Abies amabilis Dougl. ex Forbes   Pacific Silver Fir

Pinaceae   Pine family

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Pacific silver fir *(Abies amabilis),* also known as silver fir and Cascades fir, has a gray trunk, a rigid, symmetrical crown, and lateral branches perpendicular to the stem. It contrasts strikingly with the more limber crowns, acute branch angles, and generally darker trunks of its common associates—Douglas-fir *(Pseudotsuga menziesii),* western hemlock *(Tsuga heterophylla),* and mountain hemlock *(T. mertensiana).* The species name, *amabilis,* means lovely.

Habitat

Native Range

Pacific silver fir (fig. 1) is found in southeastern Alaska, in coastal British Columbia and Vancouver Island, and along the western and upper eastern slopes of the Cascade Range in Washington and Oregon. It also grows throughout the Olympic Mountains and sporadically in the Coast Ranges of Washington and northern Oregon. Near Crater Lake, OR, Pacific silver fir disappears from the Cascade Range and then reappears at a few locations in the Klamath Mountains of northwestern California. The major portion of its range lies between latitudes 43” and 55” N. *(35).*

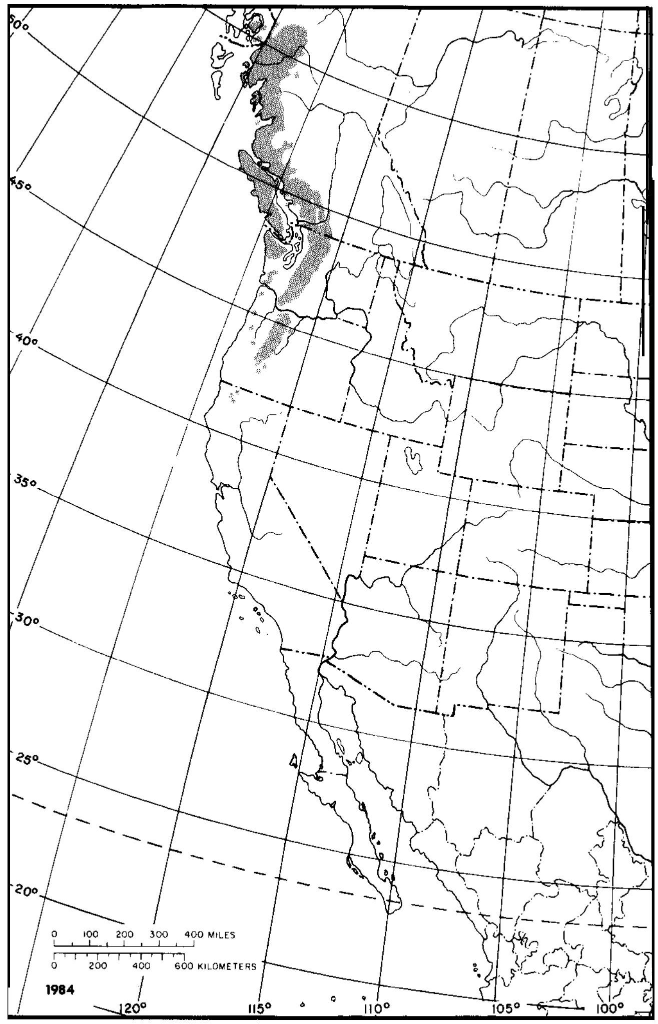

Figure *l-The native* range *of Pacific silver fir.*

Climate

Climate throughout the range of Pacific silver fir is distinctly maritime. Summers are cool, with mean daily temperatures of 13” to 16” C (55” to 61” F), and winter temperatures are seldom lower than -9” C (16” F) (35). Mean number of frost-free days ranges from 40 near tree line to more than 250 at low elevations (26). Length of growing season also differs from year to year at a given location. Mean annual precipitation varies greatly, ranging from 6650 mm (262 in) on the west coast of Vancouver Island to an extreme low of 965 mm (38 in) on the eastern side of Vancouver Island. Average annual precipitation in the Cascade Range is more than 1500 mm (59 in); winter snowpacks are as much as 7.6 m (25 ft) deep (9). A summer dry season is characteristic of this region, but Pacific silver fir is dependent on adequate soil moisture during the growing season. It is most abundant on sites where summer drought is minimal, such as areas of heavy rainfall, seepage, or prolonged snowmelt.

Soils and Topography

Pacific silver fir grows on soils developed from nearly every type of parent material found in the Northwest. Layering in soil profiles caused by successive deposits of volcanic ejecta, colluvium, or glacial till is especially common *(1,43).* The greatest known growth rates for Pacific silver fir occur at low elevations on fine-textured residual soils from

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sedimentary and basaltic rocks (16). Growth is reduced on poorly drained or shallow rocky soils.

In northern Washington and British Columbia, podzolization is the dominant process in well-drained soils under Pacific silver fir. A typical podzol is characterized by strong acidity of organic (pH 3.3 to 4.0) and mineral horizons, moderate to thick (3 to 45 cm; 1 to 18 in) surface accumulations of organic matter, and moderate to extremely low base saturation. In Oregon, podzolization is less strongly expressed and soils are more shallow and rocky, Pacific silver fir has been found on many soil suborders throughout its range: Folists in the order Histosols; Aquents, Fluvents, Orthents in the order Entisols; Andepts, Aquepts, Ochrepts, Umbrepts in the order Inceptisols; and Aquods, Humods, and Orthods in the order Spodosols (35).

At upper elevations in Washington, soils beneath Pacific silver fir stands are generally low in available nitrogen, with availability decreasing with age (44). External nutrient cycling is slow; a mean nitrogen residence time as long as 120 years has been found in old-growth forest floors (24). Nitrification has not been found to occur. Availability of phosphorus tends to be low but availability of base elements does not appear to limit plant growth (42). Internal cycling meets much of the annual nutrient requirements. Foliar nitrogen concentrations between 0.7 and 1.2 percent and foliar phosphorus concentrations of 0.11 to 0.20 percent have been reported *(3,42,52)*. Pacific silver fir differs significantly from western hemlock in its ability to accumulate specific elements (46).

Pacific silver fir grows at sea level along the coast from Alaska to the Olympic Peninsula; farther inland, it is absent at lower elevations. Its range in elevation is narrowest in Alaska, 0 to 300 m (0 to 1,000 ft), and greatest in the western Cascade Range of Washington, where Pacific silver fir may be found from 240 to 1830 m (800 to 6,000 ft). In British Columbia it is found from 0 to 1525 m (0 to 5,000 ft) in elevation on western Vancouver Island and from 180 to more than 1680 m (600 to more than 5,500 ft) on the lower mainland. Pacific silver fir grows on the highest ridges and peaks in the Coast Ranges of Washington, from 365 to 850 m (1,200 to 2,800 ft). In the Olympic Mountains, it is the predominant montane species up to 1400 m (4,600 ft), with lower limits at sea level on the west side and at 360 m (1,200 ft) in the central mountains. It is found between 610 and 1830 m (2,000 and 6,000 ft) in the Cascade Range in Oregon as far south as the divide between the Rogue and Umpqua Rivers. On the east side of the Cascade Range, it is confined to high elevations, down to 1160 m (3,800 ft) in Oregon and 1000 m (3,300 ft) in Washington *(30,35)*.

Associated Forest Cover

Western hemlock is a common associate throughout most of the range of Pacific silver fir, in the *Abies amabilis* zone and portions of the *Tsuga heterophylla* zone (9). Noble fir *(Abies procera)* is an important associate in southern Washington and northern Oregon. Other associates west of the Cascade Range are Douglas-fir, western redcedar *(Thuja plicata)*, and grand fir *(Abies grandis)*, with Sitka spruce *(Picea sitchensis)* and lodgepole pine *(Pinus contorta)* important near the coast. At subalpine elevations in the *Tsuga mertensiana* zone *(9)*, Pacific silver fir is associated with mountain hemlock, Alaska-cedar *(Chamaecyparis nootkatensis)*, and subalpine fir *(Abies lasiocarpa)*. Toward the eastern limits of its range, it grows with a mixture of coastal and interior species: western larch *(Larix occidentalis)*, western white pine *(Pinus monticola)*, lodgepole pine, subalpine fir, grand fir, and Engelmann spruce *(Picea engelmannii)*. Shasta red fir *(Abies magnifica* var. *shastensis)* is an associate in the extreme southern portion of its range. Extensive pure stands of Pacific silver fir have been reported in the Mount Baker and Mount Rainier regions and elsewhere in the southern Washington Cascade Range (40).

Pacific silver fir is a major species in the forest cover type Coastal True Fir-Hemlock (Society of American Foresters Type 226) (5). It is also found in the following types:

205	Mountain Hemlock
206	Engelmann Spruce-Subalpine Fir
223	Sitka Spruce
224	Western Hemlock
225	Western Hemlock-Sitka Spruce
227	Western Redcedar-Western Hemlock
228	Western Redcedar
229	Pacific Douglas-Fir
230	Douglas-Fir-Western Hemlock

Shrubs associated with Pacific silver fir are primarily ericaceous. Blueleaf huckleberry *(Vaccinium deliciosum)*, Cascades azalea *(Rhododendron albiflorum)*, and rustyleaf menziesia *(Menziesia ferruginea)* are common understory species at higher elevations; copper bush *(Cladothamnus pyrolaeflorus)* is important in subalpine British Columbia (2). Alaska huckleberry *(Vaccinium alaskaense)*, big huckleberry *(V. membranaceum)*, ovalleaf huckleberry *(V. ovalifolium)*, and devilsclub *(Oplopanax horridum)* are widespread associates. At its lower limits of elevation, Pacific silver fir is found with salal *(Gaultheria shallon)* and Oregongrape *(Berberis nervosa)*.

Common herbaceous associates are common beargrass *(Xerophyllum tenax)*, bunchberry *(Cornus canadensis)*, twinflower *(Linnaea borealis)*, queens-cup *(Clintonia uniflora)*, dwarf blackberry *(Rubus lasiococcus)*, strawberryleaf blackberry *(R. pedatus)*, rosy twistedstalk *(Streptopus roseus)*, coolwort foamflower *(Tiarella unifoliata)*, and deer-fern *(Blechnum spicant)*. *Rhytidiopis robusta* is a constant bryophyte associate.

Major habitat types include *Abies amabilis-Tsuga mertensiana / Vaccinium membranaceum-Rhododendron albiflorum* on cold, wet sites at high elevations and *Abies amabilis/Xerophyllum tenax* on shallow coarse-textured soils at various elevations. *Abies amabilis / Vaccinium alaskaense* is a widespread type on modal sites. *Abies amabilis/Rubus lasiococcus, Abies amabilis /Streptopus roseus, Abies amabilis I Tiarella unifoliata,* and *Tsuga heterophylla-Abies amabilis / Blechnum spicant* are herb-dominated types found in moist habitats. The *Abies amabilis / Oplopanax horridum* type occupies wet, alluvial habitats *(2,9)*.

Life History

Reproduction and Early Growth

Flowering and Fruiting-Pacific silver fir is monoecious; self-fertilization is possible because times of pollen dispersal and seed cone receptivity overlap on the same tree. Flowers differentiate from axillary buds of current-year lateral shoots in early July of the year before seed development (32). When receptive to pollination, the seed cones appear purple, erect, and 8 to 16 cm (3 to 6 in) tall on the upper surfaces of l-year-old branches in the upper parts of tree crowns. Just before pollination, the pollen cones appear red, pendent, and usually abundant on the lower surfaces of the branches somewhat lower on the crowns than the seed cones. Cone buds burst the following May, and pollination occurs about 2 weeks later-before vegetative bud burst. The pollen does not germinate and begin forming its pollen tube until 4 to 5 weeks later, resulting in a 6-week delay between pollination and fertilization *(7,33)*.

Initiation of phenological events varies with latitude, altitude, aspect, weather, and snowpack and is apparently related to mean soil and air temperatures. For example, pollination may occur in mid-May at 900 m (2,960 ft) in central Washington but is delayed until mid-June at 1600 m (5,250 ft) and until late May in southern British Columbia *(7,32,33)*.

Seeds are fully mature in late August, and dissemination begins in mid-September-one of the earliest dispersal times for Pacific Northwest conifers. Initiation of dispersal is apparently independent of altitude or latitude (7); most seeds are shed by the end of October but may be shed until the following April *(21,331*.

Seed Production and Dissemination-Cone production begins at years 20 to 30 *(33,37)*. Good seed years vary from region to region; a good seed crop generally occurs every 3 years (8). Pacific silver fir is not considered a good seed producer; this condition is attributed to frequent years of low pollen, the extended period between pollination and fertilization, and archegonial abortion producing empty seeds (33). Percentage of sound seed varies, with reports of 6.7 to 35 percent and 51 percent in one location (4). Germinative capacity varies widely—from 3 to 70 percent- but averages 20 to 30 percent. Cleaned seeds range from 17,200 to 45,860/kg (7,800 to 20,800/lb) (37).

The seeds are heavier than seeds of most Pacific Northwest conifers except noble fir. Seeds each contain a single wing but often fall from the upright cone axis by pairs on ovuliferous scales, as the bracts contort and tear themselves from the cone-a process that does not require wind. When the seeds are dispersed by the wind, they do not carry far; unsound seeds are carried farther than sound seeds. In one study, only 9 percent of the sound seeds were found more than 114 m (375 ft) from the stand edge, compared with 41 percent at the stand edge and 34 percent more than 38 m (125 ft) (4).

Seedling Development-Pacific silver fir germinates in the spring after overwintering under snow. Germination is epigeal (37). Seedlings germinating on snow because of early snowfall or late seed fall are generally short lived. Germination can occur on a variety of media: on litter humps and in moist depressions in the subalpine zone; on edges of melting snowpack in subalpine meadows; and in litter, rotten wood, moss, organic soils, mineral soils, and fresh volcanic tephra *(2,11,25)*. Survival is better on mineral seedbeds than on organic seedbeds. Early mortality of seedlings is attributable more to germination on snow, adverse climatic effects, and competing vegetation than to disease *(18)*.

Cool, moist habitats are best for germination, but full sunlight produces maximum subsequent growth. Seedlings can also grow under dense shade; seedlings 8 to 12 years old and about 10 cm (4 in) tall can frequently be found beneath older, closed forest canopies. Seedlings that survive continue to grow very slowly, existing as advance regeneration that can be 65 to 110 years old and only 45 to 200 cm tall (18 to 80 in). When existing as advance regeneration, Pacific silver fir has flat-topped crowns caused by slow height growth relative to lateral branch growth.

Seedlings are sturdy and erect and resist being flattened by litter and heavy, wet snow. Survival of Pacific silver fir as advance regeneration at middle elevations, where western hemlock is primarily found in openings, is attributed partly to its ability to resist being buried by litter after snowmelt *(40)*. At the highest elevations, Pacific silver fir is found primarily in openings and less frequently beneath the canopy (38). Stems of seedlings growing on slopes often have a "pistol-butted" sweep, caused by heavy snow creeping downhill.

Vegetative Reproduction-Although Pacific silver fir can produce epicormic or adventitious sprouts, it does not regenerate by stump sprouting. Upturning of lower branches after tops of young trees are cut may resemble sprouting.

Sapling and Pole Stages to Maturity

Growth and Yield-There is a broad range of height growth rates of Pacific silver fir because of the wide variation of climates with elevation and latitude. Site index values (at 100 years) in southern British Columbia range from 12 to 46 m (40 to 150 ft) (26) and have been negatively correlated with elevation in Washington *(16)*. In subalpine tree clumps at higher elevations, Pacific silver firs reach heights of 18 to 24 m (60 to 80 R).

The largest Pacific silver fir tree known was in the Olympic National Park, WA. It was 256 cm (101 in) in d.b.h. and 74.7 m (245 ft) tall. Trees 55 to 61 m (180 to 200 ft) tall and more than 60 cm (24 in) in d.b.h. are common in old-growth stands. Trees 500 to 550 years old have been found on Vancouver Island and in the North Cascades National Park, WA. Maximum age reported is 590 years (48).

Early height growth from seeds is generally considered very slow; 9 or more years are usually required to reach breast height. Juvenile height growth ranges from 10 to 40 cm (4 to 16 in) per year, depending on length of the growing 'season *(50)*. Planted seedlings also grow slowly, with height increments of 3 to 15 cm (1 to 6 in) for the first few years after planting *(47)*. On productive sites at low elevations, Pacific silver fir is capable of much greater rates, averaging 90 cm (35 in) per year above breast height on some 30-year-old trees *(16)*. Growth of released advance regeneration is more rapid than early growth from seeds *(20,49)*. After an initial lag following overstory removal (as by avalanche, windstorm, or clearcutting), growth rates of 50 cm (20 in) or more per year can occur (49). When released from suppression, advance regeneration trees change from flat-topped to more conical crowns (fig. 2) *(41)*.

Table l-Volume yield of second-growth stands in Washington and British Columbia, dominated by Pacific silver fir, based on sample plot data

Plot location and elevation	Proportion of Pacific silver fir[1]	Age	Density	Volume
	pct	*yr*	*trees/ha*	*d/ha*
Washington:				
King County, 975 m	100	47	1,850	980
Whatcom County, 760 m	95	70	2,879	875
Vancouver island, BC (28):				
Santa Maria Lake, 533 m	85	100	1,361	1593
Labor Day Lake, 922 m	65	125	1,016	1505
Haley Lake, 1204 m	64	108	1,011	950
Haley Lake, 1119 m	59	92	1,302	1197
Sarah Lake, 116 m	53	111	420	1220
	pct	*yr*	*trees/acre*	*ft³/acre*
Washington:				
King County, 3,200 ft	100	47	749	14,004
Whatcom County, 2,500 ft	95	70	1,165	12,504
Vancouver Island, BC (28):				
Santa Maria Lake, 1,750 ft	85	100	551	22,764
Labor Day Lake, 3,025 ft	65	125	411	21,506
Haley Lake, 3,950 ft	64	108	409	13,576
Haley Lake, 3,670 ft	59	92	527	17,105
Sarah Lake, 380 ft	53	111	170	17,434

[1]Based upon the total number of trees in sample plots.

Pacific silver fir occasionally shows an abnormal height growth pattern, in which various sapling and pole-size trees curtail height growth for at least 1 year while adjacent trees grow normally. Causes of this phenomenon are not known.

Height-age and site index curves for Pacific silver fir have recently been constructed (23); however, little information on yield of second-growth stands is available. Data from sample plots on a variety of sites (table 1) indicate that large volumes can be expected from Pacific silver fir in pure stands or mixed with hemlocks. Close spacing and lack of taper are partly responsible for high volumes found in pure, even-aged stands of Pacific silver fir.

Volume in old-growth stands is extremely variable, depending on the mix of species and degree of stand deterioration. One densely stocked plot at 1100 m (3,600 ft) in the north Cascades had 1813 m^3/ha (25,895 ft^3/acre), 83 percent Pacific silver fir by volume. An older, more open stand in the same area had 840 m^3/ha (12,000 ft^3/acre).

Stands at upper elevations (predominantly Pacific silver fir) in western Washington carry large amounts of leaf biomass-18 to 25 t/ha (8 to 11 tons/acre); total standing biomass ranges up to 500 t/ha (223 tons/acre) in mature and older forests. Leaf area indexes of 14 have been reported *(14)*. A large proportion of the net primary production is below ground in subalpine stands; this is apparently a characteristic of the cool sites and low nutrient mobilization rates rather than the species itself. Values of net primary production in two upper elevation Pacific silver fir stands in western Washington were determined ***(15).*** In the 23-year-old stand, total net primary production was 18 000 kg/ha (16,060 lb/acre); in the 180-year-old stand it was 17 000 kg/ha (15,170 lb/acre). Of this, the above-ground portion was 6500 kg/ha (5,800 lb/acre) and 4500 kg/ha (4,010 lb/acre) for the two stands, respectively. Woody growth made up 65 percent of this amount in the younger stand, and 50 percent in the older stand. The below-ground portion was 11 500 kg/ha (10,260 lb/acre) and 12 500 kg/ha (11,150 lb/acre) for the two stands, respectively. Small conifer roots and mycorrhizae made up 65 percent of this amount in the younger stand and 73 percent in the older stand.

Rooting Habit-Pacific silver fir seedlings have roots that more closely resemble a true taproot system than do western hemlock seedlings *(38)*, and the roots can penetrate more compact soils than can the roots of western redcedar, Sitka spruce, and western hemlock (27). Seedlings can develop adventitious roots where volcanic tephra covers the original soil surface *(1)*. Advance regeneration has, small root-to-shoot ratios, and the roots are predominantly in the organic layers. Mature Pacific silver fir can have a relatively flat, shallow, platelike root system on poorly drained or shallow soils or in areas where there is nutrient immobilization in the forest floor ***(15).*** On soils where podzolization develops and organic matter accumulates, feeding roots become concentrated in organic horizons as a stand ages.

Peak growth of seedling roots occurs when shoots are least active. Activity is high in early spring and late autumn even in cold soils. Roots can also be active during the winter when soil temperatures are just above freezing; however, water conductance is dramatically reduced after seedlings are preconditioned to cold temperatures (39). At upper elevations in both young and mature stands, a large proportion of annual biomass production is in the root systems ***(15).*** Roots are intensely mycorrhizal at upper elevations, and ***Cenococcum graniforme*** is a major mycorrhizal symbiont (45).

Reaction to Competition-Pacific silver fir can grow in a variety of stand development conditions. It can seed onto outwash after glacial retreat *(35)*, seed into burned areas, develop from advance regeneration after removal of the overstory, and grow slowly from a suppressed tree into an overstory tree in more uneven-aged stands where disturbances are minor.

Advance regeneration may have a cone-shaped crown or can become flat topped, with lateral branch growth greatly exceeding height growth. After extensive removal of the overstory, some (but not all) advance regeneration can accelerate in diameter and height growth and form a new forest *(20)* (fig. 2).

Even-aged, pure, or mixed stands vary in stocking but can have more than 2,470 stems per hectare (1,000/acre). When crowns close during the sapling and pole stages, understory vegetation is almost completely eliminated by shade, causing an open forest floor. Lower limbs become shaded and die, creating branchfree boles. This condition may last 200 years *(31)*.

Eventually the overstory crowns abrade and let more light into the understory, allowing development of shrubs and advance regeneration. This may occur after one to three centuries-probably depending on site quality, spacing, and disturbance history-and has been observed to last to age 500 years ***(31).*** Individual overstory trees eventually die and advance regeneration grows slowly upward, creating a multi-

Figure 2—*Pacific silver fir advance regeneration after release by clearcutting.*

Figure *3-Old-growth stand of Pacific silver fir. Barring a major disturbance, the overstory slowly breaks up and the tolerant Pacific silver fir grows in the partial shade. (Courtesy of Robert G. Wagner, Oregon State University, Corvallis)*

aged, old-growth forest with a major component of Pacific silver fir that will be self-perpetuating, barring a major disturbance (fig. 3). Pacific silver fir is referred to as the climax species at mid-elevations of its range *(9)* because of its ability to survive in the shade and to emerge in all-aged stands.

Because of its slow early height growth, associated species such as western hemlock, Douglas-fir, and noble fir initially overtop Pacific silver fir when grown in the open. After the initial overtopping, on many sites Pacific silver fir appears to outgrow and become taller than western hemlock after 100 years *(19).* On cool, moist sites at the upper extremes of the range of Douglas-fir, Pacific silver fir can stratify above Douglas-fir as well *(40).* Noble fir appears to maintain a height advantage over Pacific silver fir indefinitely on all sites where both species grow.

Pacific silver fir is one of the most shade-tolerant trees in the Northwest. There is confusion regarding its relative shade tolerance compared with western hemlock. It has been described as equal, greater, and less shade tolerant than hemlock (26,401. It can most accurately be classed as very tolerant of shade.

Most silvicultural treatments of Pacific silver fir have dealt with regeneration and early stocking levels after old-growth stands were logged. Regeneration practices vary from clearcutting followed by burning and planting to clearcutting with reliance on natural advance and postlogging regeneration, Each practice successfully obtains regeneration for certain sites and management regimes. Early stocking control-thinning sapling and pole-size trees to 495 to 740/ha (200 to 300/acre)—is practiced to increase growth rates of individual trees. Trees left in pole-size stands after thinning markedly increase in diameter growth and apparently respond to fertilization. Possible commercial thinning regimes, rotation ages, and regeneration plans for managed stands (where advance regeneration may not be prevalent) are primarily in the planning stages.

Young, post-harvest stands can develop densely from advance regeneration. These stands may require thinning to maintain diameter growth, to keep from buckling in heavy snow or wind, and to ensure advance regeneration before the next harvest.

Damaging Agents-Pacific silver fir is easily killed by fire because of its shallow rooting habit and thin bark. It has lower resistance to windthrow than Douglas-fir, western hemlock, or western redcedar. It is susceptible to windthrow after heavy partial cuts *(9)*, on the borders of clearcuts or partial cuts, and even in closed canopy stands during strong winds. Resistance to breakage from snow and damage by frost is moderate. The foliage of ***Abies amabilis*** and other true firs is more easily damaged by volcanic tephra than is the foliage of associated conifers *(22).* Several types of animal damage have been reported: heavy browsing by Roosevelt elk *(34)*, bark stripping by bears in pole-size stands, clipping of terminal buds by grouse and rodents *(13)*, and cutting of cones and cone buds by squirrels.

Pacific silver fir is susceptible to many types of insect damage. Seed chalcids ***(Megastigmus pinus*** and ***M. Zasiocarpae)*** and cone maggots ***(Earomyia abietum)*** have been known to infest a high proportion of cones during good seed years *(17).* Western hemlock looper ***(Lambdina fiscellaria lugubrosa)*** and western blackheaded budworm *(Acleris gloverana)* are serious defoliators of mixed Pacific silver fir and western hemlock stands in British Columbia. Many other loopers are of minor importance; two species that cause periodic outbreaks are the greenstriped forest looper ***(Melanolophia imitata)*** and saddleback looper ***(Ectropis crepuscularia).*** The western spruce budworm ***(Choristoneura occident&s)*** also feeds on Pacific silver fir in pure and mixed stands.

The silver fir beetle ***(Pseudohylesinus sericeus)*** and fir root bark beetle ***(P. granulatus)*** can be very destructive together and in combination with the root rotting fungi ***Armillaria mellea, Heterobasidion annosum, Phellinus weiri,*** and ***Poria subacida.*** The last major outbreak of silver fir beetles lasted from 1947 to 1955; it killed 2.5 million m^3 (88 million ft^3) of timber in Washington *(12).*

An imported pest, the balsam woolly adelgid *(**Adelges piceae**),* is the most devasting killer of Pacific silver fir. Attacks on the crown by this insect result in swelling or "gouting" of branch nodes, loss of needles, and reduced growth for many years; attacks on the stem usually cause a tree to die within 3 years. Trees of all ages and vigor are susceptible, although some individuals seem to have natural resistance. In southern Washington, damage has been heavy on high-quality sites at low elevations, such as benches and valley bottoms (28). In British Columbia, heaviest damage is on similar sites below 610 m (2,000 ft). Pacific silver firs growing with subalpine firs at high elevations are relatively immune and suffer only temporary gouting. Spread of the aphid has been slow since the major outbreak of 1950-57, but infested areas remain a problem. No effective direct control methods have been found for forest stands.

Pacific silver fir is a secondary host for hemlock dwarf mistletoe ***(Arceuthobium tsugense)*** and can be infected in mixed stands containing western or mountain hemlock. ***A. abietinum*** also attacks Pacific silver fir and western hemlock, it is more common in central Oregon in the Cascade Range. Needle casts ***(Lophodermium uncinatum, Phaeocryptopus nudus, Virgella robusta)*** and rusts ***(Uredinopsis*** spp.) are common on reproduction in some localities in British Columbia.

Thinning studies on the west coast of Vancouver Island indicated that Pacific silver fir is more susceptible to ***Heterobasidion annosum*** root and butt rots than are western hemlock, Douglas-fir, or Sitka spruce. Airborne infection of Pacific silver fir stumps was not seasonal as in other species, and infection rates were high throughout the year (29). Pacific silver fir is also one of the Northwest conifers most susceptible to laminated root rot ***(Phellinus weiri)*** (27) and shoestring rot ***(Armillaria mellea).***

Overmature Pacific silver firs are highly prone to heart rot, primarily by the Indian paint fungus ***(Echinodontium tinctorium)*** and the bleeding conk fungus ***(Haematostereum sanguinolentum).*** In British Columbia, Pacific silver firs were free of decay to age 75; then incidence increased with age to 11 percent at 275 years, 40 percent at 375 years, and 100 percent in trees more than 400 years *(6).* Released advance regeneration scarred by logging is rarely infected by heart rot fungi. In one instance, ***E. tinctorium*** was nearly absent in young stands 30 years after release, even though adjacent unlogged stands were heavily infected. Lack of suitable branch stubs for entry by fungi and rapid closing of wounds because of accelerated growth are believed to prevent infection (20).

Deterioration is rapid after logging, windthrow, or death caused by insects or diseases. Within 5 years of death, loss in cubic volume can be from 50 to 100 percent. Primary decay fungi on dead wood are ***Fomitopsis pinicola, Ganoderma applanatum, Hirschioporus abietinus,*** and ***Poria subacida.***

Special Uses

Pacific silver fir is marketed with western hemlock and is typically used for construction framing, subflooring, and sheathing. It is commonly used for construction plywood even though it is not as strong as Douglas-fir. Because of its light color and lack of odor, gum, and resin, Pacific silver fir is well suited for container veneer and plywood. It is occasionally used for interior finish and is suitable for poles. Good yields of strong pulp can be produced by both mechanical and chemical processes. It is a minor Christmas tree species, and its boughs are occasionally used for decorative greenery.

Because Pacific silver fir is common on midslopes of the Cascade Range, it is a large component of many municipal watersheds, wilderness areas, and recreation areas. Its beauty and ability to withstand or respond to human impact make it a suitable species for multiple-use management.

Genetics

Despite its extensive range, Pacific silver fir is not a highly variable species. Cortical oleoresin analyses of sample trees from northern California to the Alaska border revealed no chemical variants, and variation among populations was similiar to that within populations *(51).* Similar results were obtained from analyses of bark blister and leaf and twig oils.

No artificial hybrids of Pacific silver fir and any other species have been described. It does not hybridize with any of its true fir associates even though pollen shedding and cone receptivity periods may overlap in some localities *(7).* Some morphological intermediates of Pacific silver fir and subalpine fir have been described, but these proved not to be hybrids (36).

The only known cultivated variety of Pacific silver fir is ***Abies amabilis*** var. ***compacta,*** a dwarf form that has current branches 2 to 3 cm (0.8 to 1.2 in) long.

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