Picea breweriana Wats. Brewer Spruce

Pinaceae Pine family

Dale Thornburgh

Brewer spruce *(Picea breweriana),* named for its first collector, is often considered "mysterious" because this attractive conifer is found on seldom-visited high mountain ridges and steep north slopes. Its other common name, weeping spruce, is derived from the distinctive feature of many ropelike branchlets that hang in a fringe from all but the topmost slender horizontal limbs. This branching habit results in many knots in the wood, which has little commercial importance.

Habitat

Native Range

Brewer spruce (fig. 1) is found only in the mountains of northwestern California and southwestern Oregon near the Pacific coast between latitudes 40" 50' N. and 42" 40' N. The best developed stands are on the high ridges of the western Siskiyou Mountains in California and Oregon. Other concentrations are found on high ridges and in upper valleys of the Marble, Salmon, and Trinity Mountains of California *(7).* Throughout the rest of the range, Brewer spruce grows as a single tree and as scattered small populations in valleys and on ridgetops *(9,12,16).*

Climate

The range of Brewer spruce is primarily influenced by the maritime climate of the Pacific Ocean: cool, wet winters and warm, relatively dry summers. The climate changes drastically, however, from west to east across the range of Brewer spruce, which is 113 km (70 mi). On the most westerly ridge occupied by Brewer spruce, average annual precipitation is more than 2800 mm (110 in); farther east, it is less than 1000 mm (39 in). Most of the precipitation falls as winter rain or snow; less than 5 percent occurs in the summer. The amount of snowfall and accumulated snowpack varies greatly from year to year and geographically across the range. A few stands of Brewer spruce in valleys receive no snow some years, whereas other stands accumulate up to 4 to 5 m (13 to 16 ft) (5). Humidity is high in the western part of the range and relatively low in the eastern part. Summer fog is common along the westernmost ridges and valleys. Summer thunderstorms are common in the eastern portion of the range. Temperatures also vary widely. In the western portion, the mean temperature in January is 5" C (41" F); in July, 11" C (52° F). On the eastern edge of the range, the mean temperature is -1" C (30" F) in January and 20" C *(68"* F) in July.

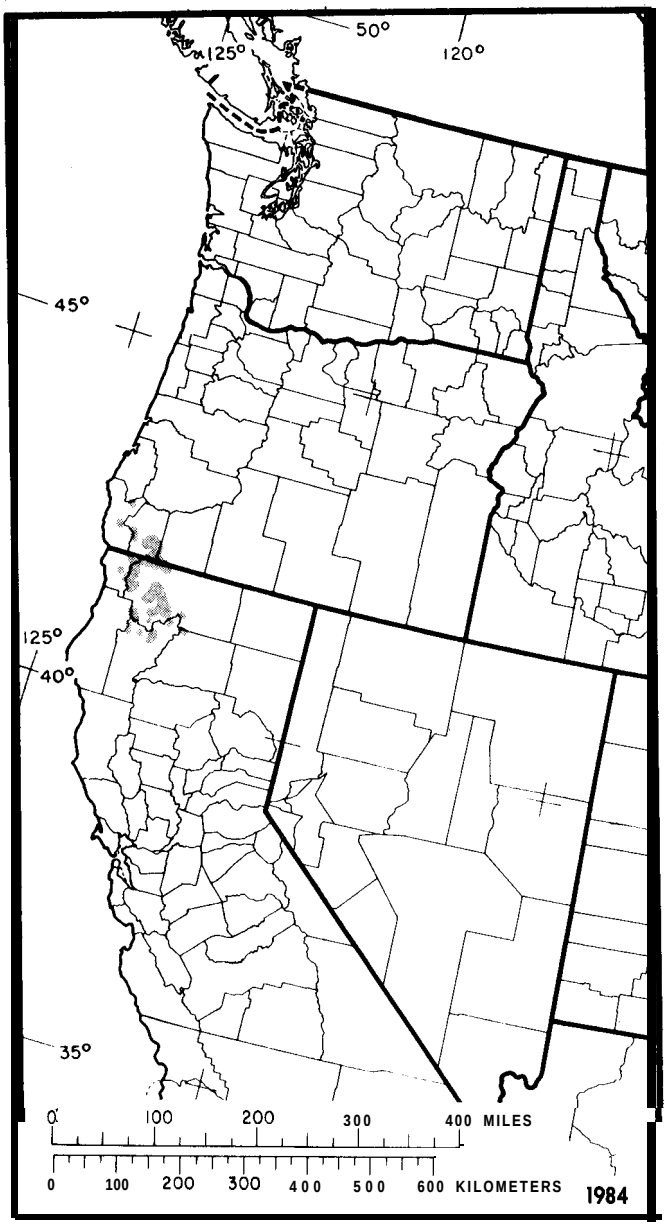

Figure *1-The native range of Brewer spruce.*

The author is Professor of Forestry, Humboldt State University, Arcata, CA.

The varied climate indicates that Brewer spruce has an ecological amplitude that should enable it to obtain a wider and more contiguous distribution. Its sensitivity to fire seems to have restricted its range *(13)*.

Soils and Topography

Brewer spruce grows on a wide variety of geologic parent materials and soils. It is found on soils developed from sedimentary, granitic, serpentine, and metavolcanic rocks. Most of the large stands of Brewer spruce are found on shallow, rocky, undeveloped soils of the order Entisols; a few stands are on deeper, well-developed soils. Throughout its range, Brewer spruce is never found in areas where the soils are saturated during the growing season. It appears to be generally restricted from the more fertile soils by competition from true firs ***(Abies*** spp.). Brewer spruce is more abundant on less fertile soils.

Brewer spruce is found on most topographic locations-ridgetops, north- and south-facing slopes, benches, and valley bottoms. The only habitat restriction is boggy or wet areas. The apparently preferred location is the steep, north-facing slopes where the largest stands are located. In the western Siskiyou Mountains, these locations are north slopes near the tops of the ridges, but in the eastern Salmon Mountains, the largest stands are on middle, north-facing slopes. Brewer spruce is found from elevations of 700 to 2100 m (2,300 to 6,900 ft) in the western Siskiyou Mountains and from 1370 to 2290 m (4,500 to 7,500 ft) in the eastern Klamath region.

Associated Forest Cover

Brewer spruce grows with a wide variety of associated plants and vegetation types in the montane and subalpine forests of the Klamath region. Although it grows throughout the region, its range is one of local, disjunct populations of various sizes. In some areas, it is an occasional climax tree species in mixed stands dominated by California red fir ***(Abies magnifica),*** white fir ***(A. concolor),*** or mountain hemlock ***(Tsuga mertensiana).*** In other areas, it grows in small, pure, dense stands on north-, east-, and west-facing slopes. It is also found as individuals invading seral pine stands and montane chaparral. In the Siskiyou Mountains, Brewer spruce seedlings and saplings are found in montane chaparral on all aspects. It is associated with Sadler oak ***(Quercus sadleriana),*** huckleberry oak *(Q. **uaccinifolia),*** and greenleaf manzanita ***(Arctostaphylos patula).***

Some of the best-developed stands of Brewer spruce are located on moderate east- and west-facing slopes with deep soil. These forests in the California red fir/Sadler oak habitat have a 70 to 80 percent canopy cover. Density of trees over 10 cm (4 in) in d.b.h. is 125 to 320 Brewer spruce per hectare (50 to 130/acre), 30 to 95 white fir per hectare (12 to 39/acre), 10 to 70 Douglas-fir ***(Pseudotsuga menziesii)*** per hectare (4 to 28/acre), 0 to 10 sugar pine *(**Pinus lambertiana)*** per hectare (0 to 4/acre), and 5 to 60 California red fir per hectare (2 to 24/acre). The total basal area ranges from 35 to 54 m^2/ha (153 to 235 ft^2/acre). Dense reproduction is present in the tolerant conifers: Brewer spruce, California red fir, and white fir; Brewer spruce has about one-third the total number of seedlings under 180 cm (70 in) in height.

Brewer spruce is an element of the following vegetation habitat types of the Klamath region *(2,12,13,14)*. Plants of major importance are listed for each type.

- *Abies concolor* zone, Siskiyou Mountains

Abies concolor / Vaccinium membranaceum (white fir/thinleaf huckleberry) habitat type. Brewer spruce is a minor climax species. Other shrubs: Sadler oak.

Abies concolor / Pachistima myrsinites (white fir/Oregon boxwood) habitat type. Brewer spruce is often a codominant climax species. Other trees: Douglas-fir and sugar pine. Other shrubs: Sadler oak, Oregongrape ***(Rerberis neruosu).*** Other herbs: western prince's-pine ***(Chimaphila umbellata),*** rattlesnake plantain ***(Goodyera oblongifolia),*** and vanillaleaf ***(Achlys triphylla).***

Chamaecyparis lawsoniana / Rhododendron occident&e (Port-Or-ford-cedar/western azalea) habitat type. Brewer spruce is often a minor climax species. Other trees: western white pine *(**Pinus monticola).*** Other shrubs: Sadler oak.

- ***Abies concolor*** zone, central Klamath region

Abies concolor / Chimaphila umbellata (white fir/western princes-pine) habitat type. Brewer spruce occasionally occurs as a minor climax species. Other trees: Douglas-fir, sugar pine, ponderosa pine *(**Pinus ponderosa),*** and incense-cedar ***(Libocedrus decurrens).*** Other shrubs: western, hazel *(**Corylus cornuta),*** wood rose ***(Rosa gymnocarpa),*** and snowberry *(**Symphoricarpos hesperius).***

- ***Abies magnifica*** zone, Siskiyou Mountains

Abies magnifica / Quercus sadleriana (California red fir/Sadler oak) habitat type. Brewer spruce often occurs as a minor climax species. Other trees: white fir, Douglas-fir, western white pine, and sugar pine. Other shrubs: thinleaf huckleberry.

Figure 2—*Dense stand of Brewer spruce in the* Abies magnifica *zone of the Siskiyou Mountains.*

Abies magnifica */Arctostaphylos* ***nevadensis*** (California red fir/pine mat manzanita) habitat type. Brewer spruce occasionally occurs as a codominant climax species. Other trees: western white pine. Other shrubs: Sadler oak and greenleaf manzanita.

Picea breweriana */Quercus* ***vaccinifolia*** (Brewer spruce/huckleberry oak) habitat type. Brewer spruce occurs as a codominant climax species. Other trees: western white pine, California red fir, Douglas-fir, and incense-cedar. Other shrubs: greenleaf manzanita, pine mat manzanita, and Sadler oak.

Picea hreweriana */Quercus* ***sadleriana*** (Brewer spruce/Sadler oak) habitat type. Brewer spruce occurs as the dominant climax species (fig. 2). Other trees: western white pine and white fir. Other shrubs: huckleberry oak and thinleaf huckleberry.

- ***Abies*** *magnifica* zone, central and eastern Klamath region

Abies *magnifica* / ***Leucothoe davisiae*** (California red fir/mountain laurel) habitat type. Brewer spruce is an occasional minor climax species. Other trees: white fir, lodgepole pine *(Pinus* ***contorta),*** western white pine, and mountain hemlock ***(Tsuga*** *mertensiana).* Other shrubs: swamp current ***(Ribes lacustre),*** mountain alder ***(Alnus tenuifolia),*** and mountain ash *(Sorbus californica).* Other herbs: groundsel ***(Senecio*** *triangularis),* queenscup *(Clintonia uniflora),* starflowcr *(Trientalis* ***latifolia),*** trillium ***(Trillium ovatum),*** and false Solomon's seal ***(Smilacina stellata).***

Abies magnifica */Linnaea* ***borealis*** (California red fir/twinflower) habitat type. Brewer spruce is an occasional codominant climax species in open forest stands. Other trees: Douglas-fir, white fir, western white pine, mountain hemlock, sugar pine, ponderosa pine, western ***yew (Taxus brevifolia),*** incense-cedar, Engelmann spruce ***(Picea engelmannii),*** lodgepole pine, and subalpine fir ***(Abies Zasiocarpa).*** Other shrubs: Sadler oak, wood rose, and snowberry. Other herbs: queenscup.

Abies magnifica */Quercus* ***vaccinifolia*** (California red fir/huckleberry oak) habitat type. Brewer spruce is an occasional minor climax species. Other trees: white fir, Douglas-fir, sugar pine, lodgepole pine, and western white pine. Other shrubs: greenleaf manzanita, pine mat manzanita, and bush chinkapin ***(Castanopsis sempervirens).***

- ***Tsuga mertensiana*** zone, Siskiyou Mountains

Tsuga mertensiana / Vaccinium membranaceum (mountain hemlock/thinleaf huckleberry) habitat type. Brewer spruce is a codominant climax species. Other trees: California red fir, western white pine, and Alaska-cedar ***(Chamaecyparis nootkatensis).***

- ***Tsuga mertensiana*** zone, central and eastern Klamath region

Tsuga mertensiana */Phyllodoce* ***empetriformis*** (western hemlock/heather) habitat type. Brewer spruce is an occasional codominant climax species. Other trees: California red fir, white fir, western white pine, and lodgepole pine. Other shrubs: Labrador-tea ***(Ledum glandulosum).***

Tsuga mertensiana */Quercus* ***vaccinifolia*** (western hemlock/huckleberry oak) habitat type. Brewer spruce is of minor importance as a climax species. Other trees: California red fir and western white pine. Other shrubs: pine mat manzanita, bush chinkapin, and greenleaf manzanita.

Brewer spruce is a minor component in three forest cover types (4): Mountain Hemlock (Society of American Foresters Type 205), Red Fir (Type 207), and California Mixed Subalpine (Type 256).

Life History

Reproduction and Early Growth

Flowering and Fruiting-Brewer spruce is monoecious. Strobilus buds form in early summer and develop in the fall. The dark purple male strobili are borne the following spring in axils of needles of the previous year's shoots, on branches throughout

the tree. The pollen-bearing strobili are from 19 to 32 mm (0.75 to 1.25 in) long and about 13 mm (0.5 in) in diameter. Pollen is shed in early summer; the male strobili dry and fall soon after pollen is shed. Female strobili are borne at the tips of primary branches in the upper two-thirds of the crown. They develop into erect, dark green, cylindrical conelets that are 38 mm (1.5 in) long and 13 mm (0.5 in) thick when receptive. The female conelets are apparently receptive at the time pollen is shed. The location of female and male flowers throughout the tree, concurrent with timing of strobilus development, apparently encourages selfing of Brewer spruce located singly or in small, isolated stands. After pollination, the conelets turn down and mature the same season into dark brown cones 8 to 15 cm (3 to 6 in) long. The fruit matures from September to October; dissemination immediately follows,

Seed Production and Dissemination-Seed production starts when the trees are from 20 to 30 years old. Actual production has not been determined. Observations indicate that mature Brewer spruce trees are fair seed producers; crops occur at 2-year intervals, and some trees produce cones each year.

The seeds are 3 to 5 mm (0.1 to 0.2 in) long; the wing is four times as long as the seed. The seeds are the largest of the North American spruces: 134,500/kg (61,000/lb), with a range of 112,500 to 163,000/kg (51,000 to 74,000/lb). The relatively large wing aids dissemination of the seed by the wind. Cones and seeds do not appear to be a preferred food for rodents.

Seeds may be stored for 5 to 17 years in sealed containers at low temperatures, 1° to 3" C (33" to 38" F), at a moisture content of 4 to 8 percent. A cold, moist stratification of 30 days increases germination. Germination of sound seed ranges from 50 to 96 percent; the reported average is 88 percent (15).

Seedling Development-The germination of Brewer spruce is epigeal, seedlings becoming established on all types of natural seedbeds: decaying logs, forest humus, loose soil from upturned roots, and leaf litter under brush fields. Throughout the range of Brewer spruce, natural regeneration is abundant under dense Brewer spruce-white fir stands. These stands contain an average of 1,360 Brewer spruce and 3,460 white fir seedlings per hectare (550 and 1,400/acre) less than 15 cm (6 in) in height. Brewer spruce seedlings cannot survive strong sunlight. The shallow, slow-growing root system causes the seedlings to be susceptible to the high moisture stress and temperatures of exposed sites. Brewer spruce seedlings are usually lacking in clearcuts, even when these are adjacent to stands containing large cone-bearing trees.

Seedlings are small, with four to seven cotyledons. Initial growth is slow; the epicotyl height growth is less than 6 mm (0.24 in) the first season.

Subsequent growth of seedlings is slow but quite variable. Under dense stands, the age of seedlings 1.37 m (4.5 ft) tall ranges from 27 to 82 years. Brewer spruce seedlings growing in south-facing montane chaparral were from 25 to 40 years old when they were 1.37 m (4.5 ft) tall. Small Brewer spruce survive overstory removal.

Vegetative Reproduction-Layering has not been observed in natural stands of Brewer spruce. Artificial propagation is best from seed *(10)*.

Sapling and Pole Stages to Maturity

Growth and Yield-After the seedling stage, height growth of Brewer spruce is slower than its common associates, Douglas-fir, white fir, red fir, and western white pine. In several stands in the Siskiyou Mountains, annual height growth of sapling and pole-size Brewer spruce averaged 0.15 m (0.5 ft).

Most mature stands of Brewer spruce consist of a wide range of ages and sizes. Numerous stands contain Brewer spruce up to 117 cm (46 in) in diameter, the largest 125 cm (49.3 in) in d.b.h. and 48.8 m (160 ft) in height. The biggest Brewer spruce listed by the American Forestry Association *(1)* has a circumference of 4.17 m (13.67 ft) at 1.37 m (4.5 ft) above the ground and is 51.8 m (170 ft) tall; it is located in the Siskiyou National Forest in southwest Oregon. The general structure of a mixed species, all-aged stand (Sadler oak habitat type) is shown in table 1.

Little volume or yield information is available for these Brewer spruce stands. The total basal area of the few stands sampled averages 47 m^2/ha (205 ft^2/acre), with a current annual increment of 2 m^2/ha (9 ft^2/acre) *(15)*.

Rooting Habit-Brewer spruce has a shallow root system on all soils; however, on deeper soils, a few vertical roots may extend several meters in depth.

Reaction to Competition-Brewer spruce is tolerant of shade at all ages and is very competitive. In the *Abies magnifica* zone on mesic to xeric sites, it is more competitive than mountain hemlock, Port-Orford-cedar, white fir, Douglas-fir, Alaska-cedar, incense-cedar, sugar pine, western white pine, ponderosa pine, lodgepole pine, and Jeffrey pine. California red fir is considered slightly more competi-

tive on mesic sites because of its faster height growth and longer lifespan.

Brewer spruce is well adapted to growth at cool temperatures during the growing season. Its light compensation point is less than 2 percent of full sunlight. Brewer spruce can withstand considerable soil drought but is extremely sensitive to high evaporation demands. The stomata close under high evaporation, halting photosynthesis ***(17).***

Brewer spruce is best managed on mesic sites characterized by the presence of Sadler oak. It grows best in mixed-species stands with uneven-aged management.

Brewer spruce can be planted under montane chaparral dominated by Sadler oak, huckleberry oak, and greenleaf manzanita. It has the ability to grow well under competition for soil moisture and light.

Damaging Agents-The shallow root system of Brewer spruce makes it more susceptible than its associates to windthrow. In some areas, the high incidence of root rot ***(Heterobasidion annosum)*** further lowers its resistance to wind. Thin bark and long weeping branches make Brewer spruce susceptible to fire. Areas predictably occupied by Brewer spruce are limited to fire-resistant open forests on north-facing slopes or rocky ridges (fig. 3). A series of major forest fires in 1987 burned throughout the range of Brewer spruce. Most of the small, pure

Table l-Stand structure of mixed species, all-aged Brewer spruce stands (Sadler oak habitat type)

Diameter class	Brewer spruce	White fir	Red fir	Douglas-fir	Western white pine	Sugar pine
cm			*trees/ha*			
3 to 29	430	506	82	69	—	—
30 to 59	114	32	27	2	7	—
60 to 89	17	15	15	—	2	—
90 to 119	2	—	7	—	—	—
120+	—	—	2	2	—	2
in			*trees/acre*			
1 to 11	174	205	33	28	—	—
12 to 23	4 6	13	11	1	3	—
24 to 35	7	6	6	—	1	—
35 to 47	1	—	3	—	—	—
47+	—	—	1	1	—	1

stands on north slopes were not damaged. In the more prevalent mixed stands, low-intensity ground fires killed the Brewer spruce and white fir, but the thick-barked Douglas-fir, pines, and California red fir survived. The recovery of Brewer spruce may take decades or centuries because of the extent of these fires. The increased potential of forest fires and inability of Brewer spruce seedlings to tolerate high moisture stress may result in its rapid extinction. If global warming occurs *(11),* it could threaten the existence of localized tree species such as Brewer spruce.

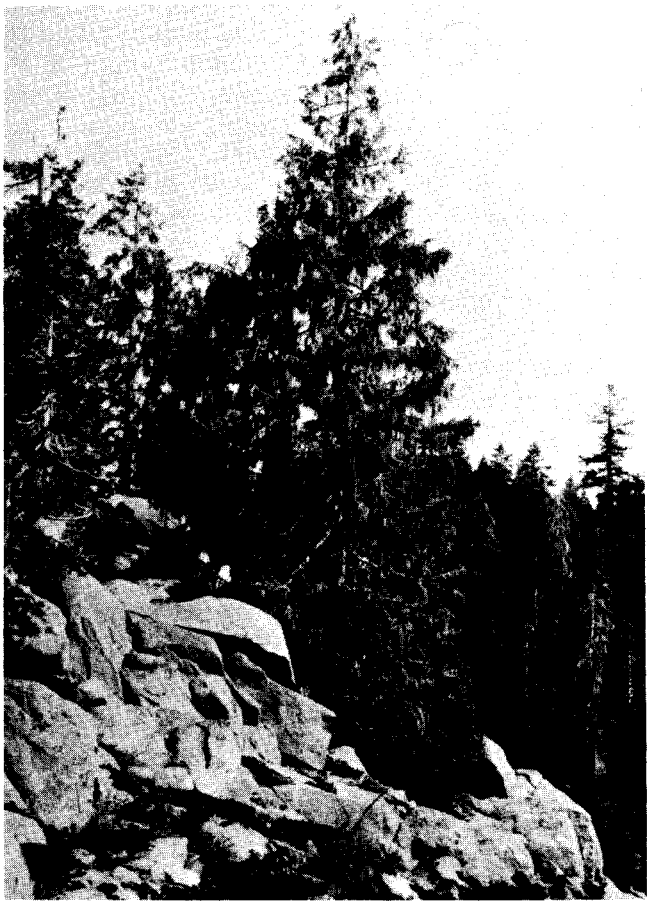

Figure *3-Brewer spruce on the Klamath National Forest, CA.*

As a small tree, Brewer spruce has enough flexibility to bend under the weight of heavy snow. It develops a pistol butt as the tree matures.

Comparatively little damage from insects or fungi has been recorded for Brewer spruce (3). The Cooley spruce gall adelgid ***(Adelges cooleyi)*** is common but does little damage (6). Seed chalcids ***(Megastigmus*** spp.) have been observed in mature seeds. In some areas, 36 percent of the Brewer spruce was parasitized by the dwarfmistletoe ***Arceuthobium***

campylopodum (8). Brewer spruce is intolerant of industrial fumes.

Special Uses

The wood of Brewer spruce has no special uses. Harvested trees are normally mixed with other species and utilized as low grade lumber. In Europe, it has been considered one of the most popular of all ornamental conifers *(10)*.

Genetics

Little if any variability has been observed throughout the restricted range of Brewer spruce. In the eastern Klamath area, Brewer spruce grows adjacent to Engelmann spruce without hybridization *(12)*.

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