A PRIMER OF FORESTRY

PART I—THE FOREST

GIFFORD PINCHOT

Bulletin 24
Division of Forestry
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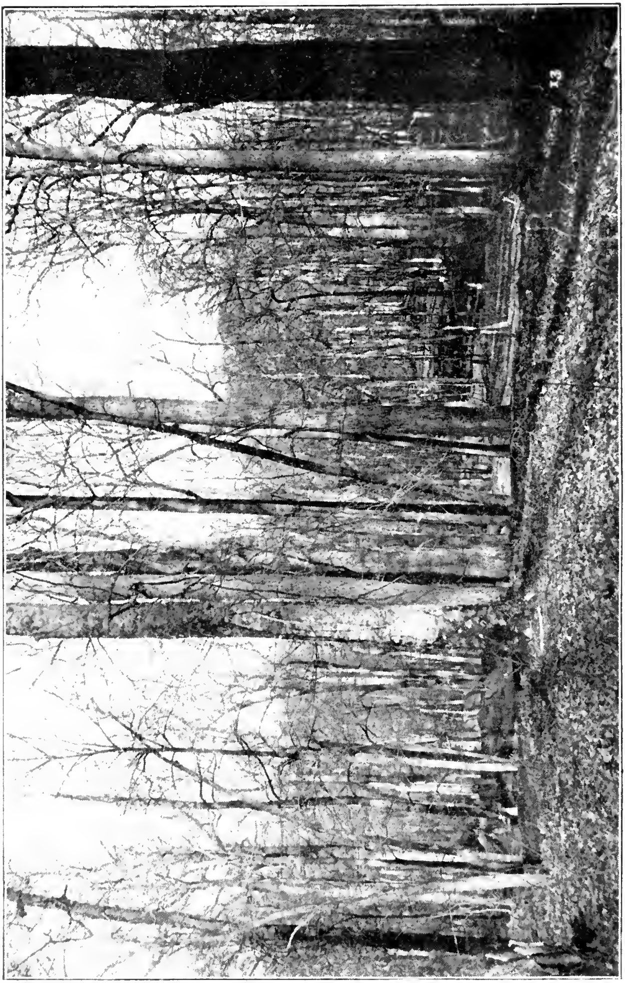
Ruth Ross M. See,

Glen Summit.

June 1900 –



A FOREST IN THE SOUTHERN ALLEGHENY MOUNTAINS. NORTH CAROLINA.

BULLETIN NO. 24.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF FORESTRY.

A PRIMER OF FORESTRY.

PART I.—THE FOREST.

By GIFFORD PINCHOT,
FORESTER.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Forestry,
Washington, D. C., May 8, 1899.

Sir: I have the honor to transmit herewith the manuscript of the first half of "A Primer of Forestry," and to recommend its publication as Bulletin No. 24, Part I, of this Division. The present part ("The Forest") deals with the units which compose the forest, with its character as an organic whole, and with its enemies. It may be said to sketch the foundation of the practice of forestry and of forest policy. Part II will be entitled "Practical Forestry," and will deal with the practice of forestry, with work in the woods, with the relations of the forest to the weather and the streams, and will conclude with a brief description of forestry at home and abroad.

For many of the illustrations of Part I, I am indebted to the kindness of several gentlemen not connected with this Division. Their names and the plates and figures which I owe to their courtesy are as follows:

The Director of the U. S. Geological Survey, figs. 65, 66, and 74; Mr. George W. Vanderbilt, of Biltmore, N. C., figs. 8, 54, 58, the frontispiece, and Pl. XXIII; Forstmeister U. Meister, of Zurich, Switzerland, fig. 41 and Pl. XL; the inspector-general of forests to the government of India, Pls. IV and XII; Mr. A. R.

Moore, of Millville, Cal., Pls. V, XIII, and XLII; Mr. U. F. Bender, of New York City, fig. 79; Mr. A. P. Low, of the geological survey of Canada, Pl. XI; Mr. A. G. Wallihan, of Lay, Colo., Pl. XIV.

Three plates are from sources difficult to trace. The remainder of the plates and figures (except figs. 14 and 59, which are diagrams) are from photographs in my collection, which were taken, in about equal proportions, by Mr. Henry S. Graves, now Assistant Chief of this Division, and myself.

Respectfully, GIFFORD PINCHOT,
Forester.

HON. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS.

A PRIMER OF FORESTRY.

CHAPTER I.

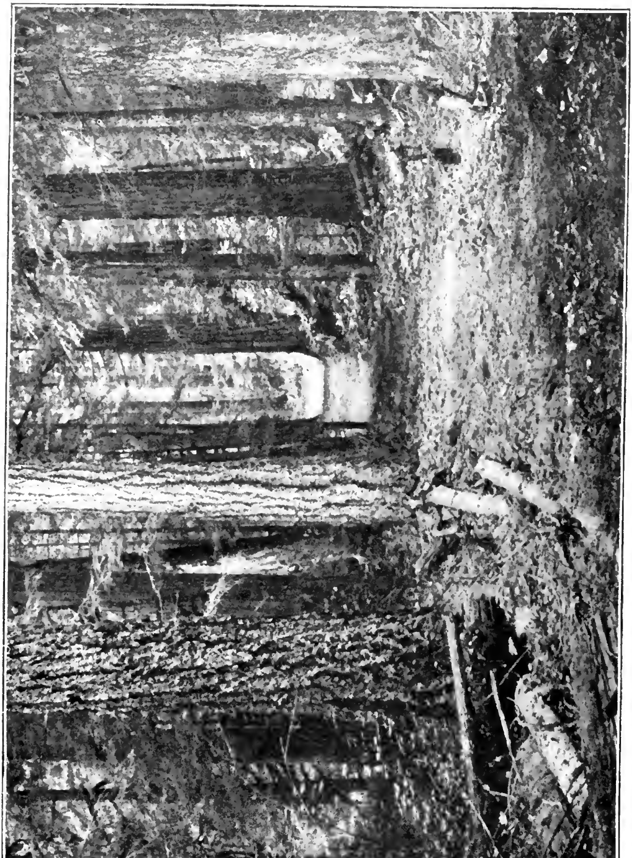
THE LIFE OF A TREE.

The object of forestry is to discover and apply the principles according to which forests are best managed. It is distinct from arboriculture, which deals with individual trees. Forestry has to do with single trees only as they stand together on some large area whose principal crop is trees, and which therefore forms part of a forest. (See frontispiece.) The forest is the most highly organized portion of the vegetable world. It takes its importance less from the individual trees which help to form it than from the qualities which belong to it as a whole. Although it is composed of trees, the forest is far more than a collection of trees standing in one place. It has a population of animals and plants peculiar to itself, a soil largely of its own making, and a climate different in many ways from that of the open country. Its influence upon the streams alone makes farming possible in many regions, and everywhere it tends to prevent floods and drought. It supplies fuel, one of the first necessaries of life, and lumber, the raw material, without which cities, railroads, and all the great achievements of material progress would have been either long delayed or wholly impossible. (See Pl. I.) The forest is as beautiful as it is useful. The old fairy tales which spoke of it as a terrible place are wrong. No one can really know the forest without feeling the gentle influence of one of the kindliest and strongest parts of nature. From every point of view it is one of the most helpful friends of man. Perhaps no other natural agent has done so much for the human race and has been so recklessly used and so little understood.

FIG. 1.—Roots, stem, and crown of a young Shellbark Hickory. Milford, Pa.

THE PARTS OF A TREE.

In order rightly to understand the forest, something must first be known about the units of which it is made up. A tree, then, is a woody plant growing up from the ground usually with a single stem. (See fig. 1.) It consists of three parts: First, the roots, which extend into the ground to a depth of 3 or 4 feet, or still farther when the soil is not too hard and they do not find moisture enough near the surface. (See figs. 2, 3, and Pls. II, III.) They hold the tree in place,



A FOREST IN WESTERN WASHINGTON.

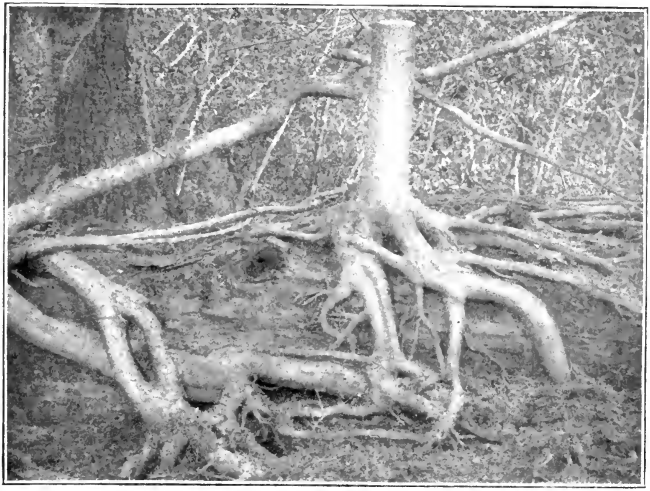


FIG. 2.—Roots of the Western Hemlock. This young tree started on a fallen Red Fir; its roots spread under the moss and litter, and when fire came they were exposed. Olympic Forest Reserve, Washington.

FIG. 3.—Upturned skeleton roots of a Red Fir. The small roots have been burned away and the others cleared of soil by the fire. Olympic Peninsula, Washington.

and take up from the soil water and certain mineral substances which the tree needs in its growth. Second, the trunk, stem, or bole, which supports the crown and supplies it with mineral food and water from the roots. (See fig. 4.) Third, the crown itself, with its network of branches, buds, and leaves, in which all the food taken up by the tree from the soil and air is worked over and made ready to assist in the growth of the whole plant. (See figs. 5–7 and Pl. IV.) The crown has more to do with the life of the tree than its other parts, for the most important processes in the reproduction of the tree and the digestion of its food take place in the crown. For this reason, and because we can control its shape and size more easily and directly than that of the roots or trunk, the crown is of special interest to the forester. It is almost exclusively with the crowns that he has to deal in tending a crop of trees

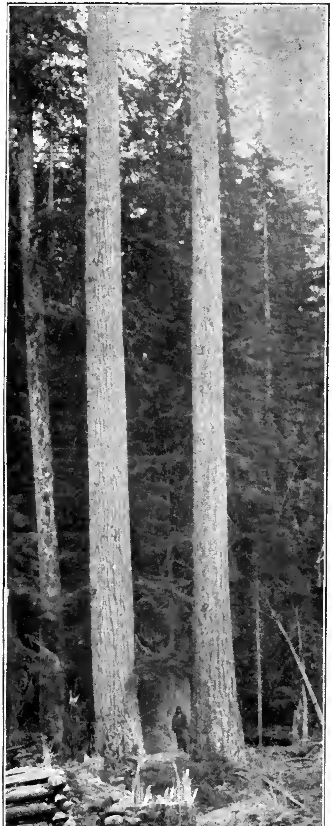


FIG. 4.—Trunks of two Red Firs. The figure of a man between them gives an idea of their great size, which, however, is not unusual. Olympic Forest Reserve, Washington.

UPTURNED ROOTS OF WESTERN HEMLOCK, SHOWING HOW THOROUGHLY THE SMALL ROOTS PENETRATE THE SOIL. OLYMPIC PENINSULA WASHINGTON.

and preparing the way for the succeeding generation. As they stand together in the forest, the crowns of the trees form a broken shelter, which is usually spoken of as the leaf canopy, but which may better be called the cover. (See fig. 8.)

FIG. 5.—Crown and stem of a young Western Larch. Priest River Forest Reserve, Idaho.

THE FOOD OF A TREE.

The materials upon which a tree feeds are derived from the soil and the air. The minute root hairs which spring from the rootlets take up water from the ground, and with it various substances which it holds in solution. These are the earthy constituents of the tree, which reappear in the form of ashes when any part of it is burned. The water which contains these materials goes straight from the roots to the leaves, in which a most important process in the feeding of the tree takes place. This process is the assimilation or taking up and breaking up, by the leaves, of carbonic acid gas from the air. It goes on only in the presence of light and heat, and through the action of chlorophyll, a substance from which the leaves and the young bark get their green color.

Plants containing chlorophyll are the chief means by which mineral materials are changed into food, so that nearly all plant and animal life depends upon them. Plant cells which contain chlorophyll break up the carbonic acid gas with which they come in contact, retain the carbon, one of its elements, and send back the other, oxygen, into the air. Then, still under the influence of the sunlight, they combine the carbon with the oxygen and hydrogen of the water

FIG. 6.—Crowns of the Black Hemlock (to the left) and Western Cedar. Washington Forest Reserve.

from the roots into new chemical compounds, in which nitrogen and the earthy constituents mentioned above are also present; that is to say, the food materials which reach the tree through the roots and

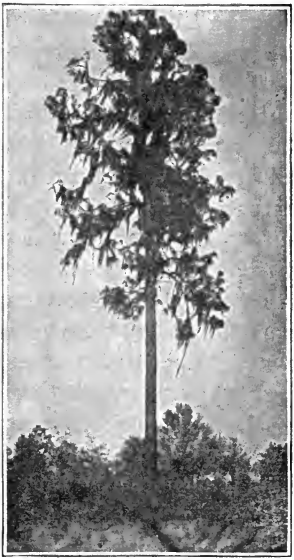


FIG. 7.—Stem and crown of a Longleaf Pine, the latter covered with moss swaying in the wind.

leaves are first digested in the leaves somewhat as food is digested in the human body, and are then sent to all living parts of the roots, stem, and crown, where they pass through another process of digestion, and are

ROOTS OF WESTERN HEMLOCK. OLYMPIC PENINSULA, WASHINGTON.

A portion of the deep vegetable mold in which this tree stands has been burned away and the roots are exposed.

FIG. 8.—The forest cover. Spruce in Bavaria, Germany.

FIG. 9.—Yearly growth of a branch of Horse Chestnut. The bands of wrinkles mark the divisions between the growths of four successive years. The distance between these bands would never have been greater than it was when the branch was cut.

then either used at once in growth or stored away until the proper moment arrives. This is the general rule, but it is believed that in some cases food taken up by the roots can be used without first being digested in the leaves.

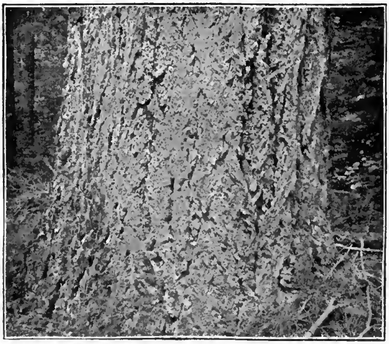


FIG. 10.—Bark of the Western Hemlock. Washington Forest Reserve.

THE COMPOSITION OF WOOD.

Wood is made up chiefly of carbon, oxygen, and hydrogen. When perfectly dry, about half its weight is carbon, and half oxygen and hydrogen, in almost the same proportion as in water. It contains also about 1 part in 100, by weight, of earthy constituents, and nitrogen to the same amount. When wood is burned, all these materials disappear into the air except the earthy constituents. Now the nitrogen and water taken up by the roots were originally in the air before they reached the ground. It is true, therefore, that when wood is burned those parts of it which came from the air go back into it in the form of gas, while those which came from the soil remain behind in the form of ashes.

FIG. 11.—Wood and bark of the Western Yellow Pine. The cut is perpendicular, and the specimen stands as it did in the tree. The picture shows the division of the bark into scales by the successive layers of cork cambium. The true cambium is between wood and bark.

STEM AND CROWN OF A FOREST TREE IN BRITISH INDIA.

The stem is about three feet in diameter.

HOW THE TREE BREATHES.

Besides giving out oxygen in assimilation, trees also take in oxygen from the air through their leaves, and through the minute openings in the bark called lenticels, such as the oblong raised spots or marks on the young branches of Birch and Cherry and many other trees. All plants, like all animals, breathe; and plants, like animals, breathe in oxygen and breathe out carbonic acid gas. This process of respiration or the breathing of the tree goes on both day and night, but it is far less active than assimilation, which takes place only in the light. Consequently more carbonic acid gas is taken into the tree than is given out, and the surplus carbon remains to be used in growing.

FIG. 12.—Wood and bark of the Western Yellow Pine. The cut is a cross section and would have been horizontal as the specimen stood in the tree. Besides the division of the bark into scales this picture shows two of the deep cracks in the bark, at the bottom of which lenticels are placed.

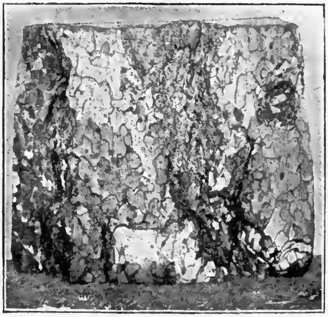


FIG. 13.—Bark of the Western Yellow Pine. Outer surface, showing the scales made by the successive layers of cork cambium.

TRANSPIRATION.

The leaves give out not only the oxygen derived from the decomposition of carbonic acid gas taken from the air and carbonic acid gas produced in breathing, but also great quantities of water vapor. The amount of water taken up by the roots is very much larger than is required to be combined with carbon and the earthy constituents in the leaves. In order that fresh supplies of earthy constituents in solution may reach the leaves rapidly, the water already in them must be got out of the way. This is effected by transpiration, which is the evaporation of water from all parts of the tree above ground, but principally from the leaves. Even where the bark is very thick, as on the trunks of old Oaks and Chestnuts, transpiration goes on through the lenticels in the bottoms of the deep cracks. It sometimes happens, especially in spring before the leaves come out, that transpiration can not get rid of the water from the roots as fast as it rises, and that it falls in drops from the buds, or later on even from the leaves themselves.

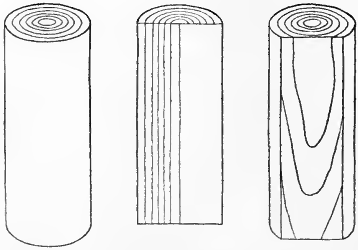


Fig. 14.—By comparing this diagram with Pls. VII–IX and fig. 16, the place of each cut in the tree will be made clear.

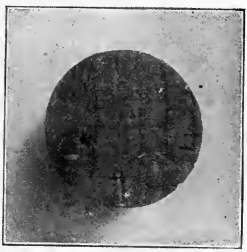
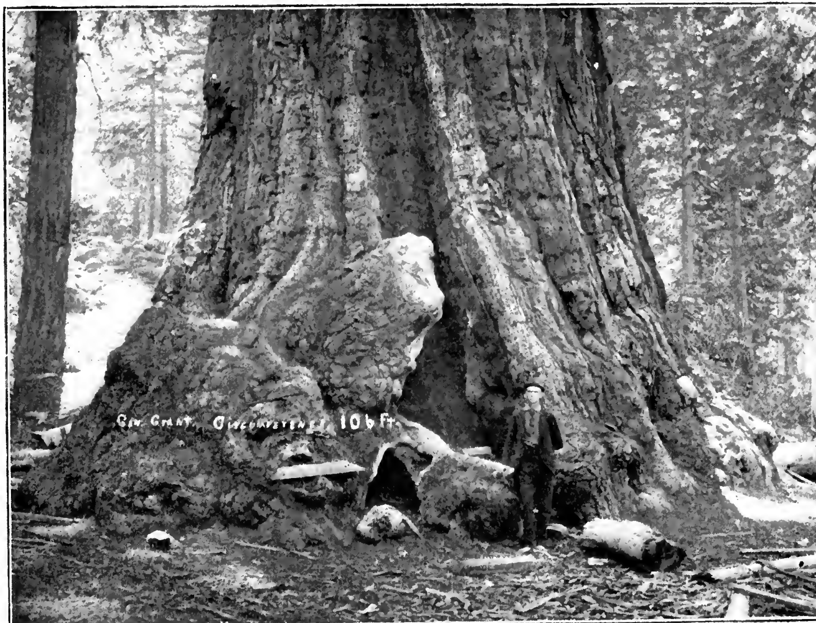


Fig. 15.—Top of a common cork, slightly moistened to bring out the lines of annual growth, which are rather unusually plain in this specimen.



BARK OF ONE OF THE BIG TREES OF CALIFORNIA. GENERAL GRANT NATIONAL PARK.

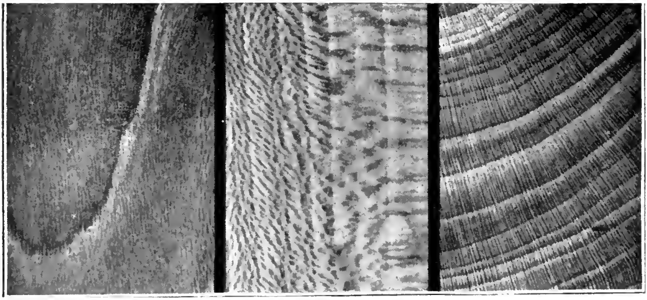


FIG. 16.—Wood of the Eastern Sycamore or Button-ball tree.

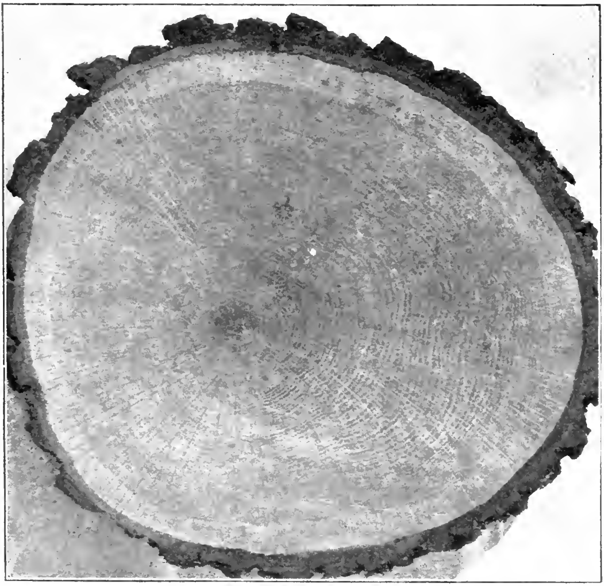
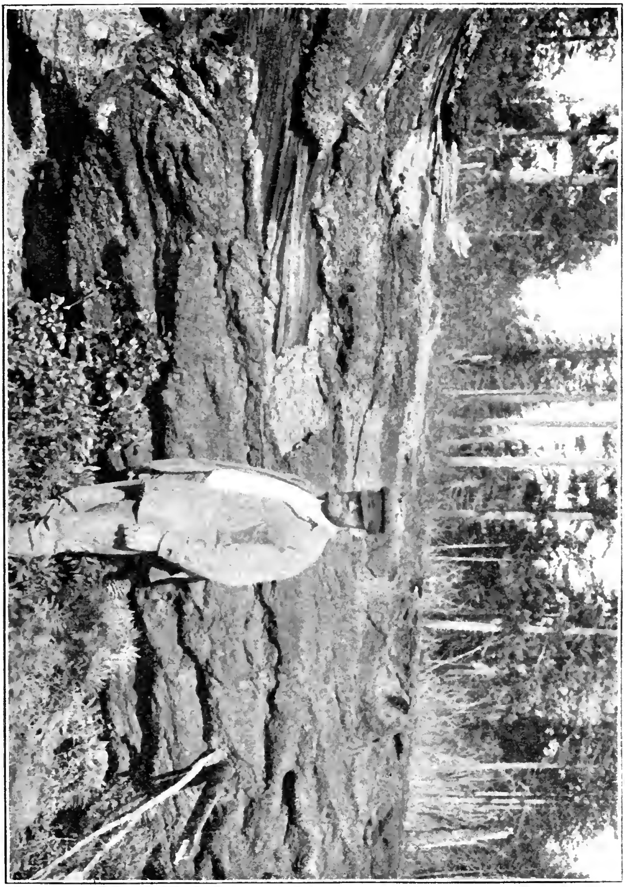


FIG. 17.—Cross section through a Black Oak. Milford, Pa. The silver grain, the rings of annual growth, and the dark heartwood and lighter sapwood are visible, and the line between the rough corky outer bark and the thinner and lighter-colored inner bark may be seen.

THE GROWTH OF A TREE.

The addition of new material in the way described in the preceding pages is the foundation of growth. Except in the buds, leaves, fruit, and the twigs less than a year old, this material is deposited in a thin coat over the whole tree between the wood and the bark. The new twigs grow in length by a kind of stretching, but only during the first year. Thus it is only by means of these youngest twigs that a tree increases in height and in spread of branches. After the first year their length is fixed, younger twigs stretch out from the buds, and the older ones grow henceforth only in thickness. (See fig. 9.) The fresh coat of new material mentioned above covers them year by year. There are two layers in this coat, separated by a third one of tender forming tissues called the cambium, in which the actual making of the new substance goes on. The inner side of the cambium layer forms new wood, the outer side new bark. Besides the true cambium, which forms both wood and bark, there is another cambium which makes the corky outer bark, and nothing else. This cork cambium may encircle the whole tree, like the true cambium, as in the Red Cedar, or it may form little separate films in the bark, but in either case it dies from time to time, and is re-formed nearer the wood. (See figs. 10–13 and Pls. V and VI.)

FIG. 18.—Cross section of a fallen Black Oak. Milford, Pa. The slabs shown in figs. 19 and 22 were sawed lengthwise from this tree, beginning where the black lines are seen on the cross section.



BARK OF MATURE RED FIR. OREGON.

THE STRUCTURE OF WOOD.

Wood is chiefly made up of very small tubes or cells of various kinds, which have special uses in the life of the tree. Some conduct water from the roots to the crown, some store away digested food, and others merely strengthen the structure of the wood and hold it together. The wood of cone-bearing or coniferous trees

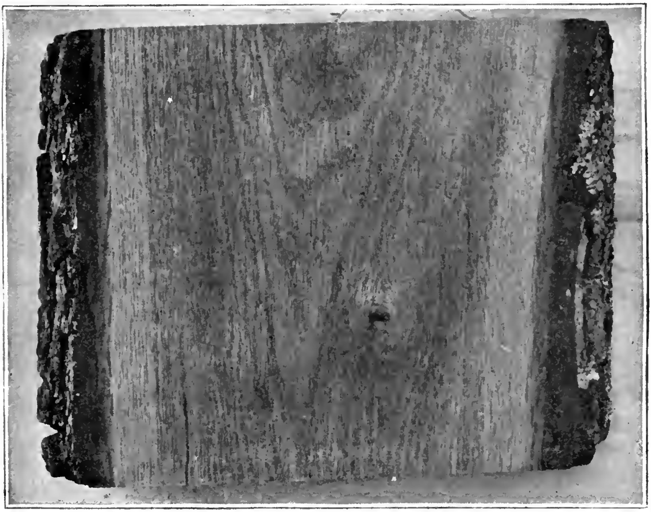


FIG. 19.—Slab sawed lengthwise from a Black Oak. Milford, Pa. The saw passed about midway between the center of the tree and the bark. The line between the heartwood and the sap is plainly shown.

(like the Pines and Spruces) has but few kinds of cells, while that of the broadleaf trees (such as Oaks and Maples) is much less simple. (See figs. 14, 16, 20, and Pls. VII–IX.) But in each case some of the cells have thick walls and small openings, and others wide openings and very thin walls. In climates which have regularly one

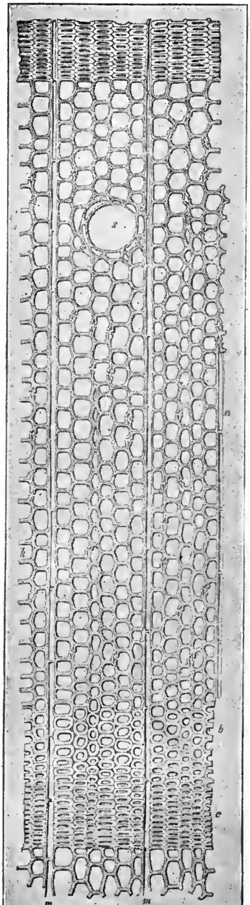
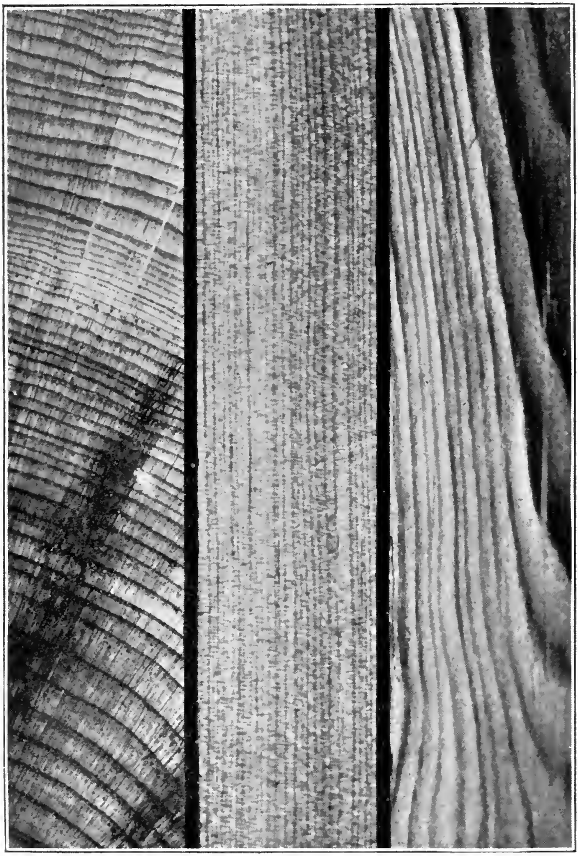


FIG. 20.—Wood of a Spruce, greatly magnified. (From Hartig. Anatomie und Physiologie der Pflanzen, Berlin, 1891.)

season of growth and one of rest, like our own, the cells of the layer of new wood formed each year at the inner surface of the cambium are arranged in a definite way. When growth begins in the spring, and the fresh twigs and leaves put out, there is a great demand for water in the crown to supply these moist green new parts of the tree. Water rises in most trees through the newer layers of the wood, and especially through the last ring. Consequently, at first the tree makes thin-walled cells with wide openings, through which water can rise rapidly to the ends of the branches. Later on, when the demand for water is not so great, and there is plenty of digested food to supply building material, the cells formed are narrow and thick-walled. (See fig. 20.) Thus the summer wood in each year's growth is heavier, stronger, and darker in color than the spring wood. In the wood of many broadleaf trees, such as Oak and Chestnut, the spring wood is also marked by a band of open tubes of larger size called ducts. In others, such as Maple and Beech,



WOOD OF THE WHITE PINE.

these ducts are scattered through the whole season's growth, and in all conifers, as for example the Pines and Cedars, they are entirely wanting. But the differences in hardness and color between the growth of spring and summer are still present. It is sometimes possible to see the line which separates the growth of two seasons in the bark, as in the case of common cork, which is the outer bark of the Cork Oak, a native of southern Europe. (See fig. 15.)

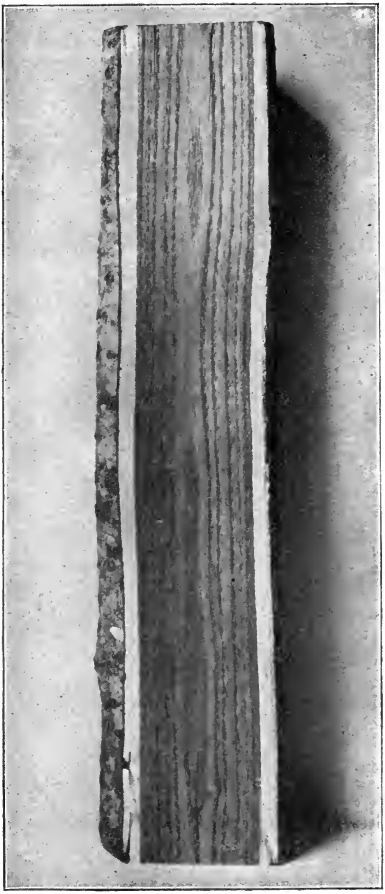


FIG. 21.—A section of the common Staghorn Sumach, showing the darkened heartwood, the white sapwood, and the inner and outer bark. Dark coloring matter is often deposited in the heartwood, as in the case here shown. Milford, Pa.

If the trunk or branch of an Oak tree is cut smoothly across, thin whitish lines may be seen running from within outward. Some of these lines begin in the center of the tree, and others in each one of the annual rings.

These are the medullary rays, which make the silver grain in quartered Oak and other woods. (See figs. 17, 19, 22, and Pls. VII–IX.) They exist in all kinds of trees, but in many, as, for example, in the Chestnut and in most conifers, they are so fine as hardly to be seen

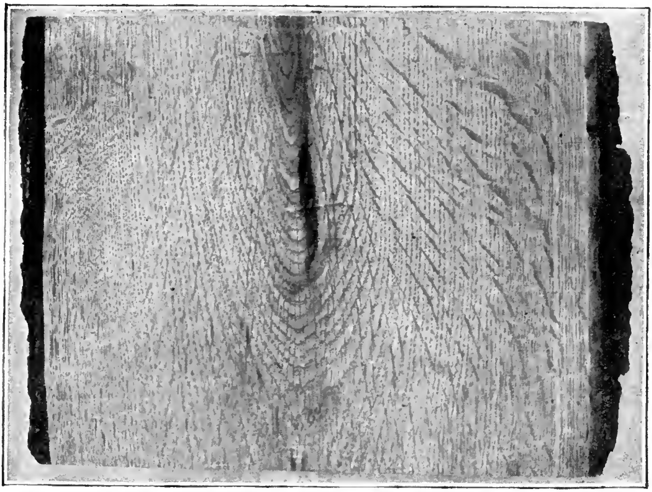
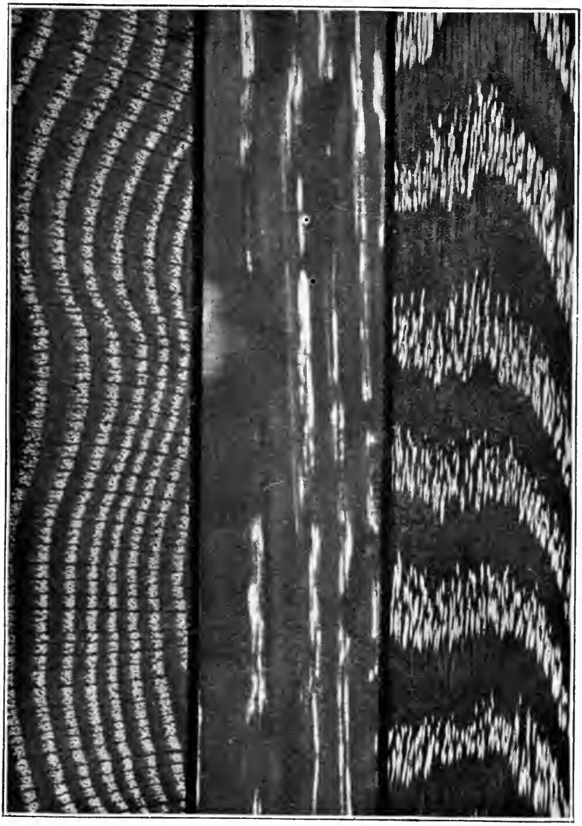


FIG. 22.—Slab sawed lengthwise from a Black Oak. Milford, Pa. The saw passed almost through the center of the tree, but not quite. The lines of annual growth are cut through obliquely, and the silver grain appears quite plainly, both in the middle and at the sides.

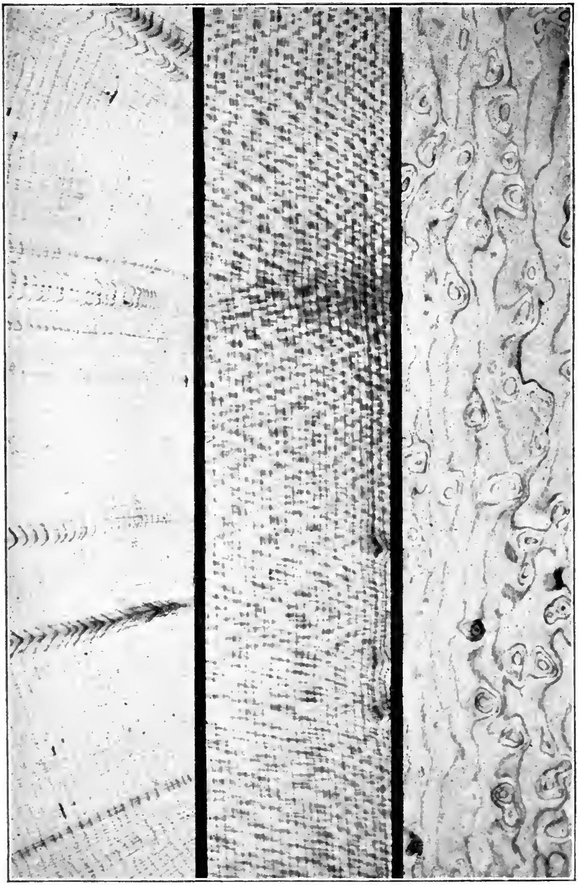
with the naked eye. Seasoning cracks which run across the rings of growth always follow the lines of these rays, while others most often follow along some annual ring.

ANNUAL RINGS.

It is correct to speak of these rings of growth as "annual rings," for as long as the tree is growing healthily a ring is formed each year. (See figs. 17, 22, and



WOOD OF THE RED OAK.



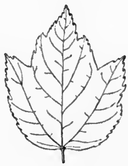
WOOD OF THE SUGAR MAPLE.

Pls. VII–X.) It is true that two false rings may appear in one year, but they are generally so much thinner than the rings on each side that it is not hard to detect them. Very often they do not extend entirely around the tree, as a true ring always does if the tree is sound. Whenever the growth of the tree is interrupted and begins again during the same season, such a false ring is formed. This happens when the foliage is destroyed by caterpillars and grows again in the same season, or when a very severe drought in early summer stops growth for a time, and in similar cases.

HEARTWOOD AND SAPWOOD.

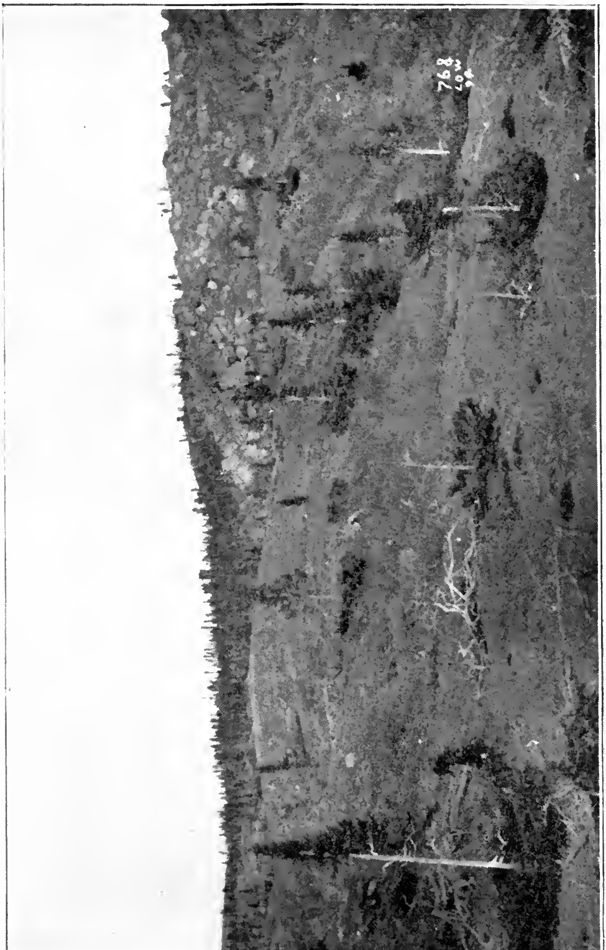
An annual layer once formed does not change in size or place during the healthy life of the tree, except that it is covered in time by other younger layers. A nail driven into a tree 6 feet from the ground will still be at the same height after it is buried under 20 or 50 or 100 layers of annual growth. But in most trees, like the Oaks and Pines, the wood becomes darker in color and harder after it has been in the tree for some years. The openings of its cells become choked so that the sap can no longer run through them. From living sapwood, in which growth is going on, it becomes heartwood, which is dead, because it has nothing to do with growth. (See figs. 19, 21.) It is simply a strong framework which helps to support the living parts of the tree. This is why hollow trees may flourish and bear fruit. Sapwood rots more easily than heartwood, because it takes up water readily and contains plant food, which decays very fast. Not all trees have heartwood, and in many the difference in color between it and the sapwood is very slight. Since water from the roots rises only in the sapwood, it is easy to kill trees with heartwood by girdling them, provided all the sapwood is cut through. But in those which have no heartwood the tubes of the older layers of wood can still convey water to the crown, and when such trees are girdled it is often several years before they die.

A great many theories have been proposed to account for the rise of water into the tops of tall trees, some of which, as in the big trees of California, may be over 300 feet from the ground. But none of these theories are quite satisfactory, and it must be admitted that we do not yet know how the trees supply their lofty crowns with the water which keeps them alive.



CROSS SECTION OF A RED FIR, SHOWING SEASONING CRACKS AND ANNUAL RINGS. WESTERN OREGON.

The rings are much wider near the heart than near the bark, as usually happens with large trees This tree grew very rapidly.



BLACK SPRUCE ON THE HAMILTON RIVER, LABRADOR, NEAR THE NORTHERN LIMIT OF TREE GROWTH.

CHAPTER II.

TREES IN THE FOREST.

The nature of a tree, as shown by its behavior in the forest, is called its silvicultural character. It is made up of all those qualities upon which the species as a whole, and every individual tree, depends in its struggle for existence. The regions in which a tree will live, and the places where it will flourish best; the trees it will grow with, and those which it kills or is killed by; its abundance or scarcity; its size and rate of growth—all these things are decided by the inborn qualities, or silvicultural character, of each particular kind of tree.

THE VARIOUS REQUIREMENTS OF TREES.

Different species of trees, like different races of men, have special requirements for the things upon which their life depends. Some races, like the Eskimos live only in cold regions. (See Pl. XI.) Others, like the South Sea Islanders, must have a very warm climate to be comfortable, and are short-lived in any other. (See fig. 23.) So it is with trees, except that their different needs are even more varied and distinct. Some of them, like the Willows, Birches, and Spruces of northern Canada, stand on the boundary of tree growth within the Arctic Circle. Other species grow only in tropical lands, and can not resist even the lightest frost. (See Pl. XII.) It is always the highest and lowest temperature, rather than the average, which decides where a tree will or will not grow. Thus the average temperature of an island where it never freezes may be only 60°, while another place, with an average of 70°, may have occasional frosts. Trees which could not live at all in the second of these places, on account of the frost, might flourish in the lower average warmth of the first.

In this way the bearing of trees toward heat and cold has a great deal to do with their distribution over the surface of the whole earth. Their distribution within shorter distances also often depends largely upon it. In the United States, for example, the Live Oak does not grow in Maine, nor the Canoe Birch in Florida. Even the opposite sides of the same hill may be covered with two different species, because one of them resists the late and early frosts and the fierce midday heat of summer, while the other requires the coolness and moisture of the northern slope. (See fig. 24.) On eastern slopes, where the sun strikes early in the day, frosts in the spring and fall are far more apt to kill the young trees, or the blossoms and twigs of older ones, than on those which face to the west and north, where growth begins later in the spring, and where rapid thawing, which does more harm than the freezing itself, is less likely to take place.

FIG. 23.—A forest of Palms in southern Florida.

REQUIREMENTS OF TREES FOR HEAT AND MOISTURE.

Heat and moisture act together upon trees in such a way that it is sometimes hard to distinguish their

A TEAK FOREST IN BRITISH INDIA.

The Teak tree yields one of the most durable and valuable kinds of timber, especially adapted to shipbuilding, but it will not grow where there is the slightest frost. Its durability is shown by the condition of the old stump, from which the large tree on the left grew as a sprout.

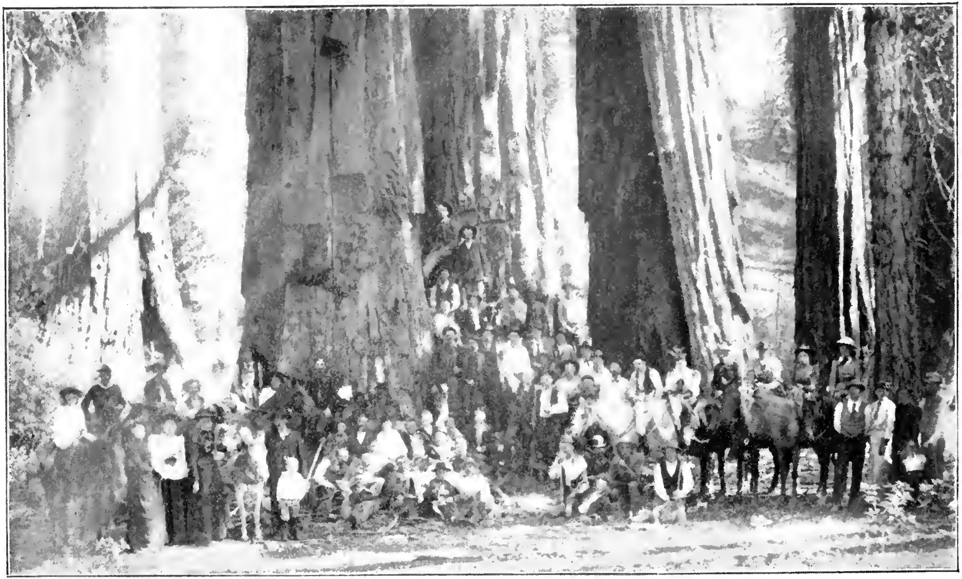
effects. A dry country, or a dry slope, is apt to be hot as well, while a cool northern slope is almost always moister than one turned toward the south. Still the results of the demand of trees for water can usually be distin-

FIG. 24.—The Black Hemlock in its home. Cascade Mountains of Washington.

guished from the results of their need of warmth, and it is found that moisture has almost as great an influence on the distribution of trees over the earth as heat itself. Indeed, within any given region it is apt to be much more conspicuous, and the smaller the region the more noticeable often is its effect, because the contrast is more striking. Thus it is frequently easy to see the difference between the trees in a swamp and those on a dry hillside near by, when it would be far less easy to distinguish the general character of the forest which includes both swamp and hillside from that of another

FIG. 25.—Cypress in a hollow. Pine on the slightly higher land near by. Wet weather spring, Southern Georgia.

forest at a distance. (See fig. 25.) In many instances the demand for water controls distribution altogether. For this reason the forests on the opposite sides of mountain ranges are often composed of entirely different trees. On the west slope of the Sierra Nevada of California, for example, where there is plenty of moisture, there is also one of the most beautifull of all forests. (See fig. 26 and Pl. XIII.) The east



FOREST ON THE WESTERN SLOPES OF THE SIERRA NEVADA. CALIFORNIA.

This Sierra forest is one of the richest and most beautiful of all woodlands. It contains the great Sequoia, massive and imposing beyond all other trees, and the graceful Sugar Pine, the largest and among the most useful of Pines. The large trees in the middle of the picture are Sequoias.

slope, on the contrary, has almost no trees, because its rainfall is very slight, and those which do grow there are small and stunted in comparison with the giants on the west. (See Pl. XIV.) Again, certain trees, like the Bald Cypress and the River Birch, grow only in very moist land; others, like the Mesquite and the Pinyon or Nut Pine, only on the driest soils; while

FIG. 26.—Dense forest in a region of great rainfall. Olympic Peninsula, Washington.

still others, like the Red Cedar and the Red Fir, seem to adapt themselves to almost any degree of moisture, and are found on very wet and very dry soils alike. In this way the different demands for moisture often separate the kinds of trees which grow in the bottom of a valley from those along its slopes, or even those in the gullies of hillsides from those on

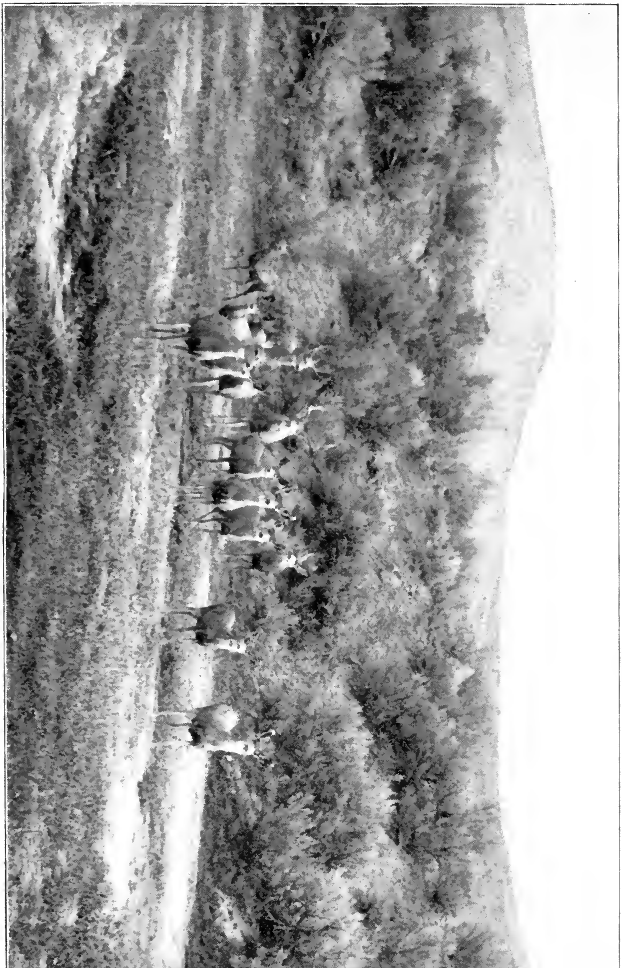
FIG. 27.—Light crown of an intolerant tree, the Western Larch. The tree with heavy foliage and horizontal branches in the background to the right is a Western White Pine, a tolerant species. Northern Idaho.

the rolling land between. (See Pl. XV.) A mound not more than a foot above the level of a swamp is often covered with trees entirely different from those of the wetter lower land about it.

Such matters as these have far more to do with the places in which different trees grow than the chemical composition of the soil. But its mechanical nature—that is, whether it is stiff or loose, fine or coarse in grain, deep or shallow—is very important, because it is directly connected with heat and moisture and the life of the roots in the soil.

REQUIREMENTS OF TREES FOR LIGHT.

The relations of trees to heat and moisture are thus largely responsible for their distribution upon the great divisions of the earth's surface, such as continents and mountain ranges, as well as over the smaller rises and depressions of every region where trees grow. But while heat and moisture decide where the different kinds of trees can grow, their influence has comparatively little to do with the struggles of individuals or species against each other for the actual possession of the ground. The outcome of these struggles depends less on heat



A REGION OF LITTLE RAIN. COLORADO.

and moisture than on the possession of certain qualities, among which is the ability to bear shade. With regard to this power trees are roughly divided into two classes, often called shade-bearing and light-demanding, following the German, but better named tolerant and intolerant of shade. (See figs. 27, 28.) Tolerant trees are those which flourish under more or less heavy shade in early

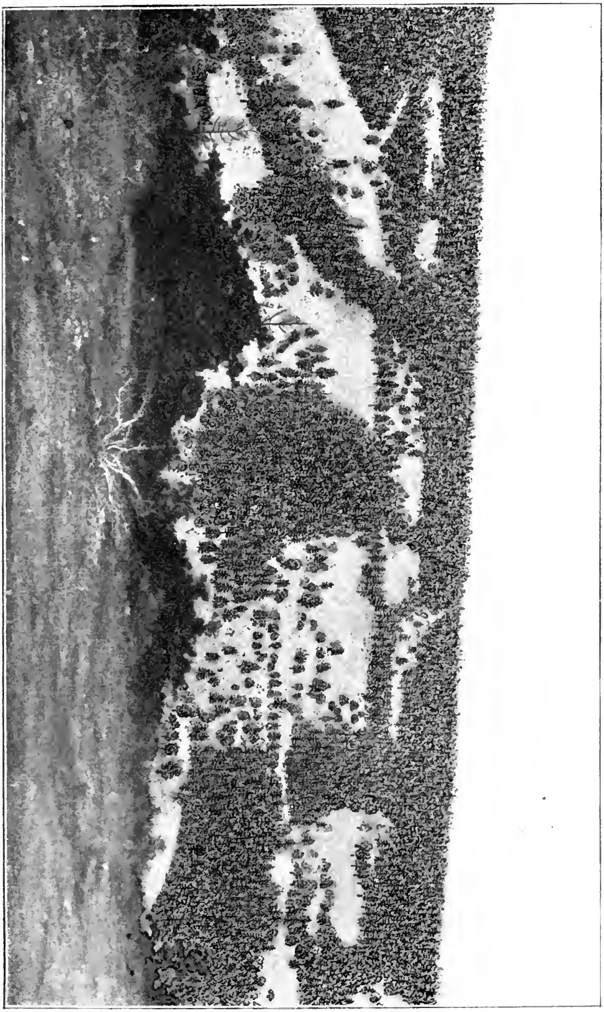
FIG. 28.—Heavy crowns of a tolerant species. The Alpine Fir in northern Washington.

youth; intolerant trees are those which demand a comparatively slight cover, or even unrestricted light. Later in life all trees require much more light than at first, and usually those of both classes can live to old age only when they are altogether unshaded from above. But there is always this difference between them: the leaves of tolerant trees will bear more shade. Consequently those on the lower and inner parts of the crown are more vigorous, plentiful, and persistent than is the case with intolerant trees. Thus the crown of a tolerant tree in the forest is usually denser and longer than that of one which bears less shade. It is usually true that the seedlings of trees with dense crowns are able to flourish under cover, while those of light-crowned trees are intolerant. This rough general rule is often of use in the study of forests in a new country, or of trees whose silvicultural character is not known.

FIG. 29.—A small Red Spruce in the Adirondack Mountains of New York. For many years this tree stood under the dense cover of taller trees. During that time its branches spread to the sides, but it made scarcely any growth in height. Then more light came to it, probably by the fall of some tall neighbor, and it began to recover its strength and grow much faster. The thin upper part of the crown is where this faster height growth has been going on.

TOLERANCE AND INTOLERANCE.

The tolerance or intolerance of trees is one of their most important silvicultural characters. Frequently it is the first thing a forester seeks to learn about them, because what he can safely



FOREST-FILLED GULLIES ON THE EAST SLOPE OF THE CASCADE RANGE. OREGON.

undertake in the woods depends so largely upon it. Thus tolerant trees will often grow vigorously under the shade of light-crowned trees above them, while if the positions were reversed the latter would speedily die. (See Pl. XVI.) The proportion of different kinds of trees in a forest often depends on their tolerance. Thus Hemlock sometimes replaces White Pine in Pennsylvania, because it can grow beneath the Pine, and so be ready to fill the opening whenever a Pine dies. But the Pine can not grow under the Hemlock, and can only take possession of the ground when a fire or a windfall makes an opening where it can have plenty of light. Some trees, after being overshaded, can never recover their vigor when at last they are set free. Others do recover and grow vigorously even after many years of starving under heavy shade. The Red Spruce, in the Adirondacks, has a wonderful

FIG. 30.—A Pitch Pine, producing seed abundantly, as shown by the numerous cones, but with no seedlings beneath it. Fire has run over the ground, and the surface is very dry. A strong breeze was blowing when the picture was taken. New Jersey.

Fig. 31.—Winged seeds: 1, Basswood; 2, Boxelder; 3, Elm; 4, Fir; 5 to 8, Pine.

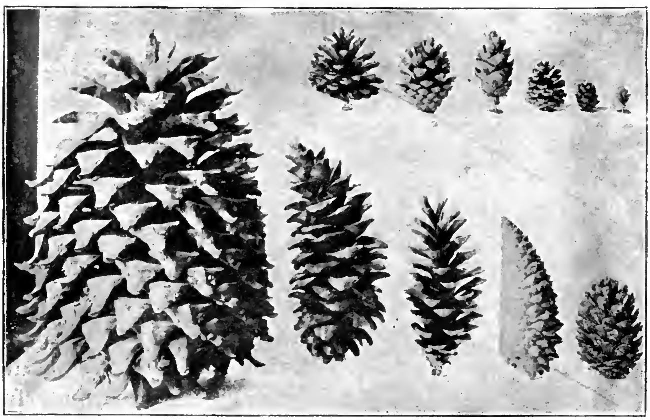


Fig. 32.—Cones: Beginning at the left, these cones come from Coulter's Pine, the Western White Pine, the Eastern White Pine, the Knob-Cone Pine, the Fox-Tail Pine, the Pitch Pine, the Lodgepole Pine, the Red Fir, the Short-leaf Pine, the Eastern Hemlock, and the Eastern Arbor Vitæ.

A GROUP OF HEMLOCKS AND RHODODENDRONS GROWING IN THE SHADE OF OAKS AND CHESTNUTS. MILFORD PA.

power of this kind, and makes a fine tree after spending the first fifty or even one hundred years of its life in reaching a diameter of a couple of inches. (See fig. 29.)

The relation of a tree to light changes not only with its age, but also with the place where it is growing, and with its health. An intolerant tree will stand

FIG. 33.—Young Oaks starting under an old forest of Pines. Eastern North Carolina.

more cover where the light is intense than in a cloudy northern region, and more if it has plenty of water than with a scanty supply. Vigorous seedlings will get along with less light than sickly ones. Seedlings of the same species will prosper under heavier shade if they have always grown under cover than if they have had plenty of light at first and have been deprived of it afterwards.

THE RATE OF GROWTH.

The rate of growth of different trees often decides which one will survive in the forest. For example, if two intolerant kinds of trees should start together on a burned area or an old field, that one which grew faster in height would overtop the other and destroy it in the end by cutting off the light. Some trees, like the Black Walnut, grow rapidly from their earliest youth.

FIG. 34.—Pure forest of Western Yellow Pine in the Black Hills of South Dakota. The trees here are smaller in size than those of Montana (see fig. 35), but their power of reproduction is much greater.

Others grow very slowly for the first few years. The stem of the Longleaf Pine, at 4 years old, is usually not more than 5 inches in length. During this time the roots have been growing instead of the stem. The period of its rapid growth in height comes later.

The place where a tree stands has a great influence on its rate of growth. Thus the trees on a hillside are often much smaller than those of equal age in the rich

STUNTED WHITE-BARK PINE AND BLACK HEMLOCK AT TIMBER LINE ON MOUNT HOOD, OREGON.

hollow below, and those on the upper slopes of a high mountain are commonly starved and stunted in comparison with the vigorous forest lower down. (See Pl. XVII.) The Western Chinquapin, which reaches a height of 150 feet in the coast valleys of northern California, is a mere shrub at high elevations in the Sierra Nevada. The same thing often appears in passing from the more temperate regions to the far north. Thus the Canoe Birch, at its northern limit, rises only a few inches above the ground, while farther south it becomes a tree sometimes 120 feet in height.

FIG. 35.—Western Yellow Pine in mixture with other trees. Flathead Valley, Montana.

THE REPRODUCTIVE POWER OF TREES.

Another matter which is of the deepest interest to the forester is the reproductive power of his trees. Except in the case of sprouts and other growth fed by old roots, this depends first of all on the quantity of the seed which each tree bears; but so many other considerations affect the result that a tree which bears seed abundantly may not reproduce itself very well. (See fig. 30.) A part of the seed is always unsound, and sometimes much the larger part, as in the case of the Tulip Tree. But even a great abundance of sound seed does not always insure good reproduction. The seeds may not find the right surroundings for successful germination, or the infant trees may perish for want of water, light, or suitable soil. Where there is a thick layer of dry leaves or needles on the ground, seedlings often perish in great numbers because their delicate rootlets can not reach the fertile soil beneath. The same thing happens when there is no humus at all and the surface is hard and dry. The weight of the seed also has a powerful influence on the character of reproduction. Trees with heavy seeds, like Oaks, Hickories, and Chestnuts, can sow them only in their own neighborhood, except when they stand on steep hillsides or on the banks of streams, or when birds and squirrels carry the nuts and acorns to a distance. (See Pl. XVIII.) Trees with light, winged seeds, like the Poplars, Birches, and Pines, have a great advantage over the others, because they can drop their seeds a long way off. (See figs. 31, 32.) The wind is the means by which this is brought about, and the adaptation of the seeds themselves is often very curious and interesting. The wing of a Pine seed, for example, is so placed that the seed whirls when it falls, in such a way that it falls very slowly. Thus the wind has time to carry it away before it can reach the ground. In heavy winds Pine and other

FIG. 36.—Mixed forest of White Pine, Chestnut, and Oak at Milford, Pa.

A NATURAL AVENUE OF RED CEDARS. NEW JERSEY.
The seeds of these trees were dropped by birds which perched on the fences.

winged seeds are blown long distances—sometimes as much as several miles. This explains how certain kinds of trees, like the Gray Birch and the White Pine, grow up in the middle of open pastures, and how others, such as the Lodgepole Pine, cover great areas, far from the parent trees, with young growth of even age.

FIG. 37.—Pure forest of White Cedar near Toms River, New Jersey.

THE SUCCESSION OF FOREST TREES.

Such facts help to explain why, in certain places, it happens that when Pines are cut down Oaks succeed them, or when Oaks are removed Pines occupy the ground. It is very often true that young trees of one kind are already growing unnoticed beneath old trees of another, and so are ready to replace them whenever the upper story is cut away. (See fig. 33.)

PURE AND MIXED FOREST.

The nature of the seed has much to do with the distribution of trees in pure or mixed forest. It is the habit of some trees to grow in bodies of some extent containing only a single kind; in other words, in pure forest. (See fig. 34 and Pl. XIX.) The Longleaf Pine of the South Atlantic and Gulf States is of this kind, and so is the Lodgepole Pine of the West. Conifers are more apt to grow in pure forest than broadleaf trees, because it is more common for them to have winged seeds. The greater part of the heavy-seeded trees in the United States are deciduous, and most of the deciduous trees grow in mixed forest, although there are some conspicuous exceptions. But even in mixed forests small groups of trees with heavy seeds are common, because the young trees naturally start up beneath and around the old ones. A heavy seed, dropping from the top of a tall tree, often strikes the lower branches in its fall and bounds far outside the circle of the crown. Trees which are found only, or most often, in pure forest are the social or gregarious kinds; those which grow in mixture with other trees are called scattered kinds. Most of the hardwood forests in the United States are mixed; and many mixed forests, like that in the Adirondacks, contain both broad-

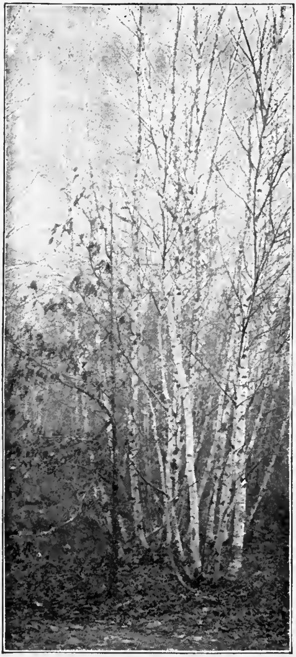
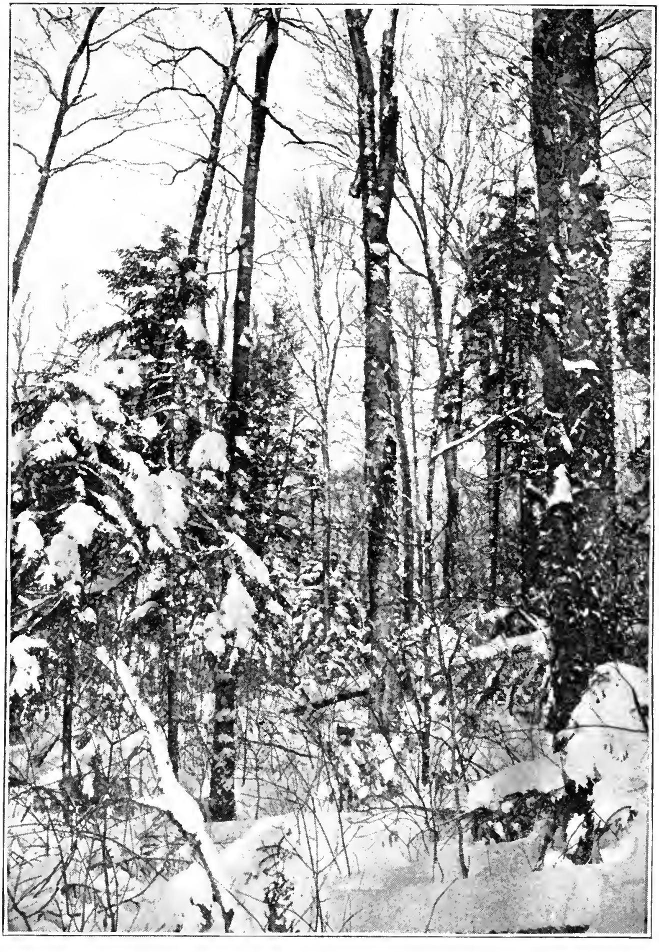


FIG. 38.—Sprouts of Gray Birch with a small White Oak in the foreground. Milford, Pa.

PURE FOREST OF YOUNG RED FIR. WESTERN OREGON.

Except in parts of Washington and Oregon, the Red Fir is less often found pure than in mixture with other trees. It is one of the most valuable timber trees of the world, and is very widely distributed in the Western States. On the northern part of the Pacific slope it is very abundant and of great size, and its wood is widely used, both at home and abroad, under the misleading name of Oregon Pine.

A MIXED FOREST OF CONIFERS ON THE WESTERN SLOPE OF THE CASCADE RANGE. VALLEY OF CASCADE CREEK, SKAGIT RIVER BASIN, WASHINGTON.



MIXED FOREST IN THE ADIRONDACK MOUNTAINS, NEW YORK. A GROUP OF YOUNG SPRUCES UNDER OLDER SPRUCE, BIRCH, AND MAPLE.

In the foreground are many young broadleaf seedlings. The Adirondack forest contains Beech, Birch, Maple, Cherry, and Poplar among the broadleaf trees, and Pine, Spruce, Hemlock, Larch, Fir, and Cedar among the cone bearers.

leaf trees and conifers. (See fig. 36 and Pls. XX, XXI.) The line between gregarious and scattered species is not always well marked, because it often happens that a tree may be gregarious in one place, and live with many others elsewhere. The Western Yellow Pine, which forms, on the plateau of central Arizona, perhaps the largest pure Pine forest of the earth, is frequently found growing with other species in the mountains, especially in the Sierra Nevada of central California. (See figs. 34, 35.)

FIG. 39.—Sprouts of Pitch Pine from the neighborhood of Toms River, New Jersey.

Trees which occupy the ground to the exclusion of all others do so because they succeed better, under the conditions, than their competitors. (See fig. 37.) It may be that they are able to get on with less water, or to grow on poorer soil, their rate of growth or power of reproduction may be greater, or there may be some other reason why they are better fitted for their surroundings. But the gregarious trees are not all alike in their ability to sustain themselves in different situations, while the differences between some of the mixed-forest species are very marked indeed. Thus Black Walnut, as a rule, grows only in rich moist soil, and Beech only in damp situations. Fire Cherry, on the other hand, is most common on lands which have been devastated by fire, and the Rock Oak is most often found on dry barren ridges. The Tupelo or Black Gum and the Red Maple both grow best in swamps, but it is a common thing to find them also on dry stony soils at a distance from water. The knowledge of such qualities as these is of great importance in the management of forest lands.

FIG. 40.—Chestnut sprouts from the stump. Milford, Pa.

REPRODUCTION BY SPROUTS.

Besides reproduction from seed, which plays so large a part in the struggle for the ground, reproduction by sprouts from old roots or stumps is of great importance in forestry. (See fig. 38.) Trees differ very much in their power of sprouting. In nearly all conifers except the California coast Redwood, which has this ability beyond almost every other tree, it is lacking altogether. The Pitch or Jack Pine of the Eastern United States has it also to some extent, but in most places the sprouts usually die in early youth, and seldom make merchantable trees. (See fig. 39 and Pl. XXII.) In the broadleaf kinds, on the other hand, it is a general and

SUCKERS, OR SPROUTS, FROM THE TRUNK AND BRANCHES OF A PITCH PINE.
SOUTHERN NEW JERSEY.

A year before the picture was taken a forest fire passed over this place and burned to the top of the tree, destroying all the needles; yet, the tree was not killed, although scarcely any other kind could have survived. It put out a vigorous growth of suckers, and it still has a chance for life. Such examples are common throughout the burnt parts of southern New Jersey, where large and vigorous sprouts from the roots of trees of this species which have been killed to the ground by fire are very frequent.

very valuable quality. Young stumps, as a rule, are much more productive than old ones, although some prolific species, like the Chestnut (see fig. 40), sprout plentifully in old age. Other species, like the Beech, furnish numerous sprouts from young stumps and very few or none at all from old ones, and still others never sprout freely even in early youth.

CHAPTER III.

THE LIFE OF A FOREST.

The history of the life of a forest is a story of the help and harm which the trees receive from one another. On one side every tree is engaged in a relentless struggle against its neighbors for light, water, and food, the three things trees need most. On the other side, each tree is constantly working with all its neighbors, even those which stand at some distance, to bring about the best condition of the soil and air for the growth and fighting power of every other tree. (See Pl. XXIII.)

A COMMUNITY OF TREES.

The life of a community of trees is an exceedingly interesting one. A forest tree is in many ways as much dependent upon its neighbors for safety and food as are the inhabitants of a town upon one another. (See fig. 41.) The difference is that in a town each citizen has a special calling or occupation in which he works for the service of the commonwealth, while in the forest every tree contributes to the general welfare in nearly all the ways in which it is benefited by the community. A forest tree helps to protect its neighbors against the wind, which might overthrow them, and the sun, which is ready to dry up the soil about their roots or to make sun cracks in their bark by shining too hotly upon it. It enriches the earth in which they stand by the fall of

A SPRUCE FOREST IN THE ALLEGHENY MOUNTAINS. NORTH CAROLINA.

The health and fertility of this forest are due to the mutual help of the trees.

its leaves and twigs, and aids in keeping the air about their crowns, and the soil about their roots, cooler in summer and warmer in winter than it would be if each tree stood alone. (See Pl. XXIV.) With the others it forms a common canopy under which the seedlings of all the members of this protective union are sheltered in early youth, and through which the beneficent influ-

FIG. 41.—A forest in Switzerland where the mutual help of the trees is at its best. The Sihlwald, where this picture was taken, has been well managed since before the discovery of America.

ence of the forest is preserved and extended far beyond the spread of the trees themselves. But while this fruitful cooperation exists, there is also present, just as in a village or a city, a vigorous strife for the good things of life. For a tree the best of these, and often the hardest to get, are water for the roots and space and light for the crown. In all but very dry places there is water enough for all the trees, and often more than enough, as for example in the Adirondack forest. The struggle for space and light is thus more important than the struggle for water, and as it takes place above ground it is also much more easily observed and studied. (See fig. 42 and Pl. XXV.)

Light and space are of such importance because, as we have seen, the leaves can not assimilate or digest food except in the presence of light and air. The rate at which a tree can grow and make new wood is decided chiefly by its ability to assimilate and digest plant food. This power depends upon the number, size, and health of the leaves, and these in turn upon the amount of space and light which the tree can secure.

FIG. 42.—On the edge of a very dense forest. The leaning trees are dead, killed by the crowding and shade of their stronger neighbors. Spruce in the White Mountains, New Hampshire.

THE LIFE OF A FOREST CROP.

The story of the life of a forest crop is then largely an account of the competition of the trees for light and room, and, although the very strength which enables them to carry on the fight is a result of their association, still the deadly struggle, in which the victims are many times more in number than those which survive, is apt alone to absorb the attention. Yet the mutual help of the trees to each other is always going quietly on.

THE FOREST FLOOR. INTERIOR OF A HARDWOOD FOREST ON ROCKY GROUND. NORTHERN NEW JERSEY.

Every tree continually comforts and assists the other trees, which are its friendly enemies. (See figs. 43, 44.)

The purpose of the present chapter is to follow the progress of a forest crop of uniform age from the seed through all the successive phases of its life until it reaches maturity, bears seed in its turn, and finally declines in fertility and strength until at last it passes away and its place is filled by a new generation. The life history which we are about to follow, as it unfolds itself through the course of several hundred years, is full of struggle and danger in youth, restful and dignified in age. The changes which pass over it are vast and full of the deepest interest, but they are very gradual. From beginning to end one stage melts insensibly into the next. Still, in order to study and describe them conveniently, each stage must have limits and a name.

Fig. 43.—A forest tree, deprived of its companions, slowly dying. A Larch in the Priest River Forest Reserve, Idaho.

THE SEVEN AGES OF A TREE.

A very practical way of naming and distinguishing trees is the following, which will be used in referring to them hereafter in this discussion. Young trees which have not yet reached a height of 3 feet are seedlings. (See figs. 45–49 and Pls. XXVII, XXVIII.) They are called seedlings in spite of the fact that any tree, of whatever age, if it grew from a seed, is properly called a seedling tree. Trees from 3 to 10 feet in height are small saplings, and from 10 feet in height until they reach a diameter of 4 inches they are large saplings. (See figs. 50, 51, 57.) Small poles are from 4 to 8 inches in diameter,

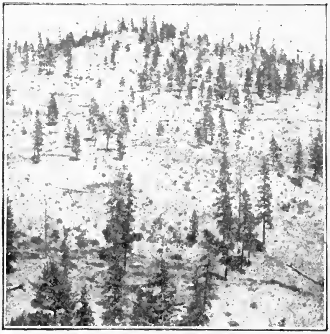


FIG. 44.—Forest trees standing too far apart to help each other. Lake Chelan, Washington.

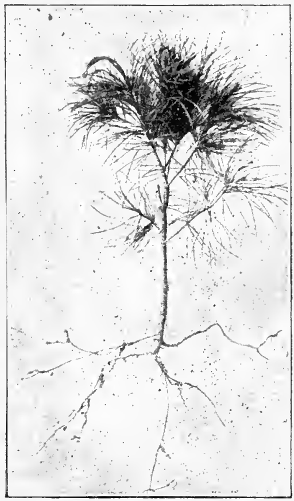


FIG. 45.—A White Pine seedling, showing the slender roots. Milford, Pa.

and large poles from 8 to 12 inches in diameter. (See figs. 54, 55, and Pl. XXIX.) Trees from 1 to 2 feet through are standards, and finally, all trees over 2 feet in diameter are veterans. (See figs. 34, 56, and Pls. I, XXXI, XXXII.)

It is very important to remember that all these diameters are measured breast high, or at the height of a man's chest, about 4 feet 6 inches from the ground. In forestry this is, roughly speaking, the general custom.

WHITE PINES HELPING AND HINDERING EACH OTHER. DUBOIS PA.

HOW THE CROP BEGINS.

Let us imagine an abundant crop of tree seeds lying on the ground in the forest. (See Pl. XXVI.) How they came there does not interest us at present; we do not care to know whether they were carried by the wind, as often happens with the winged seeds of many trees, such as Pines and Maples, or whether the squir-

FIG. 46.—Seedlings of Western Hemlock growing thickly on a fallen log. Western Washington.

rels and birds dropped and planted some of them, as they frequently do acorns and chestnuts, or whether the old trees stood closely about and sowed the seed themselves. We will only suppose them to be all of one kind, and to be scattered in a place where the soil, the moisture, and the light are all just as they should be for their successful germination, and afterwards for the later stages of their lives. Even under the best conditions a considerable part of the fallen seed may never germinate, but in this case we will assume that half of it succeeds. (See fig. 46.)

As each seed of our forest germinates and pushes its first slender rootlet downward into the earth, it has a very uncertain hold on life. Even for some time after-

FIG. 47.—Seedlings of White Pine under a spreading Scrub Oak. Milford, Pa. The young Pines are overshaded by the worthless Oak, and will die unless the latter is cut away.

wards the danger from frost, dryness, and excessive moisture is very serious indeed, and there are many other foes by which the young seedlings may be overcome. It sometimes happens that great numbers of them perish in their earliest youth because their roots can not reach the soil through the thick dry coating of dead leaves which covers it. But our young trees pass through the beginning of these dangers with compara-

CHESTNUT OAK ACORNS GERMINATING IN THE WOODS IN NOVEMBER. MILFORD, PA.

The surface of the ground, composed of finely broken fragments of leaves, twigs, etc., under a layer of dead leaves, forms an excellent seed bed when sufficiently moist. Among the leaves are those of the White, Black, and Chestnut Oaks, and the Chestnut.

tively little loss, and a plentiful crop of seedlings occupies the ground. As yet, however, each little tree stands free from those about it. As yet, too, the life of the young forest may be threatened or even destroyed by any one of the enemies already mentioned, or it may suffer just as severely if the cover of the older trees above it is too dense. In the beginning of their lives seedlings often require to be protected by

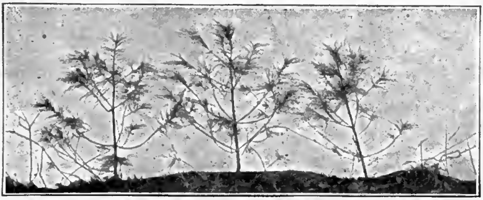


FIG. 48.—Young White Pines (seedlings) whose lower branches have just begun to interfere. Milford, Pa. These are vigorous young trees, with plenty of light, as may be seen by the grass which is growing around them. Grass in the woods almost always means that the cover is too thin for the good of the soil.

the shade of their elders, but if this protection is too long continued they suffer for want of light, and are either killed outright or live only to drag on stunted and unhealthy lives. (See fig. 47.)

THE FOREST COVER ESTABLISHED.

The crop which we are following has had a suitable proportion of shade and light during its earliest years, and the seedlings have spread until their crowns begin to meet. Hitherto each little tree has had all the space in the air and soil that it needed for the expansion of its top and roots. This would have been entirely good, except that meanwhile the soil about the trees has been more or less exposed to the sun and wind, and so has become dryer and less fertile than if it had been under cover, and consequently the growth has been slow. But now that the crowns are meeting, the situation becomes wonderfully changed. The soil begins to improve rapidly, because it is protected by the cover of the meeting crowns and enriched by the leaves and twigs which fall from them. (See figs. 48, 49.)

Fig. 49.—Group of White Pines (small saplings) in an opening among older trees. Milford, Pa. The lower branches are crowding each other vigorously, and will soon begin to die.

THE BEGINNING OF THE STRUGGLE.

In so far the conditions of life are better, and in consequence the growth, and more especially the height growth, begins to show a marked increase. (See fig. 50.) On the other hand, all the new strength is in immediate demand. With the added vigor which the trees are now helping each other to attain comes the most urgent need for rapid development, for the decisive struggle is at hand. The roots of the young trees contend with each other in the soil for moisture and the plant food which it contains, while in the air the crowns struggle for space and light. The latter is by far the more important battle. The victors in it overcome by greater rapidity of growth at the ends of the branches, for it is by growth there, and there only, that trees increase

BALSAM FIR SEEDLINGS UNDER PARTIAL COVER ON LUMBERED LAND. ADIRONDACK MOUNTAINS, NEW YORK.

in height and spread of crown. Growth in this way was going on unchecked among the young trees before the crowns met, but now only the upward-growing branches can develop freely. The leaves at the ends of the side branches have now less room and, above all, less light, for they are crowded and thrust aside by those of the other trees. Very often they are bruised by thrashing against their neighbors when the wind blows, or even broken off while still in the bud. Leaves exposed to such dangers are unhealthy. They transpire less than the healthy, undisturbed leaves of the upper part of the crown, and more and more of the undigested food from the roots goes to the stronger leaves at the top as the assimilating power of the side leaves dwindles with the loss of light. The young branches share the fortunes of their leaves and are vigorous or sickly according to the condition of the latter. For this reason the growth of the tops increases, while that of the lower lateral branches, as the tops cover them with a deeper and deeper shade, becomes less and less. Gradually it ceases altogether, and the branches perish. This

FIG. 50.—Small saplings of White Pine growing thickly together. Milford, Pa. The space between each cluster or whorl of side branches marks one year's growth. These young Pines are beginning to grow rapidly in height because they can no longer spread at the sides.

process is called natural pruning, and from the time when it begins the existence of the young forest, unless it should be overtaken by fire or some other great calamity, is practically secure.

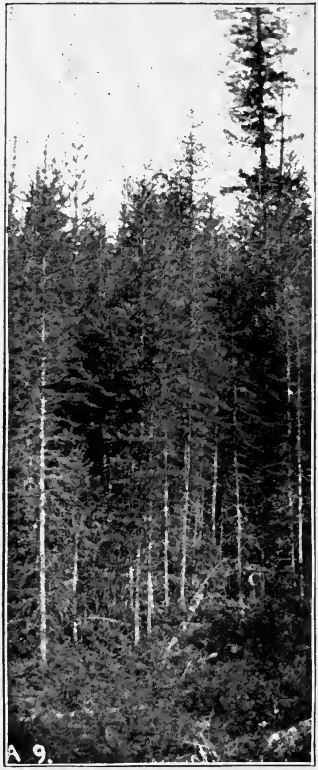
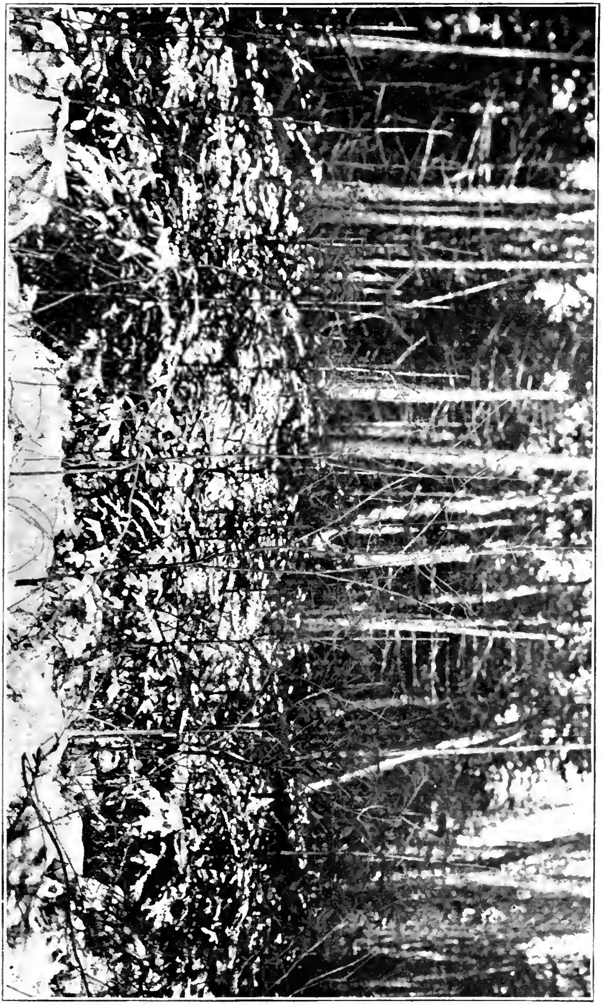


FIG. 51.—Large saplings and small poles. Western Larch and Western White Pine. Priest River Forest Reserve, Idaho.

GROWTH IN HEIGHT.

At this time, as we have seen, the crowns of all the young trees are growing faster at the tops than at the sides, for there is unlimited room above. (See fig. 51.) But some are growing faster than others, either because their roots are more developed or in better soil than those of the trees about them, because they have been freer from the attacks of insects and other enemies, or for some similar reasons. Some trees have an inborn tendency to grow faster than others of the same species in the same surroundings, just as one son in a family is often taller than the brothers with whom he was brought up.

Rapid growth in height, from whatever cause it proceeds, brings not only additional light and air to the



BALSAM FIR, RED SPRUCE, AND HARDWOOD SEEDLINGS IN AN OPENING IN THE FOREST. ADIRONDACK MOUNTAINS, NEW YORK.

The crowns have met, and rapid growth in height has begun.

tree which excels in it, but also the chance to spread laterally, and so to complete the defeat of its slower rivals by overtopping them.

FIG. 52.

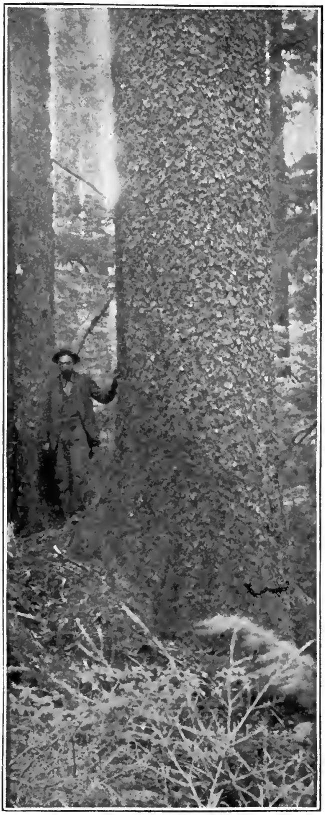


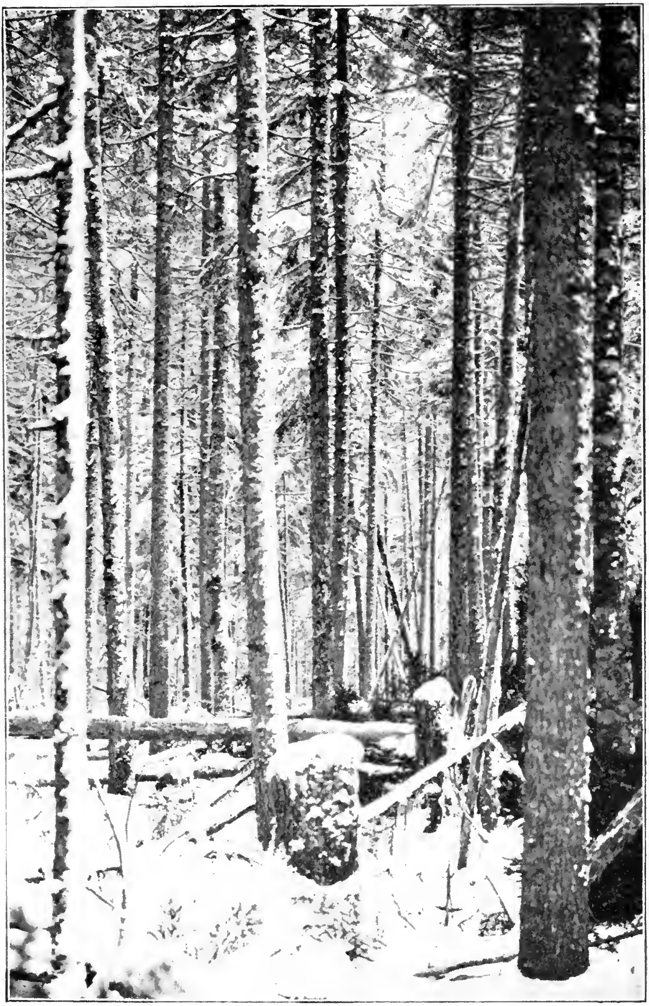
FIG. 53.

A tall clear trunk made by natural pruning, and the base of the same tree. Sitka Spruce in the Olympic Forest Reserve, Washington.

THE STRUGGLE CONTINUED.

FIG. 54.—Natural pruning on Pine poles still unfinished. Biltmore, N. C.

Those trees which have gained this advantage over their neighbors are called dominant trees, while the surviving laggards in the race are said to be overtopped when they are hopelessly behind, and retarded when less badly beaten. Enormous numbers of seedlings and small saplings are suppressed and killed during the early youth of the forest. In the young crop which we are following many thousands perish upon every acre. Even the dominant trees, which are temporarily free when they rise above their neighbors, speedily come into conflict with each other as they spread, and in the end the greater portion is overcome. It is a very deadly struggle, but year by year the differences between the trees become less marked. Each separate individual clings to life with greater tenacity, the strife is more



A FOREST OF SPRUCE POLES. ADIRONDACK MOUNTAINS, NEW YORK.

protracted and severe, and the number of trees which perish grows rapidly smaller. But so great is the pressure when dense groups of young trees are evenly matched in size and rate of growth that it is not very unusual to find the progress of the young forest in its

FIG. 55.—Poles of Longleaf Pine. Southern Florida.

early stages almost stopped, and the trees uniformly sickly and undersized, on account of the crowding.

The forest we have been following has now passed through the small-sapling stage, and is composed chiefly, but not exclusively, of large saplings. Among the overtopped and retarded trees, which often remain in size classes which the dominant trees have long since outgrown, there are still many low saplings. Even between the dominant trees, in a healthy forest, there are always great differences. Increase in height is now going on rapidly among these high saplings, and either in this stage or the next a point is reached when the topmost branches make their longest yearly growth, which is one way of saying that the trees make their most rapid height growth as large saplings or small poles. (See Pl. XXIX.) Later on, as we shall see, these upper branches lengthen much more slowly, until, in standards and veterans, the growth in height gradually diminishes, and in very old trees finally ceases altogether.

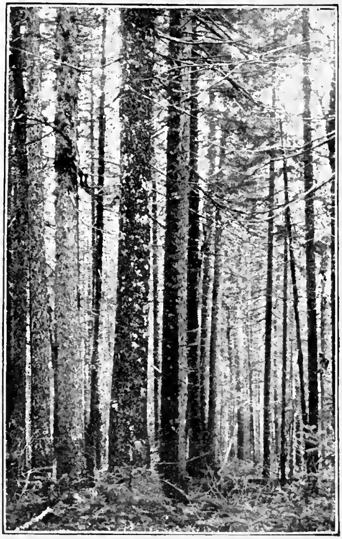


FIG. 56.—Standards and poles of Spruce. White Mountains, New Hampshire.

NATURAL PRUNING.

While the trees are pushing up most rapidly the side branches are most quickly overshaded, and the process of natural pruning goes on with the greatest vigor. Natural pruning is the reason why old trees in a dense forest have only a small crown high in the air, and why their tall, straight trunks are clear of branches to such

IMPERFECT NATURAL PRUNING ON A WHITE PINE THAT STOOD TOO MUCH ALONE IN EARLY YOUTH. MILFORD, PA.

a height above the ground. (See figs. 52–56 and Pl. XXX.) The trunks of trees grown in the open, where even the lower limbs have abundance of light, are branched either quite to the ground or to within a short distance of it. But in the forest not only are the lower side branches continually dying for want of light, but the tree rids itself of them after they are dead and so frees its trunk from them entirely. When a branch dies the annual layer of new wood is no longer deposited upon it. Consequently the dead branch, where it is inserted in the tree, makes a little hole in the first coat of living tissue formed over the live wood after its death. The edges of this hole make a sort of collar about the base of the dead branch, and as a new layer is added each year they press it more and more tightly. So strong does this compression of the living wood become that at last what remains of the dead tissue has so little strength that the branch is broken off by an ice storm or by the wind, or even falls of its own weight. Then in a short time, if all goes well, the hole closes, and after a while little or no exterior trace of it remains. Knots, such as those which are found in boards, are the marks left in the trunk by branches which have disappeared.

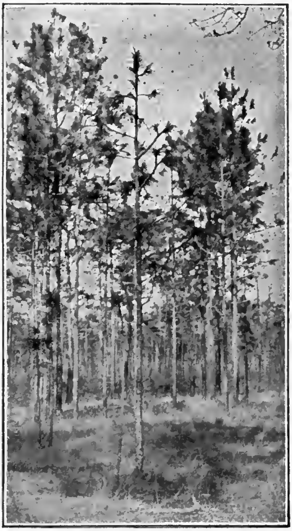


FIG. 57.—Pointed crowns of saplings of Longleaf Pine growing rapidly in height. Southern Florida.

THE CULMINATION OF GROWTH.

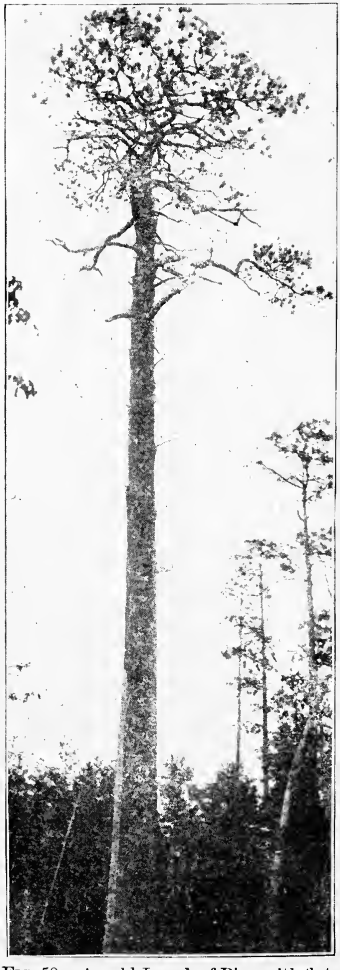


Fig. 58.—An old Longleaf Pine with flattened crown. Eastern North Carolina.

While the young trees are making clean trunks so rapidly during the period of greatest yearly height growth they are also making their greatest annual gains in diameter, for these two forms of growth generally culminate about the same time. A little later, if there is any difference, the young forest's highest yearly rate of growth in volume is also reached. For a time these three kinds of growth keep on at the same rate as in the past, but afterwards all three begin to decrease. Growth in diameter, and in volume also, if the trees are sound, goes on until extreme old age, but height growth sinks very low while the two others are still strong. For many years before this happens the struggle between the trees has not been so deadly, because they have been almost

A DENSE FOREST OF STANDARDS AND VETERANS OF RED FIR AND LOWLAND FIR.
LAKE CRESCENT, OLYMPIC PENINSULA, WASHINGTON.

without the means of overtopping one another. When the end of the period of principal height growth is reached the trees are interfering with each other very little, and the struggle for life begins again in a different way. As the principal height growth ceases, and the tops no longer shoot up rapidly above the side branches, the crowns lose their pointed shape and become comparatively flat. (See figs. 57, 58.) The chief reason why trees stop growing in height is that they are not able to keep the upper parts of their crowns properly supplied with water above a certain distance from the ground. This distance varies in different kinds of trees, and with the health and vigor of the tree in each species, but there is a limit in every case above which the water does not reach. The power of the pumping machinery, more than any other quality, determines the height of the tree.

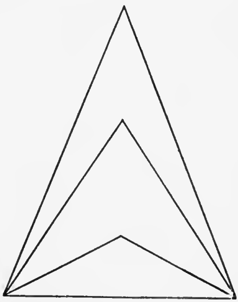


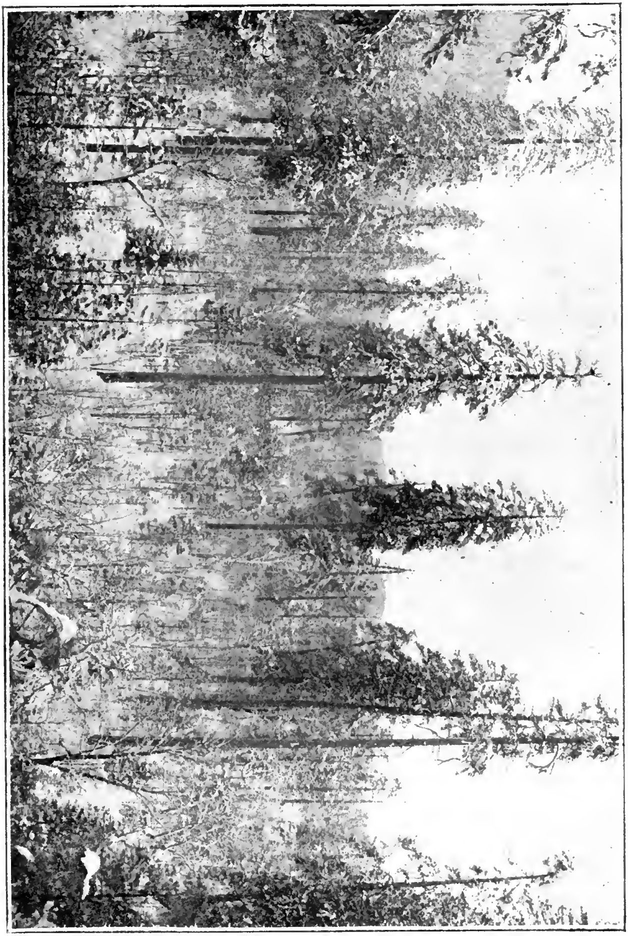
FIG. 59.—Diagram to show why a sharply conical crown receives more light than a flat one.

THE END OF THE STRUGGLE.

Now that the tree can no longer expand at the top, it must either suffer a great loss in the number of its leaves or be able to spread at the sides; for it is clear that not nearly so many leaves can be exposed to the light in the flattened crown as in the pointed one, just as a pointed roof has more surface than a flat one. (See fig. 59.) It is just at this time, too, that the trees begin to bear seed most abundantly, and it is of the greatest importance to each tree that its digestive apparatus in the leaves should be able to furnish a large supply of digested food. Consequently the struggle for space is fiercely renewed, only now the trees no longer attempt to overtop one another, having lost the power, but to crowd one another away at the sides. (See fig. 60.) The whole forest might suffer severely at this point from a deadlock such as sometimes happens in early youth

FIG. 60.—White Pine standards in the Adirondack Mountains, New York.

were it not for the fact that the trees, as they grow older, become more and more sensitive to any shade. Many species which stand crowding fairly well in youth can not thrive in age unless their crowns are completely free on every side. Each of the victors in this last phase of the struggle is the survivor of hundreds (or sometimes even of thousands) of seedlings. Among



YOUNG GROWTH UNDER OLD TREES. SOUTHWESTERN OREGON.

very numerous competitors they have shown themselves to be the best adapted to their surroundings. (See fig. 61 and Pl. XXXI.)

Natural selection has made it clear that these are the best trees for the place. These are also the trees which bear the seed whence the younger generations spring. Their offspring will inherit their fitness to a greater or less degree, and in their turn will be subjected to the

FIG. 61.—An open forest of intolerant Longleaf Pine. Southern Florida.

same rigorous test, by which only the best are allowed to reach maturity. Under this sifting out of the weak and the unfit, our native trees have been prepared, through thousands of generations, to meet the conditions under which they must live. This is why they are so much more apt to succeed than species from abroad, which have not been fitted for our climate and soil by natural selection.

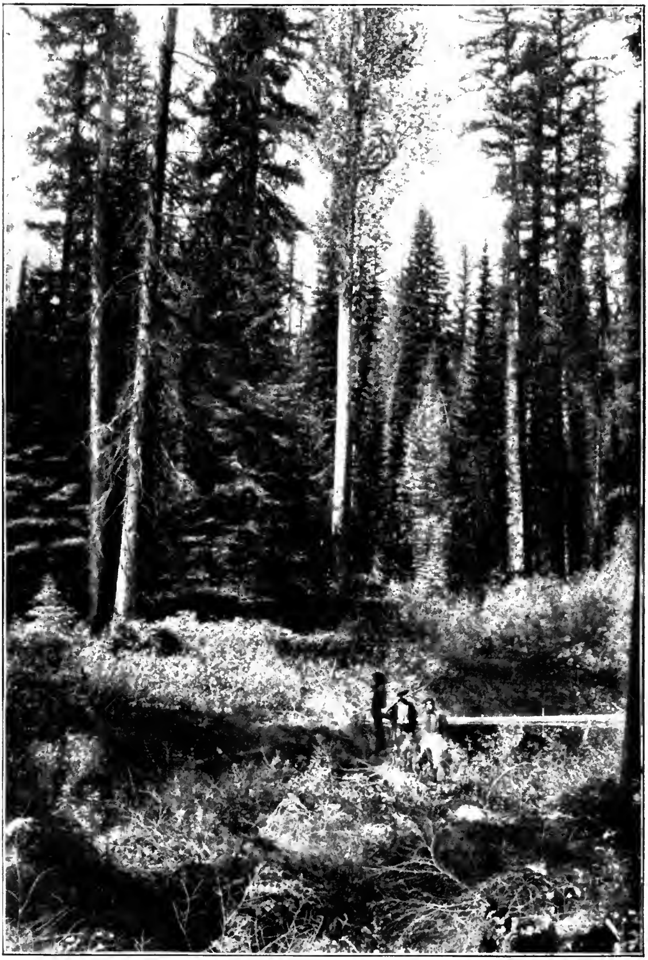
The forest which we saw first in the seed has now passed through all the more vigorous and active stages of its life. The trees have become standards and veterans, and large enough to be valuable for lumber. Rapid growth in height has long been at an end, diameter growth is slow, and the forest as a whole is increasing very little in volume as time goes on. The trees are ripe for the harvest.

Out of the many things which might happen to our mature forest we will only consider three.

DEATH FROM WEAKNESS AND DECAY.

In the first place, we will suppose that it stands untouched until, like the trees of the virgin forest, it meets its death from weakness and decay.

The trees of the mature primeval forest live on, if no accidents intervene, almost at peace among themselves. At length all conflict between them ends. The whole power of each tree is strained in a new struggle against death, until at last it fails. One by one the old trees disappear. But long before they go, the forerunners of a new generation have sprung up wherever light came in between their isolated crowns. As the old trees fall, with intervals, often of many years, between their deaths, young growth of various ages rises to take their place, and when the last of the old forest has vanished there may be differences of a hundred years among the young trees which succeed it. (See Pl. XXXII.) An even-aged crop of considerable extent, such as we have been considering, is not usual in the virgin forest, where trees of very different ages grow side by side, and when it does occur, the next generation is far less uniform. The forest whose history has just been sketched



FOREST ON THE SOUTH FORK OF THE FLATHEAD RIVER, MONTANA.
All the stages of tree growth are often present in one place, as here.

was chosen, not because it represents the most common type of natural forest, but because it illustrates better than any other the life and progress of forest growth. (See Pl. XXXIII.)

The wood of a tree which dies in the forest is almost wholly wasted. For a time the rotting trunk may serve to retain moisture, but there is little use for the carbon, oxygen, and hydrogen which make up its greater part. The mineral constituents alone form a useful fertilizer, but most often there is already an abundance of similar material in the soil. Not only is the old tree lost, but ever since its maturity it has done little more than intercept, to no good purpose, the light which would otherwise have given vitality to a valuable crop of younger trees. It is only when the ripe wood is harvested properly and in time that the forest attains its highest usefulness.

FIG. 62.—Lumbered and burned forest near Port Crescent, Olympic Peninsula, Washington.

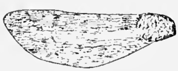
DESTRUCTIVE LUMBERING.

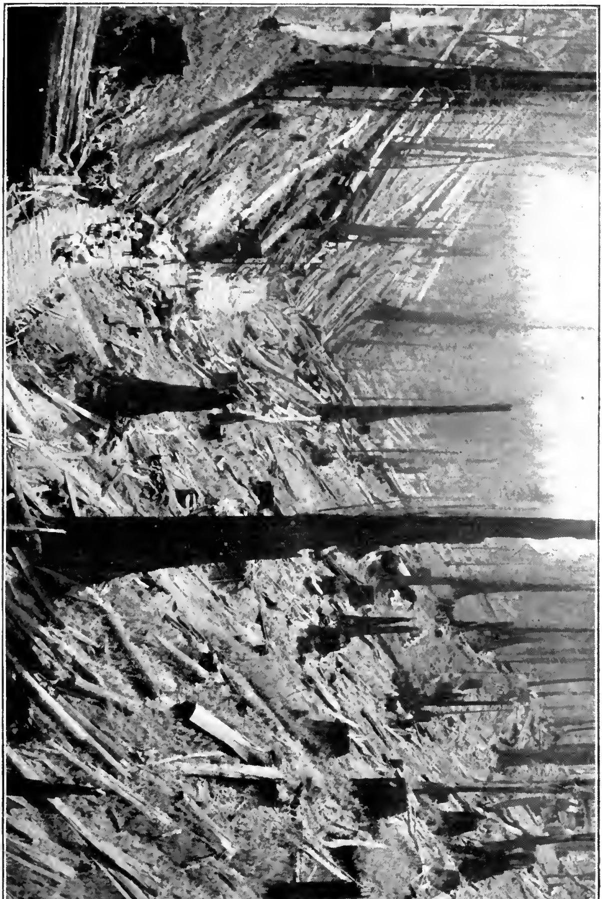
A second thing which may happen to a forest is to be cut down without care for the future. The yield of a forest lumbered in the usual way is more or less thoroughly harvested, it is true, but at an enormous cost to the forest. Ordinary lumbering injures or destroys the young growth, both in the present and for the future, provokes and feeds fires, and does harm of many other kinds. In many cases its result is to annihilate the productive capacity of forest land for tens or scores of years to come. (See fig. 62 and Pl. XXXIV.)

CONSERVATIVE LUMBERING.

The methods of forestry, on the other hand, maintain and increase both the productiveness and the capital value of forest land; harvest the yield far more completely than ordinary lumbering, although less rapidly; prepare for, encourage, and preserve the young growth; tend to keep out fires; and in general draw from the forest, while protecting it, the best return which it is capable of giving.

The application of these methods is the third possibility for the crop just described. There are still many places in the United States where transportation is so costly that, as yet, forestry will not pay from a business point of view. Elsewhere right forest management is the wisest, safest, and most satisfactory way of dealing with the forest. It is briefly described in Part II of this primer.





DESTRUCTIVE LUMBERING IN THE COAST REDWOOD BELT. CALIFORNIA.
Logging works in Bear Gulch, Eureka, Humboldt County.

CHAPTER IV.

ENEMIES OF THE FOREST.

The forest is threatened by many enemies, of which fire and reckless lumbering are the worst. In the United States sheep grazing and wind come next. Cattle and horses do much less damage than sheep, and snow break is less costly than windfall. Landslides, floods, insects, and fungi are sometimes very harmful. In certain situations numbers of trees are killed by lightning, which has also been known to set the woods on fire, and the forest is attacked in many other ways. For example, birds and squirrels often prevent young growth by devouring great quantities of nuts and other seeds, while porcupines and mice frequently kill young trees by gnawing away their bark.

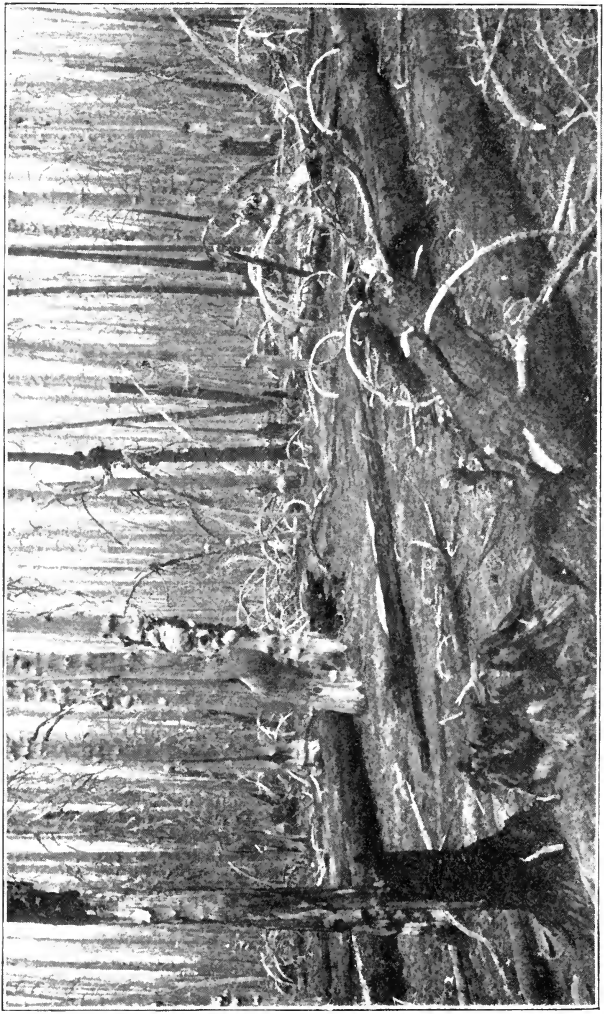
MAN AND NATURE IN THE FOREST.

Most of these foes may be called natural enemies, for they would injure the forest to a greater or less extent if the action of man were altogether removed. Wild animals would take the place of domestic sheep and cattle to some degree, and fire, wind, and insects would still attack the forest. But many of the most serious dangers to the forest are of human origin. Such are destructive lumbering, and excessive taxation on forest lands, to which much bad lumbering is directly due. So high are these taxes, for in many cases they amount to 5 or even 6 per cent yearly on the market value of the forests, that the owners can not afford to pay them and hold their lands. Consequently they are forced to cut or sell their timber in haste and without regard to the future. When the timber is gone the owners refuse to pay taxes any longer, and the devastated lands revert to the State. Many thousand square miles of forest have been ruined by reck-

FIG. 63.—A burnt forest in the Priest River Forest Reserve, Idaho.

less lumbering because heavy taxes forced the owners to realize quickly and once for all upon their forest land, instead of cutting it in a way to insure valuable future crops. For the same reason many counties are now poor that might, with reasonable taxation of timber land, have been flourishing and rich.

A short description of destructive lumbering will be



A BURNT FOREST IN THE HIGH MOUNTAINS. CASCADE FOREST RESERVE, OREGON.

The branches and smaller trees were bent and twisted by the intense heat found in Part II of this primer, together with some consideration of the most effective remedy, which is found in conservative ways of handling the forest, that is, in forest management.

GRAZING IN THE FOREST.

Whether grazing animals are comparatively harmless to the forest or among its most dangerous enemies

Fig. 64.—A band of sheep passing through the forest. These sheep were being herded illegally in a forest reserve. Eastern slope of the Cascade Mountains near Badger Lake, Wasco County, Oregon.

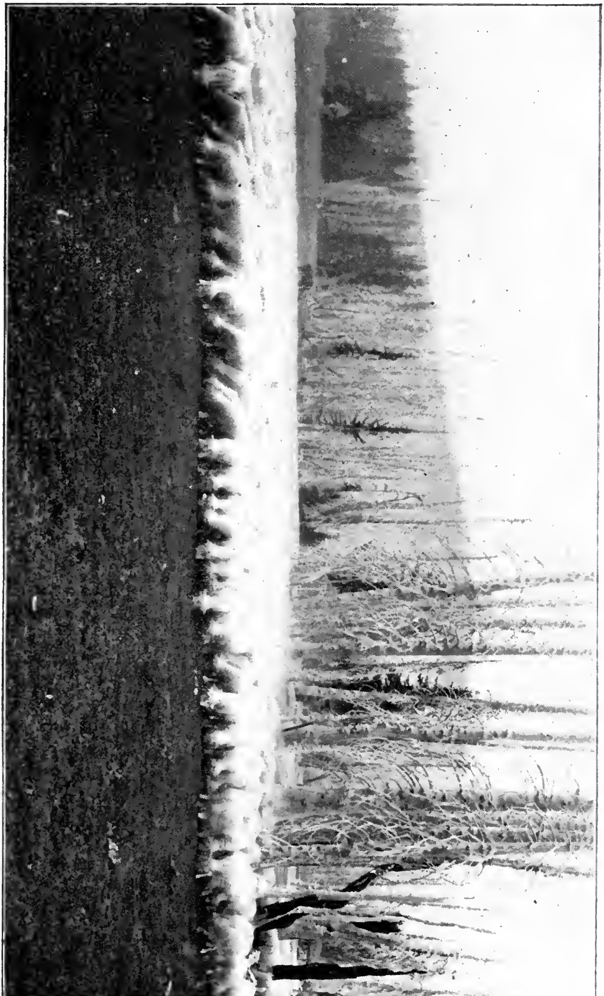
depends on the age and character of the woods as well as upon the kind of animals that graze. A young forest is always more exposed to such injury than an old one, and steep slopes are more subject to damage than more level ground. Whether the young trees are conifers, and so more likely to suffer from trampling than from being eaten, or broadleaf trees, and so more likely to be devoured, they should be protected from pasturing animals until they are large enough to be out of danger.

GRAZING AND FIRE.

Grazing in the forest does harm in three ways. First, it is a fertile cause of forest fires. (See figs. 64–66 and Pl. XXXV.) Burning the soil cover of grass and other

FIG. 65.—A forest of Lodgepole Pine in a region used for grazing. Bighorn Forest Reserve, Wyoming.

plants improves the grazing, either permanently, by destroying the forest and so extending the area of pasturage, or temporarily, by improving the quality of the feed. For one or the other of these objects, but chiefly for the latter, vast areas are annually burned over in nearly every part of the United States where trees grow. The great majority of these fires do not kill the old trees, but the harm they do the forest and, eventually,



A BAND OF SHEEP ON A HIGH PRAIRIE. EASTERN SLOPE OF THE CASCADE MOUNTAINS, WASCO COUNTY, OREGON. ALTITUDE, 5,800 FEET.

These sheep were being herded illegally in a forest reserve.

the fodder plants themselves, is very serious indeed. The sheep men of the West are commonly accused of setting many forest fires to improve the grazing, and they are also vigorously defended from this charge. But the fact remains that large areas where sheep now graze would be covered with forests except for the action of more or less recent fires.

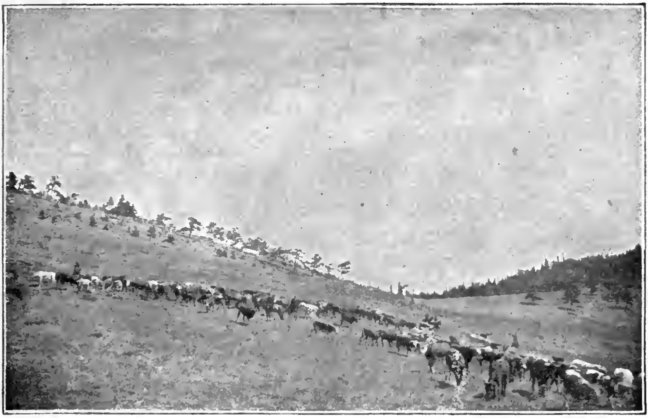


FIG. 66.—Cattle in the Bighorn Forest Reserve, Wyoming.

TRAMPLING.

Trampling is the second way in which grazing animals injure the forest. Cattle and horses do comparatively little harm, although their hoofs compact the soil and often tear loose the slender rootlets of small trees. Sheep, on the contrary, are exceedingly harmful, especially on steep slopes and where the soil is loose. In such places their small, sharp hoofs cut and powder the soil, break and overthrow the young trees, and often destroy promising young forests altogether. (See Pls.

XXXVI, XXXVII, XXXVIII.) In many places the effect of the trampling is to destroy the forest floor and to interfere very seriously with the flow of streams. In the Alps of southern France sheep grazing led to the destruction, first, of the mountain forests, and then of the grass which had replaced them, and thus left the soil fully exposed to the rain. Great floods followed, beds of barren stones were spread over the fertile fields by the force of the water, and many rich valleys were almost or altogether depopulated. Besides the loss occasioned in this way, it has cost the French people tens of millions of dollars to repair the damage begun by the sheep, and the task is not yet finished. The loss to the nation is enormously greater than any gain from the mountain pastures could have been, and even the sheep owners themselves, for whose profit the damage was done, were losers in the end, for their industry in that region was utterly destroyed.

BROWSING.

The third way in which grazing animals injure the forest is by feeding on the young trees. In the western part of the United States, where most of the forests are evergreen, this is far less important than the damage from either fire or trampling, for sheep and other animals seldom eat young conifers if they can get other food. Even where broadleaf trees prevail browsing rarely leads to the destruction of any forest, although it commonly results in scanty young growth, often maimed and unsound as well. Goats are especially harmful, and where they abound the healthy reproduction of broadleaf trees is practically impossible. In the United States they are fortunately not common. Cattle devour tender young shoots and branches in vast

A BURNT FOREST IN WHICH THE YOUNG TREES ARE RETURNING AMONG LOGS AND BRUSH WHERE SHEEP CAN NOT PASS. EASTERN SLOPE OF THE CASCADE MOUNTAINS, WASCO COUNTY, OREGON.

Between the logs in the foreground all young growth has been trampled out by sheep.

quantities, often living for months on little else, and sheep are destructive in the same way. Hogs also find a living in the forest, but they are less harmful, because a large part of their food consists of seeds and nuts. East of the Great Plains very large numbers of cattle and hogs are turned into the woods, but sheep grazing in the forest is most widely developed in the West, and especially in California, where it should be

FIG. 67.—Larch trees killed by the larva of a small sawfly. The land has just been lumbered for Spruce. Adirondack Mountains, New York.

prevented altogether, in Oregon and Washington, where it should be regulated and restricted, and in some interior regions, like Wyoming and New Mexico, where it should be rigidly excluded from all steep mountain regions, and carefully regulated on more level ground.

FOREST INSECTS.

Insects are constantly injuring the forest, just as year by year they bring loss to the farm. Occasionally their ravages attain enormous proportions. Thus a worm, which afterwards develops into a sawfly, has since 1882 killed nearly every full-grown Larch in the Adirondacks by eating away the leaves. (See fig. 67.) Even the small and vigorous Larches do not escape altogether from these attacks. Conifers, such as the Larch and Spruce, are much more likely to suffer from the attacks of insects than broadleaf trees. About the year 1876 small bark beetles began to kill the mature Spruce trees in the Adirondacks, and ten years later, when the worst of the attack was past, the forest was practically deprived of all its largest Spruces. This pest is still at work in northern New Hampshire and in Maine.

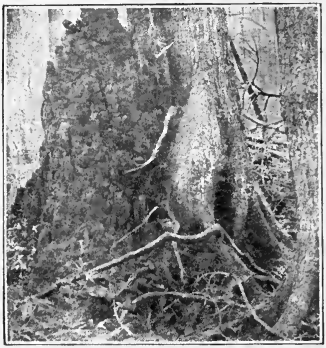
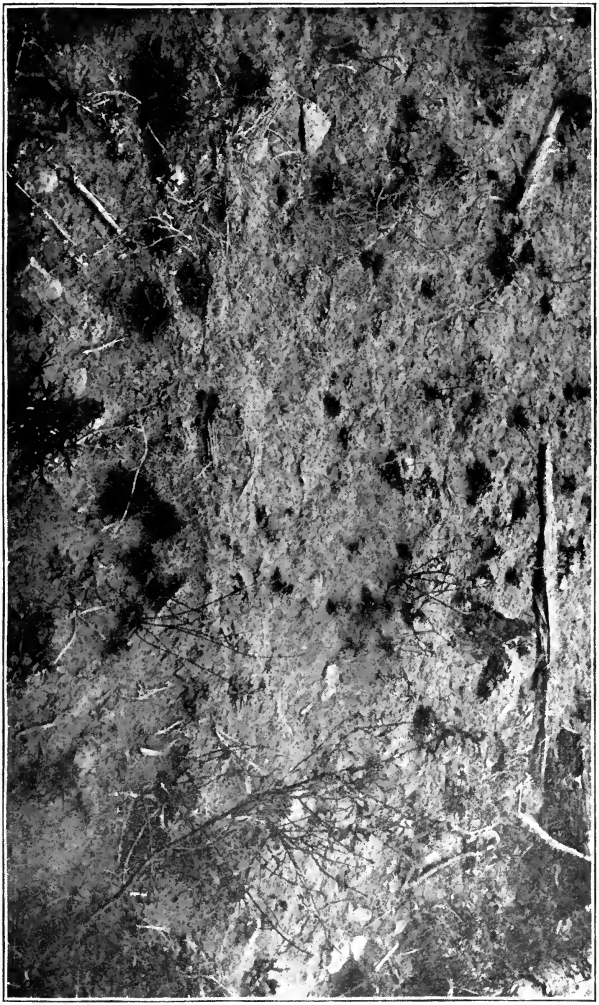


Fig. 68.—Rotting wood from an old Red Fir stub. The young Hemlock to the right began life on the bark of the Fir. Olympic Forest Reserve, Washington.

FOREST FUNGI.

Fungi attack the forest in many ways. Some kill the roots of trees, some grow upward from the ground into the trees and change the sound wood of the trunks to a useless rotten mass, and the minute spores (or seeds) of others float through the air and come in contact with every external part of the tree above ground. (See fig. 68.) Wherever the wood is exposed there is danger that spores will find lodgment and breed disease. This



SLOPE OVER WHICH A BAND OF SHEEP HAS PASSED. EASTERN SLOPE OF THE CASCADE MOUNTAINS, WASCO COUNTY, OREGON.

The area was burnt at one time. Since the burning the humus has been kept from forming and the young trees from springing up by the sheep which pass over the tract every year.

is a strong reason why all wounds, such as those made in pruning, should be covered with some substance like paint or tar to exclude the air and the spores it carries.

WIND IN THE FOREST.

The effect of wind in the virgin forest is not wholly injurious. Although in many regions it overthrows great numbers of old trees, their removal is usually fol-

FIG. 69.—A windfall in the Olympic Forest Reserve, Washington.

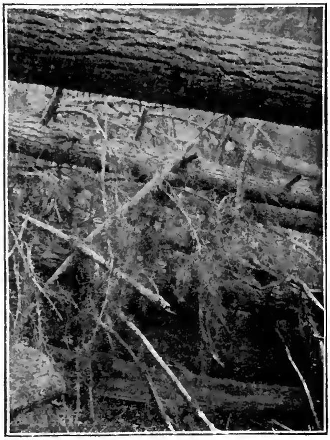


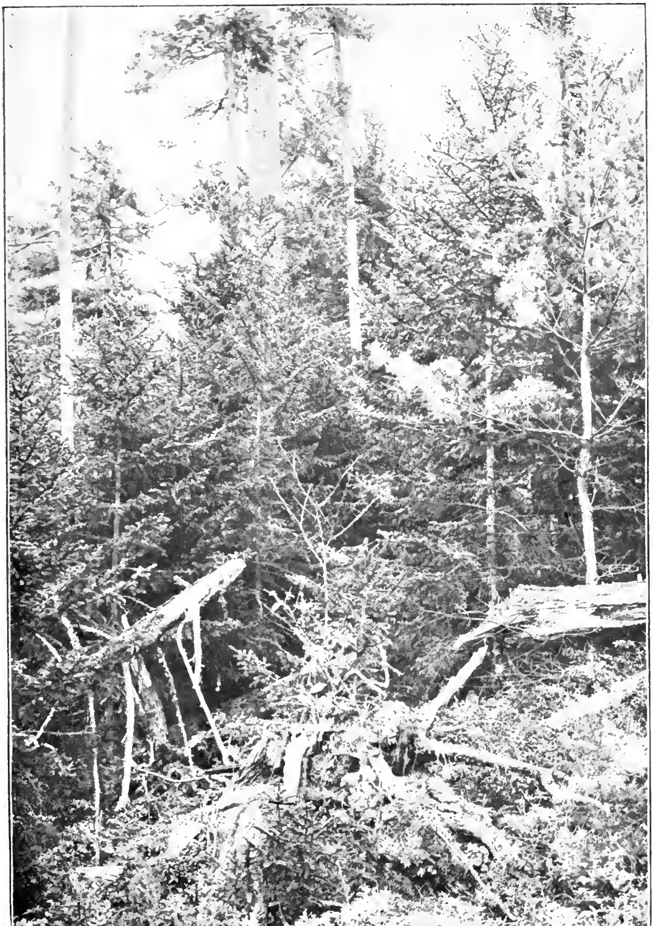
FIG. 70.—In the same windfall. Olympic Forest Reserve, Washington.

lowed by a vigorous young growth where the old trees stood. (See Pl. XXXIX.) In this way the wind helps to keep the forest full of young and healthy trees. But it also breaks and blows down great numbers of useful growing members of the forest. Much of this windfall occurs among shallow-rooted trees, or where the ground is soft because soaked with water, or where the trees have been weakened by unsoundness or fire. Some storms are strong enough to break the trees they can not overthrow. Damage from wind is not uncommon in many parts of the United States, and in places the loss from it is very serious. (See figs. 69, 70.) Near the town of High Springs, for example, in Alachua County, Fla., in a region very subject to such accidents, there is a tract of many square miles, once covered with Longleaf Pine, over which practically all the trees were killed by a great storm several years ago. Some were thrown flat, some were so racked and so broken in the top that they died, and very many were snapped off at from 15 to 30 feet above the ground. There is little use in taking precautions against such great calamities, yet the loss from windfall may be very much reduced by judicious cutting. An unbroken forest is least exposed.

FIG. 71.—A young Spruce loaded with snow. Avalanche Lake, Adirondack Mountains, New York.

SNOW IN THE FOREST.

Snow often loads down, breaks, and crushes tall young trees, especially if wet snow falls heavily before the broadleaf trees have shed their foliage in the fall. Such injury is difficult to guard against, but it is well to know that very slim, tall trees suffer more than those whose growth in diameter and height have



YOUNG SPRUCES AND PINES SPRINGING UP IN A WINDFALL.
ADIRONDACK MOUNTAINS, NEW YORK.

kept better pace with each other. (See figs. 71, 72, and Pl. XL.) In many regions snow is so useful in protecting the soil and the young trees that the harm it does is quite overbalanced by its benefits.

FOREST FIRES.

Of all the foes which attack the woodlands of North America no other is so terrible as fire. Forest fires spring from many different causes. They are often kindled along railroads by sparks from the locomotives. Carelessness is responsible for many fires. Settlers and farmers clearing land or burning grass and brush often allow the fire to escape into the woods. (See fig. 73.) Some one may drop a half-burned match or the glowing tobacco of a pipe or cigar, or a hunter or prospector may neglect to extinguish his camp fire, or may build it where it will burrow into the thick duff far beyond his reach, to smolder for days, or weeks, and perhaps to break out as a destructive fire long after he is gone. Many fires are set for malice or revenge, and the forest is often burned over by huckleberry pickers to increase the next season's growth of berries, or by the owners of cattle or sheep to make better pasture for their herds.

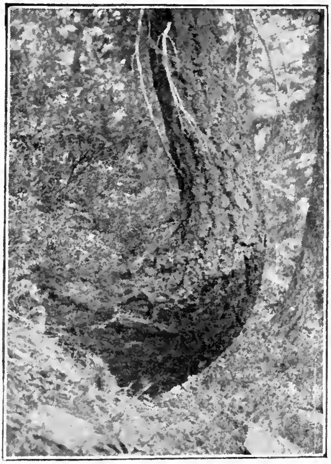


FIG. 72.—A young Red Fir bent down by snow in early youth. It is scarred by fire on the underside. Washington Forest Reserve.

There is danger from forest fires in the dry portions of the spring and summer, but those which do most harm usually occur in the fall. At whatever time of the year they appear, their destructive power depends very much on the wind. They can not travel against it except when burning up hill, and not even then if the wind is strong. The wind may give them strength

FIG. 73.—A clearing in Spruce timber. The great cost and difficulty of such clearing is well illustrated. In the foreground is a field of potatoes. Olympic Forest Reserve, Washington.

and speed by driving them swiftly through unburned, inflammable forests, or it may extinguish the fiercest fire in a short time by turning it back over its path, where there is nothing left to burn. In fighting forest fires the wind is always the first thing to consider, and its direction must be carefully watched. A sudden

DAMAGE FROM SNOW IN THE SIHLWALD, ZURICH, SWITZERLAND.

The slim trees were bent and the stouter trees unharmed by heavy snow, which fell in autumn, before the leaves had dropped.

change of wind may check a fire, or may turn it off in a new direction and perhaps threaten the lives of the men at work by driving it suddenly down upon them.

HISTORIC FOREST FIRES.

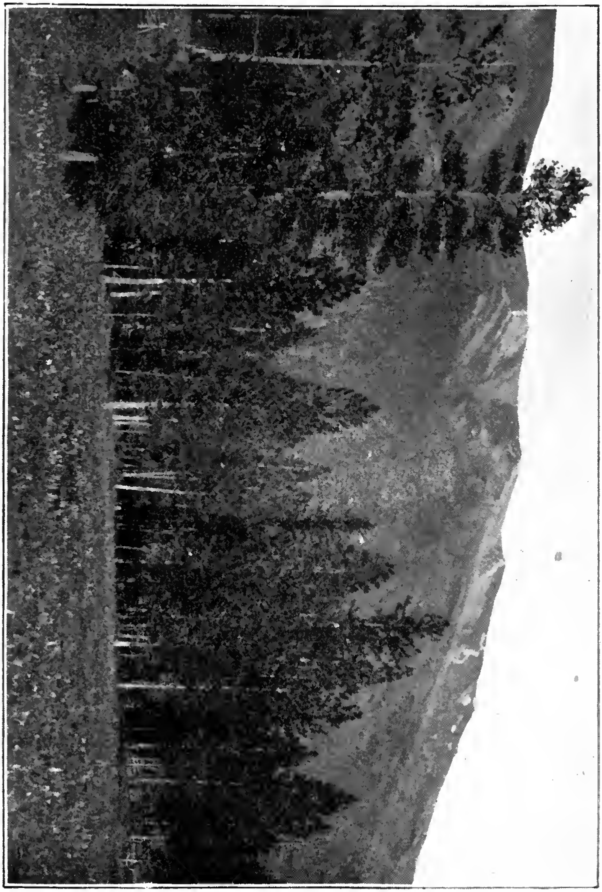
When all the conditions are favorable, forest fires sometimes reach gigantic proportions. A few such fires have attained historic importance. One of these is the Miramichi fire of 1825. It began its greatest

FIG. 74.—A forest fire on the Yukon River, Alaska. Bow of a canoe to the left.

destruction about 1 o'clock in the afternoon of October 7 of that year, at a place about 60 miles above the town of Newcastle, on the Miramichi River, in New Brunswick. Before 10 o'clock at night it was 20 miles below Newcastle. In nine hours it had destroyed a belt of forest 80 miles long and 25 miles wide. Over more than two and a half million acres almost every living thing was killed. Even the fish were afterwards found dead in heaps on the river banks. Five hundred and ninety buildings were burned, and a number of towns, including Newcastle, Chatham, and Douglastown, were destroyed. One hundred and sixty persons perished, and nearly a thousand head of stock. The loss from the Miramichi fire is estimated at $300,000, not including the value of the timber.

FIG. 75.—Fire sometimes renews an old forest by killing the veterans and so permitting vigorous young trees to take their place. The rotting stubs of fire-killed veterans of Red Fir are seen in the picture surrounded by young standards of Red Fir and Western Hemlock. Olympic Forest Reserve, Washington.

In the majority of such forest fires as this the destruction of the timber is a more serious loss, by far, than that of the cattle and buildings, for it carries with it the impoverishment of a whole region for tens or even hundreds of years afterwards. The loss of the stumpage value of the timber at the time of the fire is but a small



BURNT-OVER MOUNTAINS ABOVE THE FLATHEAD VALLEY. MONTANA.

The white patches on the mountain in the background are made partly by snow and partly by bleached fire-killed trees still standing. The trees in the foreground are Western Yellow Pine and Red Fir.

part of the damage to the neighborhood. The wages that would have been earned in lumbering, added to the value of the produce that would have been purchased to supply the lumber camps, and the taxes that would have been devoted to roads and other public improvements, furnish a much truer measure of how

FIG. 76.—A Rocky Mountain coniferous forest killed by fire. Valley of the North Fork of Sun River, Montana.

much, sooner or later, it costs a region when its forests are destroyed by fire. (See figs. 76–81, and Pls. XLI, XLVI, XLVII.)

The Peshtigo fire of October, 1871, was still more severe than the Miramichi. It covered an area of over 2,000 square miles in Wisconsin, and involved a loss, in timber and other property, of many millions of dollars. Between 1,200 and 1,500 persons perished, including nearly half the population of Peshtigo, at that time a town of 2,000 inhabitants. Other fires of about the same time were most destructive in Michigan. A strip about 40 miles wide and 180 miles long, extending across the central part of the State from Lake Michigan to Lake Huron, was devastated. The estimated loss in timber was about 4,000,000,000 feet board measure, and in money over $10,000,000. Several hundred persons perished.

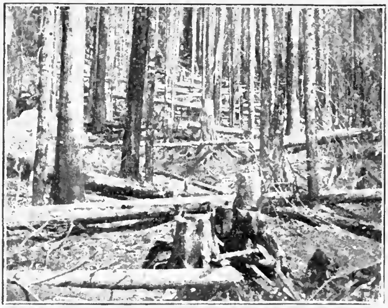
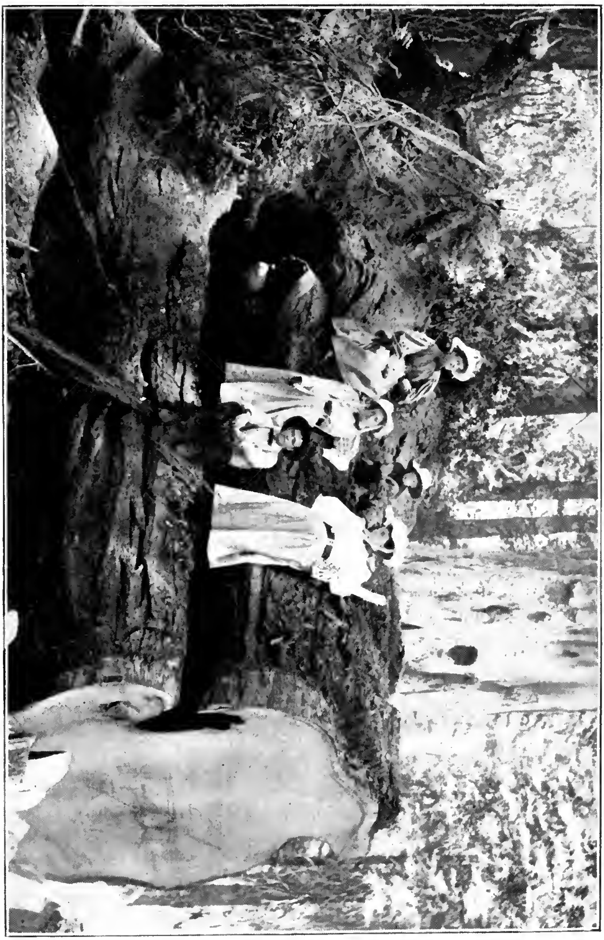


FIG. 77.—A burnt forest near Monte Cristo in the Washington Forest Reserve.

In the early part of September, 1881, great fires covered more than 1,800 square miles in various parts of Michigan. The estimated loss, in property, in addition to many hundred thousand acres of valuable timber, was more than $2,300,000. Over 5,000 persons were made destitute, and the number of lives lost is variously estimated at from 150 to 500.

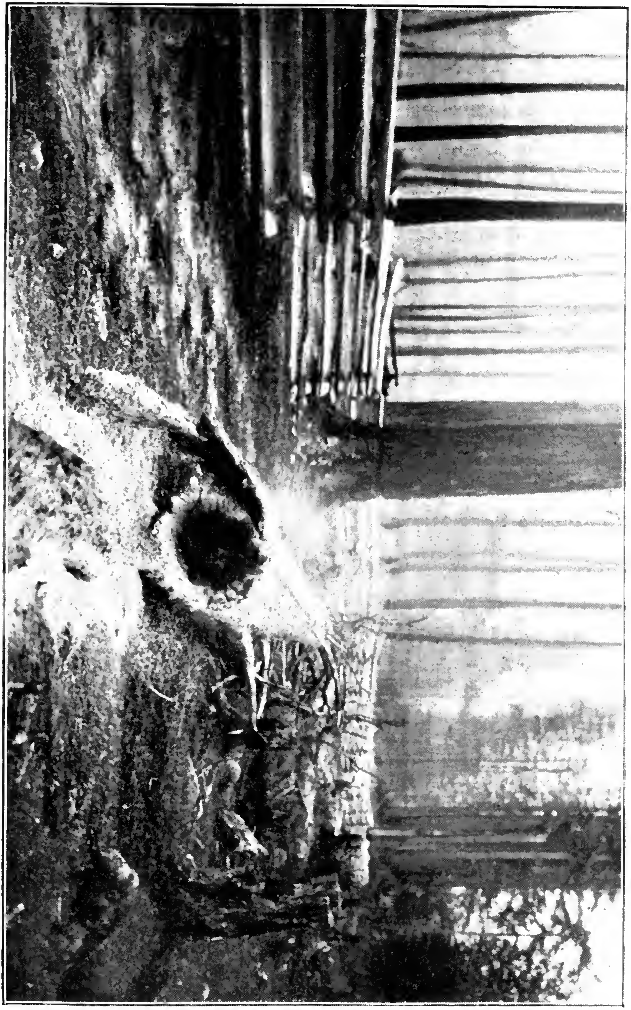
FIG. 78.—A single Red Fir, spared by the fire, remains to indicate what the burnt area is capable of producing. Washington Forest Reserve.

The most destructive fire of more recent years was that which started near Hinckley, Minn., September 1,



A FIRE-SCAR AT THE FOOT OF A FALLEN SEQUOIA. SIERRA NEVADA, CALIFORNIA.

The attempt of the tree to cover the wound is plainly seen on the cut at the right.



FIRE BURNING ALONG A FALLEN LOG. CASCADE RANGE, OREGON.

1894. While the area burned over was less than in some other great fires, the loss of life and property was very heavy. Hinckley and six other towns were destroyed, about 500 lives were lost, more than 2,000 persons were left destitute, and the estimated loss in property of various kinds was $25,000,000. Except for the heroic conduct of locomotive engineers and other railroad men the loss of life would have been far greater.

This fire was all the more deplorable, because it was wholly unnecessary. For many days before the high wind came and drove it into uncontrollable fury, it was burning slowly close to the town of Hinckley, and could have been put out.

MEANS OF DEFENSE.

The means of fighting forest fires are not everywhere the same, for they burn in many different ways; but in every case the best time to fight a fire is at the beginning, before it has had time to spread. A delay of even a very few minutes may permit a fire that at first could easily have been extinguished to gather headway and get altogether beyond control.

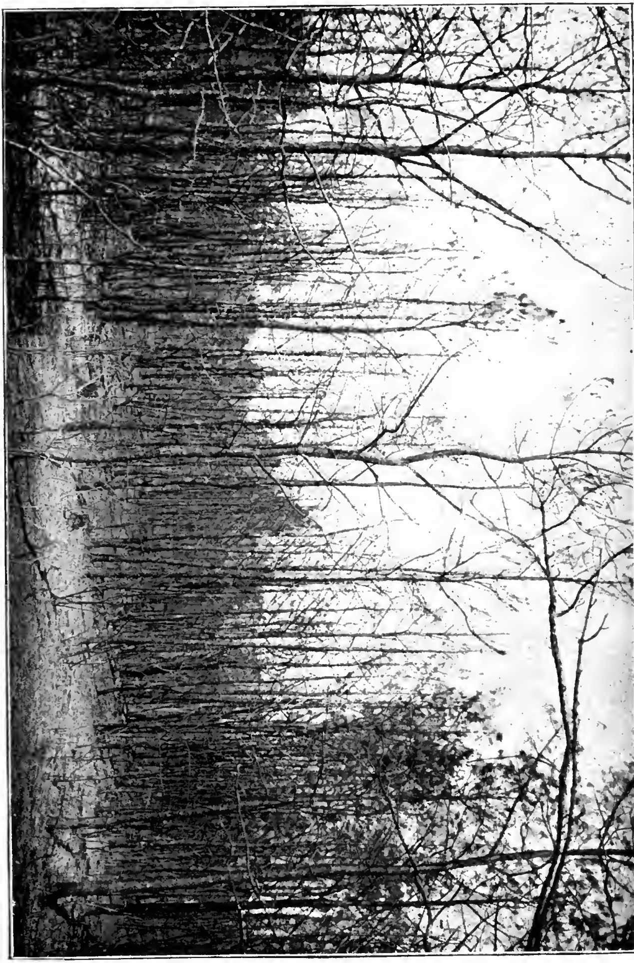
When there is but a thin covering of leaves and other waste on the ground a fire usually can not burn very hotly or move with much speed. The fires in most hardwood forests are of this kind. They seldom kill large trees, but they destroy seedlings and saplings and kill the bark of older trees in places near the ground. The hollows at the foot of old Chestnuts and other large trees are often the results of these fires, which occur again and again, and so enlarge the wounds instead of allowing them to heal. (See Pl. XLII.) Moderate fires also occur in dense coniferous forests when only the top of a thick layer of duff is dry enough to burn. The heat may not be great enough to kill any but the smallest and tenderest young trees, but that does not mean that such fires do no harm. The future of the forest depends on just such young growth, and whenever the forest floor, which is so necessary both to the trees and for the water supply, is injured or destroyed by fire, the forest suffers harm.

FIG. 79.—A surface fire burning slowly against the wind. Southern New Jersey.

SURFACE FIRES.

Surface fires may be checked if they are feeble by beating them out with green branches, or by raking the leaves away from a narrow strip across their course. The best tool for this purpose is a four-tined pitchfork, or a common stable fork. In sandy regions a thin and narrow belt of sand is easily and quickly sprinkled over the ground with a shovel, and will check the spread of a weak fire, or even of a comparatively hot one if there is no wind. Dirt or sand thrown on a burning fire is one of the best of all means for putting it out. (See fig. 79.)

In dense forests with a heavy forest floor, fires are often hot enough not only to kill the standing timber, but to consume the trunks and branches altogether, and even to follow the roots far down into the ground. In forests of this kind fire spreads easily, creeping along on the surface or through the duff or under the bark



A BURNT PINE FOREST. SOUTHERN NEW JERSEY.

The fire, which burnt the leaves from nearly all the crowns, had passed less than twenty-four hours before the picture was taken.

ROAD AND PATH ACTING AS FIRE LINES. NEW JERSEY.

This picture shows how a road or a fire path may check a surface fire. The limit of the fire is shown by the unburned grass. Even the small path in the foreground was sufficient to check this fire.

of rotting fallen trees. (See Pl. XLIII.) In the same way it climbs dead standing trees, and breaks out in bursts of flame high in the air. Dead trees help powerfully to spread a fire, for in high winds loose pieces of their burning bark are carried to almost incredible distances, and drop into the dry forest far ahead, while in calm weather they scatter burning fragments all about them when they fall. (See fig. 80.)

FIG. 80.—The effect of repeated fires. Not only the old trees are dead, but the seedlings which succeeded them have perished also. Western Yellow Pine in the Black Hills Forest Reserve, South Dakota.

GROUND FIRES.

When the duff is very deep or the soil peaty, a fire may burn beneath the surface of the ground for weeks or even months, sometimes showing its presence by a little smoke, sometimes without giving any sign of life. Even a heavy rain may fail to quench a fire of this kind, which often breaks out again long after it is believed to be entirely extinct. Fires which thus burn into the ground can sometimes be checked only by digging a trench through the layer of decaying wood and other vegetable matter to the mineral soil beneath. Ground fires usually burn much more slowly than surface fires, but they are exceptionally long lived, and very hard to put out. It is of the first importance to attack such fires quickly, before they have had time to burrow far beneath the surface of the ground. Surface fires are usually far less troublesome, but in either case fires which kill the trees are generally repeated again and again until the dead timber is consumed. (See fig. 81 and Pls. XLIV, XLV, XLVI, XLVII.)

BACK-FIRING.

The most dangerous and destructive forest fires are those which run both along the ground and in the tops

FIG. 81.—The result of recurring fires. The forest floor has disappeared and the pure white sand, which looks like snow in the picture, is left without protection. Southern New Jersey.

of the trees. When a fire becomes intensely hot on the ground it may run up the bark, especially if the trees are conifers, and burn in the crowns. Such fires are the fiercest and most destructive of all. Traveling sometimes faster than a man can run, they consume enormous quantities of valuable timber, burn fences, buildings, and domestic animals, and endanger or even destroy human lives. They can be checked only by

FALLEN AND STANDING FIRE-KILLED TIMBER READY FOR THE NEXT FIRE.
FRIEST RIVER FOREST RESERVE, IDAHO.

rain or change of wind, or by meeting some barrier which they can not pass. A barrier of this kind is often made by starting another fire some distance ahead of the principal one. This back-fire, as it is called, must be allowed to burn only against the wind and toward the main fire, so that when the two fires meet both must go out for lack of fuel. To prevent it from moving with the wind, a back-fire should always be started on the windward side of a road or a raked or sanded strip, or some other line which it can be kept from crossing. (See fig. 82.) If it is allowed to escape it may become as dangerous as the main fire itself. Back-fires are sometimes driven beyond control by a change of wind, but the chief danger from their use is caused by persons who, in excitement or fright,

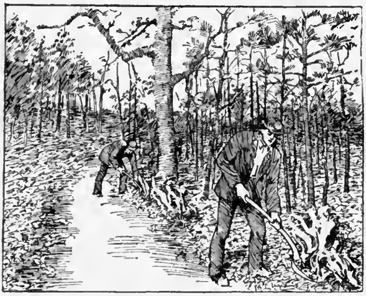


FIG. 82.—Setting a back-fire on the windward side of a road. Southern New Jersey. Drawn from a photograph.

FIG. 83.—A fire line along a railroad with two cleared spaces separated by a double row of trees intended to catch the sparks.

light them at the wrong time or in the wrong place. Still, there is no other means of fighting fires so powerful, and none so effective when rightly used.

FIRE LINES.

Fire lines—strips kept free from all inflammable material by burning or otherwise—are very useful in checking small fires and of great value as lines of defense in fighting large ones. (See fig. 83.) They are also very effective in keeping fires out of the woods, as, for example, along railroad tracks. But without men to do the fighting they are of as little use against really dangerous fires as forts without soldiers against invading armies.

END OF PART I.

A CEDAR SWAMP AFTER A FIRE. SOUTHERN NEW JERSEY.