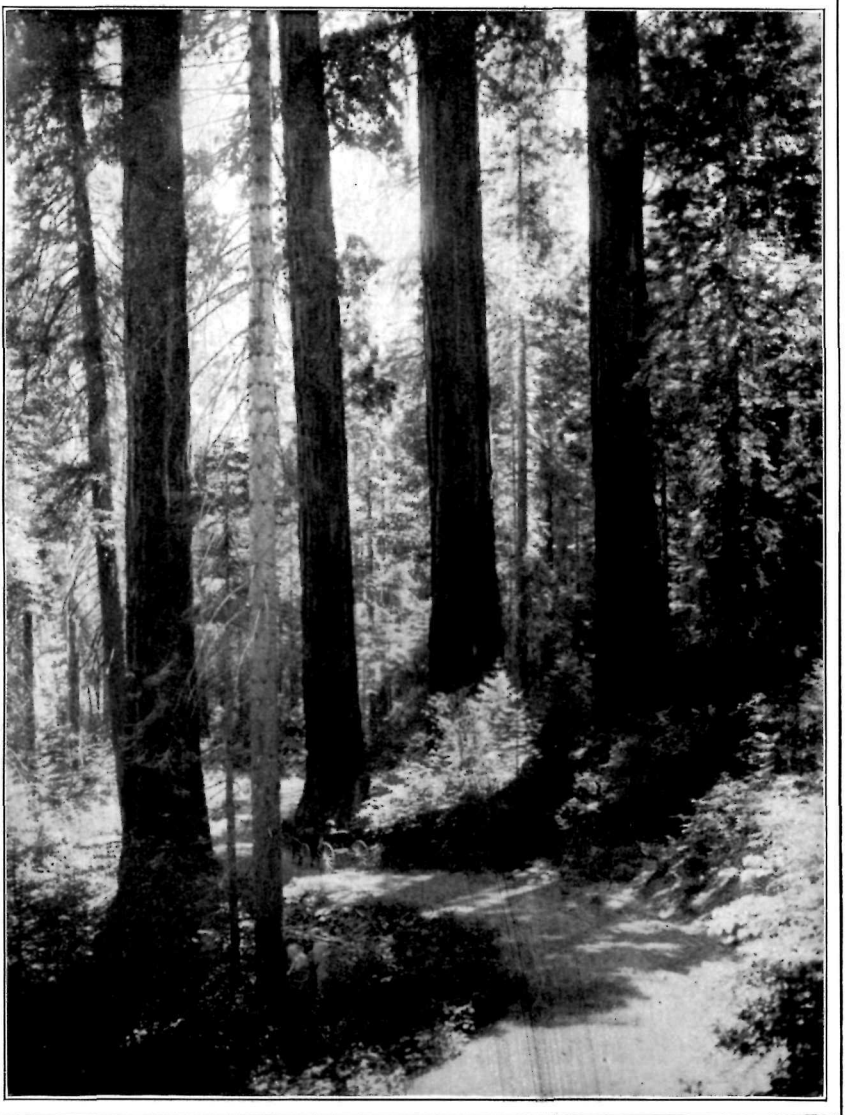
FORESTS OF YOSEMITE, SEQUOIA, AND GENERAL GRANT NATIONAL PARKS



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Sketch of Yosemite National Park and an Account of the Origin of Yosemite and Hetch Hetchy Valleys, by F. E. Matthes. 1912. 48 pages, including 24 illustrations. 10 cents.

Contains a description of the general features of the Sierra Nevada and the Yosemite National Park and an account of the origin of the Yosemite and Hetch Hetchy Valleys.

The Secret of the Big Trees, Yosemite, Sequoia, and General Grant National Parks, by Ellsworth Huntington. 1913. 24 pages, including 14 illustrations. 5 cents.

Contains an account of the climatic changes that are indicated by the thickness of the growth rings in the big trees, and gives a comparative statement of the climatic conditions in California and Asia during a period of 3,400 years.

Panoramic view of Yosemite National Park, 18½ x 18 inches, scale 3 miles to the inch. 25 cents.

FORESTS OF YOSEMITE, SEQUOIA, AND GENERAL GRANT NATIONAL PARKS.[1]

By C. L. Hill, *Forest Examiner, U. S. Forest Service.*

THE FOREST TYPES.

The forests of Yosemite, Sequoia, and General Grant National Parks in the central and southern Sierra Nevada are said by naturalists and travelers to surpass any other of their kind in the size and beauty of trees and the number of species represented. The forest is predominantly a coniferous one. The broad-leaf trees, while represented by a comparatively large number of species, are mostly small, unfit for lumber production, and, with the exception of the oaks, are mostly confined to the stream courses and moist flats. Within these parks are found not less than 10 species of pines, 2 of true firs, besides the Douglas fir, and 1 each of cedar, hemlock, and the so-called nutmeg, while among the broad-leaf trees there are 6 species of oak, 2 each of alder, cherry, maple, and dogwood, 1 cottonwood, an aspen, the bladder nut, the so-called mountain mahogany, and several willows. Several of the broad-leaf species, however, and one conifer, the nutmeg, seldom or never grow to be more than shrubs in this region.

Nowhere do all these species grow together. For just as people differ in their likes and dislikes, so each kind of tree has its own preferences and peculiar requirements as to the moisture, heat, light, and soil upon which its life and growth depend.

One of the most striking features of the Sierra forest, which impresses the traveler journeying into it, is the broad belt into which the forest is divided, approximately in accordance with elevation. These belts are due to the effect of the altitude on the moisture and heat which are available to the trees. To be sure, at the same altitude a ridge or south slope may be so hot and dry as to permit a displacement of the forest prevalent at that altitude by an extension of the one below it; or, a protected gulch may be so moist and cool as to permit the downward extension of the type above it. These lines between the types are seldom level or in any other way hard

[1] In the preparation of this manuscript use has been made of many publications, especially those of the late Prof. William R. Dudley, of John Muir, and of George B. Sudworth, to all of whom grateful acknowledgment is made.

and fast, but the different forest types and belts are still very real and discernible.

OAK-DIGGER PINE TYPE.

As one approaches the mountains from the hot, treeless valleys on his way to the parks the first trees met, except in the moist water courses, are stunted and scattered oaks, which begin to appear upon the foothills. Higher, on the approaches to the Yosemite Park, there begins to appear, at about 1,000 feet elevation, the straggling, irregular-branching, gray leaved digger pine mixing with the oaks and brush. This mixture of trees, or forest type as it is called, continues for some 2,000 feet higher, more or less, according to conditions. Throughout its range this type is interspersed frequently with heavy chaparral brush. Within the Yosemite Park it is found only on the lower slopes of the deep canyons of the main rivers, such as the South Fork of the Merced into which one looks from the Wawona Road, in the southern part of the park. In the region of the Sequoia and General Grant Parks the digger pine does not grow, but the oak and chaparral continue to the main forest belt at about 4,000 to 5,000 feet elevation. The digger pine is of no importance as a lumber tree. Its wood is heavy and resinous and has a high fuel value, but is brash and very difficult to split. It is, however, a picturesque scenic element in a country where better pines can not grow.

YELLOW-PINE TYPE.

At an elevation of about 3,000 feet in the Yosemite region and 4,000 feet in that of the Sequoia and General Grant Parks one begins to see the trim trunk and the slender, cylindrical crown of long, glossy needles of the yellow pine. In the Yosemite the appearance of the yellow pine is gradual; at first it is seen in protected spots among the digger pine, which it more and more displaces as the altitude increases. In the southern region the oak and chaparral give way, for the most part suddenly in a clearly defined line, to the forest of yellow pine. In this forest the yellow pine is sometimes pure, but usually one can soon notice, scattered occasionally among the yellow-pine trees, the tapering, heavily ridged trunk and drooping, feathery-foliage sprays of the incense cedar. This cedar is easily distinguished from the pines by its leaves, which, instead of being long needles, are like small green scales closely clothing the slender flexible twigs. The usual proportion of the two trees in this type of forest is about 90 per cent pine and 10 per cent cedar.

On ridges and exposed slopes the yellow pine often grows alone, but is likely to be stunted and scattered. In the moist ravines, where the soil and moisture are most favorable for both species, the cedar,

by its superior power of living in the shade, often captures from the yellow pine a larger proportion of the ground than it normally occupies.

Scattered throughout the yellow-pine type are oak trees—on the drier slopes and ridges the California black oak and in the well-watered flats the holly-leaved or maul oak. Both these trees grow to large size, especially the holly-leaved oak. Brush is also frequent within the yellow-pine type wherever openings afford access to the sun, but the pines rise over the oaks in lordly height and give the predominant character to the forest.

A large portion of the roads leading through the outer part of the Yosemite Park to the valley proper run through this type, which also covers the floor of the valley. In the Sequoia Park the proportional area covered by this type is much smaller. The type is largely passed as a continuous body before one reaches the General Grant Park.

SUGAR-PINE TYPE.

At an elevation of about 4,000 feet in the Yosemite and about 5,000 feet in the Sequoia and General Grant Parks, sugar pine begins to appear in the forest, and shortly above these elevations, in the steep moist gulches, appears the white fir.

Sugar pine can immediately be distinguished from the yellow pine by its closely checked bark and its short, silvery foliage on wide spreading branches, from the tips of which hang its tremendous cones.

The white fir has very short needles thickly clothing the slender branchlets in sprays which are flat and fanlike, and the tree always retains a distinct pyramidal form.

Sugar pine seldom grows in pure stands or forms even one-half of the forest, but it is so valuable a timber and so striking a feature of the forest in which it grows that this forest is known as the sugar-pine type. For the first 1,500 feet or so after entering this type the bulk of the forest is still yellow pine, with a mixture of 15 to 40 per cent of sugar pine, and cedar in about the same proportion as in the yellow-pine type. The sugar pine demands more moisture than the yellow pine, so that it is confined largely to the well-watered flats and the easterly and northerly slopes which, by reason of their exposure, are cool and moist. On the steeper southern and western slopes the heat and dryness compel the sugar pine to give way to the upward extension of the yellow-pine type. In the steep, moist watercourses the yellow pine is displaced in the forest mixture by white fir, and the forest is one of white fir, sugar pine, and cedar. As one passes higher toward the 6,000-feet elevation, the increasing

coolness enables the fir to encroach upon the yellow pine to a larger and larger extent, and above 6,000 to 7,000 feet the usual forest is that of white fir, sugar pine, and cedar. In the best watered places at this altitude the white fir, by its dense growth, may crowd out the light-loving sugar pine. At this elevation the yellow-pine type is confined entirely to the warm less fertile slopes and ridges, and the yellow pine of the lower elevations is replaced partially or entirely by the Jeffrey pine, which is a closely related form much the same in appearance, but distinguishable by its large, heavy cones and the unmistakable odor of pineapple, which can be detected in the deep crevices of its heavy trunk bark.

At about 7,000 feet in the Yosemite region and 7,500 in the Sequoia and General Grant Parks the total heat of the growing season begins to drop below the requirements of the sugar pine, which is restricted to warm exposures, more and more of the forest area being surrendered to the hardy fir. The incense cedar also disappears at about the same altitude as the sugar pine.

The Jeffrey pine clings to its precarious hold on the rocky ridges and sunny slopes to an elevation of perhaps 500 feet above the sugar pine; but finally it, too, vanishes, and the fir reigns supreme over the forest.

In scattered groves through the central and southern Sierras, but mostly in the sugar-pine forest type, is found the giant sequoia, the forest monarch of the world; the oldest, largest, and most majestic of all earth's living things. Description of this tree, however, will be better understood if a general survey of the forest types of the Sierra region is first completed.

In favored spots in the sugar-pine type, and also in the upper part of the yellow-pine type in Yosemite Park, occurs another tree, the Douglas fir. This is the same tree which grows to such magnificent dimensions in the Pacific Northwest. Here, however, it is not in its region of best growth and does not equal either the yellow pine or the sugar pine in size. Its foliage is much like that of the true firs but is less dense, and the tree is always distinguishable from its associates in the Sierra forests by its gracefully pendant twigs and branchlets. A fine specimen of the Douglas fir stands directly by the Wawona Road, near where it crosses Alder Creek, at what is known as Mosquito Camp in the southern part of the Yosemite Park. This tree does not grow in the Sierras as far south as the Sequoia and General Grant Parks.

The oaks which grew in the yellow-pine belt continue into the sugar-pine type, but diminish both in size and number. At this elevation there is also some brush in the forest openings and on exposed slopes it may be exceedingly dense, but the species are different from those found below the sugar-pine type.

FIR TYPE.

This type is more nearly pure than any heretofore described. But, while it is thus nearly all composed of fir, the white fir is not long alone, for at about the altitude where the sugar pine disappears one can begin to see, among the sharp spires of the white fir, the more rounded domes of the great red fir.

The fir forest holds its sway for from 1,000 to 2,000 feet. This is the region of long winters, storms, and heavy snows. The forest is dense and dark, strikingly in contrast with the open, sunny character of the lower Sierra forests. Yet the delicate tracery of the fir's feathery fronds gives to it a beauty of its own, and the sparkling mountain meadows, which dot this forest type more frequently than any of the others, are a perennial source of pleasure to the traveler.

SUB-ALPINE TYPE.

Finally even the red fir gives way to the increasing cold. But above the fir there are not wanting several hardy pioneers of the tree world to push their way out among the rocks and snow. Around the meadows and down the edges of many streams in the fir type, and pushing its way out upon the rocky slopes and heights beyond, wherever there is a little water seepage, may be found the lodgepole pine, often called tamarack by the California mountaineers. In the upper regions of the Tuolumne in Yosemite Park this slender, graceful, two-leaved pine covers large areas above the limits of other merchantable tree species.

Coming across from the eastern slope of the mountains, and not uncommon at high altitudes south of the Kings River, is the desert or single-leaved pinyon pine. As far north as the Yosemite this tree has been found on the western slope in only one place—in the Piute Creek gorge above the Tuolumne River.

Perched on the high basins and on the rocky spurs of the peaks, a southward wanderer from its northern home in Idaho, Washington, and British Columbia, may be found the western white pine; and even more hardy, venturing out upon the bleakest summits, the last outpost of the trees in their conquest of the rocks, are the white-barked pine and mountain hemlock. Seldom, however, do trees extend above 10,000 feet in the Yosemite region and 11,000 feet in the Sequoia and General Grant Parks. At 11,500 feet the last outpost of the forest is passed.

THE SEQUOIA.

Such is the Sierra forest in its general outline. There has been reserved until last the account of the noblest tree of them all—the giant sequoia. It could not well be described in the general purview

of the forest since it occurs, for the most part, only in detached groves, and, while it finds its home chiefly within the altitudinal limits of the sugar-pine type, it extends in the southern part of its range both downward into the yellow-pine type and upward into the fir. The range of this sequoia is exceedingly limited. It grows nowhere except on the western slopes of the Sierras, and

FIG. 1.—Mariposa Grove, Yosemite National Park.

The Mariposa Grove is situated in the southern portion of the Yosemite National Park, 35 miles from Yosemite Valley. There are two other groves of big trees in the Yosemite National Park—the Tuolumne Grove of 20 trees 17 miles northwest of Yosemite Valley and the Merced Grove of 40 trees 9 miles northwest of Yosemite Valley.

Photograph by Pillsbury Picture Co.

here only from Placer County on the north to Tulare County on the south.

In the Yosemite Park there are three groves of the big tree—the Tuolumne Grove, 1½ miles northwest of Crane Flat Station, on the Coulterville Road, and 17 miles from Yosemite Village; the Merced Grove, a few miles southwest of the Tuolumne Grove; and the Mariposa Grove (fig. 1), which may be reached by road from

FIG. 2.—The Grizzly Giant, Mariposa Grove, Yosemite National Park.

Height, 204 feet; 93 feet in circumference and 29 feet in diameter at base; 64 feet in circumference and 20 feet in diameter at a point 10 feet above the ground.

Photograph by Pillsbury Picture Co.

Wawona, at the southern extremity of the park. The Mariposa is the largest of these groves, containing in its two divisions about 545 trees. The Merced Grove contains less than 100 trees and the

FIG. 3.—Base of Grizzly Giant, Mariposa Grove, Yosemite National Park.
Photograph by Pillsbury Picture Co.

Tuolumne not more than 40. The most famous tree in these groves is the Grizzly Giant (figs. 2 and 3), in the Mariposa Grove. This tree is 93 feet 7 inches in circumference at the ground and 64 feet 6 inches at 10 feet above. It has a height of 204 feet. It has been supposed by many to be the largest tree in existence, but it can hardly sustain this claim.

Size of big trees in Mariposa Grove.

[All dimensions are in feet.]

Trees.	Girth at base.	Approximate diameter at base.	Girth about 10 feet above ground.	Approximate diameter about 10 feet above ground.	Height.
Grizzly Giant	93	29.6	64.5	20.5	204
Faithful Couple	94	29.9	63	20	244
Michigan	55.5	17.7	40	12.7	257
Fresno	63	20	38.5	12.2	273
Columbia	80.5	25.6	52	16.5	294
Old Guard (South Tree)	45	14.3	31	9.9	244
Lafayette	92.5	29.4	53	16.9	273
Nevada	48.5	15.4	35	11.1	278
General Sherman	63	20	41.5	13.2	267
General Grant	67	21.3	42	13.4	271
General Sheridan	76	24.2	51	16.2	263
Philadelphia	61.5	19.6	50.5	16.1	275
St. Louis	73	23.2	51	16.2	269
Lincoln	72	22.9	54.5	17.3	258
Washington	92	29.3	65	20.7	235
William McKinley	70	22.3	46.5	14.8	243
General Logan	76	24.2	49.5	15.7	259
Galen Clark	59.5	18.9	47	14.9	238
Pittsburgh	53.5	17	41	13	242
Vermont	47	14.9	38	12.1	257
Wawona (26 feet through opening)	.....	.....	60.5	19.2	227
New York	52	16.5	45.5	14.5	237
Forest Queen	53.5	17	38	12.1	219
Boston	58	18.4	47	14.9	248
Chicago	57	18.1	40.5	12.9	223
Whittier	62	19.7	47	14.9	268
Longfellow	51.5	16.4	43	13.7	273
Capt. A. E. Wood	52	16.5	40	12.7	310
Mark Twain	53	16.9	41	13	331
Mississippi	54.5	17.3	37.5	11.9	269
Stonewall Jackson	53	16.9	38.5	12.2	265
Georgia	48	15.3	35	11.1	270
South Carolina	74	23.5	54.5	17.3	264

Southeastward from the Mariposa Grove, along the Sierra Range, there are only two widely separated groves until the Kings River is crossed. On the southern drainage of the Kings and its south fork lie several groves of the big trees. The largest of these lies in the Converse Basin. Here appears one of the most striking changes in the distribution of the big tree, for here the sequoia, instead of being confined to isolated groves, spreads out over hill and valley to form a veritable forest. It is sadly unfortunate that most of the sequoia-covered areas here, as elsewhere outside the few national parks, are privately owned and are disappearing before the attacks of the lumberman. The Converse Basin area has been almost entirely lumbered. The sequoia trees are so huge that ordinary lumbering methods are powerless, and the trees have to be dynamited to reduce them to dimensions which can be handled and sawed, and often one-half or three-fourths of the tree is so shattered as to be useless.

This waste is so excessive in proportion to the amount saved for usefulness to man, and the profit to the lumberman, largely because of this waste, is so small that it is doubly sad to see thus needlessly

FIG. 4.—General Grant tree, General Grant National Park.

Height, 264 feet; diameter, 35 feet. The General Grant Grove, in the park of the same name, has an area of 235 acres and contains 190 trees exceeding 10 feet in diameter.

sacrificed a tree which is unique in size and grandeur and age and of which there are so relatively few as to make it a priceless legacy from the hoary ages of the past.

Almost at the top of the divide which separates the Kings and the Kaweah Rivers lies the General Grant National Park, inclosing the big-tree grove of the same name. This park has an area of 4 square miles and ranges in altitude between 6,000 feet on the west and 8,000 on the east. The big trees are confined to the northeastern portion, and were originally a part of the Converse Basin Forest. The grove consists of about 262 trees and contains an unusual proportion of exceedingly large ones. The largest tree is the General Grant (fig. 4). It is 107 feet 4 inches in circumference at the ground and about 69 feet (or 23 feet in diameter) at 12 feet above the ground. It is 264 feet in height.

Between the General Grant Park and the Sequoia Park lies the Redwood Mountain Forest, privately owned and lumbered to a considerable extent. This forest is notable because it exhibits, for the first time in a southward journey over the distribution of the big tree, another notable circumstance in its behavior. For while the sequoia generally grows scattered through the forest of other trees, much as does the sugar pine, and to the north grows entirely in this manner, in the Redwood Mountain Forest it covers a considerable area in nearly or quite pure stand.

The Sequoia National Park includes seven townships or about 252 square miles. It contains 11 groves of big trees, of which the largest is the Giant Forest (see title-page). In the northern part of the park, reached by the Old Colony Road, are the Dorst Creek Groves, on the stream of that name, which is a tributary of the North Fork of the Kaweah River. They contain 766 trees. In the southeastern part of the same township is also the small Swanee River Grove.

The Giant Forest, next to the south, lies on the Marble Fork of the Kaweah, near its mouth. This noble forest, named by the venerable naturalist, John Muir, has an area of about 10 square miles and contains about 5,000 trees. Part of this forest is in private ownership, but the trees have been protected from destruction, and this forest constitutes the largest forest intact of this species. Its largest tree is the General Sherman (fig. 5) which is 103 feet in circumference at the ground and 82 feet 4 inches at 12 above the ground. It is now 280 feet high, but, like most of the giants, was once much taller, having lost many feet of its top by lightning. In volume of wood, at least this tree seems to have valid claim to be called the largest known tree; although if form and freedom from damage be counted, its claim may well be disputed by the Boole tree in the Converse Basin.

On the East Fork of the Kaweah River, 3 miles west of Mineral King, are the East Fork forests, of which the northern and larger one is 3 miles long by a half mile wide. These groves have been

much injured by lumbering. On many other streams through the southern part of the park are groves, forming a more or less interrupted forest of the big trees. They then pass over the divide

FIG. 5.—General Sherman, Giant Forest, Sequoia National Park.

Height, 286 feet; diameter, 36 feet.

into the basin of the Tule River, where the most extensive forests of the species are found. Farther south the trees diminish, both in numbers and size, and south of Tulare County the big tree is found no more.

DESCRIPTIONS OF THE TREES.

GIANT SEQUOIA (SEQUOIA WASHINGTONIANA).

This tree is the crowning achievement of the vegetable kingdom in size and majesty and age. It is one of the only two survivors of a once numerous genus, which, before the glacial period, was spread across the American Continent and, indeed, across Europe as well. The other now living sequoia is the redwood (*Sequoia sempervirens*) of the California coast which nearly divides honors with the big tree itself as the largest conifer, if not the largest tree, in the world. The redwood is as tall, or even taller than the big tree, both attaining heights beyond 300 feet; but while the big tree attains a diameter of nearly 30 feet (above the root swelling), the redwood is always more slender.

In foliage the big tree is a scale-leaved tree; but in the seedling stage the leaves are entirely free from the twig and are needle-like in form, while in youthful trees, though increasingly scale-like, they still have long, free tips. In youth the branches of the big tree are slender, and the basal ones are long, giving to the tree a broadly pryamidal form. The big tree is still young when other trees of the forest around it are mature or even approaching old age. So it is not until 200 or 300 years of age that the lower branches are thinned out. As maturity approaches, at perhaps 1,000 years of age, the remaining branches, now grown to enormous size, stand out in gnarled and picturesque strength and are clothed with dense masses of blue-green foliage. The bark of the tree, at first smooth and purplish to leaden gray, soon becomes broken into ridges, and on the great trunks of the giant veterans the smooth surface film has long since been flaked off, exposing the cinnamon-red color beneath. On such trunks the bark is from 1 to 2 feet thick and is separated into long, heavily-rounded parallel ridges which makes the great stems look like the titanic fluted columns of some giant temple.

The size of the big tree has been often exaggerated. The extreme height actually measured is about 330 feet. That they may reach 350 feet is not unlikely, for the largest trees have almost without exception been broken off at the top by lightning. But statements of 400 feet or over are unquestionably beyond the truth. The extreme diameter above the enormous root swellings is about 27 feet. Obviously this is the only significant way to measure the diameter, for the root swelling is no part of the cylindrical shaft. But such measurements can be made only with difficulty, and measurement at more convenient points have been made at no standard height for the big tree. That the measurements at the base are not really signifi-

cant is apparent from a comparison of the figures which have been given for the General Grant and General Sherman trees.

FIG. 6.—Mariposa Grove of big trees.

The big tree grows very rapidly in youth, but not sufficient study has been given to its growth to make reliable averages available. Under favorable conditions it may grow to be a foot in diameter at 40 years old, and it is then about 60 feet high. Such a rate of

growth has been known to continue for 250 years. Indeed John Muir reports one tree which was 9 feet in diameter and 243 feet high at an age of 259 years. Such growth is doubtless much more rapid than the average, and the big tree, like all other trees, as maturity comes, slows down its rate of growth. In one tree reported by Prof. William R. Dudley the increase in diameter for several centuries was only from 4 to 6 inches per century. But this maturity with the big tree does not ordinarily come under at least 1,000 years. At any rate, it is fairly certain that most, even of the great veterans of the big-tree forest, are much younger than is popularly supposed, and are probably from 1,500 to 2,500 years old. The strongest influence upon the growth of the tree is that exercised by the quality of the location in which it grows. Two trees have been found very near each other, one 24 feet in diameter, the other 25 feet, while the age of the first was 1,300 years and that of the second was 2,300 years. The oldest tree of whose age record there is no question was slightly over 3,000 years. The exact age of a tree can be determined in no other way than by counting the rings of wood which the tree lays on, one for each year of growth. The two trees which have just been cited will serve to show how impossible is even an approximately correct determination of the age of one standing tree by the use of averages or by comparison with the age of another single tree. It is not denied that the sequoia may grow to greater age than 3,000 years. John Muir counted the age of one giant stump in the Kings River Forest in which the rings for many hundred years were so fine as to require 50 or even 100 of them to make a single inch of radial growth, and the rings were much disturbed in places by fire and other injury; but he states that he counted at least 4,000 years of growth. It would therefore be rash to say that the big tree can not attain an age of even 5,000 years. On the other hand, the largest trees are certainly the strongest survivors among many that have perished around them, and these exceptionally sturdy trees grew, in all probability, with more than average rapidity. Estimates of 8,000 years for the age of these trees, based on averages or upon the growth of smaller felled trees, are valueless and almost certainly beyond the truth.

But even an age of 4,000 years must fill him who reflects upon it with awe. The ancestors of other trees which are found with the sequoia in the forest undoubtedly lived at the beginning of that period as now. But of only the sequoia were the very trees upon which we look to-day living in that far-off dawn. When Cheops dreamed the first pyramid some of these hoary giants of to-day doubtless already were springing up and hopefully taking possession of this very soil above which in lordly height and grandeur they

look down upon us of four millenniums after; while Abraham and Moses and David established and led the people of Israel these hopeful seedlings grew through an exuberant youth; in the lusty strength of approaching prime they were entering into their kingdom over the forest when imperial Rome began; they stood in a calm and undaunted maturity when Jesus trod the Judean hills; and when William of Normandy fought on the field of Hastings they were already putting on the hoary garments of age. Yet there they still stand to-day, after another millennium has sped, in calm serenity and majesty, unhurt by disease, unscarred by all save fire and the hand of man, while we, creatures of a day, creep about and peep beneath their mighty shade and pass away, while they live on. And there is no visible reason, barring foolhardy destruction by man, why they should not still live for another millennium or more.

The big tree grows preferably in cool, moist situations, in dense forest on gentle slopes, and in basins and draws where soil moisture is plentiful. Its best development, which occurs in the sugar-pine type, is at elevations of from 6,000 to 7,000 feet, where the annual precipitation is from 40 to 60 inches. Its ability to withstand less favorable conditions is much greater than was formerly supposed, and it can grow, especially at the south, on drier ridges and slopes within its normal altitude, as well as downward into the altitude of the yellow-pine type and upward to 8,000 feet elevation into the fir.

The big tree is a frequent seeder and the most prolific one of any Sierra tree. Especially heavy seed years occur at intervals of from four to five seasons. The trees may begin to bear seed in the open as early as their twentieth year, although in dense forest the beginning is delayed until about the one hundred and fiftieth year. The cones are oval and from 2 to 3 inches long, and each cone may contain from 100 to 200 seeds, while so bountifully does the tree produce that a single full-grown specimen may bear 1,000,000 cones a year.

It was formerly believed that the big tree was a vanishing race of trees. This belief was partly due to the fact that in the Calaveras Grove, which was first discovered, and in the other northern groves there is little or no reproduction. This lack, however, is due to the more unfavorable climatic and other conditions which affect germination; in the southern part of this range seedlings and young saplings cover a favorable spot wherever an opening in the forest gives access to the sunlight and where mineral soil is near to the surface. As many as 2,500 seedlings have been counted on a square rod of ground. An excellent example of this young reproduction can be seen at Atwell's mill, on the Mineral King Road, in the Sequoia National Park. No one can see these lusty crowds of young trees, in every stage of growth, and believe that the species is in any immediate danger of extinction.

The big tree is singularly healthy and free from disease. It lives so long that lightning is sure some day to strike its lofty head, and the repeated fires of centuries may scar and disfigure its base, even though its bark is enormously thick and its wood difficult to ignite and burn. But of the diseases which take off its neighbors, the fir and the pine, it knows almost nothing, and its power of recuperation from injuries, such as fire, is greater than that of any other species of the Sierra Forest. To these facts is doubtless due the marvelous approach to immortality which is enjoyed by this wonderful tree.

The widely isolated groves in which the big tree occurs in the north, where it was first discovered, offered another reason for supposing it to be a dying race, of which such a distribution is usually a sign. But it is now known that the great canyons which form the breaks between these groves were the paths of mighty glaciers which formerly flowed down the Sierra Ranges. The sequoia now grows on the highlands where the ice first disappeared. The southern part of the range was less heavily glaciated than the northern, and this is believed to be responsible for the wider and more continuous distribution of the sequoia at present in that region. Exactly what the past history of the big tree has been must still be left to scientific discovery. But there is no reason, except perhaps at the extreme north, to suppose that in its present home it is facing decline or extinction.

The wood of the big tree when freshly cut is of a beautiful rose-red color, turning gradually darker upon exposure to the air. In the living tree the wood is never found decayed at the heart, and even after felling it may lie on the ground for centuries with no loss except of the sapwood. To its extreme durability is due the fact its most extensive use in the past has been for fence posts and grapevine stakes. The radial grain of the wood is very beautiful and would make it a handsome cabinet wood, except for the disadvantage of its extreme softness. The wood of this species, which is now made into lumber, is sold as redwood, along with the true redwood of the coast, although it is somewhat softer and more brittle than the latter. It is estimated that the largest sequoias may contain as much as a half million feet of lumber in a single tree. But every lover of this magnificent tree must hope that such use of it may not much longer continue.

WESTERN YELLOW PINE (PINUS PONDEROSA).[1]

The yellow pine (figs. 7 and 8) of the Sierras is a magnificent tree exceeded in size and beauty, except for the unique sequoia, among its associates only by the sugar pine. If not so large as the sugar pine, however, the western yellow pine holds one title to preeminence

[1] This species is known as yellow pine in Glacier and Yellowstone Parks.

in that it is the most widely distributed of North American pines. It grows from British Columbia to Mexico and from the mountains

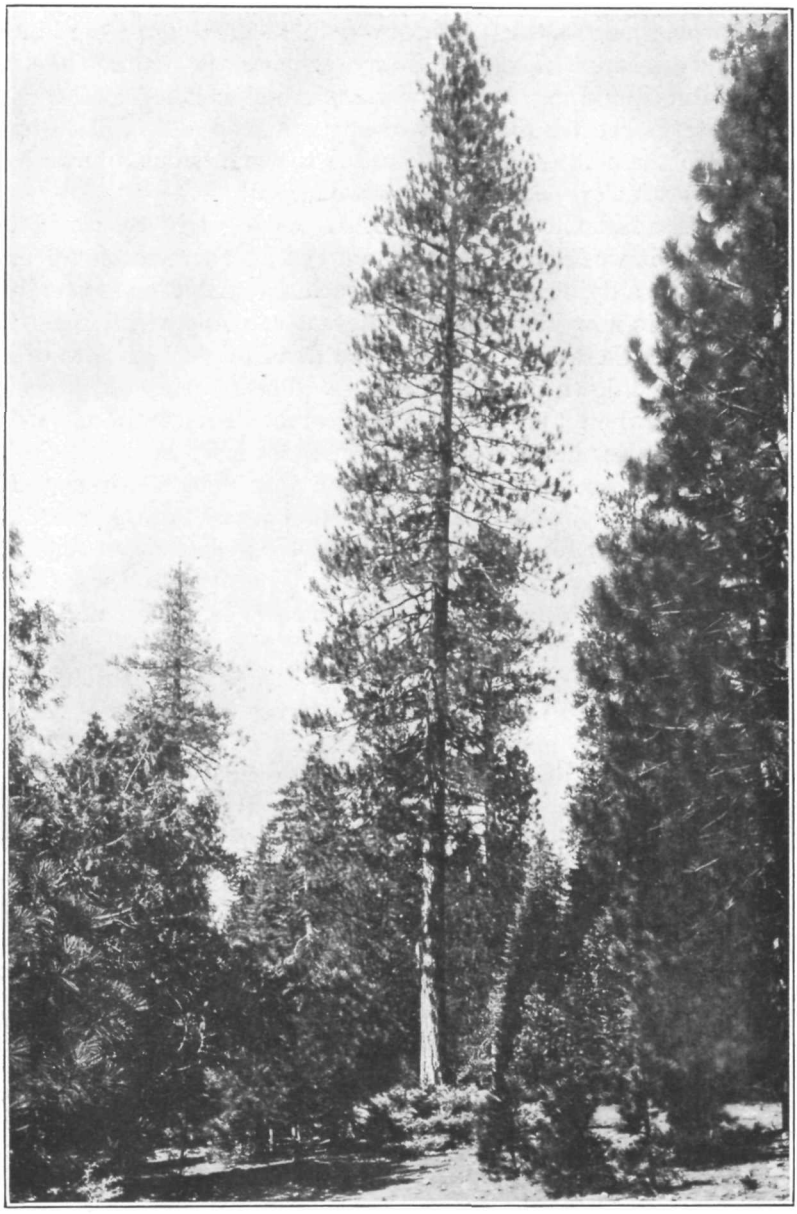

FIG. 7.—Western yellow pine (*Pinus ponderosa*) 70 inches in diameter.

of the Pacific coast to the farthest outlying spur of the Rocky Mountains—the Black Hills of South Dakota. This wide distribution is due to its great power of enduring all sorts of conditions. It rejoices

in the warm, pleasant flats of the lower Sierras and there grows to its best development; but if its seeds alight on a dry, hot ridge, it does

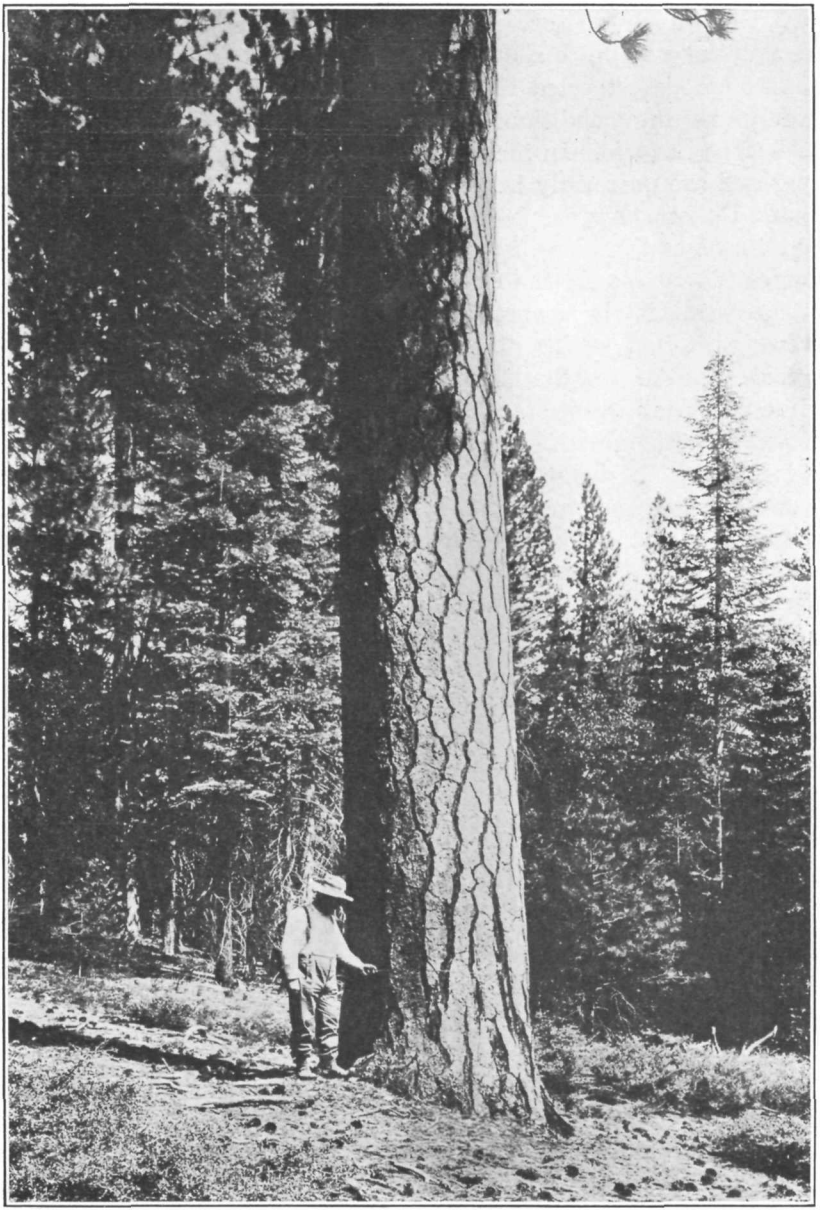

FIG. 8.—Western yellow pine (*Pinus ponderosa*) 71 inches in diameter.

not give up and die as many other trees would do, but clings to life and grows the best it can, although it can not grow into as fine a tree as in more favorable locations. In the dry Rocky Mountains it still

pushes its way, although stunted, as indeed are all trees by such hard conditions. In the region of the Sierras surrounding the national parks this tree frequently reaches a height of 200 feet and a diameter of 5 feet. Trees are occasionally found with a diameter of 6 or 7 feet and heights up to 230 feet.

As might be expected from a tree which can adapt itself to such widely varying conditions, the western yellow pine shows many variations in form. In the Sierras its leaves are from 7 to 10 inches long and are uniformly in bundles of three. In the Black Hills of South Dakota they are 2 or 3 inches shorter and may be found in bundles of two or three upon the same tree. Above an altitude of roughly 5,000 feet in the Sierras it is replaced to a greater or less extent by its closely related form, the Jeffrey pine.

In youth this yellow pine grows very rapidly if conditions are favorable. For the first two or three years of its life, to be sure, while it is establishing its root system upon which its supply of food depends, the height growth of the seedling is slow, but by the time it is passing the height of a man's head it frequently grows at a rate of 2 or 3 feet in height per year. This rapid height growth, however, begins steadily to slacken after youth is passed, and while it never wholly ceases during the life of the tree, the growth of the veterans is extremely slow. In diameter, on the other hand, the tree grows by putting on annually a new layer between the wood and the bark, thus producing the annual rings which can be seen on any smooth stump. In young and vigorous trees these rings may be one-half or even three-fourths of an inch wide, which is equivalent to a growth in diameter of 1 or 1½ inches per year. Such a rate of growth, however, never continues for many years, as the diameter growth is strongly affected by variations from year to year in the moisture supply and other conditions of life. Next to a half-inch ring may readily stand one only one-sixteenth of an inch in thickness. After the tree has reached maturity there is a marked and permanent falling off in the width of the rings and the tree continues to grow slowly until the end of life; for with trees there is no absolute limit of growth or of life, such as is caused among animals by the maturing and decay of organs.

In favorable conditions the yellow pine may grow to 12 inches in diameter in 30 years and to 30 inches in 100 years, while a 5-foot veteran may be 300 years old. Such rapid growth, however, occurs chiefly in the open. In continuous forests the trees grow more slowly in diameter than they do in the open, but faster in height, and make longer and cleaner shafts. Under average conditions a tree 12 inches in diameter is about 80 feet tall and 60 years old, one 30 inches in diameter is 150 feet tall and 200 years old, and one 60 inches in diameter is 180 feet tall and 500 years old. Good site conditions may

increase the heights for a given diameter, and poor conditions decrease them, by about 25 feet, while the ages may be increased or decreased by from 25 to 50 per cent.

The western yellow pine in the central Sierras is a very healthy tree. It suffers occasionally from fungous diseases, which cause decay, and also from the attack of mistletoe. Trees are occasionally struck by lightning, but this happens seldom, on the whole. Among the worst enemies of the western yellow pine are the bark-boring beetles. These insects enter through the bark and excavate channels in the thin layer of living tissue between the bark and the wood. If the beetles are in sufficient numbers, they girdle and kill the tree. Nearly all of the dying or gradually yellowing tree tops which are seen in this region of the Sierras are due to the attack of these beetles.

The worst enemy of the forest has been fire. Untold wealth of the Nation has been destroyed thus since the white man came to the forests of America. It has been a long lesson to learn, but the people are every year more careful with their use of fire in the woods, and, with the help of our tourists and travelers, great progress is now being made in protecting our national parks and national forests from such destruction. Every year, however, come some new friends who have never had experience in the forests of the terrible effects of this scourge, and all those who do know should help to spread the gospel of care.

The wide distribution of the western yellow pine makes it a very important tree as a source of lumber supply, to which the quality of its wood makes it excellently adapted. The wood is softer, smoother grained, and less resinous than that of almost any other yellow pine in the United States, and the California-grown timber is so remarkable in this respect as to resemble more the white pine of the East. Indeed it is known in the lumber markets under the name of California white pine. The total lumber cut of this species in the United States for 1912 was 1,220 million feet board measure, or a little over 3 per cent of the total for all species of 39,000 million feet. Of this total for the species California cut 30 per cent. The enormous total stand of the species over its very wide range will doubtless make it a much more important factor in the lumber market of the future than it is at present. An important industrial possibility in connection with this species is the fact, recently determined by experiment, that it can be made to yield turpentine rivaling both in quantity and quality that of the longleaf yellow pine of the southeastern Atlantic coast.

SUGAR PINE (PINUS LAMBERTIANA).

The sugar pine (figs. 9 and 10) is the king of all the pines of the world, both in size and beauty. Barring the sequoia only, it is the

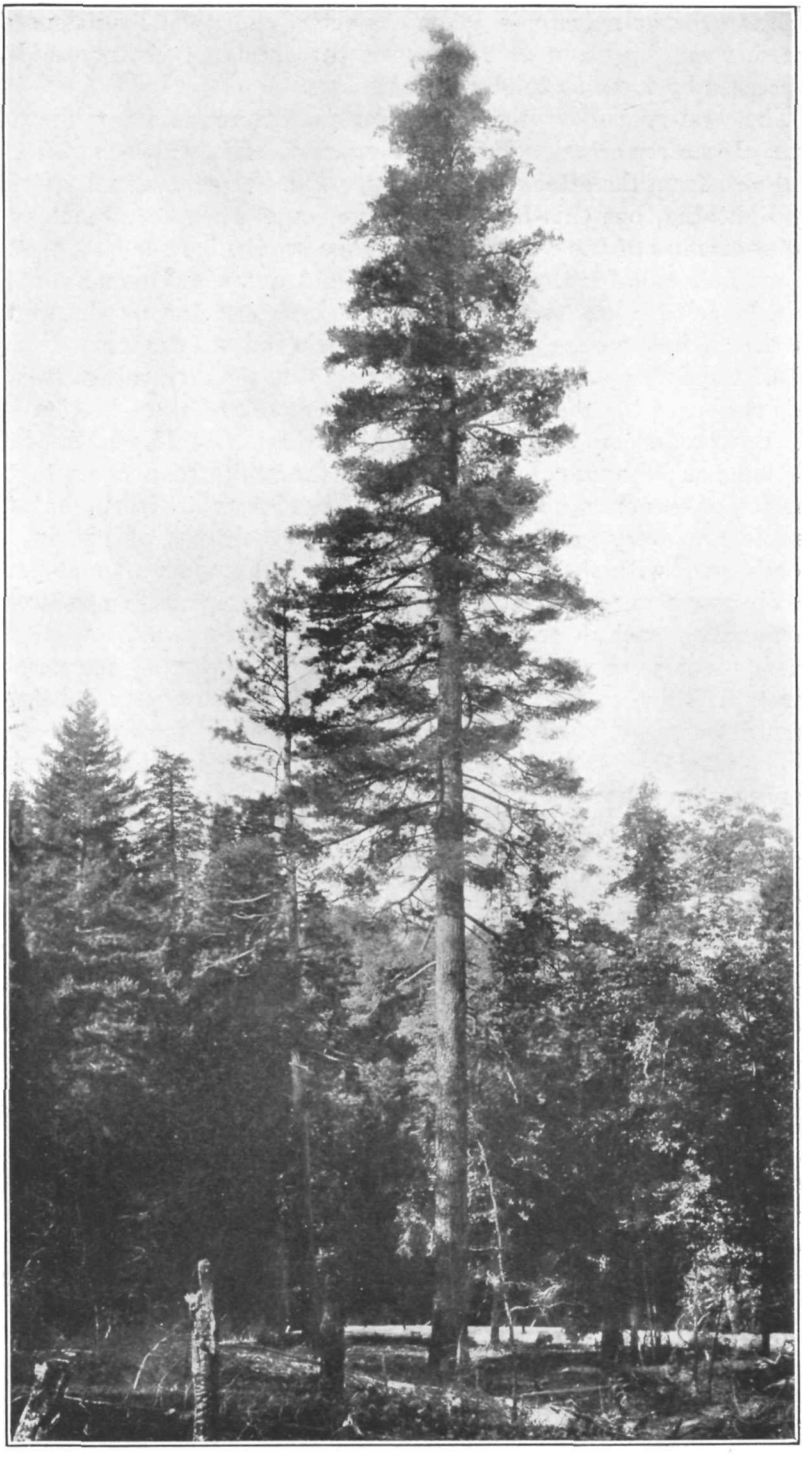

FIG. 9.—Sugar pine (*Pinus lambertiana*) 61 inches in diameter.

FIG. 10.—Sugar pine (*Pinus lambertiana*) and cone. Tree 6 feet in diameter.

largest and most beautiful tree of the Sierra forests. Trees from 4 to 5 feet in diameter are common, while ones measuring 6 feet are not rare. Occasionally specimens are found measuring 7 and 8 feet in diameter, and the largest recorded diameter is about 10 feet.

The sugar pine belongs to the white pine group, its needles being in clusters of five. In youth its bark is a smooth, shining silvery gray and its branches are more wide-spreading and regular than are those of the yellow pine. In maturity the bark becomes closely fissured, and of a rich reddish brown color, its lower branches are dropped, leaving a long, clear shaft, and its long, large top branches spread horizontally in picturesque irregularity, drooping gracefully at the tips where hang its giant cones. The cones are cylindrical, and may be from a foot to 20 inches in length, by about 3 inches in diameter before they have opened.

In its distribution the sugar pine, unlike the yellow pine, is very closely restricted, being confined to the State of California, except for a comparatively short extension northward into southern Oregon, and a small and unimportant one southward into Lower California. Its occurrence has been discussed in connection with the type.

The sugar pine is not a prolific seeder, bearing heavily only at intervals of from five to seven years. The seeds are large and sweet, and are harvested to such an extent by squirrels as to seriously reduce the supply available for the purposes of reproduction. The seeds need abundant moisture for sprouting, and the seedlings abundant light for growth. The latter seldom occur in dense numbers, as do those of the yellow pine, but are usually found scattered here and there among those of the other species composing the forest.

The growth of the sugar pine in youth is commonly less rapid than that of the yellow pine; but it continues with smaller decrease and for a longer time. At 12 inches in diameter, under average conditions, the sugar pine is 80 feet tall and about 70 years old; at 30 inches in diameter, it is 148 feet tall and 170 years old; at 60 inches in diameter, it is 180 feet tall and 400 years old; and at 80 inches in diameter, it is 185 feet tall and from 600 to 700 years old.

The sugar pine is remarkably free from diseases of the stem or trunk, and is usually free from diseases of the crown. A witches broom often develops small balls of distorted twigs and bluish leaves, but this does not often shorten the life of the tree. A bark beetle allied to the one which causes havoc in the yellow pine, attacks the sugar pine, but in the region of the national parks this attack is nothing like so extensive as in the case of the yellow pine. The sugar pine is probably more injured by fire than by any other single agency. Its bark is comparatively thin, and trees with heavy

fire scars at the base are more common than in almost any other species.

The sugar-pine lumber produced in the United States in 1912 was 123.5 million feet, of which 97 per cent was cut in California and the remaining 3 per cent in Oregon. In spite of its narrow range and the smallness of its cut, in comparison with the total for the whole country, the remarkable technical qualities of its wood and the large size of its trees, which permits them to yield a large proportion of clear material, make sugar pine a species of importance to the lumber industry.

INCENSE CEDAR (LIBOCEDRUS DECURRENS).

The incense cedar (fig. 11), like the other so-called cedars of the United States, is not a true cedar at all, although it is closely allied to the true cedars. Like most of those trees in this country, the incense cedar has scale-like leaves. It is a beautiful tree, with tapering, conical trunk and broadly pyramidal crown until old age, when its limbs are often reduced to a stubby cluster of two or three at the very top of the tree. The bark in youth is a

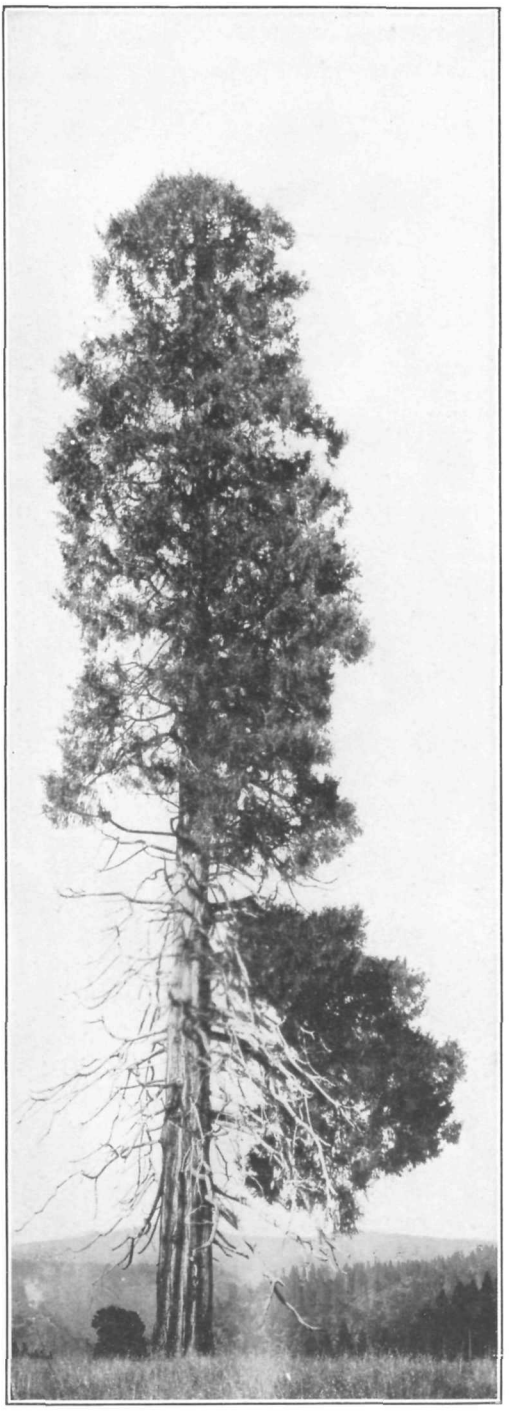

FIG. 11.—Incense cedar (*Libocedrus decurrens*).

deep red under a smooth, transparent gray surface film. On old trunks it is a reddish to grayish brown, thick, and smoothly and heavily ridged. The foliage is arranged in flat, fanlike sprays.

The incense cedar has a very restricted range, being, like the sugar pine, practically confined to the State of California. It revels in moist gulches, stream bottoms, and flats, but, like the yellow pine, it can also push its conquests out on to the dry ridges. Except in youth, it does not often grow in pure stands, the mature trees being scattered thinly through the forest. It is a prolific seeder, bearing abundantly every two or three years or oftener. The seedlings are more adaptable than those of almost any other species to varied conditions of moisture, soil, and light, and spring up often in great numbers.

In the middle Sierras mature trees are from 30 to 40 inches in diameter. Many veterans may be found from 4 to 5 feet in diameter, and occasionally one as large as 6 feet. On account of the tapering trunks, the height for a given diameter is much smaller than it is in the pines. Growth is often rapid in youth, but slows down much more rapidly than it does in the pines. Under average conditions, in the region of the Yosemite, a tree 12 inches in diameter is about 55 feet tall and from 80 to 100 years old; at 30 inches in diameter it is about 115 feet tall and 450 years old; while at 60 inches it is 145 feet tall. On very good or very poor sites the heights given will be increased or decreased by from 30 to 40 feet for the larger diameters.

Incense cedar is not seriously injured by insects. Its worst enemy is a fungus disease which produces a dry rot in the interior. This is so serious as to prevent the use of the wood for many finer purposes for which it would otherwise be fitted. Cedar is also badly damaged by fire, for, although the bark is thick, it is much more inflammable than is that of the pines.

Incense cedar in the past has been very little used for anything but fence posts and rails, for which its great durability adapts it. It is now being used successfully for piling on the Pacific coast, where ship worms attack badly such timbers made from most other woods. On account of its softness, evenness of grain and fineness of texture it has recently been successfully tried for lead-pencil making, in which perfect wood in short lengths can be used, and it seems likely to replace for this purpose the waning supply of the red cedar of the East.

FIRS.

There are two firs in the Sierra region in which the national parks are located, namely, white fir (*Abies concolor*) and red fir (*Abies magnifica*). These are among the largest trees of their kind in the

world. Mature white firs (fig. 12) are from 4 to 5 feet in diameter, occasional specimens measuring as much as 7 feet. The fir is the tallest tree of the Sierra forests, sometimes attaining a height of 240

FIG. 12.—White fir (*Abies concolor*) 9 feet 3 inches in diameter, 115 feet high.

feet. The red fir (figs. 13 and 14) is about as tall as the white, but does not usually reach as large diameter. The first, like the spruces, belong to the group of conifers which have short leaves scattered on

the twigs instead of clustered as in the pines. In the white fir the leaves are usually 1½ to 2 inches long and stand on opposite sides of the twig in a featherlike arrangement. The leaves of the red fir are shorter, three-fourths to 1 inch long, and generally curl upward. This character is often given as a distinction between the two trees, but it is quite unreliable, for white fir in unfavorable conditions or in old trees produces leaves similar in all these respects to those of the red fir. The only trustworthy leaf distinction is that in the white fir each leaf is slightly channeled lengthwise on the upper

FIG. 13.—Red fir (*Abies magnifica*) 15 inches in diameter and 35 feet high.

surface, while the leaves of the red fir are ridged, or at least convex, on both top and bottom. The appearance of the trunk bark is usually different in the two trees. That of the white fir is ashy gray in color, and the edges of its thin, irregular plates tend to curl up. The bark of the red fir is closely ridged, much like that of the sugar pine, except that it is much darker in color. An unmistakable distinction between the two trees is furnished by the color of interior of the bark, which when chipped into, is, in the white fir, a dirty or brownish yellow, while in the red fir bark it is a bright red. The side branches of the red fir are usually shorter than those of the

white fir, and, as maturity approaches, its top is rounded off so that it appears dome shaped rather than conical.

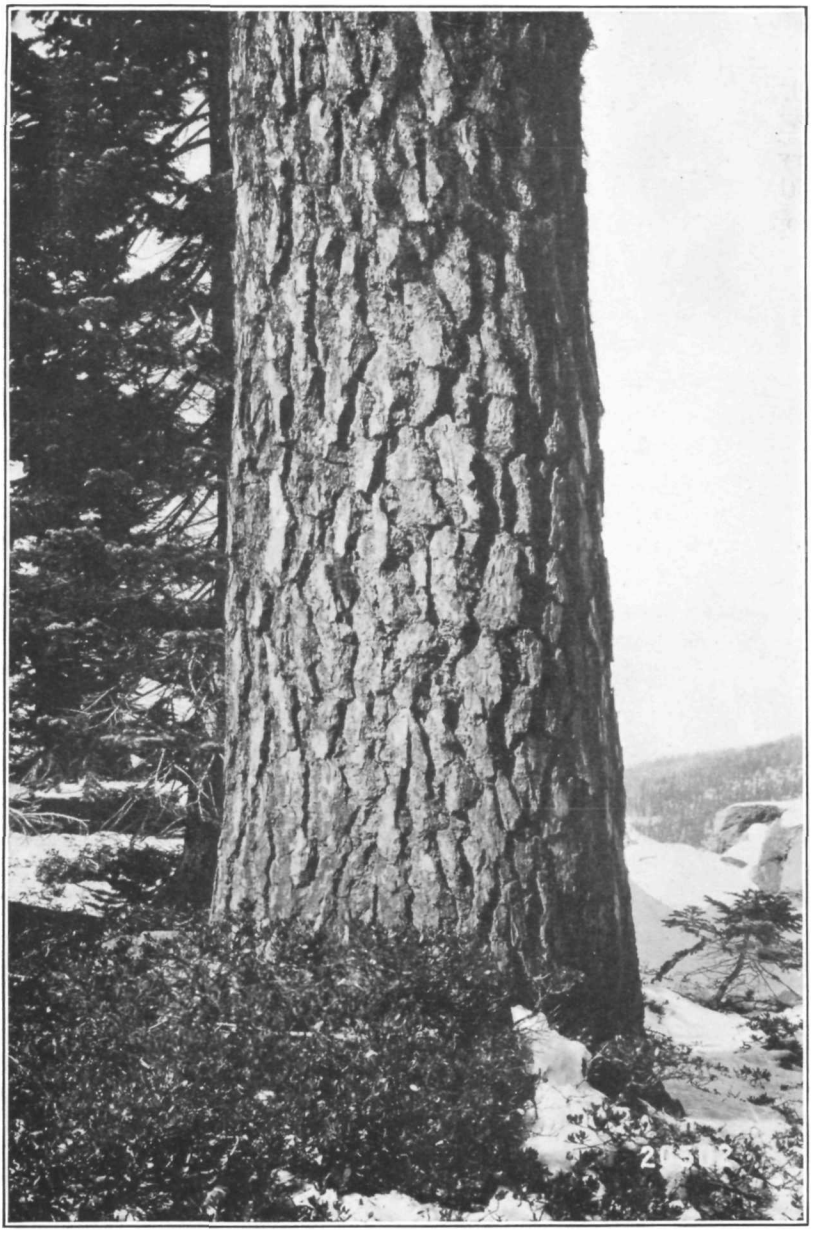

FIG. 14.—Red fir (*Abies magnifica*).

The firs seek cool and moist situations, requiring moisture in the air as well as in the ground. The requirements of the red fir are

more exacting in these particulars than are those of the white fir. These are the controlling factors in their distribution as given in the discussion of the fir type. The firs can grow in deeper shade than any of their asssociates in the Sierra forests, and this permits them often to crowd other trees out in the struggle for possession of the soil.

The white fir is a moderately prolific seeder and the red fir is a very prolific one. Heavy seed years occur at intervals of from two to three years, and some seed is borne every year. The cones of the two trees afford another means of distinction between them, those of the white fir being from 3 to 5 inches long, while those of the red fir are from 6 to 8 inches long. The usefulness of this character as a distinction is reduced, however, by the fact that the upright cones of the firs fall to pieces when they discharge their seed, so that the cones can never be found on the ground, unless, to be sure, they have been blighted and thus fall off before they are mature.

These firs grow very rapidly in diameter. The height growth in youth is less rapid than that of the pines, but it continues unabated for a longer period. Under very favorable conditions the white fir may grow to a diameter of 12 inches in 30 years and to 30 inches in 100 years. Ordinarily in this region at 12 inches diameter the trees are about 40 feet high and 50 years old, at 30 inches diameter 150 feet high and 200 years old, and at 60 inches diameter 190 feet high and 450 years old.

The firs are seriously attacked by a fungous disease, so that mature trees are seldom found which are not badly decayed. The fungus often produces unsightly cankers. The trees are also badly attacked by a mistletoe, which kills the tops, and the white fir is badly scarred by fire. The red fir grows at such high elevations that bad fires seldom occur, because of the coolness and moisture.

The wood of the firs is the strongest coniferous timber of the Sierra forests, excepting only that of the Douglas fir, and would make excellent construction timber if it were not so often checked and cracked. This defect and the fact that it warps badly in drying unfit it for use in the better grades of lumber. White fir, however, is sawed to a considerable extent for common lumber. The greatest use of the firs in the future will doubtless be for paper pulp, to which they are excellently adapted, and for which the demand in the United States is fast outstripping the supply of the eastern spruce.

LODGEPOLE PINE (PINUS CONTORTA).

This tree (fig. 15) has a very wide distribution, and in large areas of the Rocky Mountains is an important tree. It is a small tree, from 20 to 30 inches in diameter and 60 to 100 feet tall in the Sierra

region. Its leaves are about 2 inches long and wide and flat in comparison with the needles of most pines. They are distinguished from most of the other Sierra pines by their occurrence in bundles of two. The bark of the tree is thin and light colored, scaling up in small thin flakes. In the Sierras the tree grows mostly in moist soil around high mountain streams and meadows, the latter of which it is the first tree to capture as they slowly dry out. In the Rocky Mountains this tree occupies much more arid situations than it does in the Sierras.

FIG. 15.—Lodgepole pine (*Pinus contorta*) 5 feet in diameter, 120 feet high.

The lodgepole pine is a very prolific seeder, and in the high mountain meadows its reproduction is often so thick that a way can be forced through it with difficulty. This pine is exceedingly intolerant of shade. For this reason it forms a temporary type. In the Sierra Mountain meadows it is crowded out by the dense shade of the firs as soon as it has built up the ground to sufficient dryness to permit the firs to come in. A peculiarity which interestingly affects the distribution of this tree is the extreme slowness with which its small oval cones open and discharge their seed. They often stay closed for many years until the tree is killed and the cones opened by the heat of a forest fire. A dense, even-aged stand of lodgepole seedlings then springs up, ahead of all other invaders, and takes entire possession of the ground until in due course of time they are crowded out by some more slowly entering tree which can shade them out. In the Rocky Mountains vast areas are thus covered by the lodgepole pine. In the Sierras this peculiarity of the cones is much less marked,

but the lodgepole doubtless owes a large portion of the area which it covers in the northern part of Yosemite Park to the aid of fire.

The growth of the lodgepole pine is rapid at first, as it is in all trees which can endure little shading. The rate of growth falls off much earlier than it does in any of the trees which have been discussed. In the Sierra region an average 12-inch tree is about 50

FIG. 16.—White-bark pine (*Pinus albicaulis*) in its characteristic mountain habitat.

Photograph by A. H. Denman.

feet tall, a 24-inch tree is 75 feet tall, and a 36-inch tree about 90 feet tall. In favorable places in the meadows it sometimes reaches a height of 130 feet. The largest tree which has been reported in the middle Sierra region is 57 inches in diameter.

Lodgepole pine is extensively sawed for lumber in the northern Rocky Mountains, but in the Sierras better woods are so abundant and so much more accessible that the little lodgepole offers no in-

ducements to the lumberman. The straight, slender form of the tree, however, fits it excellently for use as telephone poles, and a considerable use is developing in this direction.

ALPINE SPECIES.

Among the alpine species there are two white pines, the western white pine (*Pinus monticola*) and the white-barked pine (*Pinus albicaulis*). The white-barked pine (fig. 16) is always a timber-line

FIG. 17.—Western white pine (*Pinus monticola*). Diameter 24 inches, height 50 feet.

tree, growing scattered and stunted among the rocks. Its leaves are clustered in conspicuous bunches at the ends of its branches. Its cones are from 2 to 3 inches long.

The western white pine (fig. 17) in Idaho and Washington grows at moderate elevations and is a large and important timber tree. In

the central Sierras it is found only at high elevations. Here it grows to diameters of 5 feet, but the height is usually not more than 100 feet. Its cones are much larger than those of the white-barked pine, being from 5 to 10 inches long.

FIG. 18.—Mountain hemlock (*Tsuga mertensiana*).
Photograph by Geo. O. Caesar.

The mountain hemlock (*Tsuga mertensiana*) is a peculiar little tree of the high snows and rocks (figs. 18 and 19). Its leaves have a short but distinct stem, like other hemlocks, in contrast to the stemless leaves of the spruces and firs. But instead of the thin, flat,

two-ranked leaves of other hemlocks, this one has thick, angular leaves, growing all around the twigs. It is usually from 10 to 20 inches in diameter and from 25 to 60 feet tall, although in favorable situations it sometimes grows to a diameter of 40 inches and a height of 125 feet. On bleak summits it is often only a few feet high, or sprawling on the ground. Despite the hard conditions and its small size, it clings to life and grows to a great age, but there is no reliable knowledge in regard to its growth and length of life.

FIG. 19.—A wind-swept mountain hemlock.
Photograph by A. H. Denman.

GOLDEN-CUP OAK (QUERCUS CHRYSOLEPIS).

The golden-cup oak (fig. 20) is a large and beautiful tree of the moist flats and canyons at low and moderate elevations. Its leaves are elliptical and often have short spiny teeth on their margins. Their under surface is covered with a very fine fuzz, which is bluish-white in color. Its acorns are large and fat, with a shallow and heavy, woody cup, whose inner surface is covered with a golden yellow fuzz. The wood of this tree is so heavy and tough as to give it the common name of maul oak.

FIG. 20.—Golden cup (*Quercus chrysolepis*).

FIG. 21.—Live oak (*Quercus wislizenii*).

LIVE OAK (QUERCUS WISLIZENII).

An oak which is common in the chaparral below the timber belt and is sometimes found in the lower margin of the yellow pine type is one of the live oaks (*Quercus wislizenii*), which has elliptical leaves, smaller than those of the golden-cup and shiny yellow on the underside (fig. 21). Its acorns are slender and pointed with a deep cup composed of loose, flexible scales.

CALIFORNIA BLACK OAK (QUERCUS KELLOGGII).

The black oak (fig. 22) is a large tree having large leaves lobed like those of the black oak of the east. It is the most common oak

FIG. 22.—California black oak (*Quercus kelloggii*).

throughout the yellow pine and lower sugar pine types. It prefers considerable soil moisture, but commonly occupies more or less dry slopes. Its wood is used only for fuel.

ALDER, MAPLE, DOGWOOD.

These are the only remaining species which make trees of sufficient importance for description. The alder has a smooth gray bark, thickly marked with dark spots. Its leaves are soft, and oval in shape, its margins closely toothed. The maple is a smooth barked, opposite leaved tree, the leaves being palmately veined and

lobed. The dogwood has finely square-checked bark on old stems, although the bark is smooth when younger. Its leaves are opposite like those of the maple, or whorled, with prominent pinnate veins running out to the margins in a graceful curve. In the spring the dogwood bears compact heads of small greenish flowers, surrounded by six spreading white petal-like leaves, which many people mistake for the flower. In fall the leaves of the dogwood turn to brilliant crimson and yellow, giving a flame of color to all the woods of the sugar-pine belt.

INDEX.

[Roman numerals indicate descriptions; italic numerals indicate illustrations.]