

ABIES MAGNIFICA VAR. CRITCHFIELDII, A NEW CALIFORNIA RED FIR VARIETY FROM THE SIERRA NEVADA

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ABSTRACT

Abies magnifica A. Murray bis var. *critchfieldii* var. nov. Lanner (Critchfield red fir) is described. The new variety comprises the southernmost Sierra Nevada populations of California red fir. It differs from the typical variety in having smaller cones with protruding cone bracts. Because of the protruding bracts, populations of the new variety have been assumed to be disjuncts of the bracted *A. magnifica* var. *shastensis* Lemmon (Shasta red fir), described over a century ago from Mt. Shasta and considered present in NW California and SW Oregon. However, geographic patterns of morphological variation, artificial crossing results, and recent molecular studies indicate that Shasta red fir consists of California red fir introgressed by noble fir (*A. procera* Rehder), and that the new variety is not hybridized with noble fir.

Key Words: *Abies magnifica*, *Abies procera*, California red fir, natural hybridization, Shasta red fir.

Generations of investigators have been confused and intrigued by a complex consisting of California red fir (*Abies magnifica* A. Murray bis), noble fir (*A. procera* Rehder), and morphologically intermediate populations. California red fir, which ranges south down the Sierra Nevada and noble fir, which extends north into Washington are clearly differentiated by leaf, bark, and cone characters (Lamb 1912; Lanner 1999). Between their ranges, however, lies a transition zone that includes the southern Cascades, Klamath Mts., and Coast Ranges of northwestern California and southwestern Oregon. In this region, trees with intermediate morphology occur that resemble California red fir but whose cones have the long protruding (exserted) bracts similar to those of noble fir, as opposed to the hidden (included) bracts of California red fir cones (Figs. 1, 2). These populations with exserted bracts, extending from about Mt. Lassen in California to Crater Lake in Oregon have long been referred to as Shasta red fir, *A. magnifica* var. *shastensis* Lemmon or even *A. shastensis* (Lemmon) Lemmon, the type locality for which is Mt. Shasta, California (Sargent 1898; Little 1979). Lemmon (1890) was apparently infatuated with his new variety, or species as he later discerned it, whose “peculiarity... is connected entirely with the fact of its cone-bracts becoming long and protruded, a half to a full inch between the scales, rendering the large purple cones, thus decked out with tasseled fringes, a most beautiful object”.

Remarkably, protruding bracts are also found in the southernmost Sierra Nevada populations of California red fir, about 480 km. from the nearest Shasta red firs to the north. These too have, historically, often been considered to be Shasta red fir (Sargent 1898; Sudworth 1908; Chase 1911; Jepson 1923; Peattie 1953; Griffin 1993; Stuart and Sawyer 2001), despite their geographic remoteness from the northern Shasta red fir area and the absence of any such intention in Lemmon’s varietal description (Lemmon 1890).

The pattern of morphological variation of trees in the northern transition zone, more noble fir-like from south to north, and from east to west within that zone (Griffin and Critchfield 1972) suggests hybridization leading to introgression. Hybridization is further suggested by the ease of artificially crossing these firs, especially when California red fir is the maternal parent but in the reciprocal cross as well (Silen et al. 1965; Critchfield 1988). Liu (1971) found this evidence compelling enough to denote Shasta red fir as *A. X shastensis* Lemmon.

Persuasive evidence of introgression has emerged also from recent molecular studies. Oline (2008) analyzed the distribution of chloroplast haplotypes throughout the range of California red fir and within the transition zone extending into southern Oregon. Sierra Nevada populations, including the southernmost bracted ones, displayed only California red fir haplotypes. But the transition zone populations, including one from the type locality of Shasta red fir, were polymorphic, with haplotypes of both species. Oline (2008) viewed these results as “supporting a broad zone of hybridization”. Oline’s results undermine the concept of a

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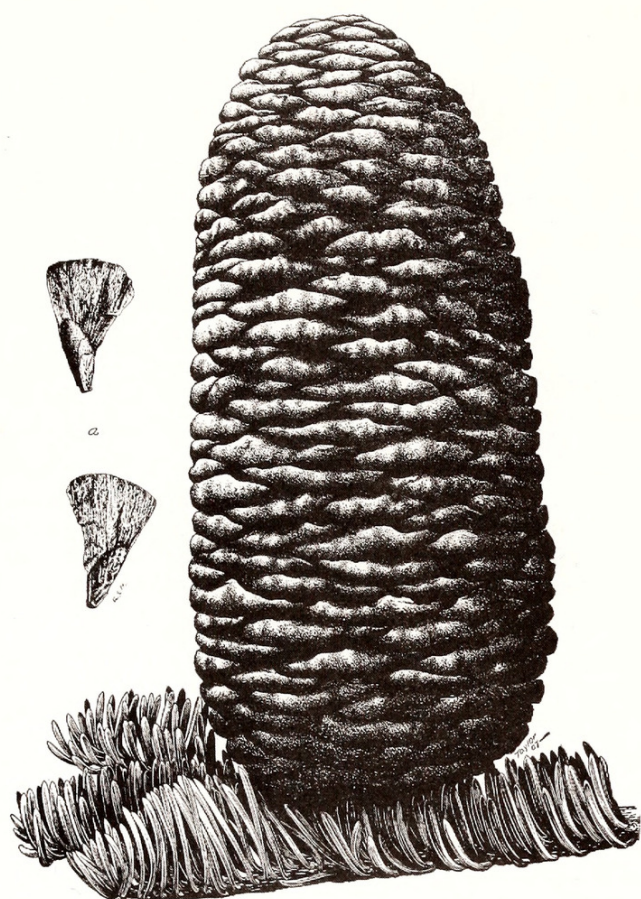
FIG. 53.—*Abies magnifica*: a, seed.

FIG. 1. Mature seed cone of California red fir with hidden (included) bracts. This morphology exemplifies the typical variety. Drawing by Taylor in Sudworth (1908).

distinctive Shasta red fir variety and strongly support viewing it as a series of hybridized and introgressed California red fir and noble fir populations—in effect a geographically widespread mature hybrid swarm.

What then of the southern “Shasta red fir” whose protruding bracts are “identical in their shape with those of the north” (Sargent 1898)? Ustin (1976) reported that California red fir cones from eight locations south of the Kings River watershed (Panoramic Point, Rabbit Meadow, Montecito, Little Baldy, Mineral King, Holby Meadow, Sherman Peak, and Mule Peak) had protruding bracts. I have examined cones or cone parts from ten additional locations south of the Kings (Alta Peak, Panther Peak, Tar Gap, Kaweah River, Mountain Home State Forest, Greenhorn Mts. (presumably Sunday Peak), Siretta Ridge, Bald Mountain, Mineral King Valley 1, and Mineral King Valley 2) and found all bearing protruding bracts. Sudworth (1916) reported finding in 1899 trees bearing cones with all protruding bracts, and trees with all hidden bracts at Alta Meadows, in Sequoia National Park. This location should be further investigated. Jeff Bisbee (personal communication) has

FIG. 54.—*Abies magnifica shastensis*: a, seed.

FIG. 2. Mature seed cone of California red fir with protruding (exserted) bracts. This morphology exemplifies the new southern Sierra Nevada variety (Critchfield red fir) as well as hybrid segregates with noble fir in NW California and SW Oregon (Shasta red fir). Drawing by Taylor in Sudworth (1908).

observed and photographed protruding bracts at Onion Valley and the Kearsarge Pass trail. These locations fall between 35°47'N (Sunday Peak) and 36°46'N (Onion Valley) and from 2012 m elevation (Mountain Home State Forest) to 2850 m (Sherman Peak).

Ustin (1976) found that cones from twenty Sierra Nevada locations north of the Kings had hidden bracts. Nor have bracted cones been reported from that area in field guides or floras I have consulted, though some show illustrations of bracted cones without explanation or comment (Storer and Usinger 1963; Storer et al. 2004). Sargent (1898), in what was perhaps the first published mention of the bracted southern red firs, pointed out that “in all the central part of the range occupied by this tree its cone bracts are acute and included”. The only apparently inconsistent observations on this point are those of cones with “slightly” protruding bracts at Onion Valley campground (Inyo National Forest) where most of the cones had protruding bracts; and at Minaret Summit and Mammoth Lakes, where they occurred north of the Kings in an area of hidden bracts (Bisbee personal communication). Photographs show these cones have only the free tips of their bracts visible. This may be evidence of interbreeding between the new variety and the

typical variety and should be examined in more detail.

Oline's (2008) finding of only California red fir haplotypes in the southern Sierra Nevada populations is not the only evidence uncoupling these populations from northern Shasta red fir. In addition, the monoterpene composition of cortical oleoresins has shown the southern red firs to be chemically much more similar to the typical California red fir than to Shasta red fir of the northern transition zone (Ustin 1976; Zavarin et al. 1978). For these reasons it is appropriate to provide for the southernmost Sierra Nevada populations of California red fir a new variety.

A NEW VARIETY OF *ABIES MAGNIFICA*

Abies magnifica* var. *critchfieldii Lanner, var. nov. (Critchfield red fir; Fig. 2).—Type: USA, California, Tulare Co., Mountain Home State Forest, SW 1/4 SE 1/4 Sec. 25, T19S R30E, MDB & M, in mixed conifer forest on well-drained south slope, 6600 ft. (2012 m), 7 October 1947, *L. T. Burcham* 260 (holotype: UC-907558 including separately filed cone coll. no. 0335).

Abies magnifica var. *critchfieldii* ex var. *magnifica* differt in strobilus parvis (9–17 cm vs. 14–23 cm) cum squamae bracteae in maturitas siue siccitas reflexae.

California red fir is a large forest tree to over 60 m tall. Young trees are pyramidal and symmetrical, old crowns become ragged from snow breakage. **Leaves** linear, 6–35 mm long and flattened on lower branches (shade leaves), 7–40 mm long and quadrangular on upper branches (sun leaves), with 2 resin ducts, crowded, bent upward, new growth silvery-glaucous turning blue-green (thus local name “silvertip”), with stomates on all surfaces, apex blunt to acute, retained to at least 12 yr. The shortest needles surround terminal buds at their base and remain to mark the annual growth increments. **Twigs** pubescent, turning from yellow-green to light brown to gray. **Winter buds** ovate with acute to rounded apex, 2–8 mm long, light brown, shiny, not resinous. **Bark** thin, silvery gray, smooth with resin blisters on young stems; thick, reddish or purplish brown (thus “red fir”), deeply furrowed between broad ridges on mature trees. **Seed cones** oblong or cylindrical, 14–23 cm long, 6–9 cm wide in the typical variety, 9–17 cm long, 3–9 cm wide in var. *critchfieldii*, purple tinged with brown when mature, bracts hidden in typical variety but protruding conspicuously and reflexing when mature, finally covering much of the cone surface in var. *critchfieldii*.

The variety is named in honor of William B. Critchfield (1923–1989), American forest geneticist, in recognition of his distinguished contribu-

tions to the genetics, systematics, biogeography, and evolution of western North American conifers, including the California red fir beneath which he enjoyed hiking in the Sierra Nevada. A native of Fargo, N. D., he earned a bachelor's degree in forestry (1949) and doctorate in botany and genetics (1956) at the University of California at Berkeley. After serving as forest geneticist with the Cabot Foundation for Botanical Research at Harvard University (1956–1959), he was a geneticist at the Institute of Forest Genetics, a unit of the USDA Forest Service's Pacific Southwest Research Station, at Placerville, CA from 1959 to his retirement in 1988.

Critchfield red fir is distributed in the southern Sierra Nevada Mountains in Tulare, Inyo, and Kern (and perhaps Fresno) counties, extending into the Greenhorn Mts. in Kern Co. It is found in Kings Canyon and Sequoia National Parks and Sequoia and Inyo National Forests. It therefore comprises the southern extremity (about 1 degree of latitude) of the range of California red fir (Griffin and Critchfield 1972). Common coniferous associates are white fir, *A. concolor* (Gordon & Glend.) Hildebr. var. *lowiana* (Gordon & Glend.) Lemmon; Jeffrey pine, *Pinus jeffreyi* Balf.; western white pine, *P. monticola* Douglas ex D. Don; lodgepole pine, *P. contorta* Douglas ex Loudon subsp. *murrayana* (Balf.) Critchf.; whitebark pine, *P. albicaulis* Engelm.; and Sierra juniper, *Juniperus occidentalis* Hook. subsp. *australis* Vasek. The type locality, Mountain Home State Forest in Tulare County, supports white fir, sugar pine (*P. lambertiana* D. Douglas) and giant sequoia (*Sequoiadendron giganteum* (Lindl.) J. Buchholz).

Critchfield red fir, as reported to date, is similar in phenotype to the typical variety except for its smaller cones with protruding bracts. However, its marginal location with respect to the species' range may be found upon further study to harbor adaptations to a drier climate than that of the typical variety.

Protruding cone bracts occur in more than twenty firs worldwide, including three North American species in addition to noble fir. They also characterize all *Pseudotsuga* and several *Larix* (Eckenwalder 2009). In bristlecone fir (*A. bracteata* [D. Don] Poit.) very long attenuated bracts characterize the species as a whole (Lanner 1999). Balsam fir (*A. balsamea* [L.] Mill.) has long-bracted populations termed “bracted balsam fir” (var. *phanerolepis* Fernald), which occur sporadically from the Appalachians of Virginia and West Virginia to the Maritimes (Hawley and DeHayes 1985). Hybridization with the long-bracted Fraser fir (*A. fraseri* (Pursh) Poir) has been invoked to explain this occurrence (Liu 1971).

It is not surprising that protruding bracts – a trait widespread in its family and common in its

genus—should appear in a fir with ordinarily hidden bracts. Whether there is some selective advantage to a tree that has papery objects sticking out from between the scales of its seed cones, or if we are merely observing a neutral character occasionally expressed and subject to fixation through random drift in a marginal population, cannot be judged at this time.

REPRESENTATIVE COLLECTIONS

CALIFORNIA. Tulare Co.: Alta Peak, Kaweah River Basin, 1901, *Ralph Hopping s.n.* (UC-400343); Panther Peak, Sequoia National Park. October 1934, *P. H. Bailey & W. W. Frost s.n.* (UC-525811); Tar Gap, vicinity of Mineral King, 9000 ft, 5 August 5 1904, *H. M. Hall & H. D. Babcock s.n.* (UC-64470); Kaweah River, ca. 1918, *Ansel Hall s.n.* (JEPS-46605). **Kern Co.:** Greenhorn Mts., 7500 ft, 31 May 1947, *Lyman Benson 1618* (SDSU-01567).

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