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Abies procera Rehd. Noble Fir

Pinaceae Pine family

Jerry F. Franklin

Noble fir *(Abies procera)*, also known as red fir and white fir, is an impressive true fir limited to the Cascade Range and Coast Ranges of the Pacific Northwest. At maturity, it typically has a clean, columnar bole and short, rounded crown. Noble fir attains the largest dimensions of any of the true fir species.

Habitat

Native Range

Noble fir (fig. 1) is found in the mountains of northern Oregon and Washington between the McKenzie River and Stevens Pass or latitudes 44° and 48° N. Most of its distribution is within the Cascade Range, particularly on the western slopes and along the crest. Isolated populations are found on peaks in the Oregon Coast Ranges and in the Willapa Hills of southwestern Washington.

Trees with needle and cone characteristics of noble fir have frequently been reported in mixture with California and Shasta red firs *(Abies magnifica* var. *magnifica* and var. *shastensis)* from northern California north to the central Cascade Range in Oregon. Studies of weight of seeds, number of cotyledons, and chemistry of terpenes strongly suggest that the populations north of the McKenzie River differ from the remainder of the fir complex and lack the apparent latitudinal clines in these characteristics found in the populations to the south. In any case, the ecological behavior of the populations from central Oregon south resembles that of California and Shasta red firs much more closely than that of noble fir.

The northern limits of the range of noble fir have also been a source of confusion. Early reports placed noble fir on Mount Baker, in the Olympic Mountains, and at other locations in the northern Cascades. Subsequent investigators have not found noble fir at these Washington sites.

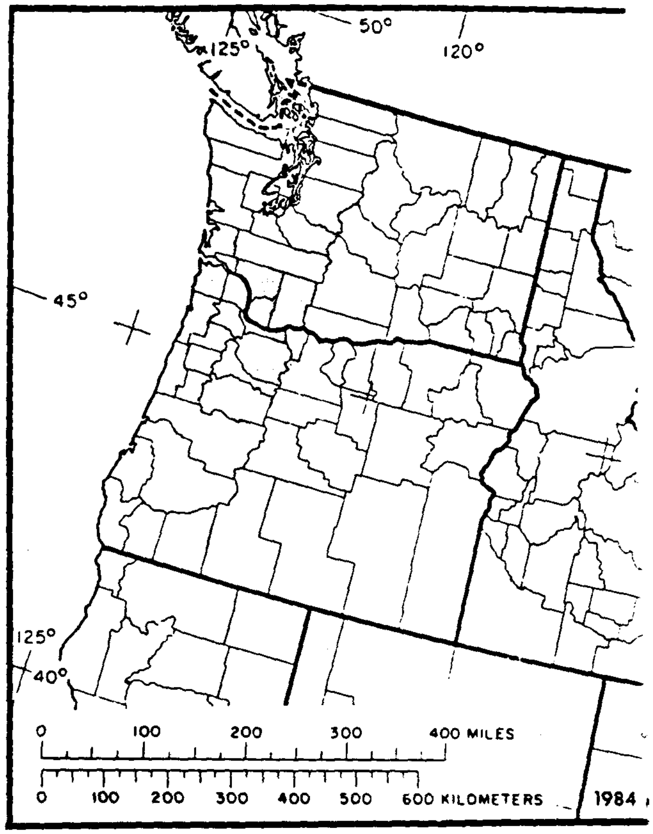

Figure 1—*The native range of noble fir.*

Climate

Noble fir lies entirely within a moist, maritime climatic region. Since it grows primarily at higher elevations—within the *Abies amabilis* zone *(10)*—high precipitation and relatively cool temperatures are characteristic. Five climatic stations within the range of noble fir provide representative data. Annual temperatures average 4.4° to 7.2° C (39.9° to 45.0° F). The mean temperature in January ranges from –4.4° to –1.1° C (24.1° to 30.0° F) and in July, from 13.3° to 16.1° C (55.9° to 60.9° F). Annual precipitation averages 1960 to 2410 mm (77.2 to 94.9 in). About three-fourths of this precipitation occurs between October and March, and much of it accumulates as snowpacks with maximum depths of 1 to 3 m (3 to 10 ft).

Soils and Topography

Noble fir inhabits rugged, mountainous regions, so steep slopes are typical. It grows on all landforms, from valley bottom to ridgetop. Positions on a slope are perhaps most typical, although the best stands

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are generally on gentle topography. In the northern half of its range, noble fir shows a preference for warm, moist exposures.

Noble fir can grow on a wide range of soils if ample moisture is available; water supply appears to be of more critical importance than soil quality. Spodosols and Inceptisols are most common. In one study of soils under seven upper-slope forest types, soils under noble fir stands had the smallest weight of forest floor (perhaps reflecting favorable decomposition conditions) and the highest levels of exchangeable calcium. Soils are typically developed in volcanic parent materials; volcanic tephra (ash and pumice) and colluvium, often including aerially deposited ejecta, are the most common materials. Profiles with multiple parent materials are often found because of multiple deposits of tephra. In the Coast Ranges, noble fir occurs on both volcanic and sedimentary bedrock.

Noble fir is generally found at elevations between 1070 and 1680 m (3,500 and 5,500 ft) in the Cascade Range in Oregon and 910 and 1520 m (3,000 and 5,000 ft) in the Cascade Range in central Washington. In the Coast Ranges of Oregon, it generally grows above 910 m (3,000 ft). It is occasionally found at much lower elevations, however, and shows excellent growth on such sites.

Associated Forest Cover

Noble fir is associated with most other Pacific Northwest conifers at some point in its range. Most commonly these are Douglas-fir *(Pseudotsuga menziesii)*, Pacific silver fir *(Abies amabilis)*, western and mountain hemlocks *(Tsuga heterophylla* and *T. mertensiana)*, western white and lodgepole pines *(Pinus monticola* and *P. contorta)*, western redcedar *(Thuja plicata)*, and Alaska-cedar *(Chamaecyparis nootkatensis)*. It is also found growing with grand and subalpine firs *(Abies grandis* and *A. lasiocarpa)*, Engelmann and Sitka spruces *(Picea engelmannii* and *P. sitchensis)*, western larch *(Larix occidentalis)*, and whitebark pine *(Pinus albicaulis)*.

Noble fir is a component of five forest cover types *(4)*: Mountain Hemlock (Society of American Foresters Type 205), Western Hemlock (Type 224), Coastal True Fir–Hemlock (Type 226), Pacific Douglas-Fir (Type 229), and Douglas-Fir–Western Hemlock (Type 230). It is a significant component only in Type 226, where noble fir stands are recognized as a major variant.

Most noble fir is found primarily within the *Abies amabilis* zone *(10)* with lesser amounts in the *Tsuga mertensiana* (particularly in Oregon) and *Tsuga heterophylla* (particularly in Washington) zones. It is a component of many recognized plant community and habitat types within these zones *(3,7,9)*. Noble fir presence by habitat type in southern Washington *(9)* is typical of the general pattern. Noble fir is poorly represented on colder sites in the *Tsuga mertensiana* zone and is scarce in the very widespread and environmentally moderate *Abies amabilis/Vaccinium alaskaense* habitat type. It is abundant in the relatively warm, well-watered *Abies amabilis/Tiarella unifoliata* habitat type and in the *Abies amabilis/Xerophyllum tenax* habitat type. Noble fir attains best development on sites characterized by rich herbaceous understories.

Understory plants associated with noble fir typically include an array of ericaceous shrubs and evergreen herbs. Shrubs *(10)* include rustyleaf menziesia *(Menziesia ferruginea)*, Alaska huckleberry *(Vaccinium alaskaense)*, big huckleberry *(V. membranaceum)*, red huckleberry *(V. parvifolium)*, ovalleaf huckleberry *(V. ovalifolium)*, Cascades azalea *(Rhododendron albiflorum)*, Pacific rhododendron *(R. macrophyllum)*, and various currants *(Ribes* spp.). Common herbs include beargrass *(Xerophyllum tenax)*, two trailing blackberries *(Rubus lasiococcus* and *R. pedatus)*, avalanche fawnlily *(Erythronium montanum)*, queenscup *(Clintonia uniflora)*, purple twistedstalk *(Streptopus roseus)*, slim Solomon's seal *(Smilacina sessilifolia)*, coolwort foamflower *(Tiarella unifoliata)*, and white inside-out-flower *(Vancouveria hexandra)*.

Life History

Reproduction and Early Growth

Flowering and Fruiting—Like other true firs, noble fir is monoecious and produces female strobili high in the crown and clusters of male strobili in a zone below. Female strobili are borne singly or in groups of two, or rarely, up to five, on the upper side of 1-year-old twigs. Male strobili are borne in clusters of up to 30 or more on the undersides of branchlets.

Phenological data for noble fir at three locales and over 3 years show the following ranges in timespans *(12)*:

Male bud burst	May 7 to June 2
Female bud burst	May 11 to June 4
Vegetative bud burst	May 21 to July 5
Pollen shedding	June 1 to July 5
Period of female receptivity	May 25 to July 6
Initiation of seed dispersal	Sept. 27 to Oct. 7

Slightly earlier dates have been recorded for some events *(6)*. Timing of phenological events has varied as much as 2 weeks in 3 years at the same site *(12)*. Events are typically delayed by 1 or 2 days for each 30-m (100-ft) rise in elevation.

Seven developmental stages have been identified for female strobili *(12)*, beginning with bud swelling and ending with cone shattering. A period of early rapid growth coincides with pollen receptivity; this growth period does not appear to be as sensitive to temperature as earlier growth periods. Cone growth is generally completed by mid-August of the same year.

Development of male strobili appears to be sensitive to temperature and humidity; pollen shedding requires warm, dry weather.

Seed Production and Dissemination—Trees may begin bearing cones at 20 years of age, although commercial seed bearing is generally considered to begin at about 50 years. Older trees can produce large quantities of seeds. The current record is an estimated 3,000 cones, potentially yielding more than 1,500,000 seeds, produced by one tree in a single year. In studies extending over the Pacific Northwest Region, noble fir produced a medium or better crop (median cone count of at least 10 cones per tree) 42 percent of the time *(7,13)*. Cone production at particular locations was much poorer, however, especially in the high Cascades and along the eastern margin of the range of noble fir. Individual stands had intervals of as long as 6 years between medium cone crops.

Seed quality is typically poor. Collections from seed traps in natural stands (equivalent to 54 seed years) had a maximum of 49 percent sound seeds; the overall average was about 10 percent. Seed quality is strongly correlated with the cone crop, which must be at least medium size before sound seeds exceed 10 percent *(7)*. Most unsound seeds collected in seed traps consist of round but unfilled seeds, relatively small amounts being damaged by insects.

Possible explanations for the poor seed quality include inadequate pollen (especially in young stands and poor seed years), poor synchrony between female receptivity and pollen shedding *(12)*, selfing, insects, and meiotic irregularities in developing pollen. The most important factors may be similar to those suggested for Pacific silver fir *(24)*. Firs have unspecialized pollen mechanisms, long periods of pollen dormancy, a short time after germination when pollen tubes must develop and penetrate the long nucellar tip, and archegonia that abort quickly if unfertilized. These traits, plus a low number of archegonia, may cause the low percentage of viable seeds.

Noble fir seeds are not widely dispersed because of their weight, which averages 29,750 seeds per kilogram (13,500/lb) *(25)*. Wind is the major agent of dispersal. Although the seeds can fly over 600 m (2,000 ft) *(22)*, most actually fall within one or two tree heights of the seed trees *(1)*. Thornburgh *(29)* thought that the local distributional pattern of noble fir was mainly controlled by limited seed dispersal capabilities coupled with low resistance to fire. Most noble firs in his study area were in burns that were narrow in one dimension. In one large burn that was wider than the others, noble fir grew mostly along the edges.

Seedling Development—Noble fir seeds are of transient viability under natural conditions, and most germinate in the first growing season after dispersal. They remain viable for only one season in the forest floor. Germination is epigeal. Noble fir seeds germinate freely, and seedlings grow well in the open or in moderate shade on any moist humus or mineral soil. Initial development of seedlings is typically slow. Total height of 1-year-old seedlings is 2 to 5 cm (0.8 to 2.0 in), of which 1 to 3 cm (0.4 to 1.1 in) is growth above the whorl of four to seven cotyledons. Seedlings typically require 3 to 5 years to reach a height of 0.3 m (1 ft).

Seed dispersed after snow covers the ground may germinate in and on the snowbanks the next spring, with essentially no chance for survival of such germinants.

Natural regeneration of noble fir appears to have variable success. In one early study, it was so rapid and abundant that it was used to support the hypothesis of reproduction from seed stored in the duff *(21)*. Noble fir was disproportionately successful at regenerating in some small burns at high elevations, but it also failed to regenerate in one small burn where it consisted of 25 percent of the potential seed source *(29)*. Competing vegetation may deter regeneration of noble fir on some sites *(6)*.

Little information is available on regeneration of noble fir after clearcutting. On some clearcuts, regeneration is successful; on others, it can be sparse despite an available seed source. Stocking was found to be superior to that of Douglas-fir on three of five upper-slope habitat types in the central Willamette National Forest in Oregon *(28)*. The 15- to 17-year-old clearcuts had 282 to 1,779 noble fir seedlings per hectare (114 to 720/acre), depending on habitat type. Growth was slow; noble fir reached heights of 30 to 51 cm (12 to 20 in) at 7 years. In summary, although development of good natural noble fir regeneration is possible, it is not yet predictable.

Early growth of planted seedlings is variable, depending on site conditions and stock. In one study, growth was slow; noble fir seedlings were only 8.4

Figure 4—*Stands of noble fir are capable of prodigious growth in volume as in this 110-year-old stand at Wildcat Mountain Research Natural Area, Willamette National Forest, in the Cascade Range, OR. Volumes in this stand exceed 2100 m³/ha (150,000 fbm/acre).*

(7,14) (fig. 4). Sustained height growth, high stand densities, a high form factor, and thin bark all contribute to the development of large volumes of trees and stands. Volumes of about 1400 m³/ha (100,000 fbm/acre) are indicated at culmination of mean annual increment on site class II lands (for example, site index 36 m or 119 ft at 100 years). In the grove at Goat Marsh Research Natural Area on the southwestern slopes of Mount St. Helens in Washington, the gross volume of the best contiguous 1-ha (2.47-acre) block is 5752 m³/ha (82,200 ft³/acre or 407,950 fbm/acre); this value significantly exceeds the best gross volume for an acre of Douglas-fir. British yield tables for noble fir plantations indicate that yields from managed stands should also be high *(2)*.

The high form class (small amount of taper) c noble fir has been noted by many foresters and scien tists *(2)*.

Culmination of mean annual increment (MAI) ap pears to be relatively late in normally stocked stand. of noble fir. Volume and, to a lesser extent, MA increase rapidly in stands from ages 70 to 100 years The approximate culmination of MAI for site class II (site index of 36 m or 119 ft) seems to be between 115 and 130 years.

Various comparisons of growth have been made between noble fir and Douglas-fir *(7,17,23)*. Site index at 100 years for noble fir is almost always higher than for Douglas-fir on upper-slope habitat types. Despite the slower initial start, noble fir overtops the associated Douglas-firs. Yields of noble fir stands at various ages are 10 to 51 percent higher in board-foot volume and 56 to 114 percent higher in cubic-foot volume than shown in the normal yield tables for Douglas-fir stands of comparable site indexes.

Rooting Habit—The main root of noble fir is slow growing, whereas lateral roots develop rapidly and have few branches *(30)*. Root systems of typical 1- to 3-year-old seedlings do not appear fibrous, and there is no well-developed taproot. The absence of an early taproot may explain why seedlings survive only in moist soils.

Little is known about the rooting habit of noble fir trees beyond the seedling stage. Noble fir appears to be at least moderately windfirm, certainly superior to western hemlock and Engelmann spruce.

Reaction to Competition—Noble fir has the most intolerance for shade of American true firs. Regeneration cannot be established under a closed forest canopy. Consequently, noble fir is considered a seral or pioneer species subject to replacement by its very tolerant associates, Pacific silver fir and western hemlock. It is classed as having intermediate tolerance to shade. Overtopped noble fir saplings and poles may occasionally persist. Seedlings became established in partial shade in the Oregon Coast Ranges *(8)* and should, therefore, be able to establish themselves successfully under all but the densest shelterwoods. This ability, along with the heavy seed, indicates that shelterwoods or small clearcuts should be the preferred cutting method for natural regeneration of noble fir.

Noble fir prunes itself well in closed stands and develops a short, rounded crown. This short crown, along with an apparent inability to form epicormic or adventitious sprouts, may be a factor in the decline and death of mature noble firs exposed to major stresses, such as along a clearcut boundary. The crown may be unable to sustain the tree when altered temperature or moisture conditions cause higher physiological demands.

Damaging Agents—Insects can be common in cones and seeds. In a study of two locales in a modest seed year, 36 per cent of noble fir seeds were affected by insects *(26)*. The fir seed chalcid *(Megastigmus pinus)* was found in 21 percent of the seeds; not all these seeds would necessarily have been filled, however, as the chalcid can develop in unfertilized seeds. Fir cone maggots *(Earomyia barbara* and *E. longistylata)* affected 12 percent and a cone moth *(Eucosma siskiyouana)* 6 percent of the seeds. Other cone insects have been identified by Scurlock *(26)*. One of these, *Dioryctria abietivorella*, can mine buds, shoots, and trunks, as well as cones.

Insects reported as attacking noble fir include two bark beetles *(Pseudohylesinus nobilis* and *P. dispar (15)*; a weevil, *Pissodes dubious*, sometimes in association with the fir root bark beetle, *Pseudohylesinus granulatus*; and a large root aphid, *Prociphilus americanus*. The balsam woolly adelgid *(Adelges piceae)* does not infest noble fir to a significant degree *(15)*, despite earlier reports of susceptibility *(6)*. *Adelges nusslini* does infest ornamental noble firs in Canada.

Mature noble firs are relatively free of serious pathogens. Gray-mold blight *(Botrytis cinerea)* and brown felt mold *(Herpotrichia nigra)* cause some damage and loss of seedlings. Numerous foliage diseases—needle cast fungi and rusts—attack noble fir, but none are considered serious threats except on Christmas trees.

Butt and root rots currently known to infect noble fir are *Phaeolus schweinitzii, Inonotus tomentosus, Poria subacida*, and possibly *Stereum chaillettii*. Hepting *(19)* identifies no major root diseases that kill noble fir, although such pathogens may exist.

Trunk rots are occasionally important, generally only in overmature timber. The principal trunk rot is Indian paint fungus *(Echinodontium tinctorium)*. Others include *Phellinus pini, Fomes nobilissimus, F. robustus, Fomitopsis officinalis, F. pinicola*, and *Polyporus abietinus*.

Noble fir in the extreme southern part of its range is attacked by dwarf mistletoe, but this is apparently *Arceuthobium tsugense* and not *A. abietinum (5)*. Mistletoe infections have been associated with extensive mortality of branches *(5)*.

Bark is occasionally stripped from the lower boles of pole-size noble firs by black bear. In one 70-year-old stand, more than half the noble firs had large basal scars from such attacks.

Climatic damage to noble fir includes occasional snow breakage of tops and leaders (especially in sapling and pole-size stands) and windbreak and windthrow of mature boles. The species is very tolerant of exposed sites, such as are found along the Columbia River Gorge between Oregon and Washington.

Special Uses

The wood of noble fir has always been valued over that of other true firs because of its greater strength. Loggers called it larch to avoid the prejudice against the wood of true fir; the two Larch Mountains opposite one another across the Columbia River near Portland, OR, were named for the noble fir that grows on their summits. Because of its high strength-to-weight ratio, it has been used for specialty products, such as stock for ladder rails and construction of airplanes.

In 1979, noble fir constituted about 12 percent of the Christmas tree production in the Pacific Northwest and was priced (wholesale) 35 to 40 percent higher than Douglas-firs. Noble fir greenery is also in considerable demand and can provide high financial returns in young stands.

Like most true firs, noble fir is an attractive tree for ornamental planting and landscaping.

Genetics

Noble fir has a high self-fertility *(27)*. Selfing produced 69 percent of the sound seeds produced by outcross pollination; there was no difference between selfed and outcrossed progeny in weight and germination of seeds or in survival after 3 years. The number of cotyledons was greater for selfed individuals, but 3- and 10-year height growth was less. Survival of outplanted outcross trees did not differ after 10 years from that of wind-pollinated and selfed trees.

Population Differences

Variation in cotyledon number and seed weight *(11)*, monoterpenes *(32)*, and seedling characteristics has been studied in noble fir populations. Substantial variability exists in cotyledon number and seedling characteristics but does not appear to be related to latitude. Furthermore, noble fir appears discontinuous in characteristics from the fir populations south of the McKenzie River in Oregon. The southwestern Oregon populations may be a part of a strong latitudinal gradient that includes California red fir and extends south to the Sierra Nevada and California Coast Ranges.

Races and Hybrids

No races of noble fir are known within its natural range, but three horticultural varieties *(glauca, prostrata*, and *robustifolia)* are known.

Noble fir has been artificially crossed with several other true firs. It interbreeds readily with California red fir, and reciprocal crossings have high yields of viable seed. Some noble fir parents yield nearly as much seed from pollen of California red fir as from local noble fir pollen. Other crossings reported in the literature are *Abies concolor* (supposedly "confirmed"), *recurvata, sachalinensis, balsamea*, and *lasiocarpa*. None of these have been repeated, however, and all are seriously questioned as to validity.

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