SILVICULTURE

Silviculture is the art and science of tree production. It is a specialized area of study within the larger field of forestry. It is based on an understanding of **silvics** which is the study of forests and forest relationships. It includes plant, soil and animal interactions with trees. Silviculture is practiced on the assumption that a forest environment can be manipulated to make it more favorable to the growth of trees than the natural environment.

OBJECTIVES

After completing this chapter, you should be able to

- define silviculture
- list some important silviculture management practices
- distinguish between natural and artificial methods of regenerating forests
- discuss the advantages of direct seeding or planting seedlings in comparison with natural methods for regenerating forests
- explain the most common methods of producing seedlings for forest regeneration
- describe the steps that should be followed in transplanting a tree seedling
- describe the characteristics of the different growth stages of trees such as seedling, sapling, pole and mature tree.
- explain why it is necessary to control populations of rodents, especially during the seedling and sapling stages of tree development
- describe some intermediate treatments applied to forests
- describe some silviculture practices used to improve the growth and quality of trees
- explain how the final use of a tree affects the harvesting method used

TERMS FOR UNDERSTANDING

allelopathic effect
artificial regeneration
bare-root stock
cleaning operation
clear cutting
controlled burn
direct seeding
even-aged stand
germination
girdling
herbicide
intermediate cutting
liberation
mature
natural regeneration
nursery
overmature
pole
prescribed burn
pruning
rodenticide
salvage cutting
sanitation cutting
sapling
seedling
selection cutting
senescent
silvics
stand
stand improvement
uneven-aged stand

FOREST REPRODUCTION AND REGENERATION

Tree farming is becoming much more common, as the need for forest products increases faster than the capabilities of natural forests to produce them. Increased production of wood products can be realized when ideal conditions are provided for the growth of trees. Silviculture applies the principles of science to the production of trees using modern technologies as tools.

Silviculture practiced in an intense management system becomes very dependent on the use of specialized machines. In every sense, tree plantations become highly specialized farms where management is as intensive as it is for any other agricultural crop. Competition from weeds is eliminated, soils are tested, fertilizers are added, diseases are treated and harmful insects are controlled.

Silviculture can also be practiced in less intensive ways. For example, a stand of naturally seeded young trees may be growing so close together that their growth is restricted by competition among the trees. Thinning the trees manipulates the environment to allow for timber production. Any cultural practice that manipulates the forest

environment to achieve specific goals in the forest is a form of silviculture.

The forest reproduction processes known as sexual reproduction and vegetative reproduction are successful methods. It is noted that sexual reproduction results in the production of seeds capable of producing young trees. Vegetative reproduction, also known as asexual reproduction, occurs when young trees are produced from leaf, root or stem tissues. Both kinds of reproduction are important in the regeneration of forests.

A population of trees established in a forest environment is called a stand. When a population of trees is few in number and widely scattered, it is considered to be a poor or weak stand, while a population of healthy trees properly spaced in the forest is considered to be a strong or vigorous stand. These terms are used throughout the forest industry to describe the characteristics of specific populations of forest trees.

Forests are usually considered to be naturally renewable without any need for human intervention. While this is generally true, forests do not always produce the kind of trees wanted or needed. Some kinds of trees compete well with other forest plants, and some trees do not. For example, the eastern white pine forests tended to be replaced by oak forests after they were harvested. The stage in the biological succession on these sites favored the climax species of trees such as oak.

When a particular kind of trees is desired in an area, it may be necessary to change the environment to favor its growth. It is for this reason that silviculture is practiced so widely on private forest lands. Some species of trees reproduce and regenerate naturally when conditions are created favorable to the species. For example, regeneration of aspen forests in the region of the Great Lakes can often be accomplished by clearcut harvest methods. This removes the shade from the soil surface allowing natural growth of young aspens. Shaded areas favor the growth of other kinds of forest plants and trees.

Two types of forest regeneration occur following timber harvests. **Natural regeneration** occurs on a forest site when young trees begin to grow there without having to be planted. Sometimes seeds have been dispersed in the area by the wind or by wild animals. Some hardwoods grow from the roots or stumps of the harvested trees. In some instances, advance regeneration occurs due to seedlings and saplings already there when the harvest took place. Natural regeneration of forest trees depends on several important growth conditions such as the availability and dispersion of fertile seed in the area, the availability of soil moisture, warm temperatures, the condition of the soil, favorable weather, favorable light intensity, and freedom from diseases and harmful insects.

Seed Distribution by Squirrels and Birds

Squirrels and birds play important roles in distributing the seeds of trees and other plants to new locations. Squirrels actively harvest seeds by gathering acorns, pine cones and other kinds of nuts to be eaten during the winter season. Some of the seeds hidden in the debris of the forest floor are forgotten, and they may eventually germinate and grow. Most of these seeds are not distributed very far beyond the trees they grow on, but squirrels play a role in planting them beneath the vegetative cover on the forest floor.

Birds distribute seeds over wide areas. Some of the seeds are carried in flight end dropped in distant locations. Other seeds may be overlooked in the shell or husk materials that surround most seeds from trees. Some seeds may have a hard enough seed coat to survive the digestive process of a bird. These seeds are distributed in the feces of birds.

Artificial regeneration is forest renewal that occurs when seeds or seedlings are planted at the harvest site. This method often results in a uniform stand of trees evenly dispersed throughout the area. The forest manager also has control over the species of trees that make up the new forest planting. Seedlings can be selected from superior parent stock that has the potential to increase yields. Trees regenerated artificially are all the same age and growth stage, which makes them easier to manage. Tree plantations are usually planted in rows. This makes it possible to use mechanical equipment within the plantation for weed control, thinning, pruning and other purposes.

Direct Seeding

Planting tree seeds to generate new forest growth is called **direct seeding**. Seeds can

be planted directly into the soil surface using mechanical equipment, or they can be dispersed in the area by aircraft. Aerial seeding is a good method to use following fires. The soil surface in a burned area is usually free of debris, and large areas can easily be planted using this method. It is important when direct seeding methods are selected to take advantage of good moisture conditions at the time of planting. Drought conditions will prevent germination of the seeds. Seeding should be timed to coincide with adequate soil moisture to assure a good stand of trees.

The use of high quality seed is important in forest regeneration. Tree seeds should be collected only from superior trees. The seed must be collected at the right stage of maturity, and it must be carefully cleaned to eliminate damaged or shrunken seed. It should be stored in a darkened location that is cool and dry to avoid untimely germination of the seed.

Seeds are sometimes damaged by extreme temperatures, drought conditions and other environmental factors. Such conditions can reduce the fertility of the seed. Seed should always be tested before it is used to make sure the seeds will sprout and grow. The process by which this occurs is called **germination**. Seed laboratories are available in most states to provide seed testing services. These laboratories issue certification tags attached to each container of seed that was part of the tested seed lot. Using certified seeds reduces the risk of establishing an inadequate population of young trees in the plantation. This is one of the greatest problems associated with direct seeding of trees.

Adequate amounts of seed must be planted to assure the population of seedlings that becomes established is properly spaced in the rows. It is important that enough young trees survive to require thinning at a later time. This allows for the removal of weak, damaged or deformed trees from the stand. Allowances must be made in the seeding rate for seed eaten or destroyed by birds, rodents, squirrels and insects. Some seeds are killed by the molds and fungi nearly always present in forest environments. Seeds can be protected from seed-eating insects, birds and animals by coating the seeds with protective chemicals such as fungicides, insecticides and repellents. Repellent-coated seeds have been used with some success to discourage rodents and birds from eating the seeds.

Not all of the planted seeds will grow. This makes it necessary to plant more seed than you expect to need. The seeding rate is different for each kind of tree, because the seeds of different kinds of trees are different sizes. The volume or weight of the seed needed to plant each acre is much less with small seeds than it is for large seeds. This is because there are more seeds per pound for small seeds in comparison with large seeds. The seeding rate is also affected by the way the trees will be used at harvest time. Trees used for pulpwood can be spaced more closely between and within the rows than is desirable for timber production.

PRODUCTION OF SEEDLINGS

A **seedling** is a tree in the early stages of development. Seedling production for forest plantings usually takes place on a massive scale. Sometimes the seedlings raised for forest regeneration are planted in cultivated fields. A large outdoor planting of tree seedlings is called a **nursery**. Tree seeds are usually planted in wide rows called beds. When the seedlings are ready for transplanting to forest sites, they are removed from the beds. Sometimes the seedlings are placed in individual plastic bags with soil on the roots. This method can be used when it is expected that planting may be delayed. Another method used is to lift the seedlings from the beds leaving the roots free of soil. Seedlings in this condition are called **bare-root stock**. Bare-root stock must be planted right away or placed in a cool, damp storage area with special care to keep the roots moist. Large numbers of tree seedlings can be produced in a relatively small area in an outdoor nursery.

Seedlings raised in greenhouses are usually planted in plastic trays with individual compartments. Containers are filled with potting soil kept damp with frequent applications of water. In most cases, seedlings require several months to a year of growth before they are ready to plant in a forest environment. During the time that seedlings are under intensive management in a greenhouse or nursery, they are more susceptible to insects

and diseases than at any other time. This is because large numbers of plants are concentrated in a small area. Some diseases and insect pests are capable of reproducing rapidly under such favorable conditions. For this reason, great care must be taken to observe the plants frequently and to respond quickly to insect and disease problems.

Two seeds are usually planted in each compartment of a multiple plant container. This is done to assure that a healthy plant is produced in every compartment. Thinning is required to reduce the seedling population in the containers to one plant per section. Seedlings produced in greenhouses are usually planted with the potting soil on their roots. They are more expensive to produce than seedlings raised in outdoor nurseries, but less root damage is likely to occur as these seedlings are transported and planted in forest sites.

PLANTING SEEDLINGS

The most critical period in the life of a tree is during the seedling stage when it is tender and succulent. For this reason, careful attention must be given to new plantings of seedlings. Healthy seedlings planted in damp soil well prepared can usually be expected to have a reasonable rate of survival. Site preparation is very important in establishing new plantings of trees. This is because excess organic matter on the soil surface makes it difficult to be sure that seedlings are planted in the mineral layer of the soil. This is especially true when the seedlings are planted by a machine.

Many methods of site preparation are used. Planting sites are sometimes prepared by gathering the surface debris into piles for burning, or by cutting it up mechanically with a brush cutter or similar machine. A distinct advantage of mechanical site preparation is that competition from existing plants can be reduced. This is important, especially when conifers are planted in an area with native hardwood shrubs and trees. Hardwood species of trees and shrubs tend to grow faster than pines in the early growth stages. Because of this, they gain early dominance and over-shade the pines, eventually causing many of them to die. For this reason, it is important to reduce the populations of hardwood shrubs and trees in an area where pine seedlings are to be planted. When it is impractical to use mechanical site preparation methods, it is important to at least clear a small site as each seedling is planted.

Live plants on the soil surface present another threat to seedlings besides competition for water, nutrients and sunlight. Some kinds of plants, such as grasses, maintain their dominance over other plants by releasing chemicals into the area close around them that provide small doses of poison to invading plants. A plant activity of this nature is an **allelopathic effect**. It is believed that some grasses have a greater allelopathic effect on hardwood seedlings than on pine seedlings. This allows pines to become established in relatively pure stands in areas where hardwood trees were once dominant.

Chemical control of undesirable shrubs, brush and trees can be achieved using chemicals that kill plants. A chemical of this type is called an **herbicide**. Herbicides can be applied in several different ways. One method of chemical application is to spray the chemical preparation on the leaves and stems of the plants to be controlled. Great care must be exercised to prevent the chemical mixture from drifting to the foliage of trees intended to survive. Herbicides are also available in dry form. This material is broadcast on the soil surface and absorbed through plant roots. Some undesirable forest trees and shrubs, such as those that send up new growth from their roots, can be controlled only by completely uprooting the plant or by killing the roots with chemicals.

The use of fire in site preparation is a proven practice, but special care must be taken to control the fire to burn only the desired area. Use of fire in this manner is called a **controlled burn** or a **prescribed burn**. Fire effectively removes debris from the surface and kills or weakens plants that might compete strongly with the seedlings for moisture and nutrients. A common practice in site preparation in areas of low rainfall is to gouge the surface of the soil and plant the seedling at the bottom of the depression formed. This concentrates most of the available moisture in close proximity to the seedling increasing its chance of survival.

The best time to plant seedlings is in the spring season before it gets too hot. Excessive heat tends to dry the soil reducing

the chances that the seedling will survive. The spring season is a time when precipitation is abundant in many areas, and seedlings require a supply of moisture to establish their roots in the soil. As each seedling is planted, its roots should have soil firmly packed around it. Mechanical planters use one or more packing wheels to firmly press the soil into place. This assures that the roots will contact the moist soil particles making it possible for them to absorb moisture and dissolved nutrients.

Large numbers of seedlings are still planted by hand on steep sloping areas, but mechanical methods of planting seedlings are also widely used. Both planting methods require the roots of the seedlings to be placed in the soil in such a manner as to avoid bending them over. Bending or twisting the roots interferes with root development and weakens the tree later on. The seedling should be placed as closely as possible in a vertical position with the soil packed firmly around the roots.

DEVELOPING NEW STANDS

The characteristics of a new forest stand are determined to a large extent by the methods used in the previous harvest. For example, **clear cutting** is a harvest method in which all of the trees in the stand are cut. The new stand of trees that follows will be an **even-aged stand** in which most of the trees are approximately the same age. This method of harvest leads to plantation tree farming. Even-aged stands also occur naturally in areas where natural disasters such as forest fires, snowslides or blowdowns have destroyed all of the trees in an area.

A harvest method called **selection cutting** removes a sustained yield of wood from the forest at regular intervals. Only the most mature trees are selected, although damaged or diseased trees are removed at the same time. The use of this harvest method maintains an **uneven-aged stand** in which trees of all ages are found in the forest.

The forest regeneration method used also has an effect on the age of the trees found in a stand. Seeding and planting seedlings on ground free of live trees results in even-aged stands, while natural reforestation tends to occur over a period of several years resulting in trees of mixed ages.

The first stage of tree growth is the seedling stage. It occurs after a seed has germinated, and continues until the tree has grown to approximately three feet in height. After that, the young tree is referred to as a **sapling**. It will continue to be known as a sapling until the lower branches begin to fall or until it reaches a diameter up to four inches. In the next stage of development, the young tree is called a **pole**. The diameter of a tree in the pole stage ranges from four to ten inches. Trees in the size range from 10-24 inches in diameter are described as being **mature**. The final development stage for trees occurs when they begin to decay. Trees at this stage of development are described as being **overmature**. A high proportion of trees in this stage of development are becoming **senescent**, meaning that they show evidence of heartrot decay and other defects due to age. During the sapling growth stage the young trees remain quite vulnerable to damage from insects, diseases and animal pests.

Rodents

Rodents make up the most diverse group of mammals. They can be identified by the four large incisor teeth in the front of their mouths. These teeth never stop growing, and rodents must gnaw on wood or other materials just to keep their teeth worn down. The front edge of a rodent's teeth is composed of harder material than the back edge, causing the back edge to wear faster than the front. The result is that the incisor teeth become chisel shaped, and they are sharpened as they wear down. A rodent must chew to continue living. Rabbits have some of the same gnawing habits as rodents, but their tooth structure eliminates them from this group of animals.

Mice, rabbits, gophers and other gnawing animals can easily kill a sapling by chewing through the bark all around the base of a tree. This condition is known as **girdling**. It results in the death of the tree because the flow of water and nutrients between the tree roots and the foliage is blocked by loss of vascular tissue. Rodents are known to experience massive population increases when their food supplies are abundant and natural predator populations are small. During these periods of abundant rodent populations, new stands of trees are in danger.

Rodent control is hard to achieve through poisons because new rodent populations move into the area almost immediately from adjacent areas. It is possible, however, to achieve some control over rodent populations with chemicals designed specifically to kill them. Such a material is called a **rodenticide**. The most effective control method for rodents living in or near tree plantings is to control the build-up of dead plant materials such as grass or brush on the forest floor. These materials provide cover in which rodents can hide from their natural enemies. They also provide shelter to them from climate and weather related hazards.

CAREER OPTION: FOREST WORKER

A forest worker performs the tasks related to reforestation and protection of stands of trees. They also do maintenance work on forest roads, trails, buildings and campsites. Some tasks include planting seedlings, removing diseased or damaged trees, pruning trees, preventing and suppressing fires, performing insect and weed control and constructing improvements in forest facilities.

Training in the use of hand and power tools is required along with a basic understanding of silviculture practices. Work of this kind is sometimes seasonal in nature. Many professional foresters obtain summer employment as forest workers during the period when they are obtaining university and college education.

INTERMEDIATE TREATMENTS

Forests require care and management during the years between planting and maturity. They may benefit from a **cleaning operation** to remove vegetation that competes with young trees. A cleaning operation may be needed to provide control of brush or any other plants that interfere with the development of a stand of young trees. Any silviculture practice applied between the seedling and sapling stages of development for this purpose is a cleaning operation. An operation of this kind done when the forest stand is older than the sapling stage is called **stand improvement**. A cleaning operation may consist of the removal of undesirable older trees in the stand to make sunlight available to the young trees. This kind of stand improvement is called **liberation**.

Control of brush may be necessary in stands of young trees, especially when moisture for the trees is in short supply. Some control of brushy plants can be done using the mechanical methods for site preparation. Care must be exercised to avoid damage to the outer bark of trees that could lead to fungi infections or other diseases.

A prescribed burn may be an effective control method in some trees if the brush and fuel on the forest floor are not too abundant. Trees must be sufficiently mature that the bark of the tree provides protection from fire. They must also be free of low-hanging branches that may catch fire, causing the foliage of the tree to burn. An abundant fuel supply on the forest floor can cause fire to be very dangerous to the stand of trees the prescribed burn is intended to protect.

Chemicals have only limited uses in established stands of trees, because they are often as dangerous to the crop as they are to the plants they are intended to control. They can be used in spot treatments of undesirable trees or shrubs when great care is exercised in applying them, and they can be injected into the trunks of problem trees. In all cases, where herbicides are used in the forest, all of the regulations for their use must be obeyed.

An **intermediate cutting** is a silviculture practice intended to improve the forest by removing some of the trees. This cutting may occur any time between the time of planting and harvesting. Early in the life cycle of a forest planting, it is often necessary to reduce the tree population in the planting to provide enough space for each tree to grow. This practice is called **thinning**. Trees planted in rows can be thinned by removing every second or third tree in the row. The trees should be carefully inspected as they are thinned to make sure that the most valuable trees are saved.

It is not always possible to protect forests from damage due to fire, insects or diseases. When any of these destructive agents

causes widespread damage in a forest, it may be necessary to remove some or all of the affected trees. The timber obtained from a cutting of this kind may have commercial value if the trees are harvested in a timely manner. This type of cutting is called a **salvage cutting**. An emergency cutting caused by disease or insect problems for the purpose of preventing the spread of the problem to other vulnerable trees is sometimes called a **sanitation cutting**. Salvage or sanitation cuttings may be combined with a complete intermediate harvest of marketable trees to improve the health of the forest.

MANAGING FOR GROWTH AND QUALITY

Several silviculture practices are known to improve the rate of growth and the quality grade of the timber produced by a stand of trees. One of these practices is thinning. The successful forest manager expects to have some seedlings die, so an adequate number of trees are planted to assure a good stand. Once the trees fill in the forest canopy, they begin to restrict the growth of adjacent trees. As they grow, some of them must be removed to make room for those that will provide the final harvest. Failure to thin will reduce the final production of a stand of trees.

Pruning is the practice of removing the lower branches of a tree. This results in fewer knots in the lumber cut from the logs of pruned trees. The cost of pruning is generally considered to be too high to justify pruning most commercial trees, but lumber quality can be greatly increased through the use of pruning. In terms of economics, however, it may be wise to restrict pruning to those species of trees that are high in value. One method of achieving some self-pruning in trees is to delay thinning until the trees are in the pole stage of development. The close proximity of trees to one another will result in some natural pruning of the lower branches.

The availability of water is often a limiting factor in the production of trees. Adequate soil moisture can advance the maturity of a tree more quickly than any other factor in its environment. Irrigation is gaining acceptance on forest plantations in many regions where natural precipitation cannot be depended upon to be adequate. This is not a common practice on most plantations, but it can be a valuable production tool especially in the production of Christmas trees and pulpwood.

Managing a forest to keep it healthy includes the use of all practices discussed in this unit. A healthy forest is capable of rapid growth and the production of high quality wood products. An unhealthy forest is not. Evidence of this can be seen by examining the annual growth rings in a tree stump. The thickness of each annual ring is evidence of the health and vigor of the tree during the year when a particular growth ring was formed. Drought conditions, insect problems and diseases can all affect the health and production of a tree.

Among the modern tools becoming available for forest management is the use of satellites to observe large areas. This technology can be used to detect differences in the surface temperatures of plants. The foliage of stressed plants tends to radiate more heat than healthy plants. This heat can be measured and recorded on a map using technology to identify locations where trees are stressed. This makes it possible for a forest manager to monitor large areas of forest land. Areas on a satellite map that show evidence of stressed trees can be checked by people on the ground to identify and treat the problem.

HARVEST CUTTING

Harvest cutting is the final event in a cycle of forest production. In even-aged stands, the trees tend to mature at about the same time, whereas uneven-aged stands can be managed for sustained yields through selective cutting practices. Unlike agricultural crops, mature trees can be harvested over a period of several years without losing their value. This makes it possible for managers of private forests to base the time and method of harvesting on timber prices. They can delay harvests when timber prices are low, or they can choose to accelerate harvesting when timber prices are high.

Most forest plans call for an intermediate timber harvest as part of the intermediate cutting. This improves the forest stand by

releasing the crop trees from competition with highly competitive species suppressing their growth. The first intermediate harvest is not usually very profitable for lumber, because it consists mostly of inferior crop trees relatively small in size, or trees of a species for which demand is generally low. In areas where a market for pulpwood exists, an intermediate harvest of these trees can be profitable, because much of the wood harvested can be sold.

Trees harvested for pulpwood usually range in size from a minimum size of 5 inches dhb to large logs. Some pulp mills process trees into chips at the pulpmill, but many large mills now process trees in the forest and haul the chips to the mill in large trucks. This makes it economical to process most of the wood in the tree into wood chips.

As a stand of timber matures, the products obtained from intermediate harvests become more valuable due to the increased size of the trees. As the trees grow in size, the stand must be thinned from a density of approximately 700 trees per acre to fewer than 70 trees per acre at the time of the final harvest. All other trees, with the exception of those that die during the production cycle, are removed during early thinning operations or harvested as part of an intermediate harvest.

Intermediate harvests that occur in the later stages of the production cycle provide trees that can be used for poles, fenceposts and lumber. Many forest owners and managers depend upon intermediate harvests to provide business income and to pay the costs of improvements in the timber stand. A very real value gained through an intermediate harvest is the growth surge that occurs in crop trees after they are released from competition for sunlight, moisture and plant nutrients.

Harvest cutting methods depend to some degree on how the harvested trees will be used. Large logs are usually cut by loggers using chainsaws. Next they must be retrieved from the sites where they have been felled to roadside areas where they are loaded on trucks. Most logging operations retrieve logs using specialized all-terrain vehicles called skidders. These machines drag the logs along the ground. Some logging operations use winches equipped with long cables to retrieve logs. Timber harvests that occur in areas inaccessible by road, or that are highly susceptible to soil erosion problems, frequently retrieve logs by airlifting them with industrial helicopters. This method is expensive, but it is also very efficient, and it reduces the need for building roads into sensitive areas.

Whole-tree harvesting is a method used to harvest small to moderate sized trees. This method is especially useful for pulpwood harvests on tree plantations, because these harvests usually consist of moderate sized trees. Large machines grasp the trunks of trees while they are sawed or sheared off at the base. After each tree is severed from the stump by one of these machines, it is stacked in a pile to be chipped or hauled intact to the pulp mill.

LOOKING BACK

Silviculture is the art and science of tree production. When silviculture is practiced, the natural environment is modified to make it more favorable to the production of trees. The production of forest products increases when growing conditions are ideal. Natural regeneration of a forest occurs when trees begin to grow in a harvested area without being planted as seeds or seedlings. Artificial regeneration of a forest occurs when seeds or seedlings are planted. Seedlings may be raised in greenhouses or in outdoor plantations. Young trees are vulnerable to damage from insects, diseases and animals. Cultural practices are used to control and limit damage to trees from these sources. The practice of silviculture makes it possible to manage forests for growth and quality. Trees should be harvested when they reach maturity to prevent them from becoming vulnerable to diseases and insect damage. Trees are harvested using methods compatible with the ways the timber will be used.

QUESTIONS FOR DISCUSSION AND REVIEW

Essay Questions

1. What is silviculture?
2. What are some important silviculture practices, and how do they improve forest production?
3. How is artificial regeneration of a forest different from natural regeneration?
4. What advantages are gained from direct seeding or planting seedlings in comparison with natural methods of reforestation?
5. Describe two common methods used to produce tree seedlings, and list the advantages and limitations of each method.
6. How should the site be prepared for transplanting tree seedlings, and what transplanting procedures should be followed?
7. Name the stages of growth that trees go through from planting to harvest.
8. What are some intermediate treatments that are applied to forests, and what advantages do they contribute to forest health and production?
9. What are some silviculture practices that are used to improve the growth and quality of trees?
10. How does the final use of a tree affect the method that is used to harvest it?

Multiple Choice Questions

1. The art and science of tree production is known as:
   a. silvics
   b. forest regeneration
   c. silviculture
   d. forestry

2. Reproduction of trees from the leaves, stems or root tissues is called:
   a. vegetative reproduction
   b. sexual reproduction
   c. silviculture
   d. suckering

3. The natural growth of a young forest following the harvest of mature trees is called:
   a. spontaneous combustion
   b. arboriculture
   c. artificial regeneration
   d. natural regeneration

4. The process by which seeds begin to sprout and grow is known as:
   a. germination
   b. gymnosperm
   c. regeneration
   d. angiosperm

5. Young trees that have been removed from the soil in preparation shipping are known as:
   a. seedlings
   b. saplings
   c. bare-root stock
   d. poles

6. Some kinds of plants release chemicals into the area close around them that provide small doses of poison to young plants that invade their territory. This defensive plant response is known as:
   a. allelopathic effect
   b. germicide
   c. herbicide
   d. chemical warfare

7. A harvest method in which the only trees that are harvested are the mature trees and diseased or damaged trees is:
   a. clear cutting
   b. selection cutting
   c. salvage logging
   d. girdling

8. A young tree with a diameter of four to ten inches is a:
   a. sapling
   b. seedling
   c. pole
   d. log

9. Removal of undesirable older trees from a stand to make sunlight available to young trees is known as a:
   a. liberation
   b. cleaning operation
   c. stand improvement
   d. sanitation on cutting

10. Pruning trees is a cultural practice that is performed for the purpose of:
   a. harvesting firewood
   b. improving lumber quality
   c. attracting wild animals
   d. harvesting damaged timber

11. A mechanical timber harvesting method that is used to harvest small to moderate sized trees is known as:
   a. intermediate harvest
   b. aerial harvesting
   c. cleaning operation
   d. whole-tree harvesting

LEARNING ACTIVITIES

1. Obtain seeds and fresh cuttings for a commercial tree species, and generate seedlings. Compare the growth of seedlings obtained from vegetative cuttings with the growth of seedlings generated from seeds. Assign students to keep a log book to record their observations and their work throughout the duration of the project. Assemble the combined data of the entire class, and assess the two methods for generating seedlings.

2. Take a field trip to a tree farm, and assign the students to prepare a written report that contains at least the following information (a) the final product or products of the farm, (b) specific cultural practices, (c) handling procedures for each product, (d) product markets and marketing plans, (e) future plans.