Abies fraseri (Pursh) Poir.

Fraser Fir

Pinaceae -- Pine family

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Fraser fir *(Abies fraseri),* also called southern balsam fir and she-balsam, is a small- to medium-size tree. It is the only fir endemic to the southern Appalachian Mountains. The largest tree on record measures almost 86 cm (34 in) in d.b.h., 26.5 m (87 ft) tall, and has a crown spread of 15.8 m (52 ft). Because of the high elevation at which Fraser fir grows, its primary value is for watershed protection and scenic attraction.

Habitat

Native Range

Fraser fir has a disjunct distribution, restricted to high elevations in the southern Appalachian Mountains of southwestern Virginia, western North Carolina, and eastern Tennessee.

- The native range of Fraser fir.

Climate

Fraser fir grows in a cold, moist climate characterized as a cool-temperate (microthermal) rain forest with a well-distributed mean annual precipitation of 1900

to 2540 mm (75 to 100 in) and average summer temperatures of 16° C (60° F) or less. Average annual temperature varies from 6° C (43° F) at the summit of Mount Mitchell in North Carolina to 9° C (48° F) at the 1524-m (5,000-ft) level in the Great Smoky Mountains National Park. At Mount Mitchell, average January-February temperature varies from -2° C (28° F) to -1° C (30° F), with 147 days below 0° C (32° F). Average July temperature is 15° C (59° F). The frost-free period is 130 to 140 days.

Fog is a very important environmental factor, reducing transpiration and adding measurably to precipitation as fog drip (21). During the growing season, fog may be present on 65 percent or more of the days.

Soils and Topography

There is considerable variation in color, depth, and organic matter content in the soils that support Fraser fir. A typical profile has well-developed organic and A_1 horizons and a B horizon differentiated by color but not by accumulations of clay or iron.

Soils are shallow and rocky, with bedrock within 50 to 80 cm (20 to 32 in) of the mineral soils surface (23). The upper 5 to 10 cm (2 to 4 in) of the mineral soil are typically black and greasy, underlaid by a leached gray or yellowish-brown sandy subsoil. Organic surface layers are occasionally thick but usually quite thin, ranging from 2 to 7 cm (0.8 to 2.8 in). The soils are extremely acid; the A horizon pH is about 3.5 and the B horizon pH 3.8 to 4.2. Soil under fir stands above 1920 m (6,300 ft) may be very shallow, with only 15 to 20 cm (6 to 8 in) of a black A horizon lying directly on bedrock (7). Most soils on which Fraser fir grows are Inceptisols.

Fraser fir grows at elevations as low as 1372 m (4,500 ft) on north slopes and protected coves but is found mostly above 1676 m (5,500 ft). It grows at 2037 m (6,684 ft) on top of Mount Mitchell, the highest point in eastern North America.

Associated Forest Cover

Fraser fir is a component of four forest cover types (10): Pin Cherry (Society of American Foresters Type 17), Red Spruce-Yellow Birch (Type 30), Red Spruce (Type 32), and Red Spruce-Fraser Fir (Type 34). It is a minor stand component at the lower elevations, increasing in frequency with altitude to form nearly pure stands at elevations above 1920 m (6,300 ft). At the highest elevation, mountain-ash *(Sorbus americana)* is practically the only canopy associate (32). At middle and lower elevations, red spruce *(Picea rubens),* yellow birch *(Betula alleghaniensis),* eastern hemlock *(Tsuga canadensis),* yellow buckeye *(Aesculus octandra),* and sugar maple *(Acer saccharum)* are the most common canopy associates (6,7,8,13,16,32). Mountain maple *(Acer spicatum)* and serviceberry *(Amelanchier* spp.) are frequent understory trees.

Shrubs associated with Fraser fir include hobblebush *(Viburnum alnifolium),* witherod *(V. cassinoides),* redberry elder *(Sambucus pubens),* southern mountain cranberry *(Vaccinium erythrocarpum),* minnie-bush *(Menziesia pilosa),* southern bush-honeysuckle *(Diervilla sessilifolia),* catawba (purple) rhododendron *(Rhododendron catawbiense),* smooth gooseberry *(Ribes rotundifolium),* and smooth blackberry *(Rubus canadensis).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- Fraser fir is monoecious. Flower buds usually open from mid-May to early June. Female flowers are borne mostly in the top few feet of the crown and on the outer ends of branches. Male flowers are borne below female flowers, but mostly in the top half of the crown. The fruit is an erect cone, 3.5 to 6 cm (1.4 to 2.4 in) long and 2.5 to 4 cm (1.0 to 1.6 in) wide. The strongly reflexed bracts, much longer than the scales, distinguish Fraser fir from balsam fir.

Seed Production and Dissemination- Seed production may begin when trees are 15 years old. Good seed crops occur every other year with light crops in the intervening year. The number of seeds ranges from 119,000 to 174,000/kg (54,000 to 79,000/lb) and averages 134,500 (61,000). The combination of lightweight winged seeds, steep slopes, and high winds makes for good seed dispersal. Seeds may be moved as much as 1.6 km (1 mi), with 50 percent falling over 274 m (900 ft) from their source. Fruit ripens and is dispersed from September through mid-October.

Seedling Development- Germination is epigeal. It approximates 50 percent of sound seeds and appears to be correlated with length of the maturation period. Germination of seeds collected on August 31 was 18 percent but increased to 66 percent for seeds gathered during cone disintegration about September 23 (26). During poor seed years, the yield and quality of seed decrease and insect damage increases (27,28). In a good year, seeds averaged 78 percent filled, with only 3 percent infested by insects. In a poor year, only 36 Percent were filled, and 29 percent of that were infested by a seed chalcid, *Megastigmus specularis.*

Fraser fir seeds germinate well on mineral soil, moss, peat, decaying stumps and logs, and even on litter that is sufficiently moist. When seeds germinate on surface litter, the seedlings usually die during dry weather. Moss and peat commonly remain damp, however, and the appearance of moss on the forest floor indicates sufficient moisture to make germination possible with survival throughout the growing season (19).

Stratification of Fraser fir seeds may not be wholly necessary. Stratification for 60 days in peat moss at 3° C (38° F) increased the speed of germination but did not affect the number of seeds germinating. Germination and initial establishment are

best under a forest cover. The greatest obstacle to natural reforestation is the desiccation of the moss and peat layer after cutting or fire, followed by surface drying of the mineral soil. Once established, growth is best in full light. Under a dense canopy, Fraser fir may be only 0.6 to 0.9 m (2 to 3 ft) tall in 20 years. In old-growth, all-aged stands, it may take 40 years to attain sapling size. In the absence of shade, it grows much faster. Planted seedlings in cutover forest averaged 2.5 m (8.2 ft) tall in 11 years, with 0.6 m (2 ft) of growth in the 11th year. Under favorable conditions of weed control and fertilization, Christmas tree plantings grow to 1.8 m (6 ft) in 6 to 8 years.

Vegetative Reproduction- Under natural conditions, layering may occur when lower branches come in contact with moist soil, but it is not an important reproductive mechanism. Fraser fir planting stock may be produced by rooting cuttings under controlled temperatures and moisture. A high percentage of stem cuttings from young trees can be induced to root. In one study, rooting was 92 percent in cuttings from 5-year-old trees, compared with 54 percent from 12-year-olds and 29 percent from 22-year-olds. Rooting of cuttings from 32- to 65-year-old trees averaged 4 to 6 percent and varied with crown position (15). It is possible to propagate Fraser fir by stump culture (32). When a Christmas tree is cut, the bottom whorl of limbs is left on the stump. After these turn upward, the most vigorous limb is allowed to develop into another tree.

Sapling and Pole Stages to Maturity

Growth and Yield- Fraser fir is a relatively small tree, rarely more than 24 m (80 ft) tall and 61 cm (24 in) in d.b.h. It is more frequently 15 to 18 m (50 to 60 ft) tall and less than 30 cm (12 in) in d.b.h.

Age at natural death is around 150 years (23). Old-growth stands of mixed spruce-fir may carry very high basal areas of 57 to 60 m^2/ha (250 to 260 ft^2/acre) with 1,977 to 2,347 trees/ha (800 to 950/acre) 2.5 cm (1.0 in) in d.b.h. and larger (7). In such stands the fir may average 25 to 28 cm (10 to 11 in) in d.b.h. Yields of mixed spruce-fir over large acreages have been reported to average 210 to 350 m^3/ha (15,000 to 25,000 fbm/acre), some stands yielding 560 to 700 m^3/ha (40,000 to 50,000 fbm/acre) (24). Pulpwood yields averaged 252 to 315 m^3/ha (40 to 50 cords/acre). In such stands, fir constituted one-fourth or less of the total volume.

At the highest elevations where fir forms essentially pure stands, it is most frequently 9 to 12 m (30 to 40 ft) tall, and most canopy stems are 18 to 23 cm (7 to 9 in) in d.b.h. Stems as large as 31 cm (12 in) in d.b.h. are very rare in such stands (31).

Rooting Habit- The root system of Fraser fir is usually shallow because it customarily occupies shallow soils. Root growth is more rapid and rooting depth greater, however, than that of its frequent associate, red spruce (8). Roots are able to penetrate to depths greater than 61 cm (24 in) where soil is available, permitting fir

to occupy somewhat drier sites than red spruce (7).

Reaction to Competition- Fraser fir is classified as very tolerant to shade and is considered a climax species. It becomes established and survives for many years under a dense canopy, growing only 2.5 to 5.1 cm (1 to 2 in) per year. When released, it has a marked capacity for recovery. Trees suppressed for 50 years or more have grown rapidly for a time after release (23). Fraser fir tends to form very dense stands which thin slowly and may stagnate in the pole stage (7).

The best means of regenerating fir is probably some method of partial cutting to establish advance reproduction. Harvest methods such as shelterwood or group selection seem ideally suited to accommodate its needs for early shelter but open conditions for later growth. Because of its extreme tolerance, it could probably be handled under a single-tree selection system as well.

Damaging Agents- Because of shallow soils and shallow root systems, Fraser fir is subject to windfall (7). Patches of windthrown trees are a common sight on exposed ridges. Occasional trees on higher ridges are struck by lightning. Heart rots are common in older trees and may increase susceptibility to wind damage. In Christmas tree plantations, two-spotted spider mite *(Tetranychus urticae)* can be particularly damaging, causing discoloration and needle loss. On soils with poor internal drainage, root rot caused by the fungus *Phytophthora* spp. becomes a major problem.

All damaging agents are insignificant in comparison to the balsam woolly adelgid *(Adelges piceae)*. It was discovered in North Carolina in 1957 on Mount Mitchell and has since spread to all areas of Fraser fir (1,2,3,4,9,17,18). Mortality progressed rapidly from 11,000 trees in 1958 to about 1.75 million by 1970. Fir mortality has been extensive in all areas except Mount Rogers in Virginia, where infestations dating back to the mid-1960's were first discovered in 1979. Adelgids attack branches, twigs, nodes, and bud bases of fir, but stem attack is the predominant form of infestation. Death usually follows 2 to 5 years after infestation of the bole because of direct translocation impairment.

Further damage by other organisms is associated with attack by the balsam woolly adelgid (11, 12). Weakened trees are often attacked by bark beetles, wood wasps, and other wood-boring insects, which also may introduce fungal pathogens (12). Incidence of root rot caused by *Armillaria mellea* was shown to increase with increasing severity of adelgid damage. Damaged and weakened trees are also more susceptible to windthrow and top breakage.

Various chemical insecticides have been found effective against the balsam woolly adelgid, but none has been found technically or economically feasible for use over large forested areas (14). Chemical insecticides are useful, however, for small and accessible stands of high value. Control by a variety of introduced predators has been ineffective.

Openings created by adelgid kill usually contain numerous fir seedlings (5), but the long-term consequences of adelgid attack are unknown. Unless new methods of adelgid control are found, the status of Fraser fir in natural stands is extremely uncertain.

Special Uses

The remaining stands of Fraser fir have very limited commercial value. However, their location in the cool climate of the loftiest peaks and ridges makes them extremely valuable for watershed protection, as they hold the shallow soil to the steep wet slopes. They are also a unique scenic attraction in a region of growing recreational appeal.

Growing and harvesting this species for Christmas trees and boughs is a multimillion-dollar business in the southern Appalachians. Because of its thick green foliage, beautiful shape, fragrance, and needles that are retained unusually well, Fraser fir is unequaled as a Christmas tree (29,32). It is also used widely as an ornamental yard tree.

Fraser fir seeds and terminal buds are eaten extensively by the red squirrel.

Genetics

Fraser fir was once considered a variety of balsam fir and designated *Abies balsamea* var. *fraseri* Nutt., but the two species are now differentiated on the basis of cone-bract and cone-scale length. *Abies balsamea* has bracts shorter or rarely slightly longer than its scales; *A. fraseri* has strongly reflexed bracts much longer than its scales (20). *Abies balsamea* var. *phanerolepis* in West Virginia and northern Virginia is considered by some to be a natural hybrid of *A. balsamea* and *A. fraseri* because it is intermediate in range and the two have certain common characteristics. Others contend that the disjunct *Abies* subpopulations of the southern Appalachians are relicts of a once-continuous ancestral fir population with clinal variation along a north-south gradient (22,25,30,33).

Artificial crosses of *Abies balsamea x A. fraseri* have been made successfully. A cultivar, *A. fraseri* cv. *prostrata,* is a dwarf shrub with horizontally spreading branches used for ornamental purposes (18).

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