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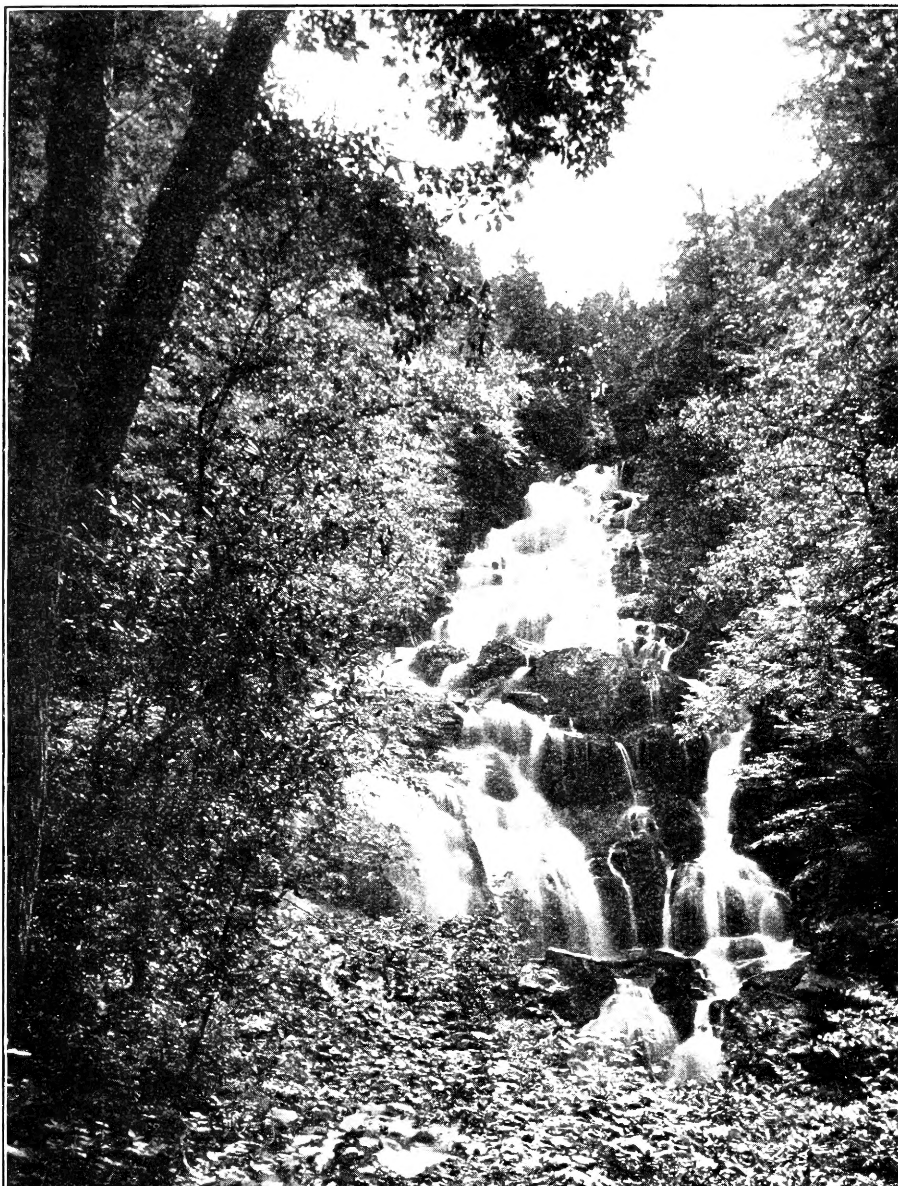

FIG. 1. In the Woods

FIRST BOOK OF FORESTRY

BY

FILIBERT ROTH

CHIEF OF THE DIVISION OF FORESTRY, UNITED STATES DEPARTMENT OF THE INTERIOR, IN CHARGE OF THE WORK IN THE GOVERNMENT FOREST RESERVES, AND FORMERLY ASSISTANT PROFESSOR OF FORESTRY IN CORNELL UNIVERSITY

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PREFACE

DURING the last twenty years the general interest in forestry has grown with remarkable rapidity in all parts of our country. The federal government has set aside large forest reserves, and several states have established reservations or parks. The private owners of large tracts of forest lands are employing trained foresters to care for their property, and an improvement in the smaller holdings is everywhere noticeable.

Forestry is taught in two special schools in America, and elementary courses on the subject are given in several colleges and preparatory schools. A desire has been expressed to introduce this useful and interesting study into our public schools and country homes, and this volume is an attempt to provide a book on the subject which shall satisfy this demand. In keeping with this purpose there has been no attempt to write a textbook or manual of forestry; but an effort has been made to present in simple, non-technical language some of the general principles underlying the science, and to state the methods which are employed and the objects to be attained in the practice of forestry.

Early association with the well-kept forests of Germany, observations made in the widely differing forest districts of our own country, and three years' experience in teaching forestry have helped to make the responsible task of preparing this book a pleasure. While, as a matter of course, the many excellent German works on forestry have served as a basis and a guide in writing the book, yet an effort has been made to use our own woods for illustrations and to adapt the subject-matter to American conditions.

The collecting of the illustrations has been greatly facilitated by the kindness of Dr. L. N. Britton, Col. Wm. F. Fox, Prof. J. A. Holmes, Messrs. Newell and Gannett of the United States Geological Survey, Dr. J. T. Rothrock, Prof. N. Gifford, and Mr. Gifford Pinchot, Chief of the Bureau of Forestry of the United States Department of Agriculture. To these gentlemen I extend my sincere thanks.

Especial thanks are due to Mrs. Anna B. Comstock of the Bureau of Nature Study of Cornell University, whose kind interest and request called this book into existence. Her good judgment has proved of great value in the arrangement of the subject-matter, and her assistance in seeing the book through the press has made its early publication possible.

FILIBERT ROTH.

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FIRST BOOK OF FORESTRY

PART I

THE FOREST

THE WILDWOODS

IT is a bright September day. Let us take a stroll into the wildwoods.

Here we are. A fringe of wild rose and raspberry bushes introduces us to a denser border of hazel, dogwood, and hawthorn, mixed with shrubby, limby trees of beech, maple, and elm. Let us break through the forest border. What a change! Within a few steps we have passed from a grassy pasture, through a dense wall of shrubbery, into the lofty, cool, and shady forest proper. Stately trees of maple, beech, elm, and oak stand widely spaced; the ground is no longer covered with grass or shrub, but is a regular forest floor, — a thick layer of leaves; while the light of day is shut out above by a dense canopy, — a roof of branches and leaves, the crowns of our trees.

It is a *mature old stand;* the trees are mostly over two feet in diameter and eighty to one hundred feet high, and it is quite safe to say that they started more than a hundred years ago.

It is a *mixed stand* of different kinds of broad-leaved trees, or hardwoods, with here and there a pine. Most of these trees are long shafted,—their trunks are long and free from limbs for thirty to forty feet from the ground,—and how greatly they differ from the beautiful shady elms about the house!

Some of the trees are not as thrifty as the rest; they appear injured; their crowns are small, and the crowns of the larger trees crowd and shade them. We will call these trees *suppressed*, and the larger ones *dominant.*

Some of the suppressed trees are nearly or quite dead, and it appears that the crowding and shading cause this injury.

Though there is an abundance of room on the ground, there are but few young trees, and these only in the places where the roof, or canopy, of our forest is less dense, where some old tree had fallen years ago. And yet these trees must have borne many a good crop of seed during their long lives. What has become of all this seed? Did it fail to germinate? Did the seedlings die? Apparently this dense stand is not a good place for young trees; and, strange enough, the few smaller trees which do exist seem to be all maple and beech, while hardly any of them are

Fig. 2. Beech Woods

(After Rothrock)

oak or hickory. Evidently the beech and maple can endure this unfavorable, dense shade better than oak, hickory, and elm. We may call the beech and the maple *tolerant*, since they *tolerate* or *endure* shade; while evidently the oak, hickory, chestnut, locust, and others are rather *intolerant* of shade and fail to start and thrive in places where the beech might still do well.

Let us walk on a little way. The woods are more open, the trees more numerous and more mixed. There are quite a number of smaller trees, some mere poles or saplings. Here we see a tree with an uncommonly broad crown; it appears as if it were monopolizing the ground in a most greedy fashion. Some people have termed such trees *wolves*, though their greed would suggest quite another animal. But whatever the name, they are hardly good neighbors for these fine little saplings of oak and chestnut.

There are a number of bushy young trees here, and even a few brambles; dogwood and hazel find sufficient sunlight. In a garden we should hardly tolerate these bushes, but would rather grub them out as weeds; and yet they are hardly more useful here in the woods, for surely they will never grow into trees, and in all cases may hinder young trees from starting or choke off the seedlings of our useful trees. They are *forest weeds*, and, while we could hardly afford to grub them out, yet we shall try to keep them down; but how? Well, Nature has already

Fig. 4. The "Short-Bodied" Tree of the Open

Cord wood but no saw-logs

cover of leaves by dragging out the logs. Then a great many seeds would reach the ground, and if they germinated would have room and light to grow.

Here is the stump of a tree apparently cut last winter. Let us examine it. It appears made up of numerous rings, one within the other. Let us count them, beginning with the pith which we see near the center. Eighty-five rings. So this tree was as high as the stump eighty-five years ago. Probably it was about three years old then; so that the tree was cut down when about eighty-eight years of age. Quite an interesting fact in itself. But let us look at these rings again. They are rather narrow near the pith. This would tell us that the tree did not fare so very well at first; probably it was shaded too much by the older mother trees which were here at that time. From the twenty-fifth ring on, they are quite broad, — the tree grew more thriftily; perhaps some of the older trees were blown down and thus the young tree had more light and room. But from the seventieth on, the growth was evidently slow; the rings are narrow and seem to grow narrower each year. This reminds us of old age. Do the trees ever grow old and cease to be active growers? If we keep our eyes open to these many records of the woods, they will tell us many a tale, and probably they will show us that trees, though they are generally quite long-lived, do, after all, grow old; that trees, like people, pass through stages similar to our youth, manhood, and decline.

Trees differ very much in this respect. A poplar tree is old at a hundred and fifty years; a cypress lives to be five hundred years and more; and some of the large redwoods, the "bigtrees," attain so great an age that the older members of this group began life long before Christ was born.

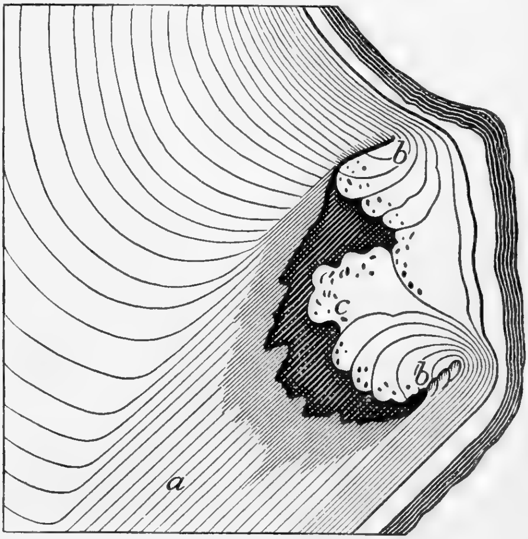


Fig. 5. Badly Healed Knot

a, wood of the knot; *b* and *c*, wood callus of the stem covering the wound; shaded portion, decayed wood; black part, a cavity remaining

Note that smooth-barked spot on yonder rough-barked oak. That is the place where a limb projected many years ago, when the tree was smaller. The limb died, decayed, broke off near the trunk, and the place healed over. Being much younger, the bark at that spot is smoother. Sometimes these limbs do not break off early enough, or the stub is too large, like the many you see on these white oaks; then the tree can never cover up the stub. The large knot hole, from which we saw the squirrel come out, is a similar case; but there the stub decayed, and the decay proceeded along the limb into the trunk and, I fear, did much mischief; for such a trunk does not make much sound timber.

Here is another smooth spot on a rough-barked tree. This is evidently not of the same kind as the one we have already noticed. Why, there are two, on opposite sides of the tree; and note there are similar spots on yonder elm! Sighting along we see more of them on other trees, and always two on each tree. They are the *blazes* of surveyors or of some one who wished to mark a line. Were we to cut through one of these blazes, as along the line *AB*, Fig. 6, *a*, it would probably have the appearance shown in Fig. 8, *b*.

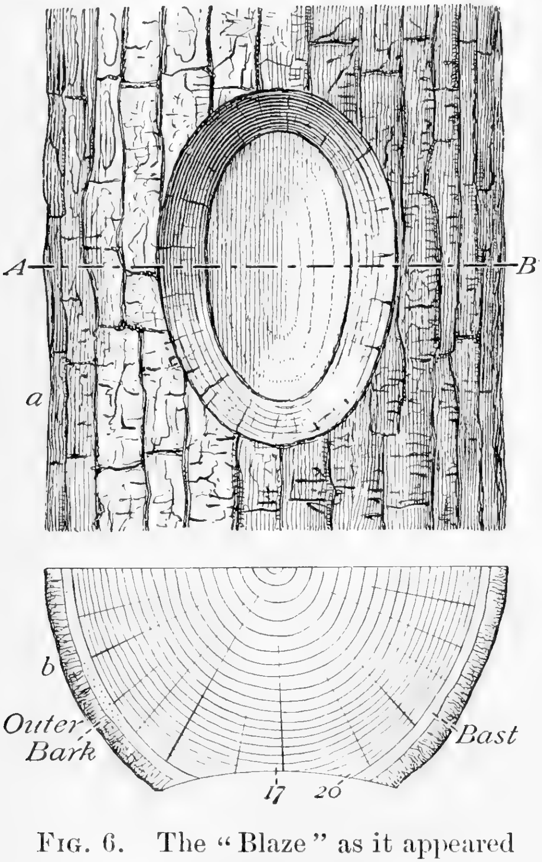


Fig. 6. The "Blaze" as it appeared when first made

a, front view; *b*, cross section on line *AB*

Counting the rings we would find that the blaze was made when the twentieth ring had been formed, and since there are now thirty-two rings on this section, it means that the blazes were cut twelve years ago. Three successive stages representing the fresh blaze, the same seven years ago, and as it now appears are shown in Figs. 6 to 8.

Let us dig up a little soil and see what it is like. Beneath the cover of dry leaves we find leaves in all stages of decay; below this, a dark soil, a leaf mold; and below this, earth. If we rub a little of this earth in our hand, we see at once that it is not a clear sand, but that it is a loam which, if moistened, would become sticky. Would these fine hardwood trees have grown here if it were a clean sandy soil?

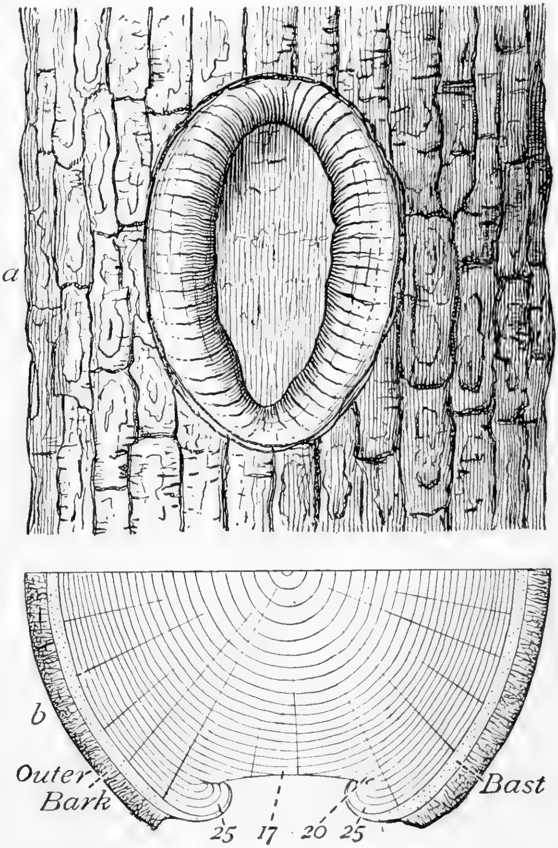


FIG. 7. The "Blaze" partly healed over, as it appeared seven years ago

We have now learned several things on our stroll; but there is still something which seems to have escaped our notice, though we have climbed and stumbled over fallen timber at almost every step. It is the great waste of material in our uncared-for wildwoods. Here are some fine, large trunks of beech and maple half decayed; there is an old elm log completely changed to a brown, powdery mass and covered with pretty moss and ferns; and yonder are two large trees of ash, one hollow, the other dead. But then, what else could we expect? As long as man does not interfere with these woods and utilize the timber, the old trees die, tumble over, and remain until decay disintegrates their bodies; and rain and snow gradually level these powdery masses and mingle them with the earth, where they serve to fertilize the ground for new generations of trees. Were it not for the fungi attending to this destructive work, the trunks and tops of a few generations of trees would cover the ground and prevent any new growth, and thus bring all forest life to a standstill.

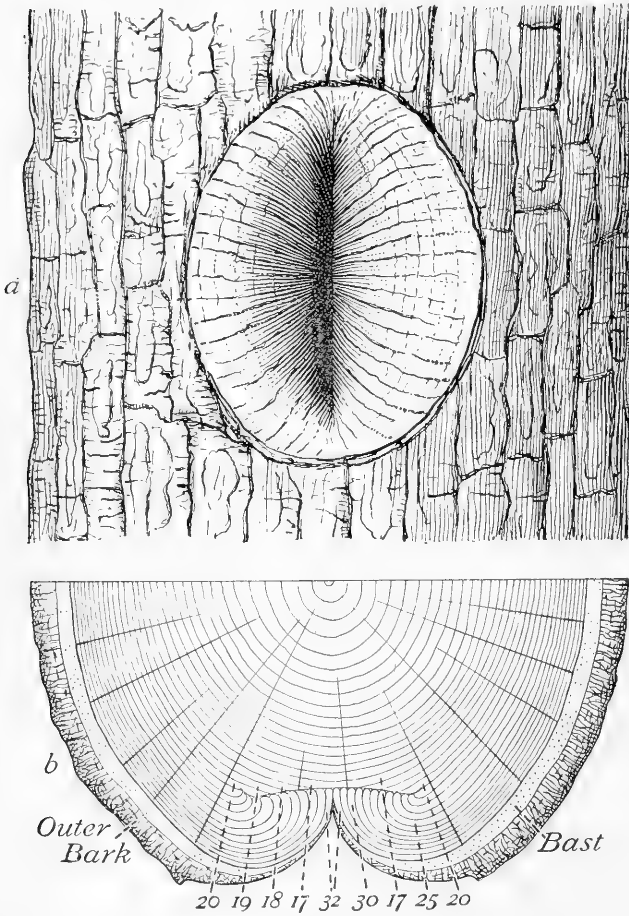


Fig. 8. The "Blaze" just covered, as it looks now

Fig. 9. Nature's Methods are Wasteful
(After Rothrock)

If we stop to think a moment, we realize that as long as man does not use or fire consume the timber, the amount of wood which decays each year in the forest must very nearly equal the yearly growth; so that it is really wasteful if a piece of woods is left entirely to itself.

We also note that these fungi are, after all, quite a useful and even a necessary part of our woods. Of course they are apt to do more than their share; and this handsome birch would live longer and its trunk would be of much more value without the fungus whose shelf-like, fruiting body we see covering an old notch, cut by some thoughtless person merely to "try the ax."

On our way home we see some other pieces of woods. Most of them are open; they lack the border; cattle graze in them, and there is a considerable growth of grass. We note a lack of young trees; and, on the whole, they give us the impression that the growth is slow, that little timber is produced, and that when the few remaining good old trees are used up, the woods will be little else than crippled brushwoods.

What Light and Shade do for the Woods

Here is apparently a windfall; all trees seem to have been blown over or broken off. It is a rough-looking place. But see the large number of young trees! Some started as sprouts from the stumps of smaller trees, but most of them appear to have started from seed. Here is a patch of very small trees, apparently not more than six years old, and two-year-old seedlings are seen everywhere. Among the young trees are tangles of wild blackberries, raspberries, and other shrubbery, and in a few places the grass is trying to cover the ground. Everything is struggling to hold its own or to gain possession of a little more soil and light.

Fig. 10. Even Spruce is made to "clean" itself
(After W. F. Fox)

Here is a dense thicket of young trees three to eight feet high. Let us count. Why, there are eight live trees on one square yard; and several smaller ones are dead among them, so that there were even more some years ago! But all of these can never hope to live and grow to any great size. Here is evidently a struggle; most of the trees must die, and those left must be injured by this struggle; for the trees which will die during the next ten years are still using up food and water, much of which is needed by those which will survive, and the crowns of these latter are crowded and thus prevented from becoming as large as they should be.

Here is an old thicket twenty to thirty feet high, and instead of as many as eight trees to a square yard, there are little more than this number per square rod. These *saplings* are slender poles, with little short crowns of live limbs, and the greater part of the pole is bare; the few remaining lower limbs are all dead, most of them decayed and broken. What has become of the limbs? The dense shade has prevented them from producing leaves, and as soon as a limb ceases to produce leaves the tree ceases to feed it; it dies, dries, decays, and drops off. These saplings have *cleaned* themselves and are still continuing to do so. Now we understand why the large, long-shafted trees we saw on our first trip have the fine, clear trunks and make such good saw-logs.

Without this cleaning our lumber would be far more knotty than it is. Shading and crowding, then, help as well as hurt in our forests. They help by killing out the weaker trees, by removing the useless limbs, and by making our trees shoot up as straight, long-shafted poles.

The question now arises: Would spruce and other tolerant trees clean as easily as these intolerant ones? Hardly; their very tolerance depends on the fact that their leaves can live and work in denser shade. But if they do not clean so well, would the boards cut from these trees be as clear or have as few knots as those of pine and chestnut? Next time we are in the lumber yard we will find out if this be true.

Since crowding and shading make the trees shoot straight up and prevent their branching or forking, it has often been claimed that shade makes trees grow faster in height. This may sometimes be true; frequently it is not. This growth in height is, of course, very important, and it is well that we should learn all we can about it.

In going about these openings and thickets we notice that the shoots from the smaller stumps of chestnut, etc., grow very long even during the first year. Many of these sprouts are over four feet long, and if we compare them with the seedlings it is evident that the sprouts are by far the faster growers. Among the seedlings we find some that made ten to fifteen inches the first year, but the little seedlings of pine are scarcely three inches tall.

If we examine the little trees three to eight feet high, we note that it is not always so easy to tell just what is the last season's growth in trees like oak, elm, etc., but in pine, spruce, balsam, red fir, etc., each year's growth is very conspicuous. In Fig. 11 the young white pine has a candlelike tip, about eleven inches long, then a whorl of limbs, below this another straight, branchless part, and so on. Now each piece between the several whorls of limbs is a year's growth, and we call the tip end, or last year's piece, the *leader*.

In spruce a few smaller limbs exist on each leader, but in young trees this branching is rarely so great as to hide or disguise the leader. Thus, in these young conifers, we can tell at a glance how much grew last year, the year before, etc., and by looking over a number of these trees we soon make up our mind whether they have grown fast or slowly in height.

Studying the trees in this way, we shall find that conifers generally grow very slowly the first five years, and most rapidly when about ten years old; and that our eastern trees usually stop growing rapidly in height when they are about sixty or eighty years old. Hardwoods behave similarly, but usually their seedlings grow much faster.

What Different Soils do for the Woods

We have seen a good forest of broadleaf trees on a loamy or clay soil; and if we should journey through the southern portion of the New England States, through New York and Pennsylvania, the Ohio valley, and the

FIG. 11. "Leaders" on White Pine and Balsam
Same scale and locality

Alleghenies, we would learn that such forests are common and cover a large portion of our best settled districts.

A trip through southern New Jersey and through the sandy coast districts of the entire South would teach us that everywhere the sand lands are stocked with open forests of pine. These forests are mostly *pure* stands; they are not a mixture of hardwoods and pine, though occasionally a few scrubby hardwood trees exist.

On the better sands of North Carolina and other states these pure stands of pine are often quite dense; the trees are tall, and all open spots are readily reclothed with young pine; but on the poor, white sands of portions of Florida we should find forests so open and parklike, the trees so far separated from each other, so little of young growth, of shrubbery or undergrowth, that the woods almost lose their forest character.

Over long stretches of these woods the soil between the scattering trees is either entirely bare or covered with creeping saw palmetto. Strange enough, the pine, which here is commonly the longleaf pine, with needles ten or twelve inches long, cleans as perfectly as if it were in the densest woods. Evidently it is very intolerant here, and possibly the poor soil helps the process of cleaning.

Is the climate the cause of these open, parklike pine woods? Let us go to one of the many "hummocks," or low flats with a more fertile soil. Within a distance of twenty yards we step from a pure and open stand of pine

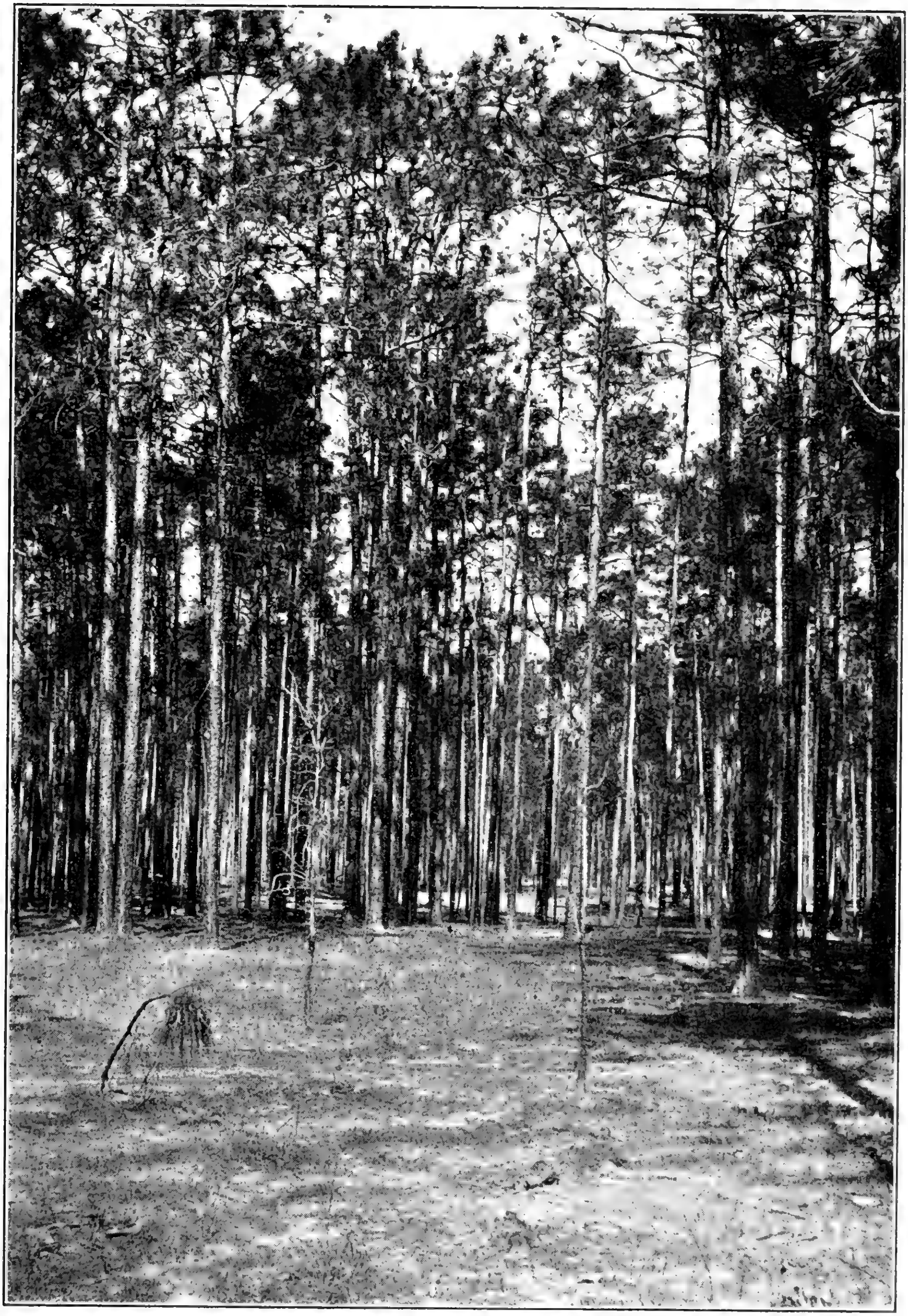


FIG. 12. Longleaf Pine

into a dense, luxuriant forest of mixed growth in which ash, oak, basswood, cedar, and cypress are often mixed with scattered cabbage palms and yuccas. Evidently it is the effect of soil.

In North Wisconsin we might see almost the same results. The heavy clay soils are covered with a good growth of hardwoods, especially birch, elm, and maple, with a goodly sprinkling of conifers, pine, and hemlock; but as soon as we enter any of the large, sandy districts a regular pinery, almost pure stands of pine, meets our eyes, and wherever the sand is unusually poor, stunted forests of jack pine replace the stately white and Norway pines.

At the border of the forests, against the prairies, where drought and sand conspire to make forest growth more difficult, the sands are not covered with grasses but with scrub woods of jack pine and scrub oaks. Similar scrub-oak woods cover the Cross Timbers of Texas and portions of other western states.

From this sketch it appears that fertile loams and clays bear mixed forests composed largely of a variety of trees, mostly hardwoods; while sandy soils are usually covered with monotonous pineries, composed of one or few kinds of trees. We also note that this distinction is very sharp; that in most sandy regions, whether north or south, the hardwoods are generally unable to replace the pine, and that wherever they attempt to do so the oak alone is partially successful.

Having seen what the soil does in determining the composition of the woods, we might also inquire whether the forest can do anything to alter the soil.

As we have learned in our former studies, the tree gets from the soil only water and certain useful salts, while the rest of the material of the tree comes from the air. The salts which it gets from the soil are its soil-food, and when these salts are lacking in a soil we call it poor and say that it needs fertilizing; *i.e.*, it needs to have these salts replaced to make it fertile or enable it to sustain plants. The salts which the tree uses, reappear as ashes when we burn the leaves, twigs, or wood.

Now when a beech tree takes up twenty pounds of such salts in a season, and perhaps fifteen pounds find their way into the leaves which are shed in the fall, these fifteen pounds may be taken up again by the tree, or its neighbor, as soon as the water has leached out and carried the salts down among the roots. In this way the trees take and give all the time. But besides these mineral salts the soil also needs decayed plant matter; it needs mold or humus to make it really fertile. This is supplied by leaves and twigs which are shed by the forest trees, and these tend, therefore, to enrich the soil. It is due chiefly to this mold that "new-cleared" land is so fertile. In many districts people clear land, use it for some time, and then restock it with forest growth, which in due time reëstablishes the former fertility.

Thus, we see that the soil determines the character of the forest, but that the forest also has the power to modify and improve the soil, and so enables the soil to grow more trees and better trees.

But this also teaches us that in all poor, sandy soils the permanent removal of the forest and, especially, the burning over of the sandy lands must needs injure the land by diminishing its fertility; and that, therefore, it is harder to start a forest, and the forest will grow much less vigorously on such maltreated lands.

What Moisture does for the Woods

On a trip along the Texas Pacific Railway from the eastern boundary of Texas westward we first pass through long stretches of pinery, then many miles of mixed forests, which, on nearing the Trinity River, change into more and more open woods composed almost entirely of oak. From the Trinity westward these oak woods grow more and more scrubby; the finest lands are prairies, and the forest is restricted to the stretches of sandy lands known as the Cross Timbers.

After crossing the Brazos River, west of Graham, the forests are reduced to patches in the river bottoms, and the broad fertile lands are either treeless prairie or mesquite openings, where scattering bushes of the thorny mesquite help to relieve the monotony.

FIG. 13. Too Dry for Forest

Chaparral of scattering scrub or scrub woods in San Jacinto Reserve, California (After Gannett)

The sandy ridges following the Brazos, Wichita, and other rivers are either bare or scantily dotted with thickets or clumps of the shrublike shin oak, while scattering, bush-like trees of red cedar dot the bluffs of the rivers.

Reaching the high and dry plateau of the Staked Plains we find that tree growth ceases; the mesquite no longer decorates the prairie, and the sand hills of these plains are desolate wastes.

We have made a long journey from a humid country to an arid one, passing through many intermediate stages. Neither soil, altitude, nor the temperature factor of the climate has changed materially, and yet we have passed from a dense and stately forest of pine through oak and mesquite openings into bare prairie and sand waste.

The great difference in the amount of moisture alone is responsible for these remarkable changes. Had we started from Duluth, Minn., and gone west or southwest, our experience would have been similar. First, long stretches of pineries, in which white and Norway pine often predominate; then, rather suddenly, oak, or else poplar and oak openings; and, within a few hours' ride by train, the open treeless prairies.

This transition from the humid forests to the drier prairie regions is very similar from Texas clear to our northern boundary, and everywhere it is caused by the lack of rain and snow, which appears to be the principal, if not the only, cause of the fading out of the forest.

At first it culls the forest and reduces the number of kinds of trees,—the elm, the ash, the basswood, etc., drop out, and the forest is finally reduced to open stands of scrubby oak. Where the moisture becomes scarcer still these scrub woods become more dwarfed, and soon the forest ceases altogether. Lack of moisture then reduces the number of species; it stunts and, if extreme, it prevents forest growth altogether.

Fig. 14. Too Much Water kills
Timber killed by water backed up by state dam in Adirondacks. (After Fox)

Thus, a lack of moisture acts like a poor, sandy soil, and wherever these two combine the effect is all the greater.

Let us now see what too much moisture does. When the lumbermen in our northern forests dam up a stream to store water for driving purposes, they select some large flat, where a pond of considerable extent is produced by the dam. In such a place large numbers of trees, which so far have been growing on dry land, are now made to stand in water; and in almost all cases they die, even if the dam is closed for but a few months of the year. Evidently these forest trees do not endure immersion of their roots; too much water kills them.

In the valleys, or "bottoms," of the Santee and other rivers of the South, floods or freshets are produced by heavy rains in the mountains at the heads of these streams. Where we can walk dry-footed to-day we can boat on ten feet of water to-morrow. These freshets last from one to three weeks and, during this time, cover entirely all young trees not tall enough to project above the water. And yet the forests of these bottoms are among the most luxuriant; there are many kinds of trees, and the trees grow to large size.

It would seem, then, that in these fertile bottoms of the South many different kinds of trees and shrubs have learned to endure periodical, complete or partial immersion of several weeks duration.

The hundreds of large and small swamps of our northern forests are generally stocked with forests of tamarack, cedar, and occasionally spruce. Generally these cedar and tamarack swamps are monotonous; the trees are small, the stands dense. The cedar swamps of New Jersey, the numerous cypress swamps of the Carolinas, Florida, and the Gulf States resemble our northern swamps, except that we have here a different set of trees and trees of larger size. In some of the "greenings" or white cedar swamps the soil is a soft mud, and the trees gain a support or hold chiefly from the general network of roots. In the Dismal Swamp and the great Okefinokee a large portion

FIG. 15. Used to Water (Cypress about Lake Norris, Florida)

of the land is constantly under water, and these swamps have more the appearance of grassy lakes.

Stretches of these swamps are entirely bare of trees and take on the regular lake character, while other portions appear like overflowed marsh lands, dotted with so-called "houses," or small clusters of gnarly cypress festooned with long streamers of Spanish moss, which help to emphasize their weird, fantastic appearance.

In swamps like the Chessahowiska of western Florida, where a warm climate and a supply of lime in the water-soaked earth assist the plants in withstanding the difficulties of too much water, the forest is often one of great variety, consisting of a mixture of red cedar, oak, basswood, yellow poplar, and ash, together with palm and yucca, and the trees display a considerable degree of thrift.

These facts lead us to believe that wet soils, like dry soils, tend to reduce the number of kinds of trees, and that this effect is greater wherever a cold climate adds to the difficulty. It also indicates that in colder countries the monotonous woods of the swamp lands are simpler in their make-up, and stunted in their growth; but that the swamp forests of warmer districts do not generally share this stunted character, since, for instance, the cypress of the southern swamps is among the largest timber of the eastern half of our country.

In the Puget Sound country, where it rains the greater part of the year, and where clouds, fog, and mist shut out the sun and prevent the trees from giving off much water from their leaves and twigs, we find some of the densest, stateliest forests of the world. They are composed of red fir, hemlock, cedar, and balsam; the trees grow rapidly and reach unusual size. A well-drained, porous soil and a very moist, cool atmosphere are evidently conducive to the best tree growth. But even here it is rather remarkable that the conifers prevail.

On the whole, then, we see that most of our trees require a moderate amount of moisture in the soil and in the air,

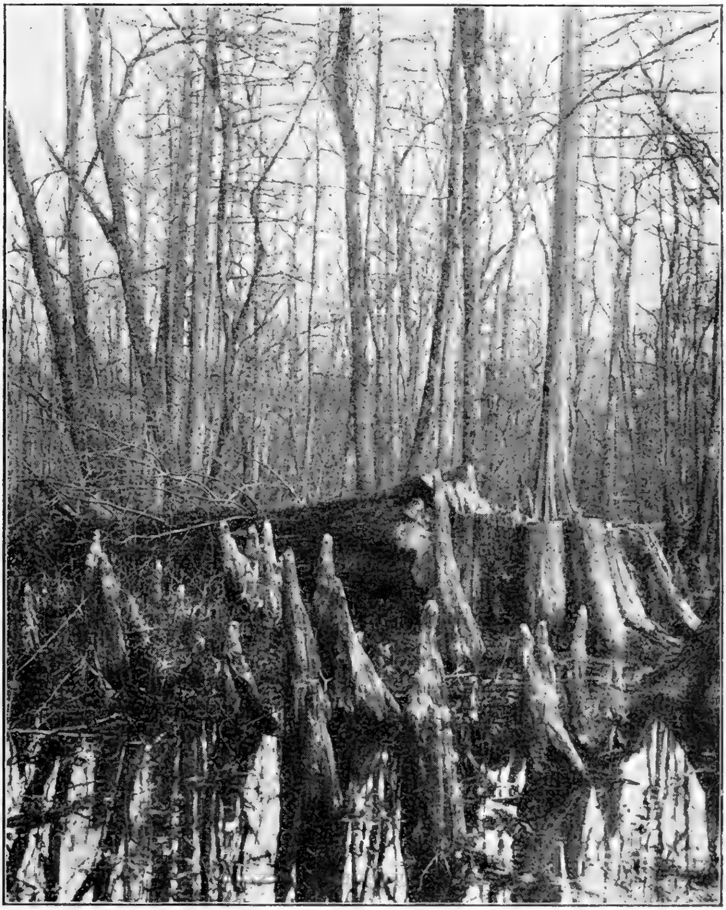


FIG. 16. Cypress Swamp

The short stumplike structures projecting out of the water are the "cypress knees," peculiar outgrowths from the roots of these trees, apparently dependent on the wet surroundings

and that too much as well as too little water is fatal to most of them. It seems also that drought is best endured by cedar, pine, and oak, while the swamp lands are occupied mostly by conifers,—cedar, tamarack, and spruce in the North; cedar and cypress in the South,—and that the swamp forests of cold countries are more monotonous and more stunted than those of warmer districts.

Having seen of how much importance moisture is to the tree, it would be of interest to learn how far the tree can correct any deficiency,—to what extent it can drain the soil of surplus water or induce a dry soil to take up and hold more moisture. Experience and observation seem to indicate that it does both.

What Heat and Cold do for the Woods

Let us make a trip from the northern boundary of our country to the Gulf of Mexico and see how the forest differs in different places along our route, keeping in mind, however, that we must compare only such forests as are stocked on well-drained lands of similar soils.

Along the south shore of Lake Superior, where long snowy winters and short frosty summers restrict farming to the raising of grass, oats, and potatoes, the forest of the fertile loam and clay lands consists of a mixed stand of inferior hardwoods and conifers. The hardwoods are principally birch, maple, elm, and basswood; the conifers, white pine and hemlock. Generally there are more of the hardwoods — they *predominate;* but

Fig. 17. Palmetto
(After Pinchot)

occasionally the hemlock, more rarely the pine, forms the body of the forest. The hardwoods are few in kind and inferior in size and quality; the most valuable trees of the forest are the conifers, pine and hemlock.

A piece of virgin forest in Indiana, where abundant crops of apples, grapes, and peaches indicate a milder climate, is usually an oak wood, heavily mixed with a great variety of other broad-leaved trees, but entirely without coniferous timber. Here we meet several kinds of oak, hickory, and ash, both black and white walnut, cherry, basswood, elm, yellow poplar, sycamore, and beech. Moreover, the trees are tall, with long, clear, heavy shafts, furnishing the choicest lumber.

In eastern Tennessee or western North Carolina the warmer climate again changes our forest picture. The yellow poplar and chestnut come to the foreground; the several oaks and hickories, a few magnolias, the locusts, catalpa, mulberry, red gum, and others swell the list of common species, and in addition the conifers reappear; the forest again has its sprinkling of pine.

Although the number of different kinds of trees has thus been increased, the forest retains its general appearance; it is a fine, stately forest of hardwoods, and many an acre of this forest could not be distinguished from similar acres of our Indiana woods.

Going through one of the fine "hummocks" of Florida, the land of cotton, the orange, and pineapple, where snow and ice are hardly known and where a frost is a general calamity, we are struck with the radical change in the appearance of the forest. It is still a forest of hard-woods, — there are live oak, red and white oaks, ash, and gum, — but among them is that peculiar tree of the torrid lands, the palm tree. And to have a few of these palms to each acre is enough to alter entirely the aspect of the forest. Usually this hummock land has some cypress and red cedar with a few scattering pine; and everywhere the yucca and dwarf palms are conspicuous among the undergrowth. Our forest has changed, and changed radically; it possesses an entirely new form, a new order of trees.

Let us review our trip. In the icy Lake Superior region the forest is made of few kinds; the conifers are an important mixture and the hardwood trees are stunted. In mild Indiana it is composed of hardwoods alone; the variety is great; the trees are large. In the warm districts of the southern Alleghenies the variety is still greater; size and quality are equally fine, and conifers reappear; while in the hot climate of Florida the variety is still greater, and the forest takes on a subtropical aspect by adding the palm.

If our comparison had been for the sand lands or the swamps, the difference would have been much less; the pinery of Florida is as monotonous as that of Minnesota.

We see that cold affects the forest just as do a poor soil and too much or too little water. It simplifies the composition of the forest and, in extreme cases, stunts its growth. But we also observe that this effect is not very serious within the borders of our land; that our most important hardwood trees extend far north and south; and that the effect is less important for our sandy or poorer lands than for more fertile districts.

Were we to inquire into the growth and behavior of our forest trees along the same route of travel north and south, we should find the effect even more important. We should learn that oak and maple in Tennessee sprout well; in the Lake Superior country, with difficulty; that most trees bear seed oftener and more abundantly, and that young growth starts more easily, grows faster, and stands more shade in warm districts than in cold. Here and there, to be sure, there would be some exceptions to this rule, but they would be just enough to emphasize its general truth.

Having learned the importance of warmth and sunshine, we realize why, in our northern states, the forest on the south side of a ridge often differs so radically from that on the north side. It is the warmth and light of the sunny south exposure which permits a greater variety of trees and banishes the frugal conifers to the colder, darker north side.

Had we extended our journey northward, far into the Dominion of Canada, we should have first passed through long stretches of pineries and woods of spruce, and finally landed in openings of birch, willow, and alder, which fade away gradually into the treeless wastes of the ever-frozen North.

Woods and the Mountains

We have all read and heard, and some of us have had the opportunity to witness, that the climate grows colder as we ascend a mountain; so that if the mountain is very high it may bear ice and snow all through summer, though it be located beneath the tropical sun of Mexico or Peru.

From what we have learned concerning the influence of cold on the forest cover we should at once infer that the forest differs at different points from below upward and that it becomes more and more simple in its composition; more and more stunted toward the top of any high mountain range or peak; and also that the forests of higher mountains, like those of the colder northern districts of our country, are composed most generally of coniferous trees.

A few excursions will test and verify these conclusions.

If we start on the Raquette River in the Adirondack Mountains of New York to go up to the top of Mount Seward, we are at first about fifteen hundred feet above sea level, and in the midst of a sandy old white pine "slash," surrounded by a rather inferior mixed growth of hardwoods and conifers. Yellow birch and maple predominate, and spruce, balsam, cedar, and hemlock make up the coniferous portion. Climbing to an altitude of about twenty-four hundred feet, we find that yellow birch is largely replaced by white birch; the maple is a scrub; and the spruce, together with cedar, forms the body of the forest. As we ascend farther the forest becomes more and more a pure stand of conifers; and, finally, on reaching the top, at an altitude of about forty-five hundred feet, we pass through thickets of dwarf balsam, from two to five feet in height, which, in many places, form such dense mats that it is possible to use the canopy of this pigmy forest for a seat.

Ascending the Alleghenies of North Carolina, beautiful hardwood forests accompany us up to an altitude of about five thousand feet; but the summits of all the peaks above fifty-five hundred feet are clad in somber forests of spruce, together with some scattering balsams.

Fully as interesting and instructive is a trip up to the crest of the Cascade Mountains of Washington from the west side. Following up the valley of the Cowlitz River we pass through dense forests of the giant red fir, cedar, and hemlock. Reaching an altitude of about two thousand feet, we find the hemlock becomes more abundant, and the red fir recedes and is replaced by the mountain balsam. At an altitude of about thirty-five hundred feet

Fig. 18. Coniferous Forests alone climb our High Mountain Ranges
Northern Cascade Mountains. (After Gannett)

the red fir disappears, and the forest is one of balsam and hemlock with cedar. As we reach a height of five thousand feet the complexion of the forest changes entirely; the dense forest of tall mountain balsam and hemlock suddenly gives way to open, more or less interrupted alpine park woods, composed of short, limby trees belonging to entirely different species, the alpine balsam and hemlock.

Thus, we see that our inference was correct: the high mountain woods of our country are generally conifers, composed of few species, and are usually more or less stunted at higher altitudes. Similarly these woods change from below upwards, decreasing in complexity of composition as well as in size and quality of the timber; and their vigor, or rate of growth and capacity to maintain and renew themselves, also decreases.

Part II

FORESTRY

RAISING OR KEEPING UP THE FOREST

We have learned something of different woods, of their appearance and composition, and how they are modified by different climates, soils, and other conditions. We are now ready to see what man does with the forest.

When the pioneer settler in the backwoods clears his farm he is anxious to destroy the forest as fast as possible, for every acre of "clear land" is a big step toward independence. In many places, especially of late years, he has been able to sell at least the better kinds of logs; but in the most cases, now as formerly, the wood is wasted. The trees are cut into pieces small enough to handle and the neighbors are invited to a "log rolling"; they pile up the logs and branches into "log heaps," and when the weather is suitable these log heaps are set afire. Fire and plow prevent the return of the forest.

This is not forestry; it is proper forest destruction, such as goes on in the settlement of every forest-covered country. The forest gives way to the field.

When the lumbermen cut the spruce in many parts of our eastern states, or the white pine in the hardwoods of Michigan or Wisconsin, they disturb the forest so little that only the experienced eye notices the fact that the

FIG. 19 *a*. Coppice Woods

(After Graves)

land has been "logged over." On the sandier "pinery" lands, where the forest is nearly all pine, the case is quite different. Here the lumberman usually leaves a "slash." Most of the forest is gone; a few young trees, some worthless cripples, and a small number of isolated stunted hardwoods still maintain the semblance of woods; while the ground is densely strewn with the tops of the

FIG. 19 *b*. Coppice Woods

(After Graves)

fallen pine. In one or two seasons these tops are dry; they take fire from some cause or other, the slash burns over, and instead of the former forest there is now a waste, which may remain in this unproductive condition for many years. Generally the lumberman does not concern himself in either case about the forest or slash he leaves behind; his business is to get out of the forest whatever he can utilize or sell; he treats it as a ripe field; he harvests, — but he does not sow. He does not intentionally destroy any forest; he merely harvests, but does not care for and protect it, and thus make an effort to keep up the forest and to grow a new crop of timber. For this reason, and to the extent that he fails in this, he is not a forester.

On the other hand, the farmer who has a piece of woodland, where, during the winter months he cuts his firewood and fencing and a few logs for the repair of buildings and implements, and during certain years, when prices are high, cuts some logs for the neighboring sawmill, but, at the same time, looks after the piece of woods, cleans it of dead timber and other rubbish, thus keeping out fire and insects, and otherwise makes an effort to keep the land covered with forest, — such a man practices *forestry*. His forest may be small or large, his ways of doing may be simple and imperfect, so that his woods do not contain as many trees as they should; the trees may not be the best kinds for the particular locality and soil; they may not be as thrifty as they should and could be; but nevertheless here is a man who does not merely destroy the woods, nor content himself with cutting down whatever he can sell, but one who cares for the woods as well as uses them, one who sows as well as harvests. He is a forester, and his work in the woods is forestry. Since his forest is small, the work is simpler, and it will be a good opportunity to learn how he cares for the woods; for trees start and grow in just the same way, whether in small or large forests.

Coppice Woods

Here is a piece of wildwoods in one of the picturesque valleys of northern New Jersey. The soil is loam, very rocky, and with too many large rocks on top of the ground to encourage its use for plowland. The woods, mostly chestnut and oak, appear rather scrubby, and we miss the large stately trees of the virgin forest; there appear to be no old trees, and nearly all trees seem to be in clusters about old and much disfigured stumps. Evidently they started as sprouts — but here comes a native who can tell us more about this:

"Yes, this is an old settled district, and the old woods were cut down more than a century ago. Since then these woods were cut over several times. Formerly, when firewood was much in demand for iron furnaces, the woods were cut over about every twenty years, but of late we leave the trees to grow larger, so that they make good railroad ties and telegraph poles, besides firewood, and this requires that they be at least thirty-five or forty years old. But still this does not make large trees, and thus our coppice woods look young and small compared with old virgin woods.

"Yes, we use chestnut and oak mostly, but that is only because they were here and nobody cared to try any others. We cut usually in winter, the best time being about February or just before spring opens, because then the stumps make the best sprouts, and sprout immediately, so that a good growth takes place that very season. If we cut in the fall or early winter, many of the stumps suffer from the weather; and before they are ready to sprout are injured and, therefore, make fewer and weaker sprouts.

"How much do we get per acre? That of course depends on the age and condition of the woods and the quality of the site [soil, exposure, etc.].

"Generally we count on a cord per acre and year, so that a thirty-year-old stand should furnish thirty cords per acre. From such a stand we should get about a hundred good telegraph poles, or else about three hundred railroad ties, besides about fifteen cords of firewood. For the poles we get four to five dollars, and for ties perhaps fifty cents each; but firewood brings only about three dollars per cord delivered."

Let us now walk into the woods and see what we can learn. Everywhere we see that both oak and chestnut, but particularly the latter, are excellently well suited to this kind of treatment; that their stumps furnish an abundance of sprouts; that the sprouts grow fast, and always much faster than young trees started from the seed. Of seedling trees we see but few, and none at all in the denser parts of the woods.

FIG. 20. Stump and Sprouts

But, though the woods are fairly good, there are several things here which might be improved by a little more care. In the first place, we notice open spots ten or fifteen yards across, where grass and weeds cover the ground together with a few isolated trees of red cedar. Apparently the forest gave out and the stumps ceased to sprout. Perhaps they were too old or else had been burned, or possibly cattle kept the sprouts down by eating off the leaves and thus killed the stumps, for, as we have learned before, the stump can live only if it has leaves to prepare food for its cells. Such spots are unproductive; they are neither good pasture nor forest.

In the woods we notice that some of the stumps have too many sprouts, that these crowd each other, some are dead and others are stunted by their neighbors. Evidently cutting out the weaker would have helped the better trees, for the poor cripples use up water and soil-food and yet are unable to make trees.

The stumps, we see, were not always cut with care. Many of them are too high; part of the bark has dropped off, and the stump is partly dry. Others are flat on top, some even slant in (see Fig. 21), and many are rough, all holding the rain water, and with this the spores (seeds) of fungi, which will cause decay.

Note also that many of these stumps are too old to make good sprouts; they are much decayed, and the few young trees they produce have a poor support. They should be replaced; there is need for new stumps.

Let us think over what we have learned about coppice woods. Since we can use only trees which sprout well, we cannot raise pine, spruce, and other conifers in this way. As most trees in coppice woods should be cut before they are forty years old, preferably when twenty or thirty years old, these woods cannot furnish large trees, such as would be needed for saw-logs to make boards for houses and furniture. As to the work itself, we see that it is quite simple. If a man had sixty acres of coppice woods and wanted to cut some fuel and other timber every winter, he might cut two acres every year, and in this way cut the entire sixty-acre tract in thirty years. By that time the two acres first cut would be thirty years old and ready for the ax, and thus the cutting might go on indefinitely. In his work he should take care to cut at the right time of the year (late winter); to cut the stumps low and smooth, with the slant to the outside; to leave some of the smaller useless trees for the protection of the

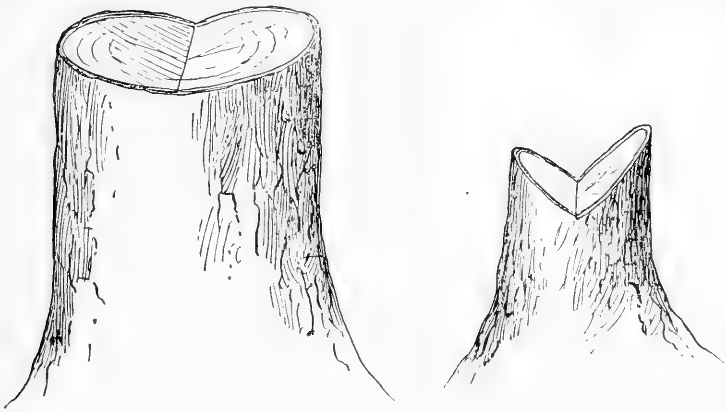


FIG. 21. The Wrong Way to cut the Stumps

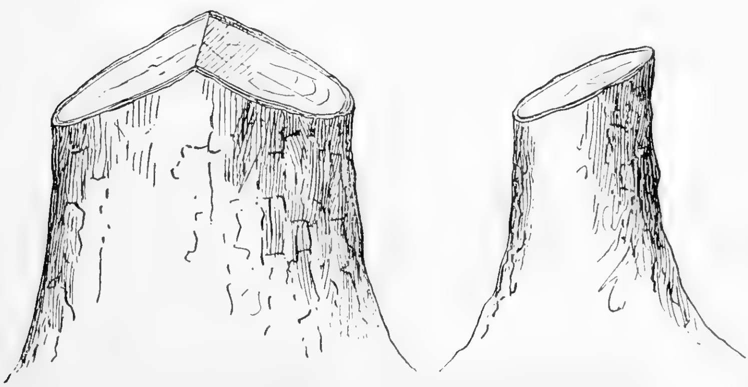


FIG. 22. The Right Way to cut the Stumps

ground and young shoots. He would naturally fill all bare spots with young trees, and would thin out the poorer sprouts when the stand is about ten years old, using the material thus cut for firewood. The old stumps, after they had furnished three crops of trees, would be replaced by young trees, which he would start by planting from a little nursery in his garden, or by sowing acorns and chestnuts on the newly cleared parts of this woodland. In this way he could cut at least two hundred dollars' worth of ties and poles each year, and have more firewood than he would need on his farm.

Looking over the list of trees which have been used as coppice, we find that it is not large and that the following are the important ones: chestnut, oak, black locust, ash, elm, maple, beech, birch; and where a light wood is used for paper pulp, etc., basswood, poplar, and willow may be used. This list would also indicate that a good coppice growth is possible in the greater portion of the eastern United States; that it fares well only in temperate and warm climates, and on fairly good soil.

In Europe, especially in France, the coppice system is very common, and rather preferred in the smaller forests of private owners and villagers. Generally the trees are cut when fifteen to twenty-five years old. The trees of oak coppice are cut in summer and the bark is peeled, dried, and sold to tanners, so that these woods are raised really as much for the bark as for the wood, and are called *tan-bark coppice.*

When the cutting in coppice woods is so regulated that the trees are about thirty years old when cut, we call this period of thirty years the *rotation,* and we say that the coppice is managed on a thirty-year rotation. Rotation in this sense simply means the age of the trees when the woods are cut down, and does not mean, as in farming, a certain succession of different kinds of crops, such as wheat, corn, oats, and clover, to be repeated in the same order.

The fact that in the northern pineries the burned-over slash lands are commonly covered by a growth of young poplar or aspen, and not by pine, has led some of the woodsmen of those regions to believe that there existed a natural rotation of forest crops resembling the rotation of farm crops; that pine could not follow pine, but that poplar and pine always alternated with each other. As a matter of fact, the poplar covers these "burns" because all through these pineries there is produced every year an abundance of poplar seed. Being extremely light, it is carried by the wind for miles and thus covers the burns. Moreover, the seeds of poplar and birch are the only tree seeds which are at once strewn abundantly over the burns, and both, especially that of the poplar, do well on this freshly burned-over land. Thus it comes that the poplar and birch thickets are the first to reclothe these burns.

We have learned that in European coppice woods the rotation is generally about fifteen to twenty-five years, and, therefore, shorter than that of the ordinary New Jersey coppice, which is usually thirty or forty years; and that it is generally not advisable to make the rotation in coppice much longer than forty years, even for oak, which endures longest; while for poplar, birch, and willow it should not be over twenty-five years.

Since large trees are not furnished by the coppice woods, and since it is often desirable and profitable to raise larger trees for timber and lumber, many people have modified their coppice in this way.

Suppose our farmer has sixty acres of coppice and cuts about two acres each year. Instead of cutting all trees he leaves standing on each acre from fifty to a hundred of the very best trees. These trees go on growing and are cut thirty years later, so that they live through two rotations of the coppice woods. By that time they are sixty years old and of considerable size. These we call *standards* and this kind of coppice woods a *standard coppice.* Sometimes the standards are not all cut down at the end of the second rotation, but some are left for a third or even a fourth rotation, and thus get to be quite large. But it is usual to cut part of the standards each time the particular piece of woods is cut over.

Since too much shade would hinder the starting as well as the growth of the sprouts, the trees left over for standards at any one time should not shade more than about one third to one fourth of the ground. Usually a thirty-year-old tree in good coppice woods has a crown covering about fifty to a hundred square feet, and it nearly doubles this every thirty years. Since an acre has 43,560 square feet, and about a fourth may be covered by the standards, we might leave about a hundred thirty-year-old trees of the larger size.

In an oak and chestnut coppice it is well to use largely these two kinds for standards, since in this way they will seed the ground and thus furnish new stumps. Generally it is better to use trees which have started from seed or have been planted to fill out gaps or fail places; but good trees from young stumps answer very well. Among the broad-leaved kinds chestnut, oak, elm, ash, hickory, and walnut make good standards; but beech and maple make too dense a shade.

The Ordinary Timber Forest

In southern Michigan we see many tracts of the ordinary broadleaf forest, such as formerly covered Indiana, Ohio, and a large portion of our eastern states. The climate of southern Michigan is temperate, even mild; the grapevine and peach tree thrive; the soil is largely drift material, — earth and stone believed to have been carried by ancient glaciers; while fertile, it is sometimes very stony, being generally strewn with bowlders. The forest is composed of oaks, — both red oaks and white oaks, — elm, ash, hickory, basswood, beech, and other broad-leaved kinds (hardwoods) in irregular mixture, with the oaks usually predominant. Most of the trees seem to be large, old veterans.

Here is a piece of woods with a beautiful border of beech, low-crowned blue beech, mixed with elm, and maple, and a fringe of hazel, dogwood, and other shrubs. The whole border is so dense that it seems as if it might shut out all visitors, as well as the injurious drying winds. Let us enter. They are very stately old woods and remind us of the virgin forest we visited some time ago. But there are many things changed after all, and the hand of man is clearly visible. There is no dead and fallen timber; it is all cleared away, evidently taken home for firewood. Nor do we notice here any old crippled trees, nor any of the greedy spreading ones which want a whole acre to themselves. No doubt they were here at one time, but all have been cut out and used up. Right here we see a fine old mixed stand of mature timber, probably every tree over a hundred years old. They are still thrifty, but their shade is too dense for any young trees to start. Let us walk on. Why, here is a park! Everything looks clean and neat, the stand is rather open, nearly everything except the maple has been cut out, and there are regular paths in all directions. Note the many auger holes in the trees; this is a "sugar bush." The farmer, finding the maple predominant in this part of his woods, cleared out much of the elm, oak, and other kinds to give the maple more room. He also cleaned up more perfectly to make his work in sap-gathering time more convenient.

Fig. 23. A Little Light starts Young Growth

Common winter scene in the north woods. (After Graves)

There are a good many small saplings of maple; evidently this opening up of the dense woods stimulated reproduction; the trees bore more seeds, and young trees found light and air to live. Some of the young stuff he has cut out and has left only the best. They will be fine sugar trees when his son takes the farm.

Here we come into a different stand. The trees are mostly poles (less than twelve inches in diameter), and must have started some thirty years ago. The large stumps of the old mother trees are rotten and covered with moss. Notice the many small stumps; evidently there has been some *thinning* done.

Here is a thicket of bushy young trees, three to ten feet high and standing rather crowded. The old stumps, just beginning to decay, seem about ten or twelve years old, and a few old trees are still left here. They need cutting out, for the young trees need the light.

Here is a piece where the owner has cut timber during the last few years. He seems to have picked out (selected) the largest trees or those which stand too close to others and thereby hinder them in their growth. He has not, however, cleared out any large piece, but merely picked out a tree here and there, and thus kept the forest intact and the ground nearly all covered or shaded, so that grass and weeds rarely get a chance to start. Going over the entire sixty-acre piece, we find that the man has cleared up and cut and thinned out everywhere; that he cut considerable timber about ten or twelve years ago, but that he has since then been more frugal. Let us go over to where he is plowing and ask him something about it.

"Am glad to tell you all I can. I came here about thirty-five years ago; the farm was in bad shape, and the first winter I cut a lot of logs for fencing, where you saw that young growth you speak of. Since then I have been cutting wood and timber for my own use every winter, and now and then a little to sell. Ten years ago I cut a large amount for the sawmill; sleighing was good and prices rather high. For firewood I cut everything, and if it does not make four-foot wood, it is cut sixteen to twenty-four inches long and split to suit the people. In this way I have cleaned up pretty much all through the piece. For the rest I merely pick out where the timber stands too close.

"Of course I can raise all kinds of timber, for the trees do not have to sprout and I can cut them at whatever age I choose. So far I have been careless. Except in my sugar bush, where I want as pure a stand of maple as possible, I have let them come in as they would.

"In the future I am going to do differently and cut out more of the kinds I wish to get rid of, thus favoring those kinds, like oak, which are of more value to me. I intend also to plant some conifers, most likely some white pine, as this does well hereabouts. How do I get a new growth started? Well, so far I have done nothing but to let it start as it would. The large tree is cut down and removed; this gives a small opening in which young growth starts, the seed, of course, coming from the trees left behind. In this way I open up new spots every year. How old do I let them grow? No particular age; I take them whenever it suits me; but, on the whole, I like to let the sound, thrifty trees (dominant trees) reach a good size, say about eighteen inches in diameter or more, before I cut them down. Just how much wood is growing per acre on my land I could not tell you, nor do I know whether I am cutting more or less than is growing here. Of course if I cut more, I reduce my wood capital; if I cut less, I increase it. So far I have probably cut less than the growth."

We have here, then, a *timber forest;* one in which the trees usually start from seed and not as sprouts, where all kinds of trees may be raised which the climate and soil permit, and where the trees may be cut at any age. The procedure is quite simple. Every year the farmer goes over part of the woods and selects such trees as suit his purpose and such trees as need cutting out to better the woods. It is a process of selection, and the woods so managed is a *selection forest.*

Since it furnishes many different kinds and sizes, and since it is so simple and natural a way of using and treating the woods, this *selection method* is well suited to many forests. It is the best and often the only safe way for mountain woods, where forests are difficult to start if once cleared away; it is the best way of treating the forest border to keep it close and dense; and it is an excellent way wherever the forest is small and the owner can go over it often, so that he knows all parts and can pick out, or select, with proper care and knowledge.

In all cases he should see to it that the ground is covered with the right kinds of trees; he should cut out those kinds which do not sell, or grow too slowly, or never grow large. What the right kinds are depends on the land. On the better kinds of soil in a temperate and warmer climate most of our broadleaf trees do well, and in many places a mixture of these with pine and spruce would be profitable. At present oak sells better than elm, ash better than maple, and any of these better than beech, while logs of white pine and spruce sell best of all.

Since such kinds as the oak are quite intolerant or sensitive to shade, they must be mixed with others that can stand more shade. Of these the beech and maple are good. Often it pays to plant them under the older oaks when these no longer shade the ground and there is light enough to encourage grass and weeds.

One of the chief difficulties in this way of treating the forest lies in the danger of damaging the young growth in felling old timber, and in cutting and barking young growth and trees in dragging out the larger logs.

Besides having the right kinds of trees, the forester should also see to it that there is no land idle, and that all trees are in a thrifty condition, growing in size and value. The amount of wood which grows each year per acre varies very much with the nature of the soil and with the kind, the number, and the age of the trees. For better lands about one cord per acre and year may be expected; on poorer lands or from more neglected woods the amount may fall to only about one half cord.

The selection forest is the oldest form of properly tended woods and has been in use in some European states for more than seven centuries. In our own country it is practiced with more or less skill by many hundreds of farmers; and even some of our large forests are lumbered on the selection principle. Thus, in the pineries of North Carolina, the home of the "tar kiln," farmers are selling the timber of their large woodlands to lumbermen, and many of these pieces are logged over for the third or fourth time in a century, each lumberman cutting only the larger trees and leaving the smaller for a future crop.

The same is true of a number of tracts of spruce lands in Maine, where some men introduced this method many years ago. Generally these large woods have not received much care. In cutting, the men often cleared large patches, which remained uncovered a long time. Commonly fire gets into these larger slashes, since it is unprofitable to remove the tops, and thus much damage is done to the remaining trees. Furthermore, the dead and fallen timber and all useless and crippled trees are always left in the woods and hinder the good trees, serving as breeding places for fungi and insects, and increasing the danger of fire.

Why do these lumbermen and holders of large forests treat their woods with less care than our farmer forester? Let us examine into this a little more closely. When the farmer wants to cut some wood he can step out any day with his men, utilizing good weather and spare time, if it be but half a day; he can cut as carefully as he wishes, since his crew is small, usually interested, instructed, and satisfied with whatever wages the work may bring.

When the lumberman goes out to log in our northern states, for instance, he must start in summer, must build camps, cook house, men's quarters, stables, storehouse, and smithy; a crew of fifty or more men must be hired, and supplies hauled for all his outfit. He must work systematically, so that everybody shall be kept busy, and in good weather or bad he must pay his men definite wages.

The farmer can draw home his logs, firewood, and fencing or other material whenever the weather and roads are good. His firewood he may pile near the house to season; his logs and his old seasoned wood he takes to mill or to town whenever hauling is good. His roads are all made, and, just as he cuts, so he hauls when it is convenient, utilizing weather and time to good advantage. If the winter is too open or otherwise unfavorable, he does no more than he is obliged to do.

Once in the woods the lumberman must build roads, clear a landing, and make sure that he has a brook or river capable of floating his logs; otherwise he must build a railway to haul them out. In all cases this item of railway building is very great, amounting generally to twenty per cent and more of all expenses. Then, when once the crew is felling and skidding or, as in the Adirondacks and many of the spruce woods, when once the logs are all skidded, he must haul them out whether there is too much or too little snow, whether the weather is good or bad. If the logs are to be driven down a brook or small stream, a broken dam or a dry season may cause lack of water and prevent the driving, and thus the logs will remain in the woods, involving great loss to the owner.

Again, the farmer forester lives in a settled country, near mills and towns where he can sell his wood, and not an inconsiderable part of his market is in his own household and farm. His market is at home or near by, and transportation to market is practicable for nearly all kinds of his wood materials.

In many parts of our country the lumberman's logs travel more than a hundred miles before they reach the sawmills or any settlements where any of the material may be used; and the greater part of his wood travels several hundred miles, some of it more than a thousand miles, before it reaches the man who is to use it.

To ship cord wood out of the woods a hundred miles without a railway would, in most cases, cost much more than the wood could be sold for. For this reason the lumberman can often take only the best kinds of logs, and of these only the lighter, which may be floated, like pine in Wisconsin, and must leave hemlock and all hardwoods where they are, to say nothing of dead material, crippled and worthless trees, small poles from thinnings, and the like.

It seems, then, that the proper care of a small forest in a settled country is quite easy, but that it is very difficult to bestow the proper care upon a large forest in out-of-the-way districts, and that often only the simplest improvements are possible. Of course there must be intermediate cases, and so there are also different degrees of care which can be given to the woods.

This also teaches us another useful lesson; it is this: Since cord wood and other cheap material cannot profitably be shipped far, and since they cannot be used up to good advantage in unsettled districts, such forests should be made up chiefly of soft woods, pine, spruce, etc., which furnish a small amount of tops and a large amount of light, valuable log material, which pays for long-distance shipment. Of old maple, birch, oak, and other hardwoods, only about thirty per cent of all the wood is in valuable logs, and seventy per cent is cheap firewood, while in good pine or spruce over seventy per cent is usually cut into valuable logs.

In managing large pieces of selection forest it is best to treat one part after another, and not to pick all over the tract. Thus, if a man has sixty acres of such forest, he would best cut over about five acres this year, five the next, and so on, and in this way get over the entire sixty acres every twelve years. This would give twelve years' rest to the five acres first cut, during which time there would be no cutting and dragging of logs and other material, and at the same time the cutting would recur often enough to keep the woods properly thinned and cleaned.

Starting the Young Growth under Seed Trees

In the selection forest old and young trees are mixed in such an irregular way that it is difficult to know how many trees there are a hundred years old, eighty years old, etc. This makes it difficult to regulate the business of the forest, to know how much is growing, to cut about the same amount of the same kinds and of similar sizes. Moreover, many a fine young tree thirty or forty years old is damaged by the felling of a large neighbor, and many good trees have to be taken out before their time because they were injured in logging. For this reason many foresters have changed this method as follows:

Suppose a ten-acre stand of spruce or beech has reached the age at which the owner wishes to cut it (maturity, or age of rotation). Instead of cutting only a tree here and there, he thins out the entire stand, taking out about twenty per cent of the trees. After a few years more, when he expects a seed year (a matter which every forester watches closely) or when an abundance of seed has been produced during the summer, he cuts out more of the trees, leaving only about fifty to seventy per cent of the original stand, so that the crowns of these trees, which are so tolerant of a great amount of shade, would be separated by about two or three yards, thereby allowing considerable light to get to the ground. The marking out for this cutting (for every tree is marked by the forester) is done in the early fall when the foliage is still on the broad-leaved trees, and the cutting is done the following winter. In the spring the seedlings spring up and grow under the protection of the mother trees, which shield them from sun, wind, and frost. After three years, when the seedlings are well started and are in need of more light, about half of the old trees are cut out; and a few years later, when the young plants are about one or two feet high, the remaining seed trees are removed, and any spots which have no young plants are stocked with plants from a nursery. In this way the forest is harvested, and a new growth started under seed trees in the period of about ten or fifteen years, which makes this new crop of trees covering our ten-acre lot near enough of an age to be treated alike and harvested together, producing a stand of uniform age. Some twenty or thirty years later the stand is thinned for the first time.

Where the forest consists of a mixture of oak, ash, elm, maple, etc., the method is about the same, only the seed trees are fewer, representing only about half or less of the original stand. Moreover, it is well in these mixed stands to give the young plants more light and remove the last of the seed trees earlier, since the young plants need more light and care less for protection.

In pine, only about twenty-five to thirty per cent of the trees need to be left for seed trees. Some men leave only about a dozen trees per acre. The seed trees should be removed when the young plants are two years old, since the young pine does not tolerate much shade.

All kinds of trees can be reproduced in this way, but the success varies considerably with different kinds and in different localities. In Europe, where this method has been tried a long time, it is commonly used for beech and balsam, less often for spruce, seldom for pine and oak.

In our own country, where land is cheap and labor dear, this method will give good results in all our large pineries, East and West, in the spruce forests of the eastern states and Canada, and in the majority of our hardwood forests.

Fig. 24. Young Growth of White Pine under Old Seed Trees

In our northern states, where the oak is more sensitive to shade, it will need to be given a little advantage in order to keep elm, maple, etc., from crowding it. Other sensitive trees, like hickory, chestnut, and walnut, need watching and should be planted before the other kinds get started.

The age at which the trees should be cut — the rotation — naturally varies for different places; it is longer for cold districts and slow-growing trees than for warm localities and rapid growers, and of course it depends also on the size of trees to be raised. In our temperate region and on better soils most of our hardwoods make good-sized timber in an eighty- or one-hundred-year rotation; on poorer lands — mountain districts such as the Adirondacks and Alleghenies — one hundred and fifty to two hundred years are needed. The white pine makes salable material at sixty years, good lumber at one hundred; the red fir, white cedar, and redwoods of the Pacific will do the same, while spruce and balsam for pulp purposes may be managed on a still shorter rotation.

In carrying out the method of starting the young growth under seed trees several things should be kept in mind. The pieces of forest which are taken in hand at any one time should not be too large. Thus, if a man had a forest of a thousand acres, worked on a hundred-year rotation, and wished to have it in such order that a fifth of all his woods were between eighty and a hundred years old, a fifth between sixty and eighty years, etc., then he might take two hundred acres in one piece and thin for seed trees, get a new crop started, and harvest everything on the two hundred acres; then take up the next two hundred acres; and in five twenty-year periods he would have harvested and renewed the woods on the entire thousand acres. But this would not be good; most likely his large open stand of seed trees would invite the winds; the old trees would blow down, and the young trees suffer from drought. For this reason it would be much better to pick out five forty-acre or ten twenty-acre pieces, and treat each by itself. To pick these cuttings, or, as they have been called, "felling areas," is not always a simple thing and requires good judgment as well as a knowledge of the woods and the lay of the land.

Generally it is better in our country to work from east to west, to prevent the regular west and northwest winds from throwing the trees; but in a hilly country this must be modified. In picking out the cuttings it is but natural that pieces where considerable young growth exists come first; and also that a really thrifty stand of timber is left and a less thrifty one taken instead, since the latter is not growing as much timber as it should, and, therefore, is not earning so much rent.

On all points where the wind is likely to do much damage, and also in the border of the woods, it is better to use the simple selection method by which the woods are left more intact, and are, therefore, more resistant.

Wherever it is possible, as in all small woods in settled districts, care should be taken not to leave fail places or empty spots, and if the young growth has not started well or evenly, planting from a nursery should help out.

Where this method is to be introduced in our own wildwoods of mixed stands the work must be suited to the case. If, for instance, we have a sixty-acre piece of woods, there would most likely be some parts stocked with old trees, some other parts where old and young are mixed, and some pieces where the ground is covered largely with young trees.

In this case it would be best to begin on the pieces of old timber. But since the crowns of our old trees are so very large, the directions about having the crowns three to five yards apart for seed trees could not easily be followed. The cutting of a large oak would often separate the neighbors by twelve yards or more. For this reason the large trees would be picked over, so that a selection system would be applied at the start. But instead of coming back at long intervals, the selection here would be repeated as often as the gaps are restocked with young growth. In this way one piece after another is renewed. If it were desirable to have the woods in a regular shape, and have it renewed in five twenty-year periods, of course one fifth, or twelve acres, would have to be cut over and renewed during twenty years. At first this would not be very strictly adhered to, and if the regular cutting does not furnish enough timber, or if any of the other parts of this piece of woods are in need of thinning or cleaning, the cutting would be extended to these parts.

In large woods the forester would need a map wherein he could readily see just what condition every acre is in, so that he might study and plan the work at his house. In carrying out the plans the cuttings would be marked out in the woods as well as on the map.

To make this map requires not only a survey in which boundary lines are run, as in ordinary surveying, but it needs an examination and an estimate, or better, a measuring of the trees,—all of them, if they are very valuable, or at least of sample pieces or stands; and it also requires a careful noting of any young growth, and a description of the land, the slope, the soil, the drainage. Whether the ground is covered with grass, weeds, and shrubbery, or is bare, should also be indicated, for all this knowledge is helpful and even necessary to a proper planning of the work.

Starting the Young Growth by Seeding from the Side

Along the Potomac, in Maryland, many old fields which were cleared and tilled in the time of George Washington are covered to-day by dense stands of jack pine. In the same way numerous old, abandoned fields in North

Carolina and Virginia are covered with pine. In this case the pine is a fine tree, called by the people of those districts shortleaf pine, and on account of its disposition to cover old fields it is also called old-field pine. It is cut in large quantities for saw-logs, and it is not an unusual sight to see men log this pine on land where the old corn rows are still visible. Evidently the seed from which these pine trees sprang came from the neighboring forest and was blown across the fields. Being so successful in many cases, this way of reproducing the forest has been used by the forester, and since the seed comes from the neighboring forests, the ground is *seeded from the side* and not under the seed trees, as in the method described before.

In using this method it is customary to fell all trees on a strip fifty to seventy-five yards wide, or about twice as wide as the trees are high, and then to wait until the strip is fairly covered with young seedling growth; then to cut another strip, widening the original strip by another seventy-five yards, and so on, until the entire piece is cut over. Of course any young growth is saved as much as possible in cutting the timber, and in valuable forests any places which are not covered within a reasonable time, say three to six years, are filled by planting. Since the seed is carried by the wind, it is well to extend the strips north and south, and begin on any particular piece along the east line, so that the prevailing westerly winds will carry the seed over the strip.

Where the forest is large there are as many strips worked at once as is necessary to cover the entire forest within the time of rotation. Thus, if we want the pine to be cut when eighty years old, and always allow each strip

Fig. 25. Natural Seeding from the Side

Young pine encroaching on cleared land. (After Bureau of Forestry)

five years' rest to seed and start a young growth, the forest might be divided into a number of parcels such that each parcel would be about sixteen strips wide, and this could be cut in eighty years' time.

Where the wood is still in the ordinary irregular mixture of old and young trees the larger trees on the western half of each parcel would grow old and produce too little wood before the time for cutting, and it is better to take out the oldest timber all over the parcel from time to time whenever convenient, independently of the regular cutting on the strips. If it is desirable to cut about the same amount of timber every year, as, for instance, where a pulp mill or sawmill is dependent on such regular supply, it is necessary with this, as with all methods, that the yearly cut should not be greater than the yearly growth. In woods where too much timber is young sapling stuff the cut must at first be kept proportionately below the normal amount. Just what this cut should be can only be found by making such a survey as was indicated in the previous chapter.

What this growth should be can be learned from the following table:

FOR PINE

NUMBER OF CORDS OF WOOD (LOGS AND CORD WOOD) WHICH MAY BE EXPECTED ON ONE ACRE OF LAND IF PROPERLY COVERED

When the Stand is Old	*On Site No. 1, or Good Pine Land*	*On Site No. 3, or Inferior Pine Land*
Years	Cords	Cords
40	40	25
60	70	40
80	95	55
100	110	65

Since much of this wood in our forests is wasted, the entire top being left in the woods, the slab and sawdust being usually burned as rubbish, it requires about three cords, or about two hundred and seventy cubic feet (solid), to make one thousand feet board measure.

Thus, even on the poorer land, our stand of pine would cut about thirteen thousand feet board measure per acre when sixty years old. In most of our Virginia and North Carolina pineries it would do much better. Generally, however, even well-kept woods are not fully stocked, and if a fully stocked wood cuts a hundred cords, a forest in which only seven tenths of the ground is covered with trees would cut only seven tenths of that amount, or seventy cords.

Dense woods of beech or spruce, or both in mixture, cut more than pine, and most of our mixed hardwoods growing on better soil could be made to cut at least as much as the pine.

Seeding from the side can, of course, be expected to succeed only with trees like the pine, spruce, red fir, cedar, birch, poplar, elm, and others the seed of which is light enough to be blown some distance.

In Europe, where it has been tried, this method has not given general satisfaction; the soil is exposed too long to sun and wind and thus loses of its fertility; grass, weeds, and bramble cover the sunny eastern edge of the strip, and often the seeding is too imperfect for those countries where land is very valuable and must never be left idle. In our own country Nature indicates the use of this method for a large portion of the pineries of the South, and parts of the Rockies, and also in the red fir forests of the Pacific coast, where millions of acres of burns have been most beautifully restocked in this manner without any care on the part of man. The chief advantages of this method are that it does away with the tedious marking; that, in felling, the men are not hampered by the fear of injuring young growth or standing timber; and that the skidding and hauling is not interfered with by standing timber and young growth, and therefore can be done much cheaper.

Starting the Young Growth by Artificial Planting or Sowing

On many of the old farms in Massachusetts, New Hampshire, and other eastern states, portions of the land have become worn out by long tillage and use. They became pastures and, finally, almost useless brush lands. Some of these were planted or sowed to white pine, and land which sixty years ago was worth almost nothing to its owner, since it could earn no rental worth mention, is now covered with a forest of white pine worth one hundred and fifty dollars and more per acre.

This way of dealing with the forest, to cut clean and then replant, is a common method in European countries

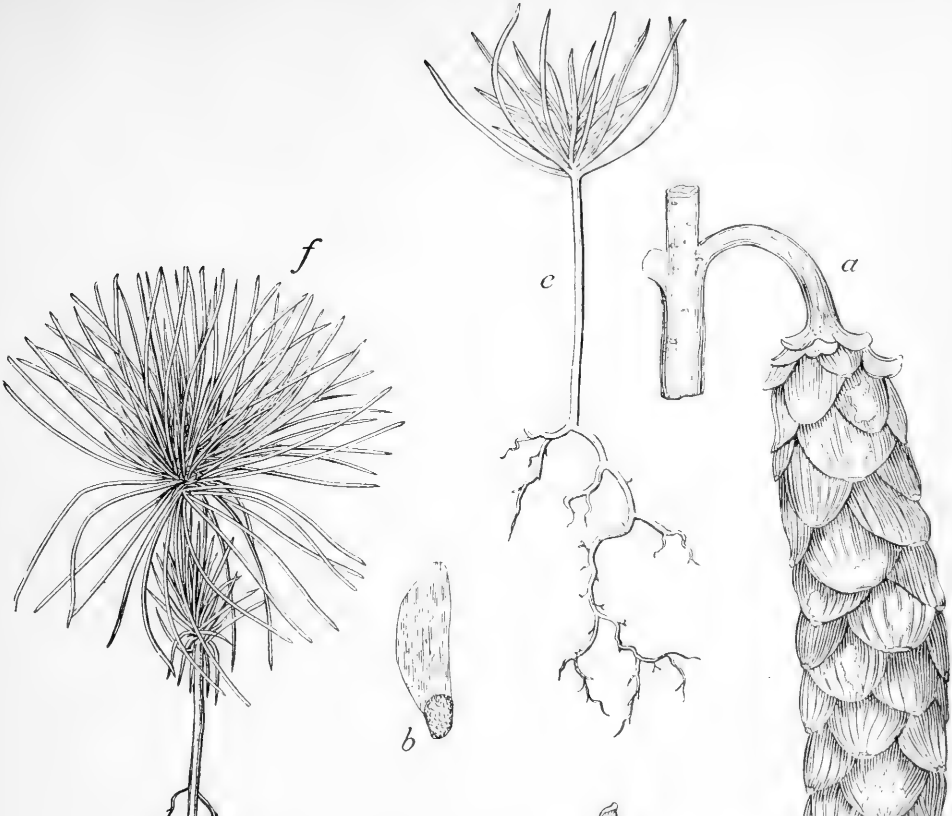


FIG. 26. White-Pine Cone, Seed, and Seedling

a, cone; *b*, seed with wing; *c*, *d*, *e*, plant of first season; *f*, plant two years old (After Division of Forestry) and much used in the pineries of North Germany, and in the spruce forests of Saxony and other districts. In our own country this method has not yet been used systematically in the care of forests, but many thousands of acres of what was formerly forest lands and large areas of prairie land have been planted and converted into useful forests.

The method is the simplest; the logging can be done at any time, in the cheapest manner, and the reproduction or starting of a new growth is simple and satisfactory.

With the natural seeding under seed trees or in clear strips one spot has thousands of seedlings on a few square rods, so that not one plant in a hundred can possibly live; and the next spot is left without any growth and must either be left idle or be replanted. All this is avoided by planting, for if done well it is usually successful, and the plants are sufficient in number and yet do not crowd each other. They therefore grow fast and symmetrically, with good healthy crowns, and the sticks are not so slender as if grown in dense thickets.

Since this method requires a large number of plants, we shall have to learn something about tree seeds, where and how to get them, how to raise plants, and how to plant them.

Nursery and Planting.—The seeds of most of our forest trees are still so high in price at seed stores that it is well to collect them whenever possible. Thus, the seed of our pines, spruces, and cedars costs from two dollars to five dollars per pound; that of ash, maple, and birch from one dollar to two dollars, and even acorns cost twenty-five cents and more per pound. It pays, therefore, to gather our own seed; for, besides being cheaper, the seeds we gather are fresh and, being matured in our own locality, are apt to furnish plants well suited to our climate.

There are a few kinds like the elms, the willows, the poplars, and also the silver and red maples which ripen their seeds in spring and early summer; but most trees ripen their seed in the fall, the majority in September and October. Some kinds bear seed nearly every year; most kinds bear every two or three years with a specially good seed year at longer intervals.

Large seeds, like those of oak, beech, chestnut, hickory, and walnut, can be picked up when they fall, and the same is true of the pods of locusts and catalpa. The seeds of basswood, maple, and ash may be beaten off the tree and caught on a sheet spread out on the ground; or they can be gathered by cutting the best bearing twigs with shears, either from the ground or from a ladder.

This way of cutting the twigs or picking off seeds is the best also for elm and for trees where the seeds are in cones or balls, as with the yellow poplar (tulip poplar), sweet gum, sycamore, birches, and conifers. The seed of willows and poplars rarely needs to be gathered, as these trees are easily grown from cuttings.

The seeds which ripen in spring and early summer, as those of elm, poplar, and willow, must be sown as soon as ripe, for they do not retain their vitality very long.

The small cones of birch, yellow or tulip poplar, and balsams fall apart easily when dry, and then the seeds and scales (chaff) may be separated; but the cones of pine, spruce, larch or tamarack, hemlock, and white cedars remain intact and have to be dried, preferably in a warm room, until the scales open and let the seeds drop out.

After we have gathered the few kinds of seeds from which we wish to raise plants we have to take care of them, for seeds are not only eagerly eaten by mice, but they spoil by drying out or by heating and molding.

Different seeds behave very differently in this respect. The seeds of pine, spruce, and other conifers may be kept in bags hung up in a dry, cool shed, but the majority of seeds of broadleaf kinds, especially all the fleshier ones, are best kept in sand.

For this purpose the bottom of an ordinary box is covered with a two-inch layer of sand (not dry, but moist like ordinary earth); then a layer of seeds one half to one inch thick is spread out on the sand; this is covered with a two-inch layer of sand, then a layer of seed, and so forth. When filled the box is nailed up and may then be placed in a cool cellar or else put into a pit dug in the garden, deep enough to receive the entire box. After the box is set in, earth is shoveled over it to cover it at least six inches deep and make a small mound to shed the water. This should be still further guarded by a covering of boards or slabs. The seed thus kept should be sowed immediately after it is taken out in the spring.

To save the trouble of keeping the seed over till spring, it is often better, where mice are not too numerous, to

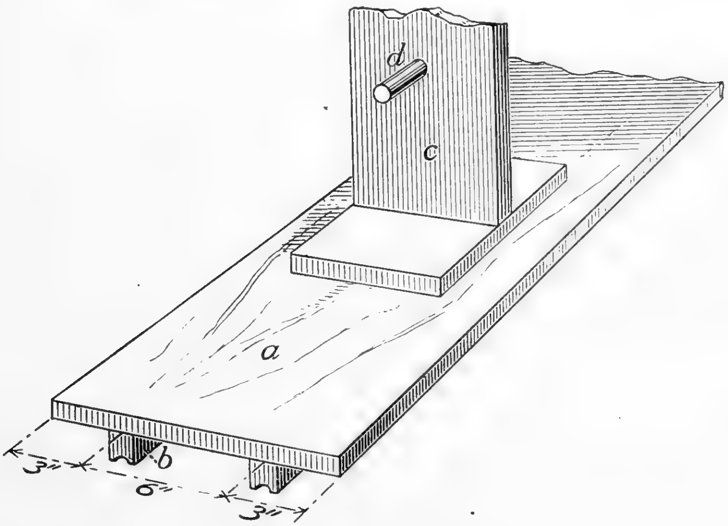


FIG. 27. Drill Board

a, board; *b*, cleat to make the drill; *c*, upright board with handle, *d*

sow the seeds in the fall. This may well be done with all fleshy seeds, like those of oak, beech, chestnut, hickory, walnut, maple, ash, etc., but seeds of conifers and most seeds which can stand only a very thin cover of earth should be kept till spring.

Seed Bed.—To raise plants of broad-leaved trees any good garden beds will do; for pine and other conifers most gardens have too much stable manure, and a small spot in the woods is often better. Broad-leaved kinds need a good loam, but can stand quite heavy clay; but the conifers fare better on a sandy soil. All seed beds should be plowed or spaded deeply to loosen the soil for the roots, and the land should be well fertilized with phosphate of lime, well rotted compost, or forest mold. All this is easily done where only a few thousand plants are to be raised; for a bed four by twelve feet is capable of producing a thousand or more of such plants as pine and spruce.

For this reason some prefer raising tree seedlings in boxes in the house, or under glass, and in many cases this way is the cheapest and most convenient. Of course where a large forest has to be supplied every year with plants it is necessary to have a large nursery.

Sowing.—In sowing large seeds it is generally better to plant in drills, which may be made with a narrow garden hoe; but for small seeds the drills should be pressed into the ground with a drill board, shown in Fig. 27, where the two cleats make the drills. In boxes and where space is valuable broadcast sowing may be employed. With most of the broad-leaved kinds the drills should not be closer than twelve inches; for conifers six inches suffices.

As soon as they are in the ground, conifer seeds should be covered about one half inch; maple, ash, etc., about

FIG. 28. Seed Beds

Part of the screens are covered with brush to give a denser cover one inch; oak, hickory, walnut, and also black locust, about two inches. An old rule says that tree seeds should have a cover three times as deep as the seed is thick. After covering, it is well to roll or press the surface of the ground with a board or roller. To prevent the drying out of the ground it is best to give the seed bed a cover of brush or else cover it with a screen. (See Fig. 28.) This screen is placed on the ground until the seedlings push out of the soil; then it should be raised, at first four inches, later on twelve inches for conifers, and for broad-leaved trees two feet, so as not to hinder the plants in their growth. This screen protects the plants against sun and wind, and thus keeps them from drying out.

Some broad-leaved trees and also the pine can sometimes be raised without the screen, but all kinds do better if thus protected; while some kinds, like spruce and balsam, do not get on well without it, and should have it all of the first and at least part of the second year.

Many seeds will germinate within a few weeks after sowing; some few, like ash, basswood, larch, and even white pine, often "lie over," *i.e.*, a part of the seed does not come up until the second year. To prevent this the seed should be soaked for several days before sowing.

The majority of fresh or properly kept tree seeds are good, and from sixty to eighty per cent of all seeds may be expected to germinate; but of those of balsams, birch, elm, ash, and maple generally less than half are good, while of yellow poplar seed ninety per cent is commonly worthless.

The number of plants which are obtained from a pound of seed depends, of course, on the number of seeds in a pound, on the per cent of good seeds, and also on the vigor of the seedlings.

The number of seeds in a pound varies within wide limits. In the light and winged seed of birch there are over four hundred thousand grains to the pound; in Norway, shortleaf, and Scotch pine, red fir, and spruce, about seventy thousand; in white pine, about thirty thousand; in white ash, about ten thousand; in basswood and sugar maple, about seven thousand, while in walnuts there are only about thirty nuts per pound. In sowing, the seeds should be well spaced so that about three to five grains of coniferous seeds come to one linear inch of the drill. Acorns and nuts are dropped about two to three inches apart, and in the case of most of the smaller seeds of broad-leaved trees one to three seeds are sown to each inch of drill.

Seedlings. — If properly cared for, *i.e.*, hoed, weeded, and, if need be, watered, and carefully sheltered, the little seedlings should take a firm hold of the ground and become fully established during the first summer. Pine, spruce, and other conifers generally remain small the first season, usually growing to a height of only one and a half to three inches; those of most of the broad-leaved kinds in the temperate zone of our country grow usually to a height of six to twelve inches the first year,

Fig. 29. Seedlings. (All two years old and about three feet high)

a, maple; *b*, box elder; *c*, aspen

and some of them, like catalpa, black locust, and the walnuts, grow commonly to a height of twelve to twenty-four inches.

During cloudy weather and in the fall the screens should be removed or used sparingly, to give the seedlings sufficient light. During the winter the tiny little plantlets of conifers may be protected with a cover of branches or leaves, but generally they do well enough without cover.

FIG. 30. Planting in Old Burned-over Slash Land in Adirondacks

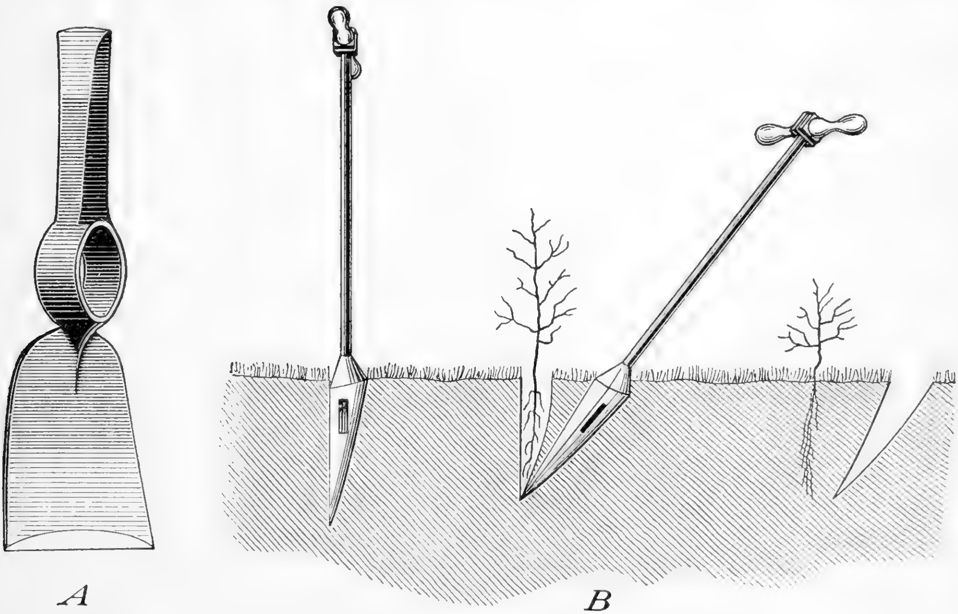
For the taller, broad-leaved seedlings a "hilling up" is usually desirable, and where tender kinds, such as hickory and chestnut, are to be raised in colder localities a cover of brush and straw is desirable.

Planting. — The plants of such trees as the elm, catalpa, and black locust, and most of our hardwoods may well be set out in the woods when one year old; and even beech and pine do well if set out at this age. Pine plants do better if set out when two years old, and spruce and balsam in their third year. When it is desirable to have stout and hardy plants, as in planting on poor soil or in places exposed to wind and sun, it is best to take the plants from the seed bed when one, or even better, when two, years old and set them in another bed in the garden, giving them more space. This transplanting makes stout, bushy, long-rooted plants, and is much used in raising spruce, balsam, and oak. Generally it costs as much to transplant a thousand plants as it costs to raise them in the seed bed to the second year.

Where the trees are set out on forest soil with stumps and small brush and rotten logs and other rubbish in the way, they are placed wherever there is good space, but preferably not closer than five feet apart. The planting is best done by two men, one digging the holes with a mattock, the other setting out the trees.

The plant should not be set deeper than it stood in the seed bed; the soil must be filled in neatly and firmly about the roots, so that the plant cannot readily be lifted out by the top after planting. In this way two men can plant eight to twelve hundred small plants per day. By using the spadelike iron shown in Fig. 31, *B*, where the hole is made by one thrust, the plant held in by a boy, and the hole closed by a second thrust, the two men can plant as many as fifteen to twenty hundred per day. This method does very well in sandy soil and with two- to three-year-old conifers.

On prairies, where the land may first be plowed and harrowed, the trees may be set in regular rows, and the



A B

Fig. 31. Planting Tools

A, ax-mattock, one of the best tools used in the woods; *B*, planting dibble, used in loose soil and for small plants

larger plants of broad-leaved kinds may well be set out in furrows.

In all kinds of planting, but especially with pine, spruce, and other conifers, the greatest difficulty is found usually in trying to keep the plants in a fresh, healthy condition. If they are bought at a nursery, a thousand or more miles away, they are apt to heat and mold if packed too closely, and dry out if packed too loosely. The best method is probably to ship them in large baskets, packed in bundles and with the roots wrapped with damp moss. Seedlings of pine, spruce, and other conifers should never be allowed to dry at their roots; in fact, a few minutes of such drying in bright sunlight is often enough to kill them.

During planting, the bunch of seedlings carried along should not be held in the hand but kept in a pail with wet moss and a little water, and in warm, sunny weather the pail should have a cover of wet sacking. The broad-leaved kinds are much more hardy, but in all cases success in planting depends on keeping the plants fresh. Planting in spring is universally preferred, though fall planting is often equally good.

Sowing in the Forest. — Where seed is cheap and where the soil is in good condition, as on newly clean-cut forest land, many people prefer to sow the seed directly on the land and thus save all the trouble of raising plants. With the seeds of oak, chestnut, hickory, walnut, beech, locust, maple, ash, and basswood this is a very good way; and even for pine and spruce excellent results are obtained by this method. In sowing, the man hoes small spots about twenty-four inches square, scraping the ground a little toward the center to make this part the highest; he then drops three to five seeds in about the middle and covers them lightly, pressing the ground afterward with the hoe. In this way he goes back and forth, sowing wherever there is room, but so that the spots are at least

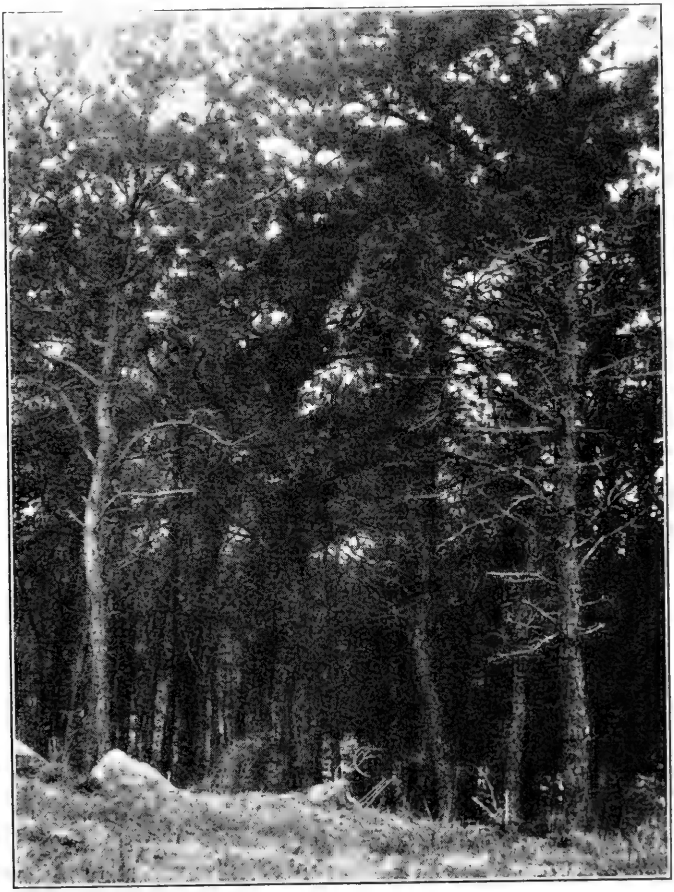


Fig. 32. Pine Grove from Planted Seed

(After Graves)

five feet apart. Where mice are numerous, and where insects, sun, and wind, together with a poor soil, combine to injure the seedlings, this method is not reliable.

Occasionally wild seedlings may be found in great abundance in the woods. When these plants are still small, *i.e.*, from one to two years old, they usually thrive if transplanted; but older plants, especially if taken from rather dark woods, are generally too spindling and rarely do well.

Poplars and willows are best started by cuttings. These are pieces of young shoots, one to two years old, gathered in March and cut into twelve-inch pieces. These pieces are bundled and then buried until spring opens, when they are set out either in the garden, if we wish plants, or else at once in the woods, where they are to remain permanently. In the garden they may be planted in a trench made with spade or plow; and in the woods they are stuck into a slanting hole made with the spade, about two inches of the cutting being left to project from the hole. In both cases the earth is packed firmly by tamping.

In our prairie regions, of course, all trees must be planted; the forest is yet to be made. Here planting, chiefly of broad-leaved kinds, has proved most successful. Later on, when the woods exist, conifers may be added.

In our forest lands such trees as poplar, willow, birch, elm, and even maple, basswood, and ash, need introduction here and there; but in our hardwood forests they will usually be numerous enough without special care.

Hickory, walnut, and even oak, chestnut, and beech may well be started by planting the seed; thus, generally, the main object of forest nurseries is to produce conifers and only secondarily to start such kinds as do not exist in a given locality, or common broad-leaved trees for poor soils and difficult waste lands.

The method of cutting clean and replanting, though used successfully for many years and in many places, and used in forests which have paid the highest yearly rental of any in the world, has, nevertheless, been criticised by many foresters. Usually it is claimed that it costs too much; that it leaves the ground bare for several years and thus exposes it to sun and wind; and, finally, that it induces the people to grow forests composed of one kind of trees, either spruce alone or pine alone, and thus increases the danger from insects and disease; for if a spruce forest is attacked by a spruce-loving caterpillar, the insect finds so much food that its numbers increase

FIG. 33. An Oak Grove from Artificial Seeding (After Graves)

all the more rapidly, and a whole forest may be destroyed. Experience in Saxony, involving thousands of acres annually, shows that planting is not costly, for it costs there only about two per cent of the total or gross income of the forest. But even if it should not be well to clear off large tracts of forest and then replant, it will be safe to do so on better lands in a temperate climate and for small areas; and it is probable, also, that it will prove satisfactory for larger areas situated near good markets, like some of our spruce forests which supply pulp mills in their midst.

Aside from this it will always be found not only helpful, but even necessary, to assist Nature in restocking the forest; for, however carefully dealt with, mistakes produce fail places, and therefore every one who cares for a forest should know how to plant and sow and should at all times be ready to do so.

It would be misleading, however, to infer that the planting of forests is always profitable in the ordinary sense of the word. Like the pioneer's clearing of forests for plowland, and like the farmer's labor of raising the bread and meat of the nation, so the planting and raising of forests, though one of the most necessary of human occupations, rarely produces those large returns which a speculative age expects from a "paying" investment. But like the conversion of the wilderness into productive farms and pleasant homes, so the planting of the forest is sure to reward in the end.

Review of Methods of starting New Growth in Forests

We have now looked over the various ways which different people employ to keep up different kinds of forests. Of course every one of these principal ways may be, and actually is, modified or changed by different men to suit particular cases. In this way there are a good many kinds of coppice, using different trees and different rotations; one man leaves only a few trees in his standard coppice, another holds over so many trees that the standard coppice approaches the timber forest. In the same way one man picks over his whole tract of selection forest every year; another works one fourth of it until this fourth is all cut over and stocked with new growth, and then goes to the next fourth, etc. In this way his selection forest becomes more regular and approaches the common method of starting the young growth under seed trees.

We have learned, too, that whatever the system of management may be, the starting of a new growth — the reproduction, the keeping up of the forest — is the main feature in the mind of the forester, and his methods are described, named, and compared with this chief object in view.

The table on the following page will help us to fix in our memory the principal methods of reproduction, each giving rise to a particular form of forest.

THE SIX PRINCIPAL METHODS OF REPRODUCTION

Method	How the Cutting is done	The Trees start from	Where the Method may be used
1. *Coppice*	All trees are cut off	Sprouts	Only for broad-leaved trees, preferably oak and chestnut, on fairly good forest soil and in mild climate
2. *Standard Coppice*	Part of the trees are held over to grow to larger size, and are cut at the end of the second or third rotation	Main crop from sprouts, the standards preferably from seed or plants	Same as coppice. For standards use oak, chestnut, ash, also pine
3. *Selection*	The largest and oldest trees and also the worthless and crowding younger trees are picked out	Mostly from seed	For all kinds of forests, on all kinds of land, and for cold and warm climates. The best way for difficult mountain forests and wherever it is hard to keep forest growth
4. *Under Seed Trees*	The piece of land is cut over two to four times within 10–20 years; the first cut merely thins out, the second leaves only the seed trees, the third cut gives light to the young growth, the fourth cut removes the last of the old trees	Seed	All kinds of forests, less good in cold climate, on poor soil, and in exposed (storm-beaten) places
5. *Natural Seeding from the Side*	Strips 50–75 yards wide are cut clean and left until seeded, when a new strip is cleared	Seed carried by the wind from neighboring forest	Only with trees which have light seed,—pine, spruce, red fir, white cedars, elm, birch, poplar, etc.,—and only in warmer localities and where seed falls abundantly and regularly, and where the soil is not covered too badly with grass and brush
6. *Artificial Seeding or Planting*	All timber is cut	Seed, or nursery plants	All kinds of forests, good and poor soil, cold and warm climate. Simplifies the business, makes cheap logging, and prevents useless crowding of young plants

CARE AND PROTECTION OF THE FOREST

A piece of wildwoods, as we have seen, may do very well without the care of man; young growth will start up where old trees die and fall; in the dense thickets the more vigorous choke out the weaker, the taller shade down the shorter; the tolerant crowd out the intolerant. A gap made by the storm is filled in sooner or later by trees starting as sprouts, or by trees whose seeds have been carried there by the wind. Large openings made by fire are restocked, here slower, there faster, according to the circumstances; and large areas of forest destroyed by some caterpillar are gradually reforested by those kinds which this particular insect does not feed upon. This would seem to tell us that forests need no care. But this is true only if we are satisfied with the small amount of good growth which most wildwoods make. Where man wishes the forest to produce a larger amount of wood and wood of particular kinds and sizes, more or less care is necessary. In the stately forests of red fir and cedar of the Puget Sound country, where a good forest soil, mild and humid climate, and excellent kinds of forest trees combine to make a forester's paradise, a little care might suffice; but even in these districts the old trees hinder the young, and the young trees crowd each other, and thus the trees themselves call for help, for interference, for improvement.

Besides this the farmer with his thirty acres of woods is not satisfied with the philosophic view that, in the wild state, forests gradually right themselves; he must know what he had better do to protect his woods against fire and insects, and how to treat them to make them more resistant against wind, snow, and frost.

Thinning and Cleaning

Going over a newly planted piece of young pine where the little plants are five feet apart, we see that each of these has more than twenty times as much space as it needs. If we come back five years later, we find the little bushy-topped trees beginning to touch each other. Ten years later we find here a thicket of saplings, twenty feet and more in height, the lower limbs mostly dead, and the short crowns firmly locked. The struggle has begun, and if no trees are taken out, the stronger choke the weaker; but, and this is the serious part, the weaker also hurt the stronger by using up some of the much-needed water and mineral food from the soil and hindering the growth of both limb and root.

If we return again ten years later, we find a large number of trees dead. Others are dying, and the living trees have grown taller and their stems have fewer dead limbs. The trees have "cleaned" more perfectly, but they have grown but little in thickness; they are a spindling lot of thin poles with a little crown of green limbs altogether too small for thrifty growth. A glance shows that the stand is suffering and that help is needed.

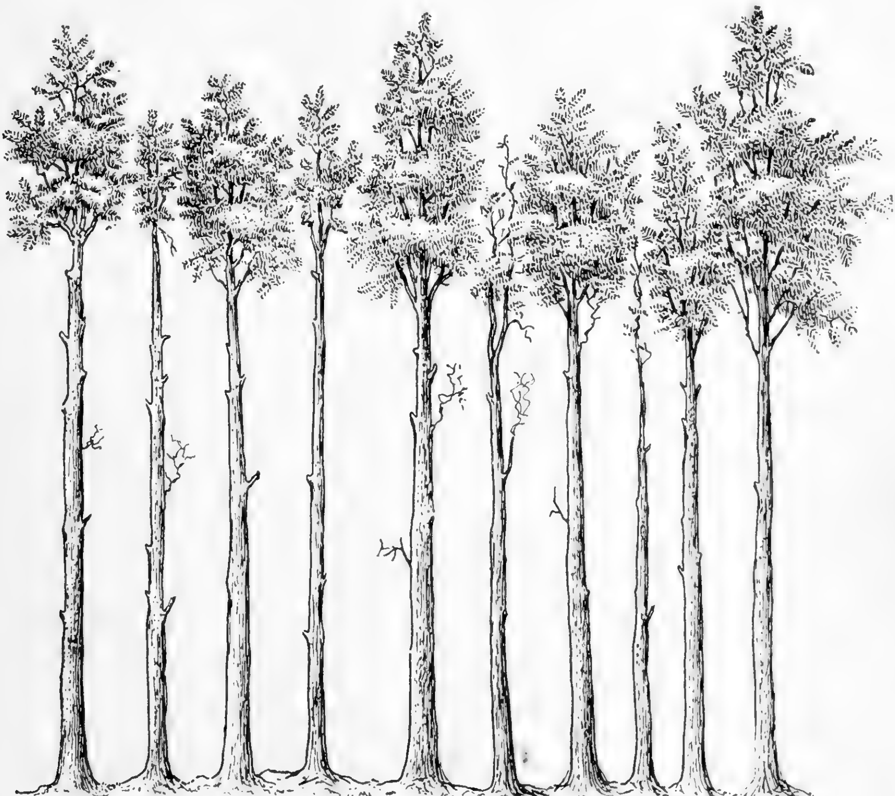


Fig. 34. Which should come out?
(After Kraft)

Here then would be our first thinning, and the question arises, What shall we take out?

A study of Fig. 34 will help us. Here the strongest trees are marked No. 1; they represent those exceptionally

L. of C.

vigorous ones which project above the general level of the canopy of the woods. The three next best trees are marked as No. 2; they represent the thrifty trees whose crowns make up the body of the canopy. Let us call the trees of class No. 1 and No. 2 the *dominant* trees. The trees No. 3 are weaker; they form a small part of the canopy and give little promise of ever making good trees. Those of No. 4 are being crowded out, and those like No. 5 are dying or dead.

If our piece of forest were twenty-five years old and the trees about thirty feet in height and we might thin out every ten years, we should take out only trees of the fourth and fifth classes; and also such trees of the third class, and even of larger size, as interfered evidently with some better trees. This would be repeated in ten, in twenty, etc., years, until the timber should be cut.

In places where the pole wood cut during the first and second thinning could not be sold, this process would cost some money; for the material cut in the thinnings should really be taken out to prevent the development of too many injurious beetles. For this reason a more thorough thinning would, in most cases, be better; and then most of the trees of even the third class would be taken out.

Where the young growth starts from natural seeding, so that often twenty and more trees start on one square foot, the crowding begins very early and it would be better if the majority of little plants were taken out or destroyed before they are a foot high. To do this well would cost too much, and the forester usually leaves the thicket to itself until it is about twenty years old, when he thins it out in much the same way as described above.

Fig. 35. Thinned, but will need it again

To get a better idea as to how much ought to be cut it may be said that for pine on good pine land there ought not to be left more than ten trees on one square rod at the age of twenty, four at forty, two at sixty, and one at a hundred years, as tabulated on the following page.

THE NUMBER OF TREES ON ONE ACRE IF FULLY STOCKED

When the Stand is Old	For Pine		For Spruce	
	On a Good Site	On an Inferior Site	On a Good Site	On an Inferior Site
20 years . . .	1600	2000	—	—
40 " . . .	700	1200	1000	2000
60 " . . .	300	600	500	800
80 " . . .	200	350	300	400
100 " . . .	175	250	250	300
120 " . . .	150	200	225	275

By dividing these figures by 160 (the number of square rods in an acre) we can readily find how many trees we may leave on one square rod.

Many foresters are guided by the crowns and thin just enough to keep the crowns from crowding.

Naturally enough, trees which, like spruce, balsam, beech, and maple, can tolerate much shade, are thinned later, and must be thinned less thoroughly, if they are to clean themselves and grow smooth stems, than the intolerant kinds, which clean more easily. On the whole, thinning is one of the most difficult things the forester has to learn, and much good sense and care, as well as experience, are needed to do it well.

That injured and crippled trees and also those with unduly spreading crowns should be taken out is self-evident. After a thinning our woods should be evenly and well stocked with as perfect trees as can be produced.

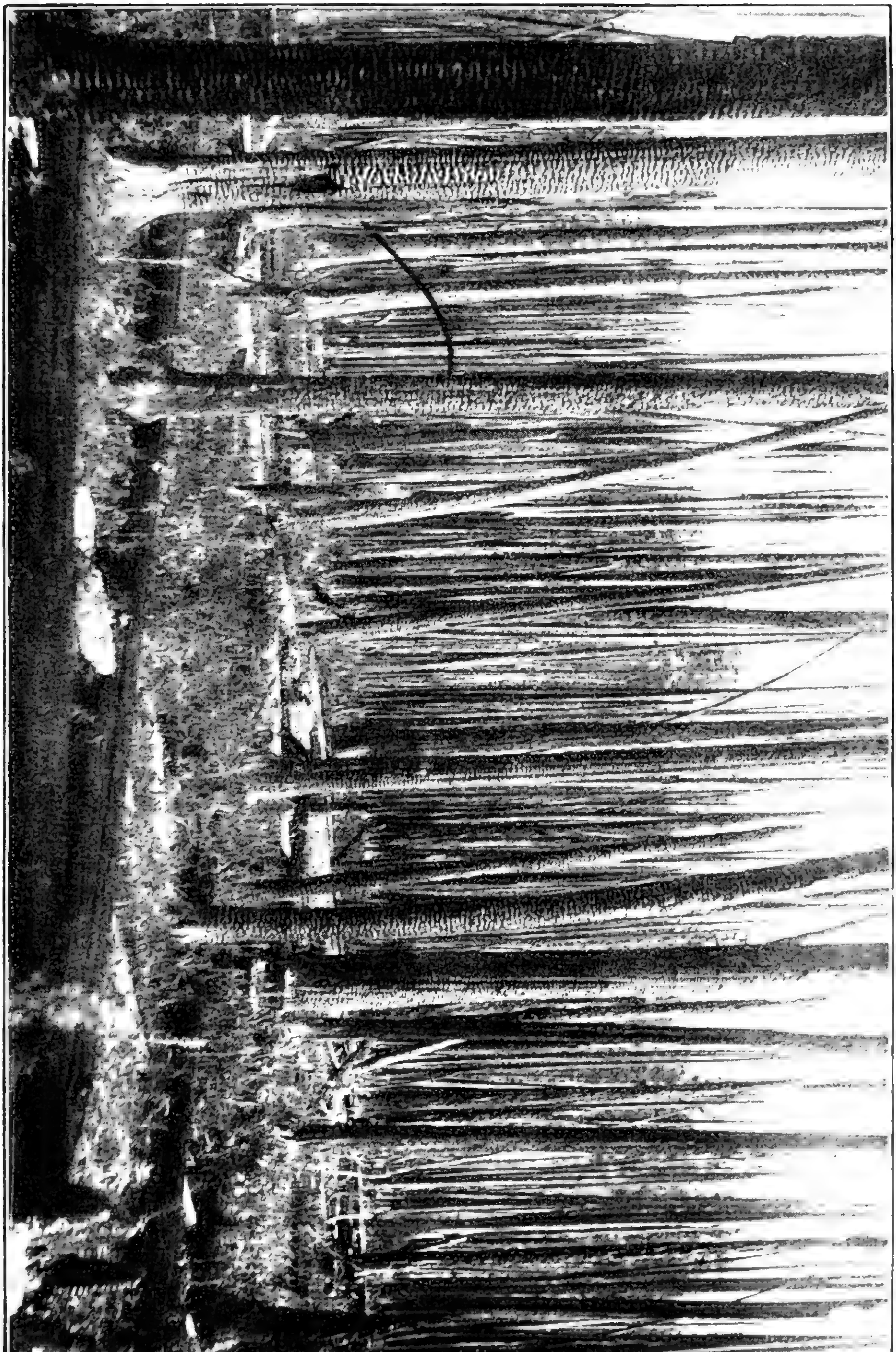


Fig. 36. A "Burn."
Priest River Reserve, Idaho. (After Gannett)

Protection against Injury from the Elements

Fire. — For our American forests, fire has been, and is even now, the most dangerous enemy. When the white man first came to this country he found an undisturbed continuous forest covering the eastern United States. When the "cruisers" of forty years ago located timber lands in Michigan and Wisconsin there were few extensive "burns," or areas where the fire had converted the forest into a barren waste. To-day many millions of acres are burns; large ones are found in Maine, Canada, in the Lake States, and the forests of the Rocky Mountains. The Sierra Nevada and Cascade Ranges are fairly dotted with unsightly burns; and even the ever-dripping, fog-shrouded forests of red fir in Washington have suffered extensive and most destructive fires.

Our hardwoods or broad-leaved forests have never been ravaged by fires to any great extent; fire is a danger chiefly of the coniferous forest, particularly of the pineries covering the large sandy districts of both the North and South and the dry mountain forests of the West.

In our settled districts forest fires are rather uncommon and the danger is steadily growing less; but in our large pineries, and wherever extensive lumbering is done in coniferous forests, fires are of common yearly occurrence. Now and then, during dry seasons, they are more numerous and some of them become truly terrific.

Fig. 37. Tangle after Fire

Priest River Reserve, Idaho. (After Gannett)

The Miramichi fire of 1825 in New Brunswick, the Peshtigo fire of 1871 in Wisconsin, the great fires in Michigan of the same year, and the great Hinckley fire of 1894 in Minnesota destroyed several towns and hundreds of farms; they cost the lives of many hundreds of people and consumed millions of feet of timber.

The behavior of fire differs very much in different kinds of woods and even in the same woods at different times. In Georgia and Florida pineries it may be merely a light "surface fire," consuming the thin layer of long pine needles, and usually traveling along at a very moderate rate. In the denser parts of the mixed woods of the Adirondacks it is a ground fire, eating along on the surface of the earth and in the dry layer of the duff so slowly that a whole day's burning adds only an acre or two to the burn.

On the other hand, a fire in one of the large slashes, especially in the drier lake countries and the West, may, after it gets well started, travel by fits and leaps; and the draft is often so great that burning brands are carried through the air for several hundred yards, lighting new fires as they fall. Then it becomes a forest fire of the dangerous kind, and if the lone settler and his family have any great distance to run in order to reach a large clearing or other point of safety, they are almost sure to be overtaken and suffocated, if not actually burned.

To what extent the woods are destroyed by the fire differs in much the same way. In the southern pinery it may be only the litter and the little seedlings and young plants which are cleaned up; in the mixed woods of the Adirondacks a large part, often all the timber, dies wherever the fire has occurred (see Fig. 42); in the Hinckley fire the forest was not only killed for miles, but in many places almost everything was cleared; all dry limbs, tops,

FIG. 38. The Camp Fire as it should be

dead timber, standing or down, were entirely consumed. In a dense stand of green pine, balsam, or spruce it is a common thing for the fire, intensely hot as it is, not merely to kill all the trees, but to burn a large part of the limbs with their resin-filled leaves, fairly roaring as it shoots up one tree after another, and often flashing through the crowns of several dozen at a time. A few years later these trees are all bare skeletons (see Fig. 36), ready to be thrown down by the winds, and the forest is changed into an impenetrable tangle, ready for another and far more serious fire.

Fires usually start in the woods through the carelessness of man, for at least all of our eastern forests were almost free from large burns until lumbering and settlement began. A common cause is the camp fire left burning in the woods. To go away from a camp fire without putting it out is gross negligence.

To have a camp fire under control, it should be built in the right place. To build a fire against a large fallen trunk, especially large rotten logs, to start it on a thick bed of pine or spruce leaves, or on a thick layer of duff, is a common mistake. Such a fire would often require more than a hundred pails of water to put it out. A better way is to pick out a clean spot — for a mere lunch or dinner fire, a sandy or gravelly river bar or similar place — and then to build the fire of two larger sticks and an armful of small material, as shown in the picture. Such a fire is convenient to cook by and easy to put out.

Fires are sometimes set intentionally; more often, however, they start from clearing land, also from locomotives, and even from lightning.

To fight fire in the woods is usually difficult. In most cases it costs considerable time and effort merely to locate it; for though the smoke is easily seen at a distance, to find the fire is often quite a task.

When finally it is located it may be half a mile from the nearest water, and to carry water even a quarter of a mile through ordinary Adirondack or similar wildwoods to put out a fire covering only two acres of land would often require ten men's service for several days, and the fire would most likely grow beyond control instead of being extinguished. For this reason water is rarely used, except where a small fire is just starting, as when we wish to put out the neglected camp fire. In fact, real forest fires are not usually put out at all; the men merely try to check their spreading and thus restrict them to as small an area as possible. After days of fighting and watching, the fire will finally die out or else be extinguished by rain.

In places where former fires have cleaned all the dead and dry material on the ground, the mere beating out of the fire at the edges and cleaning a strip twenty to thirty inches wide with a rake does good service.

Early mornings and late evenings is the time to work, for during the heat of the day the fire is usually so hot that men cannot work near it. In heavy timber where much black duff covers the ground the raking alone is useless, and a trench must be made. Such a trench, if only twelve inches wide, is a good barrier against a slowly progressing fire. In any case the fire must be watched, for it is sure to cross either line or trench. When once the heat is such that the fire travels as fast as a man walks and begins to run even in the tops of the trees, as well as on the ground, real fighting comes to an end and only a "back fire" is of any use.

A back fire is a line of fire set by the men to meet the main fire. Thus, if the main fire travels eastward and has a front of three hundred yards, the men run on ahead to eastward and start a line of fires, so that the main fire along this line finds most of the material consumed and thus loses its force, and in favorable cases is stopped entirely. Such a back fire should be started a good distance from the main fire, often half a mile or more away, along some road, trail, creek, or raked fire line or trench. The men watch the back fire to keep it from crossing their line. If it is to succeed, the back fire should have a good start, and burn fifty yards or more before it meets the main fire. Trenching for the back fire is best done early, as soon as daylight; the fire had better be started later, so that it will burn lively at once.

"An ounce of prevention is worth a pound of cure" is an old saying and applies to the forest fire.

Wherever settlement has opened large fields or clearings between tracts of forest and thus divides the woods into well-separated blocks, serious forest fires no longer need be feared.

Even a moderate amount of such clearing, together with the network of roads, has helped to protect the pineries of the South; and in New Jersey the opening of

FIG. 39. Trenching a Forest Fire

(After W. F. Fox)

broad roadways, as fire lanes, through the larger pine woods is contemplated, in order to prevent fires and to help in fighting them. Such a system of fire lanes is used in the larger forests of Europe, and even in British India, and is probably the best means of protection for many of our extensive coniferous forests. Since hardwood forests do not take fire as readily as pine, etc., strips or belts of hardwoods have been used along some of the railways in Europe to protect the pine woods from the sparks of the locomotives. For the same reason it is recommended to use such belts of hardwoods to break up larger bodies of pine, etc., and also to use a mixture of hardwoods with conifers. In addition it is necessary that everybody in and about the woods should watch and help, and for this reason should know the danger and the law.

To teach and to warn the public, the authorities of several states and the United States, as well as many private owners, are now distributing "fire notices" in conspicuous places along roads, trails, and streams in all parts of the forest.

Storms. — If we should look over the old maps of the many townships of Wisconsin, we would see so many "windfalls" marked by the surveyors that it would seem as if Wisconsin were a regular storm state. This would be an error, for a trip through the South would convince us that storms have there been more frequent, covered larger areas, acted with more force, and destroyed more

Fig. 40. Fighting Fire in the Adirondacks
(After W. F. Fox)

timber. Against storms the forester is helpless. Not so with regard to ordinary winds. Against these, as we have seen, he can protect the woods by the ordinary selection method so that no part of the forest is ever exposed;

FIG. 41. The Fires have cleaned up

(After Bureau of Forestry)

and also by beginning with the cutting of any tract or block of woods on the east side, and thus working in the direction from which the prevailing wind comes.

In other ways the elements often damage forests. Frost kills young plants; snow loads down the crowns of weaker trees and bends them low, often breaking them;

in cold weather fog and rain lay a covering of ice on all the limbs; twigs and leaves of conifers, and frequently even large branches are broken off by the great weight of this ice.

By selecting hardy kinds of trees for frosty places, and by starting young growth either in the nursery or under the protection of older trees the forester will avoid loss from frost; but, on the whole, he is rather powerless against these injuries, which, in northern localities, do considerable harm.

Protection against Animals

If we take a stroll in the woods during summer and look for animals instead of trees, we shall see a few squirrels, perhaps a rabbit, and many little paths made by mice, though probably few of the mice themselves. We may also see a number of birds busily hopping and flying about and finding food for themselves and their brood. But if we sit down by an old stump, a dead or newly felled tree, and begin to look for smaller things, we are soon convinced that for every bird and larger animal we see dozens and hundreds of the "little people," the insects. Troops of ants are busily looking for prey, seizing any stray caterpillar, grub, worm, or other animal they can master, carrying it off bodily or tearing it to pieces. Little hunting beetles go singly, exploring every crack and boring; and wee little brown beetles may be found boring in the bark and even the wood of the newly felled stem. Above and around us we notice flies, wasps, millers, and butterflies, and a world of smaller winged insects restlessly flitting about.

Insects. — Of all animals this vast army of the "little people" are by far the most dangerous enemies of the forests. Thus, the bark beetle, in the early seventies, ruined over twenty-two thousand acres of spruce in Bohemia alone; the caterpillar of the nun moth devastated in East Prussia, between 1853 and 1863, over two hundred and sixty thousand acres, killing more than four and a half million cords of timber. In our own country the gypsy moth has become the terror of woodlands in Massachusetts, and nearly a million dollars of state money alone has been expended in fighting it. The bark beetles have destroyed enormous quantities of timber in Maryland, in the Virginias, and in North Carolina; the larva of a sawfly has destroyed the tamarack in the Adirondacks; the tent caterpillar is ravaging many of our hardwoods; while tussock moth and bagworm are ruining thousands of shade trees as well as trees of the woodlands.

The "little people" accomplish these great feats of destruction through their ability to multiply very rapidly and thus to act in immense numbers. The mother bark beetle of this spring may be represented by half a million of her offspring before the end of the second season; and even the leaf-eating moth may have four hundred thousand descendants in a period of only three years.

Fig. 42. A Fire "Slash" in the Adirondacks

The fire has destroyed the foothold of the trees and they have fallen in all directions. Resembles the ordinary windfall. (After W. F. Fox)

The mischief done by forest insects is very varied. The bark beetles kill nearly all kinds of trees by a queer process of girdling; the moths operate through their larvæ, the caterpillars, and usually kill by eating the leaves and buds; the weevils destroy young plants; the pruner beetles injure by gnawing off the young tips; gall gnats and plant lice do damage by the production of galls; scale insects suck the juice, and thereby cripple the leaves and injure the bark; while the mole cricket and other insects gnaw young roots, and thereby often destroy the smaller plants. But even after the tree is dead its wood is still liable to be spoiled for most uses by some long-horned beetles and their larvæ, the "sawyers," as well as the regular timber beetles. Of all these the bark beetles and moths with their larvæ, the grubs, and caterpillars, are by far the worst enemies of the forest.

Let us examine these more closely. In Fig. 46 we have the bark beetle and its work. In the spring these tiny beetles fly, usually in pairs, and hunt up some suitable tree. After they have found what they want, usually some large, old or injured tree, they bore through the bark, and the female soon begins to bore a passage or gallery, either altogether in the soft bark or else partly in the bark and partly in the wood, as shown in the figure.

Along this passage she lays from fifty to a hundred eggs, distributing them along both sides. When the eggs hatch the little grubs begin to bore in the direction

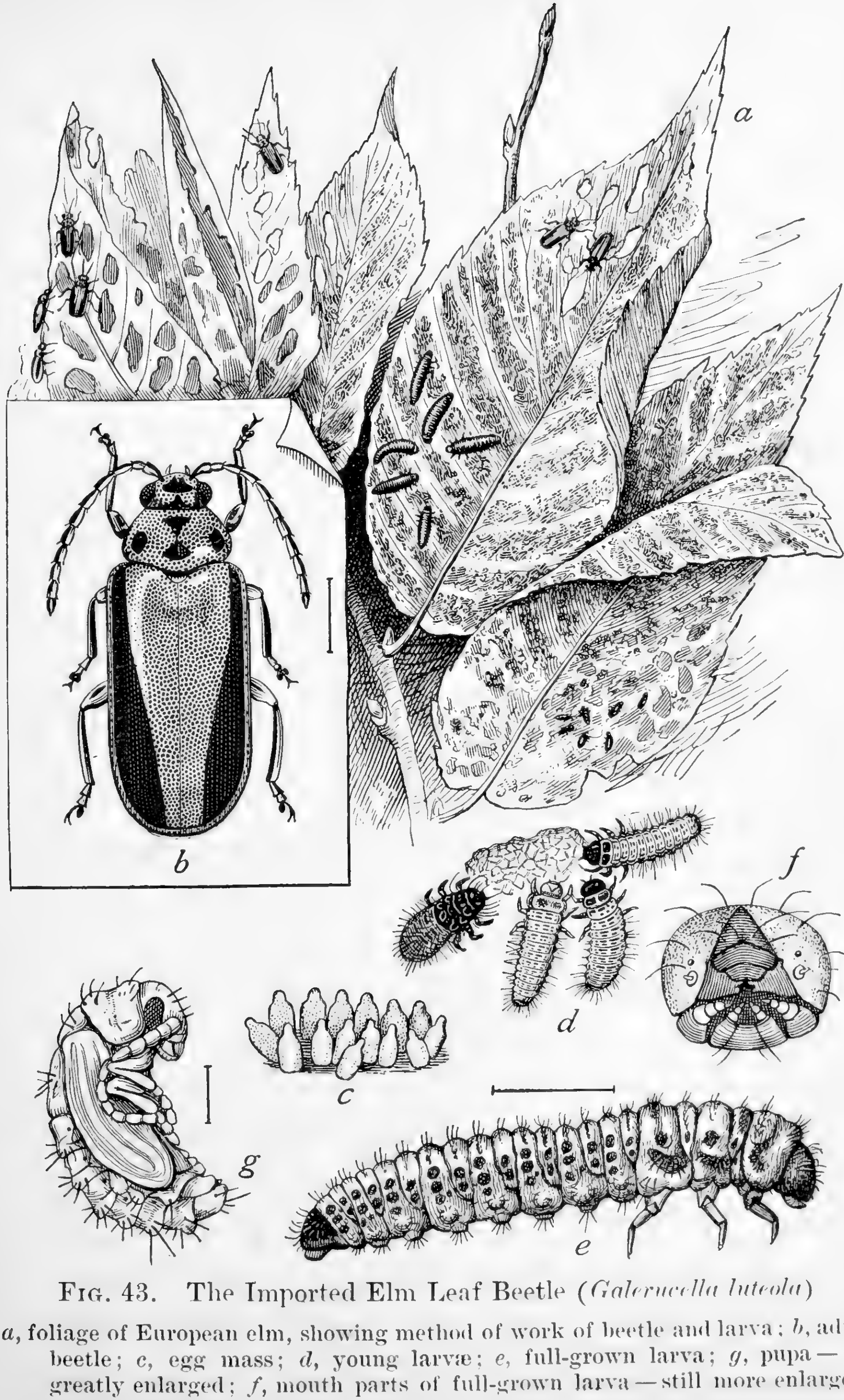


FIG. 43. The Imported Elm Leaf Beetle (*Galerucella luteola*)

a, foliage of European elm, showing method of work of beetle and larva; *b*, adult beetle; *c*, egg mass; *d*, young larvæ; *e*, full-grown larva; *g*, pupa — all greatly enlarged; *f*, mouth parts of full-grown larva — still more enlarged. (After Howard) away from the gallery of the mother beetle, and thus the many little parallel galleries and odd patterns seen in the figure are produced by this one family. After a few weeks the grub, or larva, wraps itself up in the wood dust made by its tunneling, and about three weeks later has changed into a beetle. This beetle may bore out at once and hunt another tree and thus repeat the cycle, so that a second or, in some cases, even a third brood is produced during the same season.

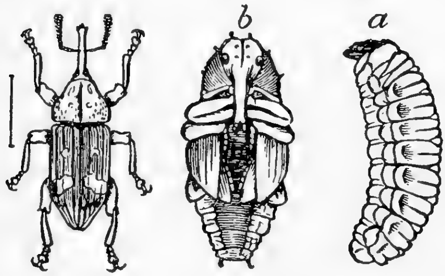


FIG. 44. Pine Weevil: Adult Beetle, Pupa, and Grub, or Larva (enlarged)

(After Packard)

Examining the figure, it is evident that, if many such families lived in this same branch, the branch would be fairly girdled; each little gallery would hinder the water from going up, and also hinder the food made by the leaves from coming down, and the effect would be exactly as if the bark were stripped and the tree girdled. As soon as these beetles appear in large numbers, so that a hundred and more occur on every square foot of the trunk, the tree is doomed. It is generally believed that these beetles prefer sickly or dying trees; but it is certain that when once they are very numerous they readily attack sound as well as injured trees.

Some bark beetles occur in our woods at all times; but it is only when their enemies are asleep, and when numerous injured, sickly, or dying trees make it especially easy for beetles to get food and multiply, that they become really dangerous.

From this it is clear that a well-kept piece of woods, where all trees are thrifty and the puny, crippled, or over-

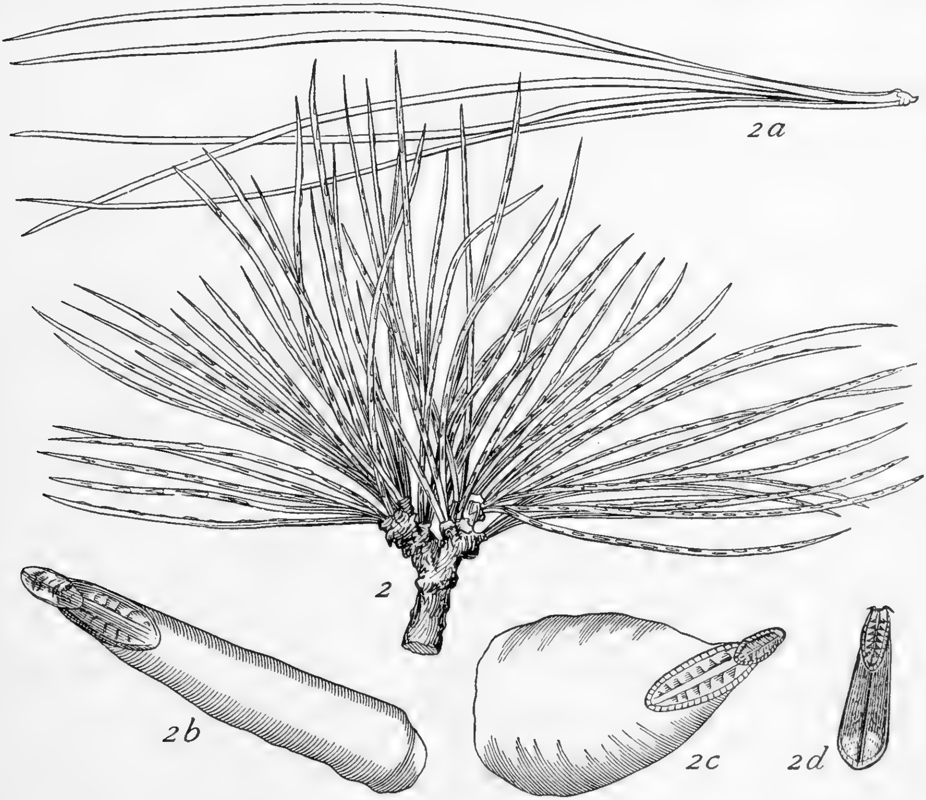


Fig. 45. Scale Insect on White-Pine Leaves

At $2a$ is a bunch of ordinary leaves for comparison; 2, twig and stunted leaves covered by scale insect; $2b$, $2c$, female, and $2d$, male of scale insect (enlarged)

ripe trees, and also all dead timber, are regularly cut out, is not likely to be infested by bark beetles. Should they come from a neighboring badly kept piece of woods, the only effective way of fighting them is by cutting a number of "trap trees." This is best done by girdling or felling a number of the smaller, poorer trees, about fifty yards

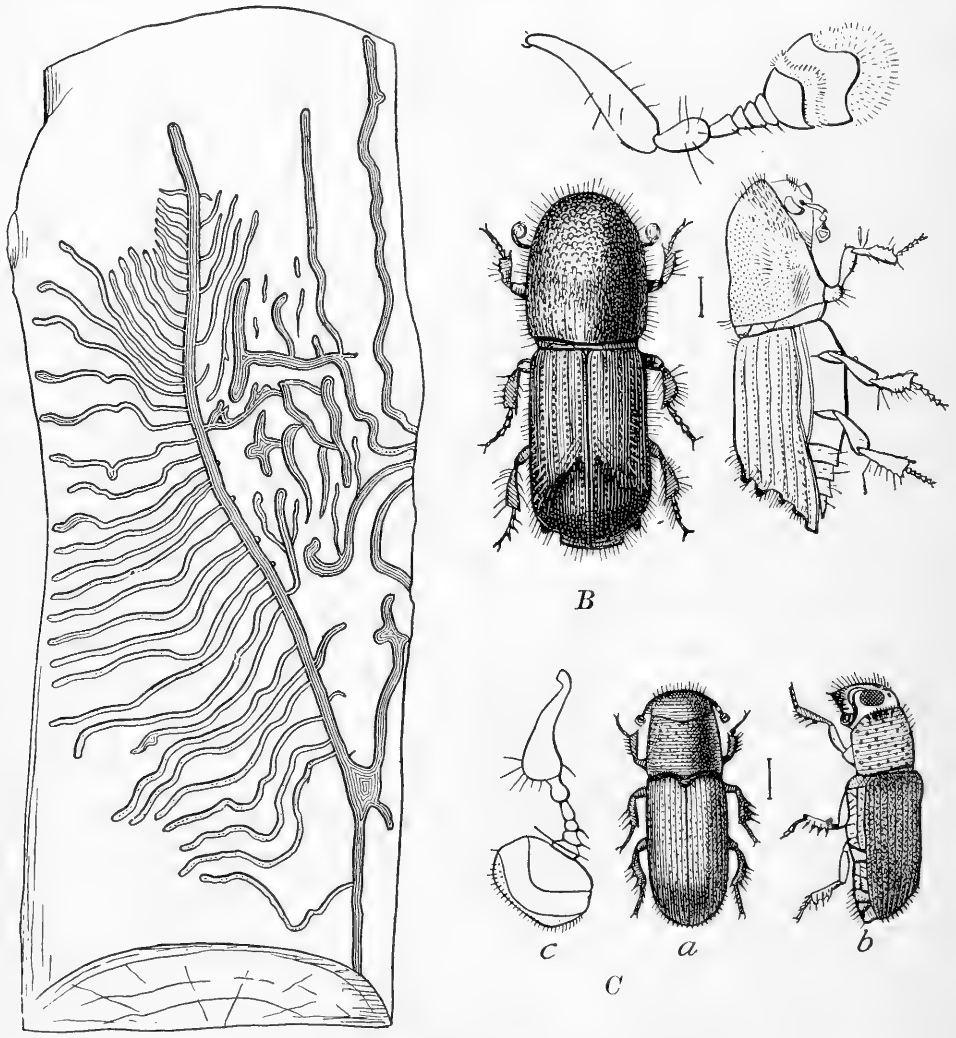


Fig. 46. Bark Beetles and their Work

A, Galleries on a block of wood, just beneath the bark; *B*, the bark beetle Tomicus; *C*, the bark beetle Dendroctonus. Natural size is indicated by straight line between beetles apart, all over the piece of woods, if it is small, or perhaps only in that part where the beetles have begun their work. In the milder part of our country the first set of

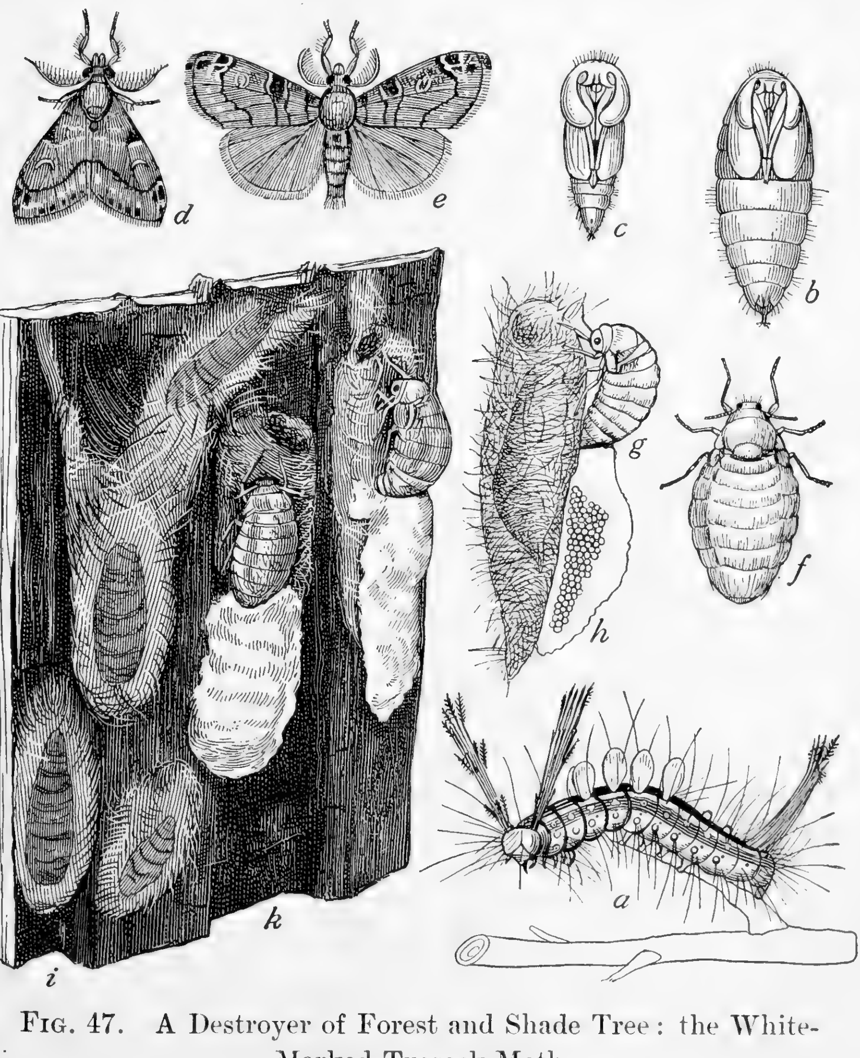


Fig. 47. A Destroyer of Forest and Shade Tree: the White-Marked Tussock Moth

a, larva; *b*, female pupa; *c*, male pupa; *d*, *e*, male moth; *f*, female moth; *g*, same depositing eggs; *h*, egg mass; *i*, male cocoons; *k*, female cocoons, with moths carrying eggs. (After Howard) trees should be cut about the middle of May; in the South this should be done earlier, in the North later. A fresh set should then be cut each month until fall. Each set of trap trees, with all twigs and smaller branches, should be burned whenever a new set of trees has been prepared. If the work is successful, the beetles are attracted by the felled trees and bore into them in large numbers. When the trees are taken out and the bark is burned it catches the young brood, since they have not yet changed into beetles and escaped. Generally these trap trees catch a large number of other wood-boring vermin besides the common beetles.

The second group of dangerous forest insects, the moths, differ very much from the bark beetles in their way of living and behavior.

Thus, the white-marked tussock moth, shown in Fig. 47, in central New York, for instance, lays its eggs about the middle of July. These eggs keep through the winter and hatch the following spring, the young caterpillar emerging about the end of May. The caterpillar feeds on the leaves of whatever tree it may be on, and grows to full size by the end of June. Then it "spins up," *i.e.*, it attaches itself to the bark on a limb or the trunk of the tree and spins around itself a cocoon, in which it stays as a pupa for about two weeks while it changes from a caterpillar into a moth or miller. Soon after the moths come out of the cocoons the female, which in this species has only dwarfed wings and therefore does not fly, begins to lay her eggs. These she lays in clusters, sometimes

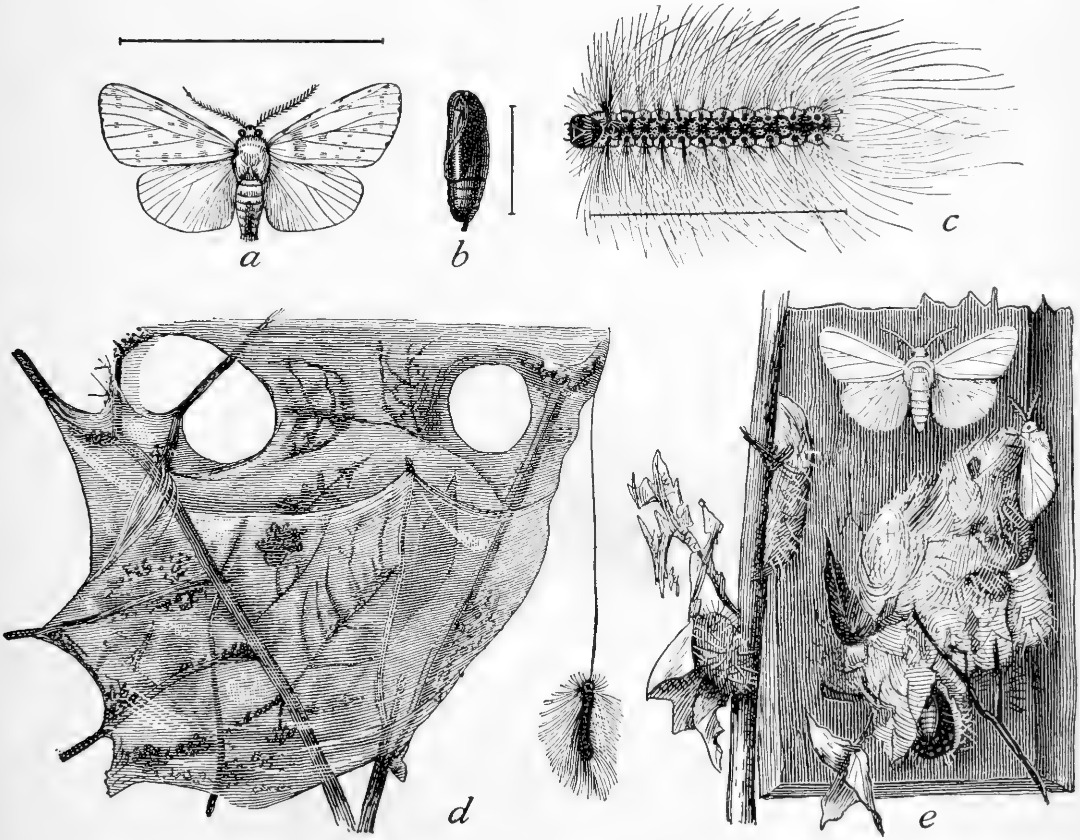


FIG. 48. Fall Webworm

a, moth; *b*, pupa (out of cocoon); *c*, caterpillar; *d*, piece of web with caterpillar hanging by its own thread; *e*, moth and cocoon on board and twig

containing three hundred or more eggs, and covers them with a white frothy matter which dries and protects the eggs during the winter. After this the female moth dies at once. In warmer districts, as in Maryland and Virginia, the eggs hatch much earlier, and instead of having only one whole generation of the insects in a year, as in the North, there are as many as three, so that the number of insects increases very rapidly.

With most of the moths that are dangerous to our forests, both male and female are winged and fly. All of them pass through the four distinct stages: egg, caterpillar, pupa, and adult or moth; and all are injurious only in the caterpillar state.

Though some moths may be found in our woods every season, it is only at long intervals that they become real pests and cause great damage; and even then the calamity rarely lasts many years in succession.

Since the caterpillars live on green leaves and buds, trees of all sizes and ages are liable to their attack. Some kinds of caterpillars prefer hardwoods, some conifers; some eat all kinds, while a few of them eat leaves of only one or a few kinds of trees.

Where the caterpillars attack a pure stand of spruce or pine forest, so that every tree furnishes the most desirable kind of food, the trouble is naturally much greater than in a mixed stand, where possibly half of all the trees are entirely safe from the attack of this particular insect.

To prevent the ravages of caterpillars, the forester can do but little. Where the land and climate permit, it is well to raise only mixed woods. Generally it is well to

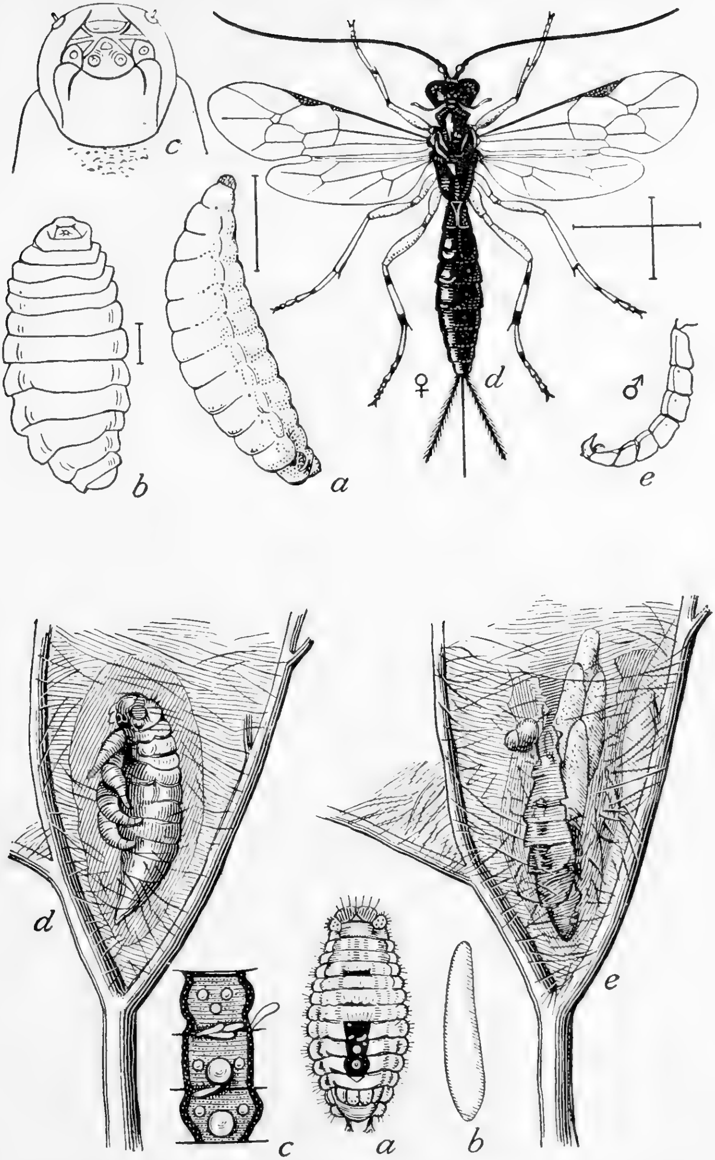


FIG. 49. One of the Greatest Friends of the Forest

Upper figure, ichneumon fly: *d*, as an adult fly; *a*, *b*, as a grub. Lower figure, destruction of caterpillar by ichneumon: *a*, caterpillar with eggs of ichneumon (white on dark area); *b*, egg (enlarged); *c*, dark area with eggs (enlarged); *d*, larvæ of ichneumon feeding on pupa; *e*, pupa of caterpillar destroyed, larvæ of ichneumon in pupa state keep the woods well cleaned and thinned; and in all cases we should encourage and protect all kinds of insect-eating birds and also such animals as the shrew, mole, and bat.

In Europe large sums have been expended in collecting egg masses as they cling to the bark of trees, also in collecting the pupæ and killing the young caterpillars while they are still in large clusters together.

These methods have also been tried in our country, but only for the protection of shade trees. In Bavaria and other states all the trees of entire forests have been supplied with rings of a special sticky preparation, which keeps the newly hatched caterpillars from climbing the stem and causes them to perish in large numbers. Though this has been successful in some cases, it is generally too expensive.

When once the caterpillars exist in large numbers man's efforts are entirely in vain; for while it is quite easy to spray a few peach trees when infested, the use of a poison spray in the woods is out of the question; the trees are too large and the cost too great.

Fortunately, the multiplication of the injurious insects, whether bark beetles or caterpillars, causes a multiplication of their strongest enemies, — predaceous and parasitic insects, and disease.

A large number of widely differing kinds of insects are hunters and live exclusively on other insects, eating or destroying them in every state, preferably as larvæ (grubs, worms, caterpillars), and also in the egg. Thus, one of the ladybird beetles was specially imported, and is used by the fruit growers of California to subdue one of the worst scale insects. But while these many useful hunting insects undoubtedly do great service in keeping down the numbers, thus preventing a real calamity of destructive insects, it is chiefly the parasites, together with diseases, which shorten and stamp out the insect plague when once it exists.

A typical case where a parasitic insect is making itself useful to the forester is shown in Fig. 49. Here one of our common ichneumon flies, by depositing its eggs on a caterpillar, insures its destruction. Commonly the caterpillar is killed even before it is able to spin up or enter the pupa state, and never does it get beyond this. Since the ichneumons usually have more than one generation during one season, their number multiplies rapidly. These little wasplike insects move rapidly from caterpillar to caterpillar, stinging and depositing their eggs, one or several, as they go, and rarely attack a caterpillar which has already been stung by one of their kind. In this way they not only kill leaf-eating caterpillars, but attack the larvæ (grubs) of beetles, and thus are the best and most powerful animal friends of the forest.

Diseases usually help in destroying forest caterpillars whenever they become very abundant. This is especially true during wet seasons and in moist localities. Some of the diseases are due to ordinary fungus plants, similar to those which kill our house flies in the fall of the year, when they may be seen clinging to window panes, surrounded by a ring of dustlike spores (seeds of fungi).

Insect pests in pine and spruce are usually much more serious than in hardwoods, since conifers generally are not so resistant as the broad-leaved trees. If the leaves of a pine tree are eaten off, it is quite sure to die; while a maple may survive though it loses its leaves two seasons in succession.

From what we have learned it is clear that the leaf-eating insects help the bark beetles, and also that these latter are favored wherever the forest trees are injured by storm and snow or by fire, and even when they are in a weakened condition from poverty of soil or lack of moisture. Thus, things are very apt to go from bad to worse, even in the woods.

Mammals. — Of the larger animals it is chiefly the rodents — mice, rabbits, and squirrels — and also the grazers — deer, sheep, goats, and cattle — which become injurious in forests.

The mice and rabbits injure young trees by gnawing the bark; mice and squirrels eat the seeds; while the grazing animals browse off the leaves and green shoots of young trees and thus cripple and often destroy them. Where cattle and sheep go in larger numbers, or where a small flock has the run of a small wood all summer, they naturally trample out many young seedlings and thus prevent the starting of any young growth. To keep down mice and rabbits it is usually sufficient to protect or quit hunting their natural enemies, the owl and the hawk (buzzard), the fox, weasel, and mink.

Where a farmer has not enough pasture and feels that he must use his woods, it has been found best to let cattle in part of the woods and keep them out of those portions where a young growth is to be started. After the saplings are ten feet high they are well out of reach of the animals, and the place may then be opened to cattle.

On the whole, grazing and the growing of timber do not go well together; for if the forest is as dense as it should be, there is but little grass, and the animals are poorly fed and constantly tempted to roam and browse. Sheep and cattle generally do not eat pine, spruce, and other conifers.

Protection against Injurious Plants

In our walk through a piece of wildwoods we noticed fungus growths, little upturned shelves on beech and maple, wherever they had been blazed or notched with the ax.

Were we to look a little more closely, we should find a great deal of such growth and learn that fungi, too, rank among the enemies of our woods. The amount of destruction in old wildwoods is, naturally, very great, for here it is necessary that the wood of dead trees be converted into dust to prevent the ground from becoming covered with dead timber. Such a cover would bring all forest growth to a standstill, there would no longer be room for trees, and its destruction by fungi, therefore, is useful. It is Nature's way of clearing the ground for new generations of trees. But, like many useful things, these fungi overdo their work, and at the slightest provocation attack good, thrifty trees. Thus, if a wind tears off the large limb of a maple, beech, birch, poplar, or other perishable kind of tree, fungi at once begin their work of destruction; the interior begins to decay; limbs and stem are hollowed out; the tree is weakened and becomes an easy prey to bark beetles or a storm. Once on the ground, a few years in our moister districts suffice to convert the trunk and all into a powdery mass of decayed wood, which is spread out by insects and water, and thus helps to improve the soil for a new growth. Though the trees with perishable woods are more subject to this injury than those in which resin and other substances make the wood more durable, yet all kinds of our trees suffer more or less. Thus, even the durable cypress is injured by a fungus, which causes it to become "pecky," and our white cedars are generally "hollow butted," the stump being decayed so much that it is a common defect of cedar timber.

From this it appears that clean woods, composed of thrifty, uninjured trees, suffer much less from injurious fungi, and also that especially the more sensitive trees, like maple, beech, spruce, etc., cannot stand being hacked and scalped with the ax, or barked in felling and dragging out timber, but are almost sure to suffer further injury if thus hurt.

In the South and West the mistletoe is a factor in the destruction of trees. In California many of the noble white oaks are yielding their lives to this parasite.

USE OF THE FOREST

We have already learned how to start new growth and how to care for it, and thereby keep up the forest. Let us now consider what we may get from the forest and how the material is usually taken out and used.

To primitive man the forest gave meat, shelter, and fuel. At the beginning of our era the people of central and northern Europe, and nearly all of the people of North America, obtained their food by hunting and fishing. With us to-day the forest no longer furnishes meat; the people are too many, the forests too small.

But while it no longer furnishes our meat, it still supplies the great mass of our fuel, as well as the lumber and timber for the houses which shelter us. In addition it was the forest, with its large, soft, easily shapen timbers, which alone made it possible for the ancient Phœnicians to trade with the people of the North Sea, and for Columbus to find the New World; and even to-day a large part of our people and goods are carried in thousands of wooden ships, landing at hundreds of miles of costly wooden wharfs. Our thousands of miles of railway rest on millions of wooden ties, and cross on thousands of miles of wooden trestles and bridges. The grain and goods of our land are hauled in wooden boxes and barrels, on wooden wagons, in wooden cars, and are housed in wooden structures; and, in spite of the great progress of our times, we still finish even the finest of parlors in wood; we prefer a wooden chair and table to any other, and the choicest of furniture is of wood in its natural colors and appearance. One of our greatest needs, that of cheap paper, was supplied only when man learned to make paper from the common product of our forest. Nor is this all, for the very mines which supply us with coal for fuel and with iron for our manufactures require millions of feet of timber every year, if they are to be worked with any degree of economy.

Thus, we see that the forest was necessary to the savage; that on the forest depended the progress of our race; and that even to-day, in this age of steel, the product of the forest is used in greater quantities and supplies a greater variety of demands than ever before.

Let us examine a little more in detail the ways in which some of our farmers utilize their woods.

Cutting Timber

Season. — Generally the work in the woods is done in winter. This is better, since the cold retards or prevents

Fig. 50. Cutting Spruce in the Adirondacks
(After W. F. Fox)

fungi from spoiling the wood by "bluing" or discoloring, or by starting decay. It is also much better on account of insects, for during winter these pests are inactive, practically dormant, and thus they do not injure the timber which is cut, nor does the felling lead to an increased multiplication of these ever-present enemies of the forest. Besides this, there is little work on the farm during winter, and thus help is more easily procured. To this must be added, in colder districts at least, the advantages gained by a good fall of snow, which makes it so much easier to drag and haul timber.

Firewood.—For this it is customary to use only such pieces as will make nothing better. For ordinary house use, all tops, the trunks of short, crooked, or otherwise unsalable trees, and in many cases even stumps, are used. If the firewood is to be sold, it is better to grade it so that the better and poorer kinds are not mixed, as is so often done; for a few sticks of poor wood give the whole pile a bad appearance and thus lower its price. Usually firewood is cut in four-foot lengths and stacked in piles four feet high and eight feet long, such a pile being one cord. A cord is a legal measure, and as such requires that the pile be four feet wide, or in ordinary cases that the pieces be cut four feet long. Where people buy stove wood sixteen to eighteen inches long, the cord is frequently meant to be a pile of this short wood four feet high and eight feet long, and thus is really but about a third of a cord.

In all cases there is much air space between the pieces of such a pile, and though the pile contains one hundred

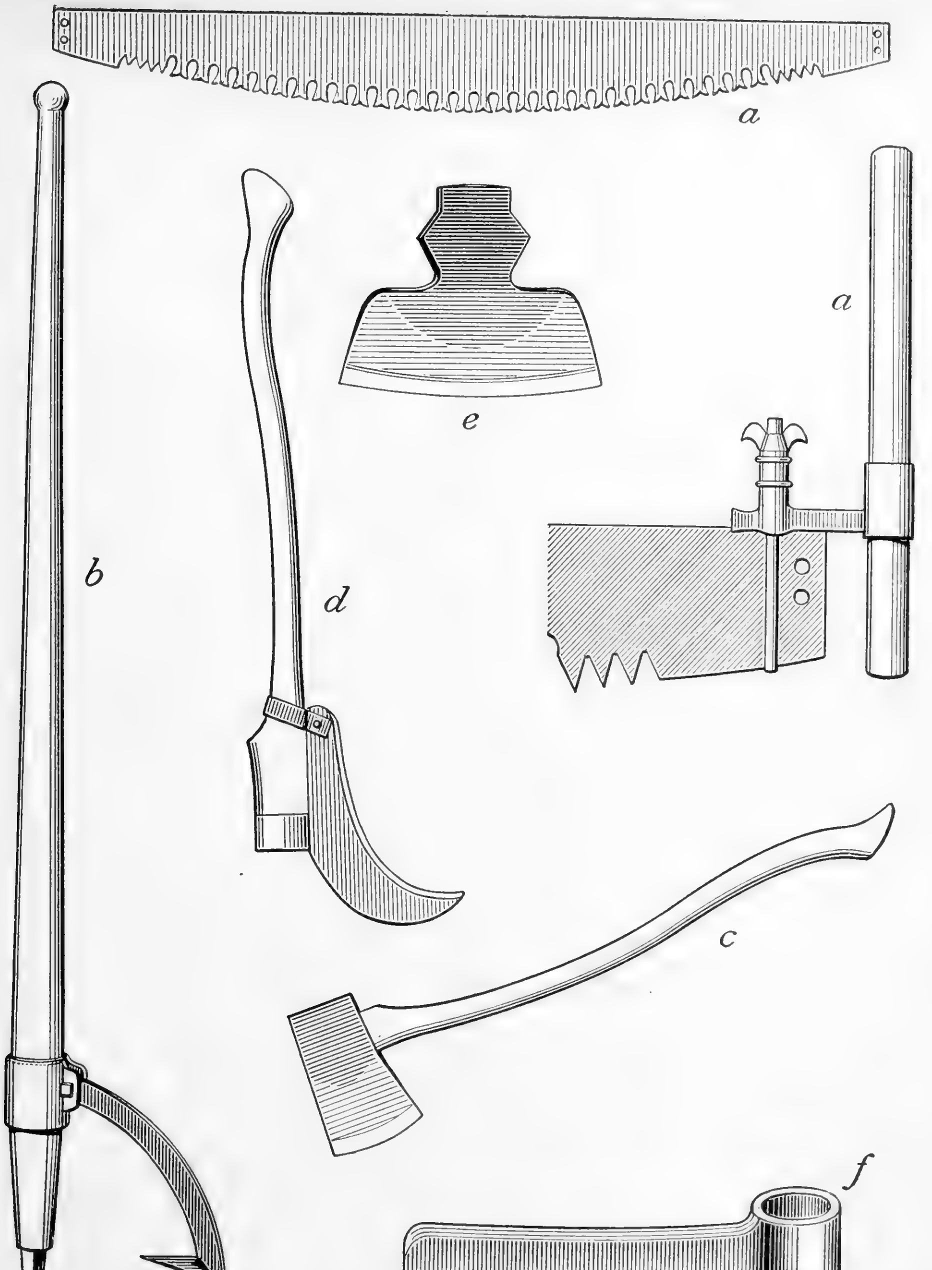


FIG. 51. The Tools we use

a, crosscut saw ; *b*, peavey, to turn logs ; *c*, ax ; *d*, billhook ; *e*, broadax, to hew logs ; *f*, frow, to split or rive shingles and twenty-eight cubic feet, there are only about ninety cubic feet of solid wood in a regular cord.

Larger pieces are split to allow a better drying or seasoning, and split wood is always preferred to round pieces.

Fig. 52. Skidding Spruce Logs in the Adirondacks
(After W. F. Fox)

A cord, as ordinarily cut, contains about two hundred pieces and weighs, when fresh, about four to five thousand pounds.

For ordinary use the heavy woods, like oak, hickory, beech, maple, etc., and especially the "second growth," are preferred. The lighter kinds, like poplar and basswood, are not readily sold for this purpose.

Of late years many farmers haul their firewood in large pieces to some convenient place near the house, and saw it into stove lengths with horse power or threshing engine.

Since firewood cannot be used economically without

Fig. 53. "Scaling," or measuring and stamping or marking Spruce Logs

(After W. F. Fox)

being first seasoned, it is often advisable to keep firewood one year on the pile, so as to get this advance in value and at the same time make easier hauling.

To leave firewood in large piles in the woods is always a bad policy, for nearly all kinds of wood commence to decay under such circumstances, and perishable woods, like beech, maple, and birch, will lose as much as twenty-five per cent of their value in one year.

Pulp Wood. — In the vicinity of pulp mills, soft woods like spruce, poplar, aspen, balsam, and also hemlock, pine, basswood, tulip poplar, and others, can usually be sold to good advantage.

Since the pulp mill can use small pieces, down to two feet in length and four inches in diameter, a great deal of the sapling material, which should be taken out in thinnings, can thus be utilized.

For pulp the wood should be green, sound, straight, and as free from knots as possible; in other words, just such wood as grows in a close stand, where the trees are obliged to clean early.

Pulp wood is sold by the cord, and when rossed, *i.e.*, the bark taken off, it sells as high as ten dollars per cord.

Pulp is made from the wood in two distinct ways, — by grinding, and by maceration with chemicals. In making "ground" pulp the blocks of wood are held and pressed by a machine against a large grindstone on which a small stream of water is playing all the time. In this way the fine particles of wood which are ground away are carried off by the water into large vats.

This coarse, mushy wood pulp is then sifted, washed, and stirred, and finally passes over an endless piece of cloth, where it is freed from the water. After this it may

FIG. 54. The "Landing" on Ampersand Creek, near "Driving Time"

merely be pressed into a soft, pasteboard-like paper, baled, and shipped to regular paper mills without drying, or else it is made at once into ordinary paper, such as is used by newspapers.

In making "chemical pulp," or "cellulose," as it is called, the blocks are chipped into short, small pieces, the fragments of knots are sifted out, and the rest of the wood is placed in large boilers called *digesters*, where it is boiled in a solution of sulphite of lime, more rarely of caustic soda. During the boiling the digester is kept firmly closed, so that a steam pressure of about a hundred pounds per square inch is developed. The boiling is continued for about six hours if soda, and for twenty-four hours, and even longer, if sulphite of lime is used. In this boiling the wood softens and becomes mushy. It is then ground, washed, and finally treated in the same way as ground pulp.

The cellulose, or chemical pulp, is much finer than ground pulp, and can be used for ordinary papers without any bleaching.

One cord of spruce gives about six to eight hundred pounds of chemical pulp or twelve hundred pounds of ground pulp. So far, nearly all pulp is used in the manufacture of paper.

Acid Wood.—In some districts of Pennsylvania, New York, and other states "acid factories" require large quantities of wood, preferably beech, maple, and birch.

This industry usually demands sound, split "body," or log wood, fifty-two inches instead of forty-eight inches long, so that the acid men get nearly one and a tenth cords for each cord they buy. In making acid the wood

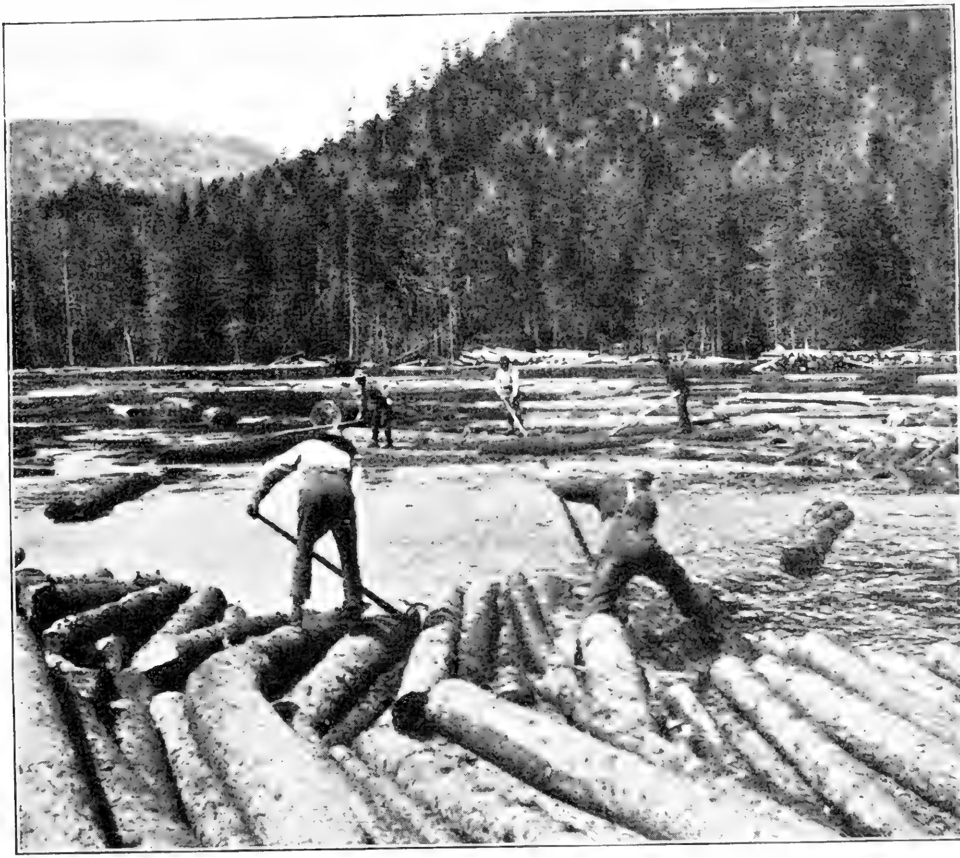


FIG. 55. Rolling in Spruce Logs on Ampersand Creek

is heated for about ten hours in large steam-boiler-like vessels called *retorts*. As the wood grows hotter and hotter it gives off gases, part of which are cooled into liquids in a "worm" or coiled tube, kept cool by a stream of cold water. The greater part of these liquids is wood vinegar, and a small portion pure acetic acid, wood alcohol, and, toward the last of the heating, some creosote and tar. The wood vinegar is employed in dye works; the alcohol by painters, hat makers, and in chemical works; while the acetic acid is largely used for vinegar.

The retort usually holds about two thirds of a cord of wood, and an ordinary factory of twenty-four retorts thus requires about sixteen cords for each charge. They usually run night and day, refilling every twelve hours, so that one of these factories uses eight thousand cords or more per year.

Posts. — In former years, when most of our farms were surrounded with rail fences, commonly of the "worm-fence" type, enormous quantities of good oak, chestnut, and other timber were converted into fence rails. Wherever logs have a reasonably good market this wasteful use of timber is disappearing, and wire or "wire-slat" fences are taking the place of the old forms. This still requires the use of posts, so that both for home use and, in many localities, also for the market it pays to raise timber for fence posts.

Since durability is the first quality in a fence post, only durable woods, like black locust, catalpa, chestnut, white oak, cedar, redwood, and kindred woods should be offered; and the post should always be large enough so that the heartwood, the only durable part, is sufficient to hold whatever the post is intended to support. Flimsy sapwood posts of cedar or any other timber can only injure the market, for it is here as in all kinds of dealing, — good or poor ware and good or poor measure make and unmake the market.

Where posts are in good demand it will often pay to treat a few acres of the woods as coppice. For this purpose the rotation is short, and, of course, only durable woods like white oak, chestnut, locust, catalpa, mulberry, etc., should be used.

Railway Ties. — With durable timber, the trees twelve to sixteen inches diameter, breast high, and also the upper logs of larger trees are often profitably cut into railway ties. These ties are usually required eight feet long, seven inches thick, with two parallel faces eight inches wide, and all bark removed; thus, each contains about five cubic feet of wood. When in the track one face is down and the other supports the steel rail. Ties are usually hewn to finish wherever the tree is felled. A common way is to fell the tree, hew two faces as far up from the butt as the stem is suited to make ties, and then to cut the ties with the crosscut saw.

Formerly railway companies would buy only hewn ties, but of late years most companies accept sawed ties as well. The sawing may be done by a small portable sawmill, and the tie is either sawed only on two faces or else is squared, *i.e.*, sawed on four sides. This sawing is better than the hewing; it makes a neater tie and furnishes slabs which may be used for fencing, sheds, etc.

Usually it pays to select the longest and straightest pieces and saw them into bridge and switch ties, or for trestle timber, for which better prices are paid.

About sixty per cent of all our ties are made of white oak; nearly twenty per cent are pine; the rest are redwood, cedar, cypress, chestnut, etc. White-oak ties generally bring about fifty cents or more per tie, delivered at the track.

Many of our railway companies keep posters at their stations, offering to buy ties; and nearly everywhere good contracts may be made by one or by several farmers acting together to furnish this kind of timber. Since every mile of railway needs about twenty-five hundred ties, and there are over two hundred thousand miles of such roads in our country, it takes millions of acres of timber to supply a single set of ties. Such a set has to be replaced about every seven years, and thus it is that the railways rank among the greatest consumers of wood in the land.

Poles and Piling. — Long, slender poles of chestnut, white oak, cedar, and other durable kinds of trees are often best sold as telegraph and telephone poles and for piling. For these purposes long, straight, and durable sticks are wanted. They run from twenty-five to fifty feet in length, with an upper diameter from five to eight inches.

The telegraph poles must be peeled. Piling pieces, which are driven in the ground for support of bridges, and even houses, are generally preferred with the bark intact.

The price paid for this class of timber is generally good, ranging from two to ten dollars apiece; but it is customary to find a buyer beforehand, to avoid having to store such timber for any length of time.

Mining Timber. — In the neighborhood of coal and other mines, many owners of woodlands find a good market for a variety of logs to be used as props and other supporting timbers. Most of this material serves to hold up the earth in the shafts or tunnels, and quite a variety of sizes as well as kinds are employed. Since wood decays very rapidly in mines, the more permanent structures are usually built of durable woods, such as oak and chestnut; but in other parts, or in localities where durable woods are costly, such perishable woods as pine, maple, birch, hemlock, etc., are employed.

The logs are commonly delivered in the rough, and are sawed and fitted by a special sawmill at the mine.

Export Timber. — Occasionally special prices are offered to woodsmen for large, choice logs of walnut, cherry, yellow poplar, and other kinds of timber, to be shipped abroad.

Export logs are graded mostly by size (diameter), the larger sizes bringing the best prices. They are commonly peeled, and their ends painted to avoid undue checking; and in many districts they are "rough hewn," *i.e.*, hewn so that part of the original round surface is left on the timber. This hewing makes it easier to store them in the holds of the ships that carry them abroad.

Ship Timbers. — In former years many men along our north Atlantic coast were engaged in getting out timber for the numerous shipyards. The hull of the wooden ship of those days had almost solid walls of heavy timbers, covered inside and out with thick planks, fastened with locust-tree nails; and the decks rested on beams supported at each side by short, heavy, bracket-shaped pieces of timber called *ships' knees*.

Though white oak was preferred, nearly all kinds of timber were used in these ships. Since the larger timbers, ribs, etc., had to be shaped according to the plan of the particular ship, they could not be bought in lumber yards; so, as soon as the size and plans of the ship were decided upon, crews of men would go to the woods and hew out the many pieces. Knees and spars (masts and other long poles) were usually kept in yards, and many men made it a business to hew out knees or scour the coast and the river valleys for fine, straight spar timber. Some fine white-pine masts brought as much as two hundred dollars apiece. To-day the ship carpenter has largely been displaced by the boiler maker, and ships are built of steel, shaped in rolling mills. Nevertheless, much timber, chiefly lumber for flooring, decking, and the finishing of cabins, etc., is still used; and occasionally crews of ship carpenters go inland to hew out a few sets of timbers.

Cooperage and Wagon Stock.—The fine grades of white-oak staves and headings for the manufacture of barrels for liquids, and also white-oak and hickory spokes and fellies used in wheels of wagons and buggies are split out of large, sound timber, mostly butt cuts, and many farmers and other people are engaged every year in this kind of work. Though the prices are usually good, this industry is apt to be very wasteful, since so many logs do not split well enough and are, therefore, left unused. Like the tan-bark man, the cooperage and spoke man should be combined with the lumberman, so that all the logs unfit for staves or spokes may be sawed into boards and planks.

Besides the fine barrels and casks for coal oil, turpentine, wine, etc., the cooper also makes barrels for sugar, apples, flour, cement, lime, salt, and other dry materials. These barrels are called slack barrels; the staves are sawed, and of late years shaved off with large machines.

Nearly all kinds of timber, but particularly elm, red oak, ash, beech, birch, and maple for staves, and bass-wood and poplar for the headings, are used in this industry. The logs or bolts are brought to the mills by farmers and others and sold by the cord. The logs should be over ten inches in diameter and should be two or three times as long as the stave, the length varying with the different sizes of the barrels.

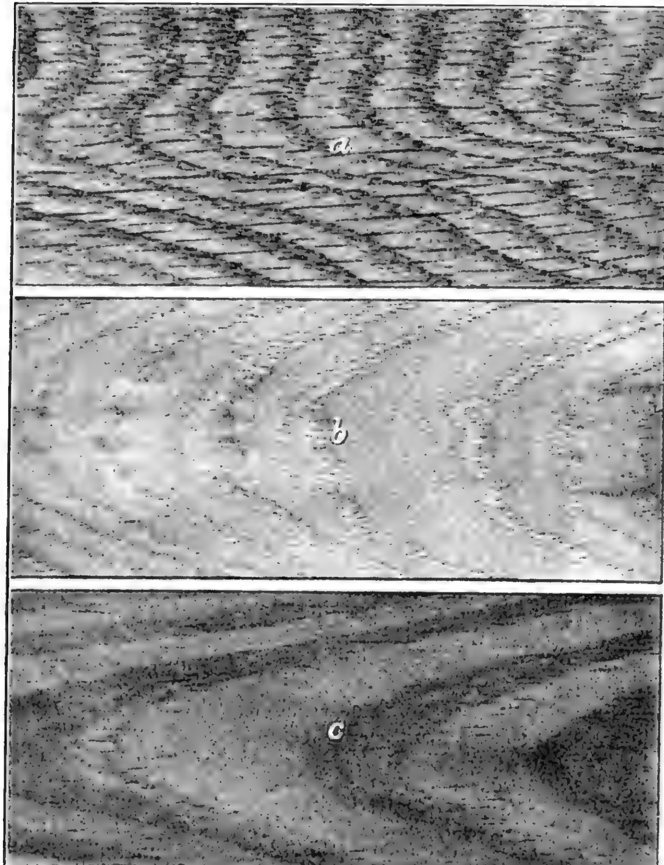
Where a wagon shop is near by, it is often profitable to cut smaller second-growth timber into wagon axles, bolsters, and wagon tongues, and sell small trees of elm and birch for hubs.

Lumber. — Wherever a lack of pulp mills and other factories makes it impossible or unprofitable to utilize the larger logs in any better way, they can always be sawed into lumber. Lumber is a general term for all kinds of boards and timber shaped with the saw.

Lumber in our country is generally, but not always, cut in lengths of even feet, eight, ten, twelve, fourteen, etc., the most common lengths being twelve, fourteen, and sixteen feet, and in widths of even inches.

In thickness lumber varies usually by a quarter of an inch, and ranges from one half to twenty inches; the thinner pieces, one quarter to one and three quarters inches thick, being called boards (planks in the South); those two to four inches thick are planks; and thicker material is timber.

Lumber is measured by the superficial foot, which is a board one inch thick, twelve inches wide, and twelve inches long, so that a board one inch thick, six inches wide, and twelve feet long measures six feet board measure, — written six feet B.M., — and a plank two inches thick, twelve inches wide, and sixteen feet long contains thirty-two feet B.M.



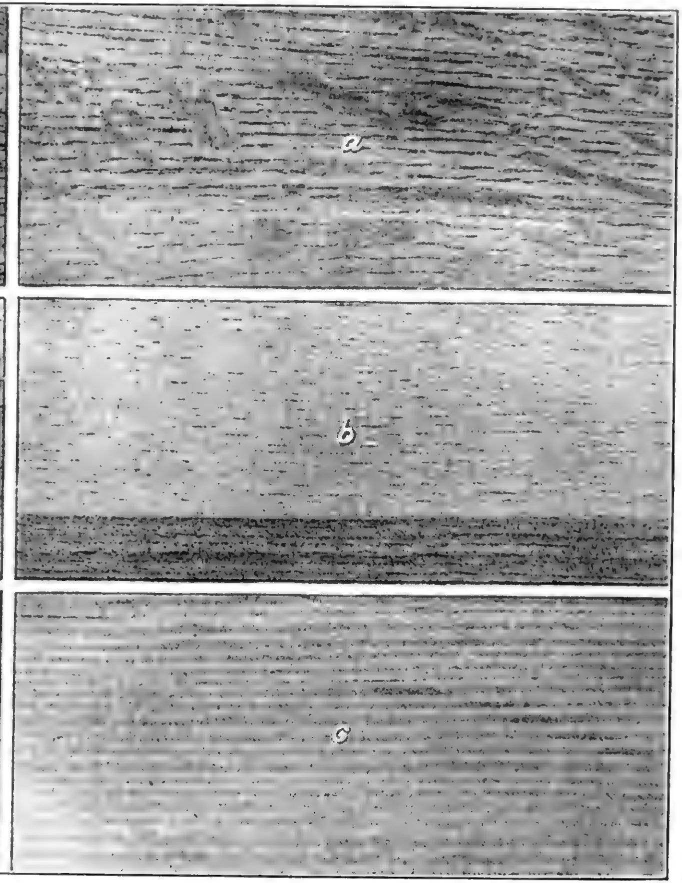


FIG. 56. Tangent or Bastard Cut

FIG. 57. Rift or Quarter-sawed

a a, oak; *b b*, hickory; *c c*, pine

Lumber is graded chiefly according to size and defects, such as knots, cracks, discolored or decayed spots, and unequal thickness. A board entirely free from any of these defects is "clear," and it is evident that young trees and badly cleaned trees are not likely to furnish much of this valuable material. Generally hardwoods are graded much more severely than conifers, and the cheaper always more severely than the dearer kinds.

For flooring, decking, and other purposes, boards are often classified into "rift" and "bastard," or tangent, as it should be called. In rift boards the rings stand nearly vertical, or never less than forty-five degrees to the surface, as seen in Fig. 58. Rift boards shrink less and wear better, and therefore bring better prices.

Lumber is regular merchandise in all parts of our country, and every town has its lumber yards, just as it has other stores, where regular lines of lumber, in stock sizes and grades, may be bought.

Aside from firewood the greater part of all timber in our country is cut into lumber, and it has been estimated that over thirty billion feet B.M. were used each year during the last quarter of a century. Of this enormous amount about seventy-five per cent is pine, spruce, hemlock, red fir, and other coniferous material, and twenty-five per cent oak, ash, elm, and other hardwoods. Of the conifers the white pine has for years furnished about fifty per cent, while of the hardwoods about thirty-five per cent is oak.

Pine, spruce, etc., are mostly cut by large crews of regular lumbermen, and are sawed in large mills, but the hardwood lumber comes mostly from the farm and is cut

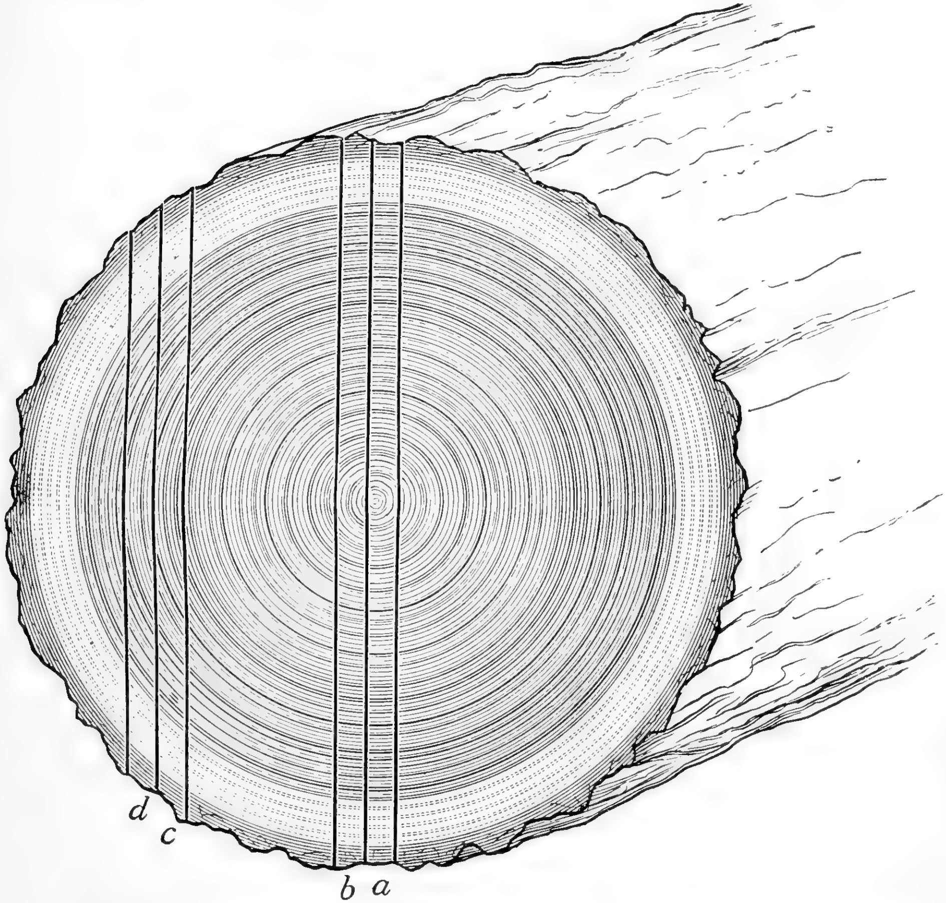


Fig. 58. End of Log, showing Rift and Bastard Cuts

Cuts *a* and *b* make all rift or quarter-sawed material; but *c* and *d* are nearly all tangent or bastard cut

in small country mills. Of the several kinds of coniferous lumber a few are of such great importance that we should know a little more about them.

White pine is the most important lumber in our country, and has been so ever since its settlement. Formerly an abundance of white pine was cut in New England, New York, and Pennsylvania, but of late the greater part comes from Michigan, Wisconsin, and Minnesota. White-pine lumber is kept in all yards of the northern states, as far west as Dakota; but the largest markets for this lumber are Chicago, St. Louis, Minneapolis, and Buffalo. White pine is used chiefly as building lumber, being soft, light, insect proof, and always to be had in any quantity in all reasonable sizes and all grades; it has become one of the favorite materials, is used for a greater variety of purposes, and brings a better price than any other of the common kinds of lumber.

In the South, where a broad belt of pineries stretches along the coast from Virginia to Texas, there are three varieties of *hard-pine* lumber, which are cut in large quantities and are shipped not only to all the northern and eastern markets, but also find their way to many foreign markets.

Of these the *longleaf* or Georgia pine lumber is the most important. Georgia pine is cut mostly into timbers of long lengths, twenty feet or more, and used for supports in large structures, in bridges, trestles, for car sills, etc. A considerable amount of this timber is exported to Europe, the West Indies, and South America under the name of *pitch pine*, but by far the greater part is either used at home or shipped to our larger eastern and northern markets. Among the most important points of manufacture and shipment are: Savannah and Brunswick, Ga.; Jacksonville and Pensacola, Fla.; Mobile, Ala.; Pascagoula, Miss.; Lake Charles, La.; and Beaumont, Texas.

The *North Carolina pine* is cut in Virginia and North Carolina, made mostly into boards, and is marketed at Norfolk and Baltimore, and has become a common article even in the retail lumber yards of our eastern and northern towns. It is often called *yellow pine* and is extensively used as flooring and ceiling, especially in schools and other public buildings, where the bright orange-red and yellow patterns of this material are brought out strongly by a "natural" or oil finish.

The *yellow pine* marketed in St. Louis, Kansas City, and points in Texas is cut mostly from the true shortleaf pine of Arkansas, Missouri, Texas, and northern Louisiana. It is cut into all sizes, boards and timber, and is the common building material of these regions.

The *yellow pine* of the Rocky Mountains and parts of California, Oregon, and Washington resembles the eastern yellow pine, but is cut from a different species of tree. It, together with red fir, forms the common building material as well as the principal mining timber of these mountain states.

Spruce is the common timber of the "white-pine state" of Maine, and of New England and eastern Canada. It is cut into a greater variety of sizes, odd lengths and odd widths not being uncommon. Though smaller and more knotty than pine, spruce also furnishes a common building material, and is used in large quantities and for almost everything from shingle to sill.

Red fir, Oregon fir, and Oregon pine are three names for the same tree and the same kind of lumber. Red-fir lumber is cut in largest quantities in Oregon and Washington, but considerable quantities are also manufactured in California and the Rocky Mountain countries. It resembles hard-pine lumber in appearance, quality, and uses, but since the trees of Oregon and Washington grow to very large sizes, two hundred feet or over in height and three to six feet in diameter, perfectly clear pieces of unusual size are obtained, and it is this great perfection of red fir which permits its export to distant countries,— Japan, China, Siberia, Australia, etc.

Redwood is a product of California and is cut from large trees of the cedar family. It is a dark, brownish-red, soft, and light material of great durability and therefore of an unusual range of usefulness. It is the common lumber of parts of California, and considerable quantities are exported, especially in the form of sawed shingles.

Cypress is a tree of the southern swamps and has of late years become one of the important lumber trees of our country. Cypress is often logged with special machinery; it is cut mostly into boards, planks, and shingles,

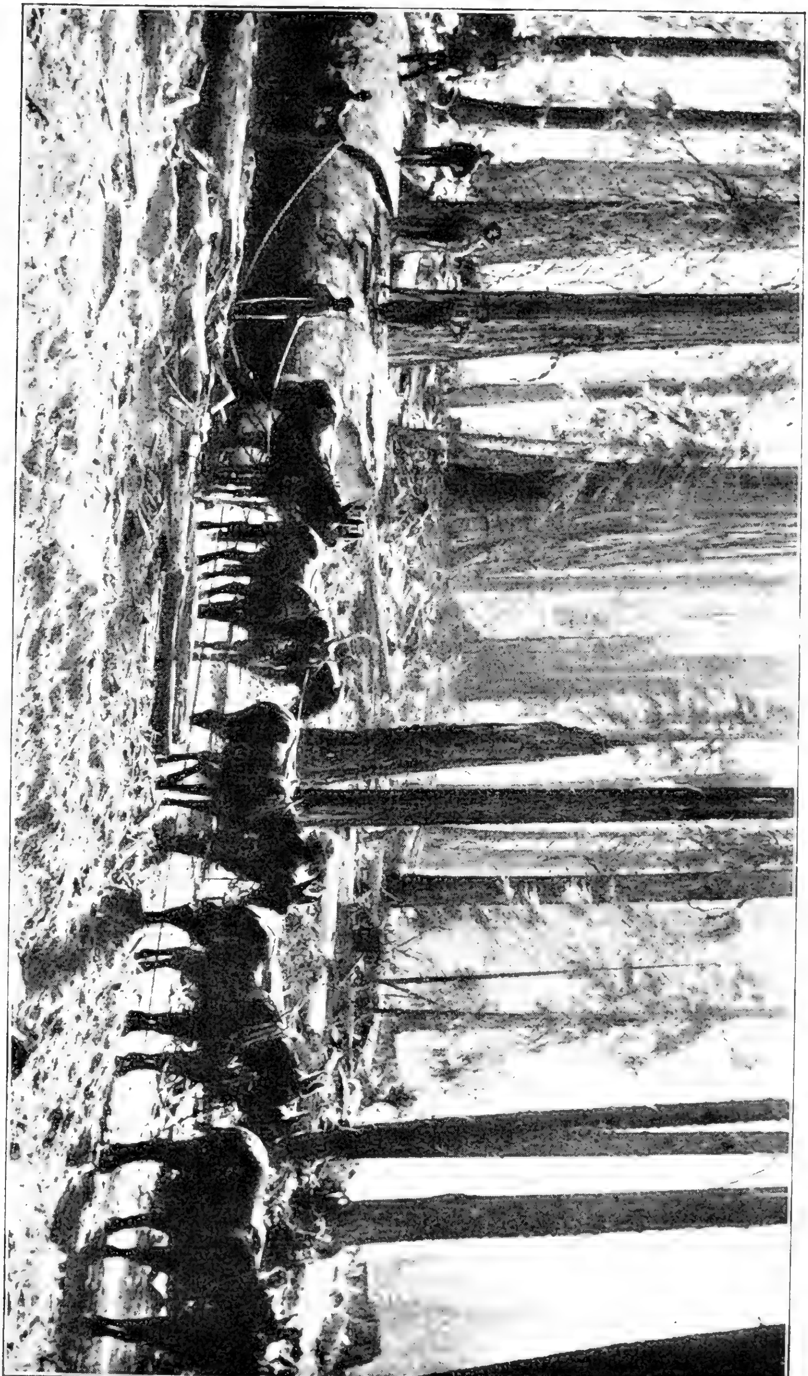


FIG. 59. "Bigtree" Logging in California

(After Pinchot)

and has become a strong rival of white pine. Louisiana, Florida, Alabama, Georgia, and the Carolinas all share in the manufacture of cypress.

Hemlock is a much despised and very much underrated material, which, in spite of its bad name, is one of our most useful building materials. Though apt to be a little shaky and somewhat prone to warp and sliver, hemlock is used everywhere in the East for studding, joists, and sheathing in frame houses, for sidewalks, fences, and boxes; and of late years entire houses, shingles, laths, and all, have been built of this Cinderella among our conifers.

A large proportion of pine and other coniferous lumber is manufactured into finished flooring, siding, ceiling, etc., by the planing mills which are to be found in connection with most of our larger modern sawmills.

Hardwood lumber is usually cut into planks, one to three inches thick, or else into timber for particular purposes, such as bridge and car timber, wagon axles, etc. It is commonly sold in the rough, *i.e.*, it is not planed and otherwise finished like pine lumber, though of late maple, birch, oak, and yellow poplar are offered quite extensively in the forms of flooring, ceiling, siding, and other finished products.

If we look about us to see where most of our lumber goes, and what it is used for, we find that the great mass of pine and other coniferous lumber is used in building houses of all kinds. The carpenter is greatly assisted in

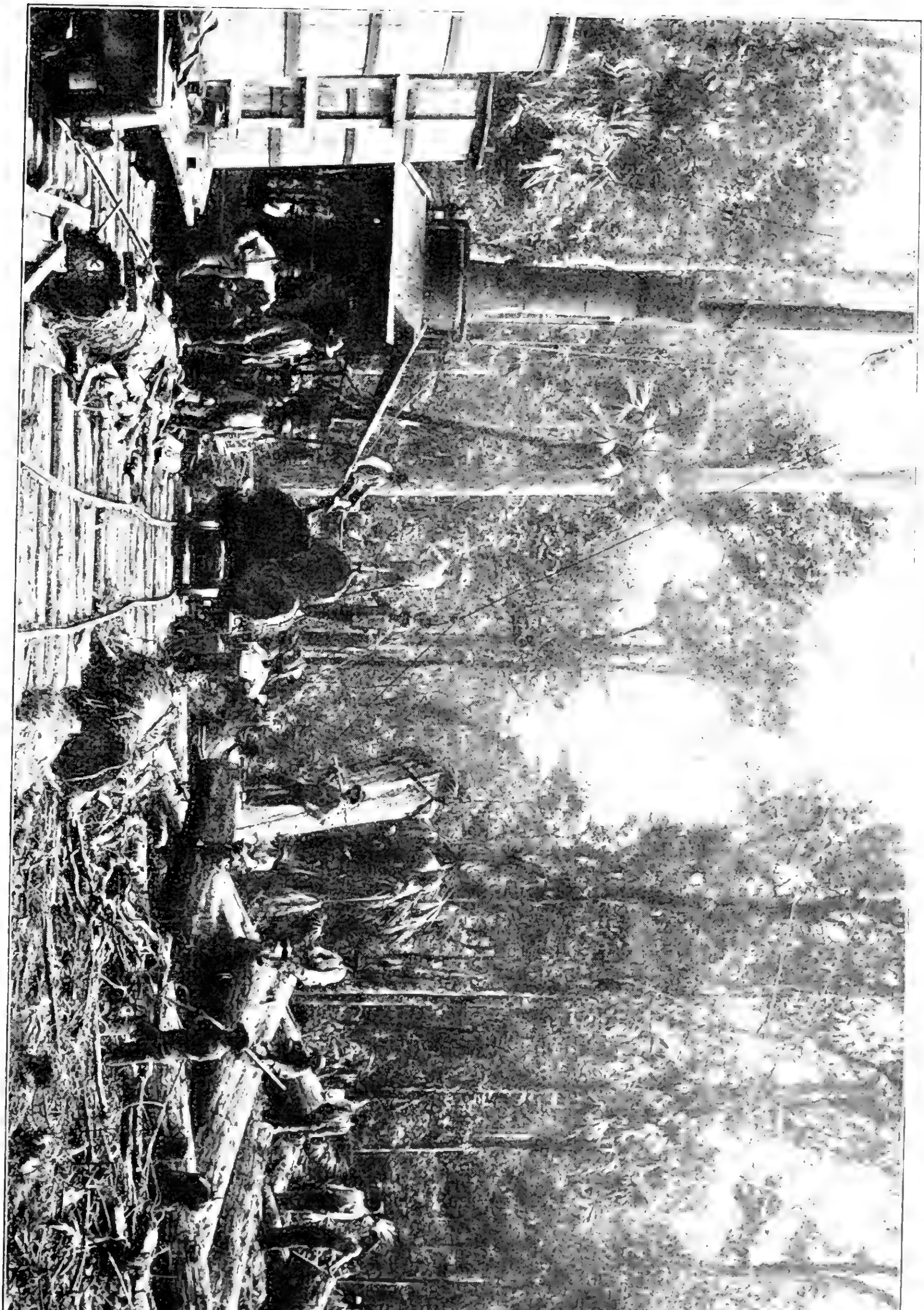


FIG. 60. Cypress Logging in Florida
(From E. C. Tufts)

his work by having lumber of definite sizes and grades. Thus, in building an ordinary frame house with walls sixteen feet high, he need not shape the frame pieces, but orders sixteen-foot studding and thus saves a great deal of extra work. Moreover, the owner also saves a great deal of material by this arrangement, since the sixteen-foot pieces all fit, and but little of his lumber is cut into short, useless pieces. Formerly hardly any hardwood timber ever entered in the construction of an ordinary house, but of late years much hardwood is used as finishing lumber, *i.e.*, for floor, ceiling, doors, etc.

The carpenter's lumber should be light to handle, soft to nail and saw; it should dry without much warping, and it should be safe against insects. On the other hand, most of it need not be pretty, since it is covered up; and it need not be very strong or tough, since it is rarely heavily loaded or jarred.

The desirable combination of qualities for house-building material is found in most conifers, but in very few hardwoods, and our frame house will cease to be common wherever pine and other coniferous lumber becomes scarce.

Most of our hardwood lumber is used for all kinds of furniture and implements. In a table or chair the pieces need not be long or broad, nor need they be light and soft. On the contrary, they must be firm and strong, quite tough, and, in addition, they should have a pleasing appearance.

In getting out logs for lumber it is usually better to fell the tree with the crosscut saw, cutting as near to the ground as possible. In the white-pine districts contracts commonly call for stumps eighteen inches or less in height, and there is no good reason why, in logging good oak, ash, etc., any man should make a three- or even four-foot stump, and thus waste at least ten per cent of the best part of the tree. These large stumps, moreover, become breeding places for insects and harbor fungi, and thus are a menace as well as a loss.

In measuring and marking off the logs a great deal of waste may be avoided if the woodsman has clearly in mind what kind of goods he wants to make of his timber. For all small jobs it pays well either to do it oneself or else to engage an experienced man and give him clear instructions as to what should go into saw-logs, ties, poles, etc.

The skidding is mostly done by dragging the log on the ground. Especially for hardwoods men use a "go-devil," or simple sled, often made of a crotch or fork of two large limbs. Where this is done one end of the log is placed on the sled and thus prevented from striking against many obstacles.

The work of loading and of hauling to the mill varies for different localities. In cold, snowy districts this is done most cheaply on sleighs; in other localities, with wagons, which of course is far more expensive.

In most localities farmers still sell their logs commonly "on the stump," *i.e.*, in the woods. This is rarely a good plan, as the buyer's workmen care too little for the woods, damage trees in dragging, and cut too much young growth that they may get as near as possible to the logs with sled or wagon. Selling at the mill is better. Some men have their logs cut on shares, and then haul and sell the lumber to the neighboring retail lumber yard. This is the right way, but unfortunately the retailer is too often disposed to take advantage of the farmer in grading and price, preferring generally to buy of the wholesale dealer rather than get his goods in small lots from his neighbors.

This is avoided in some localities where farmers coöperate and run a small mill of their own, using one or two threshing engines for power and "swapping work" as in threshing time. In this way a number of farmers cut each year a large amount of lumber, which, after seasoning in the pile one or even more years, is readily taken by some wholesale merchant at much better prices than can usually be secured from the retailer. In addition, this method always supplies the neighborhood with good seasoned material for home use.

The regular lumbering in the remote, unsettled forests of our country is carried on, of course, on a much larger scale. In such work camps have to be built, comprising cook's shanty, men's quarters, barn, smithy, office, and often a large storehouse; and provision is made to dine seventy-five and more men at one sitting.

Much preparatory work must be done. Roads, dams, or railways must be built, and supplies hauled to the camp from distant railway stations. The logging itself, for instance, in white-pine woods proceeds then about as follows: Some of the men go in pairs, each pair with a crosscut saw, felling the trees and cutting them into logs. Another set skid the logs, *i.e.*, drag them out of the woods to the roads, and with the universal "peavey" roll them up into piles on skidways. Still another set haul them to the neighboring stream, where a "landing" is cleared, on which the whole season's cutting is piled up. The hauling is done on sleighs, and on a road which has been carefully laid out so that there are no uphill pulls, and one which is kept clean during all the hauling and sprinkled with water or "iced" nearly every night. When the winter's work is over, and spring opens the stream and fills it with water, the "driving" begins. A set of men roll the logs into the water, and men go along the stream to keep them moving. The logs always catch on the banks, or on obstacles of some kind, and form "jams," which have to be broken and rebroken whenever formed. In smaller streams the ordinary flow of water is not sufficient, and the brook must be "splashed" or flooded, *i.e.*, the dam built during the summer before is opened as often as a good head of water exists, or as often as is necessary, and thus, artificially, a flood is produced which carries the logs farther and farther. In good streams this is a cheap way to transport logs; in small crooked streams it is not.

The logging of spruce in Maine and other states is done very much in the same way. In the southern pineries logging is carried on by means of railways, the skidder dragging or hauling the logs directly to the railway. Here the work goes on all the time; a log cut to-day is hauled to mill to-morrow, sawed next day, and passes at once into a dry kiln to prevent the boards from "bluing," or becoming dark.

Cypress is mostly dragged out of the large miry swamps with huge wire-rope machinery; and the monstrous logs of redwood and red fir of the Pacific coast are logged by means of heavy teams, — six to twelve yoke of oxen or teams of horses, — or else are dragged together and loaded on cars by means of donkey engines and wire cables.

Estimating and measuring Timber

When a man buys a lot of standing timber, or when a lumberman or farmer prepares for the winter's logging, he wishes to know beforehand approximately how much timber he is likely to get from the tract of land he is about to cut over. In most districts of our country this is still done by estimating or counting the trees and guessing at their contents.

On a small piece of woodland this work is quite simple, but when the estimating is to be done in some unsettled forest district, where the only landmarks consist of dim blaze lines made by surveyors years ago, separating only one section or square mile from another, it is necessary not only to estimate timber, but also to know where we are. Thus, a section has sixteen forty-acre lots, and four of these are interior "forties" which have no marked boundaries. To know when he is on one of these forties and on what part he is estimating, the man uses the same methods which the mariner employs on the high sea; he uses a compass so that he may always know where he is going, and he counts his paces to know how far he has gone, and for this reason these travelers of the woods are often called *cruisers*.

Formerly only the log or saw timber was considered, but of late years the number of posts, ties, telegraph poles, even the amount of cord wood, is estimated.

In estimating a large tree we guess its diameter and the number of logs which it will cut. Suppose we guess the tree to be twenty-four inches in diameter, breast high, or four feet from the ground, and to cut three logs, each sixteen feet long, and that we believe the bark to be about one inch and a half thick at the base; also suppose that the tree tapers about one inch for every eight feet in length. Then the first log is about twenty-one inches in diameter at the butt, or base (without bark), and nineteen inches in diameter at the top end; the second is seventeen inches at the top, and the third fifteen inches at the top. Looking in our table (Appendix I), we find that by the Doyle rule these logs contain,

The first one	225 feet B.M.
The second one	169 feet B.M.
The third one	121 feet B.M.
Total,	515 feet B.M.

which means that five hundred and fifteen feet B.M. of boards may be cut from the logs of this tree, provided the logs are straight and sound. Usually this is not quite the case, and ten to thirty per cent, according to the quality of timber, must be deducted for "defects."

After some practice in a forest the estimator or cruiser commonly decides that the trees generally cut one and a half, two, or three logs per tree, and also that it takes about eight, twelve, or twenty of these logs to make a thousand feet B.M.

Thus, in ordinary eastern spruce, the trees cut about three logs per tree and it takes about fifteen to twenty logs to make a thousand feet B.M., so that the estimator finally decides that about five trees make a thousand feet B.M. After this he merely counts the trees and divides by five, to find how many thousand feet B.M. he has estimated. In old white pine he would find that it takes about two trees to make a thousand feet B.M. (write M feet B.M.), and in large red fir and redwoods one tree often would make five to ten M feet B.M., and even more.

In such estimates poles are merely counted; the number of ties follows from the number of trees, *i.e.*, the estimator decides that the trees which would naturally be cut for ties generally cut three, four, etc., ties; while figures for cord wood and posts are usually mere guesswork, which have value only when they come from a very experienced man.

Where a large piece, say a forty-acre tract, is to be estimated, and the timber is at all valuable, it is best to work in an orderly way. We find the corner *A* and go along the line *AB* ten rods; then we go north ten rods to station No. 1. Here we put down our staff so that we keep the right spot, for there are no fences or other convenient landmarks to guide us, and then we begin to count and estimate all the trees in the square of which this station is the center. If we go four times through the forty-acre tract, this square contains $\frac{40}{16} = 2\frac{1}{2}$ acres. All we learn about this square of two and a half acres we put down on a separate page of our notebook, so that when we have finished the square, or this station No. 1,

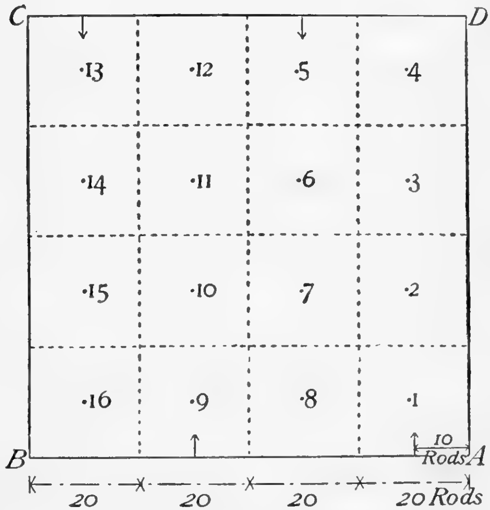


Fig. 61. Diagram to show how a Forty-Acre Lot is covered in estimating Timber. (Nos. 1–16 are the stations)

we need not remember anything more about it. Then we go to station No. 2, whieh is twenty rods from No. 1, and so on, until the "forty" is done. To have our notebooks orderly we should have them lined and arranged somewhat like the sample on the opposite page.

Whether the diameters are estimated or measured, it is better to go by even inches, as is shown in the scheme, but it is not necessary to measure by one inch, unless the number of trees is very small.

When the "forty" is finished we add up and put on the same kind of sheet all the totals. Then we can calculate the amount of wood very much closer than is ordinarily done. First we find the amount of saw timber in the logs in the way explained before. Then we calculate the real volume of the wood in the following way:

Suppose the twenty-four-inch trees are generally about ninety feet high (estimated or measured) and that they cut three logs each, so that they cut about five hundred feet B.M., as in our example. Then we look up the area of cross section of the tree in the table (Appendix II) and find that a tree twenty-four inches in diameter has an area of 3.14 square feet. If the tree were simply a cylinder of wood, we would need only to multiply this number of 3.14 with the height of the tree to find the volume in cubic feet. But the trunk of the tree tapers, and tapers irregularly, so that not even the contents of the trunk can thus be calculated. In working up many trees

ARRANGEMENT OF NOTEBOOK IN ESTIMATING AND MEASURING TIMBER

Forty No. 5. Station No. 3.

	Diameter (inches)	Oak	Chestnut	Tulip Poplar	Maple
Number of Trees	12	//			
	14	~~////~~			
	16	//	///		
	18	////			
	20	//	/	//	
	22				
	24		///		
Total		15	7	2	
Number of 16 ft. logs corresponding to the above trees	12	//			
	14	///			
	16	~~////~~	~~////~~ ///		
	18	~~////~~ ~~////~~ //			
	20	~~////~~ /	///	~~////~~ /	
	22				
	24		~~////~~ ~~////~~ /		
Number of Logs		28	22	6	
Small Trees 6–11 in. diam.		18	15	23	11

Young Growth	Considerable young red oak 1–6 ft. high; little chestnut and maple, but no poplar
Surface Cover	Considerable shrubbery, hazel, etc.; about one third area is covered with grass and weeds
Surface	Moderate slope to north; fairly smooth, no bowlders
Soil	Fine, gray, sandy, deep
Drainage	Perfect
Notes	Easy logging. Stand too open; need of more trees; well suited to hardwoods and conifers; justifies cleaning and filling in by sowing or planting

it has been found as a matter of experience and measurement that the volume of the trunk of the tree is about one half as much as the volume of the cylinder just mentioned. Usually this *ratio* between the cylinder and the real volume of the tree varies from about 0.45 to 0.60 according to the kind of tree, and naturally is larger if the entire tree, limbs and all, is taken than if only the volume of the stem is to be calculated. This figure, or ratio, is called the *factor of shape* and is very useful in tree measurement.

Since the factor of shape is equal to the volume of the tree divided by that of the cylinder, or since

$$\text{factor} = \frac{\text{volume of tree}}{\text{volume of cylinder}},$$

we can say:

$$\text{factor} \times \text{volume of cylinder} = \text{volume of tree};$$

or, $$\text{volume} = \text{area} \times \text{height} \times \text{factor of shape}.$$

In our case, then,

$$3.14 \times 90 \times .60 = 169.5 \text{ cubic feet.}$$

This includes the logs as well as limbs, and means that if the entire tree were cut into cord wood, it would make one hundred and sixty-nine cubic feet, solid wood; or, since about ninety cubic feet solid make one cord of wood in the pile (air and wood), each twenty-four-inch tree would make 1.88 cords. Allowing two cords of wood to each thousand feet B.M. of logs, we deduct one cord for the logs and find that these trees furnish each about 0.88 of a cord of firewood. When trees are very branchy, as in our old hardwood forests, the number of logs is usually

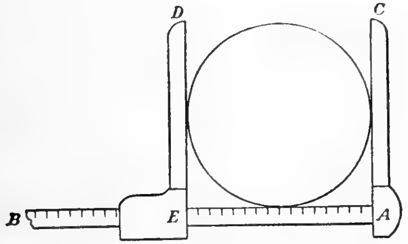


FIG. 62. Calipers for measuring the Diameter of Trees

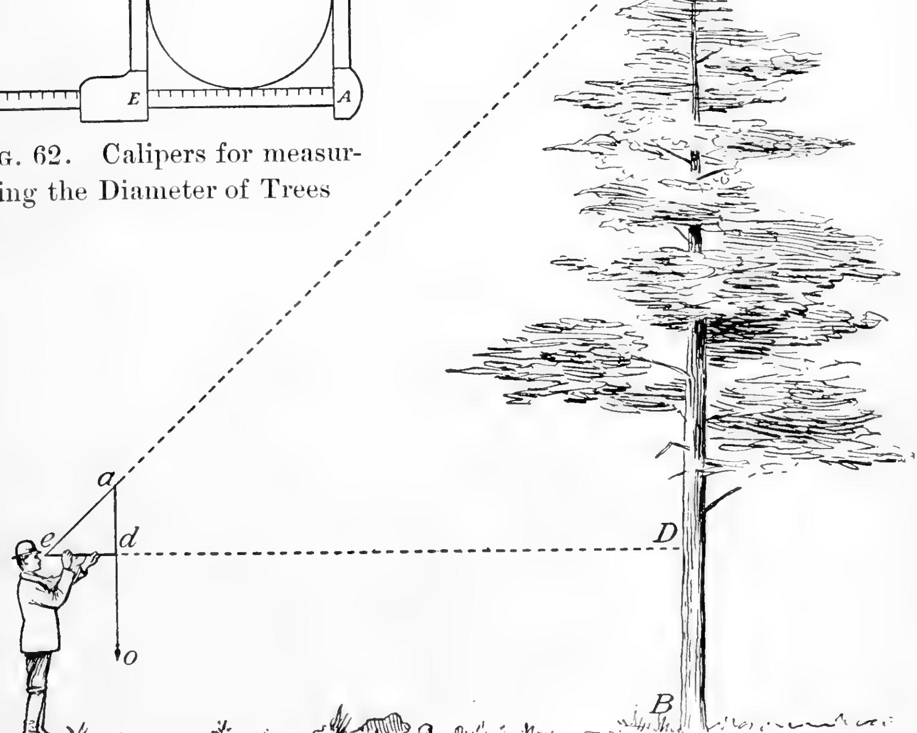


FIG. 63. Measuring the Height of a Tree

small, and the amount of firewood commonly more than half of all the timber. In pine, spruce, etc., the reverse is true; here the logs often make over seventy-five per cent of all the wood in the tree.

Since estimating is always guesswork and liable to much error, it is far better to make definite measurements wherever we can. This is always possible in the case of the diameter, and usually of the height. In doing this two men go ahead with calipers (see Fig. 62) to measure the diameter and also estimate the number of logs, and one man walks behind them and keeps tally. The measuring is done breast high, and each tree is marked with a gauge or chalk to show that it has been measured.

During the work each man calls out, as, for instance, "White oak, twenty-four, two," meaning that this tree of white oak is twenty-four inches in diameter and will cut two logs. The heights are measured as shown in the figure, with a homemade triangle or else with a special device, the Faustman "Heightmeasure."

In measuring or "scaling" a log, it is customary, in our country, not to measure its real volume, but to state how many feet B.M. of lumber might be cut from this log. Since the saw wastes a great deal of wood, cutting it into dust, and since the slabs also are largely waste, only fifty to seventy per cent of the total volume of the log can be obtained as boards.

A stick on which are marked the number of feet B.M. for each diameter and the ordinary lengths is called a *scale rule.* Of these rules the Doyle rule is by far the most common and is quite a fair rule, except for logs smaller than sixteen inches diameter. If a rule is not at hand, we can readily make one, for in Doyle's rule the contents of a log sixteen feet long are equal to the square of the diameter reduced by four. Thus, a log twenty-four inches in diameter has $(24-4)^2 = 20 \times 20$, or 400, feet B.M. if it is sixteen feet long. If it is only twelve feet long, the contents are $400 \times \frac{12}{16} = 300$ feet B.M.

The measurement is always made at the smaller or top end, and if the log is crooked, partly decayed, or excessively knotty, an arbitrary deduction is made. Where valuable timber is bought or sold these methods are improved in various ways to obtain more exact results.

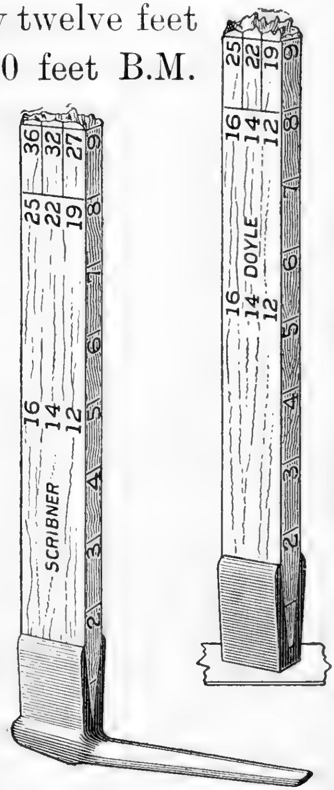


FIG. 64. Scale Rules
Only the lower end of each stick is shown

Tan Bark. — In many of the oak forests of the Allegheny region, and in the hemlock woods of Wisconsin and Michigan, many men are engaged in peeling tan bark.

This is done in summer, May to July, while the bark readily lets go of the wood. In peeling bark the tree is felled, and then girdled every four feet clear up to the crown. Then these four-foot cylinders of bark are cut lengthwise along two or more lines, and the pieces peeled off with a special peeling iron. They are then set up, rough side out, against the log to dry.

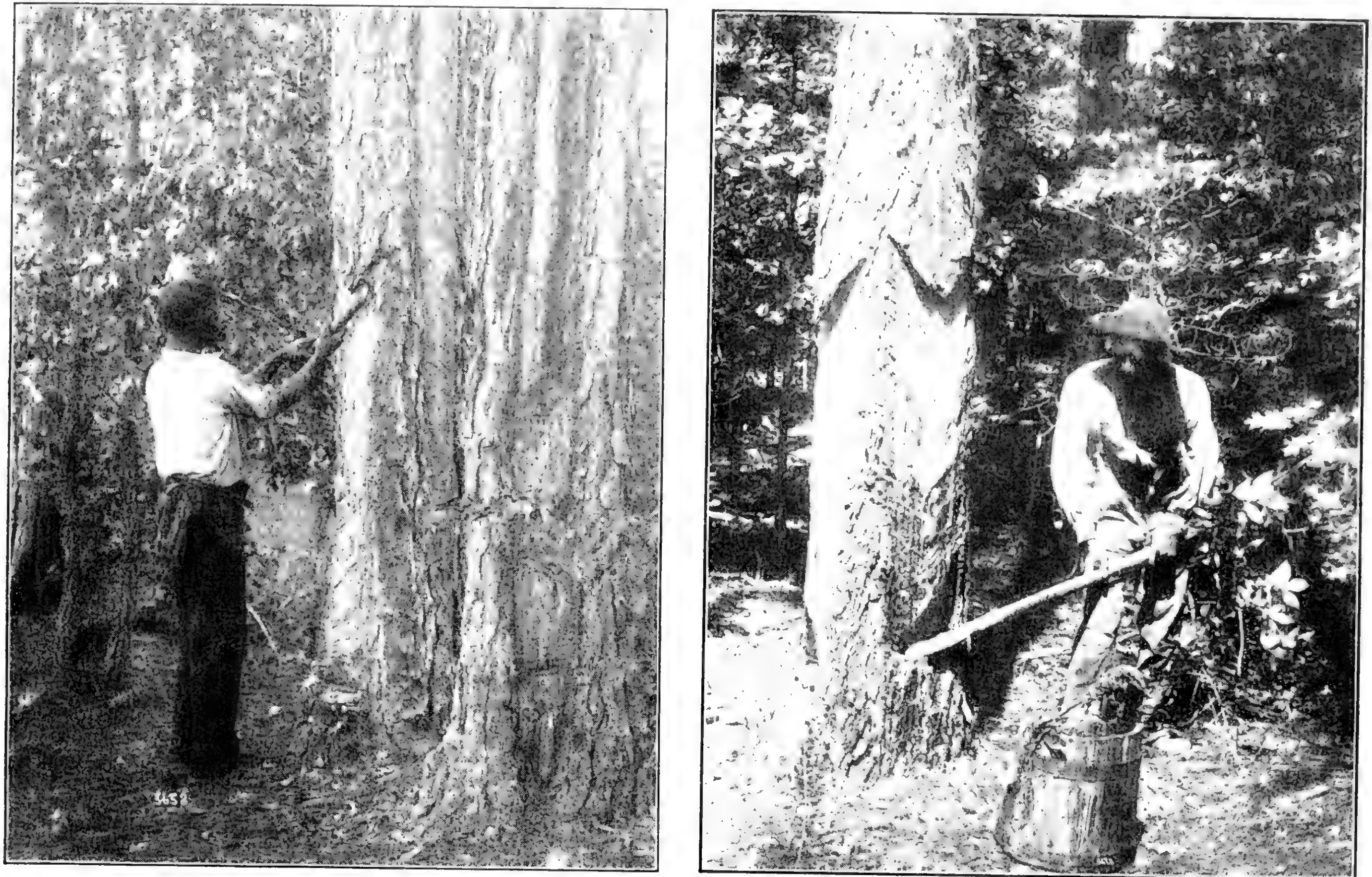
When dry they are carefully stacked in cord piles, and later on hauled out when convenient. Care is taken to do the work during dry sunny days, since bark molds very easily and is thereby spoiled.

Being bulky, bark does not pay for long-distance shipping, and tanners prefer to move their tannery to the woods and ship the hides, rather than to move the bark over great distances. In times of business depression farmers have been driven to peel bark without being able to use the logs, so that much timber has been wasted in this way. This should be, and usually can be, avoided by the use of portable mills; for even if the lumber cannot at once be used, oak and hemlock bear storing for a long time.

Resin and Turpentine Industry

In the large forests of longleaf pine covering the level, sandy coast plain of the South, the production of turpentine and resin, the "naval stores" industry, is one of the principal occupations. The process is as follows:

One or two deep pocketlike notches are cut into each tree to receive the crude resin as it oozes out of the wound. Since the resin hardens in a short time and stops up the wound, this latter must be renewed about once every week all through the "bleeding" season, from spring to fall, as shown in Fig. 65, *a*, where a man is about to cut a thin strip, or "streak," with his "hacker." Once



a *b*

FIG. 65. In a Turpentine Orchard

a, chipping, to make a fresh wound; *b*, "dipping" the "crude," or resin a month the men "dip" the "crude," and this is hauled to a distillery, a "turpentine still," where the "crude" is boiled with a little water. By this means the spirits of turpentine, or "spirits," go off as a vapor and are cooled in a coiled tube, the "worm," which is kept cool by flowing water. As soon as the "spirits" are distilled the remaining mass, the rosin, is run out like molten metal through a sieve into a trough, whence it is ladled into barrels. This soon hardens on cooling, so that the barrels need not be very tight.

Some distillers get all their "crude" from farmers; others have special crews in the woods to tap for them. Ordinarily a tree is tapped only four years, but in many of the settled districts of North Carolina trees have been "bled" for more than twenty years.

One man tends, "chips," or "streaks," about five thousand trees. His trees form a "crop," and are supposed to have ten thousand notches or "boxes." Such a crop yields during the four years of "bleeding" about fifty-four hundred gallons of turpentine and six hundred and eighty barrels (two hundred and forty pounds each) of rosin. The yield is greatest the first year, the four years comparing in this respect as 7 to 6 to 4 to 1.

When the lumberman follows the turpentine man, and uses up the timber as soon as the tapping is finished, this industry is entirely proper; but where the trees cannot be utilized afterwards it is too wasteful. The output of this industry in 1892 was about three hundred and fifty thousand casks of turpentine and about two and a half million barrels of rosin.

The ordinary tar, formerly manufactured in large quantities, especially in North Carolina, and much used on ships, was not made in the manner described, but in special charcoal pits, and was thus a product of dry distillation, akin to the tar produced in retorts.

Seeds and Mast

In nearly all of our eastern hardwood forests the nuts of chestnut, hickory, including the pecan, walnut, and butternut, and to some extent the beechnuts, are gathered and form one of the common dainties of winter-evening gatherings.

Nearly all of our large oak forests are used to pasture thousands of hogs, which fatten whenever the "mast," or crop of acorns, is good.

Aside from these simple and ancient uses, the seeds of our trees are generally allowed to go to waste; but as there arises a market for many of our tree seeds, it will prove profitable to gather them. This is so now in most parts of Europe, where the value of the seed from a small piece of woods is often far greater than that of the wood, and where, whenever a seed year occurs, hundreds of people make it a business to collect such seeds as pine, spruce, and balsam.

Pasturage

Pasturing in the forests is almost universal in all settled portions of our country, and even many of the remote districts, like those of the Rockies, Cascades, and Sierra Nevadas, furnish summer feed to several millions of sheep and cattle. In the forest of the longleaf pine in the South the cattle feed on rough pine-grass, which is renewed and also protected against a cover of pine needles by being burned over from time to time.

Though the cattle and sheep do not eat the pine, they trample down seedlings, and thus hinder the starting of young growth. This, however, is made up in part by the good they do in breaking the cover of dead leaves, etc., and thus making it possible for the seed of the pine to find the ground. On the other hand, fires set for their benefit do damage in killing seedlings and young trees, and scorching the "feet" of the old.

In our hardwoods the cattle and sheep live as much by browsing off the leaves and fresh shoots of young trees as by feeding on grass, and, therefore, pasturing in these woods always hinders the starting of young growth and leads to a crippling of many of those saplings which continue to live in spite of injury. For this reason it is generally a bad plan to pasture cattle in the woods. Where, however, this appears still advisable or necessary the work in the woods should be so regulated that the cattle can be kept off from the parts where a new growth is to be started, until the young trees are over ten feet in height. With cattle this is easily and cheaply done by a two-strand fence of barb wire, which can be used over and over again; with sheep this does no good, and they should be herded.

In the dry portions of our western mountain ranges the sheep find a summer range which is considered quite indispensable to the sheep industry of many districts. Since the forests are stocked with conifers, which the sheep do not eat, it is chiefly their trampling which does any damage. In these mountains most of the herding is done on the high ridges where timber does not grow very well, if at all, and also in the numerous "burns," where repeated fires have killed and consumed everything. These burns are without seed trees and therefore restock very slowly, commonly remaining open grazing grounds for years.

Where forest growth is very difficult to start, and where, as is usually the case in these mountain countries, it is very necessary to avoid serious erosion from the irregular flow of the streams, pasturage should be regulated or abandoned altogether.

Game and Fish

In the Adirondack Mountains the game and fish, as much as the beauty of forest and lake, have brought to these mountains millions of dollars, and helped to create a sentiment worth many millions more. Streams and lakes well stocked with fish, and a few dozen of deer to every thousand acres of forest, are capable of producing considerable income through the pleasure which they give by their beauty and the possible chase, without interfering in the least with the real objects of the forest.

In hardwood forests, like those of the Alleghenies, at least twenty-five deer should find their living on every thousand acres of land; but in all cases the number should be regulated, and old does as well as old bucks should be removed.

Pine and spruce forests naturally offer very much less feed; and, therefore, if game is to be kept, more or less hardwood should be mixed in with the conifers. Patches of coppice growth, especially of poplars, cottonwood, aspen, etc., also willows, mountain ash, maple, oak, and beech, furnish large quantities of fodder and are well suited to help the animals in severe winters, when the poorer trees may be thinned out merely to feed the game.

But, above all, the animals must be protected against the dog and gun. Of these the former is by far the more harmful, and in any district where stray dogs, these

FIG. 66. Game

protected wolves of our forest, are free to chase the game day and night, as, for instance, in many parts of the South and West, it is impossible for deer to maintain themselves.

THE BUSINESS OF THE FOREST

When a farmer carries on forestry on his thirty-acre piece of woodland he looks after it himself, plans and conducts the cutting, planting, and thinning, sells the wood, and thus performs all parts of this business, just as he does his farming. He may hire some men, he may even keep a book to see just how much his piece of woodland is bringing in, but it is a very simple kind of record. In the same way his plans are perfectly simple. He may manage it all as a piece of selection woods, cutting over a three-acre piece each year, using the same road to haul out his wood, or he may treat it as a coppice; but, in any case, he needs no map or book to see where the oldest timber is located, and what parts are in need of thinning. Half an hour's walk will show all this, and a few hours' time will suffice to mark out all the trees he wishes to take out the coming winter.

Suppose, however, he has two thousand acres of woods in four pieces, thirty miles from his home; then the case is quite different. It would take a month's faithful walking to examine this amount of land as a good forest should be examined. Moreover, he needs to note down at every step what he sees, or else he would forget it before he could reach home. But of what use is it to note down what he sees on a particular spot, unless he knows where that spot is and can send a man there, if he wants to do so? This means, then, that he should survey it first and establish some marks in the woods. Then he examines and estimates or measures the timber and describes his land. But after he has a map and description, to have it orderly he must keep it in some kind of book, arranged in some definite order. Here the bookkeeping begins, for this survey and this examination cost some money, which he must charge against his forest. Then he wants to *manage* this forest.

We will suppose he decides to treat it as a selection forest, and suppose also that he can sell the wood and timber, and wishes to use his forest to furnish work for teams and outfit, and also for his men, whether tenants or neighbors. In this case he will wish to do some logging, perhaps, every winter; and he will need, about every ten years, to return to each part of his woods to make sure that it is properly cleaned and thinned. He would have to log over about two hundred acres a year, and this would be a considerable business in itself. To do this he would need a foreman, better a forester, and a small crew of men, and considerable bookkeeping would be necessary to keep his accounts in proper order. But to handle a foreman and crew means *administration*; to survey, subdivide, map, and measure his land and timber, to plan where, what, and how much to cut and plant, to improve by roads, ditches, and otherwise, — all these mean to *regulate* his forest. We have here, then, a simple form of *forest administration* and *regulation.*

When this forest grows to twenty-five thousand acres, in perhaps thirty pieces, the owner needs several permanent foresters who know what to do and how to do it. Each of these men takes a portion of this land and carries on the business, making reports at regular times to the owner, or his office, so that the owner, like a storekeeper, knows every day about how his forest business stands. Thus, forest administration and regulation, up to certain limits, grow in complexity as the forest grows larger and more diversified, and both are necessary for order and good business.

SPECIAL KINDS OF FORESTS

So far we have been considering forests in general, but there are a few important cases which deserve special attention.

The Wood Lot

The farmer's small forest of twenty to forty acres is often entirely neglected, as a thing neither forest nor field and hardly worth paying any attention to. And yet it is in this form that a very large and a very important part of our forest wealth exists, and here is where

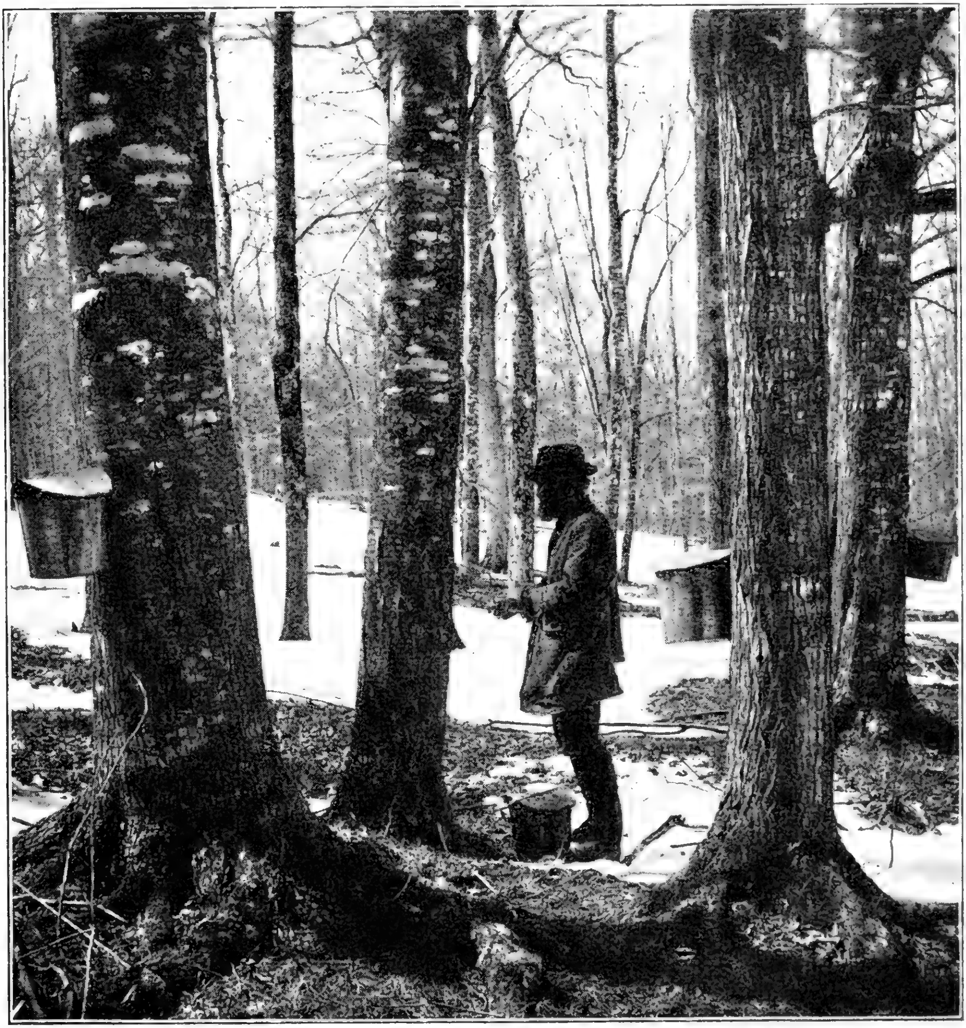


FIG. 67. Tapping the Sugar Maple
(After W. F. Fox)

the best kind of forestry is frequently met with, and where the most careful attention and the greatest outlay of labor always pays and pays handsomely. The ordinary wood lot in the eastern or forested portion of our country is usually a remnant of the old forest; it is on forest ground and commonly on rather good land, when considered from the woodsman's standpoint, so that quite a variety of timber may be grown here. Let us consider what might be done with such a wood lot in our eastern districts.

First, we will see what kinds of trees the woods contain and what condition they are in. In most cases we find a considerable number of old, long-overripe trees of maple, elm, oak, especially red oak, and others. Some of these clearly show their bad condition by large knot holes, numerous dead limbs, and other signs of degeneration. They are growing neither in value nor in wood and had better be removed; but there is no need of haste, — any time during the next ten to twenty years is soon enough; for there is no immediate danger of great loss.

Besides the old, overripe trees there are a number of younger trees with broad, spreading crowns, also trees like blue beech and dogwood, which are not wanted. We see that considerable change is needed here, merely in respect to the kinds of trees to be raised. In most cases we should wish to reduce the elm, basswood, poplar, and others, and give preference to oak. Moreover, we would rather raise white oak than red or black oak, because the former is durable and, therefore, useful even as a small tree, when it can be sold at good prices for railway ties and piling. The same is true of chestnut. In addition, it would be better in most cases to introduce

FIG. 68. Old-Fashioned Way of boiling Maple Sap
(After W. F. Fox)

considerable pine or spruce, since much coniferous lumber is used everywhere. To prevent the groves of oak from becoming too open and grassy, it would be well to mix in some beech and maple wherever this trouble appears.

The trees may be mixed all through the piece, or else the oaks, the ashes and elms, hickories and walnuts may be raised in small clumps or groves of one half to two acres in size, surrounded by the mixed woods.

A general maxim in the choice of the trees to be raised would be: "Raise only those kinds of trees which thrive and grow well in our locality, and among these select the kinds which furnish the most valuable material, and especially those the wood of which is valuable at an early age or in smaller sizes." Of course it is not necessary and would not even be profitable to change the entire thirty acres of woods in one year; but it is well to make up our minds as to what we should do with the woods, and improve them from year to year, restocking the ground with the kinds we want as we use up the old and thin out the inferior trees.

In most woods we would also find much dead material still on the stump or on the ground, also thickets of young stuff in which good and bad trees alike are trying to hold the ground. These cases, as well as the maintenance of a close border and the restocking of all bare places, should in all such woods receive prompt attention, for dead material in a forest is always a source of mischief. A lot of scrubby blue beech is apt to crowd out the finest saplings of oak, and a bare place in the woods is fallow land, bringing no rental, but serving as a starting point of brambles and other forest weeds.

As to the best way of managing the woods, the farmer forester has the widest choice. With him any method, if at all applicable to the kinds of trees he wishes to raise, will bring good results. Generally the common selection method will prove most satisfactory, since, as we have learned, it is well suited to all the different kinds of trees, to all climates and soils, and incurs less danger of injury by wind and insects.

On an ordinary thirty-acre tract about three acres may be gone over each year, cleaned and weeded of useless stuff, the denser thickets thinned, perhaps a few of the oldest trees cut out, and all open spots restocked. At first this will best be done by sowing and planting, for if we wish to increase the proportion of white oak and introduce pine and spruce, the only safe way is to sow or plant in the manner before described. A small basket of white-oak acorns, chestnuts, and beechnuts sown in the fall, and a few hundred plants of white pine raised from a few ounces of seed in a small flower bed in the garden and set out in the spring, will soon produce a complete change in the complexion of this forest. In many localities a few acres of good "sugar bush" may prove desirable, though frequently this is better attained by trees along roads and fences and in open groves about the farm premises. The same is true of nut trees, of which a goodly number of the choicer kinds should be grown on every farm. It is just as easy in most places to grow a good walnut or a good hickory as it is to grow pignut, elm, or ash; and in warmer districts a grove of fine-grade chestnuts or select pecans may often bring in considerable money by the fruit alone.

In suitable localities a part of the forest may well be managed as coppice, and this same method is a very good means of starting a new forest on old, worn-out plowland and on pasture, for it is very easy to pass from a coppice to a standard coppice, and from this to regular selection woods.

The use of the wood lot as pasture land is ordinarily a mistake; for if the forest is well stocked with trees, the grasses have no chance, and there is nothing for the cattle, sheep, etc., to do but to browse and gnaw bark. In a small tract of hardwood forest the grazing will almost always reduce the capacity of the woods to half and less, so that only half as much wood is produced, and it is not uncommon to see these over-pastured wood lots change into mere "cripples," or stands of dwarfed and deformed trees, which rarely grow into anything better than cheap firewood. When the wood lot must be pastured, the directions concerning pasturage mentioned before should be followed. In using their woodland farmers accomplish much by a little organization and coöperation. In some localities, where formerly the logs were rolled up and burned, and the lumber used on the farm was bought at the lumber yard ten or fifteen miles away, the farmers now use portable sawmills, just as they use threshing machines, thus cutting not only the lumber and timber for home use, but sawing timber for railways, wagon makers, furniture makers, and other consumers.

In cases where the lumber and timber is not sold beforehand it should be piled and covered in the best possible way, for it is usually through careless handling that the lumber of small mills becomes less acceptable and has to be sold at lower prices.

An illustration of what may be done by careful, systematic management is shown in the following particularly interesting case of timber exploitation, in no feature imaginary or theoretical, but actually carried out a few years ago.

Forty-three acres of well-stocked rough timber land in eastern Pennsylvania were bought for $5800, together with forty-eight acres of improved farm land, for which $2500 additional was paid. A portable second-hand mill was purchased for $1000; mill shed and shanties were erected, and this outlay, together with all the wages (nearly $4000) and cost of hauling, railway and canal freights (little over $4000), brought up the total outlay, land included, to $18,855. As the mill was at once set in operation, some income was derived from the first, thus obviating the necessity of considering the interest on the several expense accounts.

The following represents the cut from these forty-three acres made in just two years, with only the partial personal attention of the owner, and without the employment of a special superintendent:

AMOUNT AND VALUE OF ARTICLES AND LUMBER SOLD

			Sold for
Miscellaneous:			
111 tons of oak bark			$1,224
801 cords of firewood			2,640
196 telegraph poles			500
16,800 hickory spokes			388
66,000 feet slabs (running measure), used largely in mines			333
For custom sawing			130
Sawdust			7
Total,			$5,222
Lumber (board measure):			
Hickory butts (bought by paper mill for cogs),	feet	9,680	
Birch, sycamore, and second-cut hickory (sold to toy concern)	feet	11,822	
Ash	"	957	
Walnut	"	3,414	
Yellow poplar	"	12,941	
Gum	"	1,386	
Maple	"	1,042	
Chestnut	"	34,719	
Oak	"	162,552	
Total,		238,513	6,522
Railroad ties	number	9,345	5,282
Switch timber	feet, linear measure	6,217	821
Other materials			654
Total,			18,501
Place and mill were then sold, the former at $4623, the latter at $1000, making a total of			24,124
Against an expense of			18,855
Leaving a profit of			$5,269

Here was a tract of forty-three acres of timber with a yield of less than sixteen thousand feet B.M. per acre, as ordinarily estimated, a stumpage of about five dollars per thousand feet, and a profit of over one hundred dollars per acre. Though it is not possible to repeat this everywhere, it goes far to explain why good hardwood timber in eastern Pennsylvania and New Jersey sells at one hundred to one hundred and fifty dollars per acre when farm land does not bring one half as much, while only thirty years ago the case was exactly the reverse and the farms were rated by the amount of cleared land. It also shows how, at least in a large part of the eastern United States, woods may be exploited in a careful instead of wasteful manner, and how many a small holder, who can give the matter his personal attention and do much of the work at odd times, may make his wood lot a source of revenue.

Waste Lands

On every trip through the country, especially in all hilly districts or in walks about any of our smaller towns and villages, one notices pieces of land from a few rods to several, often many, acres in extent which have practically gone to waste. Some of these pieces are rich spots along our streams, perhaps a little wet or subject to overflow; others are dry, often stony, hillsides, where the removal of the woods, the decay of the roots, and subsequent plowing deprived the soil of a hold and allowed the rain water to carry it away, leaving the surface a mass of gravel and stones. Generally these places are used as pastures, but their grazing value is very slight, and where this grazing value becomes less than one dollar per acre each year it is in most cases better to convert such waste land into woods; for, as we have seen, a soil which is quite poor for agriculture may still be very good for trees. Most of these hillsides or bluffs at one time carried a good growth of trees, and it is not uncommon for such lands to change without help from bare pasture lands into brush lands and, if left alone, gradually to revert to regular forest. Usually this process is too slow; lack of seed trees and repeated fires keep these wastes in their bad condition, and it is far better, therefore, to restock these places by sowing or planting. In the New England States some waste places have been restocked by white-pine seed in spots five or six feet apart, and the same may be accomplished at small cost and with good success by sowing acorns, chestnuts, and seed of locust, maple, and elm.

Where the ground is rocky and poor, and the success of sowing rather doubtful, especially in the case of pine and other conifers, it is much better to plant young trees one or two years old. When a mixture of oak, chestnut, locust, elm, and maple is used the woods may at first be treated as coppice. Later on it may be changed to a standard coppice, and from this to an ordinary selection wood, which will, in the end, prove the best for such lands.

On wet overflow land willow produces fine crops of long sprouts for basket weaving. Poplar, ash, elm, sycamore, and, in the Southern States, sweet gum, water oak, and other valuable trees thrive in similar situations.

What such reforestation can do for a piece of land, even in our country, is best illustrated by some of the worn-out pastures in our New England States, where land which produced no income at all has been converted into forests cutting over thirty thousand feet B.M. of shook boards at the age of sixty years and less; or, in other words, a forest capable of producing yearly a net income of three dollars and more per acre.

Forest Plantations on Prairies

As with so many other good things, the forest is never so keenly missed as in the vast treeless regions of the West. Generally the land is fertile, but lack of moisture has helped the grasses to monopolize the land. In all the states east of the Rocky Mountains numerous forest plantations have been established. The majority contain only hardwoods, particularly maple, box elder, cottonwood, elm, ash, catalpa, walnut, and locust. Pine and other conifers have also been tried with success.

The majority of failures in these plantations appear to be due to the fact that the plants dry out at the roots before they are established, probably in most cases before

FIG. 69. Black Locust Plantation, Meade County, Kansas

Trees twelve years old, six to eight inches diameter and twenty feet high (After Toumey)

and during planting. Generally the plants are raised at distant nurseries and thus, necessarily, suffer during the long journey to the place where they are to be used.

Nevertheless, many thousands of acres of prairie in Iowa, Nebraska, Kansas, and other states have been converted into useful woods, supplying the much-needed shelter from wind, and, at the same time, producing fuel and construction material, fence posts, etc.

How successful some of these plantations are is clearly seen from Figs. 69 and 70. In this latter case the catalpa

FIG. 70. The Yaggy Catalpa Plantation, in Reno County, Kansas, showing Posts cut when Trees were nine Years Old

The posts are four to six inches in diameter, and many of the trees made two posts. (After Toumey)

trees were raised in a nursery on the farm, and set out, when one year old, in furrows six feet apart, at intervals of three and a half feet. When two years old the trees were cut off and allowed to sprout. The following winter the tall sprouts were thinned, leaving only the best sprout on each stump. The land was cultivated for three years to keep down the grass, but after this the shade of the trees sufficed for this purpose. When the trees were eight years old the largest ones were cut out for fence posts, most of them making two posts each. In two years' thinning, over fifteen thousand trees were taken from the eighty-acre tract. When the plantation was ten years old there had been raised on one acre about eighteen hundred trees, furnishing over thirteen hundred good posts, besides smaller posts or stakes and a lot of firewood, valued in all at about two hundred and sixty dollars.

This plantation is located on good bottom land, bought at twenty-five dollars per acre, and of course presents an exceptionally thrifty growth. Nevertheless, it clearly shows what may be accomplished on the western prairies and how even forestry that requires the most painstaking care may be profitable in many parts of our country.

Sand Dunes

Passing through Michigan City, Ind., one can see from the car window low ridges of bare white sand stretching along the shore of Lake Michigan. These ridges or dunes are constantly moving, and a number of houses have been covered entirely, while parts of others are seen sticking out of the sand. Similar dunes occupy long stretches of our Atlantic coast and the coasts of France, the Netherlands, and the countries about the

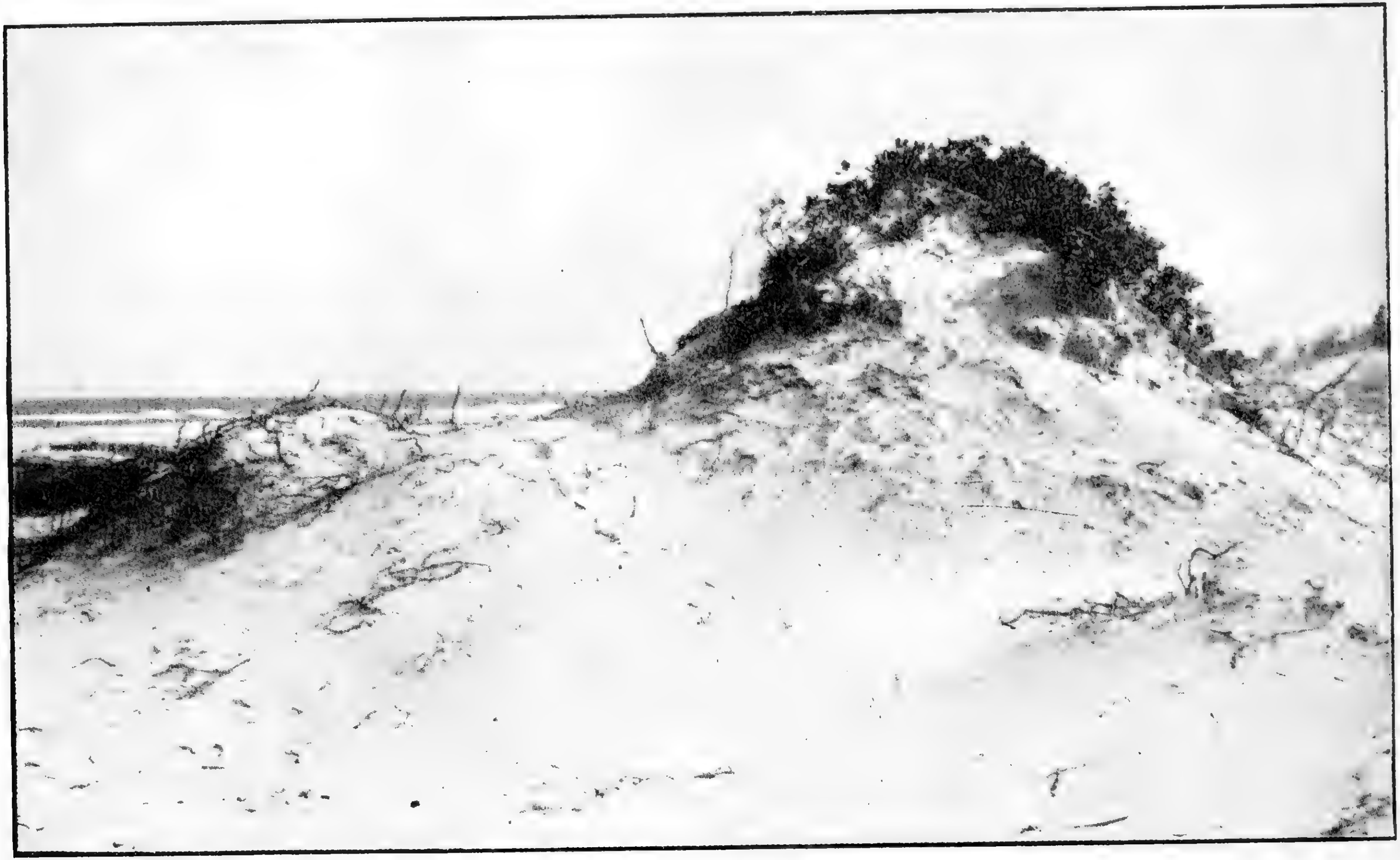


Fig. 71. Sand Dune along the Coast
(After Gifford)

Baltic. In some places they are simply a desert waste, and have comparatively little effect on the adjoining country; but in other localities, like The Landes of France, bordering the Bay of Biscay, the sand dunes formed long, continuous ridges along the shore, and thus dammed up the water in

FIG. 72. Sand Dune in Holland, after Reclamation

(After Gifford)

the streams and converted what, at one time, was a forest into a pestilential, marshy waste.

On the whole, these dunes occupy large areas; those of Europe alone have been estimated to cover over twenty thousand square miles; and since the wind easily drifts the sand farther and farther inland, it is difficult to say how much land might eventually be laid waste by these moving dunes. For over a century the people of France, the Netherlands, and other countries have fought these sands, and some excellent results have been attained.

The methods employed by all are similar. First of all a close board or brush fence is erected. This is situated about three hundred to six hundred feet from high-water mark, and runs parallel to the coast line. Usually a parallel fence is built about forty feet from the first. The sand, whether blown from the ocean or from the land side, is caught by these fences, which thus cause the formation of a new dune. As the sand gets deeper and deeper the fences are raised higher, until, in the course of several years, this new shore or littoral dune is about thirty feet high. When once of this height the new dune keeps the sand from traveling farther inland, and the sandy stretches in its rear, or on the land side, have a chance to become quiet. Then the new shore dune is covered with sand grasses, mostly the sea marram or matweed, which thrive on these mobile sands, and the land behind it is planted or sowed to pine, both plants and seed being protected by brush evenly covered over the entire tract.

The pine woods are usually treated by the selection method, so that no large bare spots are ever produced. The chief danger, fire, is guarded against by a number of fire lanes and by careful watching.

The shore dune requires continual close watching, and must be kept covered with sand grass to prevent renewed attack on the reclaimed lands, and its care, therefore, forms an important part of the forestry service.

Though very expensive, this kind of work in The Landes alone has converted more than a million acres of worthless marsh into valuable productive forests, and has changed this large area from an unsightly, pestilential region into a health and pleasure resort.

Part III

RELATED TOPICS

THE FOREST AS A PROTECTIVE COVER

Besides supplying one of the most necessary materials, wood, and besides rendering productive large areas of otherwise useless land, the forest in most places has still another function, namely, that of protection.

The forest protects the soil against washing away, or erosion, and it protects both the soil and the air in the forest against the wind and sun, and thereby keeps them cooler and moister.

A simple experiment illustrates this influence very well: Take a common wooden table and prop up one side so that it is about six inches higher than the other side; let this table top represent a gently sloping hillside. If now we pour water on this table top with a sprinkler, and thereby imitate rain, we see that the water at once runs off faster or slower, according as the table, our hillside, slants more or less.

This is exactly what happens on our sidehill or mountain wherever its rocky body is bare of any soil or cover.

If we cover the table with a four-inch layer of garden earth, and repeat our sprinkling, care being taken not to sprinkle too hard, we observe a very interesting and important fact.

There is at first hardly any water on top of the soil — it soaks in; but after a time there arise little rivulets on top, and by gathering they grow larger and we have exactly what we see in our settled plowed districts, — an ordinary *surface run-off*. But, in addition, we note after a little time that there is also a run-off along the face of the table just as before, except that the water runs slowly; it has to seep along. This is our *underground drainage*, such as occurs everywhere, and it is this underground water which feeds our springs, streams, and lakes when there is no rain; and it is underground water that we reach in digging our wells. Thus, when the rain falls on a bare rocky area some of the water evaporates, most of it runs off as fast as it falls, and when the rain is over the rocky surface is dry. On the earth or soil-covered area, on the other hand, part of the rain water runs off at the surface, but much of it soaks into the ground and stays there until there is enough to form slow underground streams. Thus, the soil acts as a water storage for plant and stream. If we stop sprinkling, the surface run-off soon stops, but the underground drain keeps on moving for many hours. This is what happens all over the land.

Fig. 73. How the Forest regulates Erosion

If now we sprinkle again, but very hard this time, we see that the water washes out gullies and carries away the soil, just as we all have seen soil carried from plowland, and just as many thousands of acres of plowland in Mississippi and other states have been gullied and ruined by water. Let us now cover part of the layer of earth on our table by a one-inch cover of moist cotton batting. Repeating the sprinkling, we find that this cover of cotton does two distinct things: it protects the soil and keeps the water from carrying it away; in addition, it keeps the soil moist for hours after we cease sprinkling. This is exactly what the forest does: the torrential rain finds a canopy of twigs and leaves to break its force, and when the water reaches the ground it finds a layer of leaves which prevents it from carrying away the soil. In addition, a network of numberless roots holds this earth for a considerable depth, and the many dead roots of former trees have softened the soil and made it more penetrable; thus, the water soaks in instead of running off.

That grass and other herbaceous vegetation cannot well replace the forest in this respect is clearly shown by the fact that the Missouri River and its tributaries, which come from prairies, are muddy torrents after every rain, while the streams of the dense forests run clear and are undisturbed by ordinary rains even though they have a greater fall.

While it is thus quite easy to see how the forest protects the soil, and, by so doing, regulates the flow of

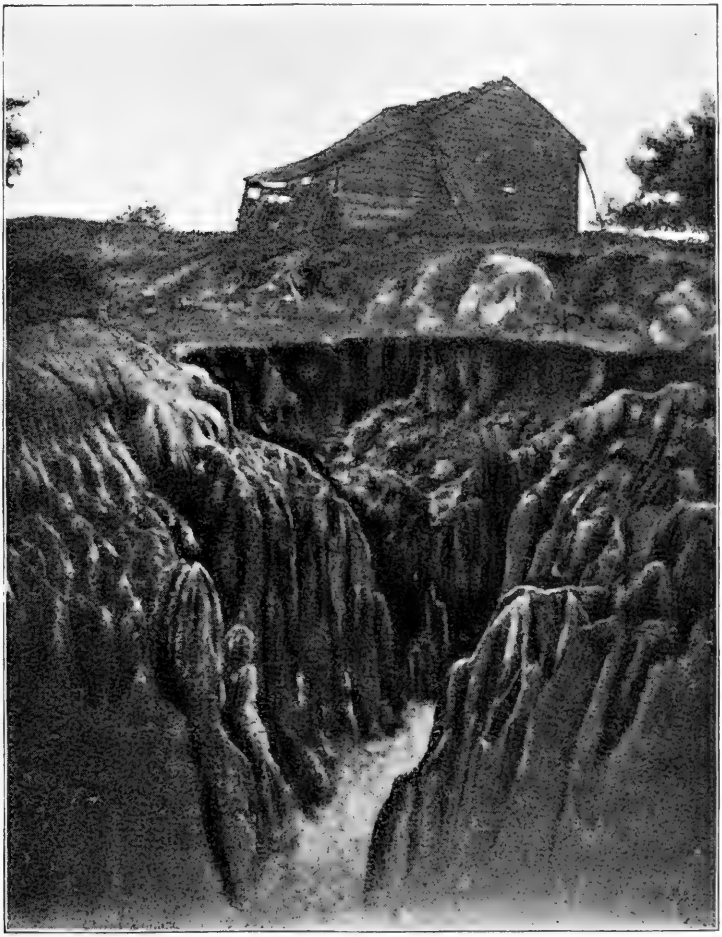


Fig. 74. How the Land erodes after the Woods are gone. (Common sight in Mississippi)
(After McGee)

water, the influence of the forest on the climate by making it more temperate and humid is not so plain, and remains still a much-disputed question.

Formerly it was claimed that the forests would increase the rainfall, making the climate moister and more equable. Great scientists and travelers have spoken on both sides of the question; and for over fifty years attempts have been made to test the truth of these things in a scientific way by carefully measuring temperature, rainfall, etc. Most of these experiments, however, have failed, and there is still much dispute as to just how much the forest can do. At present it is generally believed that the forests do not change the amount of rainfall very materially, and that the arid oriental countries like Egypt, Asia Minor, and Persia were, even during their most glorious days, dry as they now are. On the other hand, the effects explained above remain valid; and, of course, the more the conditions favor the destructive work of the water, the more apparent is this protective influence of the forest.

Thus, parts of the French Alps were cleared off about the end of the eighteenth and the beginning of the nineteenth century. Floods followed this clearing off with such regularity and force that many villages were destroyed and others abandoned because the floods covered the fields often yards deep with sterile gravel and bowlders. Then France began the great task of reforesting these mountains; and, though not half completed, this task has already cost many millions of dollars.

In our own country we are not without like examples. Lack of a forest cover in Mississippi led to a gullying which destroyed so much good farm land every year that a good authority says the damage amounted to more than the total income of the state from all its industries.

As to the influence on the moisture of the air, it is well known to every farmer that a rail fence, if allowed to be crowded by woods, is thereby prevented from drying, and rots twice as quickly as it otherwise would. Again, it is well known in all newly settled districts that a road can never be kept in good condition unless the "right of way" is cleared of timber to let in wind and sun.

Similarly, in our Lake Region hundreds of miles of "corduroy" road are dirt roads to-day and thousands of small swamps have dried up, not through any drainage, but merely because the woods were cut away. That these small changes are accompanied by great changes in the "run-off" of our larger streams is well illustrated by the fact that navigation has become difficult in a number of our important rivers, and altogether impossible in others, which within our own times were navigable.

THE FORESTS OF OUR COUNTRY

If we examine the accompanying map of our country, where the areas originally wooded are colored and the open prairies uncolored, we see that the Mississippi divides the country approximately into an eastern timbered and a western prairie portion. We see, too, that the line does not quite follow the great river, but bends across to the east, leaving part of Wisconsin and Illinois as half prairie, and then crosses it again, including the greater part of Missouri, all of Arkansas, the eastern part of the Indian Territory, and Texas in the timbered portion. Following this western timber limit, we note a belt marked with green dots, extending from Texas to Minnesota, which is a sort of half prairie country where patches of forest, usually scrub-oak woods, alternate with prairies. To the west of this we see the great prairies and plains; then a set of narrow red patches, representing the ragged, coniferous forests covering part of the numerous high ranges of the Rockies; then the bare, arid regions of the Great Basin; and west of this, a broad belt of coniferous forests skirting the Pacific from the northern boundary nearly to the southern limit of California.

Our eastern forest, we note, consists of three parts: a northern and a southern belt of coniferous forests, and a broad hardwood forest between these two.

The northern belt of conifers is composed largely of white pine, Norway pine, and hemlock in the western and central parts, and of spruce in the eastern. The great pineries of Wisconsin and Michigan and the spruce woods of Maine belong to this belt.

The southern belt of conifers is composed almost entirely of pure stands of the southern pines, the longleaf, loblolly, and shortleaf, with cypress covering the swamps.

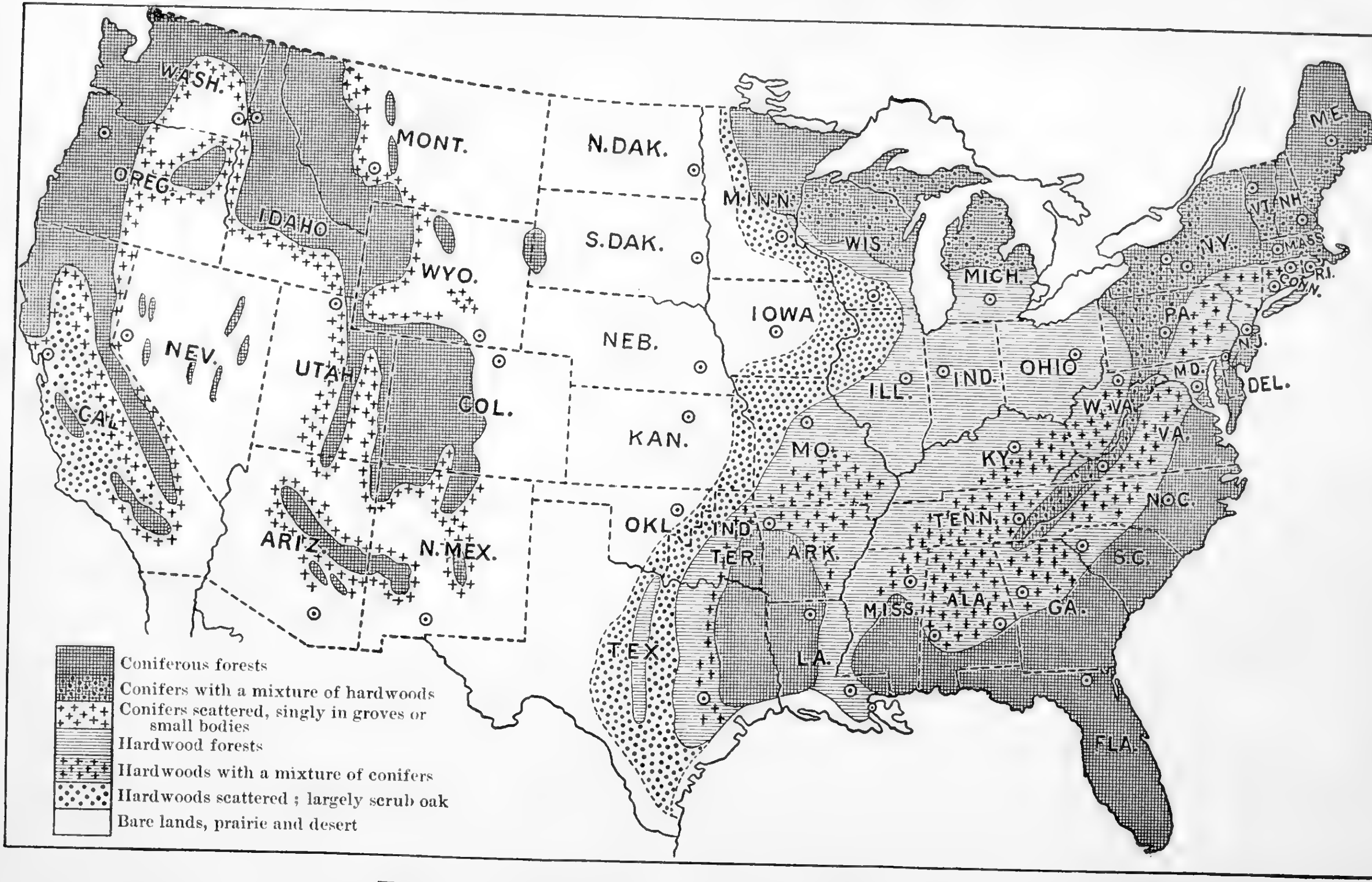


Fig. 75. General Forest Map of the United States

The broad-leaved or hardwood forests occupying the greater portion of the eastern United States may be divided into a southern and a northern half. The former extends from New England to Missouri, and is characterized by the fact that, almost everywhere, the hardwood forest is dotted conspicuously by pine; the part north and west of the Alleghenies is practically without this mixture. On the whole, this great hardwood forest may be called an oak forest with a variable mixture of chestnut, hickory, yellow poplar, elm, ash, beech, and other broad-leaved trees. At its northern limit the oaks give way to birch, and at its southern to pine.

Both the northern and southern belts of conifers are to this day large, almost unbroken forests, with comparatively little settlement. It is in the great hardwood region of our country that a goodly share of the forest has made way for the plow and that the greater part of our people live.

The coniferous forests of the Rocky Mountain ranges, composed mostly of yellow pine, red fir, and spruce, are interrupted by numerous prairies and bare lands, and thus cover but part of these mountains.

The forests of the Pacific coast region are among the most remarkable forests in the world. Those of California are largely made up of gigantic redwoods, red fir, and pine, while those of Oregon and Washington are chiefly forests of red fir, hemlock, cedar, and balsam.

Both redwood and red fir grow to be over two hundred and fifty feet high; and while an acre of good spruce land in Maine yields ten thousand feet B.M., it is not a rare thing to cut over two hundred thousand feet B.M. from an acre of redwood or red fir.

If we ask how much forest we have left, the answer is quite encouraging. In the New England States, the Lake States, and the entire South, not over thirty per cent of all the land is in use for field and meadow, leaving nearly seventy per cent for forest and waste, of which the greater part is still fairly wooded.

The forest lands of our eastern United States practically all belong to private owners, individuals, or companies, though some tracts are owned by the several states as school lands, etc. In the Western States the Federal Government still holds a considerable portion, especially of the more remote forests covering the several mountain chains.

Of the private owners, railway and lumber companies have most of the larger tracts, especially in the pineries, both north and south; while the greater part of the hardwood forests are in the hands of actual settlers or farmers.

Of late years the Federal Government has set aside a number of tracts of mountain forests in our Western States as forest reserves for the purpose of protecting these areas against erosion and consequent disturbance of water flow. There are now over forty of these reserves, including over forty-six million acres of land, an area nearly as large as North and South Carolina together.

Largely for the same purpose the state of New York has established the Adirondack Park, of which it now owns about one million three hundred thousand acres; and the state of Pennsylvania also is beginning to buy some of its denuded and burned-over mountain districts for similar use.

SOME HISTORY

Even the ancients, the Greeks and Romans, had some notion of the value of their forests, and put forth many efforts to prevent their useless destruction. These efforts were of little avail, and the Mediterranean lands to-day are sorely in need of more wood, and their mountains of a better cover.

In the colder climates of central Europe the value of forests was fully recognized as early as the year 1300. Though at that time the increasing population required larger and larger fields to provide grain and fodder, yet the clearing away of forest was regulated, and in many localities entirely forbidden. Many of the towns began to buy forest land to guard against a wood famine. The fundamental principles of forestry, that the land must be kept stocked with trees and that we must not cut more than the growth if the forest is to be kept up, were also clearly recognized.

Thus, in the Sihlwald, a tract of forest which has been in possession of the city of Zurich for about a thousand years, the amount of wood to be cut each year and the proper way of cutting it were determined by competent men more than six hundred years ago. And so well was this done, and so carefully was their plan followed out, that this forest all this time has furnished every year the fixed amount of timber, and is to-day in better condition (and, therefore, better able to supply wood) than at any time before.

Numerous laws and orders, issued from the twelfth century forward by communities, towns, and governments, regulated every feature of forest management and use. The cutting, shipping, and selling of timber, the burning of charcoal, the peeling of tan bark, the gathering of rosin, the pasturing of cattle and hogs, and even the keeping of bees and gathering of wild honey, which in those days was a very important business in many districts, were all carefully prescribed, to avoid dispute, and still more to prevent "the killing of the goose that lays the golden egg."

As with laws in all times and countries, many were unjust and oppressive; and when the French Revolution freed the people of Europe from the fetters of medieval ignorance, sophistry, and brutality, there was a reaction against the forest laws, the real worth of which was always least understood by the very people most benefited by them.

In France this reaction did serious and permanent damage; the forests everywhere were slashed and cleared, and the great expense of restocking the southern Alps, and the enormous sums paid every year to Sweden and Russia for lumber which the short-lived coppice woods of France are unable to furnish, are the fines paid for folly.

The people of the Teutonic lands were not so readily moved, and their conservative attitude with regard to the forest has been fully rewarded. In densely populated Germany the forests cover twenty-six per cent of all land; about one third of these forests belongs to the governments, about one half to private owners, and the rest to cities and villages. In Prussia and Saxony the private people can do with their forest whatever they choose, cut and clear as they please; but in most of the states the government looks upon a forest as an inheritance which the owner may use, but which he may not mismanage, and may never destroy without giving satisfactory reasons.

Most of the forests of Germany are of pine and spruce. Nearly all of the government forests are "timber forests," and are managed on a rotation of about eighty to a hundred years, so that all timber is cut long before it is overripe.

The majority of these forests are in small bodies, in the midst of settlements, and have, therefore, good permanent roads, a local market, and ample protection. The sawmill here is not a temporary affair, some mills having been in operation for several centuries.

THE WOOD

Having learned something about forests, let us now examine a little more closely their main product, the wood.

Some Structural Features

Sap and Heart.—We have observed on some of the stumps and ends of logs that different kinds differ in appearance. On the oak we saw the rough bark outside, then a layer of lighter colored wood, the sapwood; and within this the darker heartwood, containing, somewhere near the center, the tiny brownish pith. This same arrangement of sapwood and heartwood we find in the majority of our useful timber trees. In some, like hickory and elm, the sapwood is wide; in others, like the locust and catalpa, it is narrow; and in some trees, like spruce, balsam, hemlock, and maple, it has no distinct color at all. The sapwood and heartwood differ not only in color, but also in durability; the sapwood part of our oak post decays in a very short time, while the heartwood part lasts for years. This difference is very important, and particularly in those kinds of woods where the heart is durable.

Annual Rings.—We have also noticed that the wood at the end of the log appears to be made up of rings; and we learned that these are called annual or yearly rings, because one is formed each year. These rings are valuable age marks, since they tell us a good deal about the history of the tree.

Let us now take pieces of oak, maple, and yellow poplar, and of pine and hemlock, and cut the ends with a sharp pocket knife, moistening them first and making the cut a little slanting. We observe that the rings on the oak are easily counted and are distinguishable by a line of little holes or pores; those of the maple and yellow poplar are distinguished by a fine line, but not a line of pores; and those of the pine are divided by a line of darker wood, which sometimes forms a broad brown band, especially in yellow or hard pine.

Spring Wood and Summer Wood. — The inner portion of the ring, usually on the concave of the arc, is naturally formed earlier, and the outer part later in the season; we call them, therefore, the spring wood and the summer wood of the ring. In the yellow pine these two are sharply defined; the spring wood is of a light yellowish color, and the summer wood of a dark orange brown. In maple and many other woods they are not sharply defined, but it is convenient, just the same, to use the terms in talking of these woods.

Looking at Figs. 56 and 57, we notice that the patterns of rift and bastard or tangent boards are principally due to the difference between spring and summer wood. The dark bands in yellow pine are summer wood; the scratched, usually darkest, but in the picture lightest appearing portion, in ash, oak, etc., is spring wood.

Pores. — We have already noticed the conspicuous pores in the spring wood of oak. Besides the larger pores, there are many smaller ones in the same wood. Most of

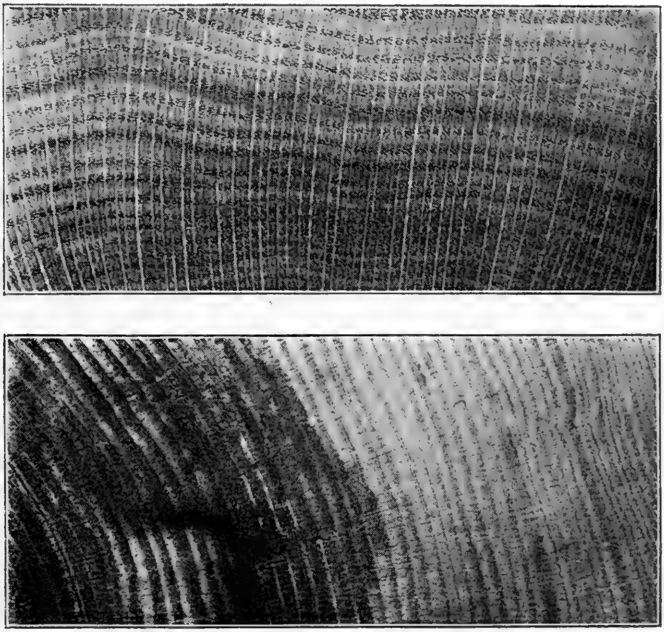


Fig. 76. Cross Section of Oak (upper), Ring-Porous Wood; Hard Pine (lower), Non-Porous Wood

these are in the summer wood of the rings, so that we have in the oak large pores in the spring wood and small pores in the summer wood, all of which serve as water ducts or vessels when first formed.

In maple and yellow poplar we can also see pores, but they are extremely small and usually require a magnifying glass to see them. These pores are nearly all of one size, and they are evenly scattered through spring and summer wood.

In pine and hemlock we do not find these pores, though in pine we do find little white specks which resemble

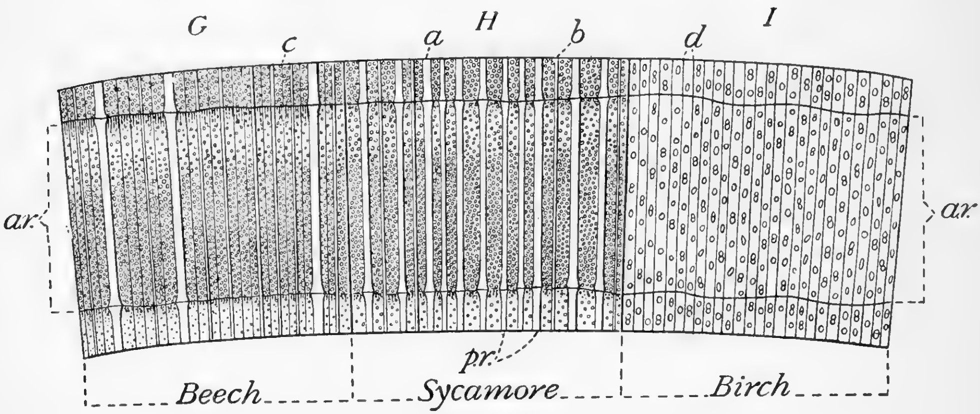


Fig. 77. Diffuse Porous Woods

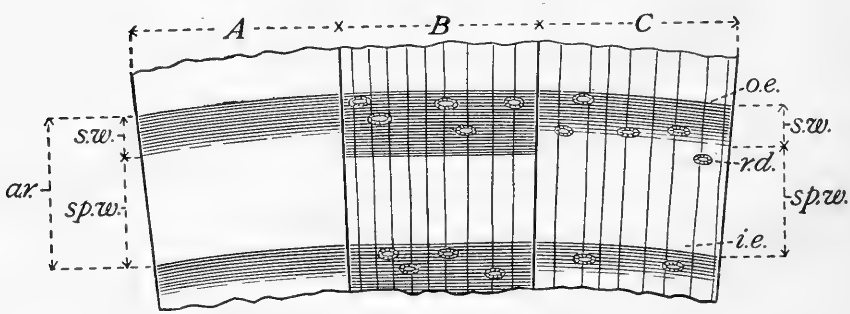


Fig. 78. Non-Porous Woods

A, fir; *B*, hard pine; *C*, soft pine; *ar.*, annual ring; *o.e.*, outer edge of ring; *i.e.*, inner edge of ring; *s.w.*, summer wood; *sp.w.*, spring wood; *r.d.*, resin ducts

pores; they are resin ducts, however, and are not like the pores we see in other woods.

The pores, especially the large ones, are easily seen on the sides of boards, and they have much to do with the pattern or picture presented by the wood. This is best seen in woods like oak, ash, and chestnut, where the pores of the spring wood are so large that they need a "filler"

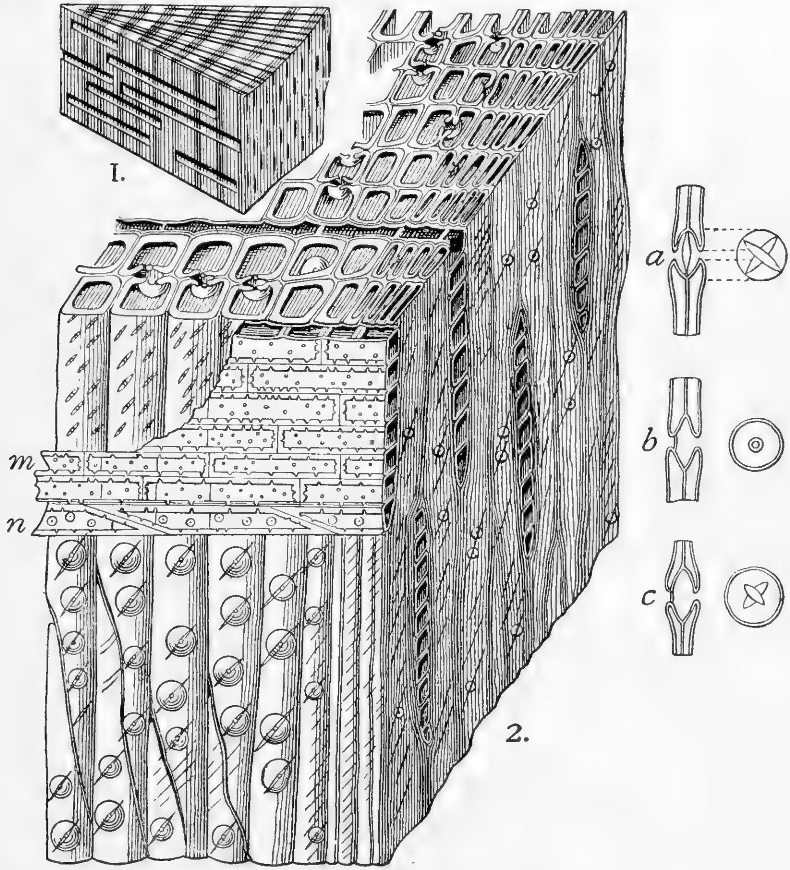


FIG. 79. Wood of Spruce

1, natural size; 2, small part of one ring magnified 100 times. The vertical tubes are wood fibers, in this case all "tracheids." *m*, medullary or pith ray; *n*, transverse tracheids of pith ray; *a*, *b*, and *c*, bordered pits of the tracheids, more enlarged

in finishing or polishing. The pores are the most important marks by which we can distinguish woods, and we divide all of our woods into three groups:

The *ring-porous woods*, like oak, ash, chestnut, locust, elm, hickory, etc., where the ring is defined by a line of large pores in the spring wood.

The *diffuse-porous woods*, like maple, yellow poplar, and cherry, where the pores are usually very small and evenly scattered through the annual ring.

The *non-porous woods*, like pine, spruce, hemlock, and all our coniferous woods.

Pith Rays.— Looking at a cross section of a log or piece of oak, we observe broad lines

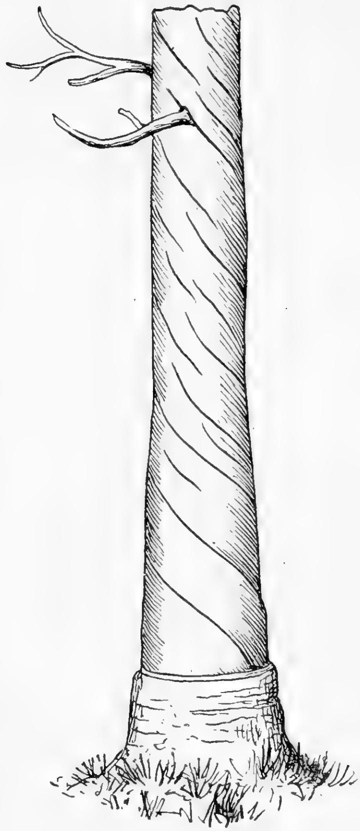


Fig. 80

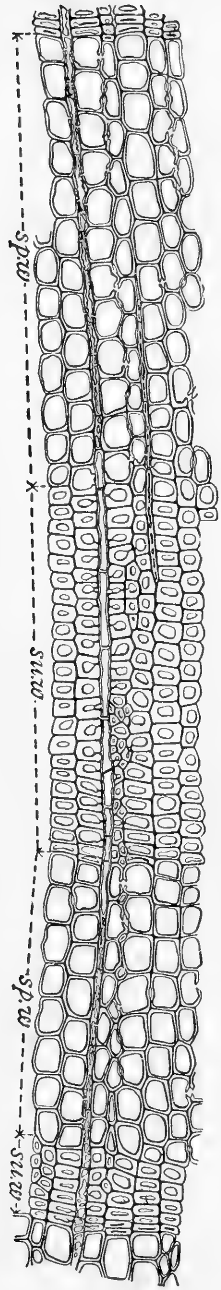


Fig. 81

Fig. 80. Spiral Grain. (Season checks, after removal of bark, indicate the direction of the fibers or grain)

Fig. 81. Shortleaf Pine. (Cross section of parts of two rings)

sp.w., spring wood with thin walls; *su.w.*, summer wood with thick walls. The cells run in rows which extend through several rings. (Magnified about 70 times) running from the bark toward the center, or pith. They are the pith rays. If we examine the side of the board, they look like broad bands if the board is quarter-sawed or rift, and as short brown lines if bastard or tangent.

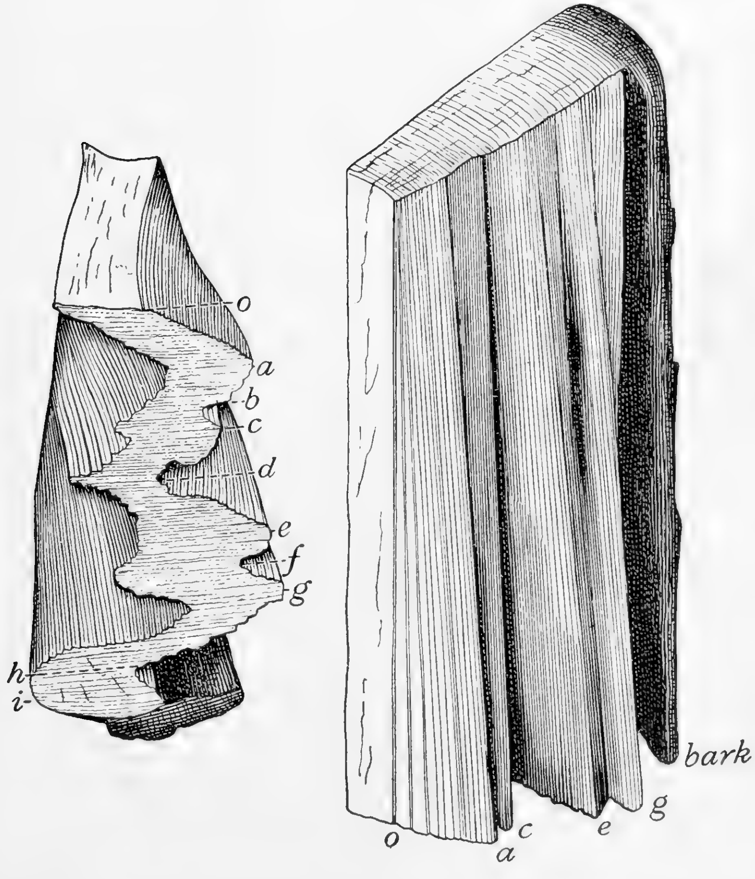


FIG. 82. Alternating Spiral Grain in Cypress. (Side and end view of same piece)

When the bark was at *o* the grain at this point was straight. From that time each year it grew more oblique in one direction, reaching a climax at *a*, and then turned back in the opposite direction. These alternations were repeated periodically, the bark sharing in these changes

In the oak, part of the pith rays are very large, the rest too small to be seen without a magnifying glass; in chestnut they are all small; in beech some are large, some small, as in oak; in maple and cherry most of them are small, but easily seen; in birch they are all too small to be seen without a magnifying glass. Thus, the pith rays, like the pores, are valuable marks by which to distinguish the different woods, and they help to make up the pattern, as is clearly seen on almost every kind of hardwood board.

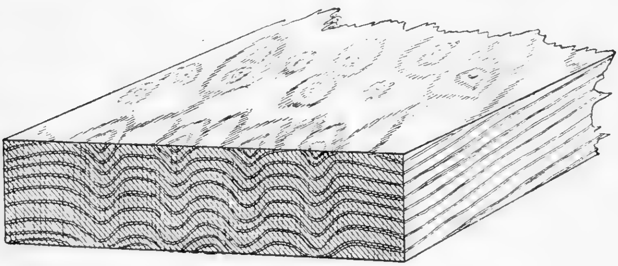


FIG. 83. A "Bird's-eye" Board

The Grain.—The wood of our trees is made up of cells, all of which are little tubes, which have walls of definite thickness and appearance. Each such cell is the abandoned dwelling of a living being, the cell proper, which fed and digested, secreted and worked, built up the little wooden case which we now call cell or fiber, and then died and disappeared. Most cells die during their first year, so that the wood is nearly all made up of little lifeless cases or tubes.

Some of these tubes are short, others long, some have thick walls, some thin, and most of them have their walls more or less sculptured. The long tubes, which make the bulk of the wood, we commonly call fibers, though there are several distinct kinds of these.

Some cells in wood are large enough to be seen with the unaided eye, but most of them are very small and

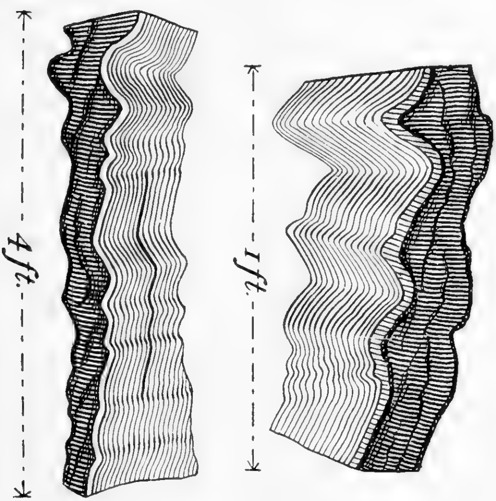


Fig. 84. Wavy Grain in Beech

(After Nördlinger)

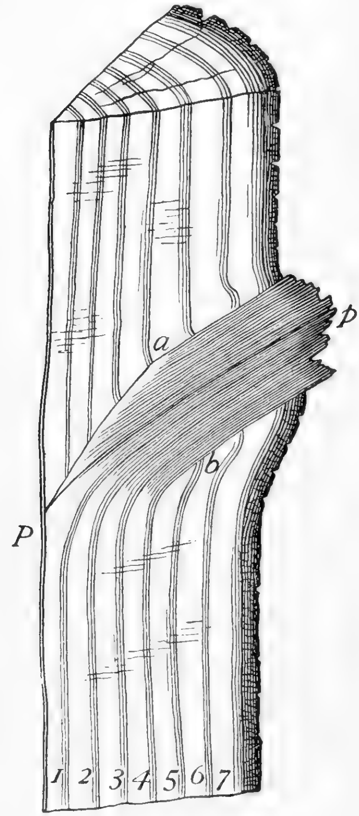


Fig. 85. Section of Knot

P, pith of both stem and limb; 1–7, seven yearly layers of wood; *a*, *b*, knot or basal part of a limb which lived four years, then died and broke off near the stem, leaving the part to the left of *a*, *b* a "sound" knot, the part to the right a "dead" knot, which would soon be entirely covered by the growing stem

can be seen only if much magnified. If the fibers run straight up and down in the log, so that it splits straight, we call it *straight grain;* if they run spirally around as well as up, we call it *spiral* or *twisted grain.* Most logs have more or less twisted grain. Sometimes the fibers twist one way in a number of rings and then in the opposite way in the rings farther out (see Fig. 82), and thus make splitting almost impossible. In maple, cypress, ash, yellow poplar, and many other woods, the surface of the log often is not smooth, but has many little projections (cypress) or depressions (maple, etc.), which continue from year to year, *i.e.*, they do not fill up, and one layer of wood after another has the dent at the same point. Similarly, the fibers often run wavy, as shown in the figure. Now if such wood is cut by the saw in a straight line, the darker summer wood in cypress, or the fibers cut almost transversely in maple and other similar woods, appear at this point as a circle of dark on a field of lighter colored wood, and we have the *bird's-eye* structure. "Curly" maple is wood in which the fibers run in wavy lines, so that part of the fibers are cut across, others cut lengthwise, thus giving bands of darker and lighter shades owing to the darker color of the cross section.

Knots. — The position of the grain and the appearance of knots are explained by Fig. 85.

Knots, like cross grain, are normal defects, and occur in all kinds of trees and nearly all kinds and grades of lumber. A dead knot, of course, is always much more serious, since it may drop out at any time and leave a hole in the structure.

Some Physical Properties

Weight. — Most of our wood is lighter than water, and therefore it floats. But if we leave a piece of wood in water a long time it sinks; and thus we see that the solid or wood substance of which the cell walls are made is heavier than water. If, therefore, the walls of all cells are very thick, the wood, like many of our tropical woods, may never float. Most of our useful timbers float when dry, and the majority weigh about four to seven tenths as much as water, or about twenty-five to forty-three pounds per cubic foot, and hence about two to three and a half pounds per foot, board measure.

Moisture. — When first formed the cell is filled with living substance resembling the white of an egg, so that the freshly formed wood is full of water. In an ordinary log of pine, more than half the cells are empty, but their walls are still moist.

Most of the water in such a log is in the sapwood, but there is much difference in different kinds of trees. Commonly it is supposed that the water in the wood, usually called "sap," goes out of the log in the fall and returns in the spring. The reason for the belief is the fact that many trees bleed in the spring but not in winter. This belief is erroneous, for by actual trial we find that the wood contains about as much water in winter as in summer.

If wood is sawed or split, so that it is exposed to air, this water evaporates. At ordinary temperature, as in a wood shed, it will dry so far that a hundred pounds of wood will contain only about ten pounds of water. If we put this lumber in a hot room or "dry kiln," it dries out still more. When it comes out of the "dry kiln" it absorbs water again, and after a few days may have as much as six pounds per hundred.

Shrinkage. — While drying, the wood shrinks, *i.e.*, it grows smaller. It shrinks about ten times as much sidewise as endwise, and shrinks less radially, *i.e.*, in the direction from the pith to bark, than tangentially, so that a "rift" or "quartered" board shrinks only about one half to two thirds as much as a tangent board.

When a board lies on the wet ground in the sun it dries and shrinks on one side and less or not at all on the other, and therefore curls or warps.

If a peeled log or a thick board dries rapidly the outer part shrinks before the inner, and thus the "jacket" is too small; it bursts, and the wood is said to "check" or crack. After the inner part dries these checks close up; but in larger pieces some stay open and grow larger for a long time. This kind of checks is permanent and is due to the greater shrinkage in the tangential direction.

Coniferous wood shrinks less, warps and checks less than hard wood, and generally heavy woods shrink more than light ones. To avoid the mischief of shrinking we use flooring in narrow strips, so that the change is distributed among many pieces, and the opening among many joints. We also use panels in doors, and veneer in furniture, and for the same reason bore out columns, and build up columns and posts of several pieces.

Strength.—Wood is very strong. To crush a cube of dry wood one inch each way, with the fibers on end, requires about six to ten thousand pounds pressure. It requires only about one third to one half as much if the piece is soaked, or if it is green; for seasoned timber is always stronger than green timber of the same kind.

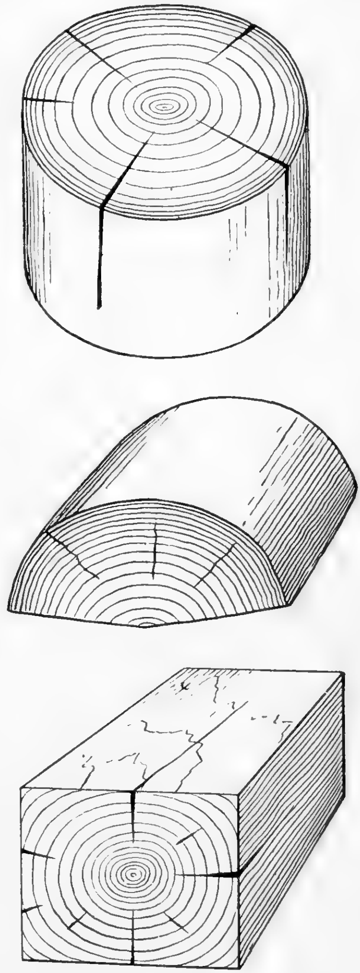


Fig. 86. Effects of Shrinkage

To pull it apart lengthwise, wood requires about twice as much power as to crush it endwise; but to pull it apart sidewise, as when we pull out a mortise, requires only about one tenth as much force as to crush it endwise.

Most conifers break without much bending; but elm, hickory, etc., are strong and yet bend far before they break. We call them *tough woods.*

Heavy woods are generally stronger than lighter woods.

Some Chemical Properties

When sufficiently heated wood burns or oxidizes; and this, while it is not a desirable quality in a building material, is otherwise one of its greatest virtues.

If heated in a close vessel, various substances are made in the form of gases; and, as we have seen, this is taken advantage of by the "acid man."

By means of chemicals wood is easily changed into sugar; and if ever this can be done cheaply enough, wood may become an important source of food.

Durability and Decay. — All kinds of wood are subject to destruction by decay-producing fungi. One of the countless millions of spores of some fungus drops on a timber, and is carried by a raindrop into the interior of a pore. If conditions are favorable, it germinates, grows into a thread of "mycelium"; and this thread, which is a series of living cells, attaches itself closely to the wall of the wood cell, secretes a juice which is capable of dissolving wood, and which changes at least a part of it into sugarlike substances which are taken into the cells of the mycelium as food. Now decay has begun, and in a short time, if beech or maple is the timber, it is penetrated in all directions. At first the wood is merely discolored, and looks "dead"; later on it becomes brittle, and finally it becomes a powdery mass, and in keeping with these changes loses its resistance.

If kept dry or if kept under water, wood does not decay. Charring the wood gives it a wrapper of charcoal, which the fungus cannot penetrate; painting and whitewashing do the same. But if painted before dry, the paint does harm by preventing the timber from drying.

Salts of zinc, copper, and mercury, and heavy oils are used to

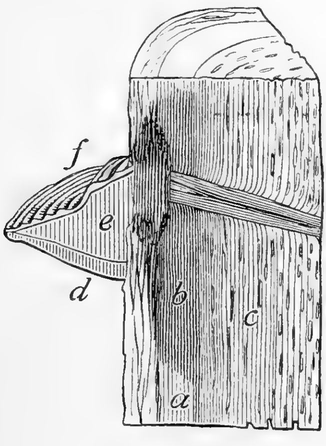


FIG. 87

FIG. 87. "Shelf" Fungus on the Stem of a Pine

a, sound wood; *b*, resinous "light" wood; *c*, partly decayed wood or punk; *d*, layer of living spore tubes; *e*, old filled-up spore tubes; *f*, fluted upper surface of the fruiting body of the fungus, which gets its food through a great number of fine threads (the mycelium), its vegetative tissue penetrating the wood and causing its decay. (After Hartig)

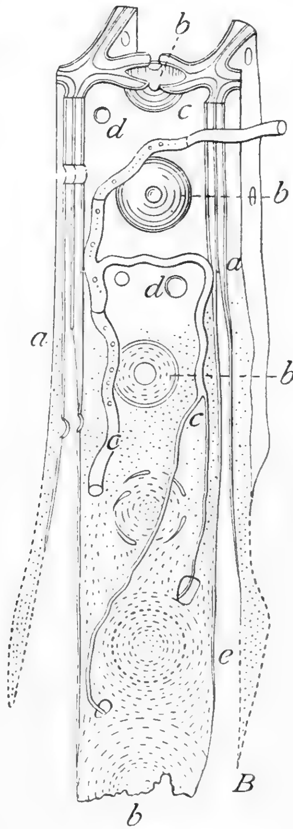


FIG. 88

FIG. 88. Fungus Threads in Pine Wood

a, cell wall of the wood fibers; *b*, bordered pits of these fibers; *c*, thread of mycelium of the fungus; *d*, holes in the cell walls made by the fungus threads, which gradually dissolve the walls as shown at *e*, and thus break down the wood structure. (After Hartig) kill the fungi. Usually the wood is boiled in the solution, or else this is injected into the wood. Railway ties are thus made to last much longer than they otherwise would.

The sapwood of all kinds of trees is very perishable; but the heartwood is usually more or less resistant. No wood is entirely exempt from destruction by decay.

All cedars, cypress, redwood, etc., also locust, walnut, white oak, chestnut, mulberry, and catalpa, make a durable timber; maple, beech, birch, poplar, ash, red oak, hickory, black gum, spruce, balsam, and hemlock are perishable; while white pine, yellow or hard pine, elm, tulip, and red gum seem to have an intermediate position.

In dry countries, like our arid West, even perishable woods last a long time; while in moist and hot districts even durable timber decays fast. Warmth and moisture help, dryness and cold hinder, and full seasoning and complete immersion prevent decay.

Wood as compared with Iron

Much is often learned by comparing a substance with its natural or most important competitor. Examining wood and iron in this way, we find:

1. Wood is a natural product; iron the product of a costly, complicated manufacture. Wood may be grown wherever man wishes to use it; the manufacture of iron is practically confined to particular localities. The mines

of both iron and coal are exhaustible; the forest, under proper management, produces forever.

2. Wood is cheap; metals are dear. Even in the form of lumber, and with the cost of long-distance transportation added, wood rarely costs the consumer in this country more than twenty-five cents per cubic foot; while iron in bars and sheets is worth at wholesale from five to ten dollars per cubic foot.

3. Wood is soft; simple tools and small effort suffice to shape it. Iron is hard; any change of form, whether by casting, rolling, sawing, cutting, planing, turning, filing, boring, or grinding, requires much labor, or else complicated and costly processes and equipments. In the ease and rapidity with which wood can be shaped, reshaped, and combined in structures, it excels all other materials.

4. Wood cleaves or splits; metals do not. While this property has its disadvantages, it is one that in some directions determines the usefulness of wood. It permits ready preparation for fencing and firewood, which latter use exceeds in bulk ten times the amount of iron and steel used in this country.

5. Wood is stronger than is usually supposed. In tensile strength (pull lengthwise or with the grain of the wood) a bar of hickory exceeds a similar bar of wrought iron of the same length and weight, and it even surpasses steel under the same conditions.

Similarly, a select block of hickory or of longleaf pine sustains a greater weight in compression endwise (parallel to the grain of the wood) than a block of wrought iron of the same height and weight, and nearly approaches cast iron in this respect.

6. Wood is light; iron and steel are heavy. The average weight of all wood used in this country does not exceed thirty-one pounds per cubic foot; that of iron and steel is from four hundred and thirty to four hundred and fifty pounds per cubic foot. This quality affects ease of handling and transportation; it permits the floating of most woods when green, and of all of them when dry.

7. Wood is a poor conductor of heat and electricity. Heated to one hundred and fifty degrees Fahrenheit, or cooled below the freezing point of water, iron, steel, and other metals are painful to the touch; and even far within these limits metals are objectionable on account of their ready conductivity of heat. Wood, on the other hand, is entirely inoffensive as long as its temperature remains within the above limits. The objections to metal dwellings on this account are experienced in heavy-armored ships, which, in spite of the excellence of an ocean climate, are notoriously uncomfortable.

When exposed to heat, wood is ignited and destroyed by fire. The inflammability and combustibility of wood at high temperatures, though among its most valuable properties, are, at times, a drawback which metals do not share; nevertheless, during conflagrations the behavior of wooden structures is often less objectionable than that of metal structures; for, though a beam of wood burns, it retains its shape to the last, and the structure may stand and be saved; while under the same circumstances metal beams twist out of shape and thereby occasion the fall of the entire structure. This behavior of wood in conflagration has induced the best authorities, fire underwriters and others, to recommend the use of wood in all large structures where the combustible contents of the rooms annul the value of fireproof metal construction.

If wood were a good conductor of electricity, its usefulness as a material of construction in our large cities would be much impaired, for it appears to be a very serious and constantly growing difficulty to protect life and property against this dangerous but useful force.

8. Woods are normally inoffensive in smell and taste. Liquors and wines of the most delicate flavors are kept in oaken casks for many years without suffering in quality. Chemical changes, often directly producing poison, prevent the use of cheap metals for these purposes.

9. Owing to their structure, all woods present varieties of characteristic aspects, and possess no small degree of beauty. A plain surface of metal, of whatever kind, is monotonous; while one of wood, unless marred by paint, presents such a variety of unobtrusive figures that the eye never tires of seeing them. That this beauty is quite

fully appreciated is best illustrated by the fact that pianos, sideboards, and other elegant furniture are not covered with sheet metal (as they might very cheaply and effectively be), and that the handsome floors of costly structures are neither painted nor carpeted.

10. Wood is easily and effectively united by the simple process of gluing, so that valuable combinations, whether for behavior, strength, or beauty, are possible. A three-ply veneer board may be not only as pretty but also more serviceable than a simple board of any one of the two or three kinds of wood of which it is composed; and a white-pine door with cherry or walnut veneer is not only fully as handsome as a walnut door, but it is far superior in its behavior, since all shrinking and warping is thereby practically prevented. Iron and steel may be welded; most metals can be soldered; but neither of these processes can be compared to gluing in ease of operation.

So far wood has been regarded only as a material of construction; but while this is perhaps the most important consideration, the use of wood as a substance which may be altered physically and chemically is far more important than is generally admitted.

11. The great mass of mankind is warmed and has its food cooked by wood fires. Even in this country to-day, in spite of the great competition of coal, three fourths of all the homes and thousands of manufacturing establishments are supplied with heat from wood.

12. Wood is ground into pulp and made into paper and pulp boards with endless variety of application. Wood pulp, made by chemical processes, results in cellulose and its countless derivatives, which are capable of supplying almost anything, from a shirt collar to a car wheel.

13. Distillation of wood furnishes charcoal to the smithy or furnace; vinegar to the table; alcohol to the artisan; creosote to the wood preserver; gas for fuel and light; tar for roof boards; pyroligneous, oxalic, acetic, and other acids, as well as acetone, paraffin, naphthalin, etc., to the manufacturing chemist; and, by a slight variation of the process, lampblack to the printer and painter.

Wood also differs from the metals in several other respects. It is not fusible; it cannot be cast; hence, to duplicate a form in wood requires the same amount of effort as did the original. Changed into pulp, and still more into cellulose, this drawback is largely overcome. Wood cannot be welded, — though, as stated before, this is more than compensated by gluing; nevertheless, an end-to-end junction of the kind produced in iron cannot be effected.

Wood cannot be rolled; it must be cut into shape; but owing to its softness and cleavability this requires incomparably less effort and equipment than the rolling of metals.

Wood is hygroscopic; it contains water under all ordinary conditions, and the amount so contained varies with external conditions and with it the dimensions of the piece. Though an advantage in a barrel or tube, by making it more secure against leakage, this peculiarity of wood is nevertheless a drawback not belonging to the metals, but corresponding to the drawback in the use of metals occasioned by their annoying expansion and contraction due to change of temperature.

Wood decays; iron and steel oxidize or rust. Both are serious drawbacks to the use of these materials; but since decay depends on living organisms, whose multiplication is sometimes extremely rapid, at other times almost imperceptible, varying with the conditions of the wood (moisture, temperature, etc.), the decay of woods is generally more damaging than the oxidation of metals. Under water, wood lasts longer than steel or iron.

HOW TO DISTINGUISH OUR COMMON TREES

Most of us know a few trees sufficiently well to distinguish one kind from another. Usually it is the general appearance, sometimes the bark or leaf, which we recognize; and often we know the tree only while in its summer dress.

Let us examine our common trees more closely and note wherein they differ.

Here is a red-oak tree. Breaking off a twig, we notice that the leaves are simple and not made up of several leaflets; that they stand singly, not in pairs; and that they are lobed, each lobe with one or two sharp points. Examining the twig of an elm, we find that the leaves are also simple, and alternate, but that they are finely toothed. On this sprig of maple the leaves are in pairs, they stand opposite, and are both lobed and toothed. On the ash we find each leaf made up of several leaflets; it is a compound leaf, and we find the leaves opposite or in pairs, while in the hickory the leaves are also compound but not in pairs.

Thus, the leaves are an excellent guide to the study of trees; and since opposite leaves also leave opposite scars and lead to opposite buds and branches, they help us to know the trees even in their winter garb.

We will arrange our common forest trees according to their leaves, and thus make a key which will help us to recognize them with more certainty. Generally we shall be assisted by the fruit, the twigs, the bark, and the buds; more rarely by the flowers, since these can be seen only during a few days in each year, and in some cases are even then quite difficult to examine.

Looking over our trees, we may at once divide them into two large groups: the evergreen or cone-bearing trees, and the broad-leaved or deciduous trees. These names we must not take too strictly, for some evergreens like the tamarack shed their leaves every fall, and some deciduous trees like live oaks are green the year round.

Our important cone-bearing trees all belong to the pine family. In the pines the leaves are needle-shaped and long (up to twelve inches), while in spruce, balsam, etc., they are short, and in most of our cedars they are mere green scales, closely appressed to the twig.

Arranging the groups of the *pine family* according to leaf, fruit, and bark, we have the following simple scheme:

Conifers

I. Pines, spruces, etc.

Bark smooth or rough but never stringy. Leaves needle-shaped. Fruit a woody cone of many scales.

A. Leaves in bundles or clusters.

a. *Pines.* Leaves in bundles of two to five in a common sheath (Fig. 89). Among pines we have approximately:

(1) Leaves five in a bundle: *white pines* (Fig. 45).

(2) Leaves three in a bundle: *yellow pines* (Fig. 89), including our southern and western lumber pines.

(3) Leaves two in a bundle: *Norway pine, jack pines,* and *piñons.*

b. *Larch* or *Tamarack.* The short, light green leaves, in clusters of ten and more, are not in a common sheath and are deciduous (Fig. 89).

B. Leaves singly scattered over the twig.

1. The cones are pendulous, *i.e.*, hang downward; they cling to the twig for months after they are ripe, and do not fall to pieces by the dropping away of the scales.

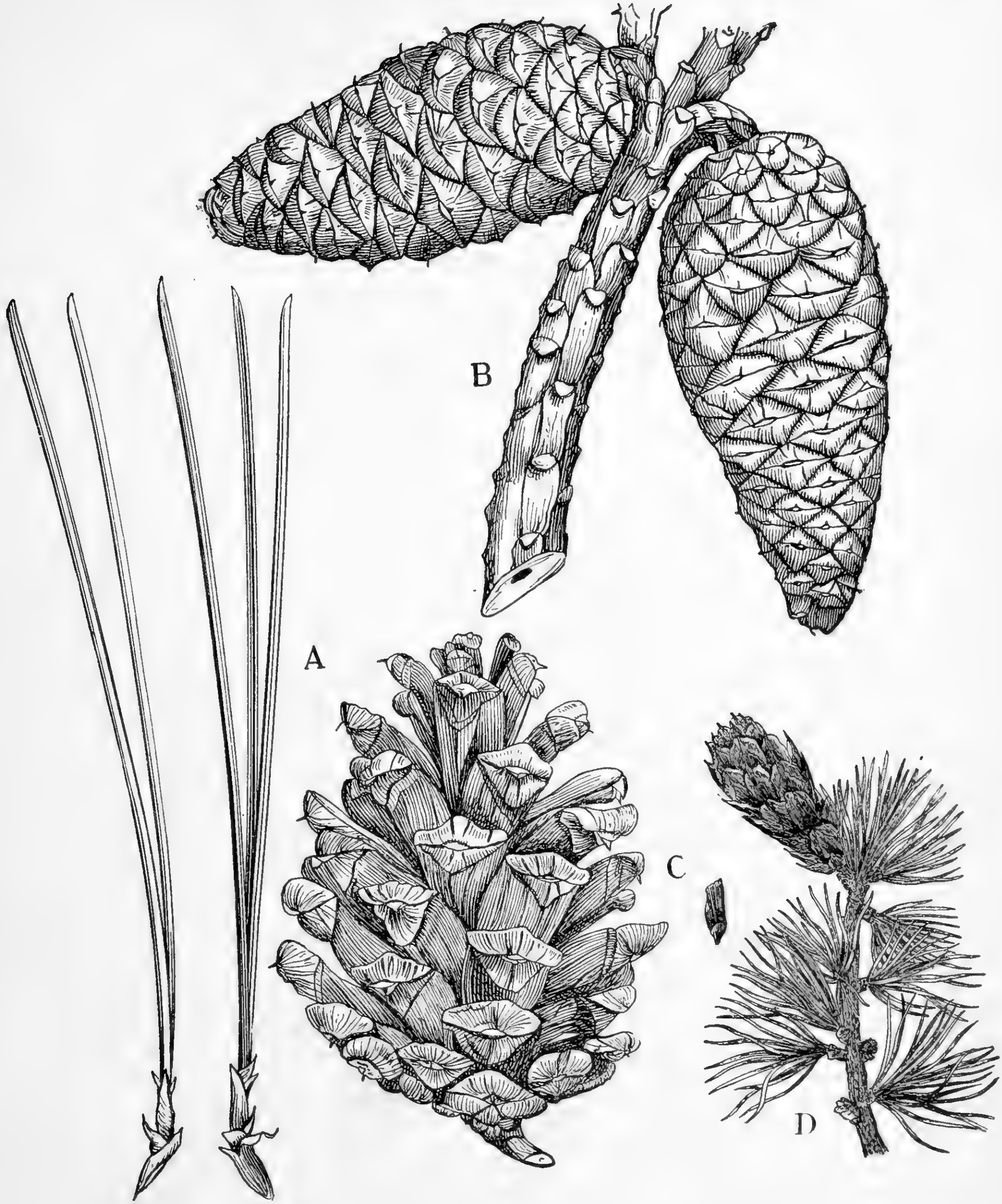


Fig. 89. Conifers with Leaves in Bundles

A, *B*, *C*, shortleaf pine; *D*, larch. *A*, pine leaves in bundles of two and three; *B*, pine cones just about ripe; *C*, old empty pine cone still clinging to branch; *D*, larch; leaves in bundles of ten or more *a. Spruces.* Leaves stiff, mostly four-sided, and pointed; the bark scales are never bright red; the wood is white (Fig. 90, *A*).

b. Hemlocks. Leaves are soft, flat, and short, usually two-ranked so that the sprig appears flat; the bark scales when broken off appear red; the wood has a reddish cast (Fig. 90, *D*).

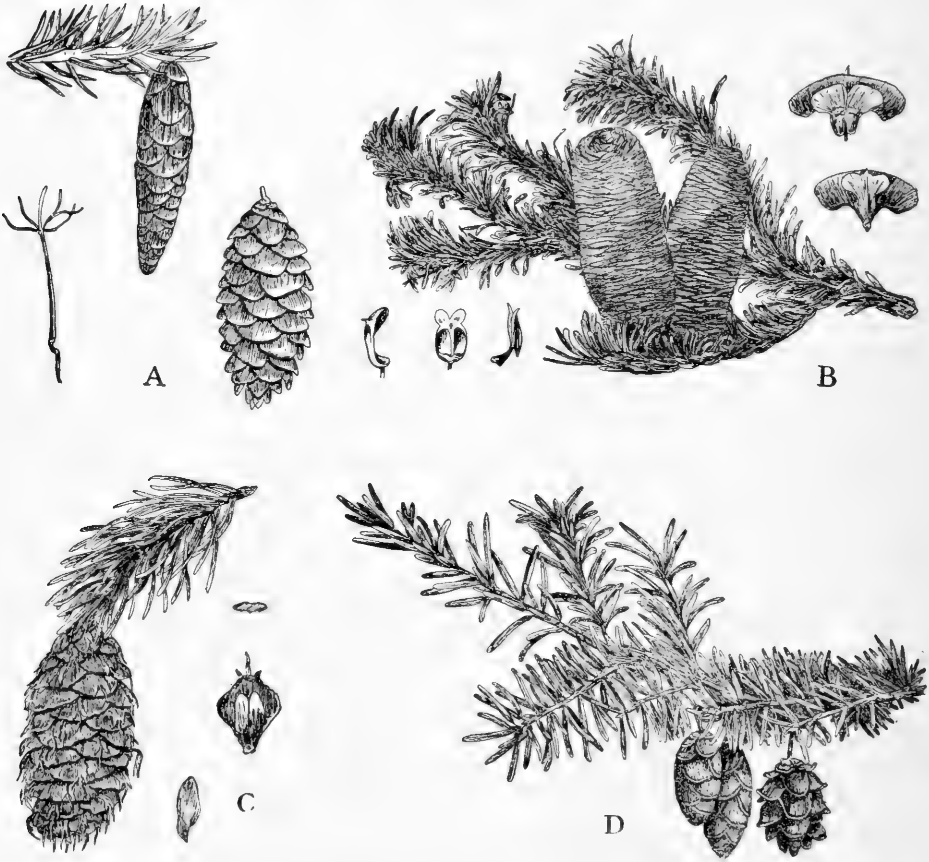


FIG. 90. Conifers with Leaves not in Bundles

A, spruce: leaves stiff and pointed, cones hang *down;* *C*, red fir: leaves soft, cones hang down, bracts protrude like little tongues; *D*, hemlock: leaves short and soft, cones small, bracts do not protrude; *B*, balsam: cones erect, fall apart after ripening, so that no old cones are found on or under the tree. (*A* and *D* after Bureau of Forestry; *B* and C after Beissner)

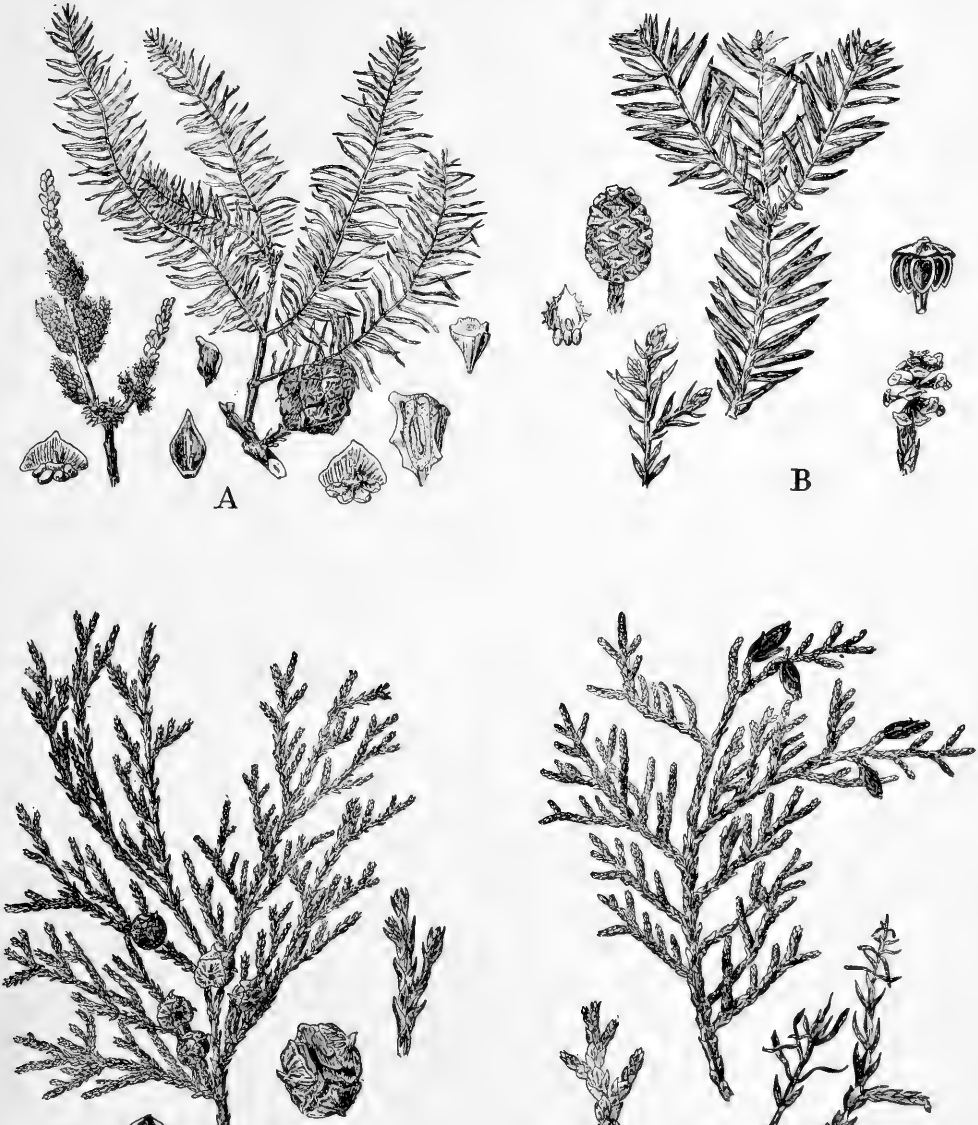


FIG. 91. The Cedars

A, cypress: the leaves deciduous, cones persist; *B*, redwood: the leaves and cones persist; *C*, white cedar: leaves are mere scales, cones spherical: *D*, arbor vitæ: cones small, elongated, but persistent. (All after Beissner) *c. Red Fir.* The leaves are flat, soft; the cones are "feathered" by sharp-pointed bracts projecting from between the cone-scales (Fig. 90, *C*).

2. The cones stand erect on the twig, and fall to pieces soon after ripening, so that no full-sized cones are seen on the trees nor under them except at the time when the cones approach maturity.

d. Balsams or *White Firs.* Leaves mostly soft, flat, and blunt; the bark mostly smooth; the crown dense and sharp-pointed (Fig. 90, *B*).

II. The cedars and their allies.

The bark has a "stringy" appearance, so that all trees of this group are conspicuous on this account. The leaves are needle-shaped or mere scales; the fruit is a small cone, and, in one group, a berry.

A. Leaves needle-shaped.

a. Cypress. Leaves deciduous, the trees bare in winter; the heartwood light brown (Fig. 91, *A*).

b. Redwood. Leaves persistent, the heartwood red (Fig. 91, *B*).

B. Leaves scalelike, appressed.

1. Fruit a persistent woody cone, which can be seen at all times of the year on or under the trees.

a. White Cedars. Cone small, spherical; heartwood light brown (Fig. 91, *C*).

b. Bigtree. Cones quite large; heartwood red.

c. Arbor Vitæs and *Incense Cedar.* Cones elongated; heartwood brownish (Fig. 91, *D*).

2. Fruit a berry, usually of a dark bluish color.

a. Red Cedars. Heartwood red.

FIG. 92. Broad-Leaved Trees with Simple, Alternate, Tooth-Edged Leaves

A, beech; *B*, chestnut; *C*, birch: the little cones fall to pieces when ripe: *D*, poplar: the fruit borne on catkins. (*A*, *C*, and *D* from Britton and Brown's "Illustrated Flora of the United States and Canada." *B* from Schwartz' "Forstliche Botanik")

Broad-Leaved Trees

I. Leaves simple (not compound, *i.e.*, not made up of several leaflets).

A. Leaves alternate, not in pairs.

1. The edge of the leaf toothed.

a. *Beech.* Trees with smooth, grayish green bark; fruit a small prickly bur (Fig. 92, *A*).

b. *Chestnut.* Large trees with rough bark; fruit a large prickly bur, often two inches wide (Fig. 92, *B*).

c. *Birches.* Trees generally with smooth whitish bark, which in most kinds curls up and peels off in thin layers. The bark of the twigs when chewed tastes of wintergreen. Fruit a small soft cone, resembling that of conifers, and falling apart when ripe (Fig. 92, *C*), thus strewing the ground with the small crosslike scales and the tiny winged seeds.

d. *Poplars* and *Cottonwoods.* Bark smooth on young trees and on limbs, rough on older stems; wood soft and white, very brittle. The fruit is very small and borne on little perishable catkins resembling willow "pussies" (Fig. 92, *D*), so that it is not ordinarily met with either on or under the tree.

e. *Elms.* Bark dark brown, rough; the fruit, which ripens in spring, is shed and blown away at once, so that it is not commonly seen; the wood is yellowish to reddish brown when fresh, and is very tough (Fig. 93, *A*).

f. *Basswood.* Bark gray and rough, with a tough stringy inner portion, the bast. The fruit is a small round berrylike nut, of which two or more are attached to a long stem coming out of a narrow, specially modified leaf. These leaves and nuts endure for months on and under the tree (Fig. 93, *B*).

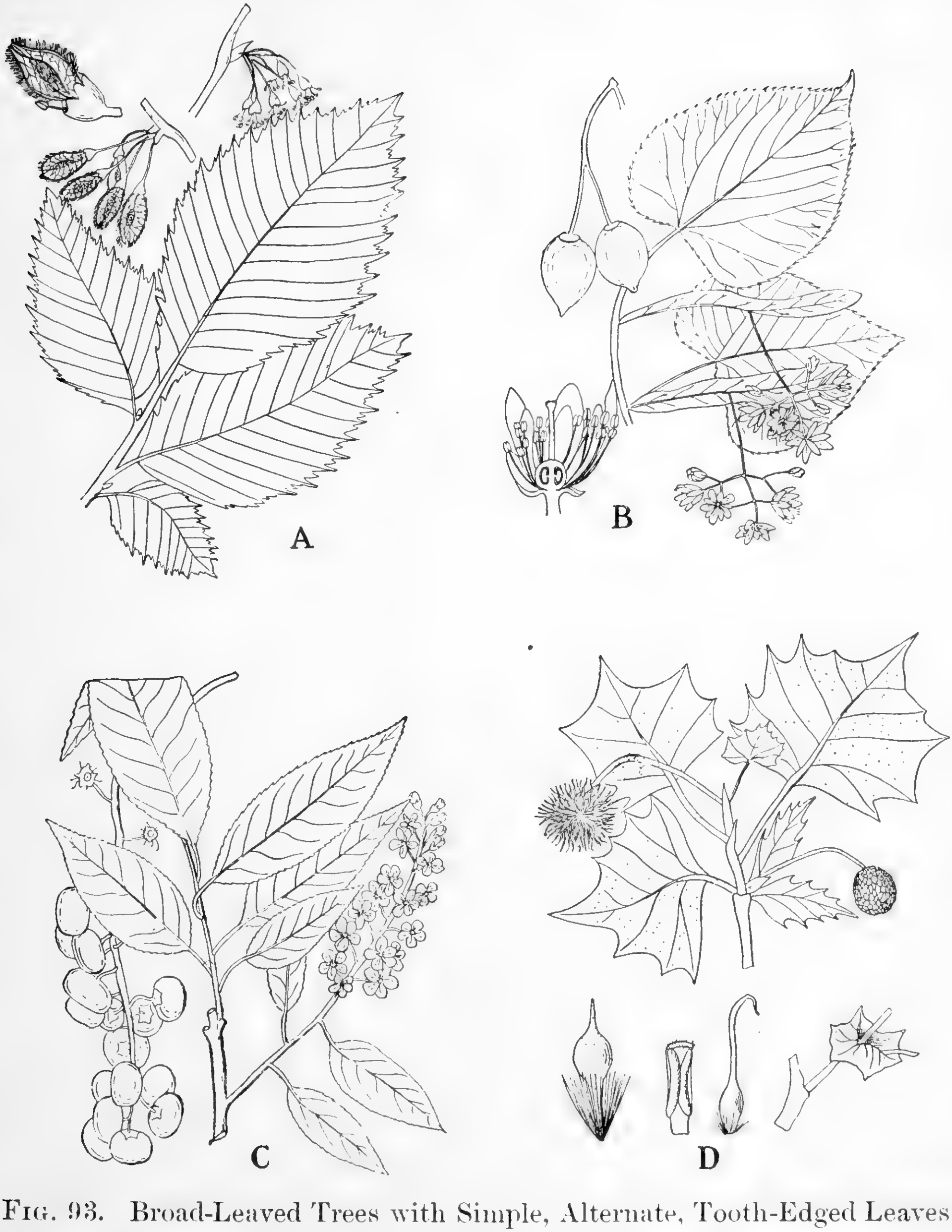


FIG. 93. Broad-Leaved Trees with Simple, Alternate, Tooth-Edged Leaves

A, Elm: fruit ripens in spring; *B*, basswood: fruit persists; *C*, cherry: bark tastes of almond; *D*, sycamore: fruit conspicuous and persistent. (After Britton and Brown's "Illustrated Flora of the United States and Canada") *g. Cherry.* Bark scaly, of dark color, its inner part with a taste of cherry seeds; heartwood of reddish color and hard. The fruit is so perishable that it helps us to distinguish the tree only for a short time in summer (Fig. 93, *C*).

h. Sycamore or *Button Tree.* Bark whitish to greenish gray, smooth, peeling off more or less regularly and thus gives the tree a very conspicuous appearance. The peculiar fruit (Fig. 93, *D*) persists all through winter and thus helps us to recognize this tree.

2. The edge of the leaf lobed.

i. Oaks. The bark of the older trees is rough; the fruit, or acorn, is similar in all kinds of oaks, consisting of a scaly cup and a leathery smooth berry or nut containing the fleshy seed. There are three distinct groups of oaks: the white oaks, red oaks (including the so-called black oaks) and the live oaks. In the different kinds of red and white oaks the leaves vary considerably in size and shape; some are large and much lobed, others small and almost or entirely without lobes, so that a part of the oaks might well be treated under another group.

The following scheme helps to separate the principal groups of oaks.

(1) Leaves with bristlelike tips on their lobes, or at their tips if entire: *red oaks.*

(*a*) Leaves large, much lobed: *red, scarlet, black,* and *Spanish oaks* (Fig. 94, *A*).

(*b*) Leaves broad, little lobed: *black jack* and *water oaks.*

(*c*) Leaves mostly entire, narrow, pointed, bristle-tipped: *willow, laurel,* and *shingle oak* (Fig. 94, *C*).

Fig. 94. Broad-Leaved Trees with Simple, Alternate, but Lobed Leaves

A, red oak; *B*, white oak; *C*, willow oak; *D*, live oak (this latter really belongs in the next group of trees, if classed by its leaves). (*A*, *C*, and *D* after Dippel; *B* from Britton and Brown's "Illustrated Flora of the United States and Canada")

(2) Leaves large, lobed, the tip of the lobes rounded and not pointed or bristle-tipped: *white, bur,* and *post oak* (Fig. 94, *B*).

(3) Leaves crenate or toothed, resembling those of chestnut: *chestnut oaks,* including the *cow oak* (Fig. 95, *A*).

(4) Leaves small, rounded, leathery, and evergreen: *live oaks* (Fig. 94, *D*). Really belonging to group 3.

j. *Tulip* or *Yellow Poplar.* A rough-barked tree with a leaf so peculiar in shape (Fig. 95, *C*) that it is never mistaken for any other. The flower resembles a tulip, is green and yellow; the fruit is a cone which persists all through winter.

k. *Sweet* or *Red Gum.* Trees with long-stalked, five-lobed, finely toothed leaves and rough, long-stalked little balls for fruit. The fruit persists a long time after ripening, so that it may be seen all winter (Fig. 95, *D*).

l. *Sassafras.* Trees with large entire edged leaves, most of which have one large lobe, giving them somewhat the shape of a mitten, while some leaves have two lobes and some have none. Fruit a blue berry ripening in summer (Fig. 95, *B*).

3. The edge of the leaf neither lobed nor toothed.

m. *Magnolias,* including the *Cucumber Tree.* Leaves very large (often more than twelve inches long); flowers large and showy; fruit a soft-scaled cone (Fig. 96, *A*).

n. *Tupelo; Black* or *Sour Gums.* Trees of the swamps, chiefly of the South, with bluish or blackish berries, each containing a stone or pit. In the cotton gum, or large tupelo, some of the leaves have one or a few irregularly disposed notches (Fig. 96, *B*).

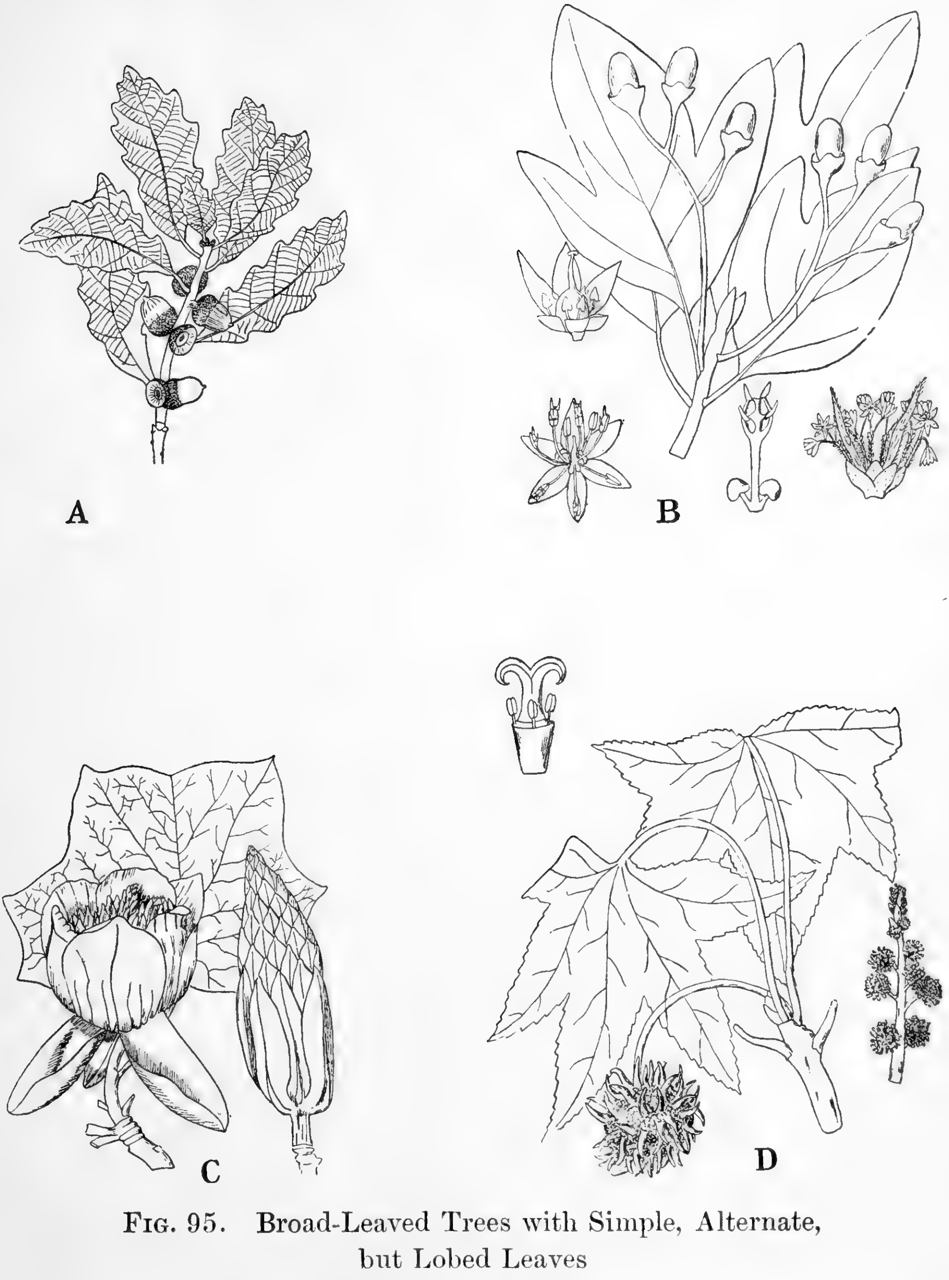


FIG. 95. Broad-Leaved Trees with Simple, Alternate, but Lobed Leaves

A, chinquapin oak; *B*, sassafras; *C*, tulip poplar: cones persist all winter; *D*, sweet gum: fruit persists. (*A* after Dippel; *B*, *C*, and *D* from Britton and Brown's "Illustrated Flora of the United States and Canada")

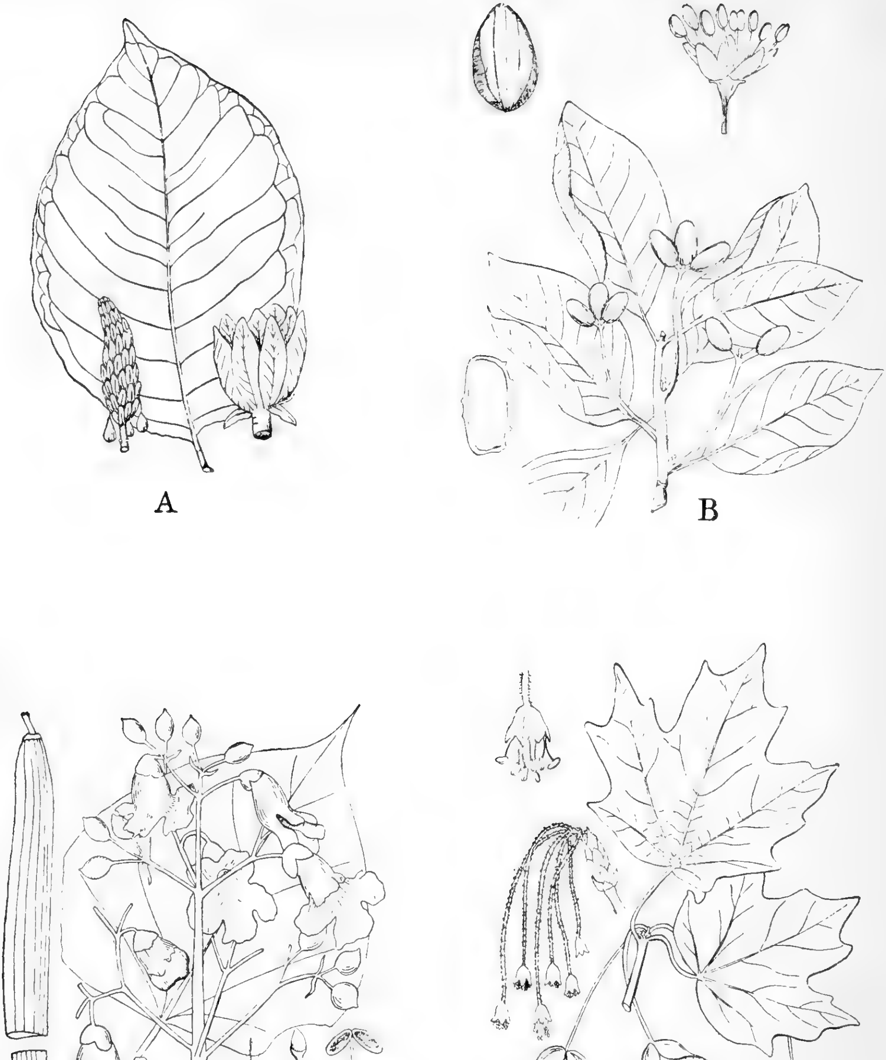


Fig. 96. Leaves Simple, Alternate, but with Entire Edge, and Trees with Opposite Leaves

A, magnolia; *B*, tupelo, or sour gum; *C*, catalpa: leaves with edges entire, fruit a long pod: *D*, sugar maple: leaves lobed, fruit two-pronged, winged. (From Britton and Brown's "Illustrated Flora of the United States and Canada")

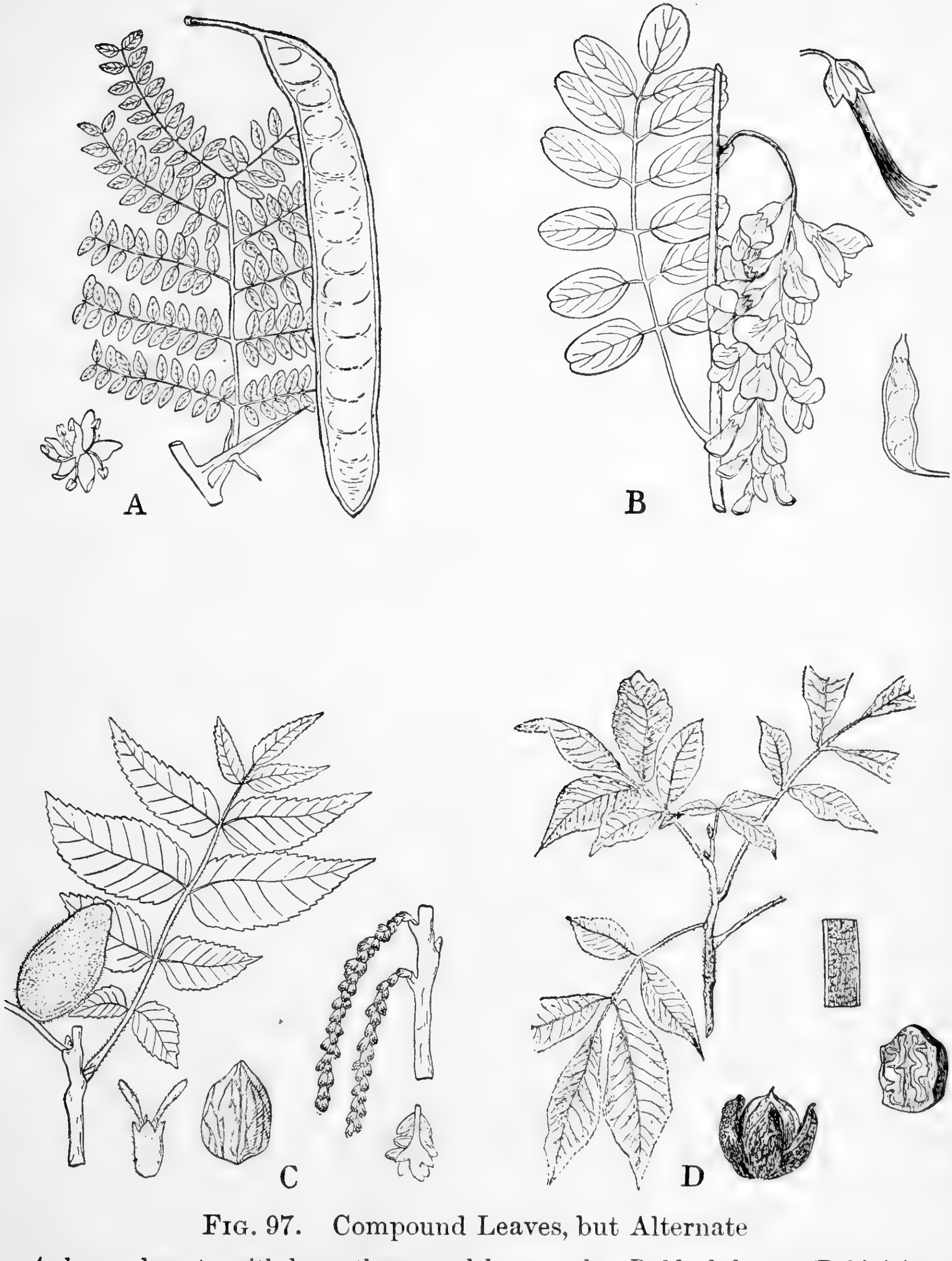


FIG. 97. Compound Leaves, but Alternate

A, honey locust: with large thorns and large pods; *B*, black locust (Robinia): small pods and thorns; *C*, butternut; *D*, hickory. (*A*, *B*, and *C* from Britton and Brown's "Illustrated Flora of the United States and Canada"; *D* after Dippel)

B. Leaves opposite or in pairs.

a. *Maples.* Rough-barked trees, with five-lobed, notched or toothed leaves, and a peculiarly shaped winged twin-fruit, which is so persistent that it may serve in most cases to identify the tree (Fig. 96, *D*).

b. *Catalpa* or *Indian Bean.* Leaves large, entire (occasionally three-lobed); flowers in large clusters, very showy; fruit a long (twelve inches and more) brown pod, resembling that of the bean (Fig. 96, *C*).

II. Leaves compound, or made up of several leaflets.

A. Leaf feather-shaped, the leaflets arranged on two sides of a straight stem (Fig. 97, *A*).

1. Leaves alternate.

a. The edge of the leaflets entire, *i.e.*, not toothed.

Locusts (Fig. 97, *A* and *B*). Of these, the *honey locust* has large thorns and broad brown pods six to ten inches long; and the *black locust*, or *Robinia*, has practically no thorns, and small pods two to three inches in length.

b. The edge of the leaflets toothed.

Walnuts and *Hickories*, including *Pecan.* In the walnut, black walnut, and white walnut, or butternut, there are usually thirteen to twenty-three leaflets to one leaf and the husk of the nut does not split open along definite lines; in the hickories, including the pecan, the husk opens along well-defined lines and the number of leaflets varies usually from five to nine, being nine to fifteen only in the pecan and water hickory (Fig. 97, *C* and *D*).

Fig. 98. Compound Leaves, Opposite

A, box elder: fruit of maple; *B*, white ash: the fruit persists all through winter; compound leaves, palmate; *C*, buckeye, or horse-chestnut. (From Britton and Brown's "Illustrated Flora of the United States and Canada")

2. Leaves opposite.

   a. *Ashes.* Rough-barked trees, with the leaflets of their leaves entire or toothed and the singularly shaped winged fruit in persistent clusters (Fig. 98, *B*).

   b. *Box Elder.* This tree is really one of the maples, has a typical maple fruit which clings to the twigs all through winter, but has a compound leaf, consisting of three to five, toothed or notched leaflets (Fig. 98, *A*).

B. The compound leaf palmate, its leaflets arranged like the fingers of the hand.

Buckeye or *Horse-Chestnut*, well illustrated by the common European horse-chestnut, whose large buds and large, smooth chestnut-brown nut inside of a prickly bur are familiar to every one (Fig. 108 *C*).

How to use the Key

It is early fall; the leaves are still on our broad-leaved trees. Here is a tree; what may be its name? Let us get a twig and examine it. It has simple, toothed leaves; they are alternate (not in pairs), there is no fruit, the bark of the tree is dark and rough, the twigs are tough. Let us glance over our Key.

Evidently it belongs to the broad-leaved trees, and to the first group under I, *A*, 1.

Were it beech, chestnut, sycamore, basswood, or birch, we should find some fruit on or under the tree.

For poplar the bark is too dark, the twigs too dark and tough; so it must be either cherry or elm. Let us cut into the bark and taste its inner part. Evidently it has no cherry-seed taste, and moreover the bark is not scaly. Hence we conclude it to be an elm.

It is late in the fall, the leaves are largely shed, but there is no snow on the ground. Here is a rough-barked tree, and we would like to know its name.

There are a few small bean pods clinging to some of its twigs, the tree is not thorny, and on the ground we find some compound leaves. Looking over our Key, we note that we have only two kinds of trees with bean-pod-like fruits, — the catalpa and the locusts.

Having evidently had compound leaves, we decide it to be a locust, and since the pods are small and the tree is not beset with large thorns, it must be a black locust.

Here is a cone-bearing tree. The needle-shaped leaves are in bundles, five leaves in one sheath. From our Key we see that this evergreen is evidently a pine, and that it belongs to the white pines.

Here is a small evergreen with scalelike leaves; the bark is "stringy," but there is no fruit either on or under the tree. Let us cut off one of the larger limbs; the wood is reddish in the inner or heartwood portion. Going over our Key, we place it at once among the cedars; and, finding a red heartwood in this small gnarly tree, we conclude it to be a red cedar, whose berries have been eaten by the birds so that we could not find any fruit.

In this way some practice will soon enable us to tell our common trees with ease, and we shall then be better prepared to learn how these different trees behave and what they need. Having gained this enjoyable familiarity with our friends, we are able to learn for ourselves what is required to make them produce the largest amount of the most valuable material in the shortest time and at the least expense.

APPENDIX I

THE DOYLE–SCRIBNER LOG SCALE

Inches in Diameter	12 Feet Long	14 Feet Long	16 Feet Long	Inches in Diameter	12 Feet Long	14 Feet Long	16 Feet Long
10	27	32	36	**36**	768	896	1024
11	37	43	49	**37**	817	953	1089
12	48	56	64	**38**	867	1011	1156
13	61	71	81	**39**	910	1070	1225
14	75	88	100	**40**	972	1134	1296
15	91	106	121	**41**	1027	1198	1369
16	108	126	144	**42**	1083	1264	1444
17	127	148	169	**43**	1141	1331	1521
18	147	171	196	**44**	1200	1400	1600
19	169	197	225	**45**	1261	1471	1681
20	192	224	256	**46**	1323	1544	1764
21	217	253	289	**47**	1387	1618	1849
22	243	283	324	**48**	1452	1694	1936
23	271	313	359	**49**	1519	1772	2025
24	300	350	400	**50**	1587	1850	2116
25	331	386	441	**51**	1657	1933	2209
26	363	423	484	**52**	1728	2016	2304
27	397	463	530	**53**	1801	2101	2401
28	432	504	576	**54**	1875	2187	2500
29	469	547	625	**55**	1951	2276	2601
30	507	591	676	**56**	2028	2366	2704
31	547	638	729	**57**	2107	2458	2809
32	588	686	784	**58**	2187	2551	2916
33	631	736	841	**59**	2269	2647	3025
34	675	787	900	**60**	2352	2744	3136
35	721	841	961				

Example: If the log is 22 inches in diameter at the smaller end and is 14 feet long, look for 22 inches under Diameter, and you will see in the column under 14 feet 283, which is the number of board feet in this log.

If the log is 18 feet long, it contains $\frac{18}{12}$ as much as a 12-foot log.

Logs 24 feet and over should be measured every 16 feet, or fraction thereof. This is not generally done, but neglect to do so causes much inaccuracy.

APPENDIX II

TABLE OF CIRCLES

Inches in Diameter	Area in Square Feet	Inches in Diameter	Area in Square Feet	Inches in Diameter	Area in Square Feet
2	0.022	26	3.68	50	13.63
4	0.087	28	4.27	52	14.74
6	0.196	30	4.90	54	15.90
8	0.349	32	5.58	56	17.10
10	0.545	34	6.30	58	18.34
12	0.785	36	7.06	60	19.63
14	1.069	38	7.87	62	20.96
16	1.396	40	8.72	64	22.34
18	1.767	42	9.62	66	23.75
20	2.181	44	10.55	68	25.22
22	2.639	46	11.54	70	26.72
24	3.141	48	12.56	72	28.67

APPENDIX III

LIST OF THE MORE IMPORTANT WOODS AND TREES OF THE UNITED STATES

[Arranged alphabetically]

A. — CONIFEROUS WOODS

Woods of simple and uniform structure, generally light and soft, but stiff; abundant in suitable dimensions and forming by far the greatest part of all the lumber used.

CEDAR. — Light, soft, stiff, not strong, of fine texture; sap and heart wood distinct, the former lighter, the latter a dull grayish brown, or red. The wood seasons rapidly, shrinks and checks but little, and is very durable. Used like soft pine, but owing to its great durability preferred for shingles, etc. Small sizes used for posts, ties, etc.[1] Cedars usually occur scattered, but they form, in certain localities, forests of considerable extent.

a. **White cedars.** — Heartwood a light grayish brown.

THE ARBOR VITÆS AND INCENSE CEDAR

1. WHITE CEDAR (*Thuja occidentalis*) (arbor vitæ): Scattered along streams and lakes, frequently covering extensive swamps; rarely large enough for lumber, but commonly used for posts, ties, etc. Maine to Minnesota and northward.

2. CANOE CEDAR (*Thuja gigantea*) (usually called *red cedar* in the West): In Oregon and Washington a very large tree, covering

[1] Since almost all kinds of woods are used for fuel and charcoal, and in the construction of fences, sheds, barns, etc., the enumeration of these uses has been omitted in this list.

extensive areas; in the mountains smaller, skirting the water courses; an important lumber tree. Washington to northern California and eastward to Montana.

3. WHITE CEDAR (*Libocedrus decurrens*) (incense cedar): A large tree, abundantly scattered among pine and fir; wood fine grained. Cascade and Sierra Nevada Mountains of Oregon and California.

THE WHITE CEDARS PROPER

4. WHITE CEDAR (*Chamæcyparis thyoides*) (often called *juniper*): Medium-sized tree; wood very light and soft. Along the coast from Maine to Mississippi.

5. WHITE CEDAR (*Chamæcyparis lawsoniana*) (Port Orford cedar, Oregon cedar, Lawson's cypress, ginger pine): A very large tree, extensively cut for lumber; heavier and stronger than the preceding. Along the coast line of Oregon.

6. YELLOW OR ALASKA CEDAR (*Chamæcyparis nootkatensis*): Medium- to large-sized tree. Mountains of Washington, coast from Puget Sound northwards.

b. **Red cedars.** — Heartwood red.

1. RED CEDAR (*Juniperus virginiana*) (Savin juniper): Similar to white cedar, but of somewhat finer texture. Used in cabinet-work, in cooperage, for veneers, and especially for lead pencils, for which purpose alone several million feet are cut each year. A small- to medium-sized tree scattered through the forests, or, in the West, sparsely covering extensive areas (cedar brakes). The red cedar is the most widely distributed conifer of the United States, occurring from the Atlantic to the Pacific and from Florida to Minnesota, but attains a suitable size for lumber only in the Southern, and more especially the Gulf States.

2. REDWOOD (*Sequoia sempervirens*): Wood in its quality and uses like white cedar; the narrow sapwood whitish; the heartwood light red, soon turning to brownish red when exposed. A very large tree, limited to the coast ranges of California, and forming considerable forests, which are rapidly being converted into lumber.

CYPRESS.

Cypress (*Taxodium distichum*) (bald cypress; black, white, and red cypress): Wood in appearance, quality, and uses similar to white cedar. "Black cypress" and "white cypress" are dark and light forms of the same species. The cypress is a large deciduous tree, occupying much of the swamp and overflow land along the coast and rivers of the Southern States.

FIR. — This name is frequently applied to wood and to trees which are not fir; most commonly to spruce, but also, especially in English markets, to pine. It resembles spruce, but is easily distinguished from it, as well as from pine and larch, by the absence of resin ducts. Quality, uses, and habits similar to spruce. The trees furnishing this wood are generally called balsams.

1. Balsam (*Abies balsamea*): A medium-sized tree, scattered throughout the northern pineries; cut, in lumber operations whenever of sufficient size, and sold with pine or spruce. Minnesota to Maine and northward.

2. Balsam or white fir (*Abies grandis* and *Abies concolor*): Medium- to very large-sized tree, forming an important part of some of the western mountain forests. The former occurs from Vancouver to central California and eastward to Montana; the latter from Oregon to Arizona and eastward to Colorado and New Mexico.

3. Mountain balsam (*Abies amabilis*): Good-sized tree, often forming extensive mountain forests. Cascade Mountains of Washington and Oregon.

4. Balsam or white fir (*Abies nobilis*) (sometimes called *red fir;* not to be confounded with Douglas fir or red fir): Large to very large tree; occurs with *A. amabilis* in the forests on the slope of the mountains between three thousand and four thousand feet elevation. Cascade Mountains of Oregon.

5. Balsam or white fir (*Abies magnifica*): Very large tree, in forests about the base of Mount Shasta. Sierra Nevada Mountains of California, from Mount Shasta southward.

HEMLOCK. — Light to medium weight, soft, stiff but brittle, commonly crossgrained, rough, and splintery; sapwood and heartwood not well defined; the wood of a light reddish gray color, free from rosin ducts, moderately durable, shrinks and warps considerably, wears rough, retains nails firmly. Used principally for dimension stuff and timbers. Hemlocks are medium- to large-sized trees, commonly scattered among broad-leaved trees and conifers, but often forming forests of almost pure growth.

1. Hemlock (*Tsuga canadensis*): medium-sized tree; furnishes almost all the hemlock of the eastern market. Maine to Wisconsin; also following the Alleghenies southward to Georgia and Alabama.

2. Hemlock (*Tsuga mertensiana*): Large-sized tree; wood claimed to be heavier and harder than the eastern form and of superior quality. Washington to California and eastward to Montana.

LARCH or TAMARACK. — Wood similar to hard pine in appearance, quality, and uses, and, owing to its durability, used in shipbuilding, and for telegraph poles and railroad ties. Our eastern tamarack is not fully appreciated; the western form is used extensively as ordinary lumber. In its structure it resembles spruce. The larches are deciduous trees, occasionally covering considerable areas, but usually scattered among other conifers.

1. Tamarack (*Larix laricina*) (hackmatack): Medium-sized tree, often covering swamps. Maine to Minnesota, and southward to Pennsylvania.

2. Tamarack (*Larix occidentalis*): Large-sized trees, scattered, locally abundant. Washington and Oregon to Montana.

PINE. — Very variable, very light and soft in "soft" pine, such as white pine; of medium weight to heavy, and quite hard in "hard" pine, of which longleaf or Georgia pine is the extreme form. Usually it is stiff, very strong, of even texture, and more or less resinous. The sapwood is yellowish white; the heartwood, orange brown. Pine shrinks moderately, seasons rapidly and without much injury; it works easily; is never too hard to nail (unlike oak or hickory); it is mostly quite durable and, if well seasoned, is not subject to the attacks of boring insects. The heavier the wood, the darker, stronger, and harder it is, and the more it shrinks and checks. Pine is used more extensively than any other kind of wood. It is the principal wood in common carpentry, as well as in all heavy construction, — bridges, trestles, etc. It is also used in almost every other wood industry: for spars, masts, planks, and timbers in shipbuilding, in car and wagon construction, in cooperage, for crates and boxes, in furniture work, for toys and patterns, railway ties, water pipes, excelsior, etc. Pines are usually large trees with few branches, the straight, cylindrical, useful stem forming by far the greatest part of the tree; they occur gregariously, forming vast forests, a fact which greatly facilitates their exploitation. Of the many special terms applied to pine as lumber, denoting sometimes differences in quality, the following deserve attention:

"White pine," "pumpkin pine," "soft pine," in the eastern markets refer to the wood of the white pine (*Pinus strobus*); on the Pacific coast to that of the sugar pine (*Pinus lambertiana*), and in the northern Rockies to the white pine (*Pinus monticola*).

"Yellow pine" is applied in the trade to all the southern lumber pines; in the Northeast it is also applied to the pitch pine (*Pinus rigida*); in the West it refers mostly to *Pinus ponderosa*.

"Yellow longleaf pine," "Georgia pine," chiefly used in advertisement, refers to longleaf pine (*Pinus palustris*).

"Hard pine" is a common term in carpentry, and applies to everything except white pine.

"Pitch pine" includes all southern pines and also the true pitch pine (*Pinus rigida*), but is mostly applied, especially in foreign markets, to the wood of the longleaf pine (*Pinus palustris*).

a. Soft pines.

1. WHITE PINE (*Pinus strobus*): Large- to very large-sized tree; for the last fifty years the most important timber tree of the Union, furnishing the best quality of soft pine. Minnesota, Wisconsin, Michigan, New England, and along the Alleghenies to Georgia.

2. SUGAR PINE (*Pinus lambertiana*): A very large important lumber tree. Oregon and California.

3. WHITE PINE (*Pinus monticola*): A large tree, at home in Montana, Idaho, and the Pacific States.

4. WHITE PINE (*Pinus flexilis*): A small tree, scattered in the mountain forests of the eastern Rocky Mountain slopes, Montana to New Mexico.

b. **Hard pines.**

1. LONGLEAF PINE (*Pinus palustris*) (Georgia pine, yellow pine, long straw pine, etc.): Large tree; forms extensive forests and furnishes the hardest and strongest pine lumber in the market. Coast region from North Carolina to Texas.
2. YELLOW PINE (*Pinus ponderosa*): Medium- to very large-sized tree, forming extensive forests in the Pacific and Rocky Mountain regions; furnishes most of the hard pine of the West; sapwood wide; wood very variable.
3. LOBLOLLY PINE (*Pinus tæda*) (shortleaf pine, old field pine, rosemary pine, sap pine, etc.): Large-sized tree, forms extensive forests; wider ringed, coarser, lighter, softer, with more sapwood than the longleaf pine, but the two often confounded. This is the common lumber pine from Virginia to South Carolina, and is found extensively in Arkansas and Texas. Southern States and Virginia to Texas and Arkansas.
4. NORWAY PINE (*Pinus resinosa*): Large-sized tree, usually scattered or in small groves, together with white pine; largely sapwood and hence not durable. Minnesota to Michigan, also New England to Pennsylvania.
5. SHORTLEAF PINE (*Pinus echinata*) (North Carolina pine, yellow pine, etc.): Resembles loblolly pine; often approaches in its wood the Norway pine. The common lumber pine of Missouri and Arkansas. North Carolina to Texas and Missouri.
6. CUBAN PINE (*Pinus cubensis*) (slash pine): Resembles longleaf pine, but commonly has wider sapwood and coarser grain; does not enter the markets to any great extent. Along the coast from South Carolina to Louisiana.
7. BULL PINE (*Pinus jeffreyi*) (black pine): Large-sized tree, tree and wood resembling yellow pine (*Pinus ponderosa*); used locally in California, replacing *Pinus ponderosa* at high altitudes.

The following are small- to medium-sized pines known generally as *jack pines*, not commonly offered as lumber in the market; used locally for timber, ties, etc.:

8. JACK PINE (*Pinus murrayana*) (lodge-pole pine, black pine, white pine, tamarack): Rocky Mountains and Pacific regions.

9. Pitch pine (*Pinus rigida*): Along the coast from New York to Georgia and along the mountains to Kentucky.
10. Scrub, jack, or Jersey pine (*Pinus virginiana*) (scrub pine): As before.
11. Jack pine (*Pinus divaricata*) (scrub pine): Maine, Vermont, and Michigan to Minnesota.

REDWOOD. (*See* Cedar.)

SPRUCE. — Resembles soft pine, is light, soft, stiff, moderately strong, less resinous than pine; has no distinct heartwood, and is of whitish color. Used like soft pine, but also employed as resonance wood and preferred for paper pulp. Spruces, like pines, form extensive forests; they are more frugal, thrive on thinner soils, and bear more shade, but usually require a more humid and colder climate.

1. Red or black spruce (*Picea mariana*): Medium-sized tree; forms extensive forests in northeastern United States and in British America; occurs scattered or in groves, especially in low lands throughout the northern pineries. Important lumber tree in eastern United States. Maine to Minnesota, British America, and on the Alleghenies to North Carolina.
2. White spruce (*Picea canadensis*): Generally associated with the preceding; grows largest in Montana and forms the most important tree of the subarctic forest of British America. Northern United States, from Maine to Minnesota, also from Montana to Pacific, British America.
3. White spruce (*Picea engelmanni*): Medium- to large-sized tree, forming extensive forests at elevations from five thousand to ten thousand feet above sea level; resembles the preceding, but occupies a different station. The common spruce of the Rocky Mountains and Cascades.
4. Tide-land spruce (*Picea sitchensis*): A large-sized tree, common in the coast-belt forest. Along the seacoast from Alaska to central California.

RED FIR or DOUGLAS SPRUCE. — Spruce or fir in name, but resembling hard pine or larch in the appearance, quality, and uses of its wood.

Red fir (*Pseudotsuga douglasii*) (yellow fir, Oregon pine, Douglas spruce): The most important tree of the western United States; grows very large in the Pacific States, to fair size in all parts of the mountains, in Colorado up to about ten thousand feet above sea level; forms extensive forests, often of pure growth. Wood very variable, usually coarse grained and heavy, with very pronounced summer wood, hard and strong ("red" fir), but often fine grained and lighter ("yellow" fir). It replaces hard pine and is especially suited to heavy construction. From the plains to the Pacific Ocean and from Mexico to British America.

TAMARACK. (*See* Larch.)

YEW. — Wood heavy, hard, extremely stiff and strong, of fine texture, with a pale yellow sapwood, and an orange red heart; seasons well, and is quite durable. Yew is extensively used for archery, bows, turner's ware, etc. The yews form no forests, but occur scattered with other conifers.

Yew (*Taxus brevifolia*): A small- to medium-sized tree of the Pacific region.

B. — BROAD-LEAVED WOODS (Hardwoods)

Woods of complex and very variable structure and therefore differing widely in quality, behavior, and consequently in applicability to the arts.

ASH. — Wood heavy, hard, strong, stiff, quite tough, not durable in contact with soil, straight grained, rough on the split surface, and coarse in texture. The wood shrinks moderately, seasons with little injury, and stands well. In carpentry ash is used for finishing lumber, stairways, panels, etc.; it is used in shipbuilding, in the construction of cars, wagons, carriages, etc., in the manufacture of farm implements, machinery, and especially of furniture of all kinds, and also for harness work; for barrels, baskets, oars, tool handles, hoops, clothespins, and toys. The trees of the several species of ash are rapid growers, of small to medium height, with stout trunks; they form no forests, but occur scattered in almost all our broad-leaved forests.

1. White ash (*Fraxinus americana*): Medium-, sometimes large-sized tree. Basin of the Ohio, but found from Maine to Minnesota and Texas.

2. Red ash (*Fraxinus pennsylvanica*): Small-sized tree. North Atlantic States, but extends to the Mississippi.

3. Black ash (*Fraxinus nigra*) (hoop ash, ground ash): Medium-sized tree, very common. Maine to Minnesota, and southward to Virginia and Arkansas.

4. Blue ash (*Fraxinus quadrangulata*): Small- to medium-sized. Indiana and Illinois; occurs from Michigan to Minnesota and southward to Alabama.

5. Green ash (*Fraxinus lanceolata*): Small-sized tree. New York to the Rocky Mountains, and southward to Florida and Arizona.

6. Oregon ash (*Fraxinus oregana*): Medium-sized tree. Western Washington to California.

ASPEN. (*See* Poplar.)

BASSWOOD.

1. Basswood (*Tilia americana*) (lime tree, American linden, lin, bee tree): Wood light, soft, stiff but not strong, of fine texture, and white to light brown color. The wood shrinks considerably in drying, works and stands well; it is used in carpentry, in the manufacture of furniture and wooden ware, both turned and carved, in cooperage, for toys, also for paneling of car and carriage bodies. Medium- to large-sized tree, common in all northern broad-leaved forests; found throughout the eastern United States.

2. White basswood (*Tilia heterophylla*): A small-sized tree, most abundant in the Allegheny region.

BEECH.

Beech (*Fagus americana*): Wood heavy, hard, stiff, strong, of rather coarse texture, white to light brown, not durable in the ground, and subject to the inroads of boring insects; it shrinks and checks considerably in drying, works well and wears smooth. Used for furniture, in turnery, for handles, plane stocks, lasts, etc. Abroad it is very extensively employed by the carpenter, millwright, and wagon maker, in turnery as well as wood carving. The beech is a medium-sized tree, common, sometimes forming forest; most abundant in the Ohio and Mississippi basin, but found from Maine to Wisconsin and southward to Florida.

BIRCH. — Wood heavy, hard, strong, of fine texture; sapwood whitish, heartwood in shades of brown with red and yellow; very handsome, with satiny luster, equaling cherry. The wood shrinks considerably in drying, works and stands well, and takes a good polish, but is not durable if exposed. Birch is used for finishing lumber in building, in the manufacture of furniture, in wood turnery for spools, boxes, wooden shoes, etc., for shoe lasts and pegs, for wagon hubs, ox yokes, etc., also in wood carving. The birches are medium-sized trees, form extensive forests northward, and occur scattered in most of the broad-leaved forests of the eastern United States.

1. Cherry birch (*Betula lenta*) (black birch, sweet birch, mahogany birch): Medium-sized tree; not common. Maine to Michigan and to Tennessee.
2. Yellow birch (*Betula lutea*) (gray birch): Medium-sized tree; the common birch of the market. Maine to Minnesota and southward to Tennessee.
3. Red birch (*Betula nigra*) (river birch): Small- to medium-sized tree; very common; lighter and less valuable than the preceding. New England to Texas and Missouri.
4. White or paper birch (*Betula papyrifera*): Generally a small tree; common, forming forests; wood of good quality but lighter. All along the northern boundary of United States and northward, from the Atlantic to the Pacific.

BLACK WALNUT. (*See* Walnut.)

BLUE BEECH.

Blue beech (*Carpinus caroliniana*) (hornbeam, water beech, ironwood): Wood very heavy, hard, strong, very stiff, of rather fine texture and white color; not durable in the ground; shrinks and checks greatly, but works and stands well. Used chiefly in turnery for tool handles, etc. Abroad much used by millwrights and wheelwrights. A small tree, largest in the Southwest, but found in nearly all parts of the eastern United States.

BOIS D'ARC. (*See* Osage orange.)

BUCKEYE — HORSE-CHESTNUT. — Wood light, soft, not strong, often quite tough, of fine and uniform texture and creamy white color. It shrinks considerably, but works and stands well. Used for wooden ware, artificial limbs, paper pulp, and locally also for building lumber. Small-sized trees, scattered.

1. Ohio buckeye (*Æsculus glabra*) (fetid buckeye): Alleghenies, Pennsylvania to Indian Territory.

2. Sweet buckeye (*Æsculus octandra*): Alleghenies, Pennsylvania to Texas.

BUTTERNUT.

Butternut (*Juglans cinerea*) (white walnut): Wood very similar to black walnut, but of light brown color. Used chiefly for finishing lumber, cabinetwork, and cooperage. Medium-sized tree, largest and most common in the Ohio basin; Maine to Minnesota and southward to Georgia and Alabama.

CATALPA.

Catalpa (*Catalpa speciosa*): Wood light, soft, not strong, brittle, durable, of coarse texture and brown color; used for ties and posts, but well suited for a great variety of uses. Medium-sized tree; lower basin of the Ohio River, locally common. Extensively planted, and therefore promising to become of some importance.

CHERRY.

Cherry (*Prunus serotina*): Wood heavy, hard, strong, of fine texture; sapwood yellowish white, heartwood reddish to brown. The wood shrinks considerably in drying, works and stands well, takes a good polish, and is much esteemed for its beauty. Cherry is chiefly used as a decorative finishing lumber for buildings, cars, and boats, also for furniture and in turnery. It is becoming too costly for many purposes for which it is naturally well suited. The lumber-furnishing cherry of this country, the wild black cherry (*Prunus serotina*), is a small- to medium-sized tree, scattered through many of the broad-leaved woods of the eastern United States. Other species of this genus as well as the hawthorns (Cratægus) and wild apple (Pyrus) are not commonly offered in the market. Their wood is of the same character as cherry, often even finer, but in small dimensions.

CHESTNUT.

1. Chestnut (*Castanea dentata*): Wood light, moderately soft, stiff, not strong, of coarse texture; the sapwood light, the heartwood darker brown. It shrinks and checks considerably in drying, works easily, stands well, and is very durable. Used in cabinetwork, cooperage, for railway ties, telegraph poles, and locally in heavy construction. Medium- to large-sized tree, very common in the Alleghenies, occurs from Maine to Michigan and southward to Alabama.
2. Chinquapin (*Castanea pumila*): A small-sized tree, with wood slightly heavier but otherwise similar to the preceding; most common in Arkansas, but with nearly the same range as the chestnut.
3. Chinquapin (*Castanopsis chrysophylla*): A medium-sized tree of the western ranges of California and Oregon.

COFFEE TREE.

Coffee tree (*Gymnocladus dioica*) (coffee nut): Wood heavy, hard, strong, very stiff, of coarse texture, durable; the sapwood yellow, the heartwood reddish brown; shrinks and checks considerably in drying; works and stands well and takes a good polish. It is used to a limited extent in cabinetwork. A medium- to large-sized tree; not common. Pennsylvania to Minnesota and Arkansas.

COTTONWOOD. (*See* Poplar.)

CUCUMBER TREE. (*See* Tulip.)

ELM. — Wood heavy, hard, strong, very tough; moderately durable in contact with the soil; commonly crossgrained, difficult to split and shape, warps and checks considerably in drying, but stands well if properly handled. The broad sapwood whitish, heart brown, both with shades of gray and red; on split surface rough; texture coarse to fine; capable of high polish. Used in the construction of cars, wagons, etc., in boat and ship building, for agricultural implements and machinery; in rough cooperage, saddlery and harness work, but particularly in the manufacture of all kinds of furniture, where the beautiful figures, especially those of the tangential or bastard section, are just beginning to be duly appreciated. The elms are medium- to large-sized trees, of fairly rapid growth, with stout trunk, form no forests of pure growth, but are found scattered in all the broad-leaved woods of our country, sometimes forming a considerable portion of the arboreal growth.

1. White elm (*Ulmus americana*) (American elm, water elm): Medium- to large-sized tree, common. Maine to Minnesota and southward to Florida and Texas.
2. Rock elm (*Ulmus racemosa*) (cork elm, hickory elm, white elm, cliff elm): Medium- to large-sized tree. Michigan, Ohio, from Vermont to Iowa and southward to Kentucky.
3. Red elm (*Ulmus fulva*) (slippery elm, moose elm): Small-sized tree, found chiefly along water courses. New York to Minnesota and southward to Florida and Texas.
4. Cedar elm (*Ulmus crassifolia*): Small-sized tree, quite common. Arkansas and Texas.
5. Winged elm (*Ulmus alata*) (wahoo): Small-sized tree, locally quite common. Arkansas, Missouri, and eastward to Virginia.

GUM. — This general term refers to two kinds of wood usually distinguished as *sweet* or *red gum*, and *sour*, *black*, or *tupelo gum*, the former being a relative of the witch-hazel, the latter belonging to the dogwood family.

1. Tupelo (*Nyssa sylvatica*) (sour gum, black gum): Wood heavy, hard, strong, tough, of fine texture, frequently crossgrained, of yellowish or grayish white color, hard to split and work, troublesome in seasoning, warps and checks considerably, and is not durable if exposed; used for wagon hubs, wooden ware, handles, wooden shoes, etc. Medium- to large-sized trees, with straight, clear trunks; locally quite abundant, but never forming forests of pure growth. Maine to Michigan and southward to Florida and Texas.
2. Tupelo gum (*Nyssa aquatica*) (cotton gum): Lower Mississippi basin, northward to Illinois and eastward to Virginia, otherwise like preceding species.
3. Sweet gum (*Liquidambar styraciflua*) (red gum, liquidambar, bilsted): Wood of medium weight, rather soft, quite stiff and strong, tough,

commonly crossgrained, of fine texture; the broad sapwood whitish, the heartwood reddish brown; the wood shrinks and warps considerably, but does not check badly, stands well when fully seasoned, and takes good polish. Used in carpentry, in the manufacture of furniture, for cut veneer, for wooden plates, plaques, baskets, etc., also for wagon hubs, hat blocks, etc. A large-sized tree, very abundant, often the principal tree in the swampy parts of the bottoms of the lower Mississippi valley; occurs from New York to Texas and from Indiana to Florida.

HACKBERRY.

HACKBERRY (*Celtis occidentalis*) (sugar berry): The handsome wood heavy, hard, strong, quite tough, of moderately fine texture, and greenish or yellowish white color: shrinks moderately, works well, and takes a good polish. So far but little used in the manufacture of furniture. Medium- to large-sized tree, locally quite common, largest in the lower Mississippi valley. Occurs in nearly all parts of the eastern United States.

HICKORY. — Wood very heavy, hard, and strong, proverbially tough, of rather coarse texture, smooth and of straight grain. The broad sapwood white, the heart reddish nut-brown. It dries slowly, shrinks and checks considerably; is not durable in the ground or if exposed, and, especially the sapwood, is always subject to the inroads of boring insects. Hickory excels as carriage and wagon stock, but is also extensively used in the manufacture of implements and machinery, for tool handles, timber pins, for harness work, and cooperage. The hickories are tall trees with slender stems, never form forests, occasionally small groves, but usually occur scattered among other broad-leaved trees in suitable localities. The following species all contribute more or less to the hickory of the markets:

1. SHAGBARK HICKORY (*Hicoria ovata*) (shellbark hickory): A medium- to large-sized tree, quite common; the favorite among hickories. Best developed in the Ohio and Mississippi basins; from Lake Ontario to Texas and west to Minnesota.

2. MOCKER NUT HICKORY (*Hicoria alba*) (black hickory, bull and black nut, big bud, and white-heart hickory): A medium- to large-sized

tree, with the same range as the foregoing; common, especially in the South.

3. Pignut hickory (*Hicoria glabra*) (brown hickory, black hickory, switch-bud hickory): Medium- to large-sized tree, abundant. All eastern United States.

4. Bitter nut hickory (*Hicoria minima*) (swamp hickory): A medium-sized tree, favoring wet localities, with the same range as the preceding.

5. Pecan (*Hicoria pecan*) (Illinois nut): A large tree, very common in the fertile bottoms of the western streams. Indiana to Nebraska and southward to Louisiana and Texas.

HOLLY.

Holly (*Ilex opaca*): Wood of medium weight, hard, strong, tough, of fine texture and white color; works and stands well. Used for cabinetwork and turnery. A small tree. Most abundant in the lower Mississippi valley Gulf States, but occurring eastward to Massachusetts and north to Indiana.

HORSE-CHESTNUT. (*See* Buckeye.)

IRONWOOD. (*See* Blue beech.)

LOCUST. — This name applies to both of the following:

1. Black locust (*Robinia pseudacacia*) (yellow locust): Wood very heavy, hard, strong, and tough, of coarse texture, very durable in contact with the soil, shrinks considerably and suffers in seasoning; the very narrow sapwood yellowish, the heartwood brown, with shades of red and green. Used for wagon hubs, tree nails or pins, but especially for ties, posts, etc. Abroad it is much used for furniture and farm implements and also in turnery. Small- to medium-sized tree. At home in the Alleghenies: extensively planted, especially in the West.

2. Honey locust (*Gleditschia triacanthos*) (sweet locust, three-thorned acacia): Wood heavy, hard, strong, tough, of coarse texture, susceptible of a good polish, the narrow sapwood yellow, the heartwood brownish red. So far, but little appreciated except for fencing and fuel; used to some extent for wagon hubs and in

rough construction. A medium-sized tree. Found from Pennsylvania to Nebraska and southward to Florida and Texas; locally quite abundant.

MAGNOLIA. (*See* TULIP.)

MAPLE. — Wood heavy, hard, strong, stiff, and tough, of fine texture, frequently wavy grained, this giving rise to "curly" and "blister" figures; not durable in the ground or otherwise exposed. Maple is creamy white, with shades of light brown in the heart; shrinks moderately, seasons, works and stands well, wears smoothly, and takes a fine polish. Used for ceiling, flooring, paneling, stairway, and other finishing lumber in house, ship, and car construction; also for the keels of boats and ships, in the manufacture of implements and machinery, but especially for furniture, where entire chamber sets of maple rival those of oak. Maple is also used for shoe lasts and other form blocks, for shoe pegs, for piano actions, school apparatus, for wood type in show-bill printing, tool handles, in wood carving, turnery, and scroll work. The maples are medium-sized trees, of fairly rapid growth; sometimes form forests and frequently constitute a large proportion of the arboreal growth.

1. SUGAR MAPLE (*Acer saccharum*) (hard maple, rock maple): Medium- to large-sized tree, very common, forms considerable forests. Maine to Minnesota and southward to northern Florida; most abundant in the region of the Great Lakes.

2. RED MAPLE (*Acer rubrum*) (swamp or water maple): Medium-sized tree; like the preceding, but scattered along water courses and other moist localities.

3. SILVER MAPLE (*Acer saccharinum*) (soft maple, silver maple): Medium-sized, common; wood lighter, softer, inferior to hard maple. Valley of the Ohio, but occurs from Maine to Dakota and southward to Florida.

4. BROAD-LEAVED MAPLE (*Acer macrophyllum*): Medium-sized tree, forms considerable forests, and like the preceding has a lighter, softer, and less valuable wood. Pacific coast.

MULBERRY.

RED MULBERRY (*Morus rubra*): Wood moderately heavy, hard, strong, rather tough, of coarse texture, durable; sapwood whitish, heart yellow to orange brown; shrinks and checks considerably in drying. Used in cooperage and locally in shipbuilding and in the manufacture of farm implements. A small-sized tree, common in the Ohio and Mississippi valleys, but widely distributed in the eastern United States.

OAK. — Wood very variable, usually very heavy and hard, very strong and tough, porous, and of coarse texture; the sapwood whitish, the heart "oak" brown to reddish brown. It shrinks and checks badly, giving trouble in seasoning, but stands well, and is little subject to attacks of insects. Used for many purposes: in shipbuilding, for heavy construction, in common carpentry, in furniture, car, and wagon work, cooperage, turnery, and even in wood carving; also in the manufacture of all kinds of farm implements, wooden mill machinery, for piles and wharves, railway ties, etc. The oaks are medium- to large-sized trees, forming the predominant part of a large portion of our broad-leaved forests, so that these are generally "oak forests," though they always contain a considerable proportion of other kinds of trees. The wood of three well-marked kinds, white, red, and live oak, are distinguished and kept separate in the market. Of the two principal kinds white oak is the stronger, tougher, less porous, and more durable. Red oak is usually of coarser texture, more porous, often brittle, less durable, and even more troublesome in seasoning than white oak. In carpentry and furniture work red oak brings about the same price at present as white oak. In the forest the red oaks everywhere accompany the white oaks, and, like the latter, are usually represented by several species in any given locality. Live oak, once largely employed in shipbuilding, possesses all the good qualities (except that of size) of white oak, even to a greater degree. It is one of the heaviest, hardest, and most durable building timbers of this country; in structure it resembles the red oaks, but is much less porous.

1. White oak (*Quercus alba*): Medium- to large-sized tree. Common throughout the eastern United States.

2. Bur oak (*Quercus macrocarpa*) (mossy-cup oak, over-cup oak): Locally abundant, common. Bottoms west of Mississippi; range farther west than preceding.

3. Swamp white oak (*Quercus platanoides*): Most abundant in the Lake States, but with range as in white oak.
4. Yellow oak (*Quercus prinoides*) (chestnut oak, chinquapin oak): Southern Alleghenies and eastward to Massachusetts.
5. Basket oak (*Quercus michauxii*) (cow oak): Locally abundant. Lower Mississippi and eastward to Delaware.
6. Over-cup oak (*Quercus lyrata*) (swamp white oak, swamp post oak): Rather restricted; ranges as in the preceding.
7. Post oak (*Quercus minor*) (iron oak): Texas to New England and northward to Michigan.
8. White oak (*Quercus durandii*): Medium- to small-sized tree. Texas, eastward to Alabama.
9. White oak (*Quercus garryana*): Medium-sized tree. Washington to California.
10. White oak (*Quercus lobata*): Medium-sized tree; largest oak on the Pacific coast. California.
11. Red oak (*Quercus rubra*) (black oak): Medium- to large-sized tree; common in all parts of its range. Maine to Minnesota and southward to the Gulf.
12. Black oak (*Quercus velutina*) (yellow oak): Very common in the Southern States, but occurring north as far as Minnesota and eastward to Maine.
13. Spanish oak (*Quercus digitata*) (red oak): Common in the South Atlantic and Gulf region, but found from Texas to New York and northward to Missouri and Kentucky.
14. Scarlet oak (*Quercus coccinea*): Best developed in the lower basin of the Ohio, but found from Maine to Missouri, and from Minnesota to Florida.
15. Pin oak (*Quercus palustris*) (swamp Spanish oak, water oak): Common along borders of streams and swamps. Arkansas to Wisconsin and eastward to the Alleghenies.
16. Willow oak (*Quercus phellos*) (peach oak): New York to Texas and northward to Kentucky.
17. Water oak (*Quercus nigra*) (duck oak, possum oak, punk oak): Medium- to large-sized tree, of extremely rapid growth. Eastern

Gulf States, eastward to Delaware, and northward to Missouri and Kentucky.

18. Live oak (*Quercus virginiana*): Short- but heavy-bodied tree, scattered along the coast from Virginia to Texas.

19. Live oak (*Quercus chrysolepis*) (maul oak, Valparaiso oak): Medium-sized tree. California.

OSAGE ORANGE.

Osage orange (*Toxylon pomiferum*) (bois d'arc): Wood very heavy, exceedingly hard, strong, not tough, of moderately coarse texture, and very durable; sapwood yellow, heart brown on the end, yellow on longitudinal faces, soon turning grayish brown if exposed; it shrinks considerably in drying, but once dry it stands unusually well. Formerly much used for wheel stock in the dry regions of Texas; otherwise employed for posts, railway ties, etc. Seems too little appreciated; it is well suited for turned ware and especially for wood carving. A small-sized tree, of fairly rapid growth. Scattered through the rich bottoms of Arkansas and Texas.

PERSIMMON.

Persimmon (*Diospyros virginiana*): Wood very heavy and hard, strong and tough; resembles hickory, but is of finer texture; the broad sapwood cream color, the heart black. Used in turnery for shuttles, plane stocks, shoe lasts, etc. Small-sized tree. Common and best developed in the lower Ohio valley, but occurs from New York to Texas and Missouri.

POPLAR and COTTONWOOD (*see also* Tulip wood). — Wood light, very soft, not strong, of fine texture and whitish, grayish to yellowish color, usually with a satiny luster. The wood shrinks moderately (some crossgrained forms warp excessively), but checks little; is easily worked, but is not durable. Used as building and furniture lumber, in cooperage for sugar and flour barrels, for crates and boxes (especially cracker boxes), for wooden ware and paper pulp.

1. Cottonwood (*Populus deltoides*): Large-sized tree; forms considerable forests along many of the western streams, and furnishes most of the cottonwood of the market. New England to the Rocky Mountains; most abundant in the Mississippi valley.

2. Balsam poplar (*Populus balsamifera*) (balm of Gilead): Medium- to large-sized tree. Common all along the northern boundary of the United States.

3. Black cottonwood (*Populus trichocarpa*): The largest deciduous tree of Washington; very common. Northern Rocky Mountains and Pacific region.

4. Cottonwood (*Populus fremontii* var. *wislizeni*): Medium- to large-sized tree, common. Texas to California.

5. Poplar (*Populus grandidentata*) (large-toothed aspen): Medium-sized tree, chiefly used for pulp. Maine to Minnesota and southward along the Alleghenies.

6. Aspen (*Populus tremuloides*): Small- to medium-sized tree, often forming extensive forests and covering burned areas. Maine to Washington, south in the western mountains to California and New Mexico.

RED GUM. (*See* Gum.)

SASSAFRAS.

Sassafras (*Sassafras sassafras*): Wood light, soft, not strong, brittle, of coarse texture, durable; sapwood yellow, heart orange brown. Used in cooperage, for skiffs, fencing, etc. Medium-sized tree, largest in the lower Mississippi valley. From New England to Texas and from Michigan to Florida.

SOUR GUM. (*See* Gum.)

SWEET GUM. (*See* Gum.)

SYCAMORE.

1. Sycamore (*Platanus occidentalis*) (buttonwood, buttonball tree, water beech): Wood moderately heavy, quite hard, stiff, strong, tough, usually crossgrained, of coarse texture, and white to light brown color; the wood is hard to split and work, shrinks moderately, warps and checks considerably, but stands well. Used extensively for drawers, backs, bottoms, etc., in cabinetwork, for tobacco boxes, in cooperage, and also for finishing lumber, for which it has too long been underrated. A large tree, of rapid growth. Common and largest in the Ohio and Mississippi valleys, at home in nearly all parts of the eastern United States. (The California species).

2. *Platanus racemosa*, resembles in its wood the eastern form.

TULIP WOOD.

1. Tulip tree (*Liriodendron tulipifera*) (yellow poplar, whitewood): Wood quite variable in weight, usually light, soft, stiff but not strong, of fine texture, and yellowish color; the wood shrinks considerably, but seasons without much injury; works and stands remarkably well. Used for siding, for paneling and finishing lumber in house, car, and ship building, for sideboards and panels of wagons and carriages; also in the manufacture of furniture, implements, and machinery, for pump logs, and almost every kind of common wooden ware, boxes, shelving, drawers, etc. An ideal wood for the carver and toy man. A large tree, forming forests, best developed in the Ohio basin. Occurs from New England to Missouri and southward to Florida.

2. Cucumber tree (*Magnolia acuminata*): A medium-sized tree resembling, and probably confounded with, tulip wood in the markets. Most common in the southern Alleghenies, but distributed from New York to Arkansas, southward to Alabama and northward to Illinois.

TUPELO. (*See* Gum.)

WALNUT.

Black walnut (*Juglans nigra*): Wood heavy, hard, strong, of coarse texture; the narrow sapwood whitish, the heartwood chocolate brown. The wood shrinks moderately in drying, works and stands well, takes a good polish, is quite handsome, and has been for a long time the favorite cabinet wood in this country. Walnut, formerly used even for fencing, has become too costly for ordinary uses, and is to-day employed largely as a veneer, for inside finish and cabinetwork; also in turnery, for gunstocks, etc. Black walnut is a large tree, with stout trunk, of rapid growth, and was formerly quite abundant, especially in the Ohio valley. Occurs from New England to Texas and from Michigan to Florida.

WHITE WALNUT. (*See* Butternut.)

WHITEWOOD. (*See* Tulip, *and also* Basswood.)

YELLOW POPLAR. (*See* Tulip.)

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