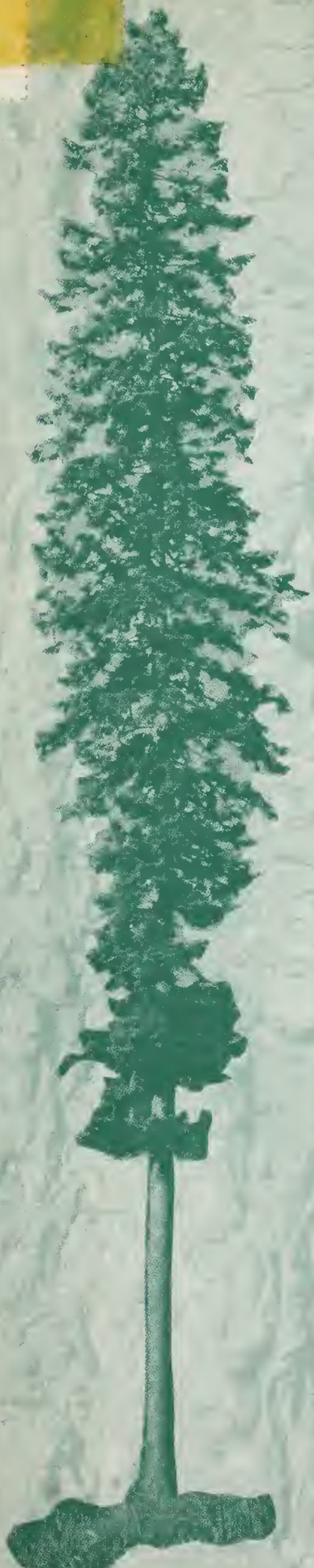
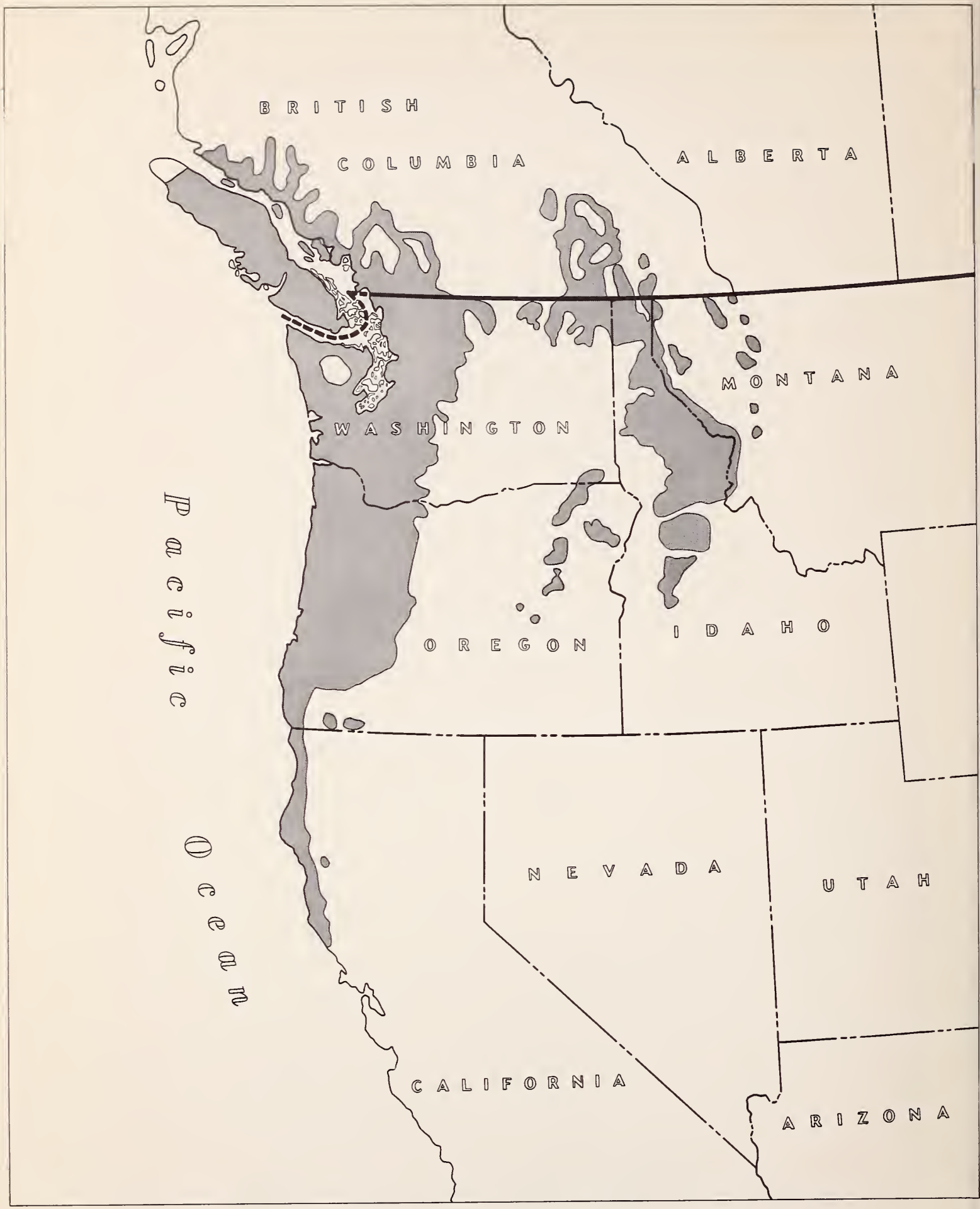


SILVICS of GRAND FIR



Botanical range of grand fir.

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SILVICS OF GRAND FIR

By

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FOREWORD

The SILVICS OF GRAND FIR is the sixth publication in the series of seven silvics manuals being published by the Intermountain Forest and Range Experiment Station as part of a larger project sponsored by the U. S. Forest Service. The other silvics manuals prepared by the Intermountain Station include ponderosa pine, lodgepole pine, western larch, western redcedar, and black cottonwood. Eventually a single publication on the silvics of many important North American tree species will be issued by the U. S. Forest Service.

Information in this publication is based on selected references and unpublished data through 1958. The author will appreciate having any omissions or apparent misinterpretations called to his attention.

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SILVICS OF GRAND FIR

By

Marvin W. Foiles[1/]

Grand fir (Abies grandis) (11)[2/] is one of the two balsam firs found in the northern Rocky Mountain region and one of seven in the Pacific Northwest. Except in the southern part of its range, where it is often confused with white fir (Abies concolor), it is distinguished from other firs in its range by its needles, which are distinctly two-ranked. Grand fir differs anatomically from white fir only by the absence of stomata from the upper surface of grand fir leaves and the presence of stomata on the upper surface of white fir leaves (9). Other common names include balsam fir, lowland fir, lowland white fir, silver fir, yellow fir, and white fir (lumber).

Grand fir grows in the stream bottoms, valleys, and mountain slopes of northwestern United States and southern British Columbia. Its wide geographical distribution is from 51° to 39° N. latitude and from 125° to 114° W. longitude (13). In the Pacific Coast region it grows in southern British Columbia mainly on the lee side of Vancouver Island and the adjacent mainland (15), in rain-protected areas in western Washington and Oregon, and in northwestern California as far south as Sonoma County. The range in the continental interior extends from the Okanagan and Kootenay Lakes in southern British Columbia south through eastern Washington, northern Idaho, western Montana west of the Continental Divide, and northeastern Oregon (18). The best commercial stands of grand fir are in the Nezperce and Clearwater regions of northern Idaho.

HABITAT CONDITIONS

CLIMATIC

Grand fir occurs on a wide variety of sites. Average annual precipitation in its territory ranges from 20 to more than 100 inches in western Washington and Vancouver Island, where grand fir grows on the rain-protected sites and avoids the extreme rainfall belt on the west side of the Coast Range and the Cascades (13, 15). Annual precipitation in the Blue Mountains of eastern Oregon averages 14 to 40 inches (17). In northern Idaho, where the best commercial stands of grand fir are found, average annual precipitation is 20 to 50 inches (4). Most of this precipitation comes during the winter. Generally 15 to 25 percent of the annual precipitation falls during the growing season. On Vancouver Island, where average annual precipitation

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2/ Numbers in parentheses refer to Literature Cited, page 11.

ranges from 27 to 111 inches, summer precipitation throughout most of the range of grand fir is comparatively low; only 2 to 5 inches fall during June, July, and August (15). Average annual snowfall ranges from a few inches on the coast to more than 500 inches in the mountains (4, 13). McMinn (12) reported that in the Abies grandis/Pachistima association of northern Idaho summer soil drought rarely occurred.

Average annual temperatures range from 42° to 50° F.; the average growing season temperature is 57° to 66° F. The frostless season varies, ranging from about 60 to 225 days, and is very irregular from year to year. Frosts may occur in any month in the interior habitat. The average growing season varies from the fairly brief 100 to 140 days in northern Idaho to 185 days on the Olympic Peninsula in western Washington (4, 13).

EDAPHIC

Grand fir grows on soils derived from a variety of parent materials. It seems to grow equally well on soils derived from sandstone, lava-weathered rock, or granite and gneiss. In the Pacific Coast region and in the Willamette Valley of Oregon it occurs most abundantly on deep, rich alluvial soils along streams and valley bottoms and on moist soils provided with seepage (13, 15). In the inland regions it also grows best on the rich mineral soils of the valley bottoms; but it also grows well on shallow, exposed soils of mountain ridges and on pure pumice soils in central and eastern Oregon. Grand fir was rated a near failure in one planting test on heavy clay-loam soils of the western Olympic Peninsula (21).

PHYSIOGRAPHIC

Grand fir grows on Vancouver Island and the adjacent mainland of British Columbia at elevations between sea level and 1,000 feet (15). In the southern interior of British Columbia it occurs only in the moist valleys of such rivers as the Kootenay, Columbia, and Okanagan and their tributaries. In western Washington and Oregon, as in British Columbia, grand fir is predominantly a lowland species. Its sites in western Washington are valleys and stream bottoms having high ground water level (13). Elevations of these sites are usually between 600 and 1,000 feet. At elevations above 1,500 feet grand fir is replaced by Pacific silver fir (Abies amabilis). Grand fir occurs in western Oregon in the lowlands of all the river regions and in the lower west Cascades to an elevation of 3,000 feet (13). In northern California it occurs in the redwood region from near sea level to about 1,000 feet and in the mountains to about 5,000 feet (18).

On the coast and in Canada grand fir is restricted to the stream bottoms and lowlands; but in the interior regions in the United States where grand fir occurs, it grows up to the tops of mountain ridges (13). Consequently, elevations of grand fir sites are higher in the interior than on the coast. In the eastern Cascades of Washington, 3,000 to 4,000 feet constitutes the upper altitude limit while in the eastern Cascades of Oregon grand fir grows at 5,000 feet. In the Inland Empire, including the Blue Mountains of Oregon, it is found as high as 6,000 feet and as low as 1,500 feet, but it is usually

found between 2,000 and 5,000 feet. In the Nezperce region of central Idaho, where grand fir reaches its maximum stand density, it grows well at altitudes of 4,000 to 5,000 feet (13). Some writers believe that the altitudinal limits of its range are set by a combination of air temperature and precipitation (10).

BIOTIC

Grand fir reaches its largest individual tree size in western Washington, Vancouver Island, and the redwood region of California. The maximum proportion of the stand structure, however, is reached in northern Idaho. The only extensive pure stands of grand fir are in the Clearwater and Nezperce regions of Idaho, where it often forms the dominant and climax stand. It forms part of the following habitat types in the Inland Empire as defined by Daubenmire (1): grand fir, western redcedar--western hemlock, western redcedar, and Engelmann spruce--subalpine fir. These associations cover the approximate range of the commercial western white pine type and extend beyond white pine to the south, east, and west in the Nezperce region of Idaho and the Blue Mountains of Oregon.

According to the Society of American Foresters' Forest Cover Types, grand fir occurs in 15 cover types (16). It is a major component of the grand fir--larch--Douglas-fir, western white pine, interior Douglas-fir, western redcedar--western hemlock, and western redcedar types.

Grand fir sometimes occurs in pure stands but is much more common in mixed hardwood and coniferous forests. In the Rocky Mountains of Montana it is associated with Douglas-fir (Pseudotsuga menziesii), western larch (Larix occidentalis), lodgepole pine (Pinus contorta), and ponderosa pine (Pinus ponderosa) (5). Associates in the white pine region of the Inland Empire are western white pine (Pinus monticola), western larch, Douglas-fir, western hemlock (Tsuga heterophylla), western redcedar (Thuja plicata), lodgepole pine, Engelmann spruce (Picea engelmannii), subalpine fir (Abies lasiocarpa), and northern black cottonwood (Populus trichocarpa) (13).

On the Pacific Coast grand fir grows with Sitka spruce (Picea sitchensis) and Pacific silver fir in addition to western redcedar, western hemlock, and Douglas-fir. It is also associated with these coast hardwoods: bigleaf maple (Acer macrophyllum), Oregon ash (Fraxinus latifolia) red alder (Alnus rubra), and northern black cottonwood (Populus trichocarpa) (5). Sprague and Hansen (17) reported grand fir growing with Oregon white oak (Quercus garryana) in the Willamette Valley. Haddock[3/] reported that grand fir grows in association with sugar pine (Pinus lambertiana) and incense-cedar (Libocedrus decurrens) in parts of southwestern Oregon. In California, at the southern limits of the range, it is found with redwood (Sequoia sempervirens), and at higher elevations with Shasta red fir (Abies magnifica var. shastensis), white fir, noble fir (A. procera), subalpine fir, and western white pine (5).

3/ Personal communication from Dr. P. G. Haddock, University of British Columbia, Vancouver, Canada.

Daubenmire (1) lists the following shrubs commonly associated with the Abies grandis/Pachistima climax association in northern Idaho: myrtle pachistima (Pachistima myrsinites), Utah honeysuckle (Lonicera utahensis), big whortleberry (Vaccinium membranaceum), mallow ninebark (Physocarpus malvaceus), Saskatoon serviceberry (Amelanchier alnifolia), snowberry (Symphoricarpos a. laevigatus), birchleaf spiraea (Spiraea betulifolia), and several roses including baldhip rose (Rosa gymnocarpa), and Spalding rose (Rosa spaldingi).

LIFE HISTORY

SEEDING HABITS

Flowering and fruiting.--Flowers are unisexual, the two kinds being borne in small conelike clusters in the early spring on branchlets of the previous season's growth and in different parts of the same tree. Male cones are ovoid or cylindrical and hang singly from the lower side of the youngest twigs of the center to upper half of the crown; the female conelets are globose or ovoid to cylindrical and stand singly and erect on the uppermost part of the crown (18). The cones, mostly yellowish green and occasionally greenish purple, ripen in September of the same year (5, 19).

Extreme frosts may occasionally inhibit normal cone and seed development. Several species of insects feed on the buds, conelets, and seeds of grand fir, sometimes destroying 10 to 25 percent of the year's seed crop (8).

Seed production.--Seed production begins at about 20 years of age and production increases with age (19). Cone production increases with the diameter and vigor of the tree. Eight-year observations of permanent sample plots from 1927 through 1934 show that grand fir was the least abundant seed producer of the species associated with western white pine. Grand fir produced no good crops and only two fair crops while western white pine produced two good crops and three fair crops. During the same 8-year period, western hemlock produced five good crops and two fair crops (4). Other sources place the interval between good seed crops at 2 to 3 years (19).

A good cone crop for grand fir in the Inland Empire is considered to be one that produces more than 40 cones per tree. A fair crop produces 21 to 40 cones per tree. The number of grand fir seeds caught annually in seed traps on two sample plots averaged 17,000 seeds per acre on the Kaniksu National Forest and 23,500 per acre on the Coeur d'Alene National Forest. Eight-year observations of seed traps under a 300-year-old stand on the Priest River Experimental Forest yielded 12,800 grand fir seeds per acre annually (4). The yield of cleaned seed per pound ranges from 12,600 to 44,300 and averages 23,200 (19).

Greater production of grand fir seed is reported from Canada than from the Inland Empire (2). Garman (2) reported the seedfall of a fair cone crop in a season when 12 grand fir trees on one acre bore one good crop, two fair crops, one poor crop, and eight no crop. Gross seedfall from the four producing trees was about 300,000 seeds per acre, 27 percent of which were viable.

Unpublished records[4/] of cone crops on immature trees in British Columbia showed that in the 27-year period 1930 through 1956 there were 9 crop-years, a crop-year being defined as a season in which at least 50 percent of the trees bore a class III crop or better. For the grand fir in this study, class III to class I crops ranged from an average minimum of 200 cones to an average for class I of about 700 cones.

Seed dissemination.--When the cones are ripe the scales fall away and release the large-winged seeds, leaving only the central spike (19). Seed is dispersed by the wind and rodents. Most of the seed is disseminated in the early fall, about 5 percent falling before September 1 and 80 percent falling before the end of October. Seed sufficient to produce adequate reproduction may be distributed up to 400 feet from the parent tree, but the average distance is about 150 to 200 feet. Seed in the duff remains viable through only one overwinter period (4).

VEGETATIVE REPRODUCTION

In nature grand fir reproduction is entirely from seed. There have been no reports of propagation by cuttings or grafting.

SEEDLING DEVELOPMENT

Germination and establishment.--Grand fir seed germinates in the spring following one overwinter period on the ground. In nature, germination is quite variable but is seldom greater than 50 percent because of embryo dormancy, injury to seed during dewinging, insect infestation, and the perishable nature of the seed. Seed is often so heavily infested with insects that an entire crop may be a failure (19).

Results of greenhouse germination tests of grand fir seed are highly variable. Results of three sandflat germination tests in the northern Rockies, averaged below, show that grand fir had the lowest germination percentage among major associates of the western white pine type (4).

Species	Germination percent
Grand fir	12
Western larch	30
Douglas-fir	41
Western white pine	44
Western hemlock	65
Western redcedar	73

4/ Personal communication from E. H. Garman, British Columbia Forest Service, Victoria, British Columbia, Canada.

The Woody-Plant Seed Manual (19) reports germination percentages from various sources ranging from 1 to 98 percent with an average of 28 percent; these percentages were based on 30 tests. The average rate of grand fir germination in those tests was about average for the true firs (19).

True firs	Germination percent
Grand	28
California red	25
Noble	24
Pacific silver	22
Subalpine	38
White	34

In the Inland Empire, germination begins in late April or early May on exposed sites and a month later on protected sites where snow lingers late. It is practically completed by July 1 on exposed sites and by August 15 on protected sites. Germination is best on mineral soil, but on seed-tree cuttings grand fir germinates nearly as well on duff as on any other surface (4).

Studies of seedling survival in the Inland Empire indicate that more than 30 percent of grand fir seedlings die in the first season, and an additional 10 percent die the second season. Losses drop off rapidly after the first 2 years, and seedlings 3 years old are fairly well established. Studies of mortality during the critical first year indicate that early season losses are due principally to biotic agents, especially damping-off fungi. However, fungi-caused mortality is very irregular (4). Later in the season as the soil begins to dry, mortality is due principally to insolation and drought. Insolation is the most important physical agent of mortality on exposed sites. Surface-soil temperatures are less important under shade or on sheltered sites, and under dense shade or on north slopes do not cause death (4). Grand fir is relatively resistant to heat injury: it is equal to western white pine and Douglas-fir and more resistant than western larch, western hemlock, and western redcedar (4). Grand fir seedlings are relatively resistant to drought on areas exposed to full sun because the deep initial root penetration protects them from drying of the surface soil. On heavily shaded, cool areas, drought is the most important physical cause of seedling mortality because initial root penetration is slower and even shallow drying of the surface soil may cause drought mortality despite ample soil moisture at deeper levels (4).

Early growth.--Initial survival and growth of grand fir are favored by a moderate overwood shade (4, 15). Under full sun it is largely subordinate to faster growing intolerant species. Under partial overwood shade grand fir is aggressive enough to form a considerable part of the dominant reproduction stand. After 20 to 30 years it maintains its position and makes most rapid growth in the open (4).

A 90-year-old grand fir stand, Coeur d'Alene National Forest, Idaho

SAPLING STAGE TO MATURITY

Growth and yield.--On optimum sites on the coast of Washington, grand fir reaches heights of 140 to 200 feet with breast height diameters of 20 to 40 inches; occasionally it reaches 250 feet in height and 50 inches in diameter (13). The largest tree recorded on Vancouver Island was 61 inches d.b.h. and 240 feet in height at 280 years of age (15). It is believed that grand fir in the redwood forests of California reaches diameters and heights as great as or greater than those attained in the coast Douglas-fir region.5/ In its best commercial range in northern Idaho, grand fir normally grows to 115 to 150 feet in height with diameters of 25 to 40 inches. On the pumice soils of eastern Oregon it attains heights of 100 to 130 feet with diameters of 20 to 36 inches. On exposed subalpine ridges of the Inland Empire, heights of 50 to 70 feet and diameters of 12 to 14 inches are common (13).

5/ Personal communication from Russell K. LeBarron, Pacific Southwest Forest and Range Experiment Station.

The rapid early height growth nearly equals that of Douglas-fir on the Pacific Coast and western white pine in Idaho. It is believed that the most rapid early height growth is on Vancouver Island where Müller (13) reported growths of 31.5 to 35.5 inches per year. Terminal shoots more than 3 feet in length are fairly common in that region, and trees 140 feet tall at 50 years of age have been measured (15). In Idaho early height growths of 6 to 8 inches on average sites and 12 to 14 inches on optimum sites have been reported. In the dry pumice soils of eastern Oregon average juvenile height growth up to 5 inches per year has been reported. On these dry sites good height growth is delayed until the taproots reach groundwater. At some time in the third decade, height growth receives considerable impetus and annual height growths of 20 to 36 inches or more are common (13). A relatively deep taproot enables grand fir to survive and grow well on rather dry soils and exposed ridges. On the moist sites the taproot is largely replaced by more shallow lateral roots.

In the upper crown levels growth is nearly equal to the more intolerant western white pine and Douglas-fir with which it is commonly associated. As an understory tree it commonly outgrows the more tolerant western hemlock and western redcedar.

Grand fir seldom grows in pure stands; therefore estimates of yields have value only in relation to mixed stands. In the western white pine region of the Inland Empire grand fir rates second only to white pine as a high yielding species. Analysis of plots used in compiling normal yield tables for western white pine revealed that stands containing large numbers of white pine or grand fir yielded somewhat more than the average (3). On fair to good sites (site index 50 to 60 feet at 50 years) predicted yields of normal stands in the western white pine type range from 49,500 to 68,700 board feet at 120 years (3).

INJURIOUS AGENCIES

During the period of stand development from establishment to maturity several agencies influence stand growth and yield. Grand fir is rated medium in fire resistance among species of the western white pine type (4); it is less resistant than thick-barked western larch, ponderosa pine, and Douglas-fir but more resistant than subalpine fir, western hemlock, and Engelmann spruce. Fire resistance is influenced by habitat. For example, in moist creek bottoms grand fir succumbs rapidly to ground fires, but on dry hillsides it is more fire resistant largely because of its deeper root system, thicker bark, and more open stand conditions. The needles are quite resistant to cold during the severest part of winter. In one study Parker (14) found that grand fir leaves withstood temperatures of -55° C. without damage. Sudden extreme drops of temperature in the fall occasionally damage needles, but they are seldom fatal. However, frost cracks and lightning scars appear more frequently on grand fir than on its associates in the Inland Empire. The cracks cause little direct mortality but become avenues of infection by decay fungi (13).

Snow is an outstanding cause of mortality in dense immature stands in the Inland Empire. On sample plots snow accounted for 48 percent of the total grand fir mortality measured in basal area (4).

Grand fir is intermediate in resistance to windthrow. It is susceptible to decay fungi, and trees containing root rot or decay are especially susceptible to wind breakage and windthrow (4).

Grand fir is susceptible to heart rot at an early age. Fungi enter the tree through dead lower branches (6) and such injuries as frost cracks, lightning scars, fire scars (13), and logging scars. Indian paint fungus (Echinodontium tinctorium) is the most destructive attacking fungus. Armillaria mellea and Poria weirii are the two most important root rot fungi. Poria subacida and Fomes annosus also attack grand fir (6). Susceptibility to early decay is one of the most important factors in management of the species.

Numerous insects attack grand fir, but most of them are secondary and have only minor economic importance. The spruce budworm (Choristoneura fumiferana) and tussock moth (Hemerocampa pseudotsugata) have caused widespread defoliation and mortality. The western balsam bark beetle (Dryocoetes confusus) and the fir engraver (Scolytus ventralis) are the principal bark beetles attacking grand fir (7). The fir cone moth (Barbara colfaxiana var. siskiyouana), the fir seed maggot (Earomyia spp.) and several seed chalcids destroy large numbers of grand fir cones and seeds (8). The balsam woolly aphid (Chermes picea), often called "gout disease of fir," has destroyed grand fir in Oregon (7) and is believed to be a serious threat in Mount St. Helens region of Washington.6/

Reaction to competition.--Grand fir is rated as tolerant in all associations in which it occurs. In the Willamette Valley it is the eventual climax type following Douglas-fir and Oregon white oak (17). In the Inland Empire it is more tolerant than any of its associates except western redcedar and western hemlock. It is the climax type on many sites too dry for redcedar or hemlock (13). In coastal British Columbia grand fir is reported similar to Sitka spruce in tolerance; that is, slightly more tolerant than Douglas-fir. It is the least shade tolerant of the true firs in British Columbia, and is much less tolerant than western hemlock, western redcedar, or Pacific silver fir (15). Grand fir is a versatile species which, although quite tolerant, has a growth rate nearly equal to that of western white pine. It often forms part of both the overstory and the understory.

Grand fir responds well to release. It can survive for many years in rather dense shade although the crowns are short and growth is slow. However, it can build crown readily when released, partly because of epicormic branching that permits rapid use of available growing space. In one study Weir and Hubert (20) reported that 75-year-old released grand fir trees developed a distinct secondary crown of epicormic branches below the original crown. On many trees this secondary crown was as large as the original crown. Mature grand firs respond well to release if the crowns are vigorous.

6/ Personal communication from George R. Staebler, Puget Sound Research Center.

Stagnation does not occur normally. Grand fir makes good growth in rather dense stands and produces high yields.

SPECIAL FEATURES

Grand fir forms epicormic branches that usually form short fuzzy patches on the bark, but they may occasionally produce large branches following release.

RACIAL VARIATIONS

According to the Woody-Plant Seed Manual (19), five climatic races have been distinguished differing in color of needles, bark thickness, and properties of wood. Müller (13) describes five fairly distinct climatic form regions of grand fir occurrence; the differences are mainly physiological and ecological.

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