To produce the millions of tree seedlings that are needed for reforestation and for planting on farm woodlands, wildlife areas, stream banks, windbreaks, and erosion-control projects in the United States, nurserymen grow more than 40 coniferous species of trees and shrubs and fifty-odd hardwood species. To get the quality, quantity, and variety needed, the growers have to observe most carefully, in exact sequence, a number of well-defined procedures. Their work embraces the attention to detail that the grower of orchids must have, the cycles of seed-time and harvest that govern the farmer’s work, the long view of things that the parent takes in rearing children. Nurserymen must have practical knowledge of a half dozen sciences—genetics, botany, entomology, soils, dendrology, pathology. Patience, too.

From the time they sow the seed in the nursery until the trees are ready to be shipped to the planting site, the men must care for the seedlings scientifically to make them strong enough to stand the hardships they will encounter in their permanent home. The nursery soil must contain certain plant nutrients in the right amounts necessary for healthy growth. The nursery stock must be protected from many diseases, weeds, as well as insects. Cold hardness, shade requirement, tolerance to sun, and other factors must be observed. Too much water makes the trees soft and weak; too little retards their growth. Some species must remain in the nursery as long as 5 years, maybe more, before they are ready to be planted in the field; others are ready in a year. All can better live and populate a new forest if they have had proper care in the nursery.

Every State in the United States has some form of planting program that requires nursery stock. The Forest Service operates nurseries to produce planting stock for reforestation on national forests and for a few States that have cooperative programs with farmers. The Soil Conservation Service has nurseries to produce trees for farms in the organized soil conservation districts. Other federal agencies, among them the Fish and Wildlife Service, of the Department of the Interior, and the Tennessee Valley Authority, conduct planting programs on land they administer. The State nurseries, which provide planting stock for use on State-owned land and for use by farmers, are increasing in number and quantity of production. Many private lumber companies, paper-pulp companies, and soil conservation districts are establishing nurseries to get stock for their own forestry programs. Some private individuals, too, are finding pleasure and profit in operating small nurseries.

This discussion deals with large-scale nursery operations, but the man who wants to grow his own stock might find in it many helpful suggestions.

Nursery-grown trees were planted on 181,000 acres in the United States in 1947. Approximately 217 million trees were used. To date, in the United States, nearly 6,700,000 acres have been planted with more than 8 billion trees and shrubs that started life in nurseries.

Selecting a good site is of first importance in successful nursery management. Its topography, location, fertility, soil texture, drainage, and availability of water affect markedly the cost and quality of the stock. One rarely finds an area that has all the desirable features of an ideal nursery site; compromises usually are necessary, but the extent and number of the exceptions determine the desirability of the site.

The acreage required depends on the age and the species of trees to be grown. Approximately 1,000,000 coni-
Production of Planting Stock

fer seedlings can be produced on an acre with seedbed densities of 30 plants to the square foot. Correspondingly greater acreage production can be had under densities of 90 to 100 plants to the square foot. Transplanted conifers in beds with 6-inch row spacing will approximate 400,000 plants an acre. Row-planted deciduous trees will produce 150,000 usable plants an acre.

In the Southern States, most of the species used for reforestation will attain field-planting size in a single growing season. In the Northern States, because of a shorter season and slower-growing species, from 2 to 5 years are needed to produce satisfactory field-planting stock. The acreage of nursery land required to meet an annual production quota, therefore, is a matter of arithmetic that takes into account species, season, and proper consideration of the fact that enough land must be provided to permit rotations of trees and soil crops.

The ideal nursery site is most likely to be a smooth, flat, moderately sandy soil on a stream terrace. The site should have a uniform slope, preferably in one direction in order to facilitate surface drainage. Terraces are needed where the nursery is on an erosive soil with a slope in excess of 2 percent. In coniferous nurseries, Nichols-type terraces are considered best so that tractor-drawn cultivating equipment can cross them. Broadleaf trees usually are grown in drill rows spaced 16 to 42 inches apart. A hilly or irregular surface adds materially to the cost of operations; it is poor economy to begin production on anything but the best available site, even though the initial investment may seem high.

Serious consideration also should be given to the hazards of flooding; the lateness of spring frosts and the earliness of fall frosts; the season at which digging can be started and its relationship to the planting area; accessibility to the nursery on all-weather roads; availability of public utilities—electric power, telephone, telegraph, and railroads and other shipping facilities.

Texture of soil bears importantly on all cultural operations of a nursery. It must be friable to permit working in the fall and winter and earlier in the spring than one does with ordinary farm crops. Sandy loam soils are considered best. They should have a silt and clay content of 15 to 25 percent, and an alkalinity range of 5.5 to 6.5 pH. Extremely sandy soils are unsuitable because leaching removes plant nutrients at a rapid rate. On the other hand, heavy soils demand greater care in nearly all cultural operations and are subject to frost heaving in the colder climates.

If the topsoil is a fertile, porous, sandy loam that is underlaid with a retentive subsoil, it is ideal for producing nursery stock. A subsoil with a hardpan should be avoided because it prevents good drainage. Seedlings grow vigorously with well-developed roots in a deep soil of good quality; they develop a ramifying root system with few fibrous roots where the soil is poor.

The species of the stock to be produced has some bearing on the selection of the nursery site, but it is not of first importance. It is wise, however, to locate the nursery within the planting region. Many nurseries produce both conifer species and deciduous species. The deciduous species generally are tolerant of a wider variety of soil conditions. Conifers do best in soils with an alkalinity range of from 5.0 to 6.0 pH. Soils with a higher alkalinity are more favorable to fungi, which cause mortality in young coniferous seedlings.

Seasonal laborers are required in nursery work, particularly for 2 or 3 months in the spring and early summer and in the fall. The nursery should be located where labor is available and where the minimum amount of time is required to go to and from work.

The first step in developing a nursery site is to bring the soil into good physical condition. Then suitable facilities—buildings for storage and equipment—must be built to meet the
needs of the program. A soil conservation plan is needed so as to retain and improve fertility and prevent erosion. Terraces and drainage should be put in where necessary. It is wise to make several maps and keep them up to date: A topographic and soil map of the nursery; a plan that shows all permanent features; and a map, to be prepared each year, that shows the current use of each unit or part of a unit, including treatment of the soil, species of nursery stock on it, and age class. The maps serve as a record of stock produced and are a year-to-year record of soil management. Permanent roads that divide the plots into workable units should be established.

**Buildings** vary in number, kind, and character with the climate and location of the nursery in relation to labor and other services.

In some climates, trees can be graded and packed for shipment as they are dug.

Where the digging season is short or the weather is unfavorable, stock must be graded and packed under shelter. In some climates, where the planting seasons do not coincide with the nursery seasons, cold storage is needed to hold nursery stock when it is out of the ground, and a well-designed building that has facilities for sorting, packing, and storage of nursery stock is essential. In mild climates, a simple shelter and a temporary heeling-in bed usually are enough.

The superintendent, or nursery foreman, should reside on the grounds so as to be always within reach. On a large nursery, houses may be desirable for other yearlong personnel. The operations of a nursery demand 24-hour attention; neglect at critical periods may mean loss of trees. Sometimes a dormitory and mess hall are necessary for laborers. Besides the quarters for personnel, buildings are needed for office, laboratory, storage of equipment, seed extracting and cleaning, and for repair work. The repair shop should be designed to handle all but major repairs to equipment. Usually the office and laboratory can be in one building, which should be placed so that visitors will go there first for a proper welcome and an introduction to the work that is being carried on in the nursery.

Irrigation is necessary to the production of good plants in most nurseries, although some species can be grown without irrigation in regions where precipitation is adequate for farm crops.

Ordinarily, an overhead sprinkler system is used for the irrigation of conifers. Usually this consists of runs of 1- to 1½-inch pipe up to 500 feet in length and 50 feet apart, with spray nozzles at 3-foot intervals, and supported on posts 2 to 6 feet above the ground. Water coverage on both sides of each pipe is obtained as the pipe is rotated from side to side by a water motor or oscillator. Other systems employ revolving sprinkler heads on upright pipes at intervals of 40 to 60 feet. The installations may be fed by permanent underground or portable surface pipes.

The quantity of water and the methods of applying it (especially to coniferous seedlings) strongly influence the quality of the stock. During the germination period, the seedbed must be kept moist but not saturated. An even distribution of water during the growing season results in a uniform growth of plants throughout the seedbed. The quantity of water needed varies with the soil, climate, and age class of the stock being grown. Under similar climatic conditions, a light, sandy soil demands more water than a heavier soil. First-year seedlings require more frequent light waterings than older stock.

Land cannot be cropped repeatedly without measures to maintain its productivity. Nursery stock returns nothing to the soil because the trees are removed, root and branch. Nutrients are taken from the soil faster than they become available naturally. Nursery stock can be grown satisfactorily for
Production of Planting Stock

several years on exceptionally good land, but the application of fertilizers becomes necessary sooner or later.

The use of soiling crops, in rotation with tree crops and supplemented by heavy applications of compost, is a good way to maintain an acceptable level of fertility and soil structure. The application of the plant nutrients that are deficient in the soil without regard to the physical condition of the soil will seldom suffice.

Much can be done to maintain good physical condition in both heavy and light soils by adding organic matter. Many kinds of rotted vegetable matter can be used: Rice, oat, and wheat straw; hardwood sawdust, which needs extra nitrogen for decomposition; pine needles and leaves, which are used in limited amounts; and other like materials. Nurseries located near peat bogs make extensive use of peat as a source of humus. About 3 percent of organic matter in the top 6 inches of soil is desirable. Compost is commonly applied at the rate of 2 to 5 tons an acre every 2 or 3 years. From 200 to 600 pounds an acre of chemical fertilizer is applied.

The principal supplements needed in nurseries are nitrogen, phosphorus, and potash. Occasionally lime, and, rarely, minor (or trace) elements are added. The three major elements must be available in sufficient amounts to supply the heavy demands made by the tree crops—it has been calculated that a crop of 2-year-old untransplanted white pine (at a density of 100 to the square foot) removed 94.6 pounds of nitrogen, 31.8 pounds of phosphoric acid, and 41.6 pounds of potash an acre. Nurserymen make repeated soil analyses to determine the amounts of chemical fertilizers and compost to add.

Fertilizers of animal and vegetable origin are preferred but are sometimes impossible to get in the quantities needed, and the fertilizers of mineral origin must be used. Experiments show that better results are had when the mineral fertilizers are added through soiling crops and fortified composts, rather than when they are applied directly in liquid or solid form to the tree crops. On the lighter soils it frequently is necessary to apply fertilizers as a side dressing to correct chlorosis and to keep the crops healthy. The most desirable amount of fertilizer can best be determined by local experimentation. The quantity depends not only on the kind of soil but also on the species of trees being produced. The condition and quality of the trees indicates whether or not adequate fertilizer is being applied.

As for seed and sowing: Where trees and shrubs native to the region are being used, the use of seed from the nearest possible source will best guarantee the hardiness and vigor that are required in the field plantings. If one cannot get seed nearby, he should obtain it from localities of similar climate and altitude. The use of northern seed in the South is likely to produce trees of slow growth and poor development, which may eventually succumb to drought and heat. Southern seed used too far north may produce trees that lack the hardiness to withstand the northern winters. It is safest to use seed from native trees that are adapted to the climate of the region and from well-formed, vigorous specimens.

The quality of the seed collected depends largely on the collector's good judgment. Immature seed definitely has poor keeping quality and lower germination capacity than well-ripened seed. The color of the seed coat usually can be considered a reliable indicator of seed maturity. Simple cutting tests will give a rough estimate of the potential germinating capacity of the seed in question. This is a common-sense economy measure to prevent collection of the immature, weeviled, hollow, or otherwise defective seed.

Sowing the tree seed, an exacting operation, must be controlled carefully to obtain the maximum germination and the desired density. The seed of some species must be sown in the fall, others in the early spring, and some as
late as July. Some may be sown either in the spring or fall; early fall sowing and immediate germination are desired for others. Each species must be given individual consideration to secure the desired size and development. Seed of some species sown in the fall does not germinate until warm weather comes in the spring.

Some of the species that require fall sowing or stratification are white pine, spruce, redcedar, juniper, and the nut and stone species of the broadleaf trees. Longleaf pine seed is sown in October; it germinates promptly and by mid-December the seedlings are well established. Jack pine and shortleaf pine are sometimes sown in late June for transplanting the following spring or are left in place for another year. In the South, shortleaf, loblolly, and slash pines are sown in March and early April. Farther north, spring sowing is done in April and May. Hard-seeded species are sown in the fall for early spring germination, or they are stratified or otherwise treated to induce germination and sown in the spring. Cottonwood seed must be sown shortly after it is collected, otherwise it will suffer serious losses in germinative capacity.

Presowing treatment to break dormancy is necessary for some species. Stratification consists of placing the seed in a moist medium, such as peat moss, sand, or sawdust, and keeping it at temperatures ranging from 32° to 41° F., for periods varying from 2 weeks to 2 months. This treatment is substituted for fall sowing. A method used to break dormancy of species with impervious seed coats is to remove a portion of the outer coat with acid. Black locust, honeylocust, soapberry, and coffeetree are sometimes treated in this manner. Scarification, that is, the reducing of the thickness of the seed coat by mechanical means, is sometimes used in place of the acid treatment. Ash, mulberry, Osage-orange, and catalpa respond to soaking in water before they are sown.

As far as possible, all seed is sown by tractor-drawn seeding machines. Some seeds are so irregular in shape or size (because of out-growth and appendages) that they cannot be sown with a machine and must be sown by hand. All conifer and many broadleaf species are sown mechanically. Cottonwood, oak, walnut, and ash are some of the seed sown by hand.

The seed cover for the germination period varies with the type of soil, climatic conditions, and the species. In the northern regions, sand is used to cover conifer seed where the soil contains a high percentage of clay, otherwise native soil is used. In the South, burlap is used extensively for cover during the germination period. Pine needles or straw may be substituted for burlap with good results. Mulching to prevent frost heaving is a requirement for fall-sown seedbeds in the northern nurseries; straw held in place with wide mesh wire is commonly used. Where the frost heaving is severe, the older seedlings and some transplants must be covered.

Hardwood seedlings, with few exceptions, are grown without mulching. In the heavier soils where crustling is serious, the seed is covered slightly deeper and, when germination starts, the excess soil and crust is removed to permit the seedlings to emerge normally. A light mulch cover of straw, pine needles, or leaves is sometimes used to keep the soil surface moist and prevent the formation of a crust.

The density of seedlings in seedbeds varies from 4 to 100 to the square foot. Those to be shipped as seedlings are given sufficient space for optimum development. The seedlings to be transplanted after 1, 2, or 3 years are grown at greater densities to reduce their cost. Broadleaf species usually are shipped as 1-year-old seedlings, but most conifers must be left in the nursery for 2 to 5 years.

Great care is taken to obtain proper density. Germinating a large enough sample of each lot of seed is standard practice to determine the number of seed to sow. Seed changes in germi-
native capacity while in storage; consequently, tests must precede the sowing of any seed lot regardless of previous tests. Low germination results in shortage of stock and irregular waste of valuable seed. Moreover, the resulting stock usually has an unfavorable top-root ratio.

**Protection** of seedlings from disease, insects, birds, rodents, ants, and weather begins before the seed is sown and goes on until the stock is shipped.

Where damping-off is common, the soil must be treated before sowing. Sulfuric acid, aluminum sulfate, formaldehyde, or ferrous sulfate are used in various concentrations, depending on the acidity of the soil, buffer action, and the severity of the disease. Some soils require one-fourth ounce or less of aluminum sulfate, while others require 1½ ounces to the square foot. Sulfuric acid is applied in a 1- to 2-percent solution at the rate of 6 gallons to 100 square feet. Formaldehyde is applied at the rate of one-fourth ounce to the square foot where the acidity of the soil should not be changed.

Protection from birds sometimes is necessary, particularly during the germination period. Some nurseries are located on flyways where the number of birds is much greater than in other nurseries. Repellents are used to some extent but usually are ineffective. Where the seedbed area is small, wire screen over the beds is cheaper. Ants, moles, crayfish, and field mice are a source of trouble in certain localities. Poison bait and carbon disulfide or other fumigants are used for them.

**Transplanting** is necessary for certain species. It is done to improve the quality of the stock, making it better fitted to survive on adverse sites. Root systems of the transplants develop a greater amount of small fibrous roots, and height growth is retarded; consequently, a better top-root ratio is secured. Transplanting is done in the fall or spring. Spring is preferable because of the danger of losses in winter.

Transplant beds are 4 to 6 feet wide with rows across or lengthwise. Where the trenches are made with a tractor-drawn trencher, the rows run lengthwise; when opened by hand, they usually run crosswise. Two-year-old transplants usually are spaced 2 inches apart; younger trees may need only 1½ inches. The distance between the rows is from 6 to 8 inches, to permit multiple row cultivation.

The use of transplant boards enables the planting at one time of a large number of seedlings. The boards are filled with seedlings in small portable shelters, then they are carried to the bed, the trees planted, and the board returned to the shelter for refilling. Throughout the entire operation, the roots must be kept moist.

A machine patterned after a celery transplanter is frequently used to transplant mechanically. When a mechanical transplanter is used, individual seedlings are inserted into the machine by an operator riding a self-propelled or tractor-drawn unit, or multiple units. The machine opens and closes the trench for the seedling. The rows are lengthwise of the bed.

Transplanting broadleaf species usually is confined to small trees that are intermingled with larger trees. They are used as liners, or transplant stock, when this method is cheaper than to discard them and grow the same number from seed.

**Cultural operations**, among them weeding, watering, and the protection from insects, disease, and other damage, require a crew of men during most of the growing season. The labor peak is reached when growth is the fastest, because of the weeding job. Summer rains interfere with virtually all of the work and, in prolonged rainy seasons, additional manpower is needed to do the various jobs in season. It is good practice to keep the soilings crops and areas around the nursery free of weeds to prevent maturing of weed seed.

The conifer seedbeds are weeded by hand until all the seedlings are large.
enough to be cultivated mechanically. In southern nurseries, machines can be used 2 to 3 weeks after germination. In northern nurseries, where initial growth is slower, machine weeding is supplemented by hand weeding the first year and, for some species, the second and third year. Transplants sometimes are hoed or cultivated to remove the greater part of the weeds, and the rest of the weeding is done by hand.

Drill-sown hardwoods are cultivated with ordinary farm-tractor cultivators in about the same manner as farm row crops. Cultivating tools should not go deeper than 2 inches. Timeliness is important to keep weeds from interfering with normal development of the trees.

In areas of high summer rainfall and longer growing season, the weeding job is greater than in drier areas or colder climates. Normally, about one-half man-day to 1,000 trees is necessary in the South and about half that in northern sections.

Recent developments indicate that costs of weeding conifers can be reduced appreciably by the use of a petroleum product known as Stoddard’s Solvent, or mineral spirits. When applied under certain temperature and soil-moisture conditions, conifers are unaffected, but most of the weeds and grasses are killed. This promises to reduce weeding costs, particularly in the South, to about 5 or 10 cents per thousand trees. Other chemicals such as 2,4-D and ammonium sulfate are being used to some extent.

Some species need shade during the first year. Tolerant trees, such as the spruce, hemlock, balsam fir, and whitecedar require 50 percent cover. In some localities where growth is slow, shade is necessary for 2 and sometimes 3 years. Other species, such as white pine and Douglas-fir, can be grown in some localities without shade but require it in others. Generally, hardwoods are grown without shade except for a small amount during the germination period. Sugar maple must be kept under shade during the first year. Care must be exercised in using shade because of the tendency of all species to develop large, succulent tops susceptible to frost damage or other injury. Winter mulches of straw, pine needles, or seed-free hay are needed in nurseries where frost heaving is serious, particularly on shallow-rooted seedlings and transplants. Where frost heaving occurs throughout the winter, mulch is applied in the late fall before snowfall. If confined to the spring period, it is applied after the snow has melted.

LIFTING, GRADING, AND PACKING of trees for shipment to planting sites is commonly termed “stock distribution.” In the Deep South the work may start around December 1 and end in late February. Northward, spring planting begins in February and continues to April, interrupted only by inclement weather. Farther north, spring planting may not begin until late April and extend to mid-May or later. Fall planting starts in October and continues until frost or snow.

Most deciduous stock is dug during the fall months, counted, graded, and held in storage or in heeling-in beds until planted.

It is essential to have a current inventory of trees in the nursery according to species and age classes. It is obtained by counting a series of random samples. The intensity of the sampling varies from 0.5 percent for beds with uniform density and size to 5 percent for those with high variability. The average density is obtained from the random samples and is used in computing the total number on hand. A smaller number of samples is dug and graded; from them is obtained the cull percentage, which is used as a factor in computing the total number of plantable trees. The sampling unit is either 6 inches or 1 foot wide, extending across the bed. Deciduous trees in rows are inventoried by a series of 1-foot random samples, amounting to 0.5 to 1 percent of the total stand.

Care must be taken to get accurate inventory data. The samples must be
representative, the counts accurate, and the grading specifications the same as those to be used in culling at the time of shipping. Inventories should not vary more than 5 percent from the shipping count.

Trees are loosened in the soil by mechanical lifters, which are connected directly to tractors that straddle the bed, or are pulled by cable and winch mounted on a tractor at the end of the bed. They are then gathered by hand, bunched, and transported to the packing shed. Digging forks are used as supplemental lifting tools in the heavier soils to retain all the fine rootlets, because stock that is stripped in lifting is inferior.

Fine rootlets must be kept moist from the time lifting starts until the trees are planted. To do this, the roots are covered with soil or wet burlap as soon as they are taken from the ground. Conifers are especially sensitive to injury of this nature. Lifting should not be done when air temperatures are below freezing. Bare roots of plants suffer damage if they freeze.

Grading and packing is done in temporary field shelters or in permanent packing sheds. Where weather conditions permit, the stock is graded and packed in the nursery near the seedbeds as it is removed from them. Where permanent packing sheds are used, the stock is taken from the fields in baskets or boxes to the sheds where it is graded and packed. Here, better control may be exercised over the graders, and the trees are better protected from sun and drying winds. For shipment, the stock is packed in crates or bales with the roots in wet sphagnum moss or shingletow. It is necessary to have an accurate count of the stock shipped, particularly where small orders are sent to farmers. Grading tables with moving belts are used to facilitate counting and packing. Graders place a specified number of trees in each compartment on the belt as it moves forward. These are dropped at the end, ready to be tied in bunches of 25 to 100, depending on the size of the stock.

It is unnecessary to tie or count accurately the stock shipped in large orders. The crates or bales are uniform in size and a random sample count is made to obtain an estimate of their contents. A 5-percent sample is usually within 3 percent of the actual count.

In normal operations, stock is lifted, packed, and shipped without delay, but that procedure is not always possible during adverse weather conditions. Nursery storage is necessary until the trees are called for. Heel-in beds under shelter can be used as temporary storage. Cold storage, with temperature between 33° and 35° F., is used at some nurseries. In late spring, cold storage is effective for holding stock dormant, when normally growth would start in the nursery beds, until it is needed at the planting site. Where heavy freezing occurs, broadleaf species are usually dug in the fall and stored in cellars. With good aeration and temperatures between 30° and 34°, it can be kept in good condition for several months.

Defining a plantable tree is an extremely difficult task. Size is not the complete answer. It has been demonstrated that trees forced with water or fertilizer have a lower survival than unforced trees of equal size. Trees with a greater number of fibrous roots have a higher survival than those with only large tap and long lateral roots. Acceptable stock must assure reasonably high survival on the area where it is planted. Critical soil-moisture and climatic conditions on the planting site may require special nursery practices to produce stock of required quality or age class. Younger, less sturdy stock of the same species will do equally well under more favorable site conditions.

Coniferous stock should have a ratio of top to root, by weight, between 1 to 1 and 3 to 1. Those with higher values than 3 top to 1 root do not survive well except in favorable years and locations.

Other factors that are used to grade coniferous stock are height, length of root, stem diameter at ground line, and development of winter buds. Height
varies from 2½ inches for some species to upwards of 10 inches for others. Longleaf pine is unique because it does not develop a stem in the nursery. Roots of all species are generally cut to 8 inches because it is difficult to plant longer ones. Trees stripped of laterals and the smaller rootlets are not considered plantable grade.

**Stem diameter or caliper** is a good indicator of grade. Small, spindly stock, resulting from overcrowding in the seedbed, may meet the requirements as to height and root length but is unplantable because of the small, weak stem. Generally, conifers should be three thirty-seconds of an inch or more in diameter. Extremely large stock with a caliper of more than one-half inch is inferior to smaller and better balanced trees.

If the desired size and other characteristics are not obtained the first year, the seedlings remain in the nursery for a year or more. If they do not develop a well-balanced system of roots in the seedbed, they are lifted and transplanted in the nursery. The age class is designated by the number of years they remain in the seedbeds and transplant beds. Thus, 1-0 indicates 1-year seedlings; 1-1 indicates 2-year-old trees, 1 year in the seedbed and 1 year in the transplant bed; and 2-1 indicates 3-year-old trees that have remained 2 years in the seedbed and 1 year in transplant bed. This system provides a ready designation of age and cultural practice.

Hardwood species have a lower ratio of top to root than conifers, averaging less than 1 to 1. Total green weight and caliper are a better basis for determining their quality. Generally, those with diameters ranging from two-sixteenths to six-sixteenths of an inch and heights of 8 to 36 inches survive better than smaller trees.

**Maintenance** of nursery buildings, grounds, and the equipment is ordinarily scheduled for the slack season. Nurseries accessible to the general public have many visitors and the impression they receive is influenced greatly by the condition of the facilities. Neat, well-maintained buildings and grounds add much to the working conditions, and properly maintained tools and motor equipment is an incentive for safe, efficient work. A regular maintenance program reduces time lost when nursery work is in progress.

The trend toward mechanization increases the investment in equipment and overhead costs. Salaries have increased sharply, and unless offset by greater production the indirect charges become excessive. The technical problems encountered in nursery work require specialized training and experience. A small nursery operated as a part-time job and with a minimum of equipment usually is less efficient than the larger nurseries with a full complement of equipment and a full-time nurseryman. Smaller nurseries near the planting area are more economical because the cost of transporting stock from larger nurseries may offset the savings of large-scale production.

The development of new machinery and techniques is an important feature of all nursery work. Cultivating seedlings with machinery results in substantial savings over hand labor. Treating seedbeds with a selective herbicide before sowing helps cut weeding costs. Much nursery work is now done by women. Threading transplant boards, hand weeding, and grading are a few of the jobs performed by them.

Cold storage for seed and stratification facilities are being installed at the larger nurseries.

The amount of planting stock grown in the United States is increasing. During the war years many nurseries were closed but have since reopened. New nurseries are being established and old ones expanded. Now that field-planting machines are being used more extensively, landowners, both large and small, are planting their forest lands and abandoned fields to trees at an increasing rate.
The Wind River Experimental Forest

Leo A. Isaac, William E. Bullard

An experimental forest is an outdoor laboratory, an area set aside for research in the reproduction, growing, and harvesting of forest crops. It covers 40 acres, or 20,000 acres, enough land so that one can conduct fundamental studies and extend the results to a commercial or pilot-plant scale. New findings and time-tested methods are tried out side by side, and the results compared as the forest develops and time passes.

One of these outdoor workshops—the Wind River Experimental Forest in the Douglas-fir region—is in the heart of the Cascade Mountains. It forms part of the upper reaches of a hanging valley that empties into the Columbia Gorge near Carson, Wash.

The Wind River locality is the cradle of forest research in the northwestern part of the United States. There, as early as 1910, some of the first cutting was done on a national forest. A year or two later the first Forest Service nursery was established, the first arboretum started, and the first natural area in the region was set aside there in 1925 to maintain in perpetuity virgin-forest conditions.

Early work in forest research was done in the nursery and on nearby Columbia National Forest land. Then, in 1932, some 10,000 acres surrounding this center was set aside as the Wind River Experimental Forest.

The tract is typical of a vast forested area at the middle elevations in the Cascade Mountains, where the soil and topography are such that the area will probably be kept forever in forest production and not diverted for grazing or other agricultural uses. It is a good timber-growing site—not the best, but about equal to the average in the region. Physical features of the experimental forest are similar to those of the surrounding country. The underlying rocks are basalts, the peaks are old lava vents, and some lava flows are still exposed. The soils are mostly red-brown shot loams, very porous, heavily

The first important factor in any reforestation job is the production of high-quality nursery stock in the quantity needed for the planting job. It is like the foundation of a building. The plantations and the planting job can be no better than the nursery stock on which they depend.

Floyd M. Cossitt is a graduate in forestry of the University of Idaho. From 1921 to 1933, he was forest ranger and junior forester in the Northern Rocky Mountain Region of the Forest Service. He worked on the Prairie States Forestry project from 1934 to 1936; since then he has been in charge of planting and nurseries in the Southern Region.

C. A. Rindt is in charge of planting, disease control, and timber-stand improvement in the Division of Timber Management in the North Pacific Region of the Forest Service. His assignments have included work on the Manistee Purchase Unit, the Emergency Rubber Project, and the Nicolet National Forest. Mr. Rindt is a graduate in forestry of Iowa State College.

Harry A. Gunning is the assistant director of the United States National Arboretum in Washington, D. C. From 1919 to 1935 he was in the Division of Plant Exploration and Introduction of the Bureau of Plant Industry, Soils, and Agricultural Engineering. From 1935 to 1948 he was chief of the Nursery Division, Soil Conservation Service. Mr. Gunning is a graduate in horticulture from Kansas State Agricultural College.