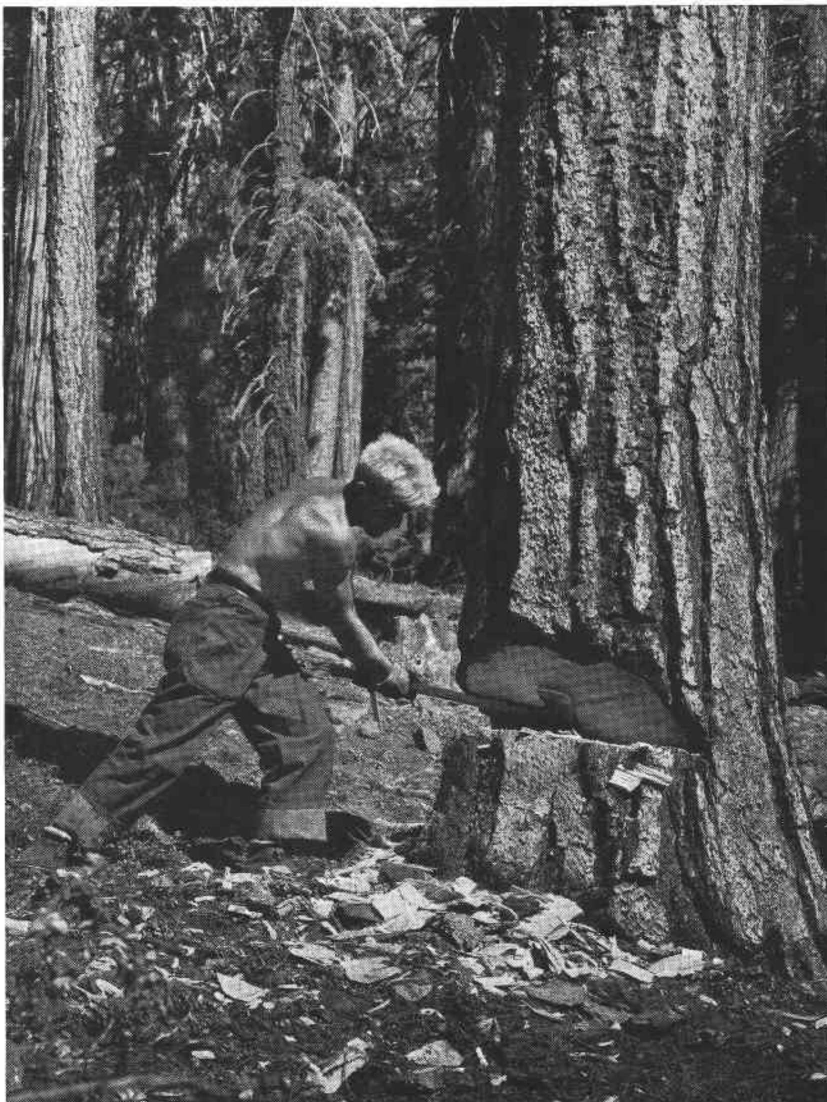
# CCC Forestry



*The CCC "Peavy" develops strength and skill in the forest.*

# CCC Forestry

*Prepared by H. R. Kylie, G. H. Hieronymus*
*and A. G. Hall*

ECW Enrollee Training
Forest Service
U. S. Department of Agriculture

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## Emergency Conservation Work

CIVILIAN CONSERVATION CORPS

ROBERT FECHNER, Director

ADVISORY COUNCIL

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## United States Department of the Interior

OFFICE OF EDUCATION

*The Office of Education edited the original manuscript and cooperated in its publication for use in the CCC educational program*

# *FOREWORD*

THIS manual of forestry and forest work is intended to serve as an aid to both the instructional and learning phases of Civilian Conservation Corps education. As a simple text relative to forest work projects, it will serve to obviate time-taking research on the part of the foreman-instructor and to give the enrollee-student a reference book for self-initiated study and reading.

The practical and theoretical aspects of forest work are not covered exhaustively, but an attempt has been made to bring out the subjects of greatest interest and value to the enrollee—in increasing his efficiency as a CCC man, in fitting him for advancement in camp responsibility, and in giving him the technique necessary to obtain a position when he returns to civilian life.

The text, photographs, pen-and-ink sketches, and charts are designed to interest and instruct readers who are not equipped with the technical background necessary to the intelligent perusal of most forestry books. It should be serviceable, therefore, to both the layman and the CCC enrollee.

A **cross-reference guide,** in the Appendix, adapts the text to the questions which may arise in teaching from the Outline of Instruction in Forestry, CCC Vocational Series 8.[1]

[1] For sale by the Superintendent of Documents, Government Printing Office, Washington, D. C., price, 15 cents.

# CONTENTS

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## Chapter I

# INTRODUCTION TO FORESTRY

### *THE FOREST*

**What Is a Forest?**

THE WORD "forest" has been variously defined. As men have become better acquainted with the forest and its uses, the definitions have changed. It is difficult to reconcile some of the earlier definitions of the forest as "a waste grounds belonging to the king" (Blackstone), with such modern definitions as "a complex association of trees, shrubs, and other plants in which each individual plays some part in the life of the community" (Graves and Guise). Some foresters recognize management as a factor in the definitions, but forests can and do exist without the slightest semblance of management.

*The forest.*

To the forester, the forest embraces more than trees and shrubs. It is an association or community of trees, shrubs, soil and soil organisms, animals, birds, and insects, each of which exerts important influences on the ultimate character and value of the area. This association should extend over a considerable area. The farm wood lot of less than 5 acres would not be classified as a forest, although it is possible to practice forestry in it.

*Forest-grown trees.*

Trees in the forest usually differ from those grown in the open or in orchards. Their shape and the absence of lower limbs is a result of natural pruning by mutual shading. It is possible to have a number of "wolf" trees in a forest. These low-crowned, wide-spreading individuals do not have typical forest form, but they exist as forest trees.

Thus we see that "forest" is a term that cannot be sharply defined. A small tract, called by foresters a wood lot, may be a forest to a city dweller. The easterner may consider the extensive areas of chaparral and manzanita in the Southwest as brushy wastelands, although they are important watershed forests.

*Open-grown trees.*

*Part of the forest heritage of the West.*

*Brush forest.*

For the purpose of this book, let us define the forest as an association of trees (as in large plantations with no undergrowth), or shrubs (as in the watersheds of the Southwest), or both (as in the hardwood and mixed forests), growing on a considerable area, upon which it is possible to practice forestry.

### *FORESTRY*

"Forestry" like the term "forest" has been defined in many ways. In Europe the first definitions of forestry laid stress on the ability of the forest and the forester to produce and maintain game for the royal hunt. The old European forester was game keeper and policeman of the hunting preserve.

*No wood is wasted in the Old World.*

See Ch. II, p. 31.

When a scarcity of timber supplies became evident in the Old World and its danger was forecast in America, forestry became the raising of continuous timber crops, and game production was relegated to minor importance. With further study of forests and forest influences, scientists discovered that protection of important watersheds, distribution of precipitation, erosion prevention, and partial control of drying winds were important forest functions. Many forest areas are managed largely with these ends in view, timber production and game management being of secondary consideration.

In recent years increased leisure time has created a demand for another forest product which in some areas exceeds all others in importance. This product, not measurable in dollars and cents or in cords or board feet, is recreation.

Some definitions of forestry imply that the profession is one to be practiced on nonagricultural land. Forestry may be, and is, practiced on land which, if cleared of trees, would be far better agricultural soil than that on which many farmers are struggling to grow crops of corn or potatoes. Much poor farm land now under cultivation would be better employed raising trees. An ideal plan might be to convert the submarginal land (that which can barely produce an income from farm crops) into forests, and such forested lands as might produce profitable agricultural crops into farms. That ideal situation has hot been reached, so forestry is practiced on rich as well as on poor land.


*Steep slopes make poor farms, but they can support good forests.*

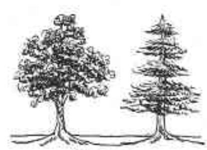
**Science or Art?**

**Forestry Defined.**

Forestry is the production and maintenance of the many and varied products of the forest. It has been defined as a science, but it is a combination of many sciences such as botany, biology, physics, and mathematics. It has been defined also as an art (the application of these sciences). The sciences are fundamentals upon which the art is based. Forestry includes the study of these sciences and their application, which is the art. Hence forestry may be simply defined as the science and art of managing forests so that they yield continuously their maximum of wood products, values, and influences.

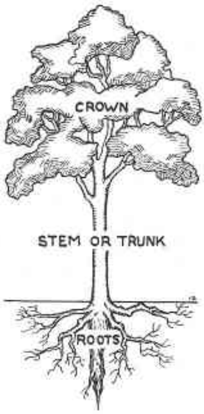
## *THE TREE*

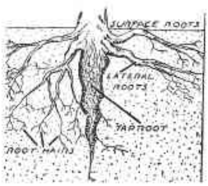
A tree is a woody plant exceeding 10 feet in height, with a single stem unbranched for some distance above the ground. Trees live on from year to year, increasing in height and diameter each season. They differ from shrubs in: (a) their manner of branching—shrubs branch at, or close to, the ground; (b) the ultimate height attained—trees commonly reach 180 to 200 feet and occasionally more than 300 feet, shrubs rarely exceed 25 to 30 feet and are usually much smaller; and (c) the shape of their crowns—trees develop crowns characteristic of the species, shrubs with



*Trees.*

*Shrubs.*

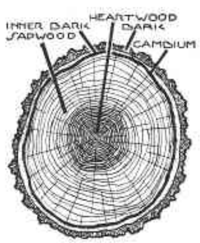



indefinite stem arrangement rarely assume a characteristic form. Certain species, however, such as the sumacs and willows, which are properly classified as trees when growing in favorable locations, may become shrubby under adverse conditions.

The tree is composed of three main parts—roots, stem, and crown. Roots extend deep into the soil and anchor the tree against strong winds. They search out the mineral elements and water necessary for maintenance of tree growth. Large roots bear smaller rootlets, and these rootlets in turn bear fine, hairlike roots which absorb the dissolved nutrients from the soil and transfer them to the rootlets, from whence they begin a journey through the roots to the stem.

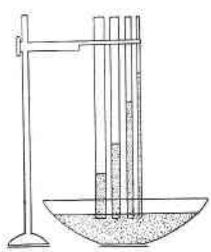
See Wood Technology, p. 151.




The stem (shaft, trunk, or bole) is a mass of elongated cells or tubes tightly bound together with other smaller cells and shielded against mechanical injury and extreme temperatures by a protective covering of bark. The vital or living mass of tissue in the stem is a thin sheath of active cells, called cambium, separating the bark and wood. Through the tubes of the new wood, inside the cambium, the dissolved food substance passes to the crown.

The crown includes the branches, twigs, leaves, and buds. The wood structure of the branches is similar to that of the trunk, the cambium layer and conducting tubes extending to the tips of the smallest twigs.

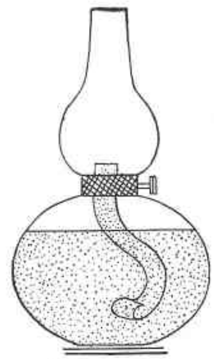
Many theories have been advanced to explain the flow of water and food from the roots to the crown. Early students of plant physiology attributed the ascent of sap to capillary action. Capillarity is the tendency of liquid to rise in fine tubes. If a fine glass tube, open at both ends, is placed upright in a vessel of water, the water level in the tube will be higher than that in the vessel. The smaller the tube, the higher the water will rise. Oil rises in a lamp wick by capillary action; and water will ascend a dry stick if one end is dipped into a vessel of it. The height to which liquid may rise by capillarity is limited, however; it is impossible for sap to reach the



*Water rises higher in fine tubes.*

crowns of large trees like the redwood and sequoia by capillarity alone.

Another force, long thought to be the cause of sap ascension, is atmospheric pressure. As leaves transpire water, according to this theory, a vacuum is created. Atmospheric pressure was thought to force sap upward to fill the void. The action of atmospheric pressure may be observed in the common mercury barometer. The greatest height to which water can be raised by atmospheric pressure is about 32 feet, but sap in trees rises to many times this height.



*Oil rising by capillarity.*

Pressure exerted by the roots has also been credited with causing sap ascent. That root pressure is an active force may be seen when a tree has been cut, especially in the spring—the stump will "bleed." This force also is limited and cannot transport sap to great heights.

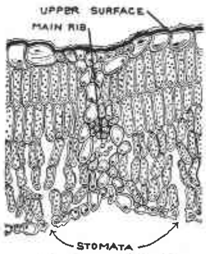
*Mercury rises by atmospheric pressure.*

The most generally accepted explanation of sap ascension is the "cohesion" theory. The column of water in a tree may be likened to a long string. A pull exerted by transpiration (release of water vapor by the leaves) on one end of this string causes movement all along the line to the roots. Energy for this process is supplied by the sun. As the sun evaporates the transpired water, it draws the water column upward to the leaves. Water under such circumstances has a tendency to stay together, or cohere. Cohesion is greater in sap than in pure water. The transpiration pull on the sap is sufficient to move the column to great heights, and the cohesive force of the sap is strong enough to hold the fine columns or "strings" together. Although no one vessel or group of vessels extends the entire length of the tree, there does exist an unbroken series of columns that zig-zag in many directions from the leaves to the roots.

*Resin flowing from stump by root pressure.*

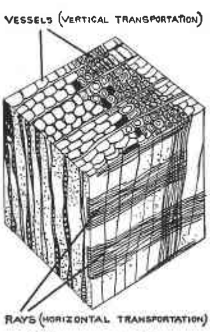
Plant physiologists are still seeking explanations of the details involved, and the movement of sap is still being investigated. It is probable that all the forces mentioned in this connection contribute to sap ascension. Clearer and more definite conclusions may be obtained by further research.

*Cohesion of liquid.*



*Section of leaf.*

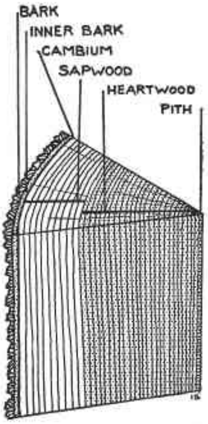
However this may be, by some force or series of forces the sap (water and dissolved nutrients) is carried to the leaves. The leaves are, in effect, small factories where the raw materials are manufactured into food. Each leaf bears many small pores or mouths, called stomata, through which it takes in air. Air is composed of nitrogen and oxygen, with small quantities of argon and carbon dioxide, varying amounts of water vapor, and minute quantities of other elements. Carbon dioxide is separated from the rest of the air by the leaves and is combined, in the presence of sunlight, with water and other elements. Wood is composed chiefly of carbon, oxygen, and hydrogen. The carbon is derived from the air, and the oxygen and hydrogen from the soil water that has ascended to the leaves. Mineral elements from the soil comprise about 1 percent of wood. It is these earthy constituents that remain as ashes when wood is burned.



*Transportation channels in wood.*

The tree's raw food must be dissolved in water so that it can ascend to the height of the crown, and when the raw materials, including water, are combined with carbon dioxide much unnecessary water remains. This is given off (transpired) through the pores of the leaves and is evaporated by the sun.

After manufacture, the elaborated food material returns downward through the cells and tubes of the inner bark, to the twigs, branches, trunk, and roots. The channels of food transportation in a tree may be compared with the blood streams in a human being—blood being carried to the lungs to acquire oxygen, and then flowing to the growing parts of the body.

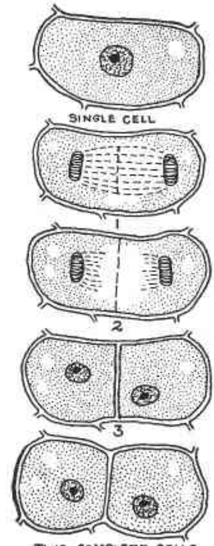


*A ring for each year's growth.*

A cross-section of the trunk reveals a series of rings, one for each year of the tree's life. In a large tree the innermost group of rings is dead, hard, brittle, and stiff. The function of this core of heartwood is to maintain the tree in an upright position. Around the heartwood is a sheath of younger wood or sapwood. The sapwood, still alive, helps in the transportation of food and water. Surrounding the sapwood is a fine layer of small cells, called the cambium, which is really the growing portion of the stem.

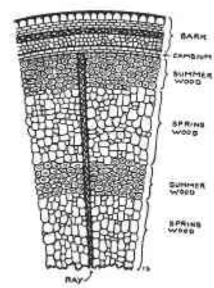
Elaborated food from the leaves travels downward through the inner bark and is diverted laterally into horizontally arranged cell groups or rays. Cambium cells absorb this food substance and grow.

Cells increase in number by cell division. A cell grows and splits into two smaller cells; the two small cells grow, and each splits into two more. By cell division and growth, the cambium forms new wood on its inner side and new bark on the outside.



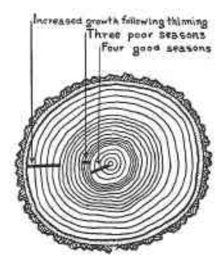
*Three stages in cell division.*

The wood growth early in the season (springwood) is formed when the trunk must transport vast amounts of water and food; therefore, its cells and tubes are large and thin-walled. The "summerwood" is composed of smaller, heavier-walled cells. This difference in cell structure produces the visible annual rings which can readily be seen on the stump of a tree. It is possible to tell the age of a tree by counting the rings from the center or pith, to the cambium. The tree's history is shown in a cross-section of the trunk—a poor growing season results in a narrow ring, a rich season in a wide one, and fires leave tell-tale scars. Removal of nearby competing trees also is indicated by the wider rings.

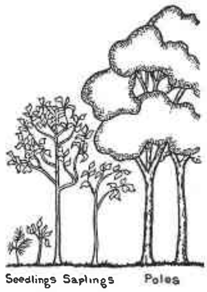



As the cambium manufactures new wood it increases in size, forcing the bark outward. The older bark, being dead, cannot stretch and expand. Consequently it cracks into the plates, ridges, or scales that are characteristic of some trees. The eucalyptus, or blue gum, sheds its bark annually. The bark of the redwood, on the other hand, remains for years, becoming very thick and ridged before dropping.

**Trees Must Have Light and Heat.**



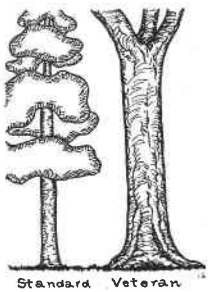

To perform the functions of growth, the tree must have heat and light in addition to water, minerals, and air. The manufacture of raw food by the leaves requires sunlight. In a dense forest the leaves soon disappear from the shaded understory and the trees develop new ones in the canopy. Some trees are better able to withstand shade than are others. These are known as "tolerant" trees. Beech, hemlock, and balsam fir are examples of tolerant trees, whereas black




locust and the larches are intolerant. But no tree can live very long without some sunlight. All growth processes of a tree require energy which is derived from light and heat. Tree growth is negligible in winter. In the extreme North, trees are often stunted and small because their growth is retarded by lack of sufficient heat.

According to their sizes, Gifford Pinchot has classified trees into seven groups:

1. *Seedlings:* Trees of seed origin, up to 3 feet in height.
2. *Small saplings:* Trees 3 to 10 feet high.
3. *Large saplings:* Trees more than 10 feet in height, and up to 4 inches in diameter.
4. *Small poles:* Trees 4 to 8 inches in diameter.
5. *Large poles:* Trees 8 to 12 inches in diameter.
6. *Standards:* Trees 1 to 2 feet in diameter.
7. *Veterans:* Trees more than 2 feet in diameter.



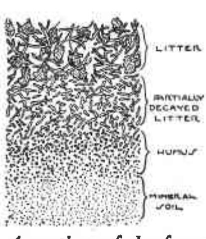

## *THE FOREST FLOOR*

**The Forest Floor—Fallen Leaves, Twigs, and Bark.**

The term "forest floor" is often confused with "forest cover." The forest floor is that covering lying close to the mineral soil under the forest. Forest cover includes trees, underbrush, and herbaceous growth.

The forest floor resembles a rug in its make-up. It is compact in its lower layers and lighter in its upper layer. It is made up of fallen leaves, twigs, pieces of bark, fruits and nuts, rotting logs, down trees, and other vegetative matter. It consists of both plant and animal life.

There are actually three layers of the forest floor. The first one, resting on and merged with the mineral soil, is a mass of humus. It is damp, dark in color, and composed of thoroughly decayed litter (fallen leaves, twigs, and bark). The middle layer is made up of partially decayed litter. The character of the leaves, twigs, and other components may be seen in the compound, and in it animal life and chemical forces are at work reducing this mass to completely disintegrated organic matter which gradually changes into soil. It is humus in the making.




*A section of the forest floor.*

The third and topmost layer is exposed to the air. It is made up of newly fallen leaves, twigs, and wood particles. This leafy covering is to the forest floor as the nap is to a rug. Raindrops falling on this cover are checked and broken up, and the run-off enters the spongy soil. When air currents pass through the forest this mass of litter keeps the soil from drying.

**Like a Huge Sponge.**

**See pp. 20, 22.**

Bacteria and fungi in the forest litter make decomposition possible. Humus is changed into soil more readily in locations where the seasons are warm and long. On the other hand, where the seasons are short, the litter accumulates in greater quantities and protects the soil and roots from killing freezes.

**Swarming Bacteria, Rapidly Growing Fungi.**

## *THE TREE COMMUNITY*

Trees in the forest are comparable to human beings in a social or economic community, except that the tree's inherent savage struggle for existence is more openly ruthless than man's subtle, diplomatic schemes to get ahead. As there are classes of people in the economic and social scales, so there are classes of trees in the forest community, as follows:

**Classes of Trees are Like Classes of People.**

- *Dominant:* Overtopping the rest of the stand.
- *Codominant:* Beneath the dominant but receiving full sunlight on top and sides of crown.
- *Intermediate:* Beneath the codominant, receiving sunlight on top only; growth retarded by dominant and codominant classes.
- *Suppressed:* Beneath all other living classes; receiving little or no sunlight; little chance for recovery.
- *Dead:* Trees which have succumbed in the struggle.

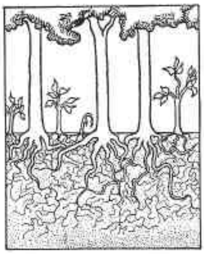

1. *Dominant,*
2. *Codominant,*
3. *Intermediate,*
4. *Suppressed,*
5. *Dead.*

Each tree succeeds in its life struggle only to the extent that the trees in the higher crown classes allow it to succeed. When the larger trees are removed, through death, lumbering, or silvicultural cuttings, the intermediate and suppressed ones have a chance to recover. Some trees, however, cannot reestablish themselves when released from long suppression.

The life and death struggle results in a survival of the fittest. On some sites and under certain conditions the fittest tree may be an important timber species. On others it may be a weed for which the lumberman can find no market. The

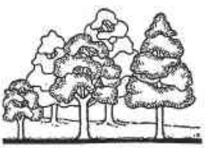
*Young trees are suppressed in dense forest.*

*Tolerant species may thrive in dense forest shade.*

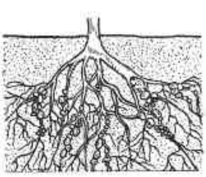


*Root competition.*

*Closely spaced.*



*Widely spaced.*



*Nitrogen nodules on roots.*

forester attempts, through wise use of the axe (removal of certain trees) and underplanting, to convert the stand to trees of economic value.

Competition for soil nutrients (foods) often results in well developed and widespreading root systems. Competition for light usually develops tall, straight survivors, and that is one of the reasons trees are placed close together in plantations. Such spacing causes the ultimate death of over half the seedlings, but the trees that survive usually are well formed timber trees devoid of large lower limbs.

Practically all trees are tender when young, and are susceptible to scorching by direct rays of the sun. Foresters protect such trees by planting them beneath "nurse" trees. The beech with its thin canopy is an excellent nurse tree. It guards against the direct sun rays but permits enough light to filter through to sustain the young trees beneath it. Intolerant trees, that is, trees unable to withstand excessive shade, planted under young beech soon harden and reach for more sunlight, finally overtopping the beech.

Some trees—the locust and Scotch pine for examples—add nitrogen to the soil through nodules formed on their roots. Trees like spruce which ordinarily perish on poor, sandy soil may still be grown on such sites if mixed with nitrogen-producing trees.

Other trees have poisonous effects. It has been noted that often no vegetation except grass will grow beneath the black walnut. Poisons given off by the roots of black walnut may be fatal to any woody vegetation with which they come in contact.

*Tolerant hemlocks under pine.*

Let us follow the struggle for existence in a forest in its natural state, one in which forestry is not being practiced. We will assume that the forest consists of large white pines and hemlocks. The larger pines have overtopped the hemlocks and are dominant, but beneath their shade the tolerant hemlocks are thriving.

*Young pines start in openings.*

As the older pines die and succumb to insects and decay, openings are left in the canopy. Ordinarily a dying tree produces an abundance of seed in its final years. These seeds and those of neighboring trees fall to the ground—to the dense, brush-covered areas of laurel and rhododendron, to the open spaces in the shadows of towering pines and hemlocks, and to the sun-lit patches of forest floor vacated by dead trees. Warm rains cause the seed to sprout. Those in the thickets are quickly choked by the brush, those in the shadows die from lack of light, but those in the openings put forth tiny stems and roots. While they are tender and succulent, the seedlings are in constant danger from all the herbivorous animals of the forest. Deer and other browsing animals feed on the new leaves, and birds eat the tender sprouting seed.

*Pines die in dense shade.*

After the first season, barely half the crop is left, where there is no protective leaf canopy, heavy rains gouge the seedlings from their beds, frost kills many more, the scorching rays of the sun burn up their unprotected buds and needles, and brush and weeds compete with them for possession of the openings and for the food elements in the soil. A few of the trees, however, become established in favorable spots.

A New Struggle.

The following spring the older trees burgeon forth, with new shoots and leaves, to fill the holes in the canopy; the shade deepens, and the seedlings begin a new struggle for light, water, and food. As the snow melts, they become exposed once more to the deer and rabbits; and late frosts retard their growth.

Pines Must Have Light.

The closing of the canopy of the older trees allows sufficient light for seedling growth and protects them from the direct rays of the sun. But as the canopy closes more and more each year the shade becomes too intense. Being less tolerant than the hemlock, the young pines yellow and begin to die. If the canopy remains closed, all the young pines will die and the tolerant hemlocks will have full possession of the area. But now a storm blows down a large overmature pine. This permits more light to reach the understory. Responding to the light, many of the young pines recover, and rapidly grow to reach a place in the sun. Growth of the hemlock also is accelerated. All this time numerous insects and diseases are attacking the trees, and an intense competition for soil, water, and food takes place. The weakened trees succumb to these attacks, and the stronger ones take possession of the root and crown space vacated by their dying neighbors.

*Pines respond to light.*

Thus the trees pass through the sapling stage—the intolerant white pines gaining dominance because of their striving for additional light. They are now tall saplings with pointed crowns and straight boles which excess shading has made limbless.

*Pines reach for the sun.*

Overtopping the hemlocks, however, does not give the pines full possession of the site. The tolerant hemlocks thrive well in the shade; and when the pines settle down to grow in diameter, the hemlocks continue to grow in height. Since pine demands more light than hemlock, successive generations of competition for a site usually result in the complete suppression of the pine. White pine seedlings cannot endure the dense shade of mature pines, but hemlock can establish itself under shade.

*Hemlocks reproduce in shade.*

Although this is the story of but two species, similar struggles go on wherever two or more trees are contending for the same limited area. Shrubby and herbaceous plants enter into the struggle particularly in the earlier stages; insects and diseases are often determining factors in the ultimate plant growth.

*The forest is an association of trees, shrubs, and other forms of life.*

## *SUMMARY*

The forest is much more than trees and shrubs. It is a complex association of many forms of life, struggling together and against each other to grow and reproduce. Competition for light and food in the forest usually results in tall, straight trees free of large lower limbs. Often, however, this survival of the fittest does not produce the best timber species or the species best adapted to man's use.

**Refer to Forest Competition, p. 9.**

Forestry, by applying the knowledge of tree growth, soils, spacing, planting, improvements, and protection to timber production, has directed the forces of nature to fulfill man's needs.

**The Tree, pp. 3, 7.**

The tree is almost as complex as the forest itself. It is a living plant, comparable in many instances to man. Like man, it needs air, light, heat, water, and food for its growth. Its roots penetrate deep into the ground in search of food material; its trunk carries the raw food to the crown where the leaves combine it with elements from the air to form nourishment for the growing cells.

**Wood Structure and Growth, pp. 6, 7.**

Billions of minute cells and tubes make up the substance we know as wood, and each year many more cells are added through the growth of the cambium layer. As the cambium grows it adds a new layer of wood on its inner side and a new layer of bark on its outer side. In the spring the cambium grows large cells with thin walls, but in the summer smaller thicker-walled cells are grown. The difference between the spring and summer wood may readily be seen on a cross-section of the tree trunk; and it is possible, by counting these annual rings, to determine the tree's age, and by examining the size and condition of the rings, to study the tree's history and to predict future growth.

Refer to
How Sap Rises,
pp. 4, 5.

The transportation of food material from the roots to the crown is a subject which has long interested scientists. Many explanations have been attempted but the most generally accepted one is the "cohesion theory" which likens the columns of sap to a series of strings pulled upward by the sun's power to evaporate moisture transpired, or given off, by the leaves.

Refer to
The Complex Forest
Floor, pp. 8, 9.

One of the important components of the forest is the forest floor (the soil, humus, and litter). It is from this source that the tree receives most of its food. In cross section the forest floor appears as a number of intermingling layers of leaves, twigs, and other litter in various stages of decomposition, resting upon and merging with the mineral soil. Bacteria and minute insects live in the soil layers and hasten the disintegration of litter into rich soil.

The forest floor acts as a huge sponge in absorbing rainfall and snow melt, retaining some of it for plant use but permitting most of it to trickle slowly into springs and streams to maintain constant flow.

See
Tree Classes,
pp. 9, 10.

Refer to
Tree Enemies,
pp. 58, 59.

Tree roots in the forest floor compete for water and food, while their trunks and crowns struggle for light. Consequently different classes of trees appear. Those seed which have been fortunate in falling in open spaces or on good soil thrive and grow into healthy trees; others, less fortunate, fight a losing battle against natural forces. Some trees are endowed with power to resist shade and will live on year after year in the shadows of towering neighbors. Grazing animals eat or trample young seedlings, insects and diseases maintain a constant attack so that only a small percentage of the seeds which reach good soil finally become timber producers.

# Chapter II

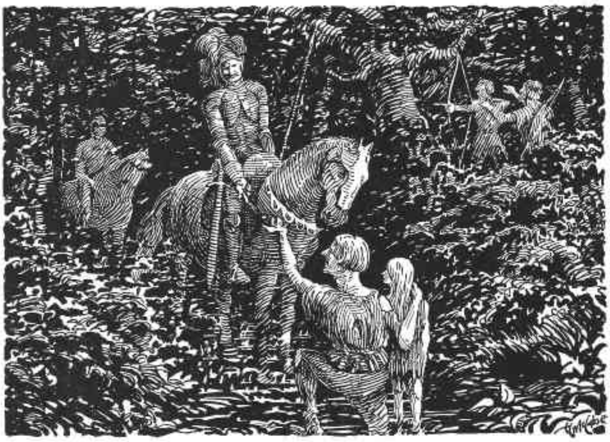
# FOREST VALUES

## *STANDARDS OF VALUE*

FORESTS offer various values and benefits to man. These may be lost through destructive lumbering, fire, tree diseases, insect attack, and improper management.

The relative importance of forest values changes. The early Greeks worshiped among the trees. Many of their gods and goddesses were reputed to live in the woods. The Druids deified the oak and worshiped in the forests.

In medieval times, when civilization came to Western Europe, nearly all the land was forested. History and literature reveal the customs of the day. Robbers hid in the forests. Hermits and peasants lived a simple life, gathering fagots,



*Forests of long ago.*

berries, and other products of the forest. Herders led their sheep, goats, and swine into the forests to feed. Kings and nobles hunted and knights traveled the trails seeking adventure.

**Forest Values Change.**

Forest values then were different from those of today, yet forests have undergone no essential change. The values of the forest, however, change with the needs of the day. Present day needs, and those forecast for the future, demand more and better managed forests.

Refer to Ch. VI.

Forest values may be divided into two main groups: *products* and *influences*, one as important as the other, in general. The head is no more important to the human body than the heart, and it is absurd to say that one is more valuable than the other. Likewise, the products we derive from forests and the desirable influences exerted by them cannot be evaluated. Both these values are vital to the needs of our modern civilization.

Individual demands for timber are not as great as they once were. As a value, however, timber holds its own. The use of steel and copper has likewise declined, and these cannot be renewed.

**Timber Value Holds.**

The use of wood is highly important to man. Wood to keep people warm and to cook their food has value. Wood has value in communication systems, which use millions of telephone and telegraph poles. Wood has value in transportation, as shown by its use in wagon and carriage construction, automobile manufacturing, and as railroad ties. Of all wood products, sawed timber is used more than any other form. It has value both in manufacturing and in building.

But forests offer many other values. Tree extracts such as turpentine and rubber are used universally. Other products derived from wood are paper, wallboard, and cellulose products, dyes, medicinal compounds, and chemicals.

Refer to Ch. VII.

The varied forest products, their relative values, consumption, and methods of utilization will be taken up in another chapter.

**Physical Influences.**

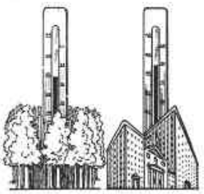
**Social Influences.**

Forest influences may be divided into two main groups: Physical and social. The physical influences affect climate, stream-flow, and soil. The social influences have to do with employment, income, standards of living, and recreation. Both groups, the physical and social, directly or indirectly affect the well-being of man.

# PHYSICAL VALUES

## EFFECTS OF FORESTS ON TEMPERATURE AND HUMIDITY

In summer when cities are sweltering, people throng to forests for recreation and rest. They know that wooded glens and breeze-swept mountains are more comfortable, cooler, and more invigorating than torrid streets. Why are forests comparatively cool in summer? One reason is that higher elevations are usually cooler than low elevations. But there are factors other than elevation, factors inherent in forests themselves, that tend to reduce summer heat.



*It is cooler in the forest than in the city.*

See Leaves, p. 6.

First, the leafy canopy protects the forest from the hot rays of summer sun; second, trees transpire water through their leaves and since evaporation is a cooling process, the evaporation of this water greatly reduces heat in the forest—just as evaporation cools a person when he perspires; third, the movement of hot currents of air is checked by standing timber.

Forests Are Cool.

Within a forest the temperature changes are not so great as in nearby open areas. Maximum forest temperatures are lower, and minimum temperatures higher, than those of adjacent fields. Raphael Zon, reporting observations over long periods in European forests, stated, "During the hottest days the air inside the forest was more than 5° F. cooler than that outside." It was found that for the coldest days of the year the air in the forest was only 1.8° F. colder than that outside.

Night Temperatures Higher; Day Temperatures Lower in Forests.

Sir William Schlich has shown that, during the summer, night temperatures are higher and day temperatures lower, in forests than in nearby open areas; the minimum at night being 3.15° F. higher, and the maximum in the day 7.42° F. lower.

Relative humidity under forest cover may be as much as 10 percent higher than that of adjacent open areas. (Relative humidity is a comparison of the *actual* moisture content of the air at a given temperature with the *possible* amount the air is capable of holding at that temperature.)

**Relative Humidity High in Woods.**

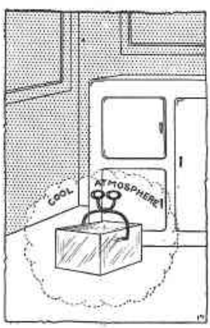
Zon reports that, in studies made in Bavarian forests, relative humidity inside the forests was found to be from 3 to 10 percent higher than that outside, the least difference occurring in winter and the greatest in summer.

*Trees give off great quantities of moisture.*

Like the moderation of temperature this condition is a result of shade, retarded air currents, and transpiration. Trees, especially thin-leaved species, give off much water through transpiration. Transpiration is a natural process associated with the tree's growth, by which water is released through the stomata or leaf pores. A comparable process is perspiration in humans. It has been estimated that a fully stocked beech stand, 115 years old, uses from 1,560 to 2,140 tons of water per acre per year, practically all of which is returned to the air as transpired water vapor.

## FORESTS AND RAINFALL

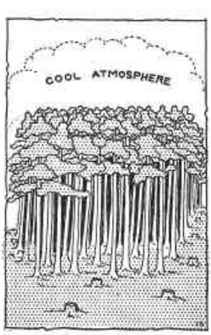
**Air Carries Water Vapor.**




**Like a Block of Ice.**

Rainfall is caused by the chilling of moisture-laden atmosphere. At varying degrees of temperature, air is capable of supporting varying amounts of vaporous water. The higher the temperature the greater the water-holding capacity of the air. When warm air, carrying a heavy load of moisture, is suddenly cooled its water-holding capacity is lessened, and the excess water falls as rain.

As we have seen, forest areas are cooler than open areas and are always more humid. These changes of conditions extend farther than the forest itself. Just as a block of ice in a room tends to reduce the temperature of the air surrounding it, so forests tend to cool the atmosphere surrounding them and to make it more humid. Observations made in balloons show that these effects are still discernible at elevations of 5,000 feet.




Moisture-bearing clouds encountering such cool and humid atmosphere, decrease in water-holding capacity and release their surplus moisture as rain. That this phenomenon actually occurs in nature is borne out by studies in Europe. In some cases more than 25 percent increase in rainfall upon forests has been recorded over long periods as compared with adjacent unforested areas. This effect on precipitation is most noticeable at high elevations. Observations show that up to 300 feet in elevation forests increase rainfall only 1.25 percent, but between 3,000 and 3,250 feet the increase may be as much as 84 percent.

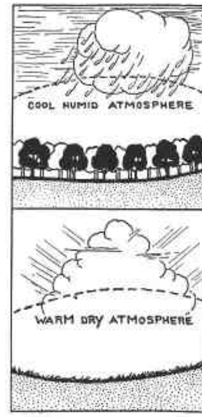
It is the opinion of experts who have given much thought to the matter that the local effects of forests on rainfall are less important than those over large areas. Forests are known to transpire large amounts of vaporous water into the air. Whereas saturated air currents are cooled and lose moisture in passing over a forest, dry air currents are enriched in moisture by contacting atmosphere over a forest.

Inland precipitation depends largely on the character of the land cover over which the prevailing winds pass after they have discharged their moisture. Water is taken up by these winds in the form of vapor. The more surface exposed to the air, the more evaporation will take place. A forest exposing more surface (ground, plus stems, plus leaves of trees) than do similar unforested areas, therefore, contributes more to the moisture content of the inland air currents, and to the amount of rainfall.

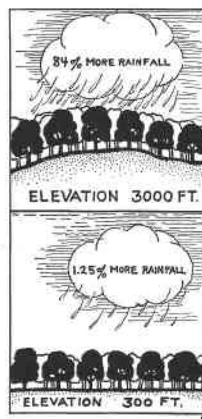
Zon contends that the moisture-laden winds from the Gulf of Mexico lose much of their water content as rain in passing over the lands near the coast. They then become dry, and precipitation ceases. If these winds did not have sources other than the ocean from which to regain moisture, rain would be confined to a narrow border along the oceans, and the interior would be quite dry. These other sources, he maintains, are the forested and vegetated areas.

### THE FOREST AND EROSION

The wearing away of land surface by water depends upon four factors: (1) The amount of rainfall; (2) the degree of slope; (3) the composition of the soil; and (4) the cover of the soil. It is evident that man cannot greatly control rain-

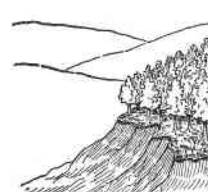



*The forest atmosphere affects rainfall.*




*The effect of forest on rainfall increases with elevation.*

An Example of Forest Influence on Rainfall.



*When vegetation is removed, the soil washes away.*

fall, neither can he change the degree of slope or the character of the soil over extensive areas. But man can control the vegetative cover on the earth's surface and can help control erosion in this manner.

**Life Depends Upon Soil.**

Life is dependent directly or indirectly upon soil. Since this is the case, it is of great importance that the best types of soils be protected. Forest vegetation is one of the best builders and retainers of soil on extensive areas, especially where steep slopes increase the force of erosion.

See pp. 8, 21.

**Erosion Can Destroy Valuable Soils.**

Erosion may destroy valuable soil or impair ground surface so that it is very difficult to reclaim it. For this reason forests should cover the greater portion of steep slopes and nonagricultural lands capable of supporting trees.

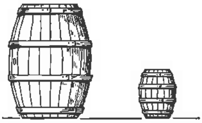
Erosion starts when rain falls upon poorly covered or bare soil and is moved by gravity to lower levels. As it moves it carries particles of earth. The greater the volume and force of the water, the greater the force of erosion. On open areas where soil is hard and compact, very little water is absorbed by the earth. This means that there is a greater run-off. There being no surface litter to check the velocity of the current, water accumulates into torrents resulting in greater erosive forces.

*Trees reduce rain impact and permit water to seep into spongy soil.*

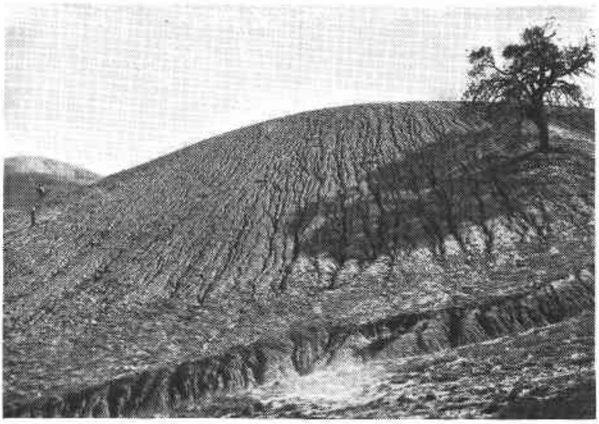
In forests, rains fall upon the leaves and branches of the trees. This reduces the impact with the ground. Rain from the trees drips upon the litter-covered forest floor and its run-off is obstructed by leaves, twigs, and plants. The water then gently enters the fibrous, porous soil of the forest and slowly runs into underground passages where it gradually finds its way into reservoirs and later into springs and streams.

**Percolation.**

Much of the water is held by the spongy earth to percolate gradually into these streams, causing streams in forest areas to be much more constant in flow than those in unforested areas.




Studies by the Wisconsin Experiment Station show that on slopes of 36 percent wild pastures (grass cover) had run-off 2½ times as great as that of hardwood forests; and on cultivated and fallow ground, the run-off was 9 times as

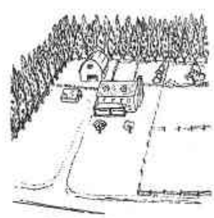


*Rains wash deep gullies in unprotected soil.*

great. Many similar studies reveal like data. Phillips and Goddard, of the Red Plains Experiment Station at Guthrie, Okla., found that burned areas in a forest eroded 15 times as fast as unburned areas (same slope and soil).

*Trees retard sand dune formation.*

Generally wind erosion does not do as much damage as water erosion. However, the wind does cause damage to soils by blowing sand over valuable areas and by drying and reducing exposed humus. The recent dust storms in the Prairie States show the extent of damage possible by wind erosion. Forests reduce wind effects and retard drying. The Shelterbelt of the Middle West is an experiment to test the value of plantations for eliminating ill effects of winds and dust storms.



*Sheltering trees.*

The extreme effects of forest destruction and the subsequent action of wind and water on soil and economic conditions may be seen in parts of China where floods and erosion have reduced the productivity of farms and have choked the rivers with deep deposits of mud.

The Soil Factory.

If forests are not disturbed in the process, they form their own valuable soils. This accumulates on the forest floor in the form of leaves, twigs, rotting branches and logs, and decayed plants and animals. Roots and partially decayed twigs make the soil porous and the constant working of bacteria and minute animal life reduce the debris to humus. Humus thus formed, works into the subsoil to combine with the chemical elements of the subsoil which are transferred to the upper layers so that a light, porous soil, rich in food elements, is the result.

### STREAM FLOW

Even Stream Flow an Object of Forestry.

In practically every section of the country the question of stream flow is of major importance. In centers of population, much water is required for domestic and commercial use. In many sections seasonal droughts cause streams to become low and sluggish or to dry up entirely. The problem of fluctuating flow seems to grow more acute, and maintaining the normal flow of water from watersheds is one of the important objects of forestry.

*Uncontrolled waters.*

As vegetation, especially forest cover, is removed from slopes, run-off is accelerated. Accumulated run-off causes floods which sweep away millions of dollars worth of property, and do vast damage. According to early estimates (the only figures available when this publication was printed) the Ohio and Mississippi flood of 1937 took 400 lives, drove 1,000,000 people from their homes, and caused property loss totaling $500,000,000.

Destruction by Floods.

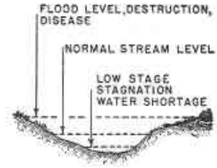
Besides flood losses in homes, livestock, and farm soil, stream beds are clogged with soil and debris, navigable channels and reservoirs are filled, roads and bridges destroyed. Debris and eroded soil are often deposited on valuable farms, and in roads, streets, and buildings.

Critical Extremes.

Permanent forest vegetation of watersheds cannot cure all the ills of floods. Of course stream flow will fluctuate, but rivers flowing from wooded watersheds have a constancy which streams in open country cannot possess. Their high water marks are lower and their low water marks are higher, and it is the critical *extremes* of water flow which demand the greatest consideration.

Like a Sponge.

In the description of the forest floor and the discussion of soil and erosion, attention was called to the fact that spongy, porous soil absorbs water from falling rain and melting snow much more readily than more compact soils. Forest litter absorbs surface water and prevents rapid run-off. The same litter prevents rapid drying out and freezing of subsoil water. This leaves more water in forest soil to find its way slowly into streams. Thus forests help to regulate the flow of streams. Rivers which have dependable water-flow offer greater values than do streams whose flow rises and falls extremely. The more forest area we have, the more and better protection we shall have from floods.

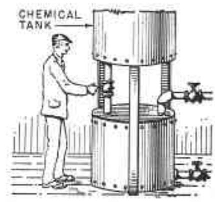



Forest Floor, p. 20.

VALUES OF EVEN STREAM-FLOW

**Domestic Water Requirements.**

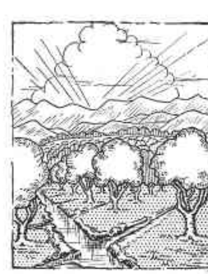
*Water supply:* Where population is concentrated, it is necessary to draw water for domestic and commercial use from large streams. If these streams are likely to flood easily in wet seasons and then become low and sluggish in dry seasons, they are not dependable sources for water. Streams not fed by fresh tributaries during hot, dry weather become contaminated and it is necessary to go to much expense to purify the water. Water heavily treated with chemicals is unpleasant to taste and in many cases not suitable for commercial use. Forest-fed streams are generally clearer, fresher, and more constant in flow than streams in open country.




*Impure water must be chemically treated.*

Along 300 miles of the eastern seaboard, cities use 2 billion gallons of water daily. New York draws water through aqueducts 92 miles long, and Boston has tapped a stream 60 miles away. Three cities in the East have spent 150 million dollars in recent years building dams and filtration systems. More and better forests would help reduce such outlays. San Francisco and Los Angeles, Calif., obtain water from reservoirs 200 to 250 miles away. The importance of water for home use, commercial use, and livestock consumption is apparent.

The great drought of 1930–31, when cities were required to transport water by trainloads, and farmers were obliged to truck water over long distances, demonstrated the necessity of better provision for water supply. Foresting watersheds of supply streams would improve the situation.



*Irrigation turns desert into orchards.*

*Irrigation:* Early settlers in the western United States braved the dangers of a rugged, untamed country, lured by adventure and the gleam of

*Water from forested hillsides is used to irrigate crops in the valley.*

gold. Backs were bent over pans of swirling gravel while eyes squinted and reddened peering for "pay dirt." Today the pay dirt of the West is the irrigated land of the semiarid regions. The gold of the Golden West lies in the orange groves of California, the produce of the Imperial Valley, the sugar beet fields of Utah, and the alfalfa and potato crops of Idaho.

**In Colorado.**

Irrigated lands in Colorado produce annual crops worth more than the aggregate of all its mines. Agriculture is now the most important industry of the Colorado River Basin. Water from the Colorado supplies millions of acres of irrigated farm land. Thousands of homes have been built and thousands of families depend upon irrigation canals.

**In California.**

The Imperial Valley of southern California, sending fruit and produce to practically every market in the country, is a rich, fertile area which owes its prosperity to irrigation.

**A 6-Billion-Dollar Investment.**

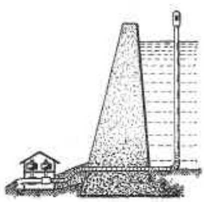
According to the 1930 census, 19 States eastward from the Pacific coast, into Arkansas and Louisiana, contain 19,547,544 acres of irrigated land, with $1,032,755,790 invested in reservoirs and distributing systems, and $4,886,892,784 in lands, buildings, and machinery. This total investment of nearly 6 billion dollars is wholly dependent on water, and since the majority of streams which supply the water for these vast irrigation projects originate in the forest, protection and care of these forests is of primary importance. Large storage basins and dams supply the water for the more extensive projects. Huge reservoirs are often located back in the mountains, at considerable distance from the water users, where they can obtain silt-free water from the forest. Many of the smaller irrigated farms are entirely dependent upon the forests for regulated water supply.

*Irrigated lands total more than 19,500,000 acres.*

Success of Irrigation Depends Upon Forests.

*Forests and water power:* Falling or rapidly flowing water has long been used as a source of power. The first water developments made use of paddles or wheels to turn machinery situated near streams. Many early sawmills and gristmills in this country were of this type. The necessity of locating such mills at the water's edge limited their possibilities.

With the development of electric power, energy produced by water could be transmitted many miles from the stream. Although the direct or mechanical power of water is still used to operate mechanism near its source, the greatest power plants are those which transform mechanical power to electric energy. Water turns huge dynamos which produce electricity to flow from the plant and supply light, heat, and power in cities, homes, and factories.



*Water supplies power; forests supply water.*

The distance to which electricity can be transmitted is limited, however, and additional water-power plants are located only where their cheapness and dependability surpass those of other power sources.

Refer to Forests and Rainfall, p. 18.

Where water-power plants are economically practical in the United States, forests are important factors in assuring the necessary water supply. It has been estimated that more than 72 percent of the total water sources of the country is in the forested mountains of the West. Because of its remote location, much of this power is undeveloped.

Water Power Developed on Forest-fed Streams.

The United States Geological Survey finds that more than 30 percent of the Nation's actual water power is produced in the Northeast where cities and factories are close to forest-fed streams.

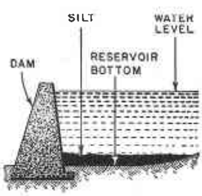
Seventy percent of all the industrial and public utility power in Maine is water-developed. California produces more horsepower from water than any other State, but much of her water power resources are unused. Boulder Dam is expected to produce $6,500,000 worth of power annually for the Southwest, in addition to supplying water for irrigation and domestic use.

**Use of Hydroelectricity Instead of Coal.**

In the Northwest water power is increasing in importance and the forests of that region help to regulate stream flow. The Northwest is far from available coal supplies, but it has a wealth of forest-fed streams capable of producing cheap power. With the further development of cities and industrial centers in that section, water may surpass all other sources of power.

*The South Atlantic drainage areas are potential power-plant sites.*

The South Atlantic drainages are typical of the water power possibilities to which forests can contribute much in the way of regulation. The maximum or flood flow of the more important streams in the South is from 150 to 400 times the minimum or dry season flow. During wet seasons water flows rapidly from deforested land, but in dry seasons the flow is not enough to supply the power demands. It has been necessary to construct dams and reservoirs to hold the water of rainy seasons for periods of light rain or no rain, and thus to maintain regular power production. Large amounts of silt carried into these basins from deforested land have increased greatly the cost of an otherwise cheap power source. Erosion control by forest cover will do much to obviate this difficulty.




*Silt from deforested hillsides filling reservoir.*

**Forests Act as Water Reservoirs.**

**The Greater the Forest Area, the Smaller the Reservoir Required.**

Forest cover assists in the underground storage of rain water, and streams regulated by adequate forest growth supply a more dependable flow of water than do streams from barren or sparsely covered land. Power plants might be constructed, with no reservoirs or but small reserves, on forest-fed streams in anticipation of consistent flow throughout the year. Such plants may be operated fully in dry seasons, entailing no loss of investment in idle machinery. Without regulation, the water flow in flood seasons is often too great to be fully utilized, and is entirely inadequate in periods of drought.

Although in many regions coal can now produce power more cheaply than water power can be transmitted from plant to consumer, coal is a resource that cannot be replenished. Power companies have improved their methods and machinery for greater efficiency, but the supply of coal cannot be renewed; as this supply decreases and the demand for power and utilities increases, forest-fed streams will become more important.

**Water Power for Use When All Coal Is Consumed.**

## *SOCIAL VALUES*

### THE FOREST AND EMPLOYMENT

Forests directly and indirectly furnish means of employment to millions of people. Men may work in the woods improving conditions for tree growth; they may work in the harvesting of forest products; they may work in the transporting of forest products and they may work in the manufacture of forest products. One of the most important values of forests is their ability to furnish jobs for workers. From the time that tree seeds are planted until a wood product, a rayon garment for example, is sold over the counter of a department store people are paid for duties performed in preparing it for human use.

**Jobs for Woods Workers.**

In Europe there are some sustained-yield forests employing one man to every 40 acres in producing and manufacturing timber; but in most of the managed forests the ratio is about a man to every 250 acres. In the United States where figures were available on sustained-yield projects, the ratio was one full-time worker to every 240 to 360 acres.

In 1929, about 1,300,000 full-time workers were employed in forests and wood manufacturing. Part-time employment would bring this well up to a million and a half workers. Properly managed and utilized forests in the United States could probably employ two million workers steadily. This is one of the forest's greatest economic and social values.

**1,500,000 Workers.**

Forests, of themselves, do not stabilize communities nor insure communal permanence; but forestry, that is, the wise use of forest land, may assist in supporting permanent, thriving communities.

Forests Help to Make Communities Permanent.

The country has many "ghost towns"—the result of rapid increase of forest and mill workers during boom times and the subsequent decrease when the mill ceased operations. In these instances a wood supply was discovered, a market developed, a town built up, schools and churches established almost overnight. When the wood supply became exhausted the livelihood of the community was taken away.

Sustained Yield Forestry Tends to Regulate Markets.

Forestry, through sustained yield of forest products, tends toward regulated markets and permanent industries and communities. A forest enterprise operated on a sustained-yield basis, which determines an annual cut not exceeding the annual growth, will last indefinitely. Communities built around such enterprises form lasting markets for agricultural and manufactured goods.

Grays Harbor.

Communal dependence upon forests is illustrated in Grays Harbor County in western Wash-

*Thriving mill communities develop in the shade of forested mountains.*

*Ghost towns are monuments to poor forest management.*

ington. This area of 1,196,000 acres, 956,000 of which are logged off, supplies 71 wood-using industries and 31 logging companies supporting a total of 10,150 workers. Other industries and services bring the total population of the county to 60,000 people, all more or less dependent upon the forest.

Bogalusa.

In Louisiana, Bogalusa supports a population of 14,000 with forest products industries—pulp, paper, naval stores, woodenware, and furniture.

Cloquet.

Cloquet, in Minnesota, was rebuilt following the great fire of 1918. The future of its 7,000 population and its numerous wood-using industries, which seems secure, depends upon the practice of forestry.

"A Tale of Two Cities."

Fortunately, these enterprises are planning systems of sustained annual yield. When thriving communities such as these are compared with the twin lumber towns of Au Sable-Oscoda in Michigan, which in 1890 had a population of 8,346 and in 1930 only 903, the value of forestry practices becomes strikingly evident.

The Exodus.

Part-time Employment.

An important phase of forest employment that has been provided in State and national forests is the part-time work for farmers, factory workers, and local woodsmen.

The Farmer-Woodsman of Europe.

In Europe this form of employment is highly developed. The Forestry Commission of Great Britain has a "small holdings project" under which the agricultural land in the Government forests is set aside for farm use. The land is leased in 10-acre lots, equipped with small farm buildings. Each tenant leasing one of these holdings is guar-

**Possibilities of the Farm and Forest.**

anteed 150 days work in the forest. This gives him a cash income and allows sufficient time for growing farm produce for his own consumption or for sale. In France, Germany, Austria, and Finland, many farmers are employed part time in the forests.

**Stabilization of Local Industries.**

A large number of small farms in this country, although they supply the family food needs, are not capable of producing incomes for their owners. In many forested regions it is possible to employ these men for a period of 5 or 6 months in the woods. This plan allows them ample time to raise small crops, and gives them from $300 to $400 per year additional. In this way considerable necessary forest work may be accomplished for which a full-time crew would be unwarranted, and small farms and local industries may become more stabilized.

This plan is being carried out on many State, national, and private forests. It is possible to extend these part-time enterprises wherever small agricultural holdings abut on large areas of forest land. In some sections of the country—Connecticut, for instance—it has been estimated that 500 men could be employed for 6 months each year on the State forest of 63,000 acres. That would average one man for 6 months on each 126 acres. Although this same figure may not hold true in all sections of the United States, it gives some indication of the part-time employment possibilities.

**Decentralization of Industry.**

Many students of industrial and social economics believe that manufacturing plants should be spread over the country instead of being grouped together in large industrial centers. One of the country's largest automobile companies has decentralized parts of its industry and has been quite successful in the enterprise. Fourteen of its small plants have been established in rural districts where agricultural products used in the manufacture of automobile parts may be grown, or where produce for home consumption or sale may profitably be raised. When the factories are closed, the men work on their farms. The plants, employing workers seasonally at a minimum wage of $6 per day, add approximately $600 to each farmer-employee's yearly income.

**An Example of the Possibilities.**

The same idea may be, and is being adapted to forest work. Industries with seasonal fluctuations of employment, particularly wood-using industries or those that can use the water power of forest-fed streams, may be situated in or near forest areas. A factory-forest community similar to the factory-farm community, or the farm-forest community, may be realized if other large companies see the advantages of securing all year employment for part-time employees. If seasonal periods of factory employment can be coordinated with seasonal fluctuations of forest work, a permanently employed community can be set up.

**The Factory-Forest Community.**

*In the great outdoors, big troubles become little ones.*

RECREATION

Recreation is anything done for the direct pleasure or enrichment which it brings to life, in contrast to things done primarily to obtain life's necessities.

**Refer to Ch. XIII.**

The health-giving properties of forest recreation have long been recognized by the medical profession. Health resorts and sanitaria are located in forested mountains where the effects of pure air, sunlight, and outdoor recreation combine in the battle against disease.

**Forests and Health.**

It is regrettable that everyone cannot spend a few days in the woods each year. Forests usually are not near big cities and population centers.

*Population centers.*

*Forest areas by States.*

**What are the Forms of Forest Recreation?**

Many of those that were so located have been used and destroyed. Existing recreational areas must be protected from fire, since fire often completely destroys forests and always renders them unfit for recreation. Forests should be protected from exploitation; the trees should be cropped, rather than mined, to maintain beautiful wooded areas best adapted for recreation.

**Picnicking.**

Picnicking is perhaps universal as outdoor entertainment, and in some regions is the most popular form of forest recreation. It requires no extra equipment for the picnicker and takes no time from work or business, using Sundays and holidays principally for this purpose. An important feature of the day-in-the-woods form of entertainment is the low-cost feature.

**Camping.**

After picnicking, camping is next in popularity. Getting outdoors and living in a primitive manner appeals to almost everyone. There is definite value in the soothing restfulness of living outdoors. Climbing mountains is better exercise than riding elevators. The boy and girl who learn to take care of themselves in camp become better fitted to live at home. Camping has far-reaching advantages to the individual and to society. The future of this great recreational activity depends largely upon the future of forests.

**Hunting and Fishing.**

**Reference, Ch. X, pp. 209, 220.**

Hunting and fishing often are part of the camper's program, but generally followers of the gun and rod take their sports seriously and go to the forests for no other purpose. However, a good huntsman or fisherman enjoys the whole outdoors, and does not limit his pleasure to the conquest of game. The demand for more game and fish is evidence of the value of forests in furnishing facilities for satisfaction of the desires of millions of sportsmen.

**Hiking.**

**Swimming.**

Other forms of forest recreation cannot be distinctly divided from camping and picnicking. Enumeration of these activities will, however, help to picture the true role of the forests in a recreational program for a people who are forgetting how to play. Hiking appeals to the nature lover and outdoors person. Swimming in cool forest streams is refreshing. Opportunities for nature study abound in the woods; plants and animals are available to the naturalist. Birds flee the dangers of populated areas and find sanctuary in the woods where bird lovers may study them.

Nature Study.


The values mentioned above are real, and tangible or physical. There is another value, often called spiritual, that may be secured by everyone. Something deep within us urges us to get out of doors where in the quiet of the woods big troubles become little ones; we orient ourselves with the general scheme of things, and are refreshed and rested.

*Big game seek the seclusion of large forest areas.*

## WILDLIFE

**Wildlife Depends Upon Forests.**

Wild animals, birds, and fish are included in a general term: wildlife. This wild population of wood and field has definite value. Lack of figures for forests alone limits a discussion of wildlife in the forest, but practically all wildlife depends wholly or in part on forests for food, cover, or both.

See Wildlife, Ch. X.

**Economic Value of Wildlife.**

The Biological Survey has set a value upon all wildlife. This is of course approximate, but an estimate of the value of meat, fur, destruction of insects, hunters' fees, and money spent by hunters and tourists in game country, indicates that the total value is well above a billion dollars. At one time, wild animals played a very important part in the economic life of the Nation. They fur-

See p. 202.

nished both food and clothing for the pioneer. Vast fortunes have been built upon fur trade, and today trapping forest animals for fur is a paying occupation.

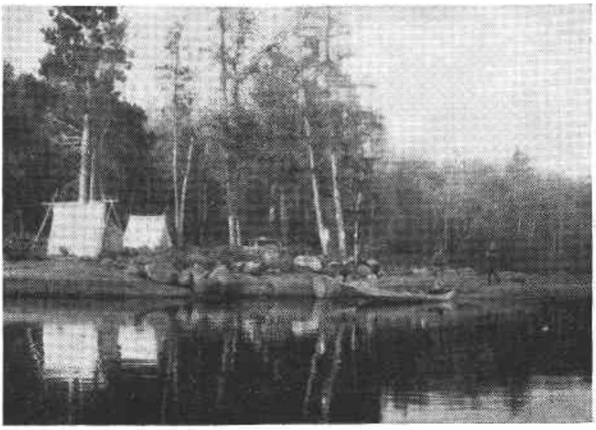
Social Value of Wild Animals.

The greatest value of wildlife is not economic. The social benefits derived indirectly through stimulating outdoor recreation are probably greatest. Esthetic and scientific values are also worthy of consideration.

## *SUMMARY*

Forest Products.

Forest values have two main divisions, namely. forest products and forest influences. The principal product of the forest is wood, and many valuable commodities are obtained from wood. The product having the most value is lumber. The annual use is about 35 billion board feet. This is used in construction and manufacturing. Other than sawed timber, fuel and pulpwood are important as values. Chemicals, dyes, and medicinal products are also obtained from wood and forest plants.



*Forests provide untold values in recreational facilities.*

Forest Influences.

Forest influences are physical and social. Physical influences are those affecting temperature, humidity, rainfall, stream flow, and erosion. Social influences are those affecting employment and healthful living. Forests and forest products manufacture provide employment for many workers. Forest recreation makes living conditions more healthful and more enjoyable.

## Chapter III

# FOREST CONSERVATION

### *FORESTS OF THE PAST*

*Virgin forests 1620.*

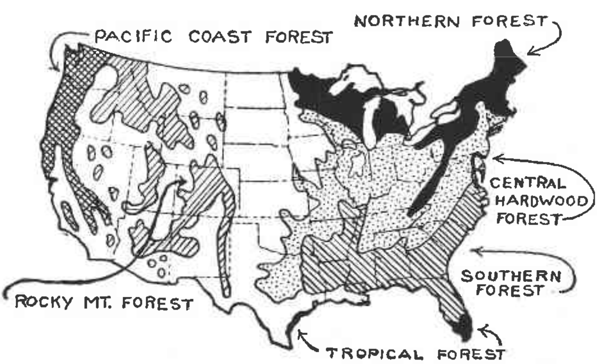
*Virgin forests today.*

EARLY explorers on this continent were confronted with a vast expanse of forested land—a seemingly unbroken wilderness. Later, colonists and inland explorers found that slightly less than half the total area now occupied by the United States, or almost 900 million acres, was covered with some sort of forest growth.

*Natural regions:* From the Atlantic seaboard to the prairies across the Mississippi was a continuous, almost uninterrupted, region of trees. Prairies and grasslands extended to the Rockies where forests again began to appear. The Pacific coast presented a belt of forested land—quite extensive in the North and tapering southward in two points to disappear in the southwestern scrub oak and chaparral. Climatic conditions separated the forests into huge natural regions. In the East were four regions—the northern forest, the central hardwood forest, the southern forest, and the subtropical forest. Two groups comprised the West—the Rocky Mountain forest, and the Pacific coast forest.

*The northern forests were principally coniferous.*

About 150 million acres of spruce, balsam fir, white pine, hemlock, arborvitae, and hardwoods




*The national forest regions.*

*Hardwoods characterized the central forests.*

made up the northern forest; further south and at lower elevations, beech, birch, maple, and other hardwoods appeared. In the central hardwood forest were 281 million acres of broad-leaf trees, principally oaks but including many other species. White pine, pitch pine, and hemlock mixed with the hardwoods in the North and shortleaf pine grew in the South. The southern forest of 250 million acres was largely pines—longleaf, slash, shortleaf, and loblolly—with cypress and white cedar in the swamps and hardwoods on the better lands. On the southern tip of Florida a tropical growth was prevalent consisting of mangrove and other tropical species.

**North American Tropics.**

**Rocky Mountain Forests.**

In the West, the Rocky Mountain forest, 65 million acres in extent, was composed largely of softwoods or conifers—pine, hemlock, cedar, fir, and spruce—in the North, with piñon and junipers in the South. The Pacific coast forest of 80 million acres contained the giant Douglas fir, redwood, bigtree, yellow pine, cedar, and some hardwoods. In southern California scrub oak and chaparral predominated except at high elevations where pines, principally Coulter and yellow, were found.

**Pacific Coast Forests.**

**"Dwarf Forests."**

**See p. 1.**

*Early forest use:* Of this total forest land area, approximately 820 million acres held good timber; about 80 million acres in the Southwest was covered with a scrubby growth of chaparral and stunted trees (now, because of the water demands of an increased population, important as watershed protection). The trees had been undisturbed by the woodsman's ax. Large, mature, and overmature trees awaited a natural death to return them to the soil from which they sprang. Settlers looked upon the trees as both friends and enemies. Here was wood with which to build homes, ships, furniture, and workshops. Those same trees provided cover under which hostile natives might advance upon the puny settlements; trees grew thickly on land that could be lush meadows for cattle.

*On guard against hostile natives.*

With these thoughts in mind the colonists proceeded to cut wood for buildings and stockades, and to clear large areas for farming. Although

*Colonists cleared land for settlements.*

the cutting and clearing practices of the colonists might be considered wasteful in the light of present-day standards, they were necessary operations at that time. Few people realized that the vast wealth of timber would some day be exhausted.

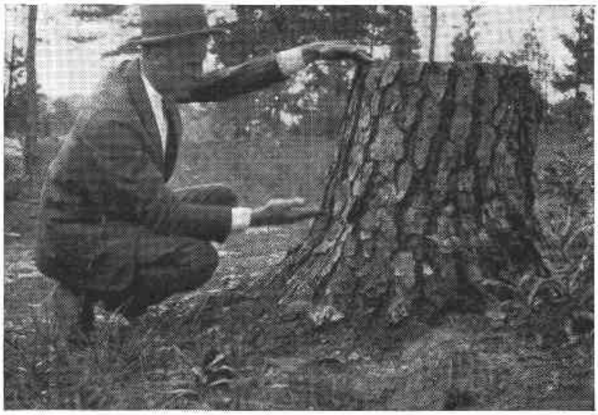
**American Lumber Centers.**

*The lumber industry:* As the population of the New World increased, more land was cleared for agriculture, and a thriving lumber business developed. Maine made an early bid for lumbering supremacy; in 1631 the first commercial sawmill made its appearance in that colony. Shipbuilding and home construction in the early nineteenth century established a demand for white pine lumber; a growing export trade put American wood on all the world's markets. From Maine the center of the industry moved to New York (1850), then to Pennsylvania (1860).

**Maine.**

**New York.**

**Pennsylvania.**



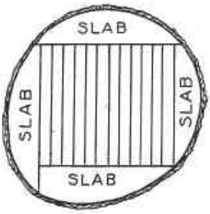
*High stumps waste much valuable timber.*

**Lake States.**

**Northwest and South.**

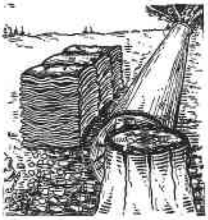
The next movement was westward to the Lake States (1870). Thus practically all the accessible virgin white pine was cut. Lumbermen then turned to the southern yellow pine which has also been largely cut out. Today the bulk of the virgin timber is in Washington, Oregon, northern California, Idaho, and Montana. Small portable mills continue in the other regions, but the large operations are confined to the Northwest and to isolated regions of the South.

Early lumbering methods were wasteful. Much good wood was left in high stumps, small logs were not utilized, and large tops remained un-




*Early milling methods wasted much wood in large slabs.*

salvaged. In the mill, unnecessarily large slabs were trimmed from the logs, and thick saws reduced up to 20 percent of the wood to sawdust. In the East, hemlock was cut only for its bark, which yielded tanning substances. The wood, not as profitable as white pine, was left to decay in the woods. The remnants of these giant hemlocks may still be found in many eastern forests.



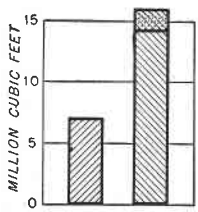
*Giant hemlock cut for bark alone.*

Lumber prices rose as the supply of big timber vanished. Trees formerly left standing as worthless were eagerly sought by the operators of small mills. Stumps were cut lower, tops were bucked up into merchantable logs, and milling practices became more efficient. In spite of these efforts to eliminate waste, it has been estimated that from 20 to 60 percent of the total wood volume, depending on the size and form of the tree, is still lost in cutting and milling.

*Improved milling methods reduce the amount of slabs and edgings.*

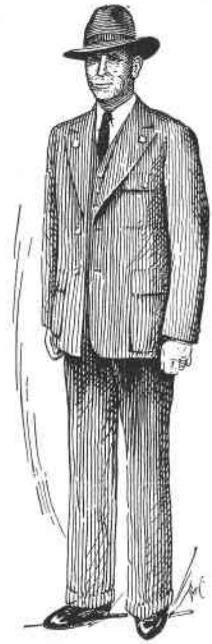
Of the original 900 million acres of forest land, about 500 million acres are capable today of producing timber in commercial quantities. Most of this land is in second-growth timber from which high yields cannot be expected for some years to come.

Approximately 60 billion board feet of saw timber annually are removed by lumbering, fire, and other agencies, from American forests. The drain on saw timber and cordwood for the period 1925–29 was nearly twice the growth. Improved




*Timber growth responds to good management on the national forests.*

forestry practices, reforestation of idle lands, better lumbering and milling methods, and closer utilization will tend to balance, in the future, the ratio of growth to drain.



*A forest officer.*

Although an abundance of timber covered about half of the country in early colonial times, a small group of far-seeing men realized that uncontrolled stripping of the forests if continued would, at some future time, result in a dearth of wood supplies. After settlements were well established, colonial leaders attempted to prevent wholesale forest destruction. Plymouth Colony and Pennsylvania were among the first to establish regulatory rules. The Federal Government, as early as 1799, established forest reserves to supply ship timbers for the Navy.

## *AGENCIES WORKING FOR CONSERVATION*

### THE UNITED STATES FOREST SERVICE

*History:* The largest organization for forest conservation and development in the United States is the Forest Service of the Department of Agriculture. The Forest Service is a direct outgrowth of an act, passed by Congress on August 16, 1876, authorizing an inquiry into the forest situation of the United States and the formulation of a forest policy. Dr. Franklin B. Hough was appointed Commissioner of Forestry to prepare this report. In 1877 an appropriation of $6,000 was made to secure further information and to make plans for a Division of Forestry. This Division, in the Department of Agriculture, was set up in 1881. That same year the Department sent a man to investigate European forestry meth ods which might be applied to American conditions.

**Forest Inquiry, 1876.**

**Forestry Commission, 1877.**

**Division of Forestry, 1881.**

The Division of Forestry slowly expanded as a clearing house for forest statistics and information, but no practical administrative work was done until Congress, in 1891, empowered the President to set aside forest reserves from the public domain. President Harrison immediately established the Yellowstone Park reserve. Under Presidents Harrison and Cleveland about 40 mil-

**Division Reserves Authorized, 1891.**

**Work of Presidents Harrison and Cleveland.**

lion acres of reserves were created in the West. These reserves were held by the Department of the Interior and were administered by the General Land Office—the Division of Forestry merely being a technical advisory board. In 1898 the Division of Forestry interested some few private forest owners in forestry, and offered advice and plans to those willing to undertake forestry practices. The Division was given a nominal promotion, in 1901, when it became the Bureau of Forestry.

**Private Forest Owners Aided, 1898**

**Bureau of Forestry, 1901.**

President Theodore Roosevelt, in 1905, had the forest reserves transferred to the Department of Agriculture; the Bureau of Forestry was renamed the Forest Service, and in 1907 the reserves became "national forests." Between 1901 and 1909 President Roosevelt, cooperating with Gifford Pinchot, the forester, added more than 148 million acres to the national forests. Smaller additions have been made since that time, and much land valued for resources other than timber has been removed from the national forests to be supervised by other agencies. The present area is more than 162 million acres.

**Reserves Transferred from Department of Interior to Department of Agriculture, 1905.**

**Forest Service and National Forests, 1907.**

**Work of Theodore Roosevelt and Gifford Pinchot, 1901–09.**

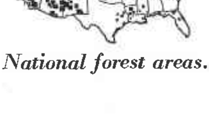
**162,000,000 Acres.**

In March 1911, Congress enacted what is popularly known as the Weeks law to protect navigable streams through the maintenance of forest cover on their watersheds. It provided for the cooperation of the Federal and State Governments in fire protection and enabled the Federal Government to purchase and acquire watershed lands.

**Federal and State Cooperation under Weeks Law, 1911.**

The purchase and acquisition of lands under the Weeks law was limited to the upper headwaters of navigable streams which the United States Geological Survey considered in need of forest cover and protection. Many important forest areas, particularly in the Lake States and in the South, could not be purchased or acquired under this act. In July 1924, therefore, the provisions were extended under the Clarke-McNary Act to include the entire country in a forest program of fire prevention, taxation study, State and Federal cooperation, assistance to private owners, and land acquisition and purchase.

**Weeks Law Extended by Clarke-McNary Act, 1924.**



*National forest areas.*

**10 Forest Regions.**

*Administration:* The national forest lands are administered by the Forest Service with headquarters in Washington, D. C. Ten regions with a regional forester in each (see map) have been set up to include all the States, Alaska, and Puerto Rico. These regions are divided into national forests, of which there are 145, averaging more than a million acres each. A forest supervisor is in charge of each of the national forests which are composed of two or more ranger districts administered by district rangers. Assistants are provided for these men as necessary to carry on the work of the forest. Numerous fire guards, lookout men, and other temporary workers are given seasonal employment each year.

**145 National Forests.**

*National forest regions.*

**Many Workers.**

**Forestry Means Use.**

The policy of the Forest Service is one of forest use. Timber crops are raised to be harvested. Cattle, sheep, and horses range on the land best suited for grazing; recreational facilities are provided where there is a demand for them; and roads and trails are built to facilitate fire fighting and travel through the forest. Broad policies are established in the Washington and regional offices, but the practical forest administrative work is carried out in the forests and ranger districts.

**Central Office Links Field Activities.**

**The Ranger's Responsibility.**

Each forest subdivision has problems peculiar to itself, and the ranger is better acquainted with these problems than are the higher executives hundreds or even thousands of miles away. Hence, the man in the field has considerable freedom in taking action that will better his forest and insure permanence and stability. In an organization where so much responsibility is vested in one man or small group of men, it is essential that only the most efficient foresters be employed—men whose interest in the public welfare transcends any private or personal aims. All permanent employees of the service are, therefore, under civil-service classification, and their work is subjected to frequent critical inspection.

**Efficiency Demanded.**

**The Ranger's Job.**

The ranger's job is to administer the forestry work of his district. If he is stationed in a grazing country, he supervises the entry and movement of all livestock—making sure that the range

A Thousand Jobs.

is not overgrazed and at the same time allowing sufficient entries to utilize all its forage possibilities. In a timbered area, he regulates timber sales, marking trees to be cut, and leaving enough young growth and seed trees to regenerate the stand. He enforces brush disposal measures to guard against fire, supervises seed collection, nursery work, and planting operations. He secures cooperation of local residents for forest protection and fire suppression; builds roads, trails, and telephone lines, and manages innumerable other projects that increase the value and utility of his district.


*A park ranger.*

Through this organization the forests of the United States are being regulated to help supply the country's enormous wood demands, to grow timber for future wood needs, and to provide a maximum of forest influences and values. State and private forest administrators are assisted by the Forest Service in planning, fire prevention, and reforestation.

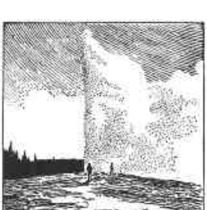
THE NATIONAL PARK SERVICE

Saving Superlative Sites.

The National Park Service was first authorized by President Wilson in August 1916, and the following year funds were appropriated for its establishment. For many years prior to that time, however, several national parks had been in existence—Yellowstone Park being established in 1872.


*Big trees.*

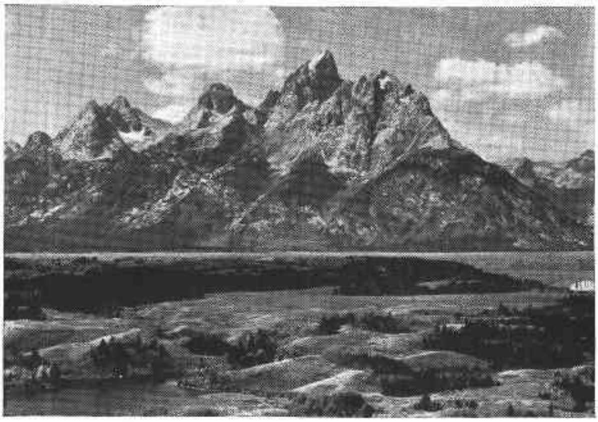
Although the national parks are areas preserved for scenic value, historical significance, and natural phenomena, there are many acres of forest land included within their boundaries. Unlike the national forests, the parks do not permit the commercial utilization of timber or forage. Timber is cut only when necessary to suppress insect or disease infestations that might spread over great areas. The forested areas in the national parks are set aside as natural museums of original conditions, somewhat similar to the primitive areas of the national forests. The big trees in Sequoia and General Grant National Parks will never be cut down, but will remain as remnants of the original, giant forests of the West. The forests of Yellow-


*A Yellowstone geyser.*

stone will serve to enhance the unique scenery of the geyser area.

Fundamental Nature Education.

The term "park" leads many people to think of the national parks primarily as recreational areas. One of the chief purposes of these holdings, according to Dr. John C. Merriam of the Carnegie Institution of Washington, is "that fundamental education which concerns real appreciation of nature."



*The national parks preserve areas of great scenic value.*

Forests for Education, Recreation, Influences.

In the parks are more than 4½ million acres of forest which add scenic touches to other natural phenomena, and which, although not serving to augment the timber supply, afford watershed protection and other forest influences. A trained, efficient personnel has been set up consisting of foresters, naturalists, botanists, geologists, and administrative executives. Their activities include research, education, protection, and park administration.

*National park areas.*

## THE SOIL CONSERVATION SERVICE

In recent years the problem of soil conservation has assumed major proportions, and much valuable work has been accomplished to save agricultural and forest lands from the forces of soil erosion and to prevent stream silting. Soil erosion occurs on sloping or hilly land where rapid run-off of rain and snow water gouges gullies or pares off sheets of topsoil. Where winds have access to loose, unprotected soil, a process known as wind erosion—resulting in dust storms—takes place.

*Check dams retard erosion.*

*Erosion has started.*

*Check dams retard water movement.*

*Trees hold soil in place.*

To acquaint landowners with methods of combating soil erosion, and to preserve valuable public and private lands, the Soil Conservation Service has been established in the Department of Agriculture. A Forestry Division has been created in the Service to apply forest knowledge to the varying erosion problems.

Much land that is now devoted to agriculture is too steep for that purpose. It will support crops for but a few years (5 to 10 is the average) before it erodes so badly that farming becomes impossible. Farmers are being taught to plant trees on such sites, and to concentrate their cultivating activities on more level land or on land that may be protected by simple terracing. Where large gullies have been eroded, terraces, small dams, and other obstructions are thrown up to retard the rapidly running water. Trees are planted in the gullies and on their banks to hold the soil in place.

See pp. 104, 205.

In places where wind erosion takes place, protective shelterbelts or windbreaks of trees are planted. These screens of trees on the windward side of a field reduce the wind velocity and thus tend to keep the fine topsoil on the fields. Besides decreasing soil erosion, windbreaks form favorable habitat for insectivorous and song birds that aid the farmer in controlling pests.

**The Forester's Job.**

Foresters with the Soil Conservation Service make surveys for planting and timber harvest, supervise planting, conduct forest research, and educate landowners to better forestry practice that will prevent erosion. Most of the actual fieldwork is being carried on by CCC camps, Transient bureaus, and relief organizations in cooperation with landowners.

## INDIAN FORESTS

**Government Indian Policy.**

*Indian reservations.*

In the Department of the Interior, a Bureau of Indian Affairs was established in 1824 to supervise the care and education of the Government's wards, the American Indians. Today there are some 360,000 Indians in the United States, many of whom have been assimilated in the business, industrial, and professional activities of the white man. Most of them, however, are situated on the 200 reservations that have been set aside for them in 26 States.

Forest Conservation on Indian Reservations.

Much of the reservation land is worthless for agriculture, but of this nonagricultural land, about 7½ million acres of commercial forest lands have been included in the Indian territories. Of this area, about 5 million acres is under sustained-yield forest management. Timber on these areas is cut according to forestry principles, and the land is maintained in a productive condition. Range management plans are in effect on the grazing areas, watershed protection is being improved through reforestation and erosion control, and fire prevention and suppression are being perfected.

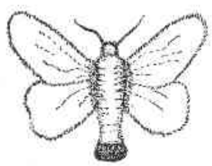
## TREE PEST CONTROL

See pp. 87, 94.

The control of tree pests (insects and diseases) is an important phase of forest conservation. Although foresters may never eradicate completely all diseases and insects that attack trees, their attacks can be controlled so that epidemics or widespread infestations will not occur.

Keeping Trees Healthy.

Pest-control work of some sort is carried on by all forestry organizations. A large contributing factor in this line of forest protection and timber stand improvement is the work of the Bureau of Plant Industry and the Bureau of Entomology and Plant Quarantine in the Department of Agriculture. These two organizations, cooperating with the various forestry services, carry on research, conduct field operations, and establish plant quarantines to stem the movement and development of pest attacks. Some of the major problems to which they have applied their facilities and experts are white-pine blister rust, brown-tail moth, gipsy moth, and satin moth.



*Brown-tail moth.*

## STATE FORESTRY

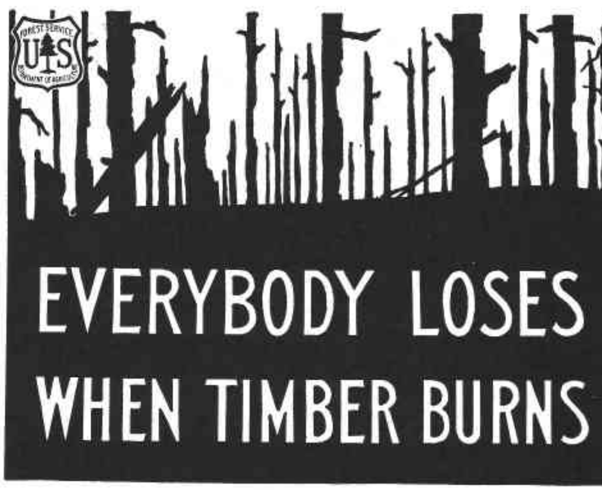
From a Small Beginning to a National Policy.

State forestry had its beginning in 1885 when California, New York, Ohio, and Colorado established commissions or boards to regulate and conserve forest resources. All States now have some provision for forestry.

**How States Can Promote Forestry.**

There are a number of ways in which States can accomplish much toward the furtherance of sound forestry principles. The bulk of the commercial forest land in the United States, about 80 percent, is in private ownership. State forestry organizations are in a position to help maintain the productivity of these areas by: (1) Portraying the advantages of forestry methods through demonstration forests; (2) offering adequate fire protection; (3) giving advice and technical aid; (4) distributing trees for reforestation; (5) establishing forests on tax-delinquent, cut-over land; (6) passing and enforcing laws relating to sane cutting practices; (7) creating forest taxation policies that recognize timber as a long-term crop; (8) carrying on research projects in forestry and forest products; and (9) educating the public to an appreciation of forest values.

*Improvements on private forests made through State cooperation—trails, telephone lines, towers.*




*A popular poster.*

The area of State forests is comparatively small—4½ million acres—of which about 75 percent is in Pennsylvania, Minnesota, and Michigan. About 1 million acres is under timber management plans.

**Fire Protection and Education—State Functions.**

Fire protection is by far the greatest contribution that the States now offer, although all but three States give aid and advice to private forest owners, and many aid by distributing trees for reforestation. Very little has been accomplished by the States in the form of forest research, except at forest schools. Of the 25 collegiate forest schools in the country, all but three are operated by the States.

**State Forest Parks.**


Forest parks, of which there are more than 2,700,000 acres, afford recreational opportunities and in this way stimulate forest appreciation and interest. In 1931, there were 50,000,000 recreational visitors in the State forests and parks. New York, with large park reserves in the Catskills and Adirondacks, maintains four-fifths of the State park area.

In addition to the classified forests and parks, there are more than 6 million acres of forest land owned by the States, but which have no specific designation. Most of these areas, however, receive protection from fire, and are under some timber-cutting regulations. Within the States are smaller political units—counties, municipalities, and towns—that own approximately 1 million acres.

**State Holdings Increasing.**

Although the State holdings, as a whole, are relatively small at present, there is a likelihood that State forests and parks will increase in area. Much abandoned, tax-delinquent land is reverting to State ownership. Many States are purchasing additional areas; and recreation, particularly forest recreation, is growing in importance. State governments are better situated to stimulate and enforce sound forest practices than is the Federal Government or any other agency.

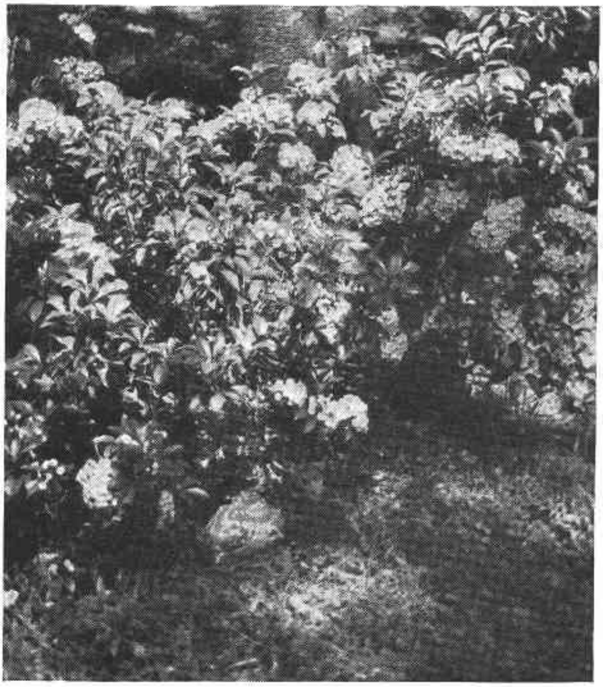
### FORESTRY ORGANIZATIONS

Governmental departments and legislation are inadequate, in themselves, to cope with the problems of forest preservation and the maintenance and use of forest values and influences. Regulations that do not have public backing are of little effect. The forestry movement in the United States has not been lacking in ardent supporters. Each year thousands of public-spirited citizens are added to the rolls of forestry and conservation groups.


*Private organizations educate the public in conservation.*

#### NATIONAL ORGANIZATIONS

Chief among the Nation-wide groups to stimulate public interest in forestry are The American



*Spotted fawn protected by a floral coverlet (cover plate: American Forests, October 1934).*

Forestry Association, The Society of American Foresters, The American Tree Association, and the Association of State Foresters.

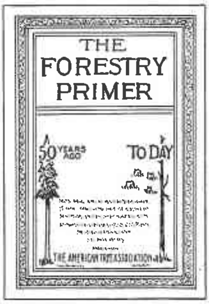
American Forestry Association.


Society of American Foresters.


The oldest forestry organization of national scope is The American Forestry Association, founded in 1875. From a small beginning, it has grown to be a major influence in popularizing the advantages of forest regulation and protection. Its magazine, *American Forests*, presents forestry and conservation articles in popular form and is widely read throughout the United States.

Foresters in North America have grouped themselves together in the Society of American Foresters. Founded in 1900, the society has grown to include more than 3,700 members. The *Journal of Forestry*, its official organ, is the only technical forestry magazine in the country. It is world-wide in scope, and through its pages about three thousand foresters are advised of forestry progress, research, and policy trends. In the United States, the society has played a large part in influencing forest legislation, administrative policies, and public sentiment.

**American Tree Association.**




"To further forest protection and extension and to increase appreciation of forests as natural resources essential to the sound economic future of the country," the American Tree Association was founded in 1922. The association has done much to popularize forestry among the general public and has instituted the teaching of forest appreciation to school children. It publishes *The Forestry News Digest*, a review of timely and significant forestry information. More than 4 million copies of the association's *Forestry Primer* have brought pertinent forestry facts to the public eye. Numerous other publications have been distributed to schools. Since 1924, four editions of the *Forestry Almanac*, a book containing articles on the history and accomplishments of all American organizations working for forest conservation and use, have been issued. The association cooperates with schools, colleges, service clubs, and patriotic groups in the spread of forest knowledge.

**Educating the Public.**

**Association of State Foresters.**

Since 1920 an important force in interstate forestry cooperation has been the Association of State Foresters. This organization formulates broad policies for State forest management, and discusses legislative changes for better forest regulation.

## OTHER ORGANIZATIONS

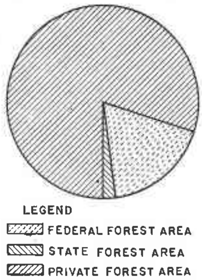
**The Movement Grows.**

Groups of foresters and others interested in forestry have been formed in certain sections of the United States to further forestry practices in their respective regions. Their problems are regional in scope and are more closely defined than those of the national organizations.

**No Matter What You Call It.**

Within the States are 47 State, county, municipal, or sectional groups alined in the interest of forestry. With varying names—committees, chambers, associations, clubs, councils, societies, institutes, and conferences—these organizations operate for the same general aims: Fire prevention and suppression, reforestation, forest education, wise use of forest products, legislation, and forest regulations. Such groups stimulate forestry and conservation.

U.S. FOREST AREAS




## FORESTRY ON PRIVATE LANDS

Inasmuch as nearly 400 million acres of commercial forest land, or about 80 percent of the total, is privately owned, it is readily apparent that if forests of the United States are to remain productive it is up to private owners to practice forestry.

### LARGE HOLDINGS

**Trees Not Like Mushrooms.**

Private forestry, particularly on the 270 million acres of industrial holdings, has many drawbacks. Wood crops, unlike mushrooms, do not spring up over night, nor do they mature in one season as do corn or potatoes. The man who plants trees must look ahead 30 to 50 years for even a short rotation crop of saw timber. In that time he pays taxes on the trees and land, protects his forest from fire, diseases, and insects; conducts cultural operations (which may not pay a profit); and when the crop is finally ready for harvest, a market must be found or developed.

**Narrow Margin of Profit.**

It is not hard to appreciate the lumberman's viewpoint when he adopts the policy of "cut out and get out." A great demand for timber has spurred operators on to immediate profits. They cut *all* the timber, then the cut-over land is allowed to revert to the State for nonpayment of taxes, and the lumbermen move on to more profitable areas. This practice has been followed in the cutting of virgin stands of mature timber.

*The early day lumberman cut everything and made a huge profit.*

The depletion of practically all large tracts of virgin timber has caused lumbermen in recent

*Much timber may be wasted in discarded tops.*

years to look for merchantable second growth. This can be found only where forests have sprung up after cutting or where early efforts were made to leave the younger trees for a second crop. The lumberman is beginning to realize, as areas of big timber become scarce, that careful logging methods and fire prevention are necessary if woods operations are to be sustained. Many owners and operators are instituting practices whereby trees are cut to certain diameter limits, or sufficient young trees are permitted to remain and grow for future crops. Some owners have divided their forests into cutting circles or blocks, which are cut periodically and on which provision is made for successive harvests.

**The Lumberman Wakes Up.**

*The modern lumberman leaves trees for future crops.*

**Pulpwood—A Good Private Venture.**

Pulpwood forests are especially adaptable to private forestry practices, because of the comparatively short period required to grow wood to pulpwood size. With the ever changing uses of wood, there is an increasing demand for products that can be derived from trees much smaller than those of early lumber days. Many new uses have been developed for cellulose; and cellulose (the basic material of woody plants) may be extracted from small trees.

**Growing Successive Tree Crops.**

Sustained-yield forestry insures perpetual crops from the forest. Now that all giant timber has been cut, except in isolated stands, owners have turned to forestry whereby large lumber businesses comparable to other large industries may be developed. Timber culture supplies the basis for enterprises that will last for generations—not a "cut out and get out" system—as there are few stands to which the lumberman may now turn. The enlightened owner practices forestry, cuts a crop each year, and leaves enough young trees growing that he may return for successive crops.

**Taxes Grow Faster Than Trees.**


*The tax problem:* One of the chief drawbacks to forest practice on private land has been the tax problem. Tax assessors, in the past, have not regarded timber as a crop, but have placed a taxable value on the land each year. Over a relatively short period of time, the taxes paid on a forest tract exceed the income from the final crops. Many States have reduced this difficulty through sane forest taxation whereby a nominal sum is charged each year, and a heavier tax is placed on the final yield.

The Private Owner Helps the State.

*Public and private cooperation:* Privately owned forests, with few exceptions, are regarded by the public as free hiking, hunting, and picnicking grounds. Although forest owners, as a rule, have no objection to such use of their land, they realize that every person entering the forest is a potential fire setter (either carelessly or maliciously). Some few owners have organized fire-fighting forces to reduce this danger; but this expense coupled with taxes creates a cost burden greater than the average forest can bear. States could extend their fire-control systems to include such areas of private land, the same as city fire departments serve the homes of their citizens. A State forest fire organization that protects State-owned land only is like a city fire department that confines its protection to the city hall and post office. The destruction of 10,000 acres of privately owned forest land means just as much to the State as the burning of an equal area of State forest. Although the profit realized at a timber sale goes to the owner, climatic influences, recreational opportunities, and abundance of timber benefit the general public much more than they do the owner. The State should share the tax and fire protection burden on lands of common benefit.

The State Should Help the Private Owner.

Cooperation Needed.

Forestry on private forest land is something to be accomplished through State and private cooperation. The landowner must be encouraged to practice forestry, but such encouragement should be in the form of reduced taxes and adequate protection, as well as in technical advice. The public has a choice between aiding the timberland owner in forestry practices, or receiving a vast amount of cut-over, burned-over, tax-delinquent land in the future.

## FARM WOODLANDS

Small Scale Forestry.

More than 185 million acres of forest land is in farm woods. These areas are particularly adaptable to forestry practice on a small scale.

The farm woodland is capable of yielding fuel, fence posts, poles, and saw timber for repairs and farm construction. In addition, many farms sell wood as a cash crop.

Farm woods comprise about one-third of the Nation's commercial forest land. Most of them (95 percent) are in the East where they occur as small holdings separated by cultivated fields or meadows. Protection from fire and insect attack, therefore, is a simpler matter in farm woods than in larger industrial holdings. Constituting part of the farm area, they are relatively easy to manage, as no additional expense is incurred because of them, and they may be worked in seasons when farming is at a standstill.

*Shaded area represents total forest area of the United States; black area represents total farm woodland in the United States.*

**Aid for Farmer Foresters.**

In many States farmers received trees free or at low cost for reforestation. Advice as to proper trees for different sites, the best planting methods, and other forestry practices is freely given. Colleges and universities aid the farmer through agricultural extension in forestry. Studies are made to find uses for woodland products, and in some States cutting and saw mill practices are taught to farmers' clubs and associations.

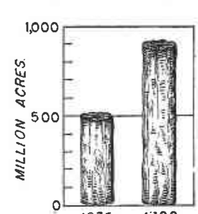
It is believed that the average farm wood lot is in better growing condition than most other privately owned forest land. The farmer can practice selection cutting and thus keep his woodland producing indefinitely.

**The Woodlot's Contribution.**

Although the woods on one farm rarely is capable of satisfying great demands, the total farm woodland acreage supplements many local markets and fills the domestic needs of the farmers. In the South, farm woods are important to the naval stores industry; and most of the country's maple sugar is secured from wood lots in the Northeast.

### *SUMMARY*

Despite early 1900 prophesies of a timber famine we still have about 495 million acres of commercial forest land in the United States; more than 10 million acres of forests removed from commercial use and dedicated to use as parks, monuments, reservations, and preserves; about 108 million




*Forest acreage.*

**Plenty of Forest Land Left.**

acres of noncommercial forest land; and from 54 to 55 million acres of abandoned farm lands. This totals nearly 670 million acres on which forest products might be grown for American use. The 10 million acres in parks and similar areas probably will not be used for timber production, but will remain as recreational areas and outdoor museums.

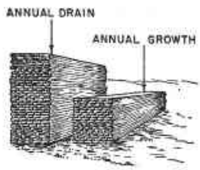
**Location of Timber Limits Use.**

*Commercial timber by States.*

The same natural regions of forest growth that were on the continent when the settlers landed still exist, but the characters of the stands have changed. Old growth or virgin timber now occupies only 20 percent of the forest area, and 75 percent of this is in the Pacific coast and Rocky Mountain regions. Only 15 percent remains in the Southeast, and 13 percent in the entire Middle Atlantic, Lake States, Central, and New England regions.

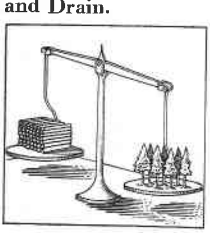
**Need for Management.**

The best forest land is now in private ownership. If these areas are to supply American timber needs they will have to be put under forest management. Public forests are largely second-growth land which was acquired after the best timber had been taken out by private operators. Second-growth forests, upon which we must depend for future wood supplies, are increasing in area and number. Abandoned farm land of the submarginal class is being added to the potential forest resources.




Based on present timber requirements it has been estimated that the forest land if put to intensive use will adequately supply the United States' wood requirements. Seven billion cubic feet of saw timber and cordwood is the estimated annual growth, but the drain is about 16 billion cubic feet. The annual drain includes about 1.8 billion cubic feet that is destroyed by fire, insects, diseases, and other causes.

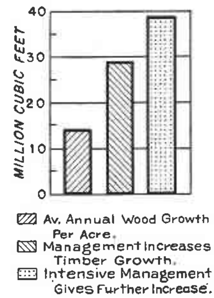
**Balancing Growth and Drain.**



There are a number of factors, however, which will tend to balance growth with drain in the future. The annual drain may be decreased not by decreasing consumption, but by more efficient fire protection and more complete insect and disease control. Wood in use may be preserved from decay and fire by preventive treatments,

See p. 162.

and ways have been devised to secure more complete utilization of timber both in the woods and in the shop. Although substitutes have replaced wood in some uses, it is not thought that the importance and demand for wood will suffer appreciably. The total effects of all these measures will decrease the annual drain.




Annual growth of forests is increasing because of the extension of forestry practices, and the reforesting of idle lands. Samuel T. Dana states that if our wood demands do not become greater they may be met by growing 29 cubic feet per acre each year on 496 million acres of forest land which now produces only 14 cubic feet per acre. It has been estimated that with crude forestry practices 39 cubic feet per acre may be expected. Intensive forestry will raise 61 cubic feet per acre per year. It is not uncommon to find second growth woodlands under management that produce a cord per acre each year. (Average 80–90 cubic feet.)

**Putting Idle Land to Work.**

To secure this growth-drain balance in the near future, much forest land now idle or growing in poor condition must be put under management. State and Federal organizations are practicing forestry as far as present appropriations will permit. When the effects of the Civilian Conservation Corps are felt, the picture may be somewhat different than at present. Some foresters believe that the CCC has advanced forestry 20 years. Coupled with this work on public land is the contribution of industrial forest owners and farmers on private land.

**Work of CCC.**

**Work Must Continue.**

Although the outlook for America's forests and products appears more encouraging than it did 30 years ago, we should not permit our interest and energy to lag. Much is yet to be done—practically and experimentally. Work that has been started must be maintained at a high degree of efficiency and with increasing intensity.

# Chapter IV

# FOREST PROTECTION

Like all living things, the forest is constantly attacked by many enemies. Probably the greatest enemy of the forest has been man.

### *MAN THE FOREST ENEMY*

**Man Causes Fire.**

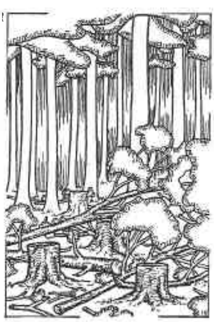
Forest fires from natural causes are uncommon except in a few regions of the country. Man-made or man-caused fires are common in most sections. During the period 1926–30 an average of 156,000 fires occurred and more than 41½ million acres burned over each year in the United States. The greatest number of fires occurred and the largest acreage was burned in the South. The least destruction by fire occurred in the southern Rocky Mountain region.

*Shaded area represents combined forest areas of the United States; black area represents total forest areas burned over annually.*

*Average Annual Burn (1926–30) on National Forest, State, and Private Forest Lands*

| Region | Number of fires | Acreage burned over |
|---|---|---|
| South | 117, 778 | 37, 571, 504 |
| Central | 12, 527 | 1, 397, 076 |
| Pacific coast | 6, 898 | 1, 283, 598 |
| Lake States | 4, 941 | 563, 536 |
| Middle Atlantic | 6, 557 | 338, 304 |
| North Rocky Mountain | 2, 548 | 283, 882 |
| New England | 3, 645 | 95, 884 |
| South Rocky Mountain | 1, 289 | 23, 111 |
| Total | 156, 183 | 41, 538, 895 |

Wasteful lumbering methods and excessive cutting have reduced the forest area. Man, instead of cutting only the mature trees, has cut all that might yield a merchantable log, and has left a field of inflammable brush and slash in which fires might gain the start necessary to consume the few remaining trees.



*Slash left after lumbering.*

Normal attacks of insects and diseases seldom completely destroy a forest area. These pests

*The last spark must be out.*

**Man Weakens Forest Resistance.**


*A costly banquet.*

usually confine their damage to old, dying trees or to weakened and suppressed ones that are soon replaced by new growth. It is only when insect and disease attack becomes widespread or epidemic that great damage is evident. By changing natural forest conditions, man has made trees more susceptible to diseases and insects.

Because of the nature of insect attacks it is difficult to compute the damage annually incurred through them. Estimates ranging from 100 to 150 million dollars have been placed as the annual cost of such attacks.

*Tree hollowed by disease.*

Diseases may be at work for years before their damage becomes evident. Diseased trees which appear sound may be found on cutting to have but a shell of sapwood surrounding a punky, decayed core. Other diseases affecting leaves and branches may not kill trees, but may so retard their growth that an undeniable loss is incurred. Over a large area the sum total of these losses may present a major problem in protection. Epidemic attack, such as that which killed the chestnut and that which now threatens the American elm, brings out new problems in wood use and demands changes in forest management policies.

**Man Concentrates Destructive Animals.**

Damage by animals in the virgin forest is usually overcome by tree growth, but man has introduced numerous domestic grazing animals into the forest which often destroy trees faster than natural means can replace them, and has caused the concentration of wild animals on relatively small feeding areas. Uncontrolled grazing of goats, sheep, cattle, and hogs destroys reproduction, and removes protective cover from the forest floor. This allows the forces of erosion to carry away valuable forest soil, and prevents the regeneration of the forest after cutting. In some regions deer and other wildlife, especially when concentrated on small areas, produce much the same effect as domesticated animals. Porcupines and rabbits kill thousands of trees by girdling them in search of the succulent inner bark; beavers often flood vast areas of rich bottomlands, ultimately killing all forest vegetation.

See Ch. XI, pp. 204, 213.

Frosts, wind, sun, and lightning add to the list of agencies that may at times destroy timber. These are forces over which man has no control. In planting trees, however, he should use only hardy species on adverse sites, and less hardy species on protected areas. Cuttings may be made so that remaining trees are left in clumps or groups in which wind damage will not be likely to occur.

*The tree struggles against wind, sun, and frost.*

Since man has added to and intensified the enemies of the forest, he must now add to and intensify forest protection if he wishes to profit by the perpetuation of forest values and influences.

Reproduction, p. 99.

## *FOREST FIRES*

### CAUSES

*Lightning:* With the exception of lightning fires, all forest fires are man-made or man-caused. Although lightning fires are common in the Rocky Mountain and Pacific coast regions, they account for less than 10 percent of the total forest fires in the United States. In the East, lightning storms are usually accompanied by rain; and in the West where "dry storms" occur, extra personnel is employed during storm periods and hazardous seasons so that fires are usually detected when small. There is no way to prevent lightning fires, but they can be suppressed in their early stages if sufficient vigilance is maintained and prompt action is taken.

*Lightning.*

**Prompt Action Necessary.**

A Good Rule for Smokers.

*Smoking:* The greatest cause of forest fires is careless smoking. Matches, cigarette stubs, cigar butts, and pipe heels are responsible for more than 21 percent of forest fires. More than 9,000 fires in the United States each year are attributed to careless smokers. These fires can be prevented by the exercise of reasonable care. It is good practice never to smoke while walking or riding through the woods. If one must smoke, it is best to take "time out." The habit of breaking a match in two before discarding it should be acquired—not that half a match will not start fire, but a match must be out before the person of average sanity will attempt to break it. When disposing of smoking material, a spot should be cleared in the turf and the stub, butt, or pipe heel should be ground under foot into the mineral soil. Automobiles should be equipped with ash receivers; the highway should never be used as a public ashtray. Disregard of such inexpensive precautions, requiring only a second or two of time, may cause the destruction of valuable forests.

Have You an Ashtray in Your Car?

Fire Bugs.

*Incendiarism:* The malicious setting of fires by "firebugs" is responsible for 17 percent of each year's fire total. Incendiaries start fires for many peculiar reasons. One of their chief objectives is to improve grazing conditions. It has been found, however, that burning kills the better grasses and forage plants along with the weeds; burned stubble causes "sore mouth" in cattle and

***Is he a murderer? He takes the life of many trees.***

sheep; and that fire increases the growth of briars and introduces inferior brush. Woods are often burned to kill off beetles that attack farm crops, but surprisingly few farm pests live in the woods. Birds that help to control farm pests nest in the woods and fire destroys them and their young. This type of incendiarism can be stopped by educating the offenders. Fires started because of spite are sometimes most easily reduced through rigid law enforcement. In many instances the personality of the forest officer and his ability to make friends and to organize fire protective units are important factors in preventing incendiary fires.

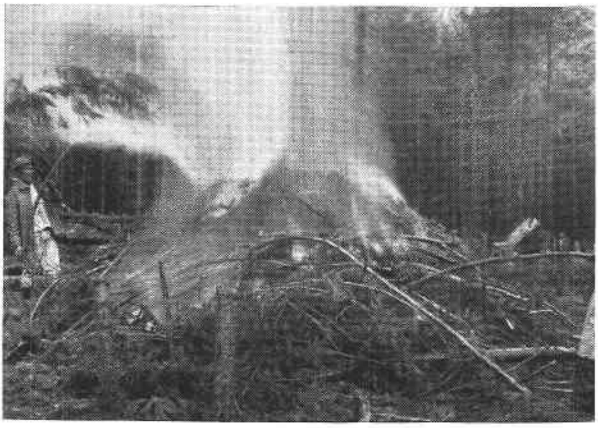
Destructive "Improvements."

Getting Even With the Warden.

*Debris burning:* The burning of brush and debris is a seasonal occurrence at farms and rural homes. More than 12 percent of the forest fires are started in this manner. Fires to remove weeds from farm areas or to consume trash are necessary, but care should be taken to see that they do not spread. The first step in burning fields, debris, or brush is to contact the local ranger or fire warden to secure his permission and suggestions as to the date and time of day to burn. Choose a quiet day with no wind, make brush piles small, clear a space to mineral soil around each pile or clear a wide line around the field to be burned. Do not start fires until after 4 o'clock in the afternoon (ordinarily fires do not spread rapidly after the sun sets), and be sure to have plenty of water, tools, and men handy in

*Safe brush burning.*

*Plowed safety strip for field burning.*



*Slash should be piled, and burned in wet weather.*

case of an emergency. The fire should not be left unattended until it has burned down and has been extinguished with water.

Safety strips protect woods from fire.

*Railroads:* Through lack of spark arresters, inadequately maintained rights-of-way, or carelessness of workmen, railroads cause more than 9 percent of the annual forest fires. Many States have laws specifying the precautions that must be practiced by railroad companies, and some railroads hire foresters to aid in fire prevention. State laws hold railroad companies financially responsible for all damage resulting from fires started by them. The use of oil and electricity for power will help to reduce the number of railroad-caused fires; cleared strips along rights-of-way are becoming more prevalent.

*Clear leaves and sticks away.*

*Recreationists:* Campers, hikers, picnickers, and others who use the woods for sport and recreation, and who should realize the need for fire prevention, cause almost 8 percent of the forest fires. Carelessness with campfires is the chief fault. Campfires should be built in stone fireplaces or in cleared areas if such are provided. It is sometimes necessary to make a fire where there are no campground improvements. In such cases a spot should be chosen near water or where there is an abundance of loose mineral earth. Never build a fire near a stump, log, or tree. A space should be cleared of all leaves and sticks and scraped down to the mineral soil; a wide area around the fire should also be cleared. Keep the fire small, and never leave it until it is out. Plenty of water should be poured on the sticks. If water is not available the fire should be permitted to burn out and should then be covered with loose earth free from all leaves and sticks.

*Be sure the fire is out.*

**The Result of Human Carelessness.**

*Other causes:* In addition to these common causes of forest fires, lumbering accounts for almost 4 percent, about 9 percent are of miscellaneous origin, and for almost 10 percent the causes are unknown. It is apparent, therefore, that less than 10 percent of the forest fires are caused by lightning and that the remaining 90 percent are man-caused and are largely the result of carelessness or indifference.

See Wood Usage, pp. 16, 148.

"Everybody Loses When Timber Burns" is a slogan we have seen blazoned on posters, blotters, letterheads, and pamphlets. Just how does everybody lose when timber burns? In the first place, we are all timber users. The average American citizen uses 130 board feet of wood and over 60 pounds of newsprint each year. This is in addition to the wood used for fuel, posts, poles, and ties. Timber destruction by fire results in higher prices for wood and wood products.

**Timber Burns Down, Costs Go Up.**

Landowners cannot afford to pay taxes on charred stumps, so the tax burden bears increasingly heavy on those who can pay. Thus forest fires raise taxes and the manufacturer or producer whose taxes have been raised must raise the price of his commodity to pay the tax. Everybody loses!

The losses listed are not the only ones. Quite often human lives and homes are lost in forest fires, and occasionally whole communities and industries are wiped out.

*Fire scars are gateways for insects and diseases.*

When the forest is not burned completely it may seem that only underbrush has been removed. But the trees themselves are damaged or made susceptible to damage. Fire, if it does not kill trees outright, retards their growth and reduces yields, produces scars through which insects may enter to eat out and destroy valuable wood or through which diseases may attack and cause decay. It is not unusual for a forest to be rendered worthless by disease and insect attack some years after a burn that "does no damage."

**Killing Old Forests, Suppressing New Ones.**

Seed and seedlings are destroyed, and it may be many years before a new generation will spring up to take the place of the old trees which are dying because of fire damage. Leaf litter and humus are consumed by the heat and flames, leaving a bare, sterile soil in which new trees cannot grow. The soil, unprotected by its former covering of spongy duff, erodes and washes away, filling streams, reservoirs, and channels with silt, reducing water power possibilities, and increasing flood damage.

*Big timber killed, young growth destroyed, litter and humus consumed.*

Fleeing the flames.

Wildlife is driven out of the forest or perishes in the flames. Young game especially is helpless in the heat and smoke of forest fire. Plants, upon which game thrives, are destroyed. The game that does escape to other areas may increase the population in those areas so that food becomes scarce, causing starvation and disease among the animals.

Fish thrive in water that is slightly acid, and when the acid content of the water is neutralized with the leachings of wood ashes or the water becomes alkaline from the same cause fish die in great numbers. Fires also kill fish food.

*Lye from wood ashes kills fish.*

Insectivorous and song birds that nest in the woods near farms and feed upon the insects that attack farm crops, are killed defending nests and young against a relentless enemy. Shelter and food for game birds are destroyed as well as their nests.

For recreational purposes the forest must have beauty and cool shade against the hot summer sun. These cannot be found on hillsides of blackened timber.

Turn to the chapter on Forest Values (Ch. II) and after reading it try to imagine a country lacking in all or part of the forests' influences. Try to picture the effect of complete or partial forest destruction on homes, businesses, health, and public and private wealth.

## FIRE PREVENTION

*Defending her nest.*

There are three major ways in which forest fires can be prevented:

(a) Education of the public, stressing careful observance of precautions and stimulating an interest in forest preservation.

(b) Removal of hazards so that the danger from disregard of precautions is lessened.

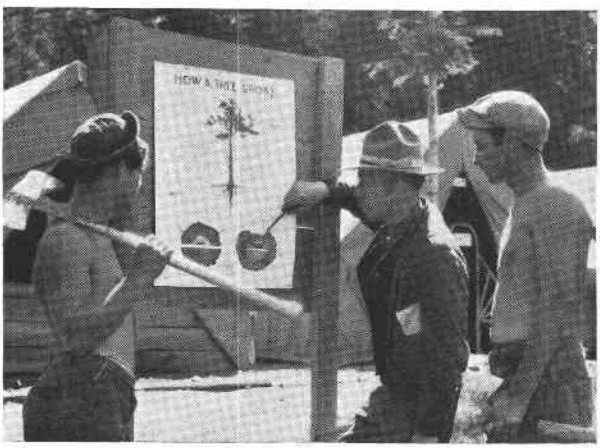
(c) Legislation to enforce precautionary measures and hazard removal.

**Education for Prevention.**

Education of the public is probably the greatest means of fire prevention. Thoughtlessness and carelessness have been responsible for most of the country's forest fires. When wood owners and wood users realize the seriousness of forest fires and have safety measures brought to their attention, through speeches, newspapers, books, displays, radio programs, and other mediums so that care with fire and fire-causing agencies becomes second nature, fires will be less frequent.

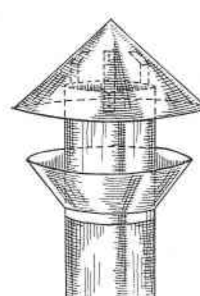
*Spark arresters and safety strip protect the woods.*

Hazard removal is closely tied to education. People who understand the causes of forest fires and the means of preventing them will do their part in helping to reduce man-made hazards. Roadside and right-of-way clean-up are two of the most necessary operations in hazard removal. Slash from logging operations should be either



*Education is an important means of fire prevention.*

piled and burned or lopped and scattered (cut up into small pieces so that it lies close to the ground and decays rapidly). Spark arresters on trains, logging engines, and cabin chimneys prevent large sparks from firing the woods. In parks, camping grounds, and recreational areas, the camp fire hazard may be reduced by constructing special fireplaces for cooking, and by clearing a fire lane around the area. Cabins, homes, and industrial plants in or near the woods should have a cleared line surrounding them; this line will protect the property from woods fires and keep property fires from spreading into the woods.



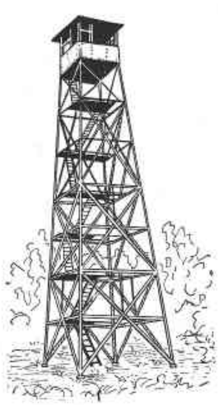
*Detail of spark arrester.*

Legislation is used as a last resort to enforce precautionary measures and hazard removal. If people can be educated to prevent fire there is no need for rigid laws to obtain the same end. In some cases it is necessary, however, to establish and enforce laws relative to brush disposal, hazard removal, campfires, and smoking. In national forests slash disposal is required on all lumber operations, and some States enforce such regulations in private logging areas as well. In most States firing the woods maliciously for any purpose is an offense punishable by law, and anyone allowing fires to spread to the forest through carelessness or disregard of precautions must pay damage and extinction costs. Often during dry seasons the forest will be closed to visitors or smoking will be prohibited. Although law enforcement is the only practical means applicable to certain classes of people, it should be used only when voluntary cooperation cannot be obtained.


*A last resort.*

FIRE CONTROL

In spite of present prevention efforts, the United States has more than 44,000 fires each year on protected lands. On unprotected lands the total is more than twice as much. The fact that protected land is equipped with fire-detection forces accounts for the large number of fires reported. Usually the fires are caught when they are small. Only the larger fires are reported on unprotected land.



*Lookout tower.*

*Detection:* One of the most important phases of fire control is detection. Fire cannot be fought until it has been discovered. If too much time elapses between the start of the fire and the time the fire fighters arrive the blaze may have spread over a large area, making it impossible to control it promptly. Almost any fire in its early stage can be extinguished by one man. The job of the detection force is to locate the fire while it is still a one-man job, although this is seldom accomplished. An efficient detection force, can, however, discover a fire shortly after it starts and while it is still small.

**Science Aids Protection.**

During fire seasons the detection organization is keyed to its utmost vigilance. Danger periods are determined by use of scientific instruments which measure wind velocity, temperature, and amount of moisture in the air, soil, and forest litter.

"Fiddle String" Versus Modern Methods.

Modern weather indicators differ greatly from the practical home-made devices of the old-timers. A fiddle string stretched between two posts would sag in dry weather and the old-time guard would look for "fire trouble." Or the rangers' corns would become troublesome when there was dampness in the air. Wind velocity was indicated by the size of tree branches set swaying.

Today, towermen and rangers are advised of "fire weather" by reports from forest headquarters and by daily weather maps. Fire weather forecasts are sent out sufficiently in advance of bad conditions that extra personnel may be available, and extra precautions taken.

*Looking for smoke.*

Primary lookouts are established on peaks and highlands where commanding views of the surrounding territories may be had. These lookouts are usually permanent steel or wooden towers, manned by trained lookout men. In extremely bad weather or when visibility is hindered by haze, secondary lookouts are maintained in trees, or other elevations, and patrolmen in cars or on horseback keep a close watch on particularly dangerous areas.

Emergency Guards.

In many regions guards are stationed, during particularly bad seasons, at points such as road intersections or where communication facilities are handy, so that they may not only detect fires and report them but may actually go to the fire and aid in leading the attack.

Many lookouts in hazardous sections are manned by two observers, one of whom acts as "smoke chaser" to tackle small fires occurring near the lookout, or to aid in leading crews to the fire.

Public Cooperation.

In the best protective units, prearrangements are made to have residents, bus drivers, track walkers, power-line patrolmen, train crews, mail carriers, passenger and mail plane pilots, and all cooperative agencies watch for and report fires.

The location of the fire is the first step in control. Then the fire must be reported to the fire-fighting crews. Thus systems of communication must be established consisting of telephones,

*Portable radio set.*

radio, roads, and trails. All permanent lookout stations are equipped with telephone, radio, or both. Cars outfitted with short-wave, transmitting and receiving radio sets are used where practicable, but the use of portable radio sets is still in its infancy. Portable field phones that can be attached any place on the line are standard equipment in most regions.

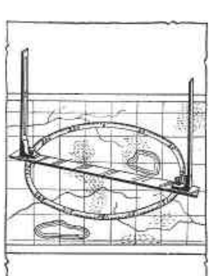
*A typical situation:* To show how a fire-control force operates it may be well to follow one through its operations from detection to arrival at the fire: The towerman on Oak Knob has received his daily weather report from the district headquarters, and the weather conditions are those under which fires thrive. A light breeze has been drying the woods for 3 days. It may be weeks before the next rain. Tearing a sheet of paper from his notebook, he drops it from the tower window. It flutters slowly toward the ground, but before it drops 10 feet it is caught by the wind, and is borne far away as he watches it through his binoculars—a handful of burning leaves might travel just as far. The leaves on the ground are swirling in little eddies around the tower base. To make certain that the telephone is working, he makes scheduled test calls at given intervals to the ranger, the guards, or a few residents on whom he may have to depend for fire-fighting aid in case of an emergency.

*Reporting a fire on field phone.*

**Where There's Smoke There's Fire.**

The towerman has a mental picture of the surrounding country; any wisp of smoke or hazy condition on the landscape will be evident to him. Just before noon he notices a thin curl of smoke rising in the distance; it ascends lazily, reaching a considerable height before it is blown into a hazy cloud. Smoke rises that way when the fire is in a protected spot away from the wind.

With the aid of his detection instruments, the towerman finds the direction to the fire. In each tower there is a large map of the area visible to the observer. The center of the map is marked with a pivot representing the tower, and degrees (360°) are marked on a circle drawn from the same center point. Using an instrument known as an alidade he sights across the pivot to the fire. The



*The alidade.*

alidade is a horizontal bar with an upright post at each end. Some fire-finding instruments are constructed with sights like a telescope. Sighting across the pivot, he reads the compass direction on the circle.

**Headquarters Is Advised.**

This information is telephoned to the ranger station along with the towerman's judgment of the distance to, and the size of the fire. If no other observer reports the fire, the ranger must proceed on this knowledge. Most protective units are laid out so that two towers view the same areas.

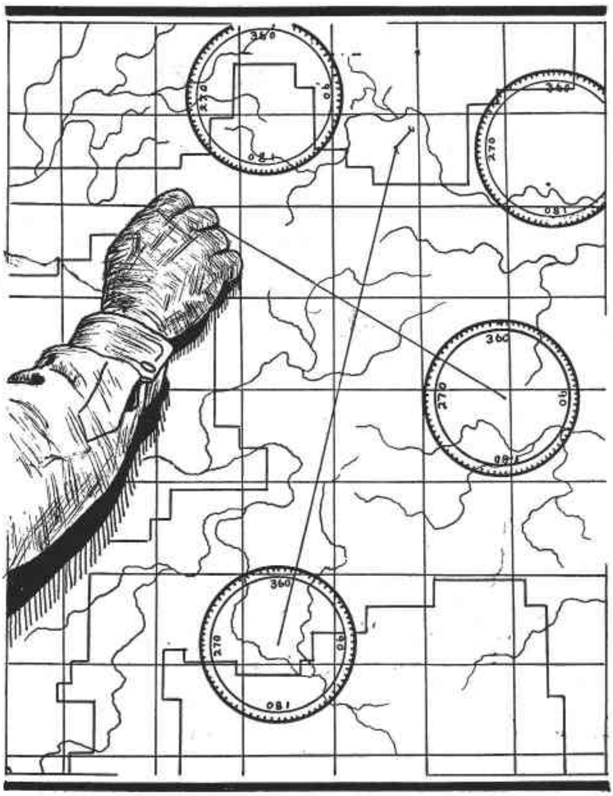

*Using the alidade.*

**Locating the Blaze.**

The towerman on Piney Summit has also seen the smoke and he too calls the ranger station. Now the ranger has two readings from different points. On a large control map, on which both towers are marked, he stretches two strings—one from the map location of each tower—in the directions reported by the towermen. The point on the map where the two strings cross indicates the location of the blaze.

From the map, the ranger picks out the best route to the fire, and locates the homes of fire wardens and a few residents. By telephone he instructs the wardens or the local inhabitants where to report. One man, a "smoke chaser," is sent from headquarters with a car or truck containing enough tools for six men. He may reach the fire in time to get it under control before the crew arrives, or to make plans for the attack if the blaze is too large for one man to handle.

The "Smoke Chaser."

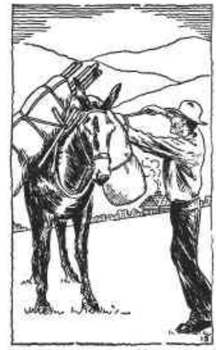



*Where the two strings cross is the location of the fire.*

The warden calls his crew together hastily but not haphazardly. His men have been ready for this emergency. The fire truck is always loaded with tools and ready for use; and, when the crew arrives from their farms, shops, stores, and other duties, away they go. Additional tools may be secured, if necessary, from the tool caches or boxes that have been placed at strategic points throughout the forest. Emergency rations of nonperish-

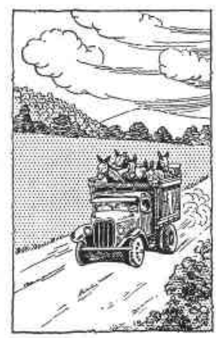
Answering the Call.

able foods have been taken along with the men and tools; local stores have lists of other foods available so that the warden or smoke chaser may order them if the fire demands additional men and supplies.



*Ready for the climb.*

That is the way a protective unit operates when it is equipped with adequate towers and telephones. Some areas, however, are not so well equipped. In these, foot or horse patrols may be used. Slower methods of communication are practiced. Messengers may carry the news of fires, and crews may be organized by more crude methods. In such units, fires grow while preparations are being made to fight them. Better towers, telephone systems, and trails are needed.



*Trucking from town.*

Although recent forest developments have brought good roads and trails to formerly inaccessible areas, there are still some places where it is necessary to go on foot and to take equipment to fires by pack animals. In such cases the men and animals are transported as far as possible in trucks.

Large fires, requiring large numbers of men over periods of days or weeks, present difficult problems in feeding and transporting the fire-fighting personnel. The mule becomes as important to the advance of the fire army as it is to a military operation, being an invaluable asset when it comes to packing in supplies over precipitous trails.

*On the way.*

**Schools for Wardens and Guards.**

*Crew training:* Each fire is a problem in itself; no two are alike. Topography, types of cover, wind, humidity, and available men differ with every occasion. At best, only broad, general plans may be made in advance of a fire season. Plans are subject to change on the job, the judgment of the fire boss or warden in charge being the governing factor in every case. Hence, fire wardens are trained in fire-fighting and usually have an intimate knowledge of the forest and local topography. Schools for wardens and guards are held each year before fire season begins. At these schools (camps in the forest) the men are taught all the fundamentals of fire control and the uses of new tools and instruments. Upon returning from the training camp, the wardens in turn instruct fire crews in the same knowledge.

### KINDS OF FIRES

Three types of forest fires are recognized by foresters: (1) Ground fires, (2) surface fires, (3) crown fires. A fourth kind may occur in the forest when a tree is fired by lightning and is extinguished before it spreads to the forest. Such fires are known as "tree fires."

*Hidden Fires in Deep Duff.*

*Ground fires:* Fires which burn in the thick duff and leaf mold and leaves on the ground or in peat lands are known as ground fires. Often they burn along under the surface, giving off little or no smoke. For this reason they are difficult to locate until they burst out in the dry leaves on top. They may burn for days or weeks unnoticed, killing roots and underground organisms essential to tree growth, and on a dry day come to the surface to start a large surface fire. These fires often occur where campfires have been built on thick mats of duff. It is not uncommon to find a foot or more of duff in dense pine, hemlock, or spruce stands, as coniferous needles decay very slowly, particularly in the North. Often when a forest fire is thought to be out ground fires will smolder for weeks. Trenching of fire lines down to mineral soil is necessary to overcome outbreaks.

*Leaf litter and young trees are consumed.*

*Surface fires* spread over the ground, consuming dry leaves, sticks, low brush, and small trees. Small reproduction is killed, and although large standing timber is not burned up, the heat retards root growth, sours sap, and burns the bark from the bases of trees. Large, basal fire scars form a port of entry for insects and diseases when the protective bark has been burned away. In a few years the butt log becomes riddled with insect tunnels, and decay starts working upward to make the tree worthless.

*Crown fires* are of two classes. The "running crown fire" spreads through the tops, leaping from tree to tree ahead of the slower-burning surface fire. As flaming branches drop to the ground, showers of sparks spray the leaf litter, advancing the destruction along the surface. The "dependent crown fire" travels with the surface fire when the condition of the overstory is such that it must be dried before ignition. Heat waves, rolling up, evaporate all leaf and twig moisture, and tongues of flame lick upward from the burning brush to transform the crowns into fiery torches.

*Racing through the tops.*

When the three types of fire sweep over a forest, an area of complete desolation remains, the ground fire penetrating deeper and deeper until only powdery ashes cover a baked mineral soil. The desolation is intensified when rains follow, washing the ashes into streams where their alkaline properties kill fish and make the water unfit for drinking, and erosion leaves a heap of rocks—sun-bleached and sterile—in place of a wooded hillside.

**When the Fires Combine, Destruction Is Complete.**

## HOW FOREST FIRES BURN

**800° F. Will Start Fire.**

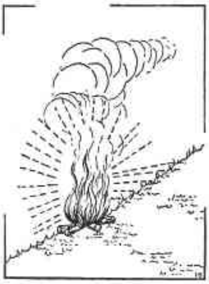
Leaf litter and wood burn when their temperatures become great enough to cause them to burst into flame. The temperature to which anything must be raised before it ignites depends upon the amount of moisture in it. Dry leaf litter will burst into flame at about 800° F. When leaf litter is moist or wet, a much hotter flame must be applied to start fire.

**Moisture Helps Determine Fire Intensity.**

The amount of moisture in leaf litter depends largely upon the amount of moisture in the air. Dry air absorbs moisture from the litter, and when the litter is drier than the air it absorbs moisture from the air. Warm air is capable of holding more moisture than cold air. At night when the air temperature is reduced, and the relative humidity of the air is high, moisture leaves the air in the form of dew. Forest fires, therefore, do not burn so rapidly at night when the dew is on the litter and the air is damp, as they do in the daytime when the moisture has been drawn from the leaves to the air. Fires are at their lowest ebb about 4 or 5 o'clock in the morning before the sun rises to warm the air. This fact is an important one to keep in mind when tempted to quit fighting during the night. A fire which cannot be controlled by a large force

**Fight Fires at Night.**

of men in the afternoon can often be completely subdued by a small crew during the night or just before dawn.



*Heat waves spread fire uphill.*

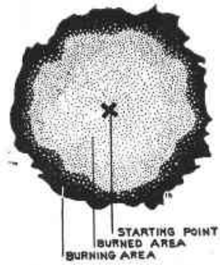
Leaf litter is dried also by heat from the fire. Fires spread because the heat from one burning spot radiates, or reaches out, to surrounding material, drying the moisture and making burning easier. Hot air, being lighter than cold air, rises, and at the same time heat is radiated sideways. Upward movement, or updrafts, and sideward radiation cause fires to burn uphill faster than down, although they will burn fast enough in

*Once green forests, now desolation.*

any direction, particularly if aided by the wind.

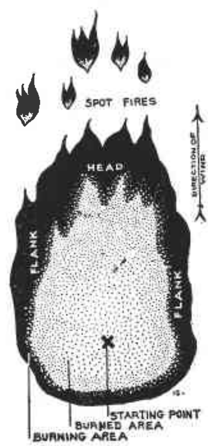
**Fires May Roll Downhill.**

Fires often spread rapidly downhill. A flaming log will leave a steep hillside and come rolling downward, gathering speed as it goes, striking rocks and bouncing over them in a shower of sparks, scattering destruction, and finally coming to rest in the leaves accumulated at the foot of the hill, whence fire spreads over a level stretch or marches up the opposite hillside.



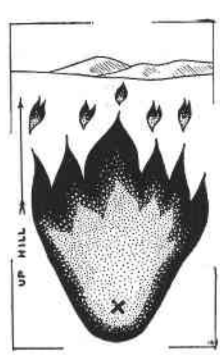

The speed at which a fire travels is governed largely by air movements. A dry day with a breeze is more dangerous fire weather than a dry day with no breeze. The stronger and drier the wind the more rapid the fire movement. Winds are usually stronger in the afternoon and early evening than they are during the night and early morning. This, too, indicates that night and early morning attacks should be made by fire-fighting crews.

The type of fuel also influences the rate at which forest fires spread. Dry leaves, grass, dense brush, and slash burn rapidly, and green material burns slowly unless aided by winds or steep slopes. Peat fires usually burn slowly but persistently.




*The fire:* Fires usually assume a more or less definite shape depending upon the direction and velocity of the wind. On level land, fires spread with the wind, in the shape of a long egg. On slopes they assume a fan shape, widening toward the top of the hill. Rapidly spreading fires on steep slopes run uphill in a wedge, pointed toward the brow of the hill, but if wind is blowing across the slope, the wedge usually broadens toward the top in the direction away from the wind.

In rugged country it should be remembered that fires burn fastest on the steepest slopes. A fire may become a two- or three-headed monster when it runs into a draw and separates to ascend the slopes.




Specific names are applied to the parts of a fire. It spreads most rapidly at the *head.* On a slope the head is usually the up-hill side, but a strong wind may force the fire across the hill and the head becomes the side away from the wind. On level land it is the side that advances with the wind. Opposite the head, on the other side of the fire, is the *rear*—the down-hill side on a slope, or the direction from which the wind is blowing in level country. The two sides connecting the head and the rear are known as *flanks.*


Fire spreads most rapidly at the head, less rapidly from the flanks, and least rapidly from the rear. This should be constantly in mind when the attack is planned. It should be remembered also that a sudden shift in wind direction may change the positions of these parts. A fire 5 miles long and 1 mile wide, advancing under a north wind, can be transformed into one with a head of 5 miles if the wind shifts eastward. The fire-fighting organization should be acquainted with the wind habits of the locality.

*Spot fires* are small fires started by sparks and burning material carried ahead of the fire by the wind. These soon assume the characteristic shape of forest fires and increase in size, aiding in the main fire's advance.

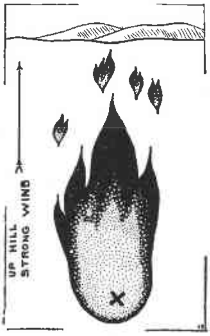

## FIGHTING FIRE

In fire fighting the problem may be summed up as "when, where, and how" to attack the blaze. The attack should start as soon as the men arrive (men should arrive just as quickly as humanly possible), and the movement of the fire becomes known. The men are fresh and in condition to work 24 hours or more if by so doing the fire can be stopped. Fires become no smaller during delays in attack; they grow, and the suppression job becomes correspondingly more difficult.

After the first day, when the job appears to be a large one, the energies of the men should be conserved for the time when they will do the most good. The largest force should start work before daybreak when the fire is comparatively quiet. Not much can be gained, on a long fire, by working the men more than 10 or 12 hours a day. A good plan is to concentrate the force, from 4 a. m. until noon, on fire fighting and to spend the heat of the day in patrol. Advantage should be taken of any time when the fire weakens—a light rain or an increase in humidity.

When the fire-fighting force is familiar with the locality in which it is fighting, night attack has many advantages over day work. The fire burns less rapidly at night, the wind is usually more quiet, and the air is cool and moist.

Before attacking, the fire boss must have a clear picture of the situation. The Western Fire Fighters' Manual advises, "Never attack haphazardly! A little head work saves a great deal of back work!" If an obviously important point is found it should be attacked at once, and scouts should be detailed to "size up" the fire and to report other vital spots where a little attention now will save much work later. Advantage should be taken of natural fire breaks, and their weak points strengthened. Winds, or probable winds, topography, types of cover, and streams are important factors in determining where to attack. Spot fires beyond the line of attack should be given immediate attention.



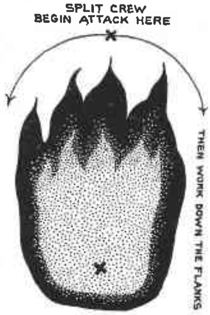

**Spot Fires Speed Up the Advance.**

Method of attack depends upon the kinds of fire, winds, topography, vegetation, and the number and experience of the men. Ground fires are fought with shovels, mattocks, axes, and water. Usually these fires take no definite direction except on slopes where the tendency is to burn uphill. They may be fought along their outer edges by digging deep trenches down through the vegetable matter to the mineral soil. Starting at the outer rim the ground is then drenched with water, if it is available. Usually such fires occur in areas where water is readily accessible and portable power pumps may be employed. Sometimes two lines of trenches are necessary to make the fire line stronger. A fire breaking out a week or two later easily may jump a small trench. It is good practice to send at least one man back after a few days to search out any warm spots that remain and to do the necessary work on them.

*The shovel prepares the line.*

Surface fires often may be fought by direct attack either with tools, water, or machinery. Brush and snags along the line are removed, and the leaves and litter scraped away with rakes. Shovels may be used to clear a line down to mineral soil and to retard the fire by throwing earth, removed from the line, over the burning edge. In the West, particularly in open stands, trailbuilders, and tractor or horse-drawn plows are used to make the fire line. Fallen logs are not

*Small fires may be beaten down.*



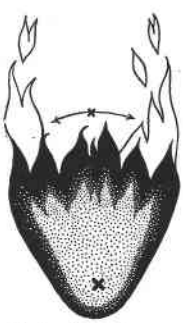
See diagram, p. 79.

permitted to lie close to the line. It is sometimes possible to use water in direct attack. In this method a line is cut with axes and brush hooks; water is applied to the burning leaves and litter. Small surface fires often may be beaten out with green branches, wet blankets or burlap bags, but fires checked this way usually require a great deal of patrolling.

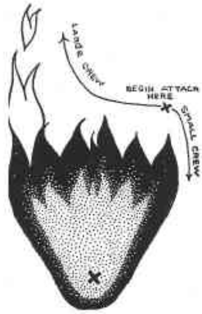
In most cases the point of attack is at the most dangerous point, the head. Often, however, on fast-moving fires, the attack is made on the flank to reduce the width of the fire front. Otherwise the head attack might not be able to extend a line fast enough to cut off the entire front.


*Building fire line to check advancing flames.*

When attacking the head, the crew begins working directly in front of the advancing fire, and splits into two groups to work around it. Usually the first man in each group wields a brush hook or small ax to cut a trail. He is followed by more men with similar equipment who lop off brush and small trees, widening the trail. Then come a group, armed with rakes, scraping back all leaves and twigs or, if the duff is deep, shoveling it away from the line down to mineral soil. Men packing spray tanks on their backs spray the fire along the line's edges with streams of water, or shovelers scoop earth to beat down the flames. Patrolmen with water, shovels, and rakes keep a sharp eye on assigned sections of


*If fire line is not built fast enough the crew is trapped.*

the trail and prevent the fire from breaking through. The trench on the down-hill side should be deep enough to catch rolling sticks and logs. Sometimes it is necessary to build barriers of logs which must constantly be watched to prevent downward spread.



*Sometimes a flank attack is best.*

Severe surface fires in which the first two methods are not practical are fought with fire. Fire trails are run some distance before the on-coming fire and are built much wider. Snags inside the fire line and near enough to its edge to create hazard should be felled; but if this is not possible, litter should be raked away from their bases. The leaves and litter along the trail on the side toward the fire are ignited with torches or burning brands. Since all the fuel has been removed from the trail, the backfire can burn only toward the main fire. It creeps slowly, but clears a wide path faster than could be cleared with tools. When the two fires meet they burn out for lack of fuel, and the area cleared by the backfire is too great for sparks to jump effectively.


*Fighting fire with fire*

The distance from the main fire to the start of the backfire depends upon the speed with which the head is advancing. Often it is necessary to burn off a large area, or to go over the brow of a hill so that a good start may be given to the backfire. The practice varies with locality and individual fires. Often too much width is allowed and timber is burned unnecessarily. In other cases, too little width is allowed and the fire jumps across the line. Experience, particularly local experience, is an invaluable asset in determining backfiring procedure. It is a job that should not be delegated to green men or poor supervision. Indiscriminate use of backfires may cause more damage than the original fire, and such use should be prohibited.

No Job for a Green Man.

From the head attack the line extends in two directions along the flanks. As the flanks burn more slowly than the head, it is often unnecessary to backfire along them; the line is swung in closer to the fire and direct attack is made.

Controlling Crown Fires.

Crown fires usually must be fought from a distance, the object being to bring the fire down to

*A wide fire line in western brush land.*

the surface where it can be fought more easily. Wide lanes are established. Roads across the path of the head are good starting places from which to backfire. Spot fires are frequent because of the height to which sparks ascend. It is necessary to have some crew members beyond the fire trail constantly to kill spot fires before they grow. Sometimes crown fires become ground fires when they reach the brow of a hill or cross a steep ridge.

Dependent crown fires, or those which travel with or after the surface fire, may be stopped with intensified surface fire-fighting tactics. Wider fire lanes are made and more territory backfired than on ordinary surface fires. The necessity of cutting timber is minimized to snags and moss-laden trees near the fire line.

In areas where tree crown fires or brush crown fires are common, wide fire lines are permanent forest improvements. They are constructed 50 feet or more in width and are cleared of all trees and inflammable material. In hardwood stands where crown fires are not so common usually only the underbrush and litter are removed from fire lanes.

**"Mopping Up."**

When the fire has been stopped there is much work yet to be done. The trail is patrolled all around the fire. Burning snags are cut down and extinguished. Although many of the men are called off as soon as the fire is controlled, a large number are kept at work patrolling and "mopping." This continues until the last spark is out, and all danger of a new break is removed.

### FIRE-FIGHTING EQUIPMENT

**There Are No Fire Hydrants in the Forest.**

Fire in the woods demands much different apparatus than that used by city fire departments. In the better city organizations adequate water supplies are nearly always available, chemical pumps may be used, and it is possible to bring tools and equipment right to the door of a burning building. Few forest fires occur where there are accessible water supplies, and fewer forests are checker-boarded with roads, as are cities. Hence the standard apparatus for forest fires consists of shovels, rakes, axes, saws, mattocks, hoes, and brush hooks. Ordinarily forest fires are not put out in the sense that one puts out a city fire such as a burning house. Rather the fire is stopped and allowed to burn out.

*Awaiting a fire call.*

**The Ax as a Fire Extinguisher.**

Axes are used to cut out small logs, brush, and small trees, burning snags, and those likely to burn. Dead, burning bark that might carry fire up into the crowns is cut away, and the ax is indispensable for camp use. Pole axes can be used with a greater degree of safety than can double-bitted axes, but experienced axmen prefer double-bitted axes, because one edge can be used for rough work and the other kept sharp for finer work.

For removing humus and litter along the fire edge and for throwing earth on fires the shovel is of prime importance. It is often used to spread backfire, and is an effective beater for small fires that cross the line.

*Leaves and litter are raked away.*

Hazel hoes, grub hoes, and mattocks are employed in line construction to tear up humus, cut roots, scrape away litter, and for trenching. They are much more effective than the shovel for any of these jobs.

A number of rakes have been developed for clearing the ground of leaves and litter. Some combine the features of the mattock and rake, having triangular teeth with sharp cutting edges, others are combination hoe and rake. When special rakes are not available, and for ordinary raking, the common, heavy, road rakes can be used quite effectively in clearing fire lines.

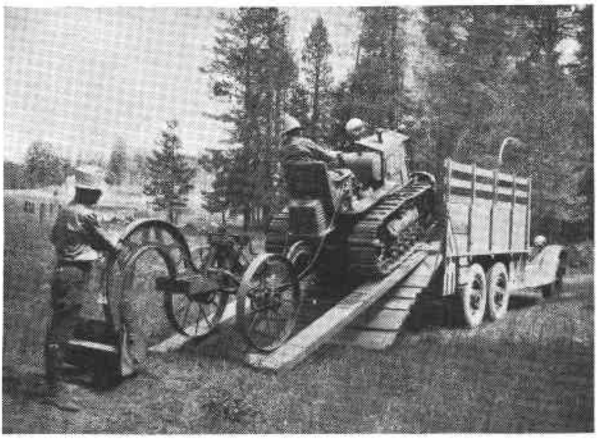
**Fire Line Construction.**

Horses and mules have been used to advantage in building fire lines with plows. Instead of the slow, laborious task of grubbing trenches in advance of a raging head, the job may be accomplished much more quickly by animal power. In rocky country this is not so effective as it is in gravelly or sandy soil. Men follow the plow with rakes and shovels to touch up the rough places and to complete the line over rocky stretches.

**By Tractors and Plows.**

The tractor has stepped in to replace the horse and mule. Having proved itself effective as the wartime tank in surmounting natural obstacles, it is now adapted to forest warfare. Large tractors are often hitched to logs or huge rocks and, with very little trouble, gouge out wide lanes down to mineral soil. Smaller tractors and plows are easier to handle in the woods, however. For most fire-control work a 2-ton machine with a wheel plow is best. It will dig a furrow 20 inches wide and from 8 to 10 inches deep. Logs up to 8 inches in diameter break under the pressure of the plow, and it is constructed so that it lifts automatically over solid rocks. Bulldozers or trail-builders are used to open up fire lanes, to push logs and good sized trees out of the path, and to scoop out turf and litter.

By Bulldozers.



*Fire line plows and other heavy equipment accelerate fire control.*

Often logs must be cut from across the line or dangerous snags must be felled with saws. When much timber must be cut to bring a crown fire to the ground the saw has no substitute, although dynamite has been used to blast down snags and to open wide lines in a hurry. A recently developed portable power drill has speeded up this work. "Shot holes" may be drilled faster than loading and firing them.

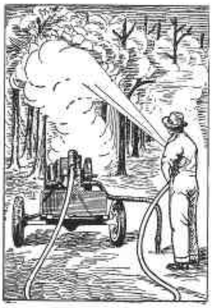
*Water is an effective check.*

Water, when it can be obtained, is very useful in extinguishing standing snags, logs, and burning stumps, and for line patrolling. Galvanized tanks or water-proofed sacks equipped with short hose and hand pumps will throw a stream of water effectively for 20 to 25 feet. Water is obtained from nearby streams or is carried on trucks to the fire. Refills are given along the line from larger tanks carried by horses, mules, or men.

**The Portable Power Pump.**

Portable gasoline pumps that can be carried by one man have recently come into use. When water is available in nearby sources these pumps, with long hose lengths, are capable of pouring powerful streams of water to stop fires, and are great aids in mopping up. In some sections of California and other States, trucks equipped with pumps like city fire engines are used to subdue fires along roads. The pumps can draw water from streams or ponds, or, if necessary, draw on the 50- to 600-gallon tanks that they carry with them. These trucks are further equipped to carry a crew of 20 men with tools and supplies. Many logging companies have pumps attached to donkey engines to attack fires near the operation, and some logging trains have been equipped with pumps and hose to fight fire along railroad lines.

**Wells Drilled to Order.**



Michigan in the past 3 years has started to use portable well-drilling outfits to supply water for fires. The driller or "washer" consists of a tank of water and a portable pump which washes a casing pipe down to a depth of 30 feet or more. Three men working ahead of a fire can sink and operate a well in 8 minutes with this apparatus. With long lengths of hose the water from one well may be used to wash in another well along the line. Of course this system is not applicable to regions where the water table is deep or where the ground is rocky, but in sandy lowlands or bog country the portable well driller and pump have great possibilities.

**Fire Torches.**

For backfiring and burning debris inside the fire line, the torch is much more effective than matches or fire brands. Gasoline and kerosene are used for fuel. Torches similar to blow torches are able to ignite the most obstinate fire-line edges with a very hot flame.

**Personal Equipment.**

For the men on the line canteens are great aids to fire-fighting, although they are not used in the attack. A swig of cold water freshens parched lips and hoarse throats and gives the tired fire-fighter new life. Among other personal equipment each man should carry an extra pair of socks, and a supply of matches, preferably in a waterproof container. Lanterns or flashlights are used for night work and night travel, and they are particularly useful at camp. Miners' lamps worn on hats and caps have proved helpful in night fighting.

**Miscellaneous Equipment.**

Miscellaneous equipment that should be included on all fires of long duration consists of sledges, wedges (for falling trees inside the fire lines), files, grinders, and whetstones (for sharpening tools). Medicine kits and first-aid kits for minor injuries and illnesses are essential and at least one man in each fire crew should be adept at first aid, and should carry a small kit with him. Injuries to fire-fighters usually consist of cuts, burns, and bruises. An ample supply of picric acid bandages and some unguent or soothing lotion for burns should be included in the equipment. When the crew is likely to encounter poisonous snakes, the first-aid man should carry an approved snake-bite kit.

**Carry Plenty of Equipment.**

The kinds of tools and the numbers of each depend upon the locality, the fire, and the crew. It is always better to have too much equipment than not enough. Excess tools may be left along the trail in safe spots to be picked up as needed or to be returned to the caches after the fire. From 40 to 50 percent extra tools are not too many to carry to a fire. Before leaving the burn, all tools should be checked in, and before they are stored away they should be repaired and sharpened for the next emergency.

**Kitchen Supplies.**

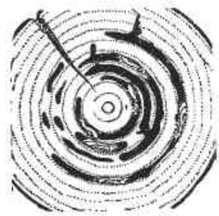
Cooking equipment varies with the size of the crew. Before fire seasons, standard kits containing enough cooking utensils and mess equipment for 5, 10, 15, 50, or 100 men crews should be made ready, nested in as small packages as possible, as well as nonperishable food for similar numbers of men. Perishable foods should be placed on order at local dealers throughout the protective area, and the fire boss should be able to order, over the telephone, by simply asking for lot number 1, 2, or 3, etc.

On large protective areas supply bases may be established at various points where hazard warrants them. These, located at farmers' homes or local wardens' headquarters, may be available for any emergency.

## *FOREST INSECTS*

Although forest insects ordinarily are not conspicuous in their attacks, and there is no romance and adventure connected with insect control as there is in fire control, the damage wrought by these pests has been estimated, at times, to be greater than that of forest fires.


Insects often kill stands of timber. More frequently, however, they do not cause immediate death. Retarded growth, poor timber, and deformed and twisted trees, worthless except for fuel, are some of the ultimate results of nonkilling insect attack. Even after trees have been removed from the forest and have been manufactured into homes and products they are not free from insect damage. Termites and other wood-destroying insects will attack finished products if they are not properly protected.



*Post damage by termites.*

In the South, termite damage is quite common. Foundations of homes and other buildings have been completely destroyed by their depredations. A few years ago, an unused building was opened for occupancy and the hardwood floors, still retaining their brilliant polish, collapsed under the first man to enter. Investigation showed that the floor boards had been so riddled by termites that only a thin layer of polished wood, apparently sound, was all that remained of once expensive and substantial flooring.

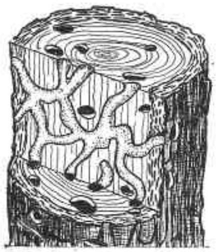
*Termites at work.*

Forest trees are attacked by insects in many ways, each producing a peculiar and important, if not vital, damage. Protectionists have developed means of suppressing these forest enemies, but often the cure is more expensive than the damage. Hence, protection from insect attack has assumed the position of control rather than complete eradication.

### INSECT TYPES AND ATTACKS

The type of attack most readily seen is that of the defoliating insects. These pests injure or destroy leaves. Some kill leaves by sucking the juices from them, others eat leaf material. Chief

*Nest and damage of tent caterpillar.*



*Elaborate tunnels of wood borers.*

among the defoliators are the moths in their caterpillar stages—gipsy moth, brown-tail moth, satin moth, and tent caterpillars—the leaf miners which eat the inner portions of leaves, the walking-sticks and leaf-eating beetles, the sawflies, and the hemlock looper.

Wood borers working under the bark are seldom seen, but their tunnels become evident when logs are sawed. Borers of many types riddle trunks and branches and often completely destroy the commercial value of any logs left in the woods for long periods.

Many beetles attack the cambium layer and girdle trees beneath the bark so that death results. They are known as bark beetles because they work in and beneath the bark. There are more than 400 species of bark beetles in the United States, some of which are of great economic importance. The southern pine beetle, western pine beetle, mountain pine beetle, and Black Hills beetle are important in this class. Bark beetles bore into the bark and construct small chambers from which many radiating tunnels are eaten. Eggs from which the larvae, or grubs, emerge are laid in the side of the tunnels. The larvae tunnel their way under the bark and feed on cambium and inner bark. Wood beetles do their greatest damage in the larval or grub stage. Eggs are laid by the adults in cracks and crevices of the bark, or small holes are made by them for this purpose. Upon hatching from the eggs, the small grubs bore into the cambium or through the wood, feeding upon wood substance and producing a series of tunnels.

*Bark cut away to show work of elm borers.*

Gall insects rarely kill trees, except when attack is epidemic or prolonged, but they distort branching and often kill small branches. If on the main stem this may result in a deformed tree from which merchantable logs cannot be cut. Galls are swellings occasioned by the egg-laying and egg-development activities of small insects. These are particularly conspicuous on the oaks.

Cone beetles, nut weevils, and seed chalcids attack the seed crop and sometimes hinder reproduction over large areas.

*Insect galls on oak.*

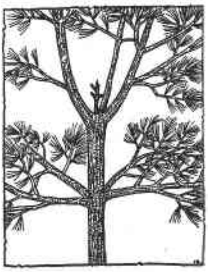
Other insects, notably the white pine weevil, attack the smaller stems and leaders by laying eggs near the tips in slits or holes which they puncture in the tender new growth. The leaders are killed off and forked tree-tops result.

**Insect Attack Varies.**

Many insects attack trees in two or more ways, and many more do damage in both larval and adult stages. Some attack only certain kinds of trees while the appetites of others extend to many kinds of vegetation.

In addition to doing direct damage to trees, insects often act as agencies for spreading diseases. The Dutch elm disease, which has become epidemic in some Eastern States, may be introduced by elm borers carrying its spores. Blue stain is another tree disease whose infection is intensified by spore-carrying beetles.

### INSECT CONTROL MEASURES



*Leaders are killed by white pine weevil.*

Insect control measures in the forest are difficult to administer. The cost of fighting an unseen enemy often exceeds the benefits derived from partial victory. In many cases the cost is justified, however, in preventing or checking killing epidemics over large areas, or in increased yields and better timber.

Plant inspections and plant quarantines, especially those enforced at harbors and border stations, have aided in keeping foreign insects out of the forest. Occasionally a foreign pest enters the country in spite of the examiners' vigilance, as did the gipsy moth in the late 1860's and the Japanese beetle more recently.

In the woods many control measures have been tried. Trees infested with bark beetles are cut, peeled, and the bark burned. In the West this work has prevented the spread of devastating beetles. Where insects are epidemic they are sometimes caught in traps. The Japanese beetle in New Jersey is partially controlled by this method. Traps baited with lanterns to attract moths are used where these pests occur in great numbers.

**Direct Attack.**

The filmy net of the tent caterpillar is often attacked with torches and the tiny worms singed

*Japanese beetle—a leaf eater.*

by the thousands. Egg masses of the gipsy moth are treated with creosote or burned with torches; and those of the brown tail moth are collected and burned.

Sprays are expensive and often are not applicable to forest trees except those on areas such as parks or recreational forests which have high value other than that for timber. Recently developed methods of dusting with poisonous powders such as those used in control of the cotton bollweevil have been fairly successful against leaf-eating insects. Aeroplanes have speeded up the application and effectiveness of such methods.

See Storing, p. 196.

Logs permitted to lie in the woods are often attacked by borers. The immediate sawing or peeling of logs will do much to prevent attack. At sawmills logs are often stored in ponds, partly for the purpose of warding off beetle and borer attack.

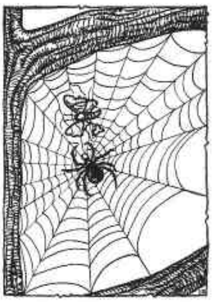
**Wood Preservation.**

Wood in use is protected by painting and by impregnation with creosote and other chemical compounds. Termites, the white ants which play havoc with the wood in many buildings, may be checked if the wood is not permitted to come in contact with the ground. These insects work under cover, and ordinarily they must have an unbroken series of wood members through which to tunnel. In termite territory, wooden structures should be supported on concrete pillars so that insects may not have unhampered access from the ground to the wood.

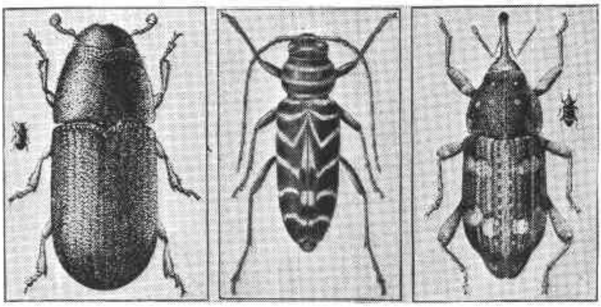
**Mixed or Pure Stands?**

Good silvicultural practices will do much to obviate insect damage. Dead and dying trees, or those in weakened condition, are breeding places for forest insects. The cutting of these trees, as part of the silvicultural operations, will reduce the insect hazard. Stand composition often influences the severity of insect damage. Pure white-pine stands are more susceptible to weevil attack than are mixed stands. Borers and other insects that have appetites for certain tree species may be held in check in mixed stands.

Insect predators and parasites have been used successfully. In nature there exists a balance among all forms of life. Predators and parasites tend to keep the dominance of any one life form in check. When this balance is upset through the importation of insects to a region where natural enemies do not exist, the insects increase and their damage exceeds natural proportions. The importation of parasites or predators, the balancing factors of nature, will help to check insect invasions. The search for such natural enemies is not an easy task; often the parasites and predators will not live under changed conditions, or their life cycles will not correspond to those of the insect pest except under certain climatic or altitudinal conditions. When a foreign insect becomes prevalent a study is made of its natural predators in its native area. These are imported, if they prove suitable.



*Caught in one of nature's traps.*



*Three destructive forest insects: left, western pine beetle; center, locust borer; right, white pine weevil.*

**Natural Allies of the Forest.**

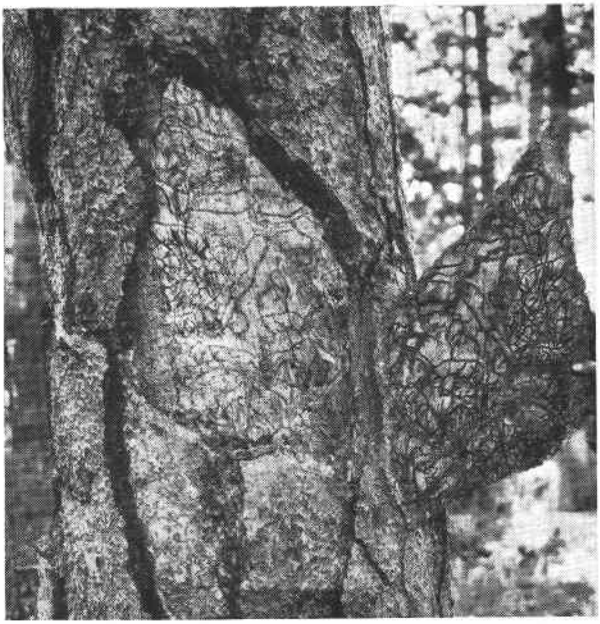
Flying birds use a tremendous amount of energy and consequently they eat more than their own weight in food each day. For some birds—the insectivorous, or insect-eating, class—this tremendous diet is composed principally of insect pests. The warblers, tanagers, cuckoos, and even grackles are important allies in eradicating worms, grubs, and caterpillars. Woodpeckers are noted for attacks on bark insects.

**The Answer.**

With increased forest sanitation, better slash disposal, protection of insectivorous birds, and intensified control measures, forest insect pests may ordinarily be kept at a minimum and their damage negligible.

## *TREE DISEASES*

There is no period in the life of a tree when it is entirely immune from disease attack. Like



*Beetles construct galleries for eggs beneath the bark.*

**Diseases Are Ever Present.**

human beings, trees are most susceptible to diseases in youth and old age, or when weakened by starvation, lack of sunlight, or the action of some external agency. As in humans, resistance to certain diseases may be developed. We are constantly besieged by germs and disease organisms but, unless we are in poor physical condition or the disease agencies are new ones against which our constitutions have not built up resistance, we ordinarily show no effects of their presence.

Native diseases that normally cause only minor losses may become epidemic when a new tree species is introduced. A tree from one region planted in another is open to attack from diseases which barely affect native growth. As a North American in the Tropics is likely to succumb to fevers which bother the natives very little, so Scotch pine in Pennsylvania, New York, and New Jersey falls before the attacks of rusts which native trees endure. Even red pine from Minnesota is not normally resistant to fungi of the Middle Atlantic States.

*Chestnut tree killed by blight.*

Normally, killing disease attacks on the human race keep pace with the birth rate. In like manner, normal attacks in the forest are balanced by growth rate and natural regeneration. When natural conditions are disturbed adversely through changed living conditions or the introduction of new diseases, epidemics occur. This happens among trees in forest and park as well as among people in the city and on the farm.

Planting for Control.

Disease attacks become most serious in stands of one species where fungi find conditions admirably suited for development and spread. Mixed plantations or stands are best suited to ward off severe attacks.

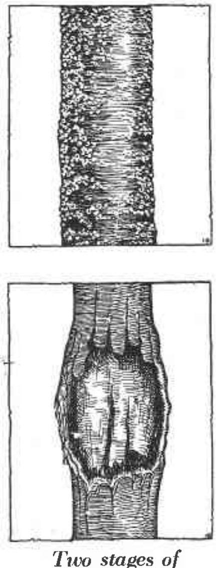
## FUNGOUS DISEASES

The most common tree diseases and practically all wood decay are caused by fungi. A fungus (plural, fungi) is a plant that does not build up raw materials for its growth as do trees and other common plants. It thrives on the food substances of other plants, living or dead. The plant upon which a fungus grows is known as the host. If fungi derive their food from living hosts they are known as parasites; when fungi live on dead hosts they are called saprophytic fungi or saprophytes.

*Fruiting body of fungus.*

Unlike most plants, fungi do not produce seed. They develop instead a fruiting body in which are formed millions of fine, dustlike particles called spores. Spores are scattered by the wind and lodge in cracks or bark injuries, where they develop into fungous plants. Fine, threadlike strands extend into the wood cells to absorb tree food, and a fruiting body later appears on the trunk or branch. The mushroomlike or shelfy protuberance which we know as the fungus is only the fruiting body. The destructive threads of the fungus penetrate through the tree, breaking down wood cells for distances of 8 to 10 feet from the fruiting body. If it does not actually render the wood entirely unmerchantable it so discolors it that the value is greatly decreased.

Another type of disease is that which produces cankers or lesions in the bark. These cankers either girdle a tree so that it dies, or so weaken it that it succumbs to winds and storms. The blight which has exterminated the chestnut over a large part of its natural range is of this type.

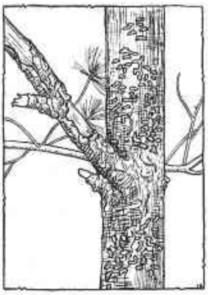


*Two stages of chestnut blight.*

The Dutch elm disease is a fungous growth which attacks the sapwood of the American elm. The first indication of its presence is the wilting, browning, or yellowing of leaves. The twigs and branches die, and finally the whole tree.

**Control Is Possible, Cure Is Doubtful.**

Not much can be done to save trees infected with these diseases. The problem of control is to keep the infection from spreading to other trees. This is accomplished by destroying infected trees. In some cases unmerchantable logs left in the woods are breeding places for destructive fungi.



*Blister rust on white pine.*

Some fungi require two hosts on which to complete their life cycles. Usually the spores from one host are longer lived than those of the other. The white pine blister rust is of this form. Five stages of development characterize blister rust, two of which occur on currant or gooseberry plants. It cannot spread from pine to pine, but must spread from pine to the alternate host and then back to pine. The spores from the pine fungus will travel effectively for more than 200 miles; those from the currant only about 1,000 feet. Therein lies its control. The removal of all currant and gooseberry plants in the vicinity of white pine will check the spread of this fungus. Ordinarily the removal of these plants is confined to an area of approximately 1,000 feet around plantations or stands densely populated with white pine. Although wind will often carry spores from the currant or gooseberry more than 1,000 feet, this distance has proved effective in cutting down the severity of blister rust attacks.

*Blister rust on currant.*

NURSERY DISEASES

Young trees in nursery beds are particularly susceptible to diseases. Crowding them together permits diseases to spread rapidly from plant to plant and makes control measures difficult. Damping-off fungi attack all kinds of seedlings and especially conifers. They usually affect trees during the first 2 or 3 weeks of their existence, while the stems are soft. After the trees become woody, damping off is reduced. Small watery spots appear on the stems of the trees, and in a

*Blister rust travels from pine to currant or gooseberry and back to pine.*

few days the plants wilt and die. As damping-off fungi are present in almost all nursery soils, sterilization of the soil or the application of some fungicide is necessary. Steam sterilization—subjecting the nursery beds to hot steam under pressure—has proved effective, but usually too costly. The treatment of beds with dilute sulphuric acid, formaldehyde, zinc chloride, aluminum sulphide, and other fungicides has been used with success. Sterile subsoil from a depth of 2 or 3 feet below the surface may be used to cover seed and thus reduce damping-off attacks.

Chemical Treatment.

Blister rusts and stem and twig blights are common in some nurseries. Blister rusts may be controlled by the removal of alternate hosts. No control for stem and twig blights has been found other than the destruction of infected plants.

Root rots are caused by fungi similar to those responsible for damping off. They are common in irrigated nurseries and where too much water is applied to beds in the early growing season. Good drainage will control this disease, and applications of aluminum sulphate have been successfully applied in some cases.

Refer to Root Rot and Damping off, p. 117.

*Mistletoe* is a parasitic flowering plant that grows on trees. Its roots or "sinkers" enter through the bark into the cambium layer, from which they draw water and sap. The plant produces a sticky, white fruit which is distributed by birds and animals to other trees. Trees infected with mistletoe develop swellings and distortions around the sinkers. These ruin the commercial value of the wood. Control is accomplished by cutting and destroying diseased trees.

*Mistletoe causes swellings on branches.*

INTRODUCED DISEASES

The tree diseases which have wrought the greatest havoc in American forests are those introduced from other countries and against which native trees have built up no resistance. Chestnut blight (from Asia, about 1890), white pine blister rust (from Europe, about 1900), and Dutch elm disease (from Europe, about 1930) are examples of foreign diseases that have gained considerable

Bad Imports.

foothold among native trees. Plant inspection and quarantine, rigidly enforced, will obviate future trouble of this kind. The Dutch elm disease entered this country before unpeeled elm logs were subject to quarantine. The strict quarantine on such logs now acts as an effective check against the establishment of new centers of infection.

### SOLVING THE DISEASE PROBLEM

**Field for Study.**

Much is yet to be accomplished in disease control. Many diseases exist about which little is known. Study of their life cycles and habits should be made so that any serious outbreak can be met with predetermined plans. The relationship of insects and tree diseases is a phase of forestry calling for further study. We know that some diseases, such as the Dutch elm disease, can be spread by insects.

**The Formula for Solution.**

The solution of the insect and disease problem lies in better forest sanitation, improved silvicultural practices, more rigid quarantine, prevention of mechanical and fire injury, more intensified research, and a forest personnel trained to recognize dangerous pests.

## *OTHER FOREST ENEMIES*

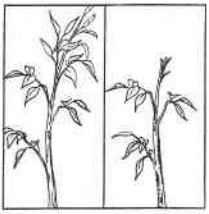
Refer to Ch. X, pp. 204, 213.

When the natural balance between animals and plants in the forest is upset, through fire, logging, concentration, or encroachment of civilization, there results an overpopulation of animals and a subsequent depletion of forest vegetation. Over a long period of time the forest may reestablish its supremacy through starvation of animal life, but the first reaction is a disappearance of young plants.

In the forest, before man's civilizing influences upset the natural balance, animals such as rabbits, porcupines, and deer were kept in check by predators, parasites, and diseases. The trees, animals, and natural enemies were part of the balance, and no permanent harm was done to the forests. It is safe to assume that in a number of States, Pennsylvania for example, the deer population is greater today than it was 400 years ago when cougar, bobcat, and other predators were numerous. Regulated hunting, the establishment of game preserves, and the eradication of predators have allowed deer to increase in spite of the hunters' guns. Deer have become so numerous and so confined to small areas that tree planting projects are ruined. It has been necessary in some instances to prolong hunting seasons and to allow large kills to prevent starvation among game animals.

*Damage by deer.*

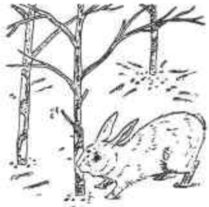
Although complete absence of grazing animals would be a material aid to timber growing, the forester realizes that forestry involves more than producing tree crops. A balance must be struck between tree crops and game crops. A sustained annual yield of all forest values is the aim of true forestry, and sound forest policy demands a sustained annual harvest of those values. Grazing wildlife must be maintained as a forest asset, but must not be permitted to become a forest enemy. Studies to determine the optimum population of wildlife per unit of area will aid in planning game management projects.



*Before and after deer attack.*

Rabbits and mice do considerable damage, particularly to young trees. Rabbits eat the leaders of young conifers and often whole pine plantations have been ruined because of their appetites for these new, tender stems. When young growth is covered with snow, larger trees are often girdled at the snow line. In nurseries mice attack seed beds, destroying both seed and young plants. Moles bore under the beds, digging elaborate tunnels and killing off roots. Poisoning has proved effective against these pests and cyanide preparations have been used. Carbon monoxide gas is pumped into the tunnels to rid beds of moles and mice.

Squirrels often hinder reproduction by eating and collecting seed. Taking no chances on the length of winter periods, they often store up much more seed than they can consume in one season. Squirrel hordes are hunted by nurserymen and seed collectors.



*Snowshoe rabbit at work.*

Porcupines kill many trees and ruin the tops of many more by girdling the trunks. The suc-

*The porcupine feasts on inner bark.*

*Beaver dams flood areas of valuable trees.*

*Damaged repeatedly by cattle.*

culent inner bark is a delicacy for porcupines. Control measures consist of shooting, blocking and destroying dens, and poisoning. Poisoned salt is distributed in rocks and dens where deer cannot have access to it.

Beavers are animals that feed chiefly on tree bark, and they fell many trees, especially aspens, around their ponds. As they are now protected in many States as valuable fur bearers, the loss from girdling and felling trees is usually accepted as of little relative importance. When their dams flood rich lowlands of valuable hardwoods, however, the damage may be of real significance.

West of the Great Plains, cattle and sheep may graze in the forest without serious damage to trees or soil. In the hardwood areas of the East, almost any grazing causes real damage because the stock feed on the most valuable tree species when they can reach them. Cattle and hog damage is most common in farm woodlots, particularly in the South, the Ohio Valley, and the Mississippi Basin. But even in the West, uncontrolled grazing—overgrazing and overstocking with no provision for forage and tree reproduction—may do much damage. Grazing is a justifiable forest practice, if controlled. Like all forest values, grazing should not be exploited to the exclusion of other values. It can be kept in balance with other resources so that the forest will yield its greatest values and influences.

**Protection against Sand Dunes.**

In coastal country or on sandy plains tree growth is often hindered or obliterated by sandstorms and the encroachment of dunes. The establishment of shelterbelts and grasses will aid in preventing sand movements until trees become established. The Landes region on the coast of France is an example of what can be done to hold back the steady march of sand dunes. Barriers were built to check sand movement and grasses and rapid-growing shrubs were planted to hold dunes in place until trees became established.

**Smoke Nuisance.**

Near manufacturing plants or in cities trees are sometimes damaged or killed by smoke or chemical fumes. Around some smelters the conifers particularly have been killed over a considerable radius by sulphurous gases. Ordinarily coal smoke is not very damaging, except when concentrated over a long period of time. Belts of trees along railroads serve as snow fences or windbreaks, and show no serious smoke damage.

**Damage Done by Humans.**

As recreational activities increase and more people visit in the forest the damage done by tourists and campers will become increasingly important. Automobiles and tramping feet soon remove all traces of ground vegetation from small recreational areas. The soil is made compact, and large trees become sickly because water and air cannot reach their roots. Tin cans, papers, and other refuse degrade forest beauty and add no incentive to public interest.

## *SUMMARY*

**Man—as the Forest Enemy.**

To reap the greatest benefits of the forest, man must protect it from the numerous enemies that are constantly attacking it. Man's influence in the past has worked to the detriment of the forest. He has brought about forest devastation through the unwise use of the ax, and through carelessness and maliciousness with fire. He has made insect and disease attacks more severe by importing foreign pests. With an average of 156,000 fires burning more than 41½ million acres of forest each year, with an annual insect damage of 100 to 150 million dollars, and with diseases causing inestimable damage, the need for forest protection is evident.

**Man—as the Forest Protector.**

Organized protection has reduced the damage done by forest fires. Although the number of fires has been increasing, the efficiency of the detection personnel likewise has increased, and large fires are rare when compared with those of 15 years ago.

**The Effect of Forestry.**

Similar advances have been made in insect and disease control. Knowledge of the forest and of its enemies has been expanded through research and experience. Sane grazing practices, improved measures of forest culture and use, and increased public interest in forest preservation have eliminated many former agents of destruction.

**Protection, Cultural Improvements Insure Forests.**

Greater protection is needed, however, if the forests of the future are to supply all that will be demanded of them. Reforestation and cultural improvements must be combined with efficient protection. One fire, one disease epidemic, or one serious insect infestation can reduce to practically nothing the effectiveness of years of tree planting and tree culture.

## Chapter V

# FOREST REPRODUCTION

**Formerly Forests Were Wasted.**

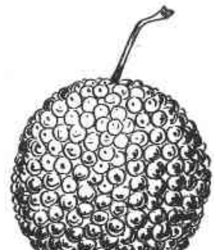
EARLY settlers of the United States cut off timbered areas, because they needed the land for agriculture. At that time there was plenty of standing timber and a small population. It would have been unwise to retain extensive forests where there was need for grain fields, orchards, and pastures. Today we need to retain our present forest areas, and in the future we can use forest products from increased areas. Forests for future use must be provided for in the present. The motorist who waits until his engine begins missing before buying gas may have to hitchhike back to town. If provision is not made for adequate forest reproduction, our forest wealth will vanish with the disappearance of our present forest areas. Thus we see the importance of reproduction as a phase of forestry.

*Sprouts on old stump.*

Trees grow from seeds or they sprout from roots or stumps. Sprout forests being less desirable than seedling forests, little discussion will be given here to sprout methods. Forests may be reproduced by either natural or artificial methods. To understand how reproduction takes place it is necessary to know the characteristics of seeds.

### KINDS OF SEEDS

Tree seeds may be divided into two general classes—heavy and light. Nuts are good examples of heavy seeds. Stones of peaches and plums are also in this class. Seeds of black gum, dogwood, most pines, and maples are in the light group. Sycamores and willows bear very light seeds. Some heavy seeds such as hickory nuts and walnuts are protected by husks or outer coverings. Other seeds such as peaches or plums develop in pulpy fruits, which decay after matu-



*Buttonball of sycamore.*

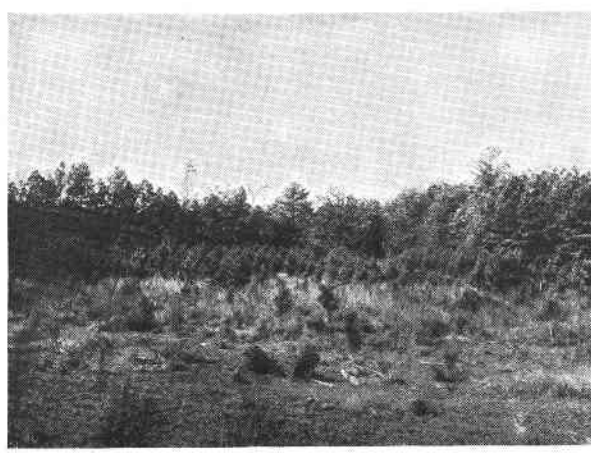
rity. Light seeds may grow in thin husks or in small fruits. Some are attached to wings or tufts of down, which enable them to be carried by the wind.

*Tufted seeds of sycamore.*

## *NATURAL REPRODUCTION*

Natural reproduction is the renewal of the forest in Nature's own way. After selected trees have been cut from an area, seed trees left in the cut-over area or nearby scatter their seed naturally in various ways over the open ground and many seeds sprout and grow into seedlings. In forests that have never been cut over, many seedlings struggle for existence beneath mature trees, waiting for the forest canopy to open up, following the death of the overmature trees.

*Natural reproduction cutting.*



*Natural reproduction on old field, seed trees in background.*

### SEED DISPERSAL

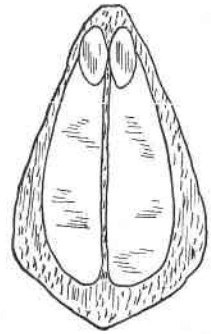
Seeds are scattered or disseminated in five ways.

*Wind* helps a great deal in the process of natural reproduction. Many a youngster has thrown a stick or stone into the branches of a tulip tree in autumn to see the "flying geese." The seeds of tulip poplars are attached to wings which flutter and whirl as they fall, resembling minute flying birds. Pine seeds have delicate, transparent wings, and maple and elm seeds are also flyers. With the help of the wind, these seeds often travel long distances to start new trees. Willows, cottonwoods, sycamores, and some

*White pine cone.*

other trees have tiny seeds attached to tufts of down which, when aided by air currents, carry them great distances like little parachutes or balloons.

*Gravity* assists in dispersing heavy seeds. By the time a heavy hickory nut falls 50 feet, strikes a branch and hurtles off against the trunk of another tree and bounds down a steep hillside, finally rolling to a stop, it may have traveled a hundred yards. Another seed, an acorn for example, falling on hard, level ground, may bound several yards away from the mother tree as a result of the velocity developed in its fall.



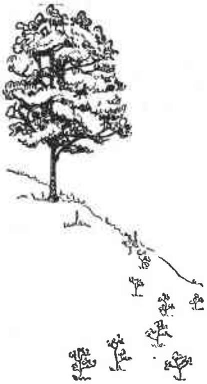
*White pine seeds on cone scale.*

*Water* is a third agent of seed dissemination. Seeds may fall in streams and take long journeys to be left on the shore to germinate. Little streamlets and heavy rains move and spread seeds about.

*Animals and birds* play a part in Nature's seed broadcasting plan. Squirrels are probably the most active animals in tree planting. They not only carry seeds and nuts for long distances, but sometimes plant them. Other small animals also bury and hide nuts and seeds. These may germinate and a great many may grow. Seeds may be picked up in the fur of animals and carried long distances. Jays and woodpeckers carry seeds and nuts to storage places. They let them fall here and there, and many reach ideal spots for germination. Birds also eat berries and fruits containing seeds which are dropped later over a wide range.

*Winged seed of maple.*

*Mechanical* means of scattering seeds is characteristic of some species. The witch hazel is probably the best example of such trees. When the seed container opens, the seeds which have been under pressure in the pod shoot from 15 to 40 feet away. Some beanlike seeds in pod containers are dispersed vigorously when the dried pods split open and twist. Thus Nature does her best to keep trees and plants growing on all the surface of the earth.



*Walnuts roll downhill to establish new trees.*

But dissemination is not the whole problem. Seeds must germinate and grow before we can have forests. Trees not having sufficient vitality

See Seed Testing, pp. 108, 109.

*Locust pods discharge seeds by twisting.*

may produce partially matured seeds in which the embryo (life germ) has not developed. Droughts may cause seeds to be sterile or lifeless. Considering the fact that some trees require 2 years to develop seeds, that only 1 year in 3 or 4 is a good seed year, and that many seeds are not viable (cannot sprout), there are none too many good seeds produced even in a healthy forest. Many of these rot, are destroyed by worms, or are devoured by birds and animals.

After good seeds are scattered they must rest in a spot suitable for sprouting and growing. There must be enough moisture to make the seeds germinate. One soaking is not sufficient—they must have continuous moisture. The seeds must be in contact with damp earth or leaves. The temperature must be right for growth. Seeds are sometimes stored for long periods in cold, running water, which shows that they must have warmth to grow.

### SEEDLING GROWTH

**Good Seed, + Moisture, + Warmth, + Food, = Healthy Seedlings.**

The young tree may live for a while, fed by the seed from which it sprouts, but unless it is bedded on or in soil which little roots can penetrate and which contains sufficient food material, the seedling cannot live. In addition to food and water, the seedling must have light and air.

**Enemies of Seedlings.**

A seedling must struggle constantly for its existence. It may put out its tender leaves too early in the spring and be nipped by a late frost, or it may be killed by the first cold winter. Heavy rains may wash the little plant from its moorings, or it may be deeply covered by leaves and debris and thus killed. Animals may feed on seedlings. Tender shoots are tasty food for rabbits, and squirrels know there is a nut or seed under a new plant. Diseases and insects are ready to prey upon young plants. Aphids live on tender roots and leaf beetles like young leaves.

On the other hand, Nature has some means of protecting these seedlings. They may spring up sheltered by old logs. They may grow under protection of light brush and leaves until they develop strength. Forest leaves protect them

*Aphids on larch.*

from pelting rains and run-off and prevent freezing of soil in winter. Older trees protect seedlings from wind and frost.

*Seedling protected from tramping hoofs.*

This is how forests are reproduced in Nature's own way. Trees, like people, seem to strive to keep their own kind in existence, and it sometimes seems doubtful whether man can improve upon Nature's ways. But natural means sometimes fail to give the forester what he wants, and so man has developed ways of helping nature to reproduce forests. This he should do since it is by man's fire and ax that forests have been destroyed.

**Man Helps Nature.**

## *ARTIFICIAL REPRODUCTION*

### CHOOSING SPECIES

Before seeding or planting forests, careful consideration should be made in choosing the species. It is not necessary to reforest an area with the same species that were removed. A farmer who has been growing corn may find later that he can produce oats more profitably. It would be wasteful under such conditions to continue growing corn. Likewise, the forest owner should choose the species that will best fulfill his requirements. In the first place, he must choose species *adaptable to the climatic and soil conditions of his locality.* The absurdity of planting tropical trees in Alaska, or willows in a desert, will illustrate this basic point. Secondly, he should choose from adaptable species *those best suited to the particular object intended.*

**Corn or Oats?**

**Choosing the Species.**

There are three general objects for which forests are grown:

(1) Watershed and other forms of protection.
(2) The production of wood and other commodities.
(3) Recreational purposes.

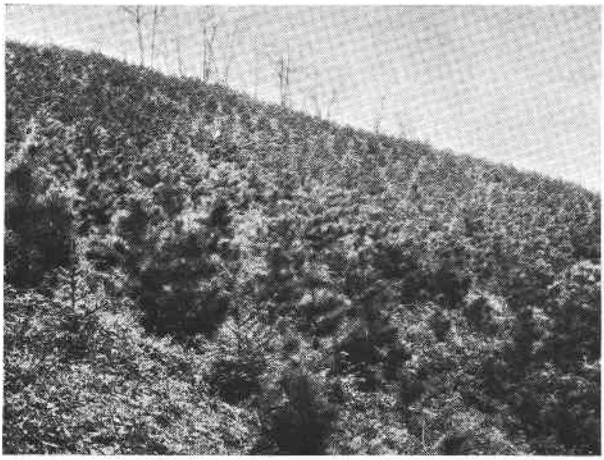
As shown in Chapter II, forests may protect soil from erosion, streams from harmful fluctuation, and farm lands from destructive winds. In order to protect land from erosion, fast growing trees which have strong root habits should be chosen. Fragile, slow-growing species are not

**Forests Help to Control Erosion.**

**Locusts Have Strong Roots.**

**Tulip Poplars Have Heavy Crowns.**

suited for this purpose. A mixture of species may be used. Fast growers with strong roots may be used to start. Black locust is good for this purpose. It makes excellent posts, which may yield a profit for the owner. A species which will bear heavy leaf crops may be introduced later to help build up soil and to retard the force of rain. In choosing trees for erosion control, future products and markets should be considered so that the cost of growing the trees may be borne in part by the products they develop.



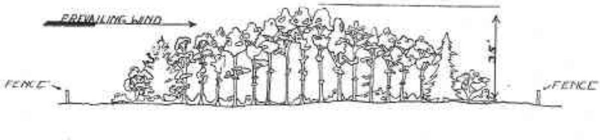
*A young plantation.*

**Forests Protect Watersheds.**

When planting for protection of watersheds any commercial species suitable for the soil and climate may be selected. If the proper species are chosen, the forest will furnish timber or other products after maturity, thus fulfilling a twofold purpose. Trees planted for protection against winds must be windfirm and tough.

**Trees for Windbreaks.**

Trees with good root systems and tall narrow crowns are well-suited for this purpose. Cottonwoods are used extensively in the Prairie States. The Shelterbelt of the Prairie States is composed of many species, each having its own purpose.




*Plan of the Shelterbelt.*

Trees for Beauty.

For forest recreation, any of the better species which will thrive in the locality may be chosen. Some foresters prefer mixed, irregular stands; others think pure, even stands more beautiful. Trees planted purely for beauty, as in cities and parks, usually have full canopies, spreading branches, and heavy foliage. Maples, elms, oaks, and similar species are favorites in temperate climates. Planting for beauty only is one of the less important functions of forestry.

### REASONS FOR PLANTING

Why Plant Trees?

When adequate reproduction of desirable trees can be secured through natural means, there is no need for tree planting. On practically denuded areas where natural reproduction cannot be depended upon, or where weed species have taken possession, planting with commercially important trees is necessary. According to *A National Plan for American Forestry*,[1] there are three principal reasons for tree planting on unproductive land: (1) For watershed protection—to prevent erosion and to regulate stream flow; (2) to meet future wood requirements and to aid stabilization of wood-using industries; (3) to aid in solving the social and economic problems of unwise land use—forest planting provides useful work for the unemployed, utilizes abandoned farm land unfit for agriculture, and increases recreational facilities.

For Protection.

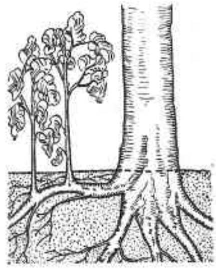
For Wood.

For Social Benefits.

### REPRODUCTION BY SPROUTS

Trees may be grown from seeds or sprouts. Seed reproduction has been discussed in connection with natural reproduction. *Sprouts* grow from stumps of trees that have been killed or cut, and from roots. Root sprouts are commonly called "suckers." Some tree species such as aspen and oak sprout freely, others do not sprout at all. Sprouts may grow from new stumps to a height of 8 or 10 feet in one season. Bruising or cutting roots encourages sprouting and suckering.

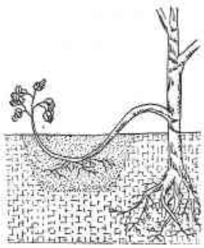
*Layering* is a process of bending and burying a section of a lower branch of a tree, or covering



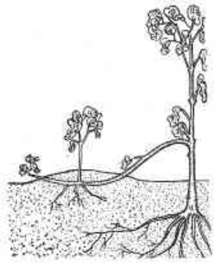
*Root suckers.*

[1] S. Doc. 12, 1933.

the branch with a mound of earth. A branch thus buried will sprout into an upright shoot or tree, and roots will extend into the earth. The connecting end of the branch should then be cut off. If soil is thrown up around the base of sprouts on a low stump, they will often take root. These rooted sprouts may be pulled from the old stump and planted. Some roots will sprout if cut in short sections and covered with soil. Some trees, such as willows, may be reproduced by cutting *shoots* or small branches and planting them in rich, damp soil. The methods of reproduction just explained are seldom used in forestry practice.



*Pit layering.*



*Mound layering.*

There are two methods of artificial regeneration by seed—*seeding* and *planting*. Seeding is sowing the seed directly on land where a stand of trees is desired. Planting is the growing of seedlings in prepared beds and then transplanting them to the field.

## HANDLING SEED

### SEED COLLECTION

**Securing a Crop of Seeds.**

There are commercial seed establishments which grow, collect, and sell seed. Usually, however, a forester can collect and prepare seeds for his needs, if the species he requires are available, cheaper than he can buy them. Special seed-tree plantations are sometimes maintained to produce seed crops only.

**The Seed-harvesting Crew.**

In seed-harvest seasons, the forester in charge of a nursery sends his assistants and temporary workmen to collect seeds. The men with their equipment are divided into small crews and sent out, usually by truck, to points nearest the available seed areas. They go into the woods and gather the seeds by the methods to be described later. At the close of the day, the truck picks them up with their sacks of seeds, and carries them back to the nursery.

**How Seeds Are Collected.**

Seeds may be collected (1) from the standing or felled tree, (2) from the surface of ground or water, or (3) from squirrel hoards. A great deal of climbing is necessary in collecting seeds from standing trees. Climbing spurs, ropes, and special tools, like rakes and pruning hooks, are used for this purpose. If seeds can be gathered on a logging operation, the cost of collecting will be less. Ripe seeds are likely to shatter off when the tree is felled, so that the majority of seeds other than those held in cones must be picked up from the ground. Lakes and streams in forests sometimes facilitate seed collection. Floating seeds may be collected by wind or water currents in quantities to be picked up by the collector.

Squirrels are hard workers and usually store more hoards of nuts, pine cones, and other seeds than they need. A part of such hoards may be taken without depriving the animals of plenty to feed on through the winter. Squirrels climb to the top of tall trees and cut off cones. In late fall unopened cones are often found beneath the trees where squirrels have cut more than they have carried away.

*A forest worker not on the pay roll.*

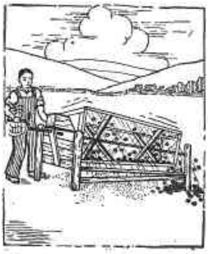
STORING

**Separating Seed from Fruit.**

*Preparation:* Nearly all forest tree seeds need some preparation before storing. Cones, nuts, and fleshy fruits demand different treatment. Small fruits such as dogwood, black gum, and black haw should be dried in the sun or in kilns, and sacked for winter. Larger, fleshy fruits like cherry and persimmon should be soaked in water and stirred until the seeds are separated from the pulp. Then the seeds should be dried for shipping or storing. Walnuts or hickory nuts may be pounded free from husks and placed in the sun to dry. Walnuts may also be run through a corn sheller to remove husks.

Separating seeds from cones is probably the most difficult of seed-preparation processes. Cones should be dried in the sun or in kilns so that they will open and permit extraction of seeds. Sun heat is usually sufficient to dry and open cones, but they must be kept on canvas or frames to prevent ground moisture from retarding the drying process. They must be covered or taken indoors at night and protected from rain. Because of the care involved in sun-drying, it is better to build drying rooms or kilns if great quantities of seeds are to be handled.

*Cones open when dried.*



*Seeds are shaken out and dewinged.*

As cones dry, many of the seeds fall out. To get the remainder the cones should be put into shakers and agitated until all seeds are released. Shakers may be made from frames covered with wire mesh. They are turned by machinery or by hand and the seeds are caught on canvas below the shakers. The wings are removed (most of these are separated from seeds in the shaking processes) by rubbing through sieves. They may be further cleaned by fanning out the chaff, after which seeds are ready for shipping, storing, or planting.

**Storage Requirements.**

*Storage methods:* Seeds are sometimes stored 2 or 3 years. All tree seeds cannot be stored under the same conditions. Some seeds are well preserved and retain their viability (ability to sprout) at given temperatures, while others rot under the same conditions. Likewise, different seeds require different moisture content for preservation. Pine, hemlock, and maple seeds require dry atmosphere, while walnuts, chestnuts, and acorns require damp, cool storage. The nuts will shrivel and dry and the embryo will die in warm, dry storage. Some seeds when exposed to natural weather changes lose fertility (embryo dies) after a time. Seeds which have hard covering like walnuts, hickory nuts, and hackberries may be stored in layers in moist sand. This helps to soften the hard shell so that the seeds can sprout quickly when planted.

**Temperature in Storing.**

**Moisture in Storing.**


The best plan is to provide suitable storage conditions for each kind of seed. To prevent humidity (moisture) changes, small seeds should be sealed in cans, bottles, or carboys. Large seeds should be put in cool bins protected from excessive changes in temperature and moisture. Cones may be kept in dry, open-air storage protected from mice and insects.

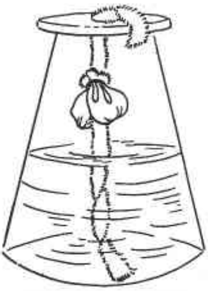
## SEED TESTING

**How "Good" Are Seeds?**

Before seeds are planted, they should be tested for viability. There are many types of seed germinators on the market. One way to test small seeds is to place a number of them between large sheets of blotting paper or heavy cloth,

**Blotter Method.**

which are kept moistened in a warm room. After the seeds germinate, those which have not sprouted are counted and compared with the good ones. In this way, the percentage of viability can be obtained.

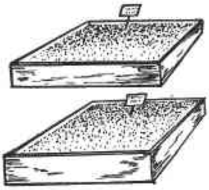


*Home-made seed tester.*

Another form of testing apparatus may be made by partially filling a glass jar with water. A piece of flannel cloth is suspended from the top of the jar and extended into the water. This forms a wick which carries moisture up to the seeds which are placed in small, flannel bags and tied to the wick inside the jar. Several different species may be tested at the same time. The percentage of viability is determined as in the blotter method.

**Testing by Planting.**

Large seeds are best germinated in soil under natural conditions. Small beds are prepared and the seeds planted as in actual seeding practice. After they germinate, they are taken up and counts are made. In cold weather, or to insure better protection, a mixture of loam and sand may be placed indoors, either on the floor or in 4-inch trays, for seed tests. Care should be taken to keep the room at proper temperature (fluctuating between 50° and 80° F.) and the soil properly moistened.



*Testing beds.*

**Why Test Seeds?**

Tree seeds rarely exceed 90-percent viability, and range down to zero. Tree seeds may lie dormant for 60 to 90 days and then sprout; hence tests on all seeds should be made well in advance of planting seasons. The percentage of viability of seed stock will be a factor in determining the amount of seed to plant.

## DIRECT SEEDING

**Advantages of Seeding.**

Sowing forest seeds broadcast directly in the field eliminates the work of preparing seedbeds and the transplanting necessary in nursery practice. This is the one advantage over nursery practice. Direct seeding may be done by seeding the entire area or by spot seeding. Partial or spot seeding is designed to start seedlings in parts of a broken stand where there is no growth, or for seeding in spots or rows in the open.

**"Spot" Seeding.**

**When to Sow Seed.**

Seeds that ripen in the spring or summer should be sown in early fall if it is not too dry.

Seeds maturing in the fall may be planted immediately to lie dormant all winter. However, if there are facilities for properly storing the seeds, they should be kept through the winter and sown early in the spring so that they may have time to develop sufficient root systems to support them throughout the dry months. Seeds that have been grown locally give better results than seeds grown under different climatic and soil conditions.

**Disadvantages of Seeding.**

Birds and small animals which eat the seeds constitute probably the greatest hindrance to direct seeding. Mice, moles, and chipmunks are efficient in finding seeds which have been planted. Sometimes a poisoning campaign before seeding will increase the chances for success; or seeds may be treated with red lead. Poor seeds rarely germinate when sown broadcast; but they may sprout in nursery beds where conditions for germination are better.

**Broadcast Seeding.**

Small seeds are sometimes sown broadcast on late snows. When broadcasting seeds in dry weather the chances for obtaining a good stand are improved if the ground is plowed or harrowed. Seeds may be broadcast by machines or by hand. Seeding by hand has proved more practical. After seed is sown on prepared ground, it should be harrowed in.

**Drilled.**

If the ground is not too rough, the seed may be drilled in lines with a horse-drawn planter. Furrows or strips may be plowed about 4 or 5 feet apart and seeds planted along the fresh furrows.

**Spot.**

Another method is to dig or loosen the ground with special tools in spots about a foot in diameter where the seed is to be sown.

**Hole.**

Large seeds may be planted in individual holes.

**How Much Seed?**

The amount of seeds to be sown varies with species, condition of seeds (more old, weak seeds are required than fresh, strong ones), condition of soil, and stand desired. The amounts required for full and spot seeding are given in tables prepared by foresters.[2] For direct seeding, the weights vary according to species. White oak may require 750 pounds per acre while western

[2] *Seeding and Planting in the Practice of Forestry*, Toumey and Korstian, pp. 242-245.

red cedar requires as low as 1½ pounds, because the seeds are so small and light.

Spacing.

Spacing of plants from broadcast seeding depends on amounts used per acre. Planting spots should be 3 to 6 feet apart in squares or in rows. Close planting results in tall, straight trees, but thinning is generally necessary after the trees grow to sapling sizes.

Protection of Seedlings.

The protection of small seedlings from animals is necessary. A young plantation should be checked carefully and upon evidence of damage, rodents or animals should be excluded. Deer or rabbits can totally destroy a young plantation in a short time. Domesticated animals likewise can ruin plantations; a herd of sheep or goats can destroy a whole plantation in a few hours.

Seeding versus Planting.

The advantages of direct seeding are: Saving of time by use of seed rather than seedlings; saving of money which would be spent for seedlings bought from nurseries, or the outlay and expense of managing a nursery; trees that survive are hardy. The disadvantages are: More and better seed is required; better preparation of ground is necessary; longer time is required for complete stand because of poorer germination, destructive agents which attend direct seeding, and poor growing conditions. Because of these disadvantages, no very great success has been obtained from direct seeding.

Planting Favored.

## PLANTING

Planting seedlings is practiced much more extensively than direct seeding. It involves many of the phases of direct seeding and may include the varied functions connected with nursery practice. Seedlings may be taken from forests where they have developed naturally. Such seedlings are called "wildings." They can seldom be found in sufficient quantities for planting. Planting stock may be purchased from commercial nurseries or may be grown in nurseries of the tree-planting agency. In Europe where tree planting has been practiced longer than it has in the United States, large private forest tree

*Special shovel for lifting wildings.*

Planting Stock.

nurseries have been developed, and the publicly owned nurseries are principally for research.

**Forest Nurseries.**

**The Seedling Crop Must Be Grown.**

In the United States, seedlings and transplants are grown largely in State and federally owned nurseries, but when commercial establishments have been developed to the point where they can furnish the required stock at prices suitable for reforestation, foresters probably will purchase seedlings rather than grow them.

**Nursery Sites Must Be Carefully Chosen.**

*Wind protection for nurseries.*

*Nursery practice:* Five major factors must be considered in establishing a nursery—climate, soil, water, transportation, and labor. Nurseries should be located in the climatic region in which the trees are to be planted. Nurseries may be protected from winds by locating them on leeward sides of high forests. Fences and walls also help to regulate the effects of climate. For the first season, seedlings are protected against wind, sun, and frost; but the protection is gradually reduced until the trees become hardy enough to plant.

**What Kind of Soil Is Required?**

**Good Drainage Necessary.**

**What Should Be the Condition of the Soil?**

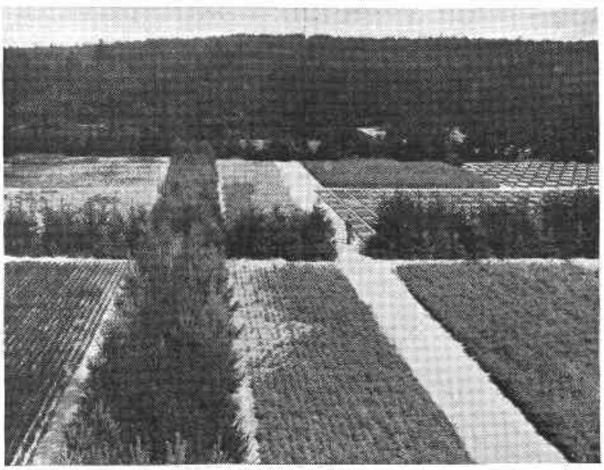
**Loose Loam Best.**

The *soil* upon which seedlings are developed must conform to specific requirements. The chemical components of soils may be changed by treating with fertilizers, but the basic conditions are rarely changed. Soils that are excessively acid or excessively alkaline must be avoided. Since plant beds must be made level or nearly so, level or gently sloping ground must be chosen. Low, flat areas that do not drain readily are unsuited for nursery practice. A successful nursery cannot be built upon heavy, clay soils. Such soil drains poorly, freezes and heaves badly, bakes and cracks in dry seasons, is difficult to work, and is too cold for proper germination. On the other extreme is a light, dry soil. Such earth cannot hold moisture or heat and is difficult to build up by use of fertilizers. Sandy loam is recommended. Soil that will support good growth of weeds or grass is basically good enough for nursery work. Such soil should be deep—free from rock or hardpan near the surface—and well drained.

**Is Water Necessary?**

*Water* must be available for use on seed and transplant beds. Rainfall cannot be depended upon entirely, and irrigation is nearly always essential. Enough water must be available for the form of irrigation selected. This may be subirrigation (leading water under the surface in porous soil pipes), surface irrigation (running water through ditches and furrows to beds), and overhead irrigation (conducting water through pipes and sprinkling automatically on the surface of the beds). Small nurseries may be watered by carrying water and sprinkling by hand. A great deal of water may be necessary at a nursery site for preparing seeds, for livestock, and for domestic purposes.

**Good Water Supply.**



*A nursery showing natural windbreaks, plant beds, transplant beds, roads and passways, and planted windbreaks.*

**Moving Seedlings from Nursery to Field.**

Nurseries designed to grow seedlings for an extensive area must have some means of *transportation* to distribute their product. Seeds, fertilizers, and supplies must be brought in. Pack animals and wagons are too slow and antiquated. The best locations, therefore, are those near railroads or highways.

**Seasons of Work.**

In the spring and fall, considerable *labor* is necessary. Since this labor is seasonal, full-time workers cannot be kept on the site. It is best to develop nurseries near villages or in sections where laborers, at relatively low wages, may be procured when needed.

**Available Labor.**

**What Size Nursery?**

The size of the area required for nurseries depends upon the output and the species desired. It has been found that trees to plant a thousand acres of forest annually can be grown in a nursery of from 1 to 3 acres, depending upon species, age of planting stock, and method of planting. An area twice the size of seed and transplant beds is required in order to have adequate space for roads and buildings, and footpaths.

No Weeds Wanted.

*Preparing soil:* Seedbeds should never be made in soil that has recently supported sod or other wild herbage, as such vegetation contains too many insect larvae and weed seed. Soil preparation had best be made slowly. Stones, stumps, and roots should be removed, all vegetation plowed under, and agricultural crops sown. To increase soil nitrogen, leguminous crops such as peas and soybeans should be grown and plowed under. Sites chosen for beds may well lie fallow for a season while all weed growth is kept down. Such sites should be worked and cultivated until the ground is thoroughly loose. Depending on the composition and amount of humus, some soil types require more preparation than others.

*Nitrogen nodules on soybean roots.*

Soil Crop Rotation.

Commercial Fertilizers.

It may be necessary on weak soils to spend time and money building up humus and correcting chemical deficiencies. This may be done by crop rotation, application of manures and humus, and by use of commercial fertilizers. Because of the added cost to the cultural process, fertilizing materials should not be used until there is evidence that these elements are lacking in the soil.

Nursery Beds.

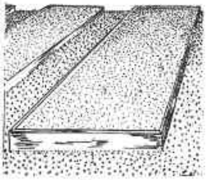
Laying Out Seedbeds.

Plenty of Space Needed.

*Seedbeds* are those in which the seeds are sown for germination. *Transplant beds* are areas prepared for receiving seedlings which have been grown in a seedbed and which require more space for further development. Seedlings which have been "lifted" from seedbeds and transplanted, are known as *transplants.* Seedbeds and transplant beds require practically the same preparation. After the composition of the soil is made suitable for beds, it is worked thoroughly to break up lumpy soil. Beds are usually laid off about 4 feet wide in order that weeding and cultural work may be done from either side. Principal roads, wide enough for teams, should be left so that water and frames can be hauled near the beds. Paths wide enough for a person to walk without stepping on the plants should lead along all the beds.

Drainage.

Beds may be flat if drainage is good, but on soils that retain water, a little slope may be provided by giving the bed a 2-inch crown. Most beds are raised 2 or 3 inches above the bordering paths. Sometimes they are surrounded by curbing made from treated 2 by 4 or 2 by 6 inch timbers, which helps to hold the soil and to keep out rodents. Some beds are made level with the ground surface, and where surface irrigation is used they are an inch or two below ground level. After they have been thoroughly cultivated seedbeds should be rolled in order to make the soil compact.



*Curbs.*

Sowing by Machine or by Hand?

*Sowing:* Seeds are usually sown broadcast. Broadcast seeding results in more plants per unit area. The amount of seed to sow depends upon the species and soil. Tables, indicating proper amounts of seed, have been prepared.[3]

Sowing the Seed.

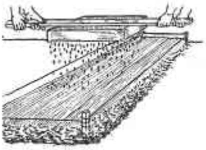
In broadcasting, seed may be sown by hand or by machine. Hand sowing has generally proved to be the better method, but an inexperienced man is apt to distribute seeds unevenly by hand. Seed counts should be made on small, marked areas to check the quantity sown. Seeds that are not readily visible may be mixed with red lead so that the quantity sown may be checked and even distribution may be obtained. It is almost impossible to get an even distribution of seeds when there is a wind blowing.

Seed Counts.

Quantity of Seed.

Firming the Soil.

After seeds have been sown, it is a good plan to roll the beds with a light roller so that the seeds will not blow away or be moved in the covering process. Firming the bed also aids in germinating seed. Small seeds should be covered lightly with sand. Large seeds such as walnuts or acorns may be covered deeper with soil. Sand may be applied to beds by sifting or scattering it with a shovel. In large nurseries mechanical sanders drawn by manpower or horsepower may be used. Sand prevents surface-hardening, which often hinders plant development.



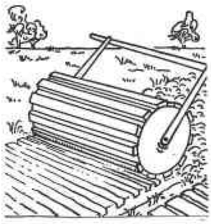
*Sander.*

Covering.

In small nurseries seeds may be drilled. The seedbed preparation is the same as for broad-

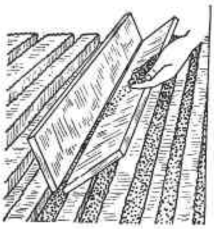
[3] *Seeding and Planting in the Practice of Forestry:* Toumey and Korstian p. 316–319.

Drills.



casting. The drills are made across the beds from 2 to 6 inches apart depending on the kind of seed to be sown. Drills may be made by drill markers or rollers. Large seeds, such as walnuts or chestnuts, should be planted in deep drills about 4 inches apart. Small seeds should be in shallow, broad drills 2 inches apart. Seeds are distributed by hand along the drill. Care should be taken to space them as uniformly as possible.

Scattering Seed.



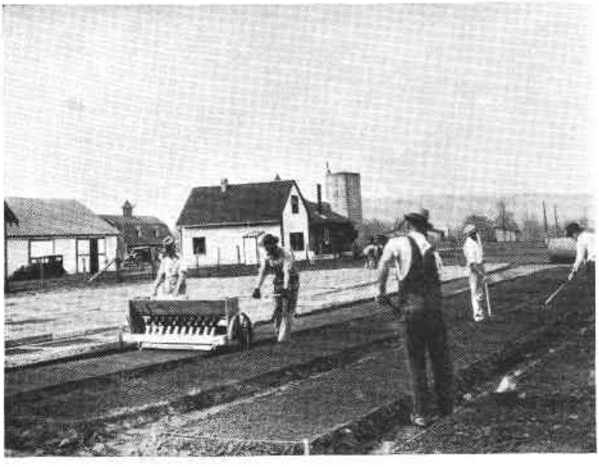
A seeding trough may be used to facilitate even distribution, in which case seeds are distributed by hand in the trough and then allowed to fall from the trough directly into the drill. There are a number of seed-drilling machines on the market. These are practical in large beds where the drills are long and widely spaced, but for small beds and narrow drills hand seeding is the better method.

Closing Drills.

Seeds are covered in various ways and at different depths, by closing the drills or scattering loose sand over the bed. Covering material may be spread over large seeds with a hoe, but for light seeds a light rake or a hand roller devised for covering is used.

Mulching.

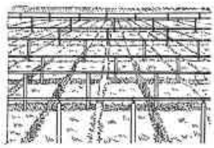
In order to prevent excessive drying, damage by beating rains, and ravaging by birds, the beds should be covered with pine branches, leaves, straw (free from seeds), burlap, or canvas. This mulch should be removed as soon as the seeds germinate.



*Preparing and planting seedbeds. The machine is a sander.*

Watering.

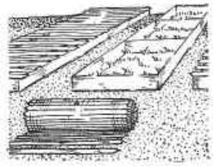
*Care of beds:* After seeds germinate, the beds require constant care. In the first place, they must be kept moist. Failure to water beds properly may result in partial germination. Seedlings should be watered before withering and drying set in. Sprinkling is the best method for small plants. Thorough waterings give better results than frequent sprinklings on seedlings that have developed a degree of strength. Too much watering may cause root-rots, damping off, or other diseases which damage nursery stock. Plants which have had too much water are weak and overgrown, and may be too fragile for transplanting.



*Overhead irrigation system.*

Shading Lath.

Coniferous seedlings require partial shading from hot sun and at times complete shade is necessary. They are usually shaded with laths or thin strips of lumber held on frames over the beds. These are usually held together by wire and may be rolled up for handling. Brush and branches, and sometimes scrim or cheesecloth screens are used. To protect against flying insects, birds, and rodents, wire screening is sometimes used to cover beds.



*Shading lath.*

Thinning.

Scissors or Shears.

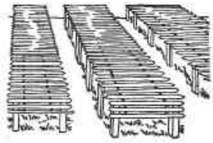
Five or six weeks after seed germination, seedlings should be thinned if they are growing too close together. They may be pulled by hand, but if the soil is so compact that plants nearby are displaced by pulling, the seedlings to be removed may be clipped out with shears. Modern nursery practice, if properly exercised, should eliminate necessity for thinning.

Root Pruning.

The root systems of seedlings may be strengthened and developed by pruning them while in the bed. This is done by cutting off the roots 5 to 8 inches beneath the surface of the bed with special root-pruning machines.

Winter Protection.

Winter protection of beds seeded in the fall requires mulching with burlap or straw. Burlap is better in climates which are not too rigorous, because mice and moles often make winter homes in straw mulch, and damage the plants. Beds left uncovered may freeze and thaw so much that seeds are heaved from the ground before they germinate. Covering should be removed when



*Protecting lath.*

germination begins. First-year seedlings in beds should be protected in like manner. In sections where snow may be heavy lath screens may be placed over the beds. Enough snow will filter through the lath to protect the trees, but the burden of snow weight will be reduced. Where there are many weather changes and heaving freezes, heavier mulches of straw or other material should be used.

**Why Transplant?**

*Transplanting:* Seeds are sown in seedbeds in sufficient quantity to produce a reasonably dense stand. When they become large (after their first to third year), they may be transplanted to other beds because better development of stock is desired or because there is no present demand for them. Efforts should be made to transplant trees to the field before they become too large to be valuable as forest-planting stock.

**When to Transplant.**

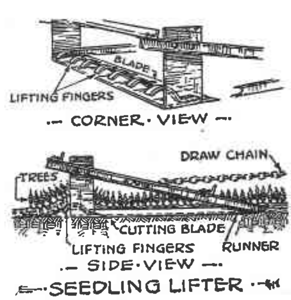
**"Rushing the Season."**

Seedlings are usually transplanted in early spring. In the North, where snows stay on late, black soil may be sown on the snow over beds to hasten melting. A bushel of soil sown on a thousand square feet of snow may hasten melting by 10 days to 2 weeks. This permits nurserymen to start work earlier and gives the transplants a chance for early growth.

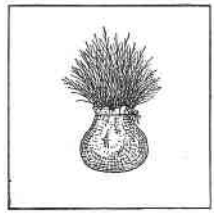
**Lifting Seedlings.**

**Machine Lifters.**

In lifting seedlings from beds, care should be taken to retain some earth on the roots and to protect them from drying. If seedlings are pulled directly from the ground, the greater part of the fragile, hairlike roots are stripped off. The plants should be lifted from below. They may be removed by using one of the various designs of shovels or lifting forks. In large nurseries, lifting machines may be drawn by horses

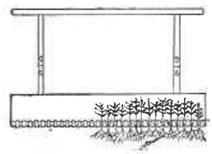



or tractors. These have blades which cut beneath the seedlings and lift them on rods. They are then shaken free of excess dirt, and bundled or packed for handling. Precautions must always be taken to protect the roots from the sun and from drying winds. Ten or fifteen minutes exposure may kill so many rootlets that the plant cannot be reset successfully.

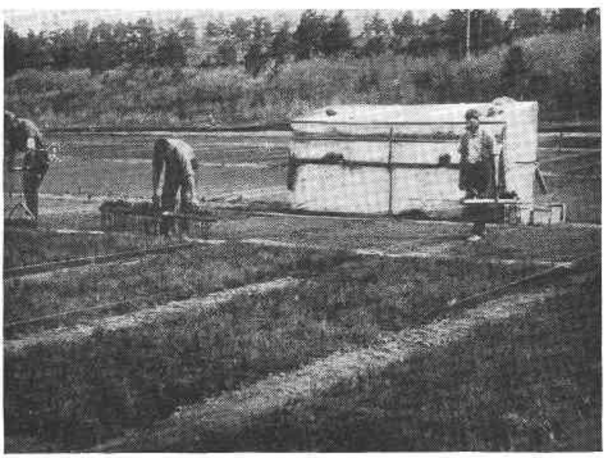


**Transplanting.**

Transplant boards are used to speed up operations in transplanting seedlings to nursery beds. The seedlings are strung in notches cut in a 6-foot board and carried to trenches made in the transplant beds. The boards are placed along the edge of the planting trench with the roots of the plants hanging free in the trench, soil is packed around the roots and the board is removed, leaving a row of trees evenly spaced in the bed.



***Plants strung on transplant board.***

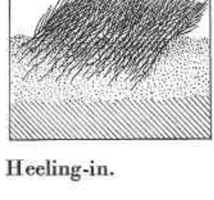


***Transplanting nursery stock. Notice transplant boards, hand trencher, and seedling shelter.***

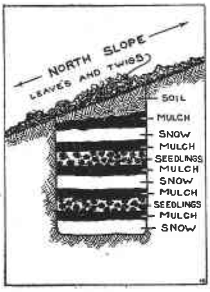
Sometimes "dibble" holes are made with dibble sticks or special planting hoes. In this method, each plant is set separately. Plants should be watered soon after transplanting and kept moist by the irrigation system used to insure proper growth.

**Dibbles.**

*Storing:* Seedlings sometimes are lifted months before planting. They are "heeled-in" or stored until the time for planting or shipping. Heeling-in is a method of storing bunches of seedlings by covering their roots with dirt to keep them living until time for planting. They may be stored in



**Heeling-in.**




*Snow pit for storing seedlings.*

cellars, in sheds, or in the open. They may also be stored in snow pits.

Snow pit storing is done as follows: Pack snow into the bottom of a pit, preferably on a north slope. Cover the snow with leaves or straw, then with a layer of earth. Place the bundled seedlings in a layer and cover with earth and mulch. Pack snow on this and protect with brush. Young trees may be kept in such pits for months.

**Cold Storage.**

Stored seedlings must have ventilation and regulated moisture. When they are in dry storage, some method of watering the roots must be used. Cold storage in commercial storage houses or in storage houses constructed on the nursery site has proved successful.

### PLANTING METHODS

**Field Planting.**

Field planting is done in the spring and fall when the ground is moist. Many methods are followed, depending upon the species, soil, topography, and custom. For best results, seedlings should be planted with their roots in a natural position. They should be set in loose, rich soil. Such conditions cannot always be met, however, and most seedlings have to struggle against adverse growing conditions. A tree should be planted deep enough to prevent drying of the roots, but not deep enough to cover too much of the stem or any of the branches or leaves. A good rule to follow is to plant a seedling slightly deeper than it stood in the nursery bed. The method to use should be decided upon after consideration of these factors.

**Natural Root Positions.**

**Depth.**

**A Good Rule.**

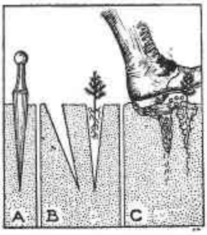
**"Dibbling."**

*Dibble planting* is the fastest method and may be very successful in some soils, but is seldom used in this country. The percentage of growing stock surviving in a dibble-planting operation is less than for some other methods. A dibble is a tool for making holes in the ground for tree planting. There are several different varieties of dibbles; some are of wood, some of iron, and others are of wood with steel points. The better ones have handles attached that make them easier to use.

*Types of dibbles.*

**How It's Done.**

In dibble planting, the workman makes a hole in the ground about 8 or 10 inches deep. The opening may be made larger by pushing the dibble from side to side. The roots of the seedlings are inserted to the proper depth and the dibble forced into the ground again an inch or two away from the plant. This closes the first hole and firms the soil around the roots of the inserted plant. The last hole may be closed at the top by the heel of the workman. This prevents drying of the ground near the rootlets of the newly set seedlings.




*Steps in dibble planting.*

**A Planting Bar.**

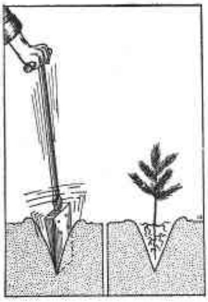
In harder soils, a long-handled dibble (3½ or 4 feet long), with a foot rest attached so that it may be forced into the ground by pressure of the foot and weight of the body, may be used. Sometimes hard ground is prepared previous to planting by plowing and cultivating. This makes hole planting much easier.

**Disadvantages of Dibble Planting.**

Hole planting has four disadvantages.

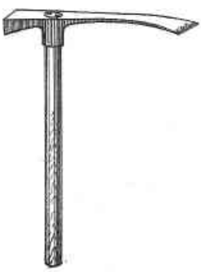
1. Roots of plants are confined to a small opening and have unnatural position.
2. The earth around the roots is packed by the dibble so that it is difficult for roots to penetrate adjacent soil.
3. It is difficult to close the hole completely. Many rootlets do not contact soil, consequently the plant is lost.
4. It is almost impossible to plant by dibble in hard, stony ground.

The one advantage of this method of planting, where it is feasible, is its speed, which reduces planting costs.



*Using a slit planting tool.*

For *slit planting,* like hole planting, there are different kinds of tools. Ordinary or special spades may be used. Slits are made, the plants inserted, and the openings closed. This method pushes the roots into a single plane, which is unnatural. Whereas dibble planting is a one-man job, slit planting requires two men for the operation, one man making the opening and another carrying and inserting the seedlings.



*Planting hammer.*

*Hammer planting,* a one-man operation, is done with a special short-handled tool, which is a combined hoe and hammer. The planter digs a hole and prepares it for planting. He places and holds the tree with his left hand while he rakes the soil around the roots with the hoe blade, then firms

Steps in Tree Planting.

(1) *Digging the hole.*

(2) *Setting the tree.*

(3) *Packing earth around roots.*

(4) *Tamping.*

the soil around the roots by tamping it with the hammer. Under this method the roots are arranged in natural positions, which is impossible in the methods formerly described. A short-handled, light grub hoe will serve as a planting tool, the back of the hoe being used as a hammer.

The most practicable method of planting for other than sandy soils is the *grub hoe* or *mattock* method. This may make the actual planting process more costly, but considering the different kinds of soils, the roots, stones and logs on areas to be planted, and the steep slopes with which it may be necessary to deal it is the best general method, as it allows proper position of roots. The final cost per acre of growing plants should be the basis for estimating planting costs.

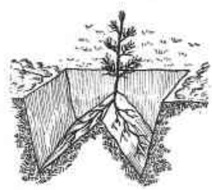
Planting crews are made up of two-man units. One man with the grub hoe or mattock digs the holes and prepares the place for planting. He may loosen the soil a little in the bottom of the hole if it is too hard, or he may cut any undesirable growth near the planting hole. He is followed by the planter, who carries the seedlings in a pail or a box. In any method, the seedlings must be carried in a container in which the roots may be kept moist. Special baskets or canvas receptacles are on the market for use in planting. The planter places the seedlings in the hole, brings the soil around the roots which are in natural positions, and firms it partially by hand, finally pressing it around the plant with his feet. He may carry a tamping mallet with a steel blade fastened on one end which he uses to scrape the soil back into the hole. He tamps it with a few light strokes of the mallet.

*Trench planting:* In sandy soils, like those of the Lake States country, furrow or trench planting is largely used. The furrows are made by specially designed plows drawn by tractor or horse power. The trees are planted in the furrow by use of dibble bars or planting spades such as formerly described.

If the field soil is extremely poor or dry, *ball planting* will be more successful than naked-root planting. Transplants are lifted from beds with a ball of the bed soil adhering to the roots. Care must be taken to keep the soil from falling from the roots. Planting in individual containers made of material which disintegrates rapidly such as cardboard or pressed clay is a form of ball planting. When planting balled stock, bigger holes must be dug; lifting, handling (often the soil around the roots must be wrapped in burlap, paper, or set in cups), and transporting must be done with extreme care. It is evident that the cost of this method would prohibit its practice except in unusual cases.

**"Wedge" Planting.**

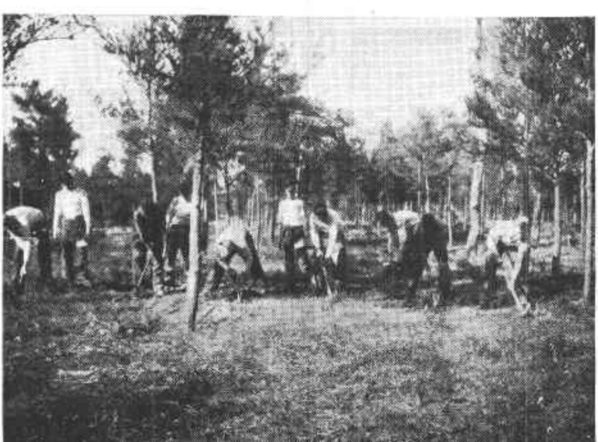
The wedge system of planting, which is being tried experimentally in this country, appears to insure high survival of planted stock. With this system, a wedge-shaped mound of earth is left in the center of the planting hole, and the tree roots are spread on each side of the inverted "V" wedge. The hole is made with a shovel or spade, as shown in the sketch. Although it takes about twice as long to plant trees by this method as it does with some of the commoner methods, the roots have a better chance for development.



*Roots spread on wedge.*

Transplanting machines are coming into use, especially on level, sandy soils. They are drawn by horses or by tractors. A trencher opens the soil, and two men riding the machine place the seedlings at the proper depth. The dirt falls back around the roots of the plant, and packing wheels firm the soil on both sides of the transplant as the machine passes. Attachments have been

*Planting machine in action.*



*A planting crew in action. The men in the front line dig the holes and prepare the soil for the plant. The men in the back line set the seedlings.*

**For Level, Loose Soil Only.**

designed to lift the trencher and planting apparatus out of the ground when obstructions are met. Machine planting promises to lower the cost of forest reproduction in some sections, but this method has as yet achieved little success, and most planting is still done by hand.

**Hand Planting Most Dependable.**

### *SUMMARY*

When natural reproduction is inadequate, artificial reproduction is used. Such regeneration may be accomplished by direct seeding or by planting. The latter method is generally more practicable than the former. The fundamentals of nursery practice and the many methods of planting have been developed by foresters so that the process of reforesting may be done better and at less cost.

Chapter VI

# SYSTEMS OF TIMBER MANAGEMENT

SILVICULTURE is the science and art of establishing and managing forests to get the best timber products. Practices to obtain continuous timber crops are called silvicultural systems of management. The systems which may best be used depend upon the stand of timber, the product, and local conditions.

**Silviculture.**

When timber is cut indiscriminately, with no thought of reproduction or of plans for sustaining the yield, lumbering becomes a mining process. But when a desirable silvicultural procedure is applied in handling timber stands, then good forestry is practiced and lumbering becomes the harvesting of continuous crops of trees.

**Crops of Trees.**

## *STANDS*

Before studying the different cutting systems one should have a general knowledge of stands, types, and classification of forests.

*Stand* is a term applied to a particular part of a forest which has definite characteristics. Forests may be divided into stand classifications by con-

**Stand Classes.**

***A pure stand of aspen.***

sidering two factors, species and age. There are two general classifications: *Coniferous* (generally called softwood) and *broad leaf* (commonly known as hardwood) stands.

**Coniferous and Broad-leaf-Forests.**

Coniferous stands are made up of cone-bearing trees such as pine, hemlock, and fir. Practically all conifers are evergreens. Broad-leaf stands are composed of the large number of tree species having broad leaves instead of needles. These, with a few exceptions, are deciduous (trees dropping their leaves in winter).

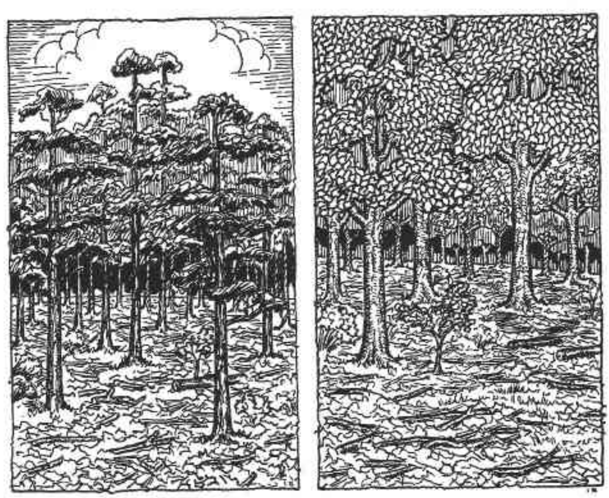
**Pure Stand.**

**Mixed Stand.**

When 80 percent or more of the crop trees in a stand are of one species, as pine or beech, then it is said to be a *pure stand.* If less than 80 percent of a stand is of a single crop species, it is a *mixed stand.*

*A selection stand.*

*Classification of stands by age:* If trees are of practically the same age, the stand is said to be *even-aged.* Most forests contain trees of all ages, from the seedling to old trees. These may be dominant, codominant, intermediate, or suppressed trees, as defined in the first chapter. Such a stand may be called *uneven-aged, all-aged,* or *selection.*



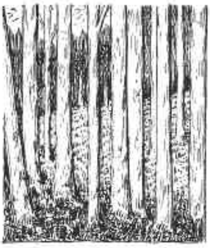
Left: *Even-aged coniferous stand.*
Right: *Even-aged hardwood stand.*

**Origin Classification.**

Forests are sometimes classified according to their origin. Trees grow either from seeds or from roots or stumps of other trees. A forest grown from seed is called a *seedling forest,* and a forest originating from sprouts or suckers is called a *sprout* or a *coppice forest*. Seedling forests grow a little slower, but the trees usually have better root systems after they are matured, and make a much better forest than a sprout forest. The stand growing from roots or stumps of old trees grows fast at first, but when the old root rots, as often occurs, the new tree has a poorly developed foundation of its own. The coppice forest produces fair poles, posts, and cordwood, but it is ordinarily not valuable for lumber.

Refer to p. 105.

## *CLEAR-CUTTING SYSTEMS*



*Even-aged mature stand.*

In mature, even-aged stands it is often good practice to cut all the merchantable timber from the area in one logging operation. This type of cut is less expensive than removing the existing stand in several operations, since approximately a fourth of the cost of large-scale logging is in moving and setting machinery, building roads, skidways, camps, and buildings.

Over a small area where trees from nearby forests furnish seeds for reproduction on the cleared portion, obtaining reproduction should not be a problem. However, character of the soil, location of seed trees, wind, and species must be considered. On larger areas it is usually necessary to reforest artificially. This can seldom be done satisfactorily by direct seeding, because of the many hindrances, such as poor germination, birds and rodents, and droughts. It is a more dependable practice to plant seedlings or transplants. This method, although costing more, eliminates much of the uncertainty, permits choice of stock, and provides proper spacing.

See Seed Trees, p. 129.

**Reproduction Problems.**

**Planting Is Dependable.**

### SHELTERWOOD METHOD

**Cutting Part of Stand.**

When local conditions permit, a modified removal plan may be used. One system of partial removal of the merchantable stand is called the *shelterwood method* of cutting. This method of removing the stand can be used successfully in even-aged stands that are wind-firm enough to prevent windfall after a part of the stand has been removed, and in which the species of repro-

*Pure stand of second growth shortleaf pine on the Arkansas National Forest.*

duction desired is so tolerant that seedlings can develop under the shade of sheltering trees.

**The Opening Cut.**

The logging operation, planned according to the shelterwood method, is begun by cutting 20 or 30 percent of the trees from the area. The remaining trees, with more space and light, have a tendency to produce better seed crops. The spaces opened by the first cutting offer good areas for germination of seed and development of seedlings. This first cut is called the *opening cut* or *preparatory cut.*

**The Seed Cut.**

*Reproduction should be well established after the second cut.*

Six or eight years after the preparatory cutting a further cut, sometimes called a *seed cut*, may be made. About half the original stand is often removed at this time. This cutting permits the establishment of new seedlings so that reproduction may be completed. Seedlings start in the new openings, and more light is afforded the reproduction already on the ground. The trees that remain bear more seed and protect the young growth from excessive sun. Within 6 or 8 years more the remainder of the stand may be cut off in the *removal cutting.* The entire stand may thus be removed over a period of approximately 15 years, and a strong crop of seedlings started on the way to produce a new forest which at maturity will have even-aged characteristics.

**The Removal Cut.**

### STRIP METHOD

Cutting a Strip at a Time.

Another plan for cutting to obtain natural reproduction is called the *strip method.* The procedure under this method is to cut strips through the entire stand. The strips should extend at right angles to the direction of the prevailing wind so that the seeds may be carried from the remaining trees to the cut-over areas. After several years the strips may be widened by cutting other strips adjacent to them. After a series of successive cuts the entire stand will have been removed.

*Clear-cutting by the strip method.*

The shelterwood and strip methods of cutting are not as popular in America as in Europe, where timber crops are managed more intensively. The time is coming when timber operators will be obliged to provide for restocking cut-over areas; then these methods may be practiced more widely.

### SEED TREE METHOD

"Mammy Trees."

Natural reseeding of some species may also be obtained satisfactorily in clear-cutting operations by leaving seed trees scattered throughout the area which has been cut over. Seed trees are known also as mother trees, and are sometimes called "mammy trees" by the Southern Negro. These trees may be left standing singly or in small groups. Sometimes trees unfit for lumber are good seeders, and are windfirm enough to stand unprotected. If such trees can be found throughout the stand, there is no cost whatever for seeding. The effectiveness of the seed tree method of restocking depends largely upon the species. Trees bearing winged seeds, such as pine and maple, reproduce themselves over a wider area than do heavier-seeded trees like the nut bearers, because the winds help to disseminate the seeds.

*Seed-tree method of reproduction.*

See Kinds of Seeds, p. 99.

Reproduction by Sprouts.

The practice of growing sprout forests may be advisable for producing some special products. Posts, poles, and fuel can well be grown from sprouts and suckers. Sprout forests can produce pulpwood in less time than seedling forests. Some pulp species, such as aspen, are good sprouters. It is practical therefore to clear-cut such stands, and to let sprouts and suckers restock the area.

Refer to p. 105.

Managing stands in this way insures high productivity because of early maturity and elimination of reproduction costs.

## *THE SELECTION SYSTEM*

*In the selection system, reproduction starts in openings.*

Of the approximate 1,600 billion board feet of commercial saw timber in the United States, 80 percent, or 1,300 billion feet, is old growth. Much of this is in even-aged stands, having reached maturity long ago. This supply of old growth timber lies across a continent from the eastern market centers. For this reason the greater part of the East's timber requirements in the future will be furnished from the second growth forests of the East and South. These forests generally are uneven-aged, and ordinarily should be cut under a *selection* system of management. The uneven, or selection stand, as formerly described, contains all ages and often many species, and the selection system of management is especially designed to put such stands on a sustained yield basis.

**Sustained Yield for Selection Forests.**

The principle of the selection system is to cut only the mature and defective trees and to reserve and protect the younger growth for future crops.

**Cut Matured Crop Trees.**

Studies of growth rate will determine the amount of wood produced by the forest in 1 year, or in a number of years. The amount of timber cut each year should be no more than the amount grown in 1 year. If cutting operations are made every 10 or 20 years the harvest should not exceed the growth during those periods.

**Growth Should Balance Cut.**

The annual growth of the forest is distributed among all the trees, but for practical purposes the annual cut is made from among the large mature trees. To aid in regulating the cut, the forester determines the annual yield or the periodic yield, and then chooses a minimum diameter limit below which no trees are to be cut, but which will yield a harvest equal to the growth for the period.

**Determining the Growth.**

For instance, on a forest of 1,000 acres the annual growth per acre may be 500 board feet. It does not pay to set up a logging outfit each year to remove only 500 board feet per acre, but in 10 years the yield amounts to 5,000 feet per acre.

**Calculating the Amount of Timber to Cut.**

Diameter Limits.

From tables which he has prepared, the forester determines the diameter limit which will yield an average of 5,000 feet per acre, or 5,000,000 feet for the entire tract. This diameter limit may be 12 inches, in which case only the trees with a diameter of 12 inches or more are cut during the logging operation. If the forester's calculations have been correct, he will be able, 10 years hence, to remove another 5,000,000 board feet from his 1,000 acres by cutting all trees above the same diameter limit.

*The irregular stand is adaptable to the selection method of cutting.*

Varying Diameter Limits.

Diameter cutting limits vary with the timber species and with the desired product. Spruce for pulpwood may be cut to a diameter limit of 8 inches, but for lumber the limit may be as high as 14 inches. The cutting limit is not always followed rigidly, as weed trees and invaluable species of smaller diameter may be removed in the cutting operations to improve the composition of the forest. These weedings may be done at little additional cost, and the product may be disposed of as fuel.

See Yields, p. 179.

As opposed to clear-cutting, the selection system has many advantages. In this type of cutting, the soil is always protected by forest growth and is not exposed to erosive forces as are clear-cut areas. Trees are harvested as they mature, and younger low-value trees are permitted to increase in diameter, height, and value before they are cut.

**The Selection System and Reproduction.**

By the removal of mature trees, space on the ground is opened in which seed may germinate, and the establishment of younger trees is stimulated. The ground and duff having been stirred in the logging operations, natural seeding is easier to obtain.

**Selection System Best for Woodlots.**

The selection system is adaptable to farm woodlands and other small tracts as well as to large holdings. Even-aged stands may be converted to selection stands by a series of cuts made at intervals, and followed by natural reproduction or planting to arrive at a wide representation of ages. Often such stands are thereby changed to contain a number of age groups, in which case the periodic growth may be harvested by cutting clumps of trees rather than individuals.

**Cutting Systems Adaptable to Stands.**

In most forests, the cutting system will not follow the bare essentials as outlined in this publication, but will include a combination of the more adaptable items of two or more systems. A forest composed of various products, species, or stands may demand special handling to obtain maximum sale values in the timber markets. Large tracts, therefore, are divided into units for cultural treatment and harvest.

## *FOREST SUBDIVISIONS*

*Short rotation stand to furnish pulpwood.*

The forest may be subdivided into units other than stands. These units may be for administrative as well as cultural purposes. A forest-land unit worked under a definite system of management frequently is called a *working circle.* This area may be quite small or it may be as large as 100,000 acres or more, depending upon the product, the market to be supplied, and the transportation problem.

**The Rotation.**

Management areas may have further subdivisions, which are governed by the *rotation* and the *cutting cycle.* A *rotation* is the number of years necessary to grow a tree crop to a given size or maturity. It corresponds rather closely to the age of the mature timber when cut, although the rotation period is usually longer than the age of the average tree when cut. This difference between age and rotation is brought about by the

**Rotation Is Time Required to Mature a Timber Harvest.**

time required to secure reproduction, and it may vary from 1 to as much as 25 years when natural reproduction is depended upon to reproduce the stand.

The Cutting Cycle.

The *cutting cycle* is the period between cuts within the same area. In clear-cutting operations the cutting cycle and the rotation are essentially the same. But when an area is cut over in periodic harvests the cutting cycle measures the time between those harvests. If for instance a unit has its periodic growth harvested every 10 years it is being operated on a 10-year cutting cycle. Short cutting cycles require only small amounts of timber to be removed from any one acre during the harvest, but the cutting area must be large; whereas a longer cycle requires the removal of larger amounts from a smaller area. The subdivision determined by the *cutting cycle* is known as a *logging unit.*

Cutting Cycle Is Time between Timber Harvests.

Blocks or Logging Units.

*Blocks* are topographic units which may form one or more logging units, or which may be part of a large logging unit. They are designated because of location—one block may be the area bounded by certain roads and streams, or may be an entire watershed or valley.

Compartments and Subcompartments.

*Compartments* are business units witbin a particular forest and are the basis for records of costs, yields, and profits. Large logging units may be divided into compartments. A further subdivision within the compartment is the subcompartment which is essentially a silvicultural or technical unit. Even further subdivision is done in intense forestry. For most extensive forest work, however, the compartment is the final division.

## *IMPROVEMENT CUTTINGS*

Quality as Well as Quantity.

Regulation of forest usage should provide for a quality yield as well as for continuous quantity yield. Silvicultural cutting systems provide for sustaining the yield, and there are two major means by which this yield of forest products may be improved or increased. One is by *protection* to eliminate loss from fire, diseases, and insects; and the other is through *cultural improvements* which will stimulate the production of better products in less time. Improvement cutting in a timber stand is the fundamental cultural operation.

**Kinds of Improvement**

Improvement cuttings may be made for the following reasons:

| | |
|---|---|
| Weeding | Liberation |
| Thinning | Salvage |
| Sanitation | Pruning |

These six cutting classifications may overlap, but each one has its distinctive purpose. All have for their general purpose the production of a better stand and an increase in rate of growth. The cost of improvement cutting should be carefully considered before making plans for the operation.

**What about a Market?**

Unless there is a market for the product obtained in the thinning operation, the expense attached to improvement cutting may reduce the profit of the whole forest enterprise.

*Thinning out undesirable trees aids the growth of crop trees.*

**What Is Thinning?**

*Thinnings:* Improvement cuttings are designed to improve timber and to shorten the rotation (hasten growth). Thinning stands is one of the best means of gaining these objectives. Whether natural forests or plantations, whether pure stands or mixed stands, whether even-aged or all-aged, too many trees per unit area will result in poor growth and development. Thinning removes the forest growth that retards proper development of the crop trees.

**The Crop Tree.**

The first principle of thinning is the recognition of crop trees. Other tree growth should be removed as demanded by the stand. In addition to the crop trees on an area some inferior trees may be left for "trainers." These will help to develop straight, clear trunks in the better or crop trees. After the crop trees have grown sufficiently to form a close stand, the trainers may be removed in another thinning. Cutting out small trees to the advantage of larger ones is known as "thinning from below."

**"Trainers."**

**Thinning from Below.**

In no case should thinning open up the stand so much that the crop trees will become excessively "limby." The canopy should be opened only enough to let in sufficient light for desired development of the crop trees.

**Weed Trees.**

*Weeding:* In young mixed stands, commonly 5 to 20 years of age, undesirable species may retard development of the better species. Trees which have no value because of species or form are known as *weed* trees. These should be removed from the stand as early as possible. Weed trees in the young stand may be removed by use of brush hooks or light axes at little cost. If they remain in the stand until it is older, the cost of removal is greater.

*In need of a sanitation cut.*

**Cleaning the Stand.**

*Sanitation:* In older stands, some trees may become infected with diseases, or they may lose their value because of injuries. They take up space and consume food that could be utilized by crop trees. Removal of such infected trees through a sanitation cut is one of the important forms of improvement cuttings.

*Liberation cuttings:* Strong, young growth of desirable species may be hampered by older growth of less desirable species or of unsatisfactory condition which overtops it. *Wolf trees* often rob young growth of its place in the forest community. Old forest trees, which have ceased growing, may retard natural increase of younger trees. Removal of the upper-story trees liberates the younger growth and permits further timber

*Young growth suppressed by poor class of trees.*

*Timber which might be salvaged.*

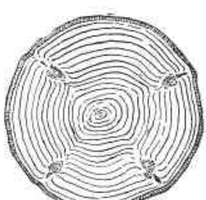
increase. Removal of top-story timber is called "thinning from above." In most cases, upper stories thus removed are merchantable timber, and this type of improvement cut may be compared to a simple selective-logging operation.

**A Stitch in Time Saves Timber.**

*Salvage cut:* In cases where timber has been killed or seriously damaged by fire, storm, disease, or insects, the stand should be improved by removal of the damaged timber. Dead and injured trees which would decay and be lost may be salvaged (used) in this way. Dead and decaying trees are hosts to insects, and salvage cuts help to remove this hazard. Taking out the dead and weakened trees provides increased space and light in which young ones may become established and develop rapidly.

**Left:** *Plantation unpruned;* **Right:** *Plantation pruned.*

**Prune for Clear Timber.**



*Pruning:* In stands which are thick enough, natural pruning takes place. Because light is excluded by closed canopies the lower branches usually drop off. However, some species have very persistent branches (do not shed naturally), and it may be desirable to prune them. Branches which adhere to the trunk cause the timber developed in the tree to be knotty. If the tree is pruned in the sapling stage, the knots of such pruned limbs are confined to the heart of the tree.

### UTILIZING THE PRODUCTS

**Wasted Timber Is Lost Money.**

When cuts are made to improve the stand, an effort should be made to use the timber and other products removed. There is not always a market for these products. With the exception of prunings and weedings of seedling stands, these products should at least pay for the cutting operation.

In some cases a profit may be realized. Liberations, salvage, and thinning crop trees should yield profits.

*The products:* Wolf trees, weed trees, and those removed in thinning may be used for posts, railroad ties, distillation wood, or pulpwood. Crop

See Increasing Wood Usage, p. 148.

*Thinning may provide a cash crop in the form of pulpwood.*

trees removed before maturity may be used for such products as poles and piling. Timber removed in a salvage cut may be used for many purposes, depending on its character and condition. Fuel wood can nearly always be disposed of, and much of the timber from improvement cuttings is fit for fuel only. Better quality timber can be used or sold as fuel if there are no other markets for it.

**Byproducts of Improvement Cuts.**

## *MARKING TIMBER*

**For Clear-Cutting Mark Seed Trees.**

In clear-cutting operations little marking need be done. If the seed tree method of reproduction is to be used, some marking system is necessary to prevent the cutting of "mother" trees. It would be a very rare stand if every tree were merchantable. It is not likely, therefore, that all trees old enough to bear seed will be mature enough or of sufficient value to cut. The trees with diameters too small to be merchantable or of little value because of poor form should be marked so that they will be saved from damage as well as from the saw. The older seed trees should be good seed bearers, windfirm, and free from serious insect and fungous infections. They

*Trees in a selection stand marked for cutting.*

may stand alone or in groups. Where the area is to be planted again there is no need for marking, unless it is desirable to leave trees for later seeding.

**For Selection Cuts, Mark Timber Trees.**

The selection system of management requires complete marking. Loggers may not be competent in judging which trees to cut. It is the duty of loggers to fell and buck timber. When selection also is left to them errors are often made.

**Minimums.**

It is well to decide upon minimum cutting diameters before beginning a felling operation, so that trees below a certain size will be left in the stand. There may be more than one minimum. Some species of trees are fairly well mature at a definite size while others of the same size should be left to grow for many years. For example, a lodgepole pine may be ready for market when its diameter reaches 12 inches, but a Douglas fir is a "youngster" at that diameter. If these two species are in the same stand, different diameter cutting minimums should be used. Marking for improvement removals may be done at the same time as marking for harvest.

**Skill Necessary.**

Marking is no job for a novice. Men should be trained by working with an experienced marker. A single worker may handle a marking job, but a crew of three is recommended. An expert and two unskilled blazers can do the marking at less cost than one skillful marker.

**Marking Practices.**

A uniform system of marking should be used in a uniform stand. The area to be marked for cutting is often divided into strips, and the marking crew blazes, or labels in some other way, the trees to be cut in the strip. One mark is usually made 4½ feet from the ground. The marks are all placed on sides of the trees that face the same direction. As the crew works back in the next strip, all the marks are visible. In this way, no tree is marked unnecessarily and trees missed in the first strip, may be seen by the crew while working back in the second. The strips are marked consecutively until the area is covered.

*A marking ax.*

**Measuring Diameters.**

In measuring diameters of standing trees, a caliper, diameter tape, or Biltmore stick may be used. This is a sure method, but rather slow. Some skillful markers place marks on the handle of the marking ax to measure diameters roughly. Trees are measured about 4½ feet from the ground. This height is chosen to insure marking above the swell of the stump. This is about breast high and accounts for the common abbreviation in logging, "D. B. H.," which means "diameter breast high." Occasionally a marker becomes skilled enough to estimate tree diameters "by eye" accurately enough to eliminate the necessity of actual measurement.

See Measuring Instruments, p. 169.

**D. B. H.**

The mechanics of marking, like the methods of working, may vary. Sometimes paint may be used instead of blazes. Paint usually is applied with a brush, but by using a spray gun, paint marking can be simplified. When marking for thinning operations a code system of marking may be used, for instance, one spot for removal, two for pruning, etc. In some forests, especially those of Europe, a weatherproof tag is tacked to the tree. These methods are not so practical as marking with an ax. The ax is fast and economical. When the blazing method is used there is no paint to spill nor tacks to drop in the leaves.

**Blazing.**

**Painting.**

**Tags.**

In the Forest Service blazing system, a blaze is made on the tree about breast high, then low on the stump the bark is chipped off and a mark stamped in the wood. This mark serves as a


*The record mark of the U. S. F. S.*

*Selective logging leaves ample timber for future harvests.*

**The Marking Ax.**

record that the tree was officially marked to be cut. A special light weight marking ax is used. It has a sharp, narrow blade and opposite the blade, on the hammer head, the raised letters "U. S." which may be impressed in the wood by a sharp blow. This ax may also be used as a branding hammer to mark or stamp logs which have been scaled.

## *FARM WOODLANDS*

**What Is Farmwoods?**


*The well-managed farm has areas reserved for wood products.*

A farm woodland or farmwoods is a tract of forest land maintained in connection with a farming enterprise. Farm woodlands are maintained to furnish fuel, posts, poles, and lumber for farm use, but often these products are cut in quantities large enough for sale in wood markets.

When a forest area is cleared for agriculture, the more rugged and stony lands and those too steep for the raising of crops are permitted to remain in timber. In recent years many farmwoods have resulted from the abandonment of overworked, infertile fields. Seed from nearby forest areas has blown into these fields and the land has reverted to forest. The loblolly or "old-field pine" in the South seeds in rapidly on abandoned fields.

**Farm Forestry—A Phase of Agriculture.**

State and Federal aid have made it possible for farmers to purchase seedlings cheaply or at cost of production from government-owned nurseries. Farmers have been quick to realize that forest cover protects the land from erosion and builds up depleted soil.

Forestry on the farm is one phase of agriculture. It is concerned with the growing of timber crops. Trees and ordinary farm crops both are dependent upon soil, moisture, and sunshine. An essential difference, however, is that most farm crops have to be started every year, whereas timber, when rightly managed, yields a crop every year or every few years without removing the entire stand at any one time. In farming or in farm forestry the owner attempts to increase the quantity and quality of yields whether they be corn, oats, sawlogs or fuel wood.

**Products for Farm Use and for Sale.**

The farmwoods is a taxable tract of land which if not properly managed may constitute a loss to the owner. Every farm, however, requires fuel wood, fence posts, poles, and lumber for repairs and small buildings. These may be cut as needed. Often a surplus, over and above what is needed on the farm, may be produced, and this surplus if properly disposed of in markets will provide a source of income.

**Year-round Employment.**

A farm with a good acreage of well-managed woodland can provide year-round employment for farm labor. In the winter when agriculture must necessarily be at a standstill, farm hands may be profitably employed in the harvesting of forest crops. In the Northeastern States, the maple-sugar industry produces an income for the farmer which in some instances is as great as that from his other crops.

*Collecting maple sap.*

Hardwood forests supply wood for distillation plants, and in many eastern sections acid factories are almost wholly dependent upon cordwood harvested in farm woodlands.

Minor products such as herbs, nuts, decorative material, and Christmas trees, and leaf mulch for small vegetable and flower gardens add to the woodlot's usefulness and income.

*A willow holt.*

Willows for baskets, lawn furniture, etc., may be grown along streams and in lowlands which are flooded periodically. This is a product which, because of high labor costs, is not profitable to the lumberman whose job is harvesting the mature timber crop.

**Increasing Land Values.**

Trees as windbreaks and as builders and protectors of soil are important to the farmer. These values have been discussed in Chapter II. Worn-out land useless for agriculture may be planted to forest trees, and after a crop of merchantable trees has been grown and harvested the land may be cleared and tilled for agriculture.

**A Haven for Wildlife.**

Small game is usually a part of the farmwoods, and the larger timber tracts may serve as game preserves. Many kinds of birds live in the forest, from whence they make their daily excursions to the farm land to feed upon weed seeds and destructive insects.

The esthetic value of the farm forest cannot be overlooked. The farmwoods adds to the beauty of the countryside and increases the sale value of the farm.

### CARE AND MANAGEMENT OF FARMWOODS

The Farmer Knows His Woods.

The general principles of forest management apply alike to extensive forests and farm woodlands. The farmer, however, usually lives close to his woods where he can keep it under his constant care, whereas the owner of a more extensive forest tract may not always have so intimate contact with his property.

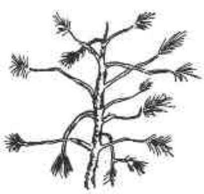
See p. 133.

Improvement cuttings, as discussed earlier in this chapter, may be practiced intensively in the farm woods and a ready use or market for the byproducts—posts, poles, or fuel wood—is usually found locally.

See Ch. IV.

Forest protection is a simpler matter in the woodlot than it is in large forest areas. The natural firebreaks of streams or plowed fields which ordinarily border the woodlot reduce fire hazard. The control of forest diseases is essentially the same in both woodlot and forest. The woodlot owner, however, can intensify the control measures and can use the diseased trees for fuel. In insect control under the most intensive management such direct methods as spraying and banding the trees may be practiced in the woodlot. These methods are rarely practical in large forest areas.

### GRAZING IN THE FARMWOODS



*Trees damaged by grazing.*

Woodlands are maintained on farms to produce timber and certain favorable influences on soil, temperature, and moisture conditions, and ordinarily they should not be used for grazing. In a stand of large even-aged trees, however, livestock in limited numbers may be permitted without resulting in much harm. The cool shade of the trees provides protection from the summer sun. A good practice is to include in the pasture enough trees to provide shade for livestock or to fence off small areas of woods for their use. In young timber, or in all-aged stands, or when reproduction is desired, livestock is decidedly detrimental to proper forest conditions.

## HARVESTING THE PRODUCTS

**Planting May Be Necessary.**

When forest trees reach maturity, or attain the size required for the desired product they should be cut and either used or sold. The cutting operation should provide for the future production of the stand. Young trees should not be injured. When ample reproduction is not already started, planting of suitable young trees may be necessary.

**A Practical Forester.**

Unlike the owner of large forests, the farmer usually harvests his own timber crop. Each year he cuts enough fuel wood to provide for his own use, and when he has mature saw-timber trees he conducts his own lumbering operation. He is able, therefore, to practice the most intensive forestry.

*Clear-cutting must be followed by planting.*

**Converting Even-Aged to All-Aged Stands.**

In an all-aged stand, cutting the larger, mature trees is the usual procedure, and reproduction occurs naturally. In even-aged stands, however, clear-cutting is often necessary, and a new stand must be established from sprouts or by planting. These practices apply more especially to large commercial operations. To provide a sustained periodic cut, and to insure a continuous supply of timber the farmer may convert an even-aged stand to an all-aged stand by removing the trees in small cuttings over a number of years. In this way reproduction is started in each cut-over area following the harvest, and the ultimate result is a stand of various ages.

## MARKETING FARM TIMBER

**Obtaining a Fair Price.**

The farmer who cannot estimate the contents of his trees in cords or board feet often sells his timber for less than it is worth. The sawmill man who makes the offer knows from his experience the amount of lumber that can be sawed from the trees. He usually allows sufficient margin on his estimate to insure a profit over and above his offer. If two or more prospective purchasers can be induced to bid for the timber, the owner stands a better chance of receiving a fair price.

If the owner learns to estimate the volume of his stand as indicated in the chapter on Forest Mensuration, he will be able to bargain intelligently with the sawmill operator. The aid of a State extension forester may be obtained through the county agricultural agent for learning how to estimate standing timber or to measure logs.

**State and Federal Representatives to Aid the Farmer.**

**Supply and Demand.**

The sale price depends upon a number of factors: (1) *The demand for the timber.* If the woodlot is the only one in the locality growing the desired product, the farmer can obtain a fair price. (2) *The kinds of trees and their quality.* Different species of wood bring varying prices on the market. Walnut, for instance, is of greater value than pine. Diseased or insect-riddled timber cannot command a high price. (3) *The location of the market.* The buyer will not pay a high price if he must haul the timber long distances. If the seller must haul the timber to the market he should raise his price according to the distances and time of travel. (4) *The cost of cutting.* The logging of large tracts of timber costs less per thousand board feet than the logging of smaller tracts, as each individual enterprise has certain initial costs which must be charged against the total output. Steep rocky land is more difficult and costly to log than is flat lowland. (5) *Cutting restrictions.* When timber must be cut immediately the price is usually less than if the buyer permits the trees to remain standing in the woodlot until a more favorable time to cut, or until the market prices rise. The woodlot owner should always specify the date when all cutting should be finished.

**Better Trees Bring Better Prices.**

**Logging Costs Influence Sale Price.**

## *SUMMARY*

**Stand Classifications.**

Timber production should be managed so that continuous crops may be harvested. Growing timber is classified according to stand types. The principal classifications governing timber management are: (1) Even-aged stands, usually harvested by the clear-cutting system, and (2) selection stands, generally harvested by the selective system.

In clear-cutting, all the timber is taken from an area in a single operation, and reproduction may be accomplished artificially (by planting); or the timber may be removed in deferred cuts, using the shelterwood method or the strip method of removal, thus providing conditions more suitable for the establishment of natural reproduction.

**Reproduction.**

In selection cutting, crop trees are removed periodically from the uneven-aged stands as they mature. Reproduction takes place naturally in the openings where timber was removed.

**Selection Cutting.**

In a forest area under management, working circles are established, upon which a definite cutting system is set up. On the working circle logging units are set off which are logged once in each cutting cycle.

**Working Units.**

The quantity and quality of timber harvested from managed forests may be improved by cuttings not primarily designed for harvesting timber. These improvement cuts may be made to thin, weed, clean, liberate, salvage, or to prune stands. By exercising care and foresight in handling the trees removed from a stand in improvement cuts, marketable products may be produced which may be sold or used by the forest owner to make a small profit, or at least to pay for the improvement operation.

**Improvement Cutting.**

The marking of timber for cutting should be done by an expert, since the success of any cutting operation depends upon the proper application of the principles of timber management.

## Chapter VII

# FOREST UTILIZATION

The term "utilization" in its broadest sense means "using in any form." Webster defines utilization as "turning to profitable account or use." Forest utilization as a term is not so wide it its meaning. Illick defines forest utilization as "converting standing timber and other forest products into forms and commodities usable by mankind." This would include methods of logging, milling, and marketing. As these phases of utilization were discussed in the previous chapter, they will not be considered here.

*How shall we use the forests?*

**Forest Utilization: Making Forest Products Usable.**

When one goes into the forest for recreation, he is using it. The artist utilizes forests when he paints a panoramic forest scene. Farmers utilize it when they use water from wooded mountains for irrigation. In general, however, forest utilization is concerned with the use of the major product, wood, and such other products as may be derived from growing forests.

**Wood for Protection.**

The earliest and most important use of wood was for protection. When the ancient tribesman built a temporary shelter from fallen poles and bark, he began to use wood to protect himself against the forces of nature. When he attached a wooden handle to his stone club head, he began using wood to protect himself against his living enemies. When he crept to a burning tree ignited by lightning, he first used wood as fuel.

Bark shelters grew into thatched huts, huts into cabins, cabins into frame buildings. Bows and arrows, crossbows, catapults, and battering rams show the evolution of wooden weapons. Rafts initiated the use of wood in transportation. Rafts were followed by dugouts, dugouts by boats, boats by sailing vessels. Great schooners eventually made possible vast world trade and great navies. Early locomotives ran on wooden rails.

*Come on now!*

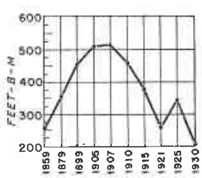
Gradually many materials have been substituted for wood, but the vast amount of wood yet in demand assures its continued use as a raw product.

## *WOOD CONSUMPTION*

In order to determine forest policies and plan for forests to meet future needs, it is necessary to study the consumption of wood. To know how wood will be used tomorrow, it is necessary to know how wood was used yesterday and how it is being used today.

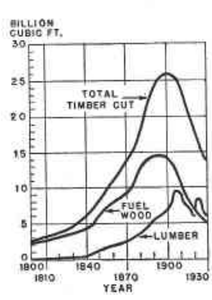
Wood in Commerce.

The use of wood in America has fluctuated greatly with the rising population. This may be indicated by a study of the per capita consumption of lumber. A century ago the use of lumber per person was about 75 board feet each year. With the industrial expansion, increased immigration, and great annual increases in the number of farms, the use of lumber grew year by year until the peak came in 1907 with per capita consumption of 525 board feet. At that time industry began releasing more substitutes for wood, and immigration was curtailed. Previously, farms had been increasing at the rate of 90,000 a year. That increase declined, and likewise, the use of lumber declined, reaching the low figure of 275 feet per capita in 1929. Since that time drastic decreases in demands have been largely due to a decline in construction brought about by the general economic depression.



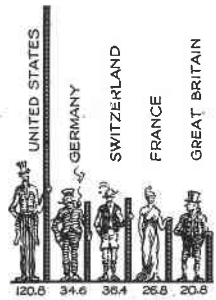

*Lumber consumption per capita.*

As shown by the accompanying figure, the amount of timber cut increased from 2½ billion cubic feet in 1800 to 26 billion in 1900. Of this amount, 14 billion feet were used for fuel and 7 billion for lumber. The use of coal and gas for fuel caused a decline in the use of wood for that purpose. This was fortunate, because at the previous rate of increase, the country would have been stripped of its forests in another half century. By 1930 the fuel wood cut was down to 5 billion cubic feet. This amount will probably decline further, whereas lumber cut will probably fluctuate for a time and then settle to a cut which will balance wood growth and consumption.



**Americans Are Wood Users.**

The United States has always used wood freely. The per capita use of wood here exceeds that of all other nations except a few sparsely settled ones where very extensive forests exist. In table 1 the 1929 per capita consumption of wood in the United States is compared with that of European countries.




*Cubic feet per capita wood consumption by nations, for 1929.*

TABLE 1.—*A comparison of the wood consumption in the United States with that in European countries*

| Nation | Per capita consumption, 1929 |
|---|---|
| | *Cubic feet* |
| United States | 120. 8 |
| Germany | 34. 6 |
| France | 26. 8 |
| Great Britain | 20. 8 |
| Switzerland | 36. 4 |
| Sweden | 162. 8 |
| Finland | 245. 8 |

*Lumber is an important low-cost building material.*

Table 2 indicates how the 14½ billion cubic feet of timber which is cut each year in the United States (average 1925–29) is used.

The decrease in world consumption of wood does not mean that wood is becoming obsolete. Shortage in available supplies and economic difficulties resulting from business depressions have caused the decreases. This reduction of the demand for lumber through substitution of other products for wood is in part offset by an increase in pulpwood requirements. Fiber and cellulose

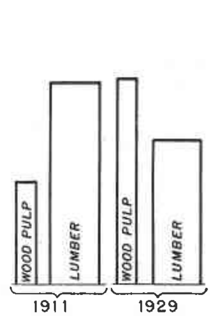


TABLE 2.—*Annual wood use in the United States (average 1925 to 1929)*

Wood Usage.

| | Thousand cubic feet | Percent |
|---|---|---|
| Lumber | 7, 371, 372 | 50. 8 |
| Fuel wood | 4, 002, 635 | 27. 6 |
| Hewed ties | 633, 034 | 4. 4 |
| Fence posts | 628, 836 | 4. 3 |
| Pulpwood | 588, 666 | 4. 1 |
| Cooperage (tight and slack) | 302, 699 | 2. 1 |
| Mine timbers | 231, 780 | 1. 6 |
| Veneer logs | 230, 607 | 1. 6 |
| Logs and bolts (for manufacture) | 156, 575 | 1. 1 |
| Shingles | 138, 558 | . 9 |
| Miscellaneous | 210, 546 | 1. 5 |
| Total | 14, 495, 308 | 100. 0 |

Pulp Consumption Up.

products are increasing in demand. These call for more pulpwood. Because of the high transportation costs of coal, fuel wood also will long be desired, especially on farms and in regions where wood is plentiful.

The extent to which other materials are to be substituted for wood depends on how effectively wood can be made to meet use requirements as compared with competing materials.

Wood has outstanding advantages as a low-cost building material, and will play a large part in Federal housing activities, the objective of which is to supply modern low-cost homes.

Recent developments in the use of metal timber connectors and in the use of structural plywood are creating new demands for wood in construction. Definite progress has been made in treating wood to make it resistant to shrinkage, swelling, fire, decay, and insect attack.

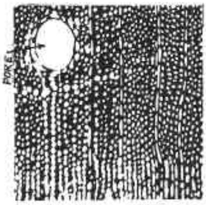
## *PROPERTIES OF WOOD*

Wood Technology.

Woods of different tree species have different properties which affect their use. The science of wood structure and properties is known as *wood technology*. The usability of wood depends upon its properties—weight, grain, color, durability, hardness, and other characteristics. The available supply of a species as well as the demand for it determines its cost and affects its use.

**Hardwoods and Softwoods Are Names Only.**

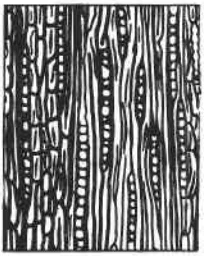
As has been shown before, tree species are divided into hardwood and softwood classes. Some so-called hardwoods are softer than some woods in the softwood class. Some of the pines (softwoods) are harder and more resistant to decay than cottonwoods (hardwoods).



*Hickory—Cross section highly magnified.*

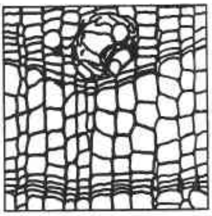
Some types of wood are especially strong, stiff, and durable. Oak, Douglas fir, and longleaf pine are well adapted for heavy construction. Hickory and ash are very strong and tough, and therefore valuable for tool handles. Because they do not decay easily, cedar, cypress, locust, and chestnut make excellent posts. Some softwoods not suitable for construction in which heavy loads must be carried, may be worked very easily and used where great strength is not essential. For instance, soft pine and similar woods may be used for sheathing or subflooring. The woods of spruce and aspen have fine texture which makes them valuable for paper and other pulp products. White oak is strong and has closed pores, and therefore makes excellent cooperage. Black walnut, oak, cherry, maple, and mahogany have beautiful grain and may be finished to make desirable furniture and cabinets. Often less valuable species of wood are substituted for the better ones in cabinetmaking, and synthetic coloring and finishing are used to imitate the more valuable woods.

**Fibrous.**



*Black oak—Cell arrangement highly magnified.*

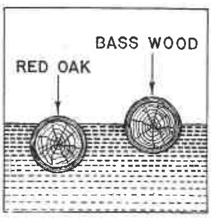
The structure of a wood determines its qualities and characteristics. The composition and arrangement of cells in different species is responsible for differences in structure. As has already been explained, the trunk of a tree is composed of heartwood, sapwood, cambium, and bark. The heartwood is composed of dead cells, and is usually darker in color than sapwood. Sapwood is composed of living cells and varies in thickness in the different species. Wood cell arrangement has been explained in Chapter I.



*White pine—Cross section highly magnified.*

In the hardwoods, large vessels extend along the grain. These appear to the naked eye as small holes or pores. Such wood is known as *porous*, as opposed to *nonporous* (coniferous) wood in which these vessels do not appear. Some hardwoods, the oaks for instance, develop large pores in the springwood and smaller ones in the summerwood, so that a definite line of pores can be seen in each growth ring. Such wood is known as *ring porous.* When, as in maple, the pores are more or less uniform in size and consistent throughout the ring, the name *diffuse porous* is applied.

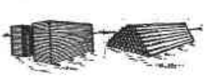

Wood has thin planes of tissues which extend ribbonlike across the grain of the tree. These strands of tissue are called *rays*, and their function is to carry sap radially through the other cells. They give strength and beauty to wood, and present beautiful surfaces when the log has been quarter-sawed. Oak and beech have well-developed rays, but in many species the rays can scarcely be seen.




*Floating logs.*

Weights of woods vary with the species. Some of the heaviest are maple, elm, white oak, hickory, longleaf pine, and Douglas fir. Aspen, yellow poplar, chestnut, white pine, hemlock, and redwood are lighter species. Heavier woods rarely will float before they are seasoned.

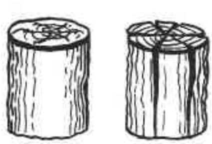
### *USE OF FOREST PRODUCTS*



Left: *Lumber.*
Right: *Timber.*

The products of the forest may be classified as follows: (1) Lumber, (2) timbers, (3) bolts, (4) fuel wood, (5) pulpwood, (6) distillation wood, (7) miscellaneous products.

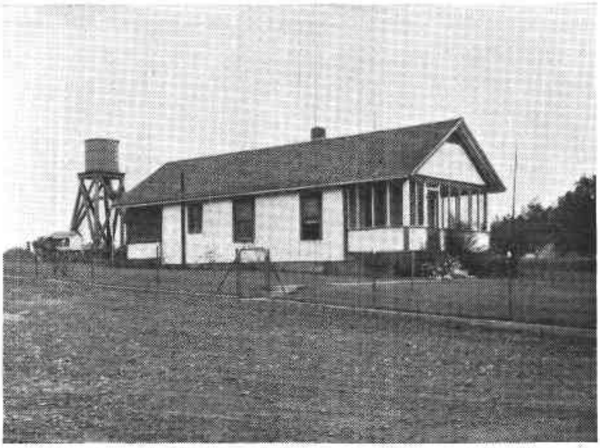
Lumber includes strips, boards, and dimension material, which is used both in construction and in manufactured products. Timbers may be subclassified as round and square. Square timbers are sawed or hewed beams and timbers used in heavy construction. Railroad ties also fall in this class of timber products. Round timbers include poles, posts, piling, and mine timbers. Bolts are short logs, used in making staves, shingles, veneer wood, and excelsior. These are often split in the woods to facilitate handling. Fuel wood is of different sizes and lengths, and includes all wood used for heating purposes. Pulpwood is used to make pulp for paper, boards, or cellulose products. Distillation wood is used to obtain wood alcohol, turpentine, tar, and some acids, with byproducts such as charcoal and acetate of lime. Hundreds of



*Bolts.*

*Fuel.*

miscellaneous forest products add to forest values. Among these the most important are naval stores (turpentine, tars, and resins), rubber, cork, medicinal products, and nuts, sugar, and sirup.



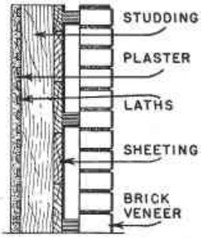
*Wood is an important construction material for many modern homes.*

USE OF LUMBER IN CONSTRUCTION

**The Forest Does Its Part.**

In 1929 the United States used 32 billion board feet of sawed timber, which was about half the total wood cut. Approximately two-thirds of this went into construction. The greater part of this lumber was used in erecting buildings, principally residences. Other forms of construction utilizing wood are fences, bridges, scaffolding, and concrete forms.

Although many materials have been substituted for it, construction still depends largely upon wood. Lumber is used for concrete forms, and brick buildings are often framed with wood. Masonry buildings are commonly finished and trimmed with wood.




*Many buildings contain much wood, although no wood is visible.*

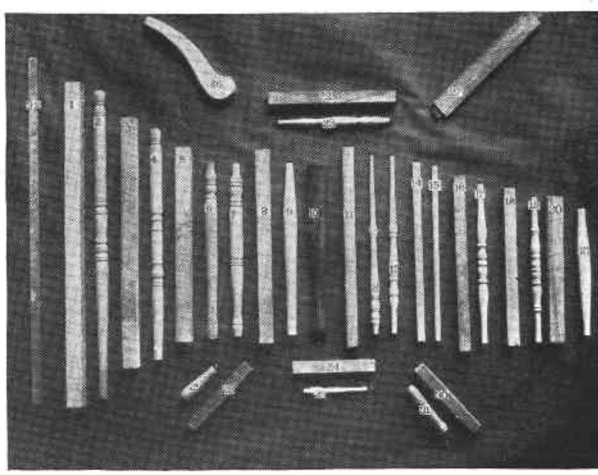
Wood is the standard material for construction of low-cost buildings. It is especially adapted to use in small dwellings, and farm buildings are almost universally made of wood.

The forest furnishes material which contributes greatly to the general advancement of the human race. Probably its best contribution is in providing material with which to build homes. The success of a nation depends upon the happiness and well-being of its families. The forest cannot better be utilized than in furnishing material for homes, residences, and for other construction.

### LUMBER IN MANUFACTURING

*Slabs, not used in manufacturing, may be used for fuel.*

In 1928, a total of 18,683,758,000 board feet of lumber was remanufactured. This is probably a typical year, since it is midway between the boom year of 1923 and the lowest depression year, 1933. Products manufactured from wood are divided into many classifications. Table 3 shows the amount of wood used in a few of the large industries, and indicates the surprising demands for wood for smaller, seemingly unimportant articles.



*Small articles may be made from odd-sized lumber which might otherwise be wasted.*

See Table 3, p. 155.

Much of the lumber used would be wasted were it not for the close utilization which manufacturers are learning to practice. First-class lumber is necessary for manufacturing cabinets, refrigerators, etc. Small pieces left from cutting, which would otherwise be wasted, may be worked into handles, furniture parts, woodenware, and novelties. We can hardly believe that the manufacture of toys requires annually more than 39 million board feet of lumber, that for toothpicks more than 7 million feet are required, and that tobacco pipes alone require 87 thousand board feet.

*Table 3.—Lumber used in the manufacture of some minor products in the United States, 1928*

| Article | Lumber used, 1,000 board feet | | Total |
|---|---|---|---|
| | Hardwood | Softwood | |
| Boxes and crates | 1, 144, 875 | 3, 671, 733 | 4, 816, 608 |
| Furniture | 1, 093, 278 | 60, 203 | 1, 153, 481 |
| Coffins and caskets | 60, 780 | 93, 795 | 154, 575 |
| Refrigerators | 79, 742 | 65, 992 | 145, 734 |
| Novelties and woodenware | 84, 715 | 56, 664 | 141, 379 |
| Handles | 123, 929 | 288 | 124, 217 |
| Matches | 1, 432 | 114, 511 | 115, 943 |
| Signs | 17, 573 | 46, 909 | 64, 482 |
| Pencils and penholders | 125 | 39, 857 | 39, 982 |
| Toys | 26, 917 | 12, 336 | 39, 253 |
| Toothpicks | 7, 483 | | 7, 483 |
| Pipes (tobacco) | 87 | | 87 |

**Where Manufactured Lumber Goes.**

## TIMBERS

Timbers include poles, piles, posts, ties, and mine timbers. Poles and piles are round, but posts and mine timbers may be either round or split. Cross ties are hewed on two or four sides, or they may be sawed. Timbers are usually derived from immature trees. Forests are often thinned and the products of these thinnings worked into timbers. By utilizing in this way young trees removed from the stand, forests may be made to pay for their maintenance while the crop trees are maturing.

**See Improvement Cutting, p. 134.**

Poles are used principally for telephone and telegraph lines and piling. During 1929, 4,557,000 poles were used for wire hanging alone. Long straight trees are required for poles and piles, and smaller trees may be worked into fence posts. More than 100,000,000 fence posts were used in 1929. Experiments with substitutes for wood as posts have proved that iron or concrete posts are practical. The number of fence posts of material other than wood now in use, however, is negligible.

**See Poles, p. 266.**

**Posts.**

Suitable substitutes for wooden ties for railroads have not been found, although many materials have been tried. Wooden cross ties afford a resili-

**Wood Makes the Best Ties.**

*Ties are hewed with a broadax.*

*Supporting timbers and ties are used in mines.*

ency which helps to absorb the shock of heavy rolling stock traveling over steel rails. Cross ties under our present 430,000 miles of railroad have to be replaced at the rate of about 150 ties per mile annually. In 1929, railroads purchased 95,521,207 ties. Most of the ties used are hewed.

Mine timbers are used in many different lengths and sizes, principally for track ties and props. Sawed mine timbers are included in lumber statistics. Most mine timbers, however, are round or split. An average of 184,875,000 cubic feet of round timbers was used annually from 1925 to 1928.

### PULPWOOD

Paper towels and napkins, and paper cups and plates are used by millions. Even paper clothing and paper shoes are now worn. The people of the United States are the greatest paper users of the world. Most of the paper now used is made from wood. Seventy years ago rags were the principal raw materials for paper manufacture.

**Wood Pulp Best Raw Material for Paper.**

Pulp made from straw, grass, and cornstalks has recently been substituted for wood pulp, but wood, being high in cellulose compounds, is the best raw material for paper making.


*Paper Products.*

Thirteen and one-half million cords of pulpwood are used annually in the United States. Practically all this wood goes into paper making. Paper products are divided into six groups: (1) Boards, (2) newsprint, (3) wrappers, (4) book paper, (5) fine paper, and (6) miscellaneous products.

Boards include paper used for carton and packing cases, and fiber boards used for ceiling and insulation in buildings. The bulk of our paper product is made up of the different kinds of fiber board. Not so much wood is used in boards, however, as in newsprint, since old paper is utilized in their manufacture. The use of fiber board as a wood product is increasing.

*Newsprint.*

Newsprint is paper used in newspapers. Millions of tons are used annually. The average number of pages in newspapers increased from 7 in 1890 to 30 in 1930. Increases in population, literacy, and advertising have caused this growth in newspaper size.

**Wrappers.**

The second greatest use of paper is for wrappers. This form of paper is used by everyone. The annual consumption is over 1½ million pounds.

**Bookstock and Fine Papers.**

Book stock requires a better quality of papers. Consumption of paper for this purpose is little less than for wrapping paper. Fine papers are higher grade papers used for print stock, writing paper, fine wrappers, and such products. Miscellaneous paper products usually include manufactured products, such as papier mâché, wall papers, and fabricated articles.

*Location of paper and pulp mills.*

The per capita consumption of paper products in this country for 1929 was 199 pounds. In 1933 the principal use of the total product was as follows:

**How Paper Is Used.**

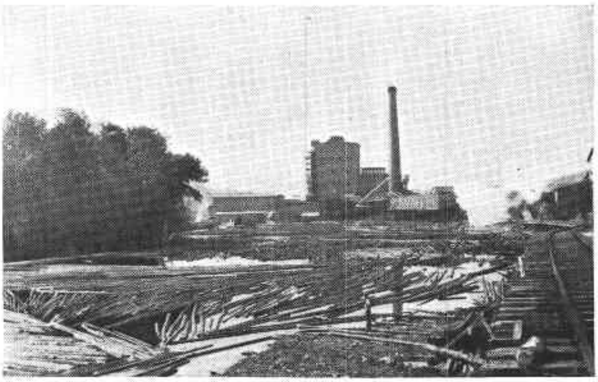
| | *Tons* |
|---|---|
| Boards | 4, 014, 000 |
| Newsprint | 3, 496, 000 |
| Wrappers | 1, 556, 000 |
| Book stock | 1, 370, 000 |

**Employment.**

The manufacture of paper is one of the great industries of the United States. In value of product and number of people employed this industry ranks high. More than 197,000 people in the United States were employed in the manufacture of paper and paper goods in 1932. In Canada paper making leads all industries.

**Manufacturing Processes.**

Paper is manufactured by two methods, mechanical and chemical. In the mechanical process the logs are ground to a pulp by machinery. This leaves all the rough material in the pulp and consequently produces a coarse-grained paper. In the chemical process, chemicals are used to



*Pulp mills employ many thousands of workers.*

break up the wood fibers and to dissolve them into a better form of pulp which makes finer paper. There are three chemical processes for pulping paper—soda, sulphite, and sulphate processes. Mechanically pulped paper is valued at about $22 per ton while chemical paper is valued at about $40 per ton (1935).

Rayon.

Cellophane.

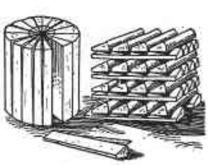
"Everything Wrapped in Cellophane."

Pulpwood for making cellulose products is growing in demand. The rayon and cellophane industries are offering new products to meet the requirements of consumers. Rayon, formerly called artificial silk, is competing with other textile products, especially silk. Articles are wrapped and protected by cellophane, and, although it is a new product, the consumption is about a hundred million pounds annually. An American who had been living abroad for 8 years was asked upon his return what he considered the most noticeable change in his native country. He replied that the greatest change was that everything was wrapped in cellophane.

*The rayon factory competes with the silkworm.*

In making rayon and cellophane, wood is pulped to obtain free cellulose. This is treated with a solution which dissolves it. It is then forced by enormous pressure through spinnerettes to form rayon threads or through slits to form sheets of cellophane.

## BOLTS



*Stave bolts.*

Bolts have recently been in great demand because of increase in the quantity of cooperage products. Staves for barrels are of two classes. Tight cooperage staves are used for barrels and casks for holding and storing liquids. Loose cooperage is used in making barrels for dry materials. Bolts for tight cooperage must be of flawless timber. Bolts are used also in making heads for tight barrels. The yearly average of staves used during the period 1925 to 1929 was 307,167,000. Loose cooperage required three times as much material as tight cooperage but of an inferior quality.

*Shingles.*

Shingles also are manufactured from bolts. The average yearly production of shingles for the period 1925 to 1929 was more than 6 million.

Demands for veneer bolts (often in log sizes) are increasing. The manufacture of veneer is a very interesting process, in which thin strips of wood are shaved from revolving logs, which have been softened by steaming. The process resembles the drawing of a continuous strip of paper from a large roll. Almost a billion board feet of logs and bolts have been used annually for veneering.

#### FUEL WOOD

The use of fuel wood has decreased because more practical fuels are becoming popular. Gas, electricity, coal, and oil are used today, but in timbered sections remote from coal fields, wood fuel is still prevalent.

*Fuel.*

*Mill waste may be used for fuel or small products.*

**Use of Fuel Wood May Pay Forest and Woodlot Taxes.**

Fuel wood, like posts, may be a byproduct of other forest crops. It may be salvaged from logging operations or from thinnings. The bulkiness of firewood prevents its being transported great distances, and consequently it is limited to local use. Fuel wood, as a forest product, is second to saw timber in quantity produced.

See Timber Map, p. 54.

Specifications in size and type rarely limit the use of fuel wood. It is measured by cords. The yearly consumption (1925 to 1929) was 61 million cords. As long as fuel wood is confined to inferior timber and to salvaged wood, its use may be encouraged.

## DISTILLATION WOOD

**Cell Components.**

Wood is composed of cells. The cell walls are made up of cellulose and lignin. There is more than twice as much cellulose as lignin in cell structure. Within the cells are water, carbohydrates, oils, tannins, dyes, resins, proteins, and acids.

When wood is heated in the absence of air, the cells break down. Gases are formed which may be condensed into alcohol and acids.


*Products obtained from a cord of hardwood.*

Most of the distilled products are taken from hardwoods. Heavy compact woods contain more of these materials than lighter and softer woods. Oak, beech, maple, and birch are perhaps best for this use. A few years ago, a million cords were required annually for distillation products, but the demand is not so great at present. In addition to strictly distilled products, charcoal, tars, and chemicals are obtained from wood in the distillation process. A cord of wood distilled by modern methods will yield about 10 gallons of wood alcohol, 25 gallons of tar and grease, 200 pounds of acetate of lime, and 1,000 pounds of charcoal. The crude alcohol may be refined to produce pure wood alcohol, acetic acid, and acetone.

**Other Wood Extracts.**

Dyestuffs, volatile oils, tannins, and turpentine may be obtained from wood by boiling or steaming it. The dyes are not very important at present as many mineral dyes are being used. Oils, however, are important in making medicinal supplies, antiseptics, and preservatives. Some oils are used in making soaps, perfumes, and flavors. Turpentine may be extracted from roots and heartwood of pines rich in resin, but extracted turpentines and tars are not as important commercially as gum products.

## MISCELLANEOUS WOOD PRODUCTS

**Naval Stores.**

Hundreds of forest products not already classified increase the usefulness of the forest. The most important of these are naval stores and rubber. Turpentine is made from resin taken directly from the growing tree. A cut is made so that the resin flows out. This is collected and distilled to obtain turpentine, tar, and pitch.

Formerly, a great deal of tar and pitch was used in calking wooden ships. Hence the name "naval stores." The Southern States produce more than half the world's supply of naval stores. Slash and longleaf pines, which are the best sources of resins for this product, are abundant in the region.

**Rubber Latex.**

Raw rubber is obtained in the same manner as gum for naval stores. The sap from rubber trees is known as latex and goes directly into rubber production. Rubber forests grow in tropical countries, and at present many plantations supplement the supply obtained from the natural rubber forests. Although little rubber is produced directly in the United States, the manufacture of rubber products is one of the country's greatest industries.

*Stripping bark from cork oak.*

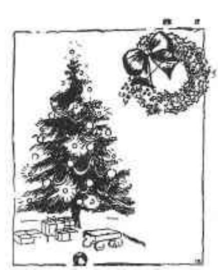
**Cork.**

Cork is the bark of the cork oak and is an important forest product. It is produced principally in Portugal and Spain.

Fruits, nuts, and extracts from forest trees add their values to the host of others. Walnuts, hickory nuts, beechnuts, chestnuts, pecans, and berries bring income to natives who have access to the forest. The manufacture of maple sugar and syrup has developed commercially in several States.

**Medicinal Products.**

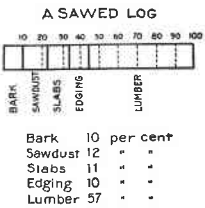
Many plants and trees furnish pharmaceutical and medicinal supplies. While some of these are now produced synthetically, the forest is still important for medicinal products.



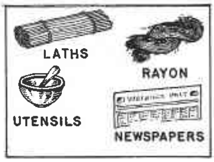
Decorative materials such as Christmas trees, holly, mistletoe, ferns, and flowers may be classed as forest products. The business of collecting, preparing, and marketing the products employs thousands of people, and involves expenditures of millions of dollars every year.

Part-time work in the harvesting and selling of minor forest products provides an income for many rural dwellers who otherwise would be almost entirely dependent upon garden crops. Seasonal market demands for many forest products often coincide with lulls in farm activities.

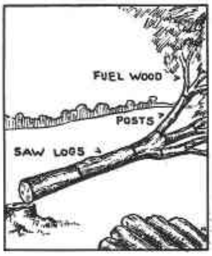
## DECREASING WOOD WASTE



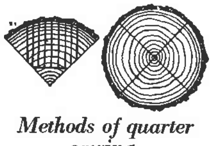

It has been estimated that only a third of the tree is actually used. Much of the two-thirds usually wasted should be salvaged. Wood left in stumps, limbs, bark, slabs, and sawdust constitutes the greatest wastes in lumbering. Development of byproducts, and the utilization of piece wood in making small articles will decrease this loss. Pulp products such as rayon, wallboard, insulation, and pressed wood can also utilize parts of the tree now not used. If slabs and edging can be used in making small articles such as lath, toys, and novelties, lumber which otherwise would be wasted may be saved. Improved logging practices may reduce waste in the woods. Use of saws with small kerfs (thickness of cutting edge) saves timber at the mill. The efficient sawyer decreases waste.




## INCREASING WOOD USAGE

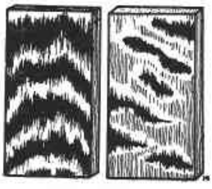



The use of wood depends largely on economic conditions. In times when business is active and economic conditions are good, much wood is used. Lumber production and consumption decreased more than 50 percent from 1929 to 1931. The economic influence cannot be controlled by foresters but there are ways by which consumption can be increased. Prevention of waste and close utilization will help to lower the cost of wood products so that they can compete with wood substitutes.



*Methods of quarter sawing.*

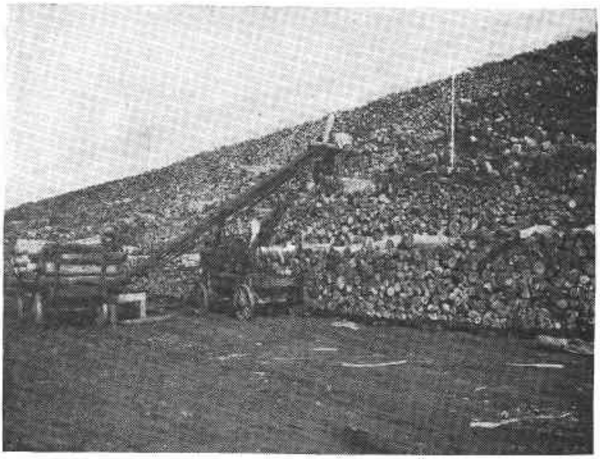
Making wood products more desirable will create a greater demand for them. Quarter sawing, for instance, instead of plain sawing makes wood more valuable. In quarter sawing the logs are quartered and boards are sawn parallel to the rays. Although this may increase waste it brings out the grain and makes the wood more attractive.



Left: *Plain.*
Right: *Quarter.*

Treating new lumber with chemicals to prevent discoloration makes it more attractive as well as more useful to purchasers. Proper seasoning and storing also render lumber more valuable.

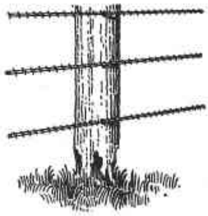
It is not possible to foresee the exact status of wood in the future. There seems to be great



*Millions of cords of pulpwood are consumed annually in the United States for paper and cellulose products.*

possibility in the chemical utilization of wood. Use of the cellulose content of wood cells has been explained. The number of products recently made possible through chemical treatment seems to point to a new field of utility for forest products.

### PRESERVING WOOD



*Untreated posts have short lives.*

**A Bad Theory.**

Much has been said about forest protection. Protecting the forests to bring about greater wood production is a basic economy. Treating wood to protect it from rapid deterioration, insect attacks, and decay is another basic economy. Some lumber dealers have argued that treatment of wood to prevent decay would decrease the lumber business. However, selling lumber that will decay quickly in hopes of increasing lumber consumption would be similar to manufacturing automobiles that would wear out quickly, in the hope of selling more machines.

Decay in wood is caused by fungi which live on the wood cells and bring about their decomposition. Fungi live and work best in moist wood. If wood is to be preserved, it must be kept dry. This can be accomplished in part by protection of roofs and eaves, and by building practices designed to shed water such as using drop-siding or weather-boarding on the outside of buildings. Another common practice which helps to preserve wood is painting. Paint has both esthetic and preservative values. It beautifies and partially


seals the pores of wood against moisture and spores of fungi.

**Essentials of a Good Wood Preservative.**

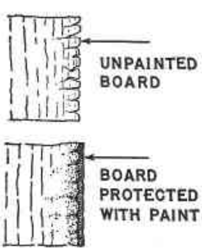
Chemical treatment of timber is a growing industry. Progressive lumber dealers believe that it will encourage the use of lumber and will prevent substitution of materials that are more lasting than untreated wood. The most common preservative is coal tar creosote. Its cost is reasonably low. It prevents wood-destroying fungi, repels wood-eating insects, partially seals pores against water, and does not readily evaporate or leach from the wood. All these requirements are essential in a good preservative.

**Brushing.**

There are several methods of applying creosote and other preservatives. Before any preservative is applied, the wood should be seasoned and dry. The *brush method* is used for painting and for light applications of creosote. The preservative may also be sprayed on the surface of the wood. Creosote-base stains of various colors may be used on rough surface not adaptable to painting.

**Dipping.**

*Dipping* is faster than the brush method and permits better penetration of the fluid. If both the preservative and the wood are heated, the preservative will permeate more readily. The best permeation is obtained when the preservative is heated to a temperature of about 200° F. If timbers which have been heated in creosote are cooled in a tank of the fluid at a temperature of about 100°, the preservative penetrates the wood better than if it is permitted to cool in open air.




**Open Tank.**

Dipping is known as the *open tank method.* It is a good method for partial treatment as used on poles and posts, when only the part to be set in the ground is treated. A small tank or a barrel set over a simple furnace may be used to hold the fluid and the upright posts.

For railroad ties, paving blocks, and other items demanding heavy treatment, the *pressure method* has been developed. There are several pressure processes in use. The most complicated one utilizes steam, air pressure, and vacuum in injecting the preservative into the wood. Special tanks and processes provide for forcing the com-

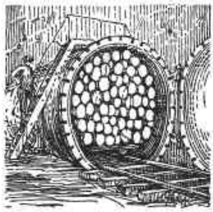
*Open tank method*

pounds into the pores of the wood. Under this method the wood (well seasoned) to be treated is sealed in pressure tanks. It is steamed under pressure to open the pores. Steam and excess moisture is then drawn from the wood by subjecting it to a vacuum. Next the hot preservative is introduced through pipes. The air pressure in the tank is then increased until the fluid is injected deep into the wood fiber. The amount of liquid applied may be regulated by changing pressures to fit the requirements of the different wood species and according to the degree of penetration desired.

**Pressure.**

**A Vacuum.**

**Then Pressure.**



### *SUMMARY*


Forest utilization is concerned with the use of the products of the forest. The principal forest product is wood. The usability of wood depends upon its characteristics and properties. A great deal of useful wood wasted in logging and manufacturing could be advantageously used.

*A wasteful practice—slabs and edgings burned on refuse heap.*

Wood products are classed as lumber, timbers, bolts, fuel wood, pulpwood, distillation wood, and miscellaneous products. Construction of residences creates the greatest demand for lumber. Nearly every type of construction demands the use of some lumber. Wood seems to be the most practical material for construction of rural homes. About 32 billion feet are used annually.

**Wood Consumption.**

**Refer to Table 3.**

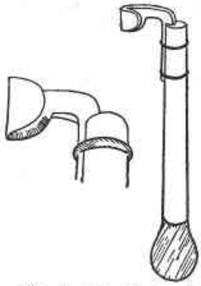
Of more than 18 billion board feet of lumber used in manufacturing in the United States in 1928, boxes and crates required nearly 5 billion feet. Hundreds of other manufactured articles require varying amounts. At the bottom of the list are tobacco pipes, for which 87,000 board feet are used.

**Wood Products.**

**13½ Million Cords.**

Pulpwood is used in the production of paper and cellulose products. The 13½ million cords of pulpwood consumed in this country are used to make fiber boards, newsprints, wrappers, and book stock. Rayon and cellophane are the two major cellulose products made from wood pulp.

Bolts are used for cooperage, shingles, veneer, excelsior, and a few other small wood products. Fuel wood is used in great quantities where wood



*Hooked knife used for cutting a turpentine "box" in pine tree.*

**A New Field of Utility for Forest Products.**

is plentiful and where gas and coal are not found. Distillation wood yields alcohol, acids, tars, grease, oils, and dyes. Naval stores and rubber are important forest products used in abundance. Decorative materials are supplied from forests, especially for Christmas seasons.

Proper forest utilization is important in that smaller areas of forests must now furnish many more people than formerly with products. Wider utilization of forest products may be brought about through systematic management and scientific knowledge, and through a more universal use of forests for their influences and recreational values.

## Chapter VIII

# FOREST MENSURATION

Knowledge of Measurement Is Essential.

Forest mensuration is the science of measuring the contents of standing or felled timber, and estimating growth and yields. Foresters, timber owners, and farmers owning woodlands should know the essentials of timber measurement.

"A Pint's a Pound."

A pioneer storekeeper who believed that "a pint's a pound the world around" developed a sizable trade in shot with local hunters. He more than likely failed as a merchant. Likewise timber owners, who do not recognize the value of forest mensuration, may make transactions in forest products to their own disadvantage, but to the decided advantage of dealers.

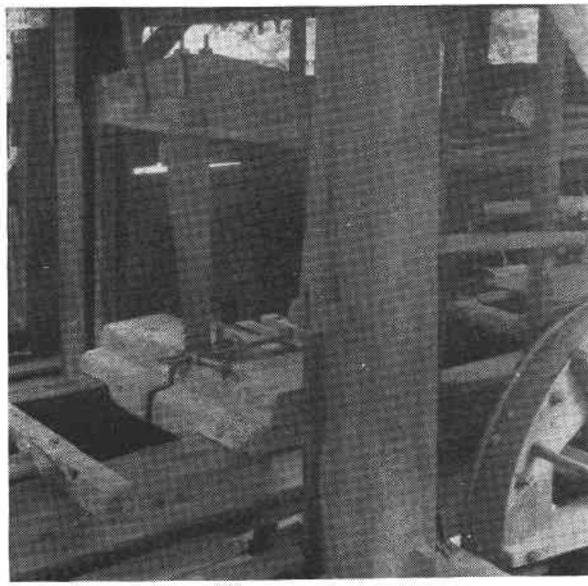
"Waste Not, Want Not."

When there was an abundance of low-cost timber and cheap labor, lumbermen did not find it necessary to make precise measurements. Transactions involving vast timbered areas were based on superficial estimates. Today, however, because of limited quantities of timber and increased production costs, timbermen, in keeping with present business practice, find it necessary to make closer estimates of timber volume.

### *UNITS OF MEASUREMENT*

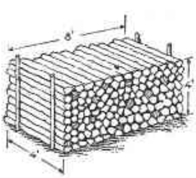
A Piece of Wood 1 by 12 by 12 Inches.

*The board foot:* A knowledge of the basic units of measure is necessary before an attempt can be made to learn the processes of mensuration. The unit of measure for lumber is the *board foot.* A board foot is a piece of wood 1 foot square and 1 inch thick, or its equivalent. A board an inch thick, 12 inches wide, and 10 feet long contains 10 board feet. An inch board 8 inches wide and 18 feet long contains 12 board feet; a 2-inch plank 6 inches wide and 8 feet long contains 8 board feet. Volumes of boards less than an inch thick are usually estimated as if they were an inch thick.



*When lumber was cut in mills of this type, precise timber measurement was not practiced.*

The Standard Cord.



*The cord:* Fuel wood, pulpwood, and similar bulk wood is measured by the cord. A standard cord is a stack of wood 4 feet wide, 4 feet high, and 8 feet long. It has a cubical measure of 128 cubic feet, but there are spaces between the pieces of wood in the stack. The actual volume of wood is from 70 to 90 cubic feet. Seasoning may reduce the actual wood content of a cord of green wood as much as 10 or 15 percent. Some pulpwood is cut 5 feet long, and fuel wood is cut less than 4 feet long, depending on sizes of stoves and fireplaces. Such wood regardless of length, stacked 8 feet long and 4 feet high, is commonly called a cord, although it is not standard size.

See Timbers, pp. 152, 155.

*Piece measurement:* Some wood products are sold by the piece. Poles, piles, posts, ties, and staves are in this classification. Poles and piles are cut in different sizes governed by particular needs. Posts have no exact dimensions, but a standard post is said to be 4 inches thick, 5 inches wide, and 7 feet long. Standard railroad ties are 7 inches thick, 9 inches wide, and 9 feet long. These products are bought by the piece. Stave and shingle bolts are bought by the hundred.

*Cubical measurement:* Very valuable woods, such as mahogany or dyewoods, are usually measured by the cubic foot. A cubic foot is a solid, a foot long, a foot wide, and a foot thick.

**What is Stumpage?**

*Acreage:* Stumpage (standing timber) is sometimes measured and bought by the acre. This is more common for pulpwood measurement than for other products, and is used extensively by large paper-mill operators of Canada.

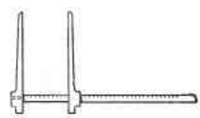
## *CRUISING*

**The Systematic Cruise.**

Estimating the volume of standing timber is known as *cruising.* The most reliable method of cruising is based upon a systematic use of measuring instruments and practices. This is called the *systematic* cruise. The volume of the trees on a representative or average portion of the forest is estimated, and the total volume calculated, based upon the volume of the part which was measured.

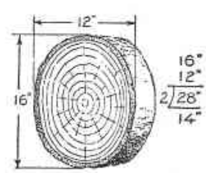
### CRUISING INSTRUMENTS

The amount of wood in a tree is determined by measurement of its diameter and height. Special instruments have been developed for use in cruising. It is desirable that one be acquainted with those commonly used.



*Calipers for diameter measurement.*

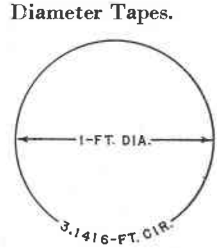
*Diameter measurement:* For measuring diameters, the caliper is the most common instrument. It is a heavy rule usually about 3 feet long, but longer for use on the very large trees. At one end of the rule a rigid arm extends at right angles, the rule and the fixed arm forming an L. Another sliding arm is attached also at right angles to the rule. The caliper is opened and the arms placed on each side of the tree trunk. The sliding arm is then moved close against the trunk, and the diameter read on the graduated (marked in units) ruler. If a tree trunk is oval instead of round, the longest and the shortest diameters are taken and averaged.




*Average diameter is found for oval logs.*

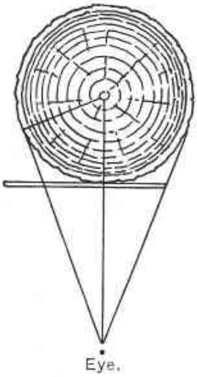
**Diameter Tapes.**

A tape may also be used to take diameter measurement. The circumference of the tree is measured and the diameter calculated by dividing the circumference by 3.1416. This is based on the fact that for every inch in the diameter of a perfect circle there are 3.1416 inches in the circumference. Diameter tapes on which these calculations may be read are available. With these tapes



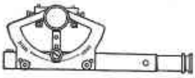
the cruiser reads diameters of the trees, instead of inches in circumference. Large trees may be measured by attaching the hooked end of the tape to the bark and running the tape around the trunk. With a tape, however, it is impossible to average the diameters of trees having oval-shaped trunks. A small fraction of their measurement is deducted if the tree has an oval shape.

*Diameter measurements may be taken with diameter tape or cruising stick.*



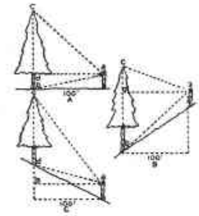

The Biltmore stick is a rule graduated to indicate the diameter of a tree. The rule is placed against the trunk of the tree at a tangent. With the eye about 25 inches away (average arm length), the diameter may be read by lining up the end of the stick with the line of vision to one side of the trunk and sighting across the rule to the other side. At the point where the line of vision crosses the stick, the graduation will indicate the diameter of the tree.

*Height measurement:* Heights of trees may be measured by an Abney hand level. The Abney is a pocket instrument for measuring angles or percent of elevation. (See chapter on Forest Engineering.) For tree measurement, the scale on the instrument should indicate elevations in percent; that is, it should be equipped with a percentage arc or limb.



*Abney level.*

The operator of the level stands a hundred feet from the tree and sights the instrument at the top of the tree or at the merchantable height. Then without moving the instrument, the level bulb attached to the side is adjusted to a level (horizontal) position. An indicator on the level tube indicates the percent of elevation on the graduated arc. The instrument is then sighted on the base of the tree and the percentage read. These two readings are added (subtracted if the eye of the instrument operator is below the base of the tree) and the sum (or difference if subtracted) of the two readings is the height of the tree in feet.



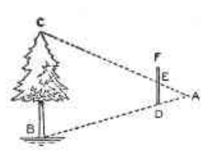
*Using the Abney level.*

There are many phases of measurement with the Abney impossible to describe in limited space. For details and full instructions, see *Forest Mensuration* by Bruce and Schumacher [1] or an Abney Handbook.[2]

**Hypsometers.**

An instrument for measuring heights of trees is called a *hypsometer*. There are many kinds of hypsometers, but only a few will be mentioned. The Forest Service hypsometer is probably the best one on the market. It works on the same principle as the Abney level, but a gravity bob, instead of a level bulb, is used to indicate the tree's height. The little plumb bob and the graduated arc are enclosed in a case. On one side of the case is an eye piece or peep hole and on the other side a little window through which the tree top may be seen. Sighting at the top of the tree at a distance of 100 feet from its base, the operator reads the tree's height on the movable scale.

The Merrit hypsometer is a very simple one, consisting of a rule graduated somewhat like the Biltmore stick, previously described. The cruiser, using a Merrit hypsometer, faces the tree at a fixed distance (usually 66 feet) holding the rule vertically at arms length. He holds the base of the rule on his line of sight to the base of the tree, sighting just under the bottom of the upright rule to the base of the tree. Without moving the rule or changing his position, he sights at the top of the tree. The marking on the rule which

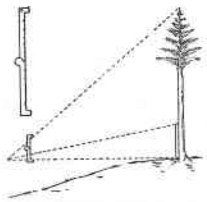



*Measuring tree height with Merrit hypsometer: Height BC. is indicated on scale DE.*

[1] *Forest Mensuration*, pp. 16–17. Donald Bruce and Francis Schumacher, McGraw-Hill Book Co., Inc., New York 1935.

[2] *The Abney Level Handbook*, pp. 16–19. H. A. Calkins and J. B. Yule, U. S. Forest Service. For sale by Superintendent of Documents, Washington, D. C. Price 5 cents.

lies in his line of sight to the top of the tree will indicate the height of the tree.



*Method of using Christen hypsometer.*

The Christen hypsometer is another simple instrument consisting of a rule or scale about 10 inches long which may be folded and carried in the pocket. The cruiser, facing the tree at sufficient distance to permit him to see its top and base, holds the instrument vertically before him. An assistant holds a 10-foot pole upright at the base of the tree. The cruiser moves the scale nearer or away from the eye until the whole length of the scale just covers the entire view (in height) of the tree. The marking on the scale which is on the line of sight with the top of the upright pole indicates the height of the tree.

## CRUISING PRACTICES

**Height Tables.**

Although cruising may be done by one experienced cruiser alone, he usually has a crew of assistants. Their job is to measure the diameters and heights of trees in a portion of the forest and to estimate total timber volumes from this data. In most cruises only enough height measurements are taken in each species to make height tables. By taking both diameter measurement and height measurement on a sufficient number of trees, average heights for different diameters in each species may be found.

**Height Averages Based upon Diameters.**

For example, in a definite locality, yellow pines with 16-inch diameters will average 38 feet of merchantable height, and trees of the same species having 20-inch diameters will average 46 feet of merchantable logs. In the same locality it may be found that red oak with 16- and 20-inch diameters average 28 and 35 feet, respectively. After such local tables are made, it is necessary only to measure diameters. Heights are then calculated from the tables. In cruises requiring more precision, each tree height may be measured separately. On cruises requiring less precision, all heights may be estimated by eye.

**Sizes of Crews.**

*The systematic cruise:* Under the systematic method, it is necessary for men to work in crews. The average-sized crew is composed of an experienced cruiser and three assistants, but three-man

*Members of CCC cruising timber.*

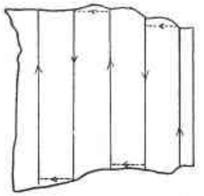
crews may work on some estimates, and a five- or six-man crew may also work to advantage, especially where hypsometer measurements are taken.

### A CREW AT WORK

**They Start.**

A four-man timber estimating crew using the *strip method* works somewhat as follows: A compass man, using a Forest Service compass, or a hand compass, starts on a compass line through the woods about 20 rods from one of the boundary lines of the tract. He goes up the slope of a hill rather than along the side because different altitudes and soils affect the size of trees, and better samples of the stand are obtained by this method than by working along the sides of slopes. The compass man drags a surveyor's chain tied to his belt as he walks along his course. The chief of the party, an experienced man, follows at the end of the chain and halts the compass man when one chain has been measured. These two men stop, and the forward man takes notes on topography, streams, and roads, and makes a rough map of the forest.

Beginning at the rear end of the chain, each caliper man paces off two rods on each side, or the leader, who acts as a tally man, assists in

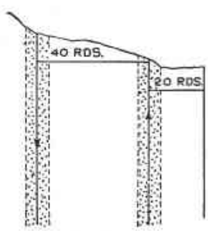


*Plan of strip cruise.*

measuring this distance. The caliper men then begin measuring the diameters of the trees and calling out their sizes to the tally man, who records them in his tally book. Defective trees are calipered and called, even if they are culls (trees unfit for lumber). One caliper man may call, "White oak, 23." The tally man records this in his tally book. The caliper man on the other side of the line then calls "Yellow poplar, 34." This is tallied and the first caller reports, "Maple, 19," and the second one, "Beech, 28, cull." No fractions of inches are called, because in diameter measurements such fractions are disregarded. Instruments are read to the nearest inch. If actual measurement falls on a half-inch mark, the nearest even inch is read. For example, both 19½ and 20½ are read as 20, or 21½ and 22½ as 22. (In height and length measurements, the same practice is applied to feet and fractions of feet.) The diameters are measured about 4½ feet from the ground. This height is handy for the workmen and is above the swell of the stump. This is called "diameter breast high" and is often abbreviated to D. B. H. All the trees above a minimum diameter on the four-rod strip are measured and recorded. The tally man walks along the compass line and inspects defective trees, estimating the usable part in each.

**Calipering Trees.**

**Tallying.**




*Strip method.*

If hypsometer readings are also being taken, two men usually work on each side of the compass line, one measuring diameter, the other estimating height of a tree at the same time. Two measurements are called to the tally man instead of one.

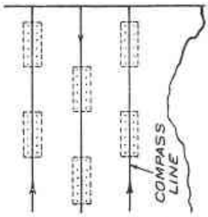
**They Finish the Strip.**

When the forward end of the chain is reached, the compass man moves forward again; the leader follows and halts him when the end of the chain reaches the mark made on the ground by the compass carrier at the position of the first halt. The procedure of measuring and tallying is repeated until the opposite boundary of the forest is reached.

**The Offset Line.**

After the strip is finished, the compass operator, with the help of another man, chains off 40 rods at right angles to the line just run. This is the center line of the return strip to be run back across the forest. Strips spaced at this distance give a 10 percent estimate of the whole forest. For a 20 percent estimate, the compass lines are spaced 20 rods apart (or 10 rods apart when the strip is reduced to 2 rods in width).

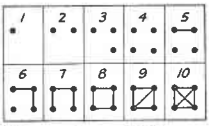
**The Return Strip.**



*Plot method.*

*The plot method:* Some cruises are made by the plot method rather than by strips. Under the plot methods the compass line is run as described in cruising strips. Plots are measured at certain distances apart along the line, instead of in a continuous strip. The plots may be square, circular, or oblong. The square acre may be paced (70 yards on each side) by the compass man. The circular acre has a radius of 118 feet or 39⅓ yards. The oblong acre—1 chain wide (66 feet) and 10 chains long—is probably most practical. This can easily be measured along the compass line and trees calipered as in the strip method. The percentage of trees to be measured in the cruise will determine the distance between the plots. Smaller plots of one-half to one-eighth acre are often used.

**Square, Oblong, or Circular Acres.**



*The system of dots and lines used by foresters in tallying.*

*The ocular cruise:* An expert cruiser may be able to make a fair timber estimate without the systematic use of instruments. He walks through the stand and examines the trees. By carefully noting the sizes and numbers of trees, he can make an estimate. Such a method of cruising is called the *ocular method,* because the eye is principally used to estimate sizes. The estimator, under this system, may carry pocket instruments, such as hypsometer and diameter tape, to check tree measurements. He may locate sample plots with average stand, pace off an acre, and count the average-size trees, thus arriving at an estimate of the total volume. Each cruiser uses his own methods based upon his experience and practice.

**Experience Instead of Instruments.**

**Each Ocular Cruiser Uses Own Methods.**

*The sample cruise:* The sample method of cruising requires enough systematic measurement to find the volume of the sample tree of each species in a forest or locality. The sample tree is an average-size tree of any one species. After the sample is found, cruising consists of counting

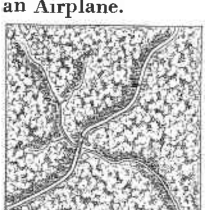
**The Sample Method.**

trees only. This may be done on strips or plots as desired. Sometimes, when no average sample has been found, counts may be made, every twenty-fifth or fiftieth tree measured, and when the entire count is completed the average volumes calculated from the trees measured.

*The seasoned woodsman estimates tree heights by eye.*


For extensive counting the cruiser carries a mechanical counter which fits in the hand. A small lever is pressed with the thumb to register each tree. The total number is recorded and may be read from a dial on the instrument and recorded. The counter registers up to 999 and then repeats. One cruiser may make counts in two species at the same time by carrying a counter in each hand.

Photograph from an Airplane.



*Aerial estimation:* Although timber cruising by aerial photography is in its infancy, many foresters believe that it has great possibilities. A series of vertical pictures covering the entire forest area are taken from an airplane (the camera being directed straight down). These are mounted, oriented, and fitted to show a complete photograph of the forest. Elevation, streams, trails, and other land marks stand out clearly, and different species and timber types may be identified if the pictures are taken in spring while leaf colors are fresh or in late autumn before leaves fall. Aerial photographs are used principally in mapping and locating types and stands. After they are located, direct measurement is taken to get averages in each type.

**Aerial Photography Valuable in Forest Mapping.**

*Rule of thumb:* Foresters and woodsmen know *rules of thumb* by which they can estimate the contents of a tree or log in board feet without the use of a volume table. A rule of thumb is a simple formula which may be easily applied in measurement. Probably the most common one is based upon Doyle's log rule, explained later. It gives the volume of a standard 16-foot log. The rule of thumb is as follows: *Subtract 4 inches from the diameter of the small end of the log inside the bark, and square the remainder.* The result is the board-foot content of the log. If the tree has more than one log, the average diameter inside the bark should be estimated, and the same calculations made. Multiply the results by the number of 16-foot logs in the tree. For instance, a tree with a 40-foot merchantable trunk would contain two and a half 16-foot logs. This rule gives high results for a three- or four-log tree. The small-end diameter of each 16-foot log in such trees may be estimated. The 4 inches deducted from the diameter under Doyle's rule is to compensate for sawdust and slabs—waste products of the sawmill operation.

**Rule of Thumb Simplifies Volume Calculation.**

**Estimating Tree Volumes by Rule of Thumb.**

*Volume tables:* For converting the measurement of diameters and heights of trees in a stand to board feet of lumber, volume tables are used. Such tables show how many board feet of lumber can be sawed from trees of different diameters and heights. Volume tables are most accurately made by measuring a number of trees carefully, following each of them through the mill, and measuring the volume of lumber sawed from each one. In this way the amount of lumber which can be expected from trees of certain size is known, and the number of board feet of lumber in a forest may be estimated.

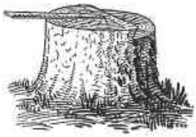
**Checks at the Mill for Volume.**

How to Use Growth Studies.

Mensuration is used for other purposes than determining timber volume. Growth studies demand exceptionally close measurements both in diameters and heights. The results of such studies are valuable in making cutting plans, in solving management problems, and in determining forest policy. Much of the research which has made the science of forestry possible is based upon accurate measurement.

Checking Up on Annual Growth.

The farmer harvests his crops annually, measuring the yield and determining his profit or loss. The forester or timber grower has to wait long periods to check his harvest. It becomes necessary, therefore, for him to make growth studies to see what forest stands are yielding. Some stands may be increasing in growth so slowly that they are not profitable. Forest increment (increase in volume) may be calculated by accurate measurement.

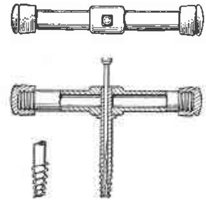


*Counting rings:* The sizes of trees at various ages in a particular stand may be found by measuring a number of trees, determining their ages, and relating age to size. If the study is being made on a plantation, a record of the age of trees should be available. If not, the best method of determining age is by counting growth rings. Each spring a tree adds a spongy growth just under the bark. In summer, a firmer growth overlays this first one. This growth of *springwood* and *summerwood* together forms an *annual ring.* These rings may be counted on cross cuts of tree trunks to determine the age of the tree. The stump of a freshly cut tree shows the rings very plainly.

See pp. 6, 7.

Logging Operations Permit Easy Count of Rings.

It would be a wasteful practice to fell trees in order to count rings, and leave them on the ground to rot. If trees are cut to make growth studies, arrangements should be made for using the timber. It is sometimes possible to combine a growth study with a logging operation. Rings may be counted on the stumps and logs, and diameter measurements taken inside the bark with an ordinary rule.



*Boring:* Where it is not possible to make studies on logging operations, precise measurements in diameter and height are made, and ages are found by use of an *increment borer.* This is a gimletlike instrument for boring into the side of the tree. It has a hollow bit that bores out a "core" of wood on which the rings may be counted. It is not necessary to draw a core all the way from the center of large trees. The number of rings per inch is calculated, and ages of trees thus computed. The increment borer makes a small hole which soon closes and does not seem to damage trees. Sometimes the hole is plugged with grafting wax to prevent the entrance of insects or diseases.

**Annual Rings as Shown by Increment Cores.**

**Determining the Yield.**

*Yields:* Rainfall, temperature, and soil conditions greatly affect the growth of forests. The *normal* yield is the yield obtainable from a completely stocked acre of healthy trees in the locality. The *empirical yield* is the average increase per acre obtainable from the actual stand of the forest.

**How to Make Yield Tables.**

*Yield tables:* Data obtained by growth measurements may be used to make yield tables from which future yields may be predicted. After the average sizes of trees of certain ages have been found, they are plotted on cross-section paper—sometimes called graph paper—and used in making the tables. On a sheet of cross-section paper, volumes are plotted on vertical squares and ages on horizontal squares. Curves for determining averages are plotted. The same methods are used in making volume tables either for trees or for logs (log rules). In cruises, heights and diameters may be plotted to obtain average heights for certain diameters.

**Use of Cross-Section Paper.**

Unless one is fairly familiar with calculations by means of cross-section charts, it is impossible to explain formation of tables in a limited space. Refer to any good text book on Forest Mensuration[3] for detailed explanation of these graphic processes.

[3] (1) Chapman, Herman H., *Forest Mensuration;* (2) Bruce and Schumacher, *Forest Mensuration;* (3) Chapman and Demerritt, *Forest Mensuration.*

## *TIMBER SURVEYS*

**Timber Cruises Are Valuable in Surveys.**

A *timber survey* extends over large areas. In making such a survey several cruising crews may work out of the same headquarters or camp, moving from one location to another. Forest areas are located, stands measured and classified, and yields predicted. Tables and maps are made as a record of the survey. The *forest survey,* although based on forest mensuration, includes other factors than the actual timber growth, or increment. Soils, drainages, and other factors affecting forest production are studied, in addition to timber stands. The crews of a forest survey may be composed of engineers, foresters, and soil experts and their assistants. The forest survey is used extensively by the United States Forest Service in land acquisition. Surveys reveal facts necessary in purchasing areas to be converted into national forests.

**Use of Forest Surveys.**

## *SCALING TIMBER*

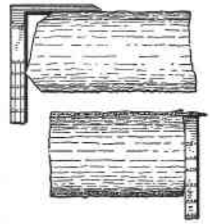
The measuring of logs to determine their volume in board feet is called *scaling.* Logs may be scaled where they are cut in the woods, on landings or skidways, or at the mill. Since log-cutting crews are usually paid by the thousand board feet, scalers may measure logs where they lie, as a basis for paying the crews. They may be scaled on skidways as a basis for paying snakers or haulers, and at the mill as a mill check. In connection with log sales, logs are usually scaled by a representative of each party to the contract.

**Why Scale Logs?**

**Log Rules Are Timesavers.**

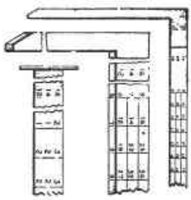
Log rules have been made to facilitate measuring the contents of logs. By measuring the diameters and lengths of logs, and referring to the log rule, the volume of lumber contained in a log of any size may be found.

*Scales:* Log scales or "scale sticks" have been devised which simplify scaling practice. They are used to measure diameters and lengths and to estimate volumes. There are many different scales, based upon various log rules, but they are basically the same and are used in the same manner. A scale stick is a rule 3 to 4 feet long, somewhat like a common yardstick. It is made of tough hickory or maple, and has a handle at one end and a protecting brass tip at the other. On some of the tips there are L extensions which aid in holding the scale on the end of logs. Others have short, sharp hooks or spurs which may be forced between the bark and the wood. They help to hold the scale on the log and aid in taking the D. I. B. (diameter inside bark) measurements. Scale sticks are marked in feet and inches along both edges. These graduations are used in measuring the logs. The log-rule values are placed on the sides of the sticks, one row of figures indicating board measures of logs of given lengths and diameters.



**D. I. B.**

*Using the stick:* The scaler places the stick on the small end of a log. If, for instance, the figures on the edge of the stick show that the log is 17½ inches D. I. B., he calls this 18 inches. A fraction of an inch is read thus to the nearest even inch. The figures on the side of the stick near the 18-inch mark indicate volumes for different lengths. If the log is 12 feet long, the scaler locates the figure in the row of volumes for 12-foot logs—160 board feet.



*Variety of scales:* There are 20 to 30 different log scales in use in the United States, based on different log rules. The Doyle, Scribner, and Spaulding are well-known scales, and many States have adopted legal scales. These are known by the name of the State, for example, the Maine scale.

**Log Scales Not Standardized.**

Log-scale values differ. Some of the differences are radical for certain sizes. An expert in forest mensuration states that the use of different scales may make from 5 to 50 percent difference in the scaled contents of the same log.[4] The Doyle scale deducts 4 inches from the diameter of the log for mill waste. The scale of a 16-foot log with a diameter of 8 inches is reduced 75 percent by this deduction. It is evident that this is too great a reduction. No mill should waste three-fourths

[4] Herman H. Chapman, *Forest Mensuration*, p. 88.

of an 8-inch log in sawing. The Doyle rule gives a low scale for logs less than 28 inches in diameter.

**Scribner Scale.**

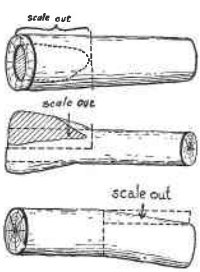
The Scribner scale seems to be more reliable. On larger logs, however, it has been found by mill tallies that the scale is low. On a 34-inch log, the Scribner scales 100 feet less than the Doyle rule. It is marked in decimals (units of 10 feet) rather than in exact measures. A mark of 9 on this scale indicates a volume of 85 to 95 feet; a mark of 15 indicates a volume of 145 to 155 feet. In a number of logs scaled by a decimal scale, some may be high, and some low, but the average will be the multiple of 10: Thus the two examples would average 90 and 150 feet respectively, and would be so tallied.

**Decimal Scales.**

Log dealers and mill men use a combination of these two rules in the Doyle-Scribner scale. This makes use of the principle of the former rule up to 28-inch diameters and the latter for larger logs. Thus the portions of each rule have been used which favor the mill owners, often to the disadvantage of the timber producer.

**Rule of Thumb for Logs.**

Logs may be scaled by a rule of thumb when logs rule or scale sticks are not available. The rule given for the estimation of tree volume (p. 177) may be used. Diameters of logs may be measured with any convenient instrument and the rule of thumb applied to get volumes of logs of each dimension.




*Scaling defective logs:* When logs have visible defects which would decrease the lumber volume, defective parts are "scaled out." Logs with excessive defects may be rejected as culls. If enough of the log can be utilized to justify sawing, deductions are made for the defective part. Rots, hollows, crooks, windshakes, cracks, and sometimes other minor defects are scaled out. The part of the log which cannot be used is measured and subtracted from the volume of a sound log of the scale dimension.

**Overrun.**

*Overrun:* Some sawmills have considerable overrun of lumber above the scale of the logs. A band sawmill, using a thin saw, can get more lumber from a log than a mill using a thicker saw. The circular saw cuts an average kerf of about three-eighths inch, while the band saw cuts less than one-fourth inch kerf. The sawyer, by expert handling of the log, can raise the overrun. A log 16 feet long has a greater diameter at one end than at the other, and since the average diameter is used in scaling, several 10- or 8-foot boards which are not included in the scale can be sawed from this log.

**Lowering Mill Waste.**

*Each log is scaled, marked, and tallied.*

*Forest Service practice:* The United States Forest Service has adopted standard scaling regulations to be followed in measuring national forest timber. The Scribner decimal C scale is used, and definite instructions are given for scaling out defects. The scaling practices are fair to purchasers and provide for a small overrun. Complete regulations of Forest Service scaling may be found in the book of instructions for scalers.[5]

**U. S. F. S. Standards.**

[5] *Instructions for the Scaling and Measurement of National Forest Timber.* Forest Service, U. S. Dept. of Agriculture, 35 cents, The Superintendent of Documents, Washington, D. C.

## *SUMMARY*

### AN EXAMPLE OF PRACTICAL FOREST MENSURATION

**The Forest Owner Secures an Estimate.**

A forest owner has an area of matured timber that he wants to sell. Before advertising it, he employs an experienced timber cruiser to make an estimate of the quantity of timber on the area. The cruiser goes into the woods alone, and by using pocket instruments for occasional checks on diameters and heights, and by counting trees on average plots which he has paced off, he calculates the volume of saw timber per acre. By examining records of previous surveys of the area, the cruiser determines the total acreage of the tract of land. He calculates the total volume of timber and reports to the timber owner.

**The Prospective Buyer Makes His Estimate.**

The owner advertises his timber for sale. He sets a stumpage price. A timber dealer needs the timber, but it is necessary for him to buy close, because poor markets force him to sell at a low margin of profit. He asks permission of the owner to make a systematic cruise of the area. With this permission, the dealer sends a crew into the woods to make a closer estimate. The crew uses the strip method, measuring the merchantable trees on 10 percent of the area. Diameter readings are taken by calipers, and local volume tables are used to convert diameter readings to volumes in board feet.

**The Timber Is Sold.**

After the systematic estimate is finished, the dealer concludes that he can afford to pay the asked price, since his estimate is higher than that made by the first cruise. The transaction is made, and the logging operation begins.

**Trees Are Marked for Cutting.**

The dealer goes into the woods himself, and with other timbermen in his employ, marks the trees to be cut, being very careful to mark only the trees above the diameter minimums specified in his contract. Men are employed to fell and buck the trees. Each sawing crew fixes its mark on the timber which it has cut.

**Regular Check Scales Are Made.**

Every day or two, a log scaler employed by the dealer, scales the timber cut by each crew and enters it on a record sheet which he turns over to the the pay-roll clerk.

After the timber has been cut, it is snaked to skidways by contract loggers. It is unnecessary to rescale the timber as a basis for paying the skidders, because the scaler has marked the scale of each log on its end.

**The Mill Owner Rescales the Logs.**

Meanwhile the dealer has sold his timber to a mill owner several miles away. The mill has its own equipment for transporting the logs. They are scaled at the skidway by a competent scaler employed by the mill and the dealer himself. They agree on the scale of defective logs, sometimes having rather heated arguments as to whether a log is merchantable or is a cull.

**A Mill Check Is Made.**

The timber has changed ownership twice and its volume has been estimated in board feet several times, but it is still to be measured many times. The mill owner, as a check on his scale and as a matter of business record, measures the exact volume of sawed timber that he obtains from the logs.

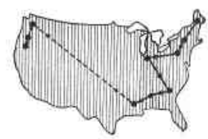
The use of forest mensuration is apparent. Further measurement of the timber would be classified as scaling lumber.

## Chapter IX

# LUMBERING

**Forestry and Lumbering.**

THE combined processes required in taking timber from the forest and converting it into usable forms are known as lumbering. Lumbering may be divided into two main processes, logging and milling. Forestry is concerned with logging more than with milling, since the latter is more related to the manufacturing industry than to the science of forestry.



*Lumber movement; shifting of lumbering centers of the United States.*

### HISTORY OF LUMBERING

**Before Sawmills Came into Existence, Sawing Was Done with Whipsaws.**

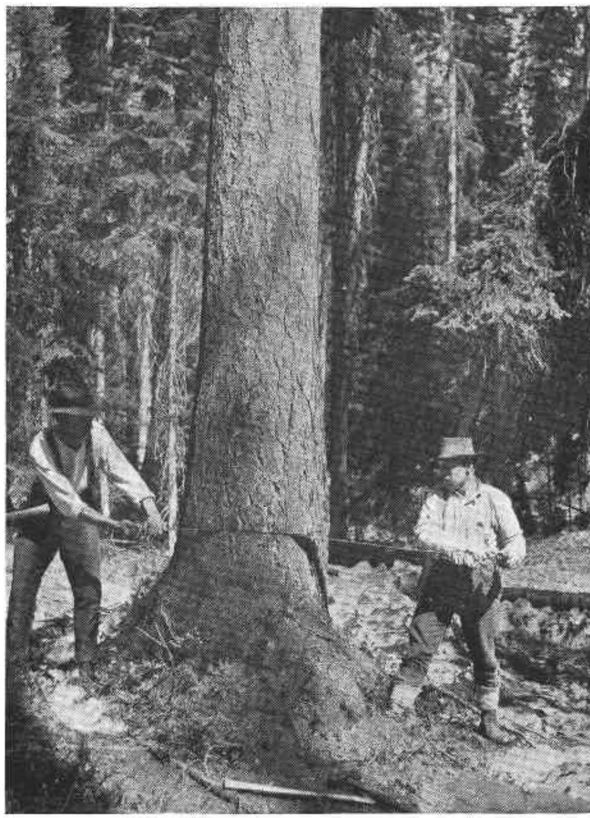
The movement of logging centers was shown in the third chapter. This movement has brought new methods and new machinery to the logging industry. Logging practices today are varied, depending upon topography and species. Early logging was done with the ax, and logs were transported by ox team. A whipsaw was used for converting logs into lumber. This was a long saw, operated by two men, which ripped boards lengthwise from logs.

*A whipsaw in action.*

**The Small Sawmill Is Very Important in Lumber Production.**

The first sawmill in this country was established about 1631 in Maine. This small mill, driven by water-power and cutting only a few hundred feet of lumber a day, was very crude compared with some of the large mills of today, with a cutting capacity of nearly a million feet a day. Trees may be felled with power saws, transported entirely by machinery, and sawed by buzzing hand saws. However, not all lumber is cut in large mills. Such mills are practical in extensive stands where the supply will not be depleted for years, but on limited tracts small portable mills are used. These small mills cut 75 percent of the lumber in some areas. They are located principally in New England and in the southeastern pine region.

**Processes in Logging.** Logging may be divided into several minor processes. These are marking (explained in Ch. 6), measuring (explained in Ch. 8), felling, lopping, bucking, skidding or yarding, and transporting.



*Felling timber is a man-sized job.*

## FELLING

Trees are felled principally by hand, although motor-driven cross-cut saws have been devised. These are bulky and unwieldy, especially on rough land. In felling, a notch is cut in the tree to help in directing the fall and to prevent splitting and breaking of the bole. The tree is then sawed off from the side opposite the notch. Trees should not be felled on other timber or young growth because of possible damage to them. Precautions should be taken to fell the tree on as smooth ground as possible, since a tree falling

*Notching a tree with power saw.*

across stumps or large stones may shatter or break, and is sure to be difficult to cross-cut. Sometimes large trees are felled into "cradles" made of brush. These cushion the tree and prevent breaking and splitting. The direction of the fall depends upon the lean of the tree, the wind, and the undercut notch. A tree standing straight may be thrown in the direction desired by notching it on the side facing the intended direction of fall. A wedge is driven into the saw cut to prevent it from closing on the saw. Heavy wedging is necessary when the desired direction of fall is contrary to the lean of the tree.

*Wedges direct the fall.*

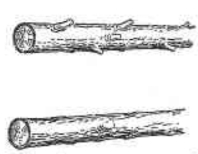
*Springboards in use.*

Trees should be sawed close to the ground, even though this slows the felling process. In logging the big redwoods of the west coast, the stumps are usually left high because trees have considerable ground swell. Saws from 12 to 18 feet in length are required, and springboards are attached for sawyers to stand on while felling the tree. A springboard is about 8 inches wide and 5 feet long. It has an iron "toe" attached to one end which holds it in a small notch chopped in the side of the stump at the required position. Springboards are not being used as extensively as they once were because lumbermen are cutting stumps lower. Power saws are also being used more in felling big timber.

*An iron "toe" grips the tree.*

### TRIMMING

The limbs are trimmed from the tree trunk. This is called *lopping* or *limbing*. In limbing trees, care should be taken to trim the branches off smoothly so that no snags or knots are left on the logs. In order to keep the top of the tree from breaking and to protect trees nearby, woodsmen often trim and top the tree before felling it. This is one of the most difficult jobs in logging and requires skillful work.



*Showing proper and improper trimming.*

### BUCKING

Cross-cutting the fallen tree into logs is called *bucking*. Small trees are usually bucked into logs by a two-man crew, while big trees, such as the redwoods, are more often bucked by a single

*A one-man cross-cut for large logs.*

*Bucking trees into logs. Note measuring stick, wedges, and sledge.*

*"Gum" bottle.*

*Transporting log on "bummer."*

*Using grab hooks and chain.*

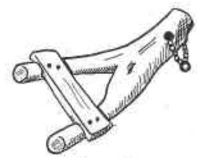
workman who uses a one-man saw. This eliminates the scaffolding on each side of big logs which would be required for two-man bucking. Experienced loggers know many tricks that aid in cross-cutting trees having a bad "lie." Sometimes the cut must be made from below. Wedges must be driven in to keep the wood from binding the saw. Various forms of false work and jacks are used to aid in bucking. In sawing pine, resin and gum gradually collect on the saw until it cannot be drawn. It is necessary to sprinkle the saw often with kerosene to remove this gum. A bucking crew working in pine usually carries a jug of kerosene and a bottle with a stopper of pine needles which permits sprinkling.

## *TRANSPORTING LOGS*

Although methods of felling and bucking have not changed greatly for a century, methods of transportation have shown decided departures from old methods. However, the old methods are used today in some sections and on small jobs. In early timber operations logging was done as near streams as possible and logs floated or driven to mills. Since railroads and motor roads now reach more timbered areas, streams are not utilized so much as in the past.

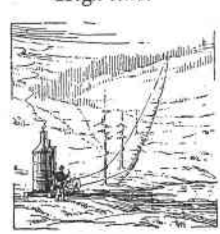
## SKIDDING

*Logging-trails.*



*Lizzard.*

*High line.*



*Low line.*

*Yarding arch.*

After logs are cut, they must be collected so that they may be taken out of the woods in loads as large as possible. Collecting logs to the skidway is commonly known as skidding. Horses, mules, and oxen may be used in collecting, but the day of oxen has almost passed. Once they were practical, and in large timber five or six yokes were sometimes used to drag out heavy logs. In small timber, especially in the East, mules and horses are used to drag or skid the logs along trails which have been "swamped out" (brush and small trees cut) through the woods to skidways on secondary trails; or the logs may go directly to the yard on the main road or stream. A yarding sled or a "lizzard" may be used to keep the front end of the log off the ground to make dragging easier. Yarding carts are also used where the ground is not too steep and the character of the woods and trails permit it. Some yarding carts are known as self-loaders, because they are so constructed that the team is used in loading the yarder.

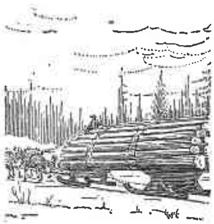
On large operations and in big timber, much of the collecting is being done by cables and steam power. Wire cables are stretched from tall trees to an engine, and steam winches are located near the road. Logs are hooked and carried on traveling pulleys along the *high line.* Sometimes a long line is dragged out by workmen and attached to logs on the ground, and the cable is rewound on the drum of the winch, thus *snaking* the log along the ground to the yard or skidway. This is called the *low-line* method.

Where topography will permit their use, caterpillar type (track-laying) tractors are used. They drag the logs directly on the ground, or carry the front end by a yarding arch, similar to the lighter yarding cart. The logs are raised by motor power and the front end is slung under the heavy arch of the yarder. The tractor can tow huge logs by this method and is able to travel over very rough ground. Yarding arches are used principally in the West where large companies operate in big timber.

## LOG HAULING

*Single sled.*

After logs have been collected, they are transported to primary roads, railroads, or streams. Three or four different methods of transporting may be used on a log before it reaches its destination. If the mill is located in or near the forest area, they may go directly to the mill. In northern United States and Canada, logs are transported by sleds. Two-sleds or bobsleds are drawn by horses and may carry several thousand feet of lumber at one load. Roads built during summer months are used after snow falls. Sled tanks are sometimes needed to haul water and sprinkle the roads so that they will freeze slick and firm. Large, steam-powered tractors once drew trains of log sleds along snow roads. Gas motors have largely replaced steam, and small tractors are sometimes employed in sledding.



*Two-sled.*

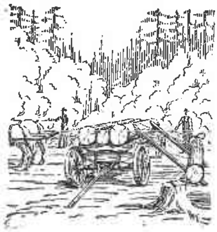
Log Chutes.

Occasionally log chutes are made on which logs are slid from mountain sides down to valley roads. These are made by spiking two small logs side by side to form long chutes so that a log will lie between the two poles and slide down the incline on them. Grease is put on the slide so that the logs will run easily. On steep slopes, the poles are roughened to prevent the moving logs from developing too much speed and jumping from the incline. Horses or mules are some times used to snake turns of logs along slides not built on inclines.

Wagon Hauling.

Hauling logs by wagon requires better roads than sledding. Wagons are used principally in the South and East. Log bunks are installed on the chassis, and special equipment for booming (tying the log on the wagon) is necessary when hauling over rough trails. Wagons with low wheels and wide tires are best suited to logging. Wide tires prevent miring of wheels on marshy ground. Logs may be loaded from a skidway or from level ground by cross-hauling. In cross-hauling the wagon is placed parallel to the log about 15 feet away. A chain attached to the center of the wagon is passed down to and around the log and back across the wagon. A team pulling on the opposite side of the wagon can roll the log up skid poles to the bunks.

The day of long hauls by wagon has practically passed. Just as tractors have replaced slow oxen in yarding heavy logs, so motor trucks have been substituted for wagon and team in main hauls. Roads suitable for wagon hauls can be made fit for truck transportation with little additional labor. Stands of timber which once would have required railroads and spurs can now be logged and moved by truck. Small operators in the South with two or three trucks may haul logs to a portable mill. Large operators in Oregon may use a fleet of 20 trucks, motor yarders and donkeys, three or four tractors, and a pair of motor log loaders. Heavy trailer-type trucks can handle loads of 3,000 to 5,000 board feet, operating over distances up to 75 miles.



*Cross hauling.*

**Motor Logging.**

*The motor truck is a modern means of transportation.*

Tramways and railroad spurs are sometimes constructed for short-distance transportation. The old wooden-rail tramroad is practically out of use. Crude tram tracks were made with poles for rails. It was not necessary to gage the track carefully as the car wheels could play slightly in and out on their axles. The cars were usually horse drawn, and the system was fairly efficient considering its cost.

**Railroad Transportation.**

Narrow- or standard-gage railroads are also used with steam or gasoline motors to draw log trains. On large operations, using locomotives for transportation, spurs are built into parts of the woods where logs can be concentrated. Internal-combustion motors are being used in locomotives, and Diesel engines are also coming into use. Gas and Diesel motors simplify fuel problems and reduce fire hazards. Steam and motor loaders are used with rail-logging operations. Cars may be loaded or unloaded at any point with loaders carried on a railway car or built on endless chain tracks like the caterpillar type tractor.

**Spur Tracks.**

*Loader.*

## TRANSPORTATION BY WATER

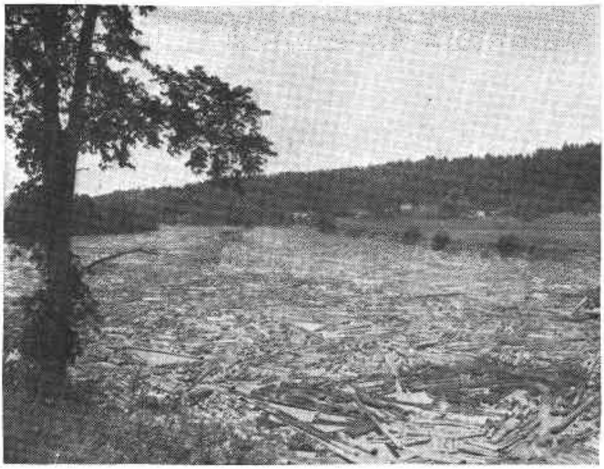
**Running Logs.**

Transportation by water is as old as the logging industry. The log drives of the North and the rafting in the Mississippi basin are epical and historical in their interest. Novels, stories, and songs center around the activities of "running" logs. In the North, the drive method is still used extensively, especially for pulp logs.

### DRIVING

**Cheap Transportation.**

The logs are collected at landings by methods already described. If the streams are high enough, the logs are dumped into the streams and floated down to mills, or perhaps to railroads. If the streams are small, drivers must wait until freshets raise the streams enough to float logs. On small streams, dams with flood gates may be constructed. The gates are closed, water is collected,



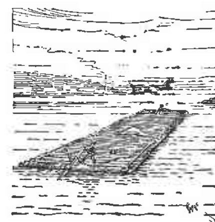
*Logs are driven to the mill in flood seasons.*

and the gates are then opened to make a "head" of water. Drives may then be made when desired.

If more than one company is operating on one stream, each operator must mark or brand his logs before driving. Booms, which collect the floating logs, are built in the streams at the log terminal and the logs caught and identified.


*Boom collecting logs.*

RAFTING



*A log raft on the way to the mill.*

**Aquatic Equestrians.**

Rafting is done on larger streams where there are no falls. Logs are fastened together by "tie poles" running from one end of the raft to the other. On larger streams, logs may be "cradled" in binding chains and floated down to mills. In the early logging days, shanties were sometimes built on the rafts for the comfort of the loggers. Weeks were sometimes required to float the rafts down to markets. Some timbermen took their saddle horses along on their rafts and rode them back from the distant milling centers.

**Three-way Water Transportation.**

Steamboats and tugs tow rafts on the larger streams or along the Northwest coast. Three methods of river transportation may be practiced by one logger. He may run his logs down a tributary stream in drives. At the mouth of the stream he may catch his logs and raft them into small units and float them to a larger stream or to navigable water. There he may combine his small rafts by lashing them into a large one, and have them propelled by a tugboat to their destination.

FLUMES

**"Fluming."**

For shorter runs by water, flumes were once used extensively. Flumes are continuous troughs of water in which timber is floated. Although they are still used to a considerable extent, they are gradually disappearing. One flume 55 miles long is in existence in California. Flumes are best adapted for movement of small material such as may be used for pulp and mine timbers. These flumes lead along mountain sides, cross hollows and ravines on trestles, and require skillful engineering in construction. They must be

*A log flume.*

built so that a definite water level may be maintained in the troughs at all times throughout their whole length, and the elevation must be such that the water will flow swiftly. Much water of course leaks from the flumeway, and from time to time headwater must be built up by diverting adjacent streams into the flume.

## *STORING LOGS*

Dry Storage.

In logging seasons, trees and logs are usually cut faster than mills can saw them. Consequently the logs must be stored by large mills which operate steadily. Logs may be stored at the mill by piling them in the yard or by keeping them in ponds or boom pockets along streams. Storage ponds serve a number of purposes: (a) Logs stored in them may be moved easily. Pond men, skilled in the use of long pike poles, can manipulate selected logs to the chain drags which convey the logs into the mill. (b) Water storage keeps the logs moist and prevents checking and cracking. (c) Bark beetles and other destructive insects cannot breed in submerged logs. (d) Water loosens gravel and stones which the logs have picked up when being dragged through the woods, and which would injure the saws if left imbedded in the wood.

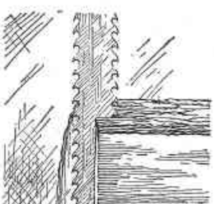
Water Storage.

*From pond to mill via chain drag.*

## *MILLING*

From the yard or storage pond the logs are carried into the mill either by an endless chain, fitted with teeth or drags to hold the logs, or by derricks. Tractors and cables, or winches, are used in some mills. The logs are scaled at the entrance and rolled to the log deck. From the deck they are rolled on the carriage, which carries them to and against the saw.

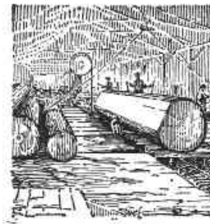
### TYPES OF SAWS



*A two-way band saw.*

Saws may be circular or they may be band type. The circular saw has the teeth on the circumference of a steel disk and turns like a wheel on its axle. The band saw is a steel belt with teeth cut on the edge. It runs at high speed over two pulleys. Some of the band saws have teeth on both edges so that the log may be driven against the saw from either side. Thus the speed of sawing can be almost doubled.

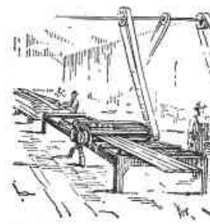
In mills demanding high production, gang saws may be used. Gang saws consist of two or more saws mounted together. Instead of sawing one board at a time gang saws will cut as many boards as there are saws.



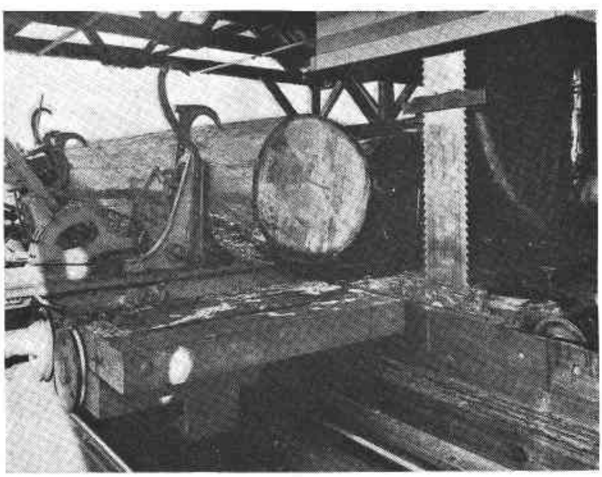
*Steam "niggers" turn logs on carriage.*

### SAWING

The efficiency of a mill depends largely upon the sawyer. Since he controls the carriage and the log, the quantity and quality of lumber cut from the log depends largely upon his skill. A mechanical device called a "steam nigger," controlled by the sawyer, adjusts the log on the carriage so that it will produce the maximum amount of clear lumber.

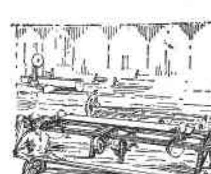


*Edger cutting to varying widths.*



*Fore-and-aft band saws increase sawmill production.*

After the boards are ripped from the log, they fall on live rolls which convey them to edgers. These are small saws adjustable to different widths. They cut the bark and rough edges from the boards, which are then cut to proper lengths by trimming saws. Sawdust, slabs, and edgings are usually carried by conveyors to the boiler room where they are used for fuel.



*Trimming to required length.*

### SEASONING

Lumber is stacked in the open to season. Narrow strips of wood are placed between each



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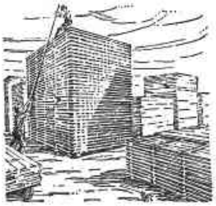

*Air spaces in lumber stacks permit seasoning.*

layer of boards so that the air may circulate freely around them. Timber requires from 3 months to a year to season, depending on climate, weather, and its condition when sawed. Seasoning may be hastened and accomplished more efficiently by kiln drying. In this process lumber is loaded on small cars and taken into kilns where it is held at the desired condition of air temperature and dryness until thoroughly dry. Kiln-dry lumber is stored in buildings to keep it from absorbing moisture again.

### PORTABLE MILLS

**Portable Rigs.**

*Portable mill.*

Where small, portable mills are used, there is no storing problem. Logs are collected and put directly on the deck. Three or four men make up the sawmill crew. Instead of transporting logs long distances to the mill, the mill is taken to the timber. Single circular saws are used principally. Gas or kerosene tractors are becoming popular for power because the tractor can be used to move the mill from one location to another as well as to drive the saw.

## *SUMMARY*

See pp. 3, 37.

Lumbering is divided into logging and milling processes, but forestry is not closely related to milling. The history of lumbering is interesting from the social as well as the commercial viewpoint. The establishment of logging centers from New England southward, then west to the Lake States helped to build up the manufacturing centers of the Northeast. Next the southern pines were cut to fill market needs. Lack of sufficient lumber in the East and development of better transportation facilities sent the lumbering center across the Western States to the redwood, ponderosa pine, and Douglas fir stands of the West coast.

**Hand Labor Still Important in Forest.**

Logging is divided into the following operations: Marking, measuring, felling, trimming, bucking, skidding or collecting, and transporting to the mill. Regardless of machinery designed for felling and bucking, these jobs are still largely done by hand. In felling, care should be taken to protect the workman from being injured, to protect grow-

ing timber from damage by the falling trees, and to protect the tree being cut from breaking or splitting. Limbs should be trimmed to make smooth logs which are easier to handle than knotty ones. Bucking is another word for log making. Tree trunks are cut into log lengths by use of two-man cross-cut saws, or in the big timber of the West coast by one-man cross-cuts.

Logs are hauled in many ways. Skidding, or collecting logs on skidways, landings, or yards may be done by snaking, using yarding sleds or carts, tractor yarding, or line skidding. Logs may be dragged along the ground by low-lines or carried through the air on high-lines. Sometimes chutes or slides made of poles are used for skidding logs.

See pp. 191, 192.

Logs may be transported from skidways or yards to mills by many forms of conveyances. Sleds drawn by horses or by tractors can carry great loads when there is sufficient snow. Wagons may be used for short hauls. Modern motor trucks are replacing sleds and wagons in hauling on main roads. Trucks have brought formerly inaccessible quantities of timber into markets. Huge loads may be transported over distances up to 50 or 75 miles.

**Truck Is Taking Place of Wagon and Sled.**

Water transportation is not used so much as formerly because stands of timber have receded from water courses, and roads have been built to many of these areas. Logs may be driven in small streams, or in larger streams, rafted and floated to markets. Steamboats may propel rafts on sluggish streams and larger rivers. Flumeways are sometimes used to float logs or small timber to mills.

**Water Transportation, pp. 194, 195.**

Tram roads with wooden or steel rails are used for transportation. Narrow-gage or standard-gage railroads are sometimes built into timber stands, but only large operators use locomotives for traction. Motor trucks are replacing railroad logging also.

**Transportation by Rail, pp. 193, 194.**

Logs are stored, when possible, in water. They are handled and preserved better in ponds than in dry storage. Logs are sawed in large mills by band saws, and trimmed and edged by highly

**Storing.**

**Sawing.**

*Self-loading logging trains are used on large operations.*

Seasoning, see pp. 197, 198.

mechanized processes. Seasoning is done in open air or in kilns. Kiln-dried lumber is preferred to open-seasoned lumber.

**Small Mills.**

Portable mills play an important part in the lumbering business. Small stands, which could not otherwise be utilized, can be economically cut by the small mill. The saw rig that can be hauled from one location to another by a tractor and then driven by the tractor is a very useful unit in the lumbering business.