect succession as well as wildlife and their habitat. Use photos, drawings, or models to show what happens to a burned area over many years.
**Answers**

*Ground/Surface/Crown Fires (from page 49)*

A = crown  
B = surface  
C = ground  

*Fire Weather Quiz (from page 51)*

A = H  
B = L  
C = H
The forestry judging event can be considered a capstone of the 4-H Forest Resources Project. Participants in the event use all the skills they have gained through participating in the 4-H Forest Resources Projects. The four participants with the highest scores at the event will represent Pennsylvania at the National 4-H Forestry Invitational in the summer.

Pennsylvania Forestry Judging consists of five competitive activities held at the annual 4-H Forestry Field Day.
1. Tree Identification
2. Forest Evaluation and Inventory
3. Compass Traverse
4. Insect and Disease Identification
5. Forestry Written Exam

Objectives
The objectives of Pennsylvania 4-H Forestry Judging are to provide the opportunity and atmosphere for 4-H members to:

1. Develop leadership skills and work toward achieving character development and effective citizenship.
2. Develop desirable attitudes toward the need and importance of conserving woodlands as a source of renewable commodities and important noncommodity benefits necessary for quality living.
3. Acquire information and understanding of practical skills in forest management and the use of forest and wood products.
**Tree Identification**
Participants will identify ten trees from the official tree list found in the Pennsylvania 4-H Forestry Judging Handbook. The trees are found in all regions of the United States, not just in Pennsylvania.

**Insect Identification**
Participants will identify five different forest insects, or evidence of their damage, from samples, photos, or slides from the official list in the Pennsylvania 4-H Forestry Judging Handbook.

**Disease Identification**
Participants will identify five tree diseases, or evidence of their damage, from samples, photos, or slides. The diseases included in the official list are found in all regions of the United States.

**Compass Traverse**
Participants will determine the distance (by pacing) and correct bearing (using an azimuth or quadrant compass) between successive points laid out on the ground. The course will consist of five points. Efforts will be made to avoid heavy brush and very steep slopes.

**Forestry Exam**
The written exam will be worth 100 points. Questions will be multiple choice, fill-in-the-blank, and true/false. All questions will come from the three Pennsylvania 4-H Forest Resources Project Books.
**Forest Evaluation and Inventory**

Participants will evaluate site and stand factors that affect the growth of forests and identify appropriate recommended practices to reach the given objective. Forest Evaluation and Inventory is divided into four parts:

1. **Site evaluation:** Using the score sheet, participants will choose the correct site quality based on soil depth, slope percent, aspect, and slope position.

2. **Stand evaluation:** Using the score sheet, participants will choose the correct condition of the stand using a number of categories, including grazing damage, fire, size distribution, forest type, stand origin, and stocking.

3. **Forest inventory:** Participants will correctly identify and measure the diameter and height of five trees, determine the board-foot volume from a volume table (not from the table on the tree scale stick), and determine the tree crown class.

4. **Recommended practices:** Based on a given scenario and the participant’s site and stand evaluation, participants will select the appropriate practices from the score sheet that will enable them to meet the scenario’s objectives.

**National 4-H Forestry Invitational**

The four highest-scoring individuals 14 years or older will go to the National 4-H Forestry Invitational in late July or early August. Teams from all over the United States participate in this event. The first contest was held in 1980, and Pennsylvania has participated since 1996. Team members will be provided with a copy of the National Handbook.

In addition to the events at Pennsylvania Forestry Judging, the national event includes an additional forest inventory event and a forestry bowl where teams compete head-to-head and test their forestry knowledge. The forest evaluation event is a team event at the national level.

If you would like to participate in Pennsylvania 4-H Forestry Judging, you should contact your county 4-H Coordinator and obtain a Pennsylvania 4-H Forestry Judging Handbook.

**Science or Roundup Project**

Participate in the Pennsylvania 4-H Forestry Judging Event in the spring. For a completed project, prepare a poster that illustrates a lesson learned from this event. If you won any awards or ribbons, display them with your score sheet.
# 4-H ACTIVITIES REPORT

This report will help you keep a better record of your club activities. Fill it in as you complete each assignment. Refer to this record when you are entering county, state, and national programs. Ask your local leader to explain these programs to you.

<table>
<thead>
<tr>
<th>My 4-H Activities Report for the 19 ______ Club Year</th>
<th>Number of new members I encouraged to join 4-H_______</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projects taken______________________________________________</td>
<td>Number of boys and girls I helped with projects______</td>
</tr>
<tr>
<td>_____________________________________________________________</td>
<td>In what way?____________________________________</td>
</tr>
<tr>
<td>_____________________________________________________________</td>
<td>__________________________________________________</td>
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<tr>
<td>_____________________________________________________________</td>
<td>__________________________________________________</td>
</tr>
<tr>
<td>Offices held________________________________________________</td>
<td>Check those attended and tell how you helped</td>
</tr>
<tr>
<td>_____________________________________________________________</td>
<td>_______ 3- or 4-day camp</td>
</tr>
<tr>
<td>Club________________________________________________________</td>
<td>_______ 1-day camp</td>
</tr>
<tr>
<td>County______________________________________________________</td>
<td>_______ Club or county tours</td>
</tr>
<tr>
<td>“Show-and-tells” given to ______________________________________</td>
<td>_______ Club picnic</td>
</tr>
<tr>
<td>Family ______________________________________________________</td>
<td>_______ Countywide picnic</td>
</tr>
<tr>
<td>Friends _____________________________________________________</td>
<td>_______ 4-H Sunday</td>
</tr>
<tr>
<td>Local club__________________________________________________</td>
<td>_______ County fair</td>
</tr>
<tr>
<td>County _____________________________________________________</td>
<td>_______ Achievement programs</td>
</tr>
<tr>
<td>Regional____________________________________________________</td>
<td>_______ Roundup</td>
</tr>
<tr>
<td>State _______________________________________________________</td>
<td>_______ Teen Leader Retreat</td>
</tr>
<tr>
<td>News articles ______________________________________________</td>
<td>_______ State 4-H Capital Days</td>
</tr>
<tr>
<td>Radio _______________________________________________________</td>
<td>_______ Camp Leadership Training</td>
</tr>
<tr>
<td>TV __________________________________________________________</td>
<td>_______ Penn State 4-H Achievement Days</td>
</tr>
<tr>
<td>Things done to improve my health______________________________</td>
<td>_______ Pennsylvania Farm Show</td>
</tr>
<tr>
<td>_____________________________________________________________</td>
<td>_______ National 4-H Week</td>
</tr>
<tr>
<td>_____________________________________________________________</td>
<td>_______ State Ambassador Conference</td>
</tr>
<tr>
<td>Community service or citizenship work done ____________________</td>
<td>_______ Judging training</td>
</tr>
<tr>
<td>By myself __________________________________________________</td>
<td>Others:</td>
</tr>
<tr>
<td>With club __________________________________________________</td>
<td>______________________________________________</td>
</tr>
<tr>
<td>Number of meetings my club(s) held this year ________________</td>
<td>______________________________________________</td>
</tr>
<tr>
<td>Number I attended __________________________________________</td>
<td>______________________________________________</td>
</tr>
</tbody>
</table>
Name ______________________________________________________

Address ______________________________________________________
________________________________________________________________

Name of club __________________________________________________

Leader’s name ___________________________________________________

**4-H Club Motto**

“To make the best better”

**4-H Club Pledge**

I pledge

my head to clearer thinking,

my heart to greater loyalty,

my hands to larger service, and

my health to better living, for

my club,

my community,

my country, and

my world.

**4-H Club Colors**

Green and White

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18 U.S.C. 707