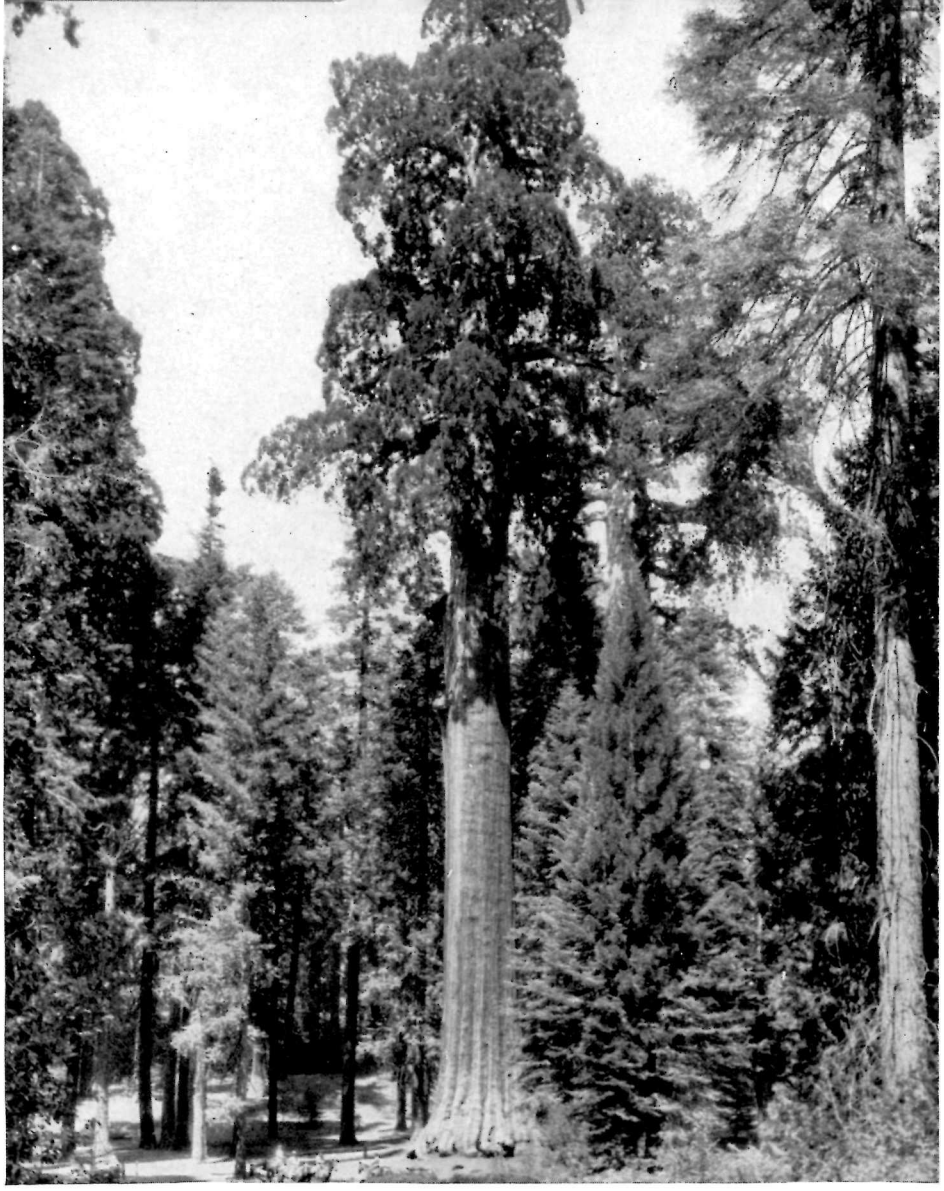


THE GIANT SEQUOIAS

of California . . .

THE

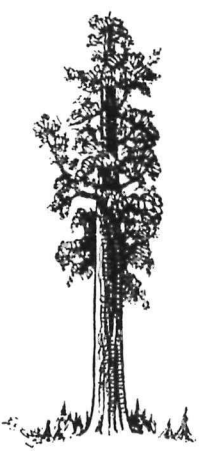
Giant Sequoias of California

by

LAWRENCE F. COOK

ASSISTANT CHIEF OF FORESTRY

NATIONAL PARK SERVICE



UNITED STATES GOVERNMENT PRINTING OFFICE

WASHINGTON : 1942

UNITED STATES

DEPARTMENT OF THE INTERIOR

Harold L. Ickes, *Secretary*

NATIONAL PARK SERVICE

Newton B. Drury, *Director*

For sale by the Superintendent of Documents
Washington, D. C. - - - Price 15 cents

Contents

ILLUSTRATIONS

In the Mariposa Grove, Yosemite National Park. *Anderson Photo.*

THE GIANT SEQUOIAS OF CALIFORNIA

Introduction

HIGH in California's Sierra Nevada stand "nature's forest masterpieces"—remnants of once widespread forests that covered a large portion of the Northern Hemisphere. Today but a relatively few of the giant sequoias [1] remain to interpret the past and give promise to the future.

Although these forest monarchs have created great interest, aroused much speculation, and resulted in many stories since their earliest discovery, they continue to be among the mysteries and wonders of nature. The human tongue, gifted as it is, has failed to describe adequately their towering majesty and solemn beauty. As individuals, and as members of a forest community, they stand supreme—the largest and perhaps the oldest living things on earth.

On his first pilgrimage to the giant sequoias the visitor views these trees with mixed feelings; awe, wonder, disbelief, and perhaps a bit of disappointment are jumbled together in a maelstrom of emotion. Much depends upon the presence or absence of familiar objects to lend scale and perspective to the scene. Viewed as an individual, standing next to familiar man-made objects, the sequoia is more readily placed in proper perspective than when found in communities of sequoias and other large-sized associated trees. Statistics mean little to the initiate because he has no past experience upon which to base mental comparisons. With increasing familiarity, however, the size and grandeur of the giant sequoia gradually become comprehensible and a true interest and deep respect develop for this forest monarch.

After seeing several of these trees, one cannot say that he has observed all that is of interest about them, for, like few other species, the giant sequoia exhibits great individuality and many unique characteristics. Each tree presents some new phase of size, persistence, or growth, and even those trees that have succumbed tell a fascinating story of life in the face of adversity. It is this tenacity to life and incomparable resistance to destruction

[1] The tree has been popularly known as Big Tree, sequoia, Sierra redwood, and giant sequoia. The last name is considered most descriptive and has recently been accepted by the Federal Government for official use.

that make the giant sequoia unique in the tree world and are the keys to its long life and great size.

Naturally many questions come to mind as the visitor becomes acquainted with this outstanding tree, and it is to answer some of the more important of these questions that this brief, nontechnical account of the giant sequoias was prepared. The park rangers and naturalists are always glad to assist in bettering your understanding of these trees, so if the answer is not found herein do not hesitate to make inquiry. By no means should the trees themselves be neglected, for it is by personal experience and reflection that a true regard and appreciation can best be developed for these monarchs of the forest world.

In the preparation of this bulletin the author is indebted to the following National Park Service colleagues for their advice and assistance: Chief of Forestry J. D. Coffman; Regional Forester Burnett Sanford; and the superintendents and staffs of Kings Canyon, Sequoia, and Yosemite National Parks. Special credit is due to Forester A. Robert Thompson for his assistance in reviewing the text and preparing the map.

Description of the Giant Sequoia

THE GIANT SEQUOIA (*Sequoia gigantea* [Lindl.] Decn.) and the redwood (*Sequoia sempervirens* Endl.) are the last surviving species of the rather large genus *Sequoia* that grew over much of the Northern Hemisphere during ancient geological times. Only two other species of trees closely resemble them—the bald cypress of our Southern States and the cryptomeria of Japan.

The giant sequoia reproduces only from the seeds that older trees rain down annually by the million. In spite of such a generous seed crop, the chances of an individual seed to germinate, survive, and grow into a mature tree are less than one in a billion, owing to the difficult growing conditions created partly by the sequoias themselves. A deep forest duff, heavy shade, and severe root competition take such a large toll of the relatively few seeds which germinate that it is only those in the most favorable sites that survive the first year or two. For normal growth the sequoia seed must germinate and develop in a continuously moist but well drained soil with plenty of direct sunlight.

Despite the difficulties of growth and the apparent scarcity of seedling sequoias in the groves, the species is in no danger of extinction through lack of reproduction, for whenever fire, wind, or other destructive agents eliminate the older trees and expose the mineral soil large numbers of

sequoia seedlings appear and quickly develop into dense stands of vigorous trees. Even in the undisturbed forests one may note occasional seedlings and trees of all ages from youth to veteran.

The sequoia flowers appear in the late winter (February or March) while deep snow is still on the ground. The tiny, bright yellow blossoms burst forth in a solid mass and change the color of the crown from deep green to golden for a short time. Clouds of yellow pollen are released.

The cones are green or brownish in color, egg-shaped, and about 1½ to 2½ inches long and three-fourths to 1 inch in diameter when fully grown, although exceptional specimens may be much larger. They require 2½ years to mature and are formed of approximately 36 hard fibrous scales, each one of which shelters 2 to 6 seeds.

FIGURE 1.—Young sequoias. These trees are 15 to 20 feet tall and approximately 15 years old.

The well-known truth that "mighty oaks from little acorns grow" is less astonishing than that of the sequoias' tiny beginnings. The seeds are flat, about the size of a pinhead, and are enclosed in a scalelike seed case from one-fourth to three-eighths inch long by one-fourth inch wide. They are shed from September on through the fall and winter, although the cones may remain on the branches for many years. Some of the seeds that are not shed immediately may remain fertile in the cones for years, When the cones of the sequoia open, the seed is released, together with tiny flakes of a purplish substance. Dissolved in water, this substance makes a good purple writing fluid.

The sequoia less than 70 years of age sometimes produces a few seeds, but large seed production normally does not occur until the tree is several hundred years old. As long as the tree survives it continues to develop large numbers of cones and fertile seeds. One can merely speculate on the vast numbers of seeds produced by a veteran that has withstood storms, fires, and even geological changes during its life span.

In youth, the sequoia has a tall slender trunk and a thin conical crown, the branches of which cover the trunk nearly to the ground. When the tree reaches its normal maximum height of 250 to 300 feet, it begins to broaden out, develop large lateral limbs, and shed the lower branches. As it reaches old age the sequoia loses its smaller branches and assumes a broad conical

Padilla Photo.

FIGURE 2.—The bark of the giant sequoia is one of its most attractive features. The President Tree, Sequoia National Park.

or open oval shape with a few immense limbs and large tufts of foliage. Some of the lateral branches of old trees exceed 4 feet in diameter—larger than the trunks of many more familiar trees. The trunks of older trees often show little taper for 100 feet or more above the large buttresses at the base.

The bark of the giant sequoia is one of its most attractive features. It is a beautiful red brown, is of a soft fibrous nature, and is fluted in long vertical plates which give the tree a columnar appearance. The bark near the base of older trees is often from 6 to 10 inches thick, and may even be 2 feet thick. Higher up on the trunk the bark becomes thin, generally not more than 2 inches thick, and has a smooth burnished cast. In younger trees a purplish tinge lends interest to the bark.

The wood of the giant sequoia is distinct from that of other conifers. The sapwood forms a pale yellow narrow band beneath the bark, whereas the heartwood is reddish purple when first exposed, but soon weathers to a dark chocolate brown. The annual growth rings are distinctly visible, except in very old trees where more recent growth may be so slight each year that the rings are almost microscopic in width. Resin canals are lacking, but the wood cells are heavily impregnated with a soluble reddish resinous material.

At one time a considerable volume of lumber was produced from the giant sequoias but, owing to the difficulty of logging such immense trees and the great loss as a result of logging breakage, only a small volume now reaches the market. Although some of the largest trees contain more than 500,000 board feet (enough to build 50 six-room houses), most of this is lost in logging or is of too poor a quality to be economically useful. The small volume still produced is similar to, and is sold as, redwood, but it is coarser grained and generally less satisfactory for most purposes. Its major value is for use where resistance to decay is important but strength is unnecessary. The excellent condition of old fallen logs, some of which fell centuries ago, testifies to the ability of this species to resist decay. It is among the most durable of woods and highly resistant to attack by termites.

One of the characteristics of the older giant sequoias is the frequent occurrence of dead tops. The reason for this phenomenon is not definitely known, but it is unlikely that all of these stag-headed crowns result from any one cause since fire, lightning, loss or interruption of the water supply, deficient soil nutrients, and root injury have been observed to affect individual trees at various times. Many sequoias have been struck by lightning and tops are occasionally burned or broken out, but no sequoia is known to have been killed by lightning. Perhaps many of the dead tops are traceable to partial destruction of the sapwood by fire near the base of the tree, since this portion supplies the channels through which water and minerals from the roots reach the needles, and an interruption of the conduction system may result in serious shortages. Practically all trees with dead tops display large fire scars at their bases. Decreased water and nutrient supplies through changed water courses, increased root competition from other trees, or perhaps a decreasing ability of older root systems to function in a normal manner may account for some of the dead tops.

The evergreen foliage of the giant sequoia consists of scalelike, sharp-pointed leaves closely overlapping each other along the twig, somewhat similar to the junipers. Each bluish-green leaf is about one-half inch long and extends outward from the axis of the stem about one-fourth of an inch. Individual leaves are not shed, but whole twigs and sometimes even branches fall.

The root system of a fallen sequoia is a source of never-ending surprise since the flat plate of closely matted roots is relatively small for such a gigantic trunk. The roots extend out from the trunk in every direction for a hundred feet or more, and the feeding roots are very close to the surface of the ground. The giant sequoia develops no permanent taproot or other roots that extend deep into the ground, but sometimes a single root may grow out near the surface for as much as 200 or 300 feet toward water. It is truly amazing that the shallow and relatively small root systems can support such vast bulks against the storms of the centuries. The trees are

FIGURE 3.—Fallen sequoias. Note the closely matted and relatively small flat plate of roots.

nicely balanced, however, and even leaning ones generally have their larger branches concentrated away from the direction of lean. It is interesting to speculate upon the vast quantities of water and minerals that these roots must have supplied to the foliage of one of these veterans through the years. When a tree finally does topple over, the roots are generally broken off close to the base of the tree.

Differences Between Giant Sequoia and Redwood

ALTHOUGH the giant sequoia and redwood are closely related, they exhibit many individual characteristics that distinguish them from each other. Perhaps the following major differences will help to answer some of the questions that may come to mind.

Natural habitat.—The giant sequoia is found growing singly or in groups scattered for a distance of 250 miles along the western slopes of the Sierra Nevada in central California at elevations of 4,000 to 8,000 feet. The redwood grows near the Pacific Ocean along the northern California coast in a more or less continuous belt about 450 miles long and 15 miles wide. (See Distribution Map on the Inside Back Cover.)

Method of reproduction.—Both species reproduce from seed, but the redwood is one of the few conifers that is also able to develop sprouts from cut stumps, roots, and burls.

Foliage.—The foliage of the giant sequoia is scalelike and somewhat resembles that of the junipers; redwood foliage is in the form of two-ranked needles like the hemlock.

Shape and size.—The giant sequoia is the largest tree in the world in volume and has an immense trunk with very slight taper; the redwood is the world's tallest tree and has a slender trunk.

Cones and seed.—The cones and seed of the giant sequoia are about three times the size of those produced by the redwood.

Woody structure.—The wood of the giant sequoia is much coarser in texture than that of the redwood, and growth rings of the redwood are wider. Both woods are highly resistant to decay.

Color of bark.—The bark of the giant sequoia is bright reddish brown, whereas that of the redwood is a dull chocolate brown.

Discovery and Naming of the Sequoias

THE FIRST of the two species of *Sequoia* to be seen by the white man was the redwood. The Spanish padres of Portola's Expedition probably first saw the redwoods in 1769 during their travels of exploration and colonization along the coast of what is now California. They called the trees "Palo Colorado," meaning red trees or redwood because of the bright red color of the heartwood.

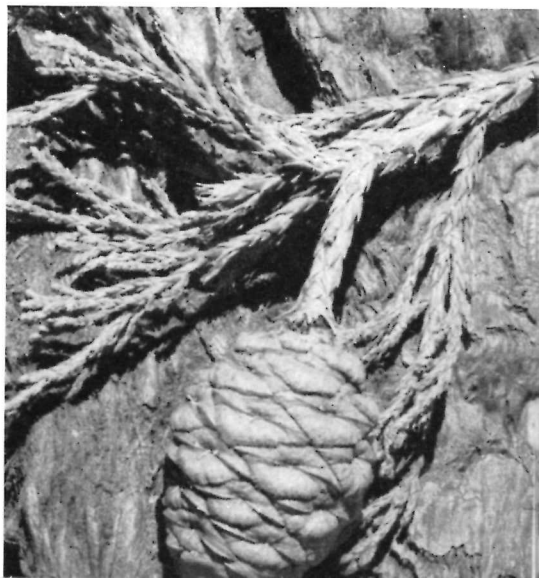
The discovery that the redwood was a new botanical species was made by Archibald Menzies, botanist with the Vancouver Expedition in 1794. It was not until 1823, however, that A. B. Lambert, an English botanist, first gave it a scientific name by publishing a description that placed the tree in the same genus as bald cypress, *Taxodium*. Since he thought that it closely resembled that species, he called the new tree *Taxodium sempervirens*.

Steven Endlicher, a German botanist, decided that specimens he had studied represented an entirely new genus and in 1847 renamed it *Sequoia* but retained the species name of *sempervirens*.

The giant sequoia was not discovered until at least 64 years after the redwood. There is some disagreement among historians as to who should receive credit for the discovery, but the most authentic evidence indicates that the Joseph R. Walker exploration party saw the giant sequoias in 1833 in either the Merced or the Tuolumne Grove of Yosemite National Park.

FIGURE 4.—Foliage and cones of the redwood, *Sequoia sempervirens*. (Approximately two-thirds of natural size.)

FIGURE 5.—Foliage and cone of the giant sequoia, *Sequoia gigantea*. (Approximately two-thirds of natural size.)



The discovery was not publicized at first except in the journal of the expedition, which was printed in 1839 at Clearfield, Pa. In 1852, when A. T. Dowd reported on his observations of the trees in what is now the Calaveras Grove, many fantastic stories quickly spread of the apparently impossible bulk of the trees. They were immediately called "Mammoth Trees" or "Big Trees" because of their immense size. All early tales of the great size of the trees were considered as exaggerations, and whenever scores of feet were discussed the listener thought that inches were meant.

By 1870 most of the larger giant sequoia groves were known, but as late as 1900 an official Government report [2] listed only 11 groves: North, Calaveras, Stanislaus, Tuolumne, Merced, Mariposa, Fresno, Dinkey, Kings-Kaweah (grouped because of lack of information), North Fork of the Tule River (also grouped for lack of information), and South Fork of the Tule River. As late as 1933 a small grove was discovered, or at least first reported.

Specimens of the Sierra Nevada species of sequoia reached England in 1853. John Lindley, a botanist, created a new genus and called it *Wellingtonia*, in honor of the Duke of Wellington who had died the previous year, and gave the species the name of *gigantea* because of the tree's size. In 1854, J. Decaisne, the French botanist, recognized that the new species belonged to the same genus as the redwood and renamed the tree *Sequoia gigantea*.

The tree has been popularly known as Big Tree, sequoia, Sierra redwood, and giant sequoia. The last name is considered most descriptive and has recently been accepted by the Federal Government for official use.

There is some question regarding the origin of Endlicher's name "Sequoia." The generally accepted belief is that he named the tree in honor of the Cherokee Indian Sequoyah (using the Latinized spelling of the name). Endlicher was a linguistic student as well as a botanist and probably was aware that this uneducated, non-English-speaking Indian had developed, in 1821, an alphabet of *86 symbols* representing each sound in the language of his tribe. This alphabet was so simple that anyone in the tribe could quickly learn to read and write, and it is considered one of the cultural masterpieces of modern times. Sequoyah was elected by the Cherokee Council in 1828 as their representative in Washington, where he became a highly respected citizen. The State of Oklahoma has recognized him as one of its leading citizens by placing his statue in Statuary Hall in the National Capitol. It is indeed fitting that this noblest of trees, with its massive red trunk, should honor one of our original Americans.

---

[2] United States Department of Agriculture. Division of Forestry. A short account of the big trees of California. 1900. (Bulletin No. 28.)

Anderson Photo.

FIGURE 6.—The famous Wawona Tree, Mariposa Grove, Yosemite National Park. Pictured in schoolbooks for three generations, this tree was cut through in 1881 for the passage of horse-drawn stagecoaches.

Distribution of the Giant Sequoias

THE GIANT SEQUOIA grows only on the western slopes of the Sierra Nevada in central California, at elevations of 4,000 to 8,000 feet, in a narrow belt for a distance north and south of about 250 miles. The most northerly grove of six standing trees is on the Middle Fork of the American River in Placer County, and the most southerly is on Deer Creek in Tulare County. The trees do not grow in a continuous belt but occur in more or less scattered groves, approximately 63 in number, which contain from as few as six up to many thousands of individual trees. The northern groves are relatively small and widely separated, but south of the Kings River the groves approach forest dimensions, are more closely spaced, and occasionally are almost connected by scattered individual trees.

The giant sequoias always grow in association with other trees, except in a few groups where the density of the sequoias prevents their lesser associates from entering the area. In most of the groves the forest is composed of white fir, sugar pine, ponderosa pine, incense cedar, and Douglas-fir, with the giant sequoias scattered as individuals or groups throughout the area. The forest floor is covered with lupines, dogwood, ceanothus, chinquapin, azalea, alder, and willow. Many beautiful grassy meadows covered with a multitude of ever-changing flowers are found within the groves.

Many of the giant sequoias are far from the beaten path in rugged mountain country, still almost as little known as they were when first discovered by the white man, so that the visitor has somewhat the exhilaration of an explorer discovering a new form of life when he comes upon them. In all the groves—even those most heavily visited—one has a deep feeling of peace and reverence, as within a cathedral.

The giant sequoia is among the most limited in range and number of individuals of any of the major tree species. A complete count of all of the larger giant sequoias has not been made, but the trees of many groves have been measured and plotted on maps. Estimates based upon these counts, however, indicate that there are probably fewer than 20,000 giant sequoias in the world more than 10 feet in diameter, although there are, of course, many times this number of smaller specimens. The total area occupied by the giant sequoia groves probably does not exceed 15,000 acres.

Reproduction does not occur naturally to any great extent outside the limits of the groves and is relatively scarce within many of them. In almost no grove, however, is it entirely absent, and well-scattered trees of all ages, from seedlings to venerable giants, may usually be found. The species is apparently in no danger of early decline in numbers or area from any known natural causes.

FIGURE 7.—Beautiful grassy meadows with a multitude of ever-changing flowers are found within the groves. Round Meadow, Sequoia National Park.

FIGURE 8.—General Grant Tree, General Grant Grove, Kings Canyon National Park.

Size of the Giant Sequoia

THE GIANT SEQUOIA stands supreme in size among the members of the plant world. No other species even closely competes with the vast volume of wood in the trunks of some of the larger sequoias which rise as immense cylinders with very gradual taper for almost 300 feet into the sky.

This species, however, is exceeded in height by at least three others. The redwood, which is the tallest tree in the world, reaches a height of 364 feet. The Douglas-fir of the Pacific Northwest and the mountain gum of Australia reach maximum heights of 324 and 326 feet, respectively. The giant sequoia is probably fourth in height at about 300 feet, but has close competition from two other American species—the Sitka spruce and western hemlock—which also approach the same height. None of these other tall trees, however, exceeds 20 feet in diameter 4½ feet above the ground.

In diameter and circumference the giant sequoia is probably exceeded by only a single tree. A tule cypress, far exceeding in size any other of that species, near Santa Maria del Tule, Oaxaca, Mexico, has a diameter of 36.1 feet and a circumference of 113 feet. This tree, however, is only 130 feet tall.

The vast size of the sequoias is difficult to comprehend fully. It is so out of proportion to commonly recognized measurements of trees or other familiar objects that figures regarding size do not register a clear picture of its vastness. One of the best illustrations known to the writer is that furnished by a single branch on the General Sherman Tree in Sequoia National Park. This branch is 6.8 feet in diameter as it turns upward from the trunk 130 feet from the ground and is 150 feet in length. Thus, it is larger than the largest specimens of many more familiar tree species, yet, in itself, is an inconspicuous part of the tree.

TABLE 1.—*Size of the largest giant sequoias* [1]

Name of tree	Location	Height to top of trunk	Perimeter of base on slope	Mean diameter— Restored base	At 60 feet	At 120 feet	Height of first large limb	Diameter of first large limb	Volume, exclusive of limbs and loss by burns
		Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Cu. Ft.*
General Sherman.	Giant Forest, Sequoia National Park.	272.4	101.6	30.7	17.5	17.0	129.9	6.8	49,600
General Grant	Grant Grove, Kings Canyon National Park.	267.4	107.6	33.3	16.3	15.0	129.8	3.2	43,038
Boole	Converse Forest, Sequoia National Forest.	268.8	112.0	33.2	15.3	13.9	126.0	-------	39,974
Hart	Redwood Canyon, Kings Canyon National Park.	277.9	73.8	26.5	14.5	12.9	-------	-------	32,607
Grizzly Giant	Mariposa Grove, Yosemite National Park.	209.0	96.5	27.6	15.8	13.1	95.4	6.0	30,300

[1] Figures were obtained by a group of well-qualified engineers and involved several hundred individual measurements and computations on each tree. Surveyors' transits were used and all measurements checked

TABLE 2.—*Size of other large giant sequoias*

Name of tree	Location	Base diameter	Height
		Feet	*Feet*
Lincoln	Giant Forest, Sequoia National Park.	31	259
President	do	29	250
McKinley	do	28	291
California	Grant Grove, Kings Canyon National Park.	30	260
Wawona (Tunnel Tree)	Mariposa Grove, Yosemite National Park.	27.5	231

TABLE 3.—*Size of other large trees*

Tree species	Location	Base diameter	Height
		Feet	*Feet*
Redwood—Founders Tree (tallest tree in the world).	Humboldt Redwood State Park, Dyerville, Calif.	15.1	364
Mountain gum (*Eucalyptus regnans*)	Mount Baw Baw, near Melbourne, Australia.	15.0	326
Douglas-fir	Near Ryderwood, Wash	12.0	324

TABLE 3.—*Size of other large trees*—Continued

Tree species	Location	Base diameter	Height
		Feet	*Feet*
Tule cypress	Santa Maria del Tule, Oaxaca, Mexico.	36. 1	130
Baobab	Christmas Island, near Singapore	30. 0	140
Kauri pine	New Zealand	24. 0	160
Jaquitiba	Brazil	23. 0	150

Age of the Giant Sequoias

A CONSIDERABLE VOLUME of fact and fiction has been printed and many conflicting claims have been made regarding the age of sequoias as well as of other species of trees. Such stories and claims have created considerable confusion.

The age of a large woody tree can be determined accurately only by an actual count of the annual growth rings on a cross section of the stump or butt log after the tree is cut down. All trees, except the group of monocotyledons to which the palm belongs, customarily produce a narrow layer of new wood just under the bark each year. There is a slight difference in the appearance of the wood cells produced in the spring and those produced in the summer. In some species this variation is more evident than in others, but it usually provides a visible series of concentric annual rings that may be counted. An estimate of the growth rate may be secured by using an increment borer to obtain a core showing the annual rings. It is not practical, however, to remove a core more than 2 feet deep in most trees, so that accurate information concerning only the more recent growth may be obtained.

All trees grow faster during their youth than later. For example, during the first 75 years in the life of a giant sequoia it may increase in diameter at an average rate of an inch every 3 to 5 years, but in some veterans it may require more than 20 years to produce a diameter increase of an inch. It is impossible to say with any appreciable degree of accuracy just how old a large standing and living tree may be.

The most accurate data for estimating the age of standing trees are obtained from fallen or cut trees of comparable size which grew under similar conditions and whose growth rings have been counted. Such counts made on a large number of sequoias of various sizes reveal that there may be a wide variation in the age of trees of approximately the same size. For example, ring counts made on two giant sequoias about 15 feet in diameter above the butt swell revealed that one was 2,410 years old and that the other was a mere youth of only 1,740 years.

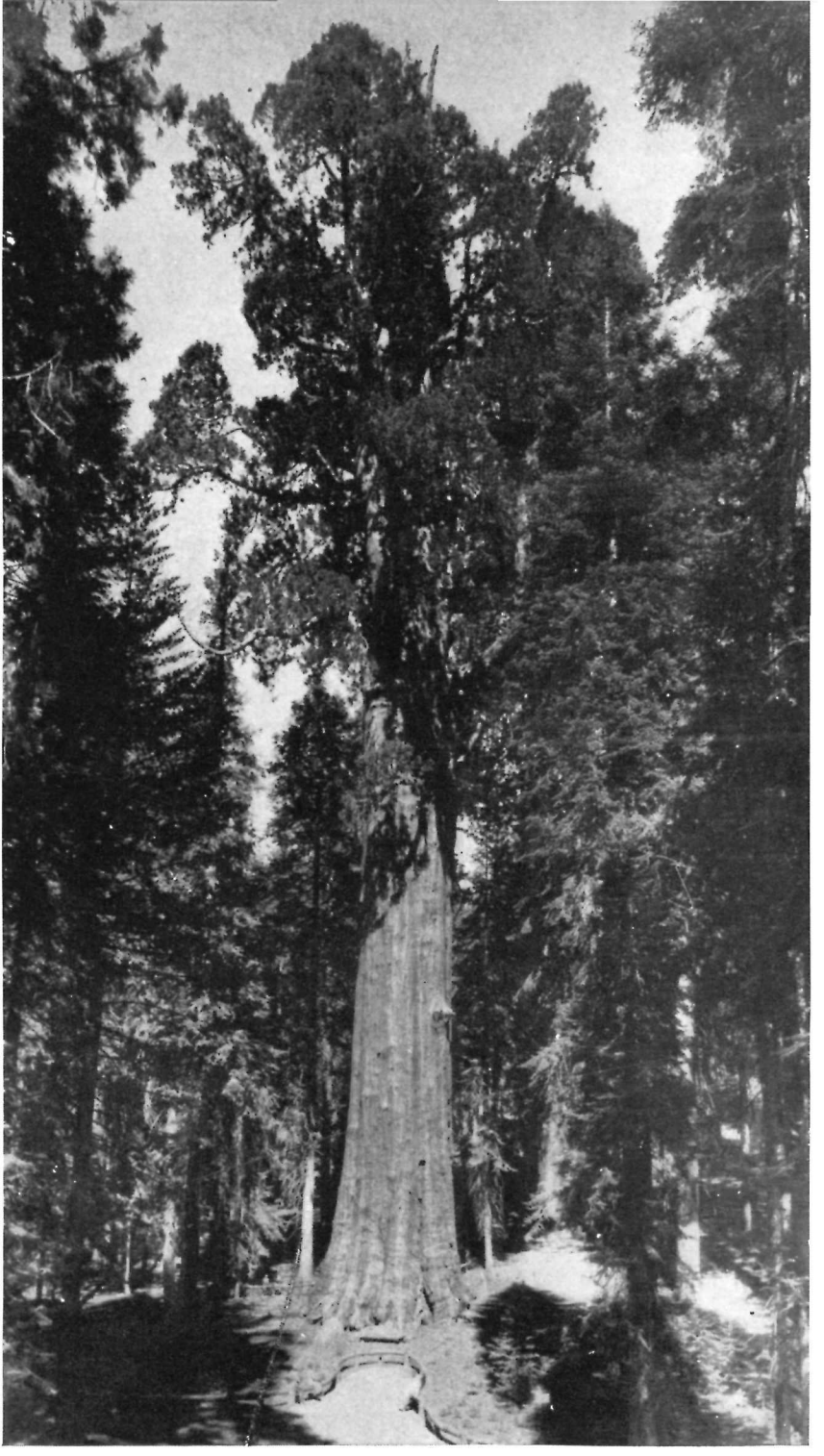


FIGURE 9.—General Sherman Tree, Giant Forest, Sequoia National Park. *Mains Photo.*

Claims of great age have been presented for many species of trees. The baobab of Africa has been estimated to reach an age of perhaps 4,000 years, but to date no authentic ring count has been presented. The banyan of India has an estimated age of 3,000 years, which is fairly well authenticated by historical data. The tule cypress of Oaxaca, Mexico, has been variously estimated to be from 2,000 to 5,000 years old, with 3,000 the estimate of the most expert investigator. Claims of age of living trees up to 12,000 years have been made for several species, including the Macrozamia of Australia which is a cycad and does not produce annual rings. The age of palms, cycads, and other monocotyledons is estimated by counting the number of persistent leaf bases on the trunk and dividing by the number of leaves probably produced each year. This, of course, may be variable and the result inaccurate. It is significant to note that in practically every case where careful study and comparisons of very large trees have been made by scientists age estimates have been materially reduced from the claims made by enthusiastic boosters, in some cases to less than 1,000 years.

Since actual ring counts on many fallen and cut sequoias show that the age of this species frequently exceeds 3,000 years, and since one was proved to be 3,210 years old, some of the larger trees may exceed 3,500 years in age. On the basis of present verified evidence, the giant sequoia is the oldest living thing on earth.

Enemies of the Giant Sequoia

BECAUSE of the large tannin content of its wood, the giant sequoia is practically immune to fatal attack by either fungous diseases or insects, although both attack the tree. The short longitudinal galleries that may be seen beneath the bark on felled or dying sequoias are due to the work of the sequoia bark beetle, *Phloeosinus rubicundulus* Sw. The insect known as the sequoia scale, *Aonidia shastae*, has been known to attack and discolor giant sequoia reproduction foliage, although no fatal attacks have been observed.

The only real threats to the life of sequoias are fire, wind, undermining by water erosion, and man's destructive acts.

Although fire is deadly to young sequoias, older trees are less susceptible to total destruction; in fact, few very large trees are known to have been killed by a single fire, even those that must have burned slowly for months. The effects of past fires are to be seen everywhere in the groves. Many of the large visible scars must have been produced centuries ago, since the nearby large but much younger pines and firs often do not show fire scars, and therefore could not have been standing at the time of the fire. Most of the giant sequoias more than 10 feet in diameter exhibit fire scars which vary in size from small basal burns to vast areas of trunk and top. There

are several trees in which the entire heart has been burned out and within which one can stand and look up through the shell, as in a giant chimney, and view the sky; yet the trees continue to support a few living branches. Other giant sequoias have but a small section of the trunk alive, all the rest having been burned away from base to top. Most of the larger scars are at the base and are frequently found on opposing faces of two trees standing close together where reflected heat from one to the other was able to keep the temperature above the kindling point and sustain the fire. The same factors account for the continuation of fire in the heart of a tree.

No other species of the plant kingdom is able to survive the intense heat of long-continued fires as does the giant sequoia. Its phenomenal resistance to fire may be attributed to the thick, asbestos-like bark, which does not burn readily even under intense heat. A single fire seldom enters the trunk unless there is already an opening through the bark. However, the first fire may kill the cambium (the living, growing tissue immediately beneath the outer bark) as a result of sustained heat generated in the large accumulations of debris often found at the bases of large trees. Later the bark cracks and falls off, thus exposing the dead sapwood, which is easily ignited by a second fire.

The recuperative power of the giant sequoia is also great. Soon after the bark is burned away the cambium begins to grow around the scarred areas and slowly attempts to close the wounds. With a relatively short life span, the average tree would find difficulty in closing a large wound, but in the case of the sequoia, with centuries in which to effect recovery, the attempt often succeeds.

The sequoias have withstood the ravages of wind and storm for centuries and the few that are known to have fallen during windstorms have done so because of the weakening of one side by fire, erosion, or softening of the ground by a change in moisture condition.

So far as known, lightning is not a usual cause of death to these trees. It is true, however, that many sequoias are struck and that some occasionally are set afire far up in the top and the branches sometimes broken off. One medium-sized tree in the Giant Forest of Sequoia National Park shows the effects of a very severe lightning stroke by its shattered crown and the large cracks that extend far down the trunk—but the tree still lives. Probably the fires of centuries ago, which are still evidenced by the burned trunks, were caused by lightning.

Changes in ground level and soil condition are probably the most common contributing causes of the death of large sequoias. Through the centuries it is inevitable that some change in local physiographic condition would occur. Streams gradually erode away the supporting ground on one side of a tree, weakening the support so that the sequoia may fall across the stream. The dam thus created backs up the water and eventually a

FIGURE 10.—The Grizzly Giant in winter, Mariposa Grove, Yosemite National Park.

marshy meadow is created about the roots of trees upstream from the fallen giant. Through the soaking of the ground some of these trees may be killed, while others may be weakened to such an extent that wind finally topples them.

Strangely enough, some of the large trees fall with a terrific roar on quiet days of late summer or in the winter. The reason for this is not known, but it may be due to internal stresses set up by a great difference in the moisture content of the outer and inner wood at the base of the tree.

Geological Record of the Sequoias

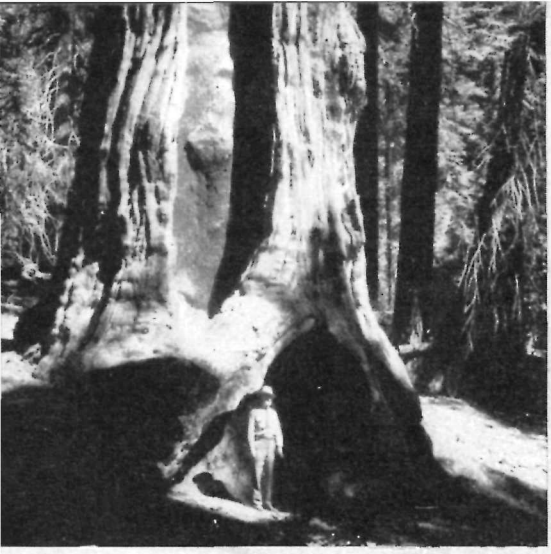
In addition to being one of the most magnificent and long-lived plants, the sequoia is distinguished by having one of the most ancient lineages of any living species. Evidence of the sequoia's antiquity is sustained by fossilized remains found buried in the mud and silts of early geological periods.

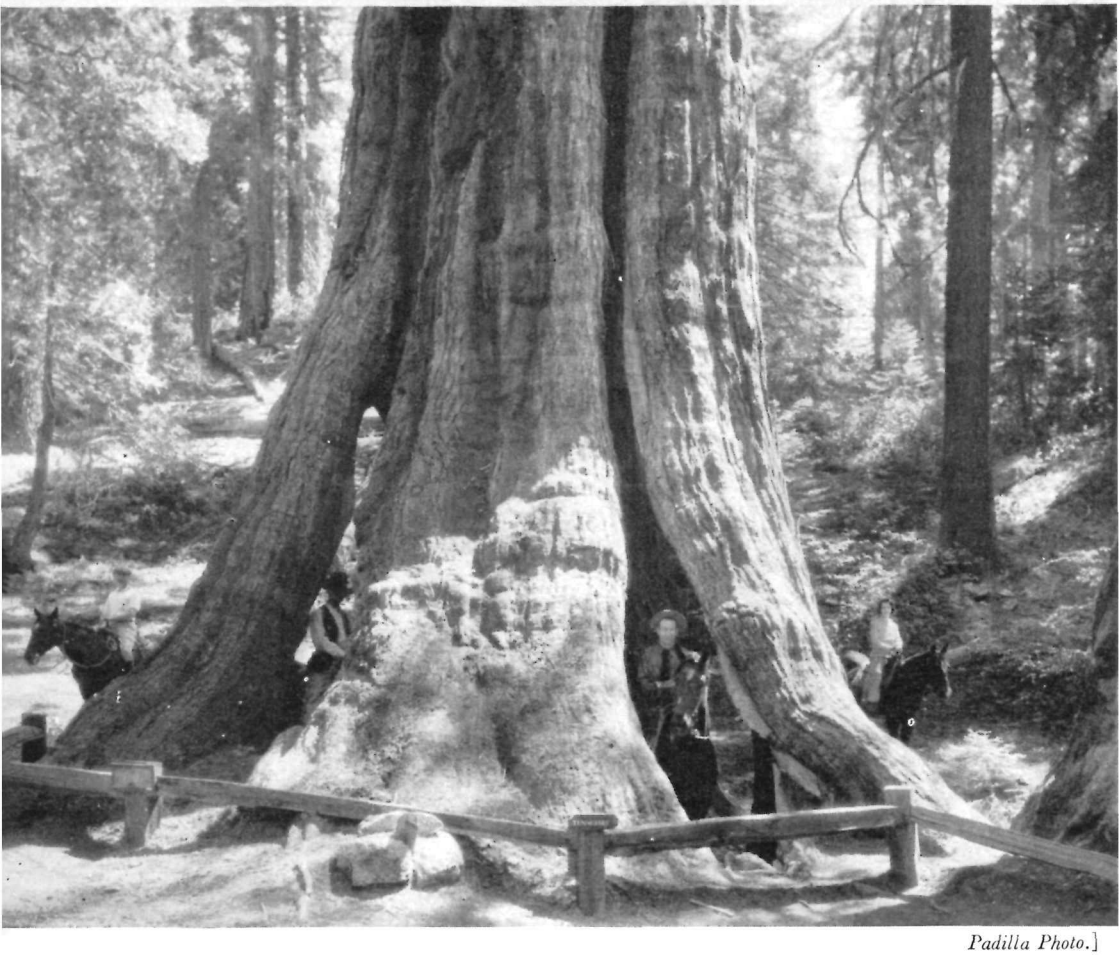
The family probably began to appear with the tree ferns, ginkgo, and other land plants during the period when giant lizards, ichthyosaurs, and dinosaurs roamed the earth millions of years ago. At least a dozen species of sequoia are known to have occurred in many parts of what is now the United States and in central and western Europe. During the period when the oaks, maples, hickories, and other hardwoods of modern time were developing, it is probable that the several species of sequoia were almost as abundant and widespread as the pines of today. At least one of the several species grew practically everywhere in the Northern Hemisphere and their fossilized cones and foliage differ but little from the living specimens of the present day.

The sequoias were particularly well adapted to preservation because of the slow disintegration of cones and foliage and the tannin content of the wood which retarded decay. In Yellowstone National Park fossilized sequoia trunks 6 to 10 feet in diameter and 30 feet high may be seen standing in the midst of several species of modern trees. Sequoia fossil beds have been found in several parts of North America, Europe, and Asia.

It is probable that the rapid decline in distribution of the sequoias and the complete elimination of all but two of its formerly large number of species may be attributed to volcanic eruptions, the creation of large desert areas, and the climatic changes that occurred several hundred thousand years ago. The more recent history of the sequoias is imperfectly known since few fossils of this period have been found. Nature is unable to expand the present natural range of the two remaining species because of the exacting limitations imposed by elevation, climate, and the influence of fire.

None of the present groves of giant sequoias are growing on recently glaciated ground. The glaciers that swept down from the Sierra Nevada in relatively recent times (20,000 years ago) were often less than 5 miles





Padilla Photo.]

FIGURE 11.—Fire scars are everywhere visible in the groves.

distant from many of the present-day groves of sequoias. Glacial action may be one of the major causes for the limited distribution in scattered groves.

Conservation of the Giant Sequoias

MANY of the early discoverers of the sequoia groves envisioned vast returns from logging these giants of the forest. The more accessible groves were promptly appropriated by lumber companies for private gain, and many giant sequoia areas passed into private hands along with the fine forests of pine that surrounded them. Logging began as early as 1862 and reached its peak from 1880 to 1900 when many groves of giant sequoia were cut. However, the vast size of the trees, difficulty of logging in the rough topography, and the immense machinery required to handle the logs partially protected the more inaccessible tracts.

The activities of the loggers stimulated the desire of a few public-spirited individuals to preserve some of the remaining groves of these little-known trees about which such apparently exaggerated reports had been made, but general lack of knowledge concerning their true size, extent, and characteristics delayed action for years.

One of the early forest conservation acts of the Congress of the United States was the passage in 1864 of an act called the "Yosemite and Big Tree Grant," which set aside 40 square miles of the Public Domain, embracing Yosemite Valley and the Mariposa Grove of sequoias "to be held as a park inalienable for all time." This area was administered by the State of California until 1906 when it was receded to the United States as a part of Yosemite National Park.

As a result of public appeals and the recommendations of the General Land Office of the United States Department of the Interior, bills were introduced in Congress in 1881 to set aside, either as a park or forest preserve, the whole western slope of the Sierra Nevada from Yosemite to the Kern River, which embraced most of the giant sequoia areas. These bills failed of passage since the opposition felt that the territory was too extensive. Later legislation, however, resulted in the creation in 1890 of the Sequoia, Yosemite, and General Grant National Parks (second, third, and fourth parks of the national park system) to preserve forever the forests of sequoias included within their boundaries. Governmental protection was placed over many more sequoias in 1893 when the Sierra Forest Preserve, at that time under the jurisdiction of the United States Department of the Interior, was set aside.

Other important sequoia groves have been preserved from private exploitation in various ways; some by outright purchase by public-spirited citizens and conservation organizations; some by direct governmental ac-

quisition; and others by a combination of these two methods in which private contributions were matched by governmental funds. The most recent acquisition, authorized by President Roosevelt in 1938, is the magnificent forest in Redwood Canyon. This forest was added to Kings Canyon National Park in 1940, thus saving for posterity one of the finest endangered groves that remained in private ownership and perhaps the best example of an all-aged sequoia stand.

A survey of the present ownership of the giant sequoia groves indicates that approximately 92 percent of the larger trees are protected by public agencies. From present knowledge of these trees the custodianship of the estimated 20,000 trees more than 10 feet in diameter is divided about as follows:

Type of ownership	*Percent*
Federal:	
National parks	68
National forests	21
Office of Indian Affairs	1
State and county parks	2
Private ownership	8

The National Park Service has devoted much thought and planning to the protection of the groves and of the important individual large trees entrusted to its care. Since fire is one of the greatest threats to the life of trees, intensive forest fire protection provisions have been made for all sequoia groves in public ownership. Great care is exercised in the selection of routes for roads, sites for structures, camps, etc., in order to avoid injury to these giant trees. Because the roots of the sequoia are all very close to the surface, it is necessary to prevent excessive trampling about the trunks. This is the reason for the barriers surrounding the more popular trees which are visited annually by thousands of persons. Public cooperation in the protection of the giant sequoias is essential.

Artificial Regeneration of the Giant Sequoia

THE GIANT SEQUOIA is being grown successfully from seed in many places outside its natural range; indeed, several trees more than 50 years of age and showing rapid growth are to be found in the warmer parts of the United States and in many places in southern and central Europe. This indicates that the species is able to adapt itself to a rather wide range of climatic conditions.

It is relatively easy to raise seedlings of the giant sequoia, although the fertility of the seed is low, being only about 10 percent. The seed should

be sown about one-fourth inch deep in well-drained but moist mineral soil to which a little wood ash has been added. Although germination requires several weeks and seedlings develop slowly during the first year, growth is rapid thereafter under good conditions.

The requirements for successful growth of the giant sequoia outside its natural range appear to be moderate winter temperatures and relatively low summer humidities. In its normal habitat temperatures range from a minimum of about 10° F. in winter to a maximum of 85° F. in summer. The annual precipitation in the groves is about 25 to 30 inches, and winter snows accumulate to depths of 12 feet. Summer rains are rare, however, and less than 1 inch falls between June and September. The sequoias are only found in places where ample underground moisture is available in summer.

FIGURE 12.—The recuperative power of the giant sequoia is great. Judge Walter Fry, first civilian superintendent of Sequoia National Park, standing beside a sequoia stub that has nearly completely covered itself with bark after 36 years of growth.

Attempts to grow these trees in Northern States and other cold or wet climates have generally failed. Several attempts have been made to grow the species in the Arnold Arboretum of Harvard University in Boston, Mass., where the trees grew slowly to heights of 3 to 6 feet, but died during the first severe winter. One of the longest-lived giant sequoias in the Northeast was located in Aurora, N. Y., on the shore of Lake Cayuga. This tree was more than 70 feet tall and 20 inches in diameter and was supposed to have been 70 years old. It was killed, however, by the severe winter of 1933–34. In Washington, D. C., several attempts have been made to grow giant sequoias but, perhaps because of the high summer humidity, they have invariably weakened and died.

A notable exception to the general rule of failure in the Eastern United States is the relatively large *Sequoia gigantea* growing on the grounds of the Tyler Arboretum near Lima, Pa. This specimen, when examined in November 1941, was 25½ inches in diameter at breast height and was estimated to be approximately 52 feet in height.

Many fine specimens, some at least 50 years old, are to be found in arboretums and city parks in England and southern Europe.

FIGURE 13.—The Stricken Tree, Giant Forest, Sequoia National Park. Lightning broke the entire top out of this tree in 1925, but the tree still lives.

Conclusion

IT IS SINCERELY HOPED that this brief account of the giant sequoia will be of assistance to those who contemplate a visit to the groves, to those whose pilgrimage has become a reality, and to those who have gained acquaintance with these forest monarchs. No bulletin of this limited scope could possibly do full justice to the unique story of these most unusual trees, and all who are interested are urged to consult the more pretentious publications on this interesting subject.

The wonder of these trees, their size, majesty, and mystery deepen with time and study. Personal acquaintance with the giant sequoias in their cathedral groves on the slopes of the Sierra Nevada cannot but produce cherished memories of a worth-while experience.

Brief Description and Location of Giant Sequoia Groves

[Numbers refer to Distribution Map on the Inside Back Cover]

1. *North* (American River) *Grove:* Consists of 6 standing and 2 prostrate trees from 2 to 12 feet in diameter. No reproduction. In Placer County at 5,100 feet elevation, on a small tributary of the Middle Fork of the American River. Inaccessible.
2. *Calaveras Grove:* About 50 acres of sequoias with more than 150 trees, of which at least 85 are 10 feet or more in diameter. One of the best known groves and the first to be publicized following its discovery in 1852. In Calaveras Big Trees State Park, 54 miles south of the North Grove, on a tributary of the North Fork of the Stanislaus River at 4,700 feet elevation. On a State highway.
3. *Stanislaus Grove:* A large, fine, privately owned grove of about 1,000 acres containing 947 trees, of which at least half are 10 feet or more in diameter. Includes one of the largest trees—the Agassiz Tree—which is 30 feet in diameter and 250 feet tall. Located 6 miles south of Calaveras Grove and on both sides of the North Fork of the Stanislaus River. Accessible only by trail.

YOSEMITE NATIONAL PARK

4. *Tuolumne Grove:* A small grove of 25 fine specimens and also the Dead Giant, 29½ feet in diameter. Covers about 20 acres. The first giant sequoias viewed by white man, in 1833, were probably in this grove or the nearby Merced Grove. Located near Crane Flat on the Big Oak Flat Road.
5. *Merced Grove:* Contains 20 large trees. Located 4 miles south of Tuolumne Grove.
6. *Mariposa Grove:* One of the most famous groves; contains more than 200 trees 10 feet or more in diameter and thousands of younger trees. Includes the Grizzly Giant, also the Wawona Tree through which a tunnel was cut in 1881 for the passage of horse-drawn stage coaches. Located in the southwest corner of the park, 35 miles by highway from Yosemite Valley.

SIERRA NATIONAL FOREST

7. *Fresno* (Nelder) *Grove:* Now covers about 200 acres. Partly cut in the 1880's and later burned, but still contains many large trees and good reproduction. About 5 miles south of the Mariposa Grove.
8. *McKinley* (Dinkey Creek) *Grove:* A fine grove covering about 50 acres and containing 170 large trees but little reproduction. On Dinkey Creek, a tributary of the North Fork of Kings River, 38 miles southeast of the Fresno Grove.

SEQUOIA NATIONAL FOREST

9. *Boole Tree Grove:* 10. *Converse Basin Forest:* 11. *Indian Basin:* Remnants of a once fine forest (probably the most extensive) which covered about 6,000 acres but was almost completely cut over between 1862 and 1900 and later burned. The Boole Tree, one of the largest trees in the world, was left standing on the slopes of Converse Mountain. Some reproduction in spots. Located on Converse, Mill, and Indian Creeks, south tributaries of the Kings River.

12 to 16. *Kings River Groves:* A group of relatively small groves, mostly inaccessible, located south of the South Fork of the Kings River. Partly in private ownership and accessible only by trail.

KINGS CANYON NATIONAL PARK

17. *General Grant Grove:* A magnificent grove covering 140 acres, with many fine and very large trees, including the General Grant, General Lee, California, and other famous trees. This grove was preserved in the former General Grant National Park from 1890 to 1940 when it was included in the larger Kings Canyon National Park. Readily accessible by highway
18. *Big Stump Grove:* This entire grove was cut over but now has very dense reproduction in spots. Contains the Adam Stump, a remnant of one of the largest trees ever cut. Partly included in Kings Canyon National Park which was established by act of Congress of March 4, 1940.
19. *Redwood Canyon* (Redwood Mountain) *Forest:* Perhaps the best example of an all-aged stand of giant sequoias. Covers more than 2,500 acres and contains thousands of these trees. Purchased in 1940 by the Federal Government from private owners for inclusion in Kings Canyon National Park. On Redwood Creek, a tributary of the North Fork of the Kaweah River. Accessible from the Generals Highway.

SEQUOIA NATIONAL PARK

20. *Lost Grove:* A small but beautiful grove through which the Generals Highway passes. Covers 57 acres and contains 15 trees more than 10 feet in diameter. Near the northwest boundary of the park.

21. *Muir Grove:* One of the most beautiful groves. Covers 450 acres and contains many very large trees. Two separate groves—Pine Ridge and Skagway— are included with this area. In the northwest section of the park on tributaries of the North Fork of the Kaweah River.

22. *Halstead* (Suwanee) *Grove:* A small but attractive grove covering 70 acres west of the Marble Fork of the Kaweah River.

23. *Giant Forest:* The largest and finest forest of giant sequoias in the world, with many portions where other species of trees are practically excluded by the density of the large sequoias. Contains three of the largest known trees—General Sherman, Lincoln, and President—as well as hundreds of other giants. The forest covers 2,387 acres. Located between the Marble and Middle Forks of the Kaweah River, at 5,000 to 7,000 feet elevation, on the Generals Highway.

24. *Redwood Meadow Groves:* Five separate groves covering 400 acres. Several unusual features are found in these groves. There are 5 large, fire-killed standing sequoias (rare in the groves). The only known young sequoias growing upstream very far from the old groves are found here, with 2 trees, 2 and 3 feet in diameter, growing more than half a mile from any others. They are apparently not relics of a former stand in this vicinity. On the headwaters of the Middle Fork of the Kaweah River. Accessible only by trail.

25. *Castle Creek Groves:* Three hundred forty-five acres of widely scattered sequoias on the south slopes of the Middle Fork of the Kaweah River. Accessible only by trail.

26. *Atwell Grove:* A fine forest with many large trees and abundant reproduction. Covers 1,440 acres, including the more or less separate Redwood Creek Grove. Partially logged years ago. The highest elevation at which a giant sequoia is known to grow naturally (8,800 feet) is found here. This tree is 13.7 feet in base diameter and 140 feet tall. On the East Fork of the Kaweah River. Accessible from the Mineral King Road.

27. *East Fork Grove:* Covers 473 acres in the park and 321 acres in the Sequoia National Forest. A fire, years ago, divided this grove into two separate units. On the south side of the East Fork of the Kaweah River. Accessible by trail.

28. *Paradise Ridge, Oriole, and Squirrel Creek Groves:* Cover 230 acres of beautiful forest including several large specimens. Near the west boundary of the park, on the north side of the East Fork of the Kaweah River.

29. *Coffeepot Canyon and Case Mountain Groves:* Outside and west of the park. Cover about 200 acres. Few large trees.

30. *Eden Grove:* Covers 864 acres, with many large trees rather widely scattered. On the south side of the East Fork of the Kaweah River.

31. *Horse Creek Grove:* This grove was first reported in 1933. Covers 90 acres and contains approximately 70 trees more than 10 feet in diameter. On a tributary of the East Fork of the Kaweah River. Inaccessible.

32. *Surprise Grove:* 33. *South Fork Groves:* Three groves covering 665 acres, with many large trees. On the north side of the South Fork of the Kaweah River. Accessible only by trail.

34. *Garfield Grove:* A fine grove covering 1,356 acres, with many large specimens. The lowest elevation at which the giant sequoia is known to grow naturally.(2,900 feet) is located beside the river below this grove. South of, and on tributaries of, the South Fork of the Kaweah River. Accessible only by trail.

35. *Dillonwood Grove:* A large grove containing many large and fine trees. Lower portion partly logged. Covers about 2,000 acres on the headwaters of the North Fork of the Tule River, partly within the park and partly within the Sequoia National Forest at 5,400 to 8,000 feet elevation.
36. *Devils Canyon and Dennison Mountain Groves:* Two small groves covering about 56 acres in the southwestern corner of the park. Inaccessible.

SEQUOIA NATIONAL FOREST

37. *Rancheria Grove:* A small grove on Bear Creek, a tributary of the North Fork of the Tule River.
38. *Mountain Home Forest:* A fine grove containing several hundred specimens and many interesting trees. One, the Hercules Tree, still lives despite the cutting of a large room in its heart many years ago. Another, the Sawed Off Tree, was cut completely through more than 50 years ago but is still standing. The area includes Balch Park, a 160-acre Tulare County Park. On the North Fork of the Middle Fork, Tule River. Accessible by road.
39. *Crystal Springs Grove:* A beautiful grove on Bear Creek below Mountain Home. Contains many interesting trees, including the Wishbone Tree, through which passes the old Mountain Home Road.
40. *Maggie Mountain Grove:* A small and rather inaccessible grove above Mountain Home on the North Fork of the Middle Fork of Tule River.
41. *Hossack Grove:* About 200 widely scattered trees on the divide between the north and south branches of the Middle Fork of Tule River. Inaccessible.
42. *Belknap Grove:* 43. *McIntyre Grove:* 44. *Wheel Meadow Grove:* A group of relatively small groves along the East Fork of the Tule River near Camp Nelson. Some groves accessible by road.
45. *Black Mountain Grove:* A large grove containing more than 500 large trees, on the slopes of Black Mountain between the Middle and South Forks of Tule River. Partly in the Tule River Indian Reservation.
46. *Lloyd Meadow Grove:* More than 100 large trees scattered for a distance of approximately 3 miles along Freeman Creek, a tributary of Kern River.
47. *Red Hill Grove:* A small inaccessible grove at the head of the South Fork of Tule River.
48. *Long Meadow Grove:* A small grove, accessible only by trail. On a tributary of the Kern River.
49. *Powderhorn Grove:* 52. *Starvation Creek Grove:* Small groves. The former is accessible by road, but the latter is rather inaccessible. On the headwaters of Deer Creek.

TULE RIVER INDIAN RESERVATION

50. *Rogers Camp* (Peyrone) *Grove:* 51. *Parker Peak Grove:* Medium-sized groves, containing more than 100 scattered specimens in inaccessible country on the South Fork of Tule River.

SEQUOIA NATIONAL FOREST

53. *Pack Saddle Grove:* A grove of about 300 large but scattered trees, including one more than 22 feet in diameter and 280 feet tall. On South Creek, a tributary of the Kern River. Accessible by trail.
54. *Deer Creek Grove:* The most southerly grove of giant sequoias. Contains 31 large trees and some reproduction. Located about 6 miles north of the southern boundary of Tulare County on Deer Creek above Hot Springs. Accessible by road.

Bibliography

THE GIANT SEQUOIA

ELLSWORTH, R. S. THE GIANT SEQUOIA. Oakland, Calif., J. D. Berger, 1924. 167 p.

FRY, WALTER and WHITE, J. R. BIG TREES. Stanford University, Calif., Stanford University Press, 1930. 114 p.

HUNTINGTON, ELLSWORTH. THE SECRET OF THE BIG TREES. Washington, U. S. Government Printing Office, 1928. 24 p. (Out of print.)

STEWART, GEO. W. BIG TREES OF THE GIANT FOREST. San Francisco, Calif., A. M. Robertson, 1930. 105 p.

UNITED STATES DEPARTMENT OF AGRICULTURE, DIVISION OF FORESTRY. A SHORT ACCOUNT OF THE BIG TREES OF CALIFORNIA. Washington, U. S. Government Printing Office, 1900. (Out of print.)

GEOLOGY OF THE SEQUOIAS

BERRY, E. W. TREE ANCESTORS. Baltimore, Md., Williams and Wilkins Company, 1923. p. 39–55.

CHANEY, R. W. REDWOODS OF THE PAST. Berkeley, Calif., Save-The-Redwoods League, 1934. 8 p.

KNOWLTON, F. H. THE FOSSIL FORESTS OF THE YELLOWSTONE NATIONAL PARK. Washington, U. S. Government Printing Office, 1928. 30 p. (Out of print.)

MERRIAM, J. C. A LIVING LINK IN HISTORY. Berkeley, Calif., Save-The-Redwoods League, 1934. 6 p.

TREE MANUALS REFERRING TO SEQUOIAS

HILL, C. L. FORESTS OF YOSEMITE, SEQUOIA, AND GENERAL GRANT NATIONAL PARKS. Washington, U. S. Government Printing Office, 1928. 40 p.

JEPSON, W. L. THE TREES OF CALIFORNIA. Berkeley, Calif., University of California, Associated Students Store, 1923. p. 13–30.

SARGENT, C. S. MANUAL OF THE TREES OF NORTH AMERICA. New York, Houghton Mifflin Company, 1926. p. 61–63.

SUDWORTH, G. B. FOREST TREES OF THE PACIFIC SLOPE. Washington, U. S. Government Printing Office, 1908. p. 138–147.

SEQUOYAH—THE INDIAN

AWTREY, HUGH R. NEW ECHOTA, BIRTHPLACE OF THE AMERICAN INDIAN PRESS. Washington, U. S. Government Printing Office, 1941. 21 p.

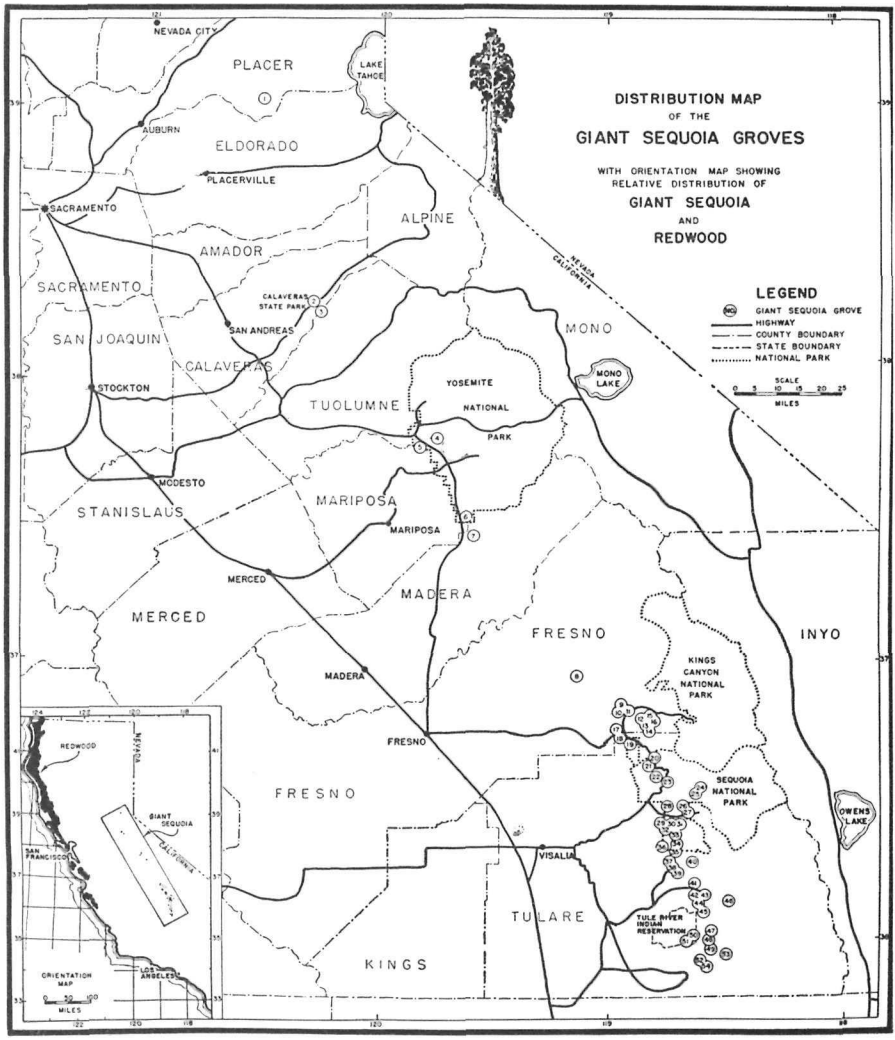

DISTRIBUTION MAP
OF THE
GIANT SEQUOIA GROVES
WITH ORIENTATION MAP SHOWING
RELATIVE DISTRIBUTION OF
GIANT SEQUOIA
AND
REDWOOD
LEGEND
GIANT SEQUOIA GROVE
HIGHWAY
COUNTY BOUNDARY
STATE BOUNDARY
NATIONAL PARK
SCALE
MILES
NEVADA CITY
PLACER
LAKE TAHOE
AUBURN
ELDORADO
PLACERVILLE
SACRAMENTO
ALPINE
AMADOR
SACRAMENTO
CALAVERAS STATE PARK
SAN ANDREAS
SAN JOAQUIN
CALAVERAS
STOCKTON
MONO
MONO LAKE
YOSEMITE
NATIONAL
PARK
TUOLUMNE
MODESTO
STANISLAUS
MARIPOSA
MARIPOSA
MERCED
MADERA
MERCED
FRESNO
INYO
KINGS CANYON NATIONAL PARK
MADERA
FRESNO
SEQUOIA NATIONAL PARK
OWENS LAKE
FRESNO
VISALIA
TULARE
TULE RIVER INDIAN RESERVATION
KINGS
NEVADA
CALIFORNIA
REDWOOD
GIANT SEQUOIA
SAN FRANCISCO
LOS ANGELES
ORIENTATION MAP
MILES

FIGURE 14.