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SILVICAL CHARACTERISTICS OF INCENSE-CEDAR

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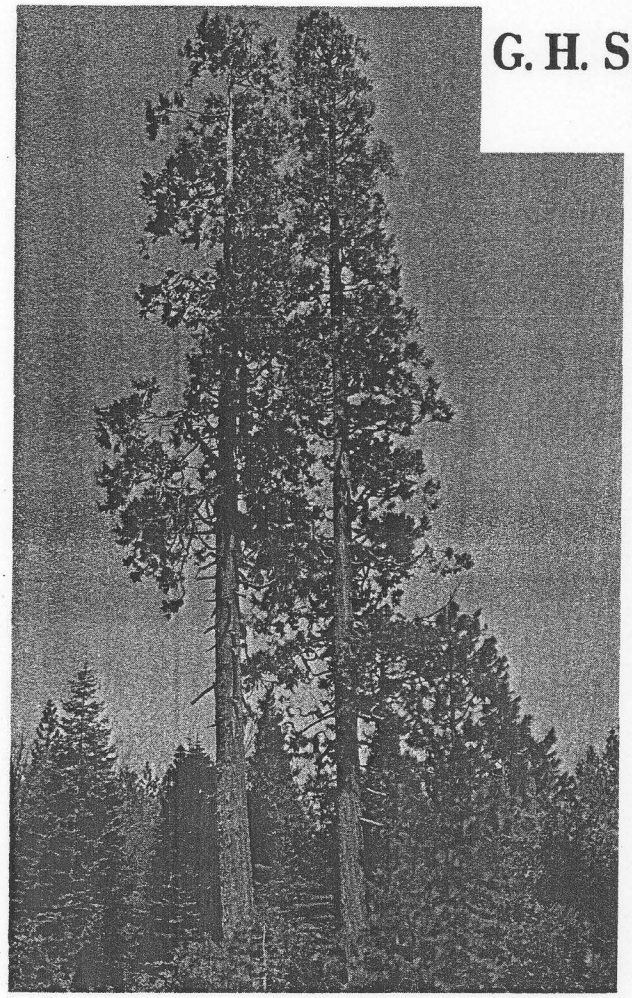

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Preface

The Forest Service is engaged in assembling information on the silvical characteristics of important forest trees of the United States. Much material that is of value in silviculture and research is widely scattered and difficult to locate. This report presents, in preliminary form, the information that has been collected for one species of tree. Similar reports are being prepared for other species at the California Forest and Range Experiment Station and at other forest experiment stations. Readers are encouraged to notify the authors of omissions, errors, or new information affecting the silvical characteristics of the species.

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By Gilbert H. Schubert

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CALIFORNIA FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

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Incense-cedar (Libocedrus decurrens Torr.) is one of the most distinctive trees in the mixed conifer stands of western United States. Its range extends from the southern slope of Mt. Hood in Oregon southward in the mountains to Lower California (26, 32, 35) (fig. 1). It occurs in the Cascade Ranges and Siskiyou Mountains in Oregon, the Coast Ranges and the Sierra Nevada in California, where it extends into western Nevada near Lake Tahoe, and in the Hanson Laguna Range and Sierra de San Pedro Martir in Lower California.

The total net volume of live incense-cedar sawtimber on commercial forest land in the United States was estimated at 13,296 million board-feet in 1952--9,725 million of it in California (7, 37). The rest was in Oregon (3,557 million) and Nevada (12 million). The value of incense-cedar in virgin stands is relatively low because of extensive decay in overmature trees. However, in managed, second-growth stands properly protected from fire and logging injury, incense-cedar should be sound. It will probably increase in commercial importance because of its suitability for soft, easily-worked lumber.

HABITAT CONDITIONS

CLIMATIC

The climate in which incense-cedar grows is characterized by: dry summers, usually less than 1 inch of precipitation per month; annual temperature extremes of below -10°F. to above 100°F.; and annual precipitation of about 20 inches or more, part of which falls as snow. The lower limit of precipitation may be about 15 inches a year, for incense-cedars are found on the east side of the Cascades and in the Warner Mountains in Oregon and California (34). Its lower temperature limit has not been determined but it probably is below -20°F.

EDAPHIC

Incense-cedar grows on many kinds of soils developed from weathering of a wide variety of parent rocks--rhyolite, andesite, diorite, sandstone, shale, basalt, serpentine, and granitic or metamorphic equivalents.

Soils of the western and eastern slopes of the Cascades and in the Siskiyou Mountains in Oregon are quite variable (33).

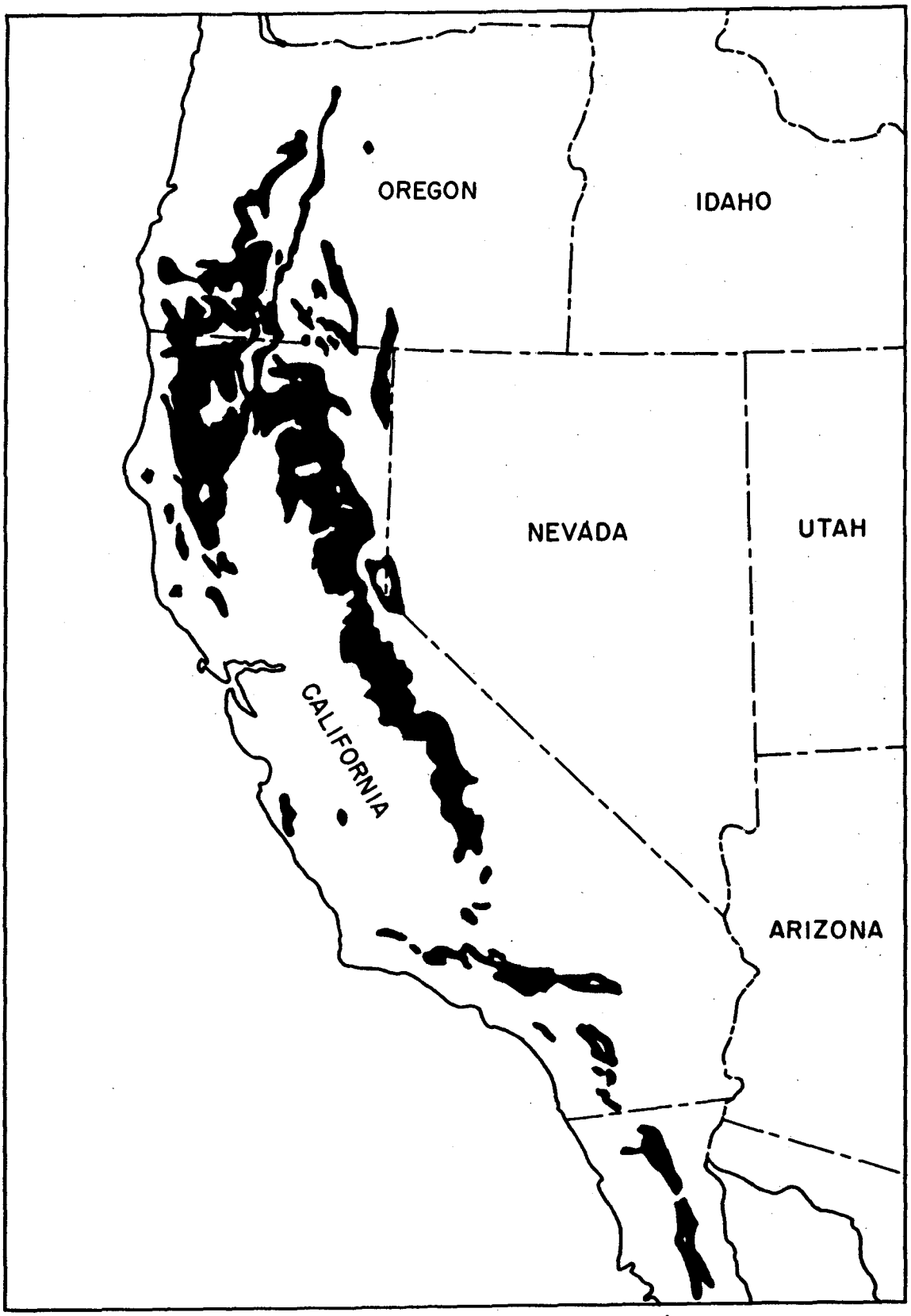

Figure 1.--The natural range of incense-cedar. (From Munns, E. N. 1938. The distribution of important forest trees of the United States. U. S. Dept. Agr. Misc. Pub. 287, 176 pp.)

The acidity varies from nearly neutral to strongly acid. Textures range from very coarse soils to very fine clays. Incense-cedar grows on most of these soils, but the best stands are generally found on three kinds: Deep, well-drained, sandy loam soils developed on granitic rocks and sandstone; deep clay loams developed on basalt and rhyolite; and deep, coarse-textured, well-drained soils developed from pumice.

In California the best stands are found on deep, slightly to moderately acid, sandy loam soils of the Holland series developed from granitic rocks and the Olympic series derived from basalt and andesite. These soils are common in the central Sierra Nevada.

In the southern Cascades, soils developed from pumice also support excellent stands, especially on benches and gentle slopes where the soils are deep, coarse-textured and well-drained.

In the Coast Ranges and Siskiyou Mountains in California, the best stands occur on deep, slightly to moderately acid, silt loams and clay loams derived from sandstone.

Incense-cedar is also found in isolated spots in the Coast Ranges growing on soils developed from serpentine. Though they make better growth than other conifers on these soils, their growth is considerably less than on the other soil types.

PHYSIOGRAPHIC

Incense-cedar is more common on west- than on east-facing mountain slopes. It grows at increasingly higher elevations toward the southern part of its range and on the east slopes, chiefly because of insufficient moisture at the lower altitudes. In the Cascades it generally occurs at 2,000 to 5,000 feet on the west side and 5,000 to 6,600 feet on the east side. In the Coast Ranges it grows between 1,200 to 6,000 feet. In the central Sierra Nevada, where the best stands occur, it is found between 2,000 and 7,000 feet. On San Jacinto Mountain in southern California, it occurs at 3,000 to 8,000 feet; and in the Sierra de San Pedro Martir, above 7,500 feet (18, 24, 25, 26, 32, 35).

BIOTIC

Incense-cedar seldom grows in pure stands except over very small areas. Under the more favorable conditions for its development, it may form up to 50 percent of the stand (8, 17, 35); however, it generally averages less than 30 percent of the total stems in the stand.

Incense-cedar is rarely a major component of any of the six forest cover types of western North America (31) in which it

occurs. It is most abundant in the ponderosa pine-sugar pine-fir type (referred to by some as the mixed-conifer type) and a minor component in the following cover types: Pacific Douglas-fir, Pacific ponderosa pine--Douglas-fir, Pacific ponderosa pine, California black oak, and Jeffrey pine.

In the northern part of its range it is commonly associated with these trees:

Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco)
ponderosa pine (Pinus ponderosa Laws.)
sugar pine (P. lambertiana Dougl.)
western white pine (P. monticola Dougl.)
white fir (Abies concolor (Gord. & Glend.) Lindl.)
grand fir (A. grandis (Dougl.) Lindl.)
western hemlock (Tsuga heterophylla (Raf.) Sarg.)
western redcedar (Thuja plicata Donn)
Port-Orford-cedar (Chamaecyparis lawsoniana (A. Murr.) Parl.)
California black oak (Quercus kelloggii (Newb.)
tanoak (Lithocarpus densiflorus (Hook. & Arn.) Rehd.)
golden chinkapin (Castanopsis chrysophylla (Dougl.) A. DC.)
Pacific madrone (Arbutus menziesii Pursh).

In the central part it is associated with:

ponderosa pine
sugar pine
Jeffrey pine (P. jeffreyi Grev. and Balf.)
lodgepole pine (P. contorta Dougl.)
white fir
California red fir (A. magnifica A. Murr.)
giant sequoia (Sequoia gigantea (Lindl.) Decne.)
California black oak
tanoak
golden chinkapin
Pacific madrone

In the southern part common associates are:

Jeffrey pine
ponderosa pine
sugar pine
Coulter pine (P. coulteri D. Don)
bigcone Douglas-fir (Pseudotsuga macrocarpa (Vasey) Mayr).

Common brush species occurring with incense-cedar are:

greenleaf manzanita (Arctostaphylos patula Greene)
mountain whitethorn (Caenothus cordulatus Kell.)
deerbrush (C. integerrimus H. & A.)
snowbrush (C. velutinus Dougl.)
littleleaf ceanothus (C. parvifolius Trel.)
bearmat (Chamaebatia foliolosa Benth.)
bush chinkapin (Castanopsis sempervirens Dudley)
salal (Gaultheria shallon Pursh.)
coast rhododendron (Rhododendron californicum Hook.)

LIFE HISTORY

SEEDING HABITS

Flowering and Fruiting

Male and female flowers occur separately (on the same tree or occasionally on separate trees) on the ends of short lateral branchlets of the previous year's growth throughout the entire crown (8, 24, 26, 36). The pollen-bearing strobili are about one-fourth inch long in early spring at the time of pollen shedding. The conelets are usually small and not noticeable until sometime later. By late summer the pendant cones are from 3/4 to 1-1/2 inches long. The cones--consisting of two seed-bearing scales with two seeds each--mature in one season and shed their seeds during late summer and fall.

Seed Production

Incense-cedars are prolific seed bearers; however, they do not produce seeds every year (16). During a period of 28 years, incense-cedars on the Stanislaus National Forest (Tuolumne County, California) had 6 cone crops rated as heavy or very heavy, 8 medium-size crops, and 14 rated as none or light. During this period the interval between medium or heavier cone crops varied from 1 to 5 years, with an average of 2 years. The interval between heavy or very heavy crops varied from 3 to 6 years.

The best seed year on record occurred in 1934 when seed trap counts on 5 Stanislaus plots indicated an estimated per acre seedfall of 186,210 seeds (16). The highest on an individual plot was 389,100 seeds per acre.

The percent of sound seed in seed trap collections varied from 14 to 65 percent (16). The highest proportion of sound seed occurred during heavy seed years and the lowest during light seed years.

Little information is available on the seed production of individual incense-cedars. The relationship between seed production and stand volume in immature and mature dominants indicates that relatively small volumes in cutover stands--as little as 500 board feet--will produce approximately 100,000 seeds per acre (16). Full-crowned dominant trees in the immature age class have been observed to bear tremendous quantities of seeds.

Destruction of seed is not particularly serious in incense-cedar. Some losses are caused by sawflies (Augomonoctenus libocedri Rohw.) which attack the cones (19, 23); however, the exact extent of the damage has not been determined. Squirrels, particularly the Douglas squirrel (Tamiasciurus douglasii Backman) at times cut down incense-cedar cones; however, they usually destroy few cones (16). During poor seed years for pines, firs, or brush, rodents eat greater quantities of incense-cedar seeds.

Seed Dissemination

Natural seed dissemination begins in late August at the lowest elevations and in October at the higher levels. Some seeds may fall during the winter months. During a period of hot, dry, windy weather, seeds are released earlier than when the weather is cool, moist, and calm. The percentage of the total seed crop that fell at different observation dates on the Stanislaus National Forest at 6,000 feet elevation was (16):

Year and date:	Percent of seed caught in seed traps	
	All seed	Sound seed
1937		
October 6	11	3
" 27	36	37
November 11	53	60
1940		
October 11	32	54
" 29	34	38
November 13	34	8

Incense-cedar seeds vary in size and weight. The number of seeds per pound averages 15,000 and ranges from 6,400 to 29,000 (36). The seeds have a relatively large wing for their weight. Consequently they are carried great distances by air currents. In still air, the seeds fall at the rate of 5.9 feet per second (30). However, the seed flight patterns under actual forest conditions are unknown.

VEGETATIVE REPRODUCTION

Incense-cedar does not reproduce naturally by sprouting or rooting.

SEEDLING DEVELOPMENT

Establishment

Incense-cedar seeds germinate in the field under a wide variety of conditions. The seeds will germinate in both organic and mineral soil. Although they will also germinate on compact roadbeds and skidroads and on the top of snow, the resulting seedlings seldom get their roots into the soil before the advent of the dry summer season.

Viability tests in the greenhouse indicate that up to 98 percent of the sound seeds can germinate (27, 28). However, germination of seed sown in the field usually varies from 20 to 40 percent (15, 24). Since a moist seedbed is required for germination, field germination will seldom approach the maximum--especially on exposed sites where soil moisture in the upper half-inch of soil is rapidly depleted through evaporation.

In the first stages of development, seedlings may require partial shade. During a period of 18 to 24 years after logging, 10,092 seedlings per acre started on a series of cutover plots on the Stanislaus National Forest (14); 84 percent were incense-cedar. Of the 2,749 seedlings that were alive at the end of the period, 78 percent were incense-cedar. Ground surface conditions and incense-cedar seedling incidence on these plots were:

Ground surface condition:	Seedling incidence (Percent)
Bare ground	1
Brush	51
Litter	41
Logs, rocks, and other debris	7

Seedling mortality is frequently high. Cutworms and drought destroy many seedlings; rodents generally are of minor importance. During a 5-year period, 53 percent of the 1- to 2-month-old incense-cedar seedlings on the Stanislaus plots were destroyed by cutworms (Noctuidae larvae) (12). The seed to seedling ratio on 4 cutover plots varied from 20:1 to 355:1 (16). Drought may cause high mortality of incense-cedar seedlings during the first growing season, but these losses are usually less than those caused by insects (12). Losses from low soil moisture are most noticeable on dry sites and on compacted landings and skid roads.

Early Growth

First-year development of incense-cedar seedlings is usually slow in comparison to that of the associated pines. The primary root grows to a depth of about 12 inches during the first growing season--about half to two-thirds the length of ponderosa or sugar pine of the same age. Lateral roots begin development early in the first season and continue at a greater rate than the taproot. Incense-cedar seedlings may take 3 to 5 years to grow the first 6 inches in height. Pines of the same age are normally 2 to 3 times as tall. After the fifth year the rate of height growth increases, but at no time does it approach that of its associates.

Seasonal Growth

Seasonal height growth of incense-cedar on the Stanislaus Experimental Forest starts earlier than for sugar pine and white fir, but later than for ponderosa or Jeffrey pine (13). The average date growth started at an elevation of 5,200 feet was May 24. Growth was completed in an average of 91 days--a longer period than for any of the associated species.

Seasonal radial growth starts before height growth. At the Stanislaus Experimental Forest the average date of beginning of radial growth was April 15. This was about the same as ponderosa pine, but earlier than sugar pine and white fir. The average period of radial growth was 136 days. Half of the total radial growth was completed in 39 days (13).

SAPLING STAGE TO MATURITY

Growth and Yield

Incense-cedar varies greatly in size in different parts of its range (18, 24, 32, 35). In the coast ranges and in southern California the largest trees are generally from 60 to 80 feet high and 3 to 4 feet in diameter. In the Sierra Nevada, incense-cedars frequently grow to a height of 150 feet with diameters up to 7 feet. The probability exists that considerably taller trees may have occurred or may still be discovered. The largest tree measured had a circumference of 36 feet (1)--about 11.5 feet in diameter. A tree 225 feet tall was recently reported in southern Oregon. At high elevations, especially on dry exposed sites, the trees are small and scrubby.

Incense-cedar is long-lived; large trees often are more than 500 years old (24). The oldest recorded age was 542 years. This tree was only 51 inches d.b.h., therefore larger trees

may be older. It has an extensive, well-developed lateral root system and is quite wind-firm.

Incense-cedar ordinarily makes its most rapid height growth between the 50th and 75th years (24). On good sites--Dunning Sites A-200 and I-175 (10)--height growth continues to be rapid up to 150 years. Beyond 150 years, height growth is very slow.

Basal area growth of incense-cedar is usually slower than that of the associated species (9, 29). On medium or poorer sites it has a lower basal-area growth rate than white fir, Douglas-fir, sugar pine or ponderosa pine. However, on some poorer sites under the most favorable conditions, the basal area growth of incense-cedars up to about 24 inches in diameter may exceed all other species except white fir (9).

Since incense-cedar is seldom found in pure stands, yields are of practical significance only in relation to the entire stand. Although the stand may contain many incense-cedars, particularly in the younger age classes, they rarely make up more than 5 to 10 percent of the stand volume (11).

Average total stand volumes in trees larger than 12 inches d.b.h. range from 20,000 to 90,000 board-feet in the Sierra Nevada. On the Stanislaus Experimental Forest the average gross volume of a cutover plot of 200 acres was 79,100 board-feet per acre; 10,100 board-feet, or 13.4 percent, was incense-cedar. The average volume per incense-cedar over 12 inches was 897 board-feet.

Incense-cedar does not readily shed its lower branches even in dense stands. Many dead branches must be removed if high quality clear lumber is to be produced in rotations of 80 to 120 years.

Reaction to Competition

Incense-cedar is usually rated as tolerant (3). It is more shade tolerant than the associated pines and Douglas-fir and less tolerant than white fir and grand fir. In the seedling stage incense-cedar can endure dense shade, but for full development from sapling stage through maturity it requires more light (24).

Incense-cedar shows good response to release. Much of the extremely slow growth of young reproduction is caused by suppression. When released, these seedlings make rapid height growth; however, since height growth is slower than that of the associated species of comparable age, incense-cedar will always be a secondary species in the final stand (9).

Principal Enemies

Incense-cedar is noted for the durability of its heartwood in timber products. Yet standing overmature trees are rated as the most defective of all associated conifers. The amount of cull has been found to increase with age of the trees and to vary between stands (20, 21). Average cull percents based on gross volume were: 4 to 6 percent for immature dominants, 21 percent for mature dominants, and 68 to 77 percent for overmature dominants.

The most important single destructive agent affecting mature incense-cedar is the pocket dry-rot fungus (Polyporus amarus Hedge.), which causes practically all of the decay in this species (5, 6, 22). In parts of the Sierra Nevada, 75 to 100 percent of the mature trees have dry-rot (22).

The spores of pocket dry-rot must be deposited on an open wound to infest trees because the mycelium is unable to penetrate through the bark into the heartwood (22). The most prevalent port of entry was found to be through fire scars (84 percent). Knots (10 percent) were next in frequency, and injuries caused by lightning and frost (6 percent) were least (5).

In the management of second-growth incense-cedar, the age at which dry-rot causes the greatest losses is of primary importance. Suppressed trees are subject to severe dry-rot infection after they reach the age of 165 years; dominant trees are generally safe up to an age of 210 (5). Since the rotation age for second-growth stands will probably be considerably less than these critical ages, dry-rot should not cause severe cull in future managed stands.

Two other diseases of incense-cedar have been reported. One is incense-cedar leaf rust (Gymnosporangium libocedri (P. Henn) Kern), which commonly kills small sprays of foliage and causes witches-brooms and swellings on the branches (6). Extensive infections of leaf rust retard growth and may kill the tree. The second is incense-cedar mistletoe (Phoradendron libocedri Howell), which commonly causes spindle shaped swellings on the branches and occasionally on the trunk (6, 38). The mistletoe occurs throughout the range of incense-cedar. Severe infections suppress growth, but there is no evidence that it kills large trees.

Many kinds of insects are found on incense-cedar, but relatively few cause serious losses (19). Some of the more damaging ones are: The cedar flatheaded borer (Chrysobothris nixa Horn), which is a common enemy of incense-cedar in the coast region; the western cedar bark beetle (Phloeosinus punctatus Lec.), which is not generally serious but occasionally kills apparently healthy trees; the western cedar borer (Trachykele blondeli Mars.) and the flatheaded borer (T. opulenta Fall), which mine in the sapwood and heartwood of living trees and are very destructive to timber where

sound wood is required; and the amethyst cedar borer (Semanotus amethystinus Lec.), which usually attacks injured or dying trees but which may occasionally kill apparently healthy trees.

Young trees are readily killed by fire. The thick bark of mature trees offers considerable protection from fire, but intense fires indirectly cause a great deal of damage by exposing trunks to infection by the pocket dry-rot fungus.

SPECIAL FEATURES

Incense-cedar and Jeffrey pines are found on serpentine soils, while ponderosa pines are not. Where these three species occur, a stand of incense-cedar and Jeffrey pine can be used as an aid in delineating this soil type.

RACES AND HYBRIDS

There are no known hybrids of incense-cedar. A few horticultural varieties are recognized in Standardized Plant Names (2). The probability exists that search and study would reveal the occurrence of local races. For example, the incense-cedars of southern California are conspicuously narrower-crowned and more spire-like in silhouette than those of the Sierra Nevada.

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