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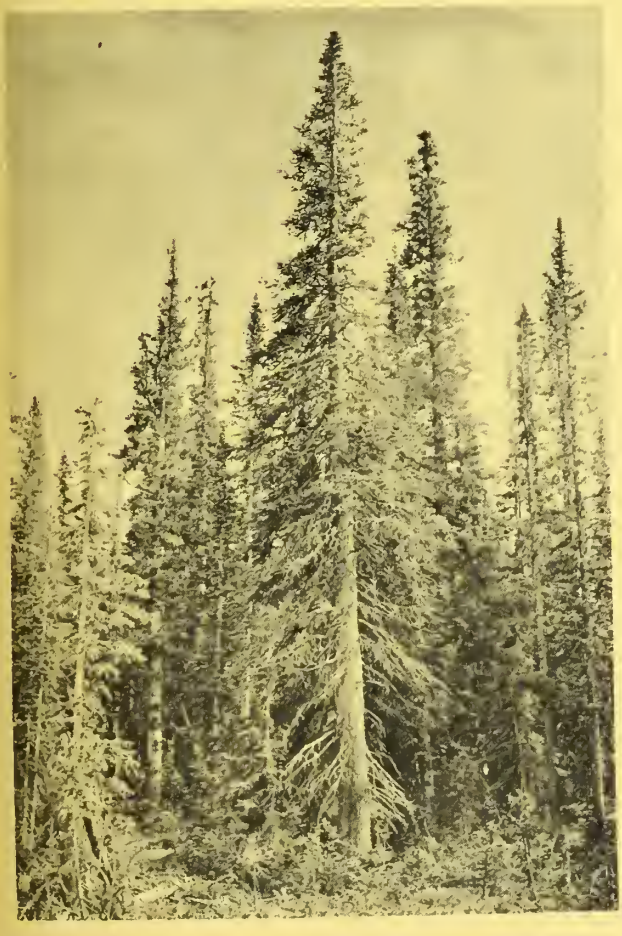
Silvical Characteristics of Subalpine Fir

by

R. R. Alexander



ROCKY MOUNTAIN
FOREST AND RANGE
EXPERIMENT STATION
Raymond Price, Director
Fort Collins, Colorado

EST SERVICE - U. S. DEPARTMENT OF AGRICULTURE

PREFACE

An early project of the Forest Service, U. S. Department of Agriculture, was the compiling of known silvical characteristics of our more important trees. Since then much knowledge has accumulated, some published and some unpublished, but scattered and often difficult to locate. To compile this material systematically and make it available to foresters generally, the Rocky Mountain Forest and Range Experiment Station is preparing reports on 4 individual tree species. Similar reports on other species are being prepared by other Forest Service experiment stations. A comprehensive national publication containing the silvical characteristics of all important forest trees of the United States will be issued soon by the Forest Service, U. S. Department of Agriculture.

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Cover Photo: Mature subalpine fir, Fraser Experimental Forest, Colorado.

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R. R. Alexander, Forester

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE U. S. DEPARTMENT OF AGRICULTURE

The station maintains central headquarters at Fort Collins, Colorado, in cooperation with Colorado State University.

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Subalpine fir (Abies lasiocarpa (Hook.) Nutt.) is the smallest of the eight species of true fir indigenous to the western United States. It is distinguished by the long, narrowly conical crown terminating in a conspicuous spikelike point.

Two varieties are recognized: the typical variety (Abies lasiocarpa var. lasiocarpa) and corkbark fir (Abies lasiocarpa var. arizonica (Merriam) Lemm.). The latter, readily distinguished by its peculiar whitish, corky bark, is restricted to the southern Rocky Mountains. Other common names for the typical variety include balsam, white balsam, alpine fir, balsam fir, white fir (lumber), and pino real blanco de las sierras; for the variety arizonica, alamo de la sierra (13).

DISTRIBUTION

Subalpine fir is the most widely distributed North American fir (fig. 1). Along the Pacific coast, the range extends from southeastern Alaska, south of the Copper River Valley (lat. 62° N.) the northwestern limit, east to central Yukon Territory (lat. 64°30' N.) the northern limit, south through British Columbia along the Coast Range to the Olympic Mountains of Washington and along both slopes of the Cascades to southern Oregon. It is not found on the west slopes of the Coast Range in southern British Columbia nor along the Coast Range in Washington and Oregon, but it does occur on Vancouver Island (23).

In the Rocky Mountain region, it extends from the interior valleys of British Columbia west of the Continental Divide and south of the Peace River (lat. 55° N.), south along the high elevations of the Rocky Mountain system to southern New Mexico and Arizona. In the north, its range extends from the high mountains of central British Columbia, western Alberta, northeastern Washington, Idaho, Montana, northeastern Oregon, to the Wind

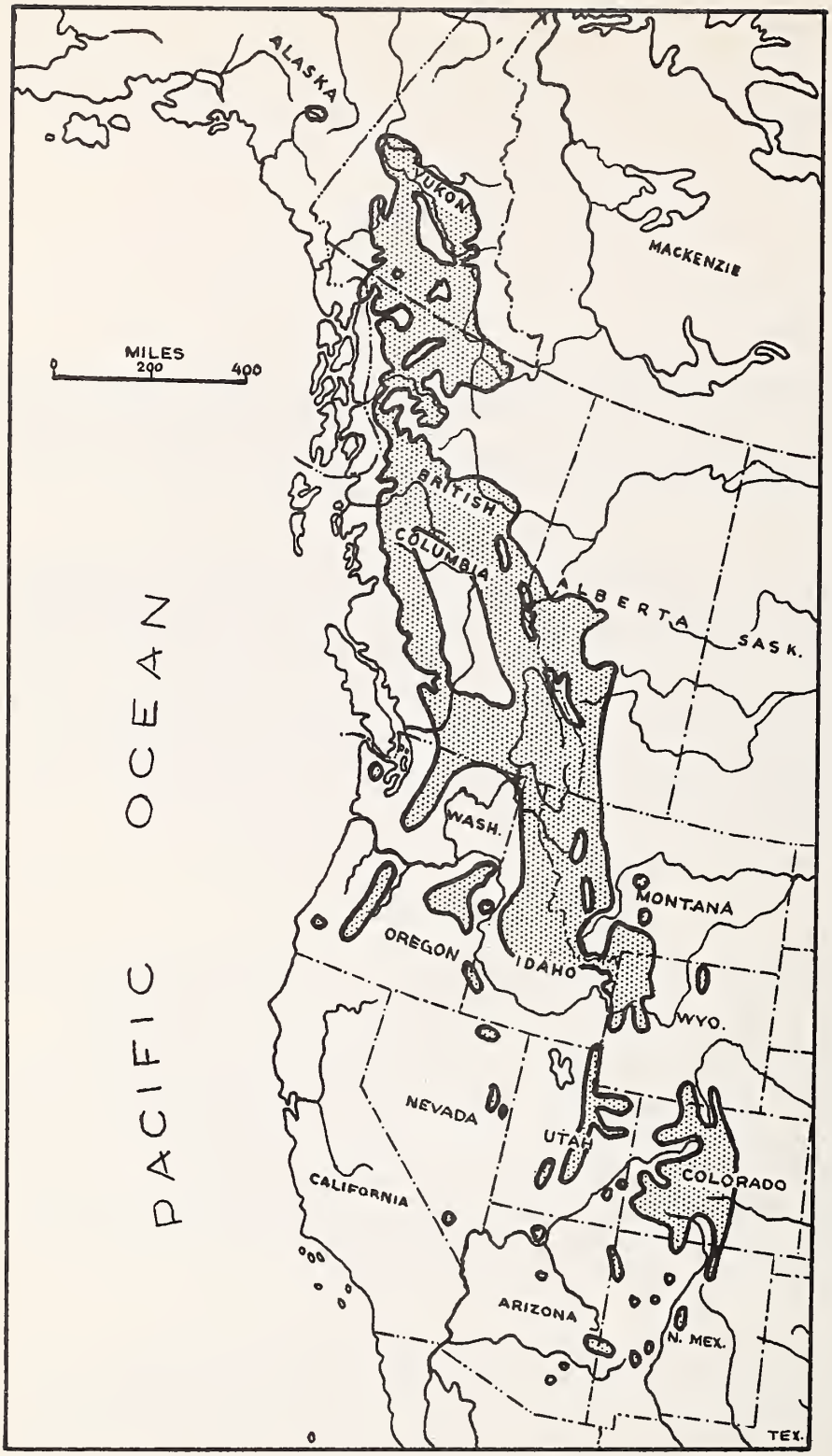

Figure 1.--Natural range of subalpine fir.

River Mountains of western Wyoming. In Utah, it occurs in the Uinta and Wasatch Mountains, but rarely on the southern plateaus. The range extends from southern Wyoming, through the high mountains of Colorado and northern New Mexico, and westward through northeastern Arizona to the San Francisco Mountains. Subalpine fir is a major component of the high-elevation forests of this region.

Corkbark fir is found in mixture with subalpine fir on scattered mountains in southwestern Colorado; northern, western, and southwestern New Mexico, west to the San Francisco Mountains in Arizona (12).

BOTANICAL DESCRIPTION (17)

Needles.--The dark, blue-green, sessile needles on the lower branches average 1 to 1-3/4 inches long and are either flattened, blunt, or notched. On the upper branches, they are about 1/2 inch in length and pointed (fig. 2).

Figure 2.--Cones and needles of subalpine fir.

Flowers. --Male flowers are dark indigo blue; female, dark violet purple.

Cones. --The characteristic purplish gray to nearly black, ovate to cylindrical cones are 2-1/4 to 4 inches long (fig. 2). Cone scales are longer than broad and three times longer than the long-tipped bracts. Seeds average 1/4 inch long, and have dark, lustrous wings.

Twigs. --Stout, pubescent, and pale orange brown; becoming smooth and gray or silver white with age. Winter buds are subglobose, resinous, and about 1/8 to 1/4 inch long, with light orange-brown scales.

Bark. --Thin, gray, and smooth except for numerous resin blisters on young trees. Bark becomes shallowly fissured with age.

Wood. --Creamy white to pale brown, soft, stiff, fine textured, straight grained, and nonresinous. Heartwood and sapwood are generally indistinguishable.

HABITAT CONDITIONS

CLIMATIC

The climate in which subalpine fir grows is cold and humid (24). Temperature extremes of less than -50°F. to more than 90°F. have been reported. Even though the tree has wide distribution, it grows within a narrow range of mean temperature conditions. Average annual temperatures are 25° to 40° F., with average July temperatures of 45° to 60° F., and average January temperatures of 5° to 25°F. (table 1).

Average precipitation is in excess of 20 inches, much of which falls as snow. More than half of it occurs in late fall or early winter on the Pacific coast and west of the Continental Divide in the northern Rockies. East of the divide in the northern Rockies and in the central Rockies, the heaviest precipitation comes in late winter and early spring, but it comes during late summer and early fall in the southern Rocky Mountains (1, 24).

Table 1.--Climatological data for 4 subdivisions within the range of subalpine fir

Location	Average temperature			Annual precipitation	Annual snowfall	Frost-free period[1]
	Annual	July	January			
	°F.	°F.	°F.	- Inches -		Days
Pacific coast	30-40	45-55	20-25	20-100	600+	0-60
Rocky Mountains:						
Northern	25-35	45-55	5-15	20- 60	250+	0-60
Central	30-35	50-55	10-15	20- 40	150-350	0-60
Southern	30-40	50-60	15-20	20- 40	200+	0-60

[1] Frost can occur any month of the year.

EDAPHIC

Subalpine fir is not exacting in its soil requirements. Growth is good on lower slopes and on alluvial flood plains, and at higher elevations on well-drained, fine- to medium-textured sand and silt loams. Growth is poor on shallow, rocky, sandy, and gravelly soils, and on saturated soils.

Subalpine fir is less exacting in its soil and moisture requirements than is Engelmann spruce (Picea engelmannii Parry), a common associate throughout much of its range, and is frequently found growing on soils too wet or too dry for spruce.

PHYSIOGRAPHIC

Subalpine fir grows near sea level at the northern limit of its range and as high as 12,000 feet in the south. In the Coast Range of southeastern Alaska, it is found from sea level to 3,500 feet; in the Coast Range and interior plateaus of Yukon Territory and British Columbia, at 2,000 to 5,000 feet; and in the Olympic and Cascade Mountains of Washington and Oregon, generally at 5,000 to 7,500 feet, but as low as 2,000 feet along cold stream bottoms and as high as 8,000 feet on sheltered slopes (23).

In the Rocky Mountains of British Columbia and Alberta south of the Peace River, subalpine fir grows at 3,000 to 7,000 feet but

is more abundant above 5,000 feet; in the northern Rocky Mountains, at 2,000 to 11,000 feet, but it is more common at 5,000 to 9,000 feet (9, 10); in the central Rocky Mountains, usually at 9,000 to 11,000 feet, but may be found as low as 8,000 feet and to timberline at 11,500 feet; and in the southern Rocky Mountains, at 8,000 to 12,000 feet, but usually on north slopes at 9,500 to 11,000 feet (3, 16).

BIOTIC

Subalpine fir is a major component of two extensive forest types that occupy the boreal forest region of the mountainous West: the mountain hemlock-subalpine fir and Engelmann spruce-subalpine fir types. In addition, it is found in varying degrees in eight other adjacent types. They are: white spruce, whitebark pine, bristlecone pine, interior Douglas-fir, aspen, lodgepole pine, western hemlock, and Pacific silver fir-western hemlock (22).

Differences in latitude and elevation influence the composition of the forests in which the subalpine fir grows. In Alaska and the Coast Range of British Columbia and through the Cascade Range of Washington and Oregon, mountain hemlock (Tsuga mertensiana (Bong.) Carr.) is the most constant associate. In Alaska and northern British Columbia, Alaska-cedar (Chamaecyparis nootkatensis (D. Don) Spach) mixes with it, and where it approaches sea level in Alaska, it mingles with Sitka spruce (Picea sitchensis (Bong.) Carr.). From southern British Columbia southward through the Cascades, it associates at its lower limits with noble fir (Abies procera Rehd.), grand fir (Abies grandis (Dougl.) Lindl.), western hemlock (Tsuga heterophylla (Raf.) Sarg.), western white pine (Pinus monticola Dougl.), Pacific silver fir (Abies amabilis (Dougl.) Forbes), and western larch (Larix occidentalis Nutt.); and at higher elevations, with Engelmann spruce, lodgepole pine (Pinus contorta Dougl.), white bark pine (Pinus albicaulis Engelm.), and subalpine larch (Larix lyalli Parl.) (22).

From the mountains and interior plateaus of central British Columbia southward through the Rocky Mountain system, its most constant associate is Engelmann spruce. Less common associates include: in British Columbia and western Alberta, white spruce (Picea glauca (Moench) Voss), western white spruce (Picea glauca var. albertiana (S. Brown) Sarg.), and aspen (Populus tremuloides Michx.); in the northern Rocky Mountains at its lower limits, western white pine, interior Douglas-fir (Pseudotsuga menziesii

var. glauca (Beissn.) Franco), western hemlock, western larch, grand fir, and western redcedar (Thuja plicata Donn); and at higher elevations, lodgepole pine, subalpine larch, mountain hemlock and whitebark pine (9, 10). In the central Rocky Mountains near its lower limits, associates are lodgepole pine, interior Douglas-fir, aspen, and blue spruce (Picea pungens Engelm.); and at higher elevations, whitebark pine, limber pine (Pinus flexilis James), and bristlecone pine (Pinus aristata Engelm.); and in the southern Rocky Mountains, near its lower limits, white fir (Abies concolor (Gord. & Glend.) Lindl.), interior Douglas-fir, blue spruce, and aspen; and at higher elevations, corkbark fir (16).

Subalpine fir frequently extends to timberline in the Rocky Mountains. Other species that accompany it are: whitebark pine and Engelmann spruce (rarely, mountain hemlock) in the northern Rockies; Engelmann spruce in the central Rockies; and Engelmann spruce and corkbark fir in the southern Rockies.

Common shrubs found growing with subalpine fir in the Canadian and northern Rockies include: grouse whortleberry (Vaccinium scoparium Leiberg), big whortleberry (V. membranaceum Dougl.), prickly currant (Ribes lacustre (Pers.) Poir.), rusty skunkbush (Menziesia ferruginea Smith), alder (Alnus spp.), willow (Salix spp.), elderberry (Sambucus spp.), Greenes mountainash (Sorbus scopulina Greene), river hawthorn (Crataegus rivularis Nutt.), myrtle boxleaf (Pachistima myrsinites (Pursh) Raf.), smooth Labrador tea (Ledum glandulosum Nutt.), bog kalmia (Kalmia polifolia Wang.), red mountainheath (Phyllodoce empetriformis (J. E. Smith) D. Don), and mertens cassiope (Cassiope mertensiana (Bong.) D. Don) (9, 11, 21); in the central Rockies: grouse whortleberry, ovalleaf whortleberry (V. ovalifolium Smith), russet buffaloberry (Shepherdia canadensis (L.) Nutt.), mountain snowberry (Symphoricarpos oreophilus A. Gray), common chokecherry (Prunus virginiana L.), silver sagebrush (Artemisia cana Pursh), bitterbrush (Purshia tridentata Pursh DC), Douglas rabbitbrush (Chrysothamnus viscidiflorus (Hook.) Nutt.), and lanceleaf yellowbrush (C. lanceolatus Nutt.) (5, 15); in the southern Rockies: common juniper (Juniperus communis L.) and creeping mahonia (Mahonia repens (Lindl.) G. Don) (18); and in the Pacific coast region: whortleberry (Vaccinium spp.), false azalea (Azaleastrum albiflorum (Hook.) Rydb.), myrtle boxleaf, beargrass (Xerophyllum tenax (Pursh) Nutt.), smooth Labrador tea, and currant (Ribes spp.). None of these are known to be indicator plants.

LIFE HISTORY

SEEDING HABITS

Flowering and fruiting

Flowers are monoecious. The male flowers are borne in clusters on the lower side of branches in the upper crown and the female flowers are borne erect and singly on the uppermost part of the crown (26). Male flowers are ripe and pollen is disseminated by the wind during the late spring and early summer. Cones mature in mid-September or early October. Seed ripens from late September to mid-October (26).

The effect of climatic and biotic factors on flowering and fruiting is not known.

Seed production

Subalpine fir may begin producing cones as early as age 20 years. The optimum age for maximum seed production is not known. Corkbark fir does not begin to bear cones until about 50 years old. Maximum seed production is by dominant trees between 150 and 200 years old (26).

Subalpine fir is rated a good seed producer, better than Engelmann spruce (11). Good seed crops are borne on an average of every 3 years, with light crops in between. Total failures occur occasionally (26).

Seed is eaten by a number of small animals, but the quantitative loss from these and other causes is not known.

Seed dissemination

When cones are ripe they disintegrate. The scales fall away with the large, winged seeds, leaving only a central spikelike axis remaining. Dissemination begins in September and is usually completed by the end of October (26). Practically all seed is dispersed by the wind.

Subalpine fir seeds are fairly large, averaging 37,500 to the pound. Corkbark fir seeds are larger, averaging about 22,300 per pound (26).

No data are available on the distance that wind carries the seed or on the amount of seed produced per acre or per tree.

VEGETATIVE REPRODUCTION

Subalpine fir frequently reproduces by layering at or near timberline, but under closed-forest conditions reproduction by layering is not important (7, 15).

SEEDLING DEVELOPMENT

Germination and establishment

Seed viability is only fair and the vitality transient (9, 26, 28). The average rate of germination, as shown below, is higher than rates for most true firs, but lower than those for many associated species (26).

True firs	Average germination Pct.	Associated species	Average germination Pct.
Subalpine	38	Engelmann spruce	69
Corkbark	31	Lodgepole pine	64
Pacific silver	24	Western larch	27
Grand	28	Western hemlock	56
Noble	24	Mountain hemlock	47
White	34	Sitka spruce	60

In nature, seeds usually germinate in the spring after lying on the ground or in snow overwinter. Some lots of stored seed may undergo embryo dormancy, which can be broken by stratification in moist peat or sand at 41°F. for a period of 60 days (26).

Germination and early survival are equally good on exposed mineral soil and on moist humus (26). Subalpine fir is usually less exacting in its seedbed requirements than is Engelmann spruce (7). It has been observed to survive on duff layers, dry soils, and other situations where spruce has failed to become established, presumably because fir has a larger seed and can produce a more vigorous root system (7). However, this is not always true. In one test in Colorado, the same number of seeds of subalpine fir,

Engelmann spruce, and lodgepole pine were sown on a natural seedbed. Three years later the number of living Engelmann spruce and lodgepole pine seedlings was two and six times greater, respectively, than that of fir (19).

Establishment and early survival are favored by relatively deep shade, but subalpine fir is found growing under all intensities of light. It can make use of lower light intensities than most associates, but it cannot compete successfully with Engelmann spruce where light intensity exceeds 50 percent of full sunlight (19).

Seedlings are often killed by drought and heat, cutworms, frost-heaving, damping-off, and rodents.

Early growth

The early growth of subalpine fir is very slow. In one study, seedlings 15 years old averaged only 11 inches in height on burned-over slopes, 9.8 inches on cutover, dry slopes, and 5.8 inches on cutover, wet flats (7).

Trees less than 5 inches in diameter are often 100 or more years old at higher elevations, and trees 4 to 6 feet high and 35 to 50 years old are common under closed-forest conditions (9, 15).

SAPLING STAGE TO MATURITY

Growth and yield

On exposed sites near timberline, subalpine fir is often reduced to a prostrate shrub, but under closed-forest conditions it attains diameters of 18 to 24 inches and heights of 60 to 100 feet. Trees larger than 30 inches in diameter and 130 feet tall are exceptional (6, 23).

Growth is never rapid and trees 10 to 20 inches in diameter are often 150 to 200 years old. Trees older than 250 years are common. But because the species suffers severely from heart rot, many trees either die or are complete culls at an early age (6, 23).

Few data are available on the yield of subalpine fir. It usually grows in mixed stands and comprises only a minor part of the volume. In old-growth spruce-fir forests, subalpine fir usually makes up less than 25 percent of the sawlog volume, which may run from 5,000 to 40,000 board-feet per acre for the total stand (7, 14).

Competition and natural enemies

Subalpine fir is classified as very tolerant throughout its life (2). It is considered more tolerant than any of its associates.

In association with Engelmann spruce throughout most of the Rocky Mountains, and mountain hemlock on the Pacific coast, subalpine fir forms a near-stable, high-elevation forest type (22). As a component of a near-climax vegetation, the natural tendency is for subalpine fir to reestablish itself when destroyed and temporarily replaced by other forest trees.

In very dense stands, subalpine fir may be free of branches for a distance of 20 to 40 feet or more, but in the open the crowns extend to the ground. This fact, combined with the relatively thin and resinous character of the bark, makes it extremely susceptible to fires (27).

Subalpine fir is attacked by several insects. The spruce budworm (Choristoneura fumiferana (Clem.)) and black-headed budworm (Acleris variana (Fern.)) defoliate it, and the western balsam bark beetle (Dryocoetes confusus Sw.) at times may be very destructive (27).

Balsam fir rust fungus (Melampsorella cerastii (Pers.) Schroet.) and wood-rotting fungi are responsible for most of the disease loss. Important trunk rots are: brown stringy rot (Echinodontium tinctorium E. & E.), red heart rot (Stereum sanguinolentum A. & S.), and red ring rot (Fomes pini (Thore) Lloyd); butt and root rots are: shoestring rot (Armillaria mellea (Vahl.) Quel.), brown cubical rot (Coniophora puteana (Fr.) Karst), white spongy root rot (Poria subacida (Pk.) Sacc.), and white pocket rot (Polystictus abietinus (Dicks.) Sacc. & Cub.) (4, 8, 20). Wood rots and broom rusts weaken affected trees and make them more susceptible to wind breakage.

RACES AND HYBRIDS

Abies lasiocarpa var. arizonica is the only recognized natural geographical variety of subalpine fir (13). Like many species with wide distribution, it has probably developed unknown races and crosses. Horticultural and ornamental varieties have been reported, but these have been oddities (29).

PROPERTIES AND USES

Subalpine fir wood is light in weight, low in bending and compressive strength, moderately limber, soft, and low in resistance to shock. Shrinkage of wood is rated small to moderately large. It is easy to work, glues well, and holds nails and screws fairly well (25).

Fir is used as lumber in building construction, boxes, crates, planing mill products, sashes, doors, frames, and food containers. It has not been widely used for pulpwood because of inaccessibility, but it can be pulped readily by the sulfate, sulfite, or groundwood processes (25).

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