

BISHOP PINE (*PINUS MURICATA*) OF INLAND MARIN COUNTY, CALIFORNIA

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ABSTRACT

The locations and characteristics of five, small, previously undescribed stands of bishop pine (*Pinus muricata*) in central Marin Co., California, are reported. Three stands lie on dry sites in the Kent Lake Drainage north of Mt. Tamalpais: San Geronimo Ridge, a spur ridge above Little Carson Cr., and Oat Hill. These stands are anomalous in occurring 15 km from the ocean and up to 435 m in elevation. The remaining two stands are on rocky, dry sites on the west slope of Bolinas Ridge, near the McCurdy Trail, and south of Wilkins Gulch. Trees of all stands have slower growth, more spindly stems, sparser crowns, and bear more abundant, serotinous cones than trees of other northern California populations. Stomatal traits and number of leaf resin canals, however, resembled coastal bishop pines on Pt. Reyes. Bishop pine once may have grown more widespread in Marin Co., but mesic-adapted stands evolved on Pt. Reyes and xeric, fire-adapted stands evolved in the interior.

This paper describes the location and habit of bishop pine (*Pinus muricata* D. Don) in inland Marin Co., California. Despite a long history of mapping and studying this species, botanists have largely ignored the stands of interior Marin Co. Although the nearby bishop pine population on Inverness Ridge and Point Reyes was described over a hundred years ago (Engelmann 1880), the only subsequent geographic comments have been by Howell (1945, 1949) and Mason (1949).

Western botanists have long been interested in bishop pine because of its complex patterns of variation and crossability among the nine disjunct, maritime (n. California to Baja California) populations, and its affinities to Monterey pine (*P. radiata* D. Don) (Duffield 1951, Critchfield 1967). Bishop pine populations north of Monterey (var. *borealis* Axelrod) are marked by an abrupt transition at Sea Ranch, Sonoma Co., in several traits within continuous pine stands. North of a narrow zone, pines differ qualitatively from those to the south in stomatal anatomy and waxiness (Duffield 1951), monoterpene compositions (Mirov et al. 1966), allozymes, and flowering phenology (Millar 1983). The origin of the sharp contact and the evolution of distinct differences seem related to population biogeographic movements and adaptation to unique soils (Millar 1985).

While studying relationships among northern bishop pine populations, I grew interested in several anomalous features of the inland Marin distribution: the pines grow farther inland, at higher eleva-

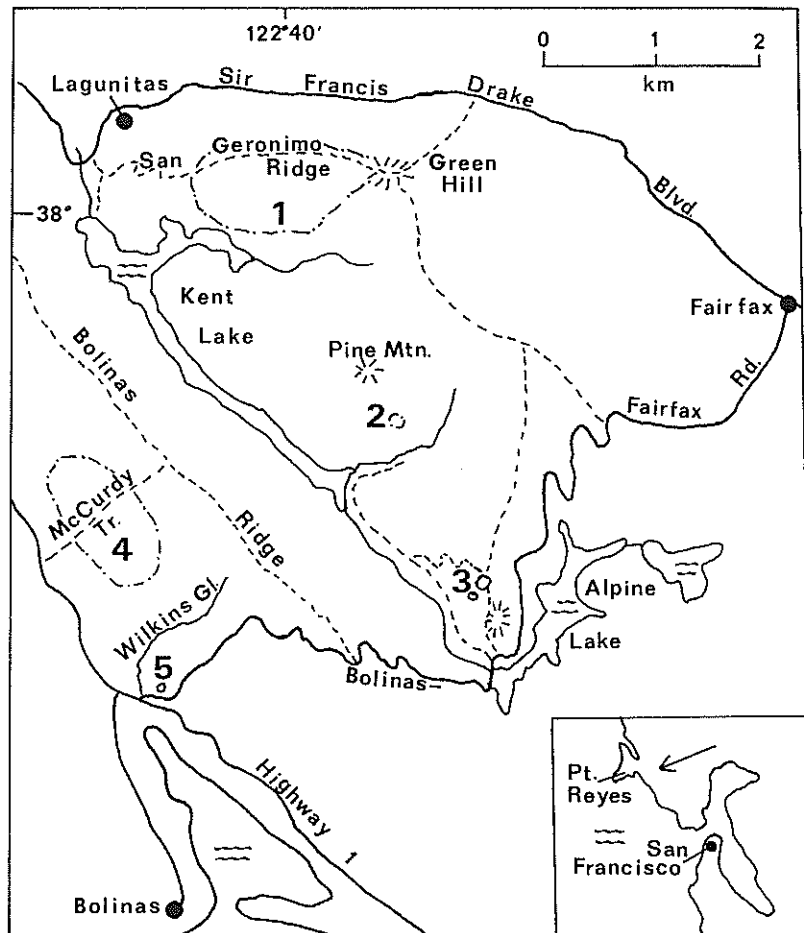


FIG. 1. Map of inland Marin Co. bishop pine stands. 1. San Geronimo Ridge stand; 2. Little Carson Creek stand; 3. Oat Hill stand; 4. McCurdy trail stand; 5. Wilkins Gulch stand. Legend: --- trail; -.- stand boundaries.

tions, and in drier habitats than most native bishop pines of northern California. They are also the only known bishop pines south of Pt. Arena that grow east of the San Andreas fault. Axelrod (1980) speculated that if the proximity of Pt. Reyes and the Inverness stands to inland Marin Co. is due to northward displacement of the Pacific plate, then the inland Marin Co. stands could be more closely related to the other bishop pine populations east of the fault than to the Pt. Reyes population.

I visited five stands of bishop pine in central Marin Co., at San

Geronimo Ridge, Oat Hill, Little Carson Creek, and Bolinas Ridge (two stands) (Fig. 1). The pines extend 6–15 km from the ocean and 60–435 m in elevation, growing on dry, exposed, and rocky ridges. Four of the stands occur on patches of Maymen gravelly loam soils; the southernmost stand on Bolinas Ridge occurs on Tocaloma-McMullin gravelly loams (Soil Conserv. Ser. 1985). Both soils are shallow, derived from sandstone, and differ considerably from the deep, quartz/diorite-derived Inverness loams underlying the Pt. Reyes population. The pines either form small oases of trees amid large expanses of coastal shrubs, similar to the habit of southern bishop pine populations, or they border forests of Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] and coast redwood [*Sequoia sempervirens* (D. Don) Endl.]. Although trees vary in age among the stands, middle age classes (15–30 years) dominate in all stands, and few trees are old enough to have survived an extensive burn in 1945.

SPECIFIC STAND DESCRIPTIONS

San Geronimo Ridge. The bishop pines on San Geronimo Ridge grow on the south-facing slope of the ridge above Kent Lake at elevation 155–435 m, and compose the largest stand in central Marin Co. (Fig. 1). Scattered pines grow within the dense manzanita chaparral (*Arctostaphylos* spp.) for about 3.5 km along the ridge as far east as Green Hill, and downslope nearly to Kent Lake. Along the ridge crest, the forest composition changes abruptly, and dense coast redwood, Douglas-fir, and tanbark oak [*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.] forests replace bishop pine on the north-facing slope. Although several large pines along the ridgetop are over 50 years old, most of the trees are younger.

Little Carson Creek. The only other stand noted in the literature is a small grove (less than 100 trees) perched at 430 m on a rocky spur of the south-facing slope of Pine Mountain above Little Carson Creek (Fig. 1). The trees in this stand are young (10–25 years old) and spindly, with sparse foliage and short needles, and are heavily laden with small stem- and branch-cones. No other trees grow in the vicinity; manzanita chaparral surrounds the stand. Although there appear to be no other pines growing on Pine Mountain, other patches of Maymen soil occur in the area, and this small stand may be the sole remnant of a larger population that was decimated by the 1945 fire.

Oat Hill. The Oat Hill stand includes two small groves (Fig. 1). The higher grove, at 395 m, straddles a summit of the ridge that extends northwest from Oat Hill. Although the grove is mostly on the flat ridgetop, a few trees grow on the exposed eastern slope. Most of the trees are young with spindly crowns, short needles, and abun-

dant, small cones; a few trees are large (50 cm DBH) and have more normal form with deeply furrowed bark.

The second grove near Oat Hill is about 0.3 km down a gully on the southwest slope. These trees also are slender with sparse crowns and poor forms. Both Oat Hill groves border on mixed forests of Douglas-fir, tanbark oak, and occasional madrone (*Arbutus menziesii* Pursh) and giant chinquapin [*Chrysolepis chrysophylla* (Dougl. ex Hook.) Helmquist], as well as open slopes of manzanita.

Bolinas Ridge. The three stands described above lie on the eastern slopes of the Kent Lake drainage, removed from the ocean by two major ridges. The remaining stands are on the western slope of Bolinas Ridge. Trees of the larger stand are scattered around the McCurdy Trail between 250 and 370 m (Fig. 1). Occasional Douglas-fir grow near the pines around gullies and at upper elevations, but bishop pine is the only tree growing on exposed slopes, where it is associated with tall, dense manzanita. This stand resembles the San Geronimo Ridge stand in the larger diameters, greater ages, and better bole forms than trees of the other stands. The trees bear abundant closed cones, which are larger than the cones from the three stands in the Kent Lake Drainage.

The second stand on Bolinas Ridge is on a rocky promontory south of Wilkins Gulch (Fig. 1). This small cluster of about 60 trees lies lower (60 m), farther south, and closer to the ocean than any of the other stands. The grove is surrounded by manzanita shrublands. The pines are even-aged (about 25 years old), have fairly good form, and bear abundant branch and stem whorls of asymmetric, heavy-scaled cones. In contrast to the other stands, some old cones on the trees were open, and I observed a few young pine seedlings growing in the bare, rocky soils at the edge of the stand. The greater lushness of the vegetation and proximity to the ocean suggest that the climate may be more mesic at this site than at the more interior locations.

GENERAL OBSERVATIONS

Foliage sampled from trees at all five stands had the "green" stomatal characteristic that is typical of bishop pines growing south of the Sea Ranch transition and west of the fault. A sample of 250 needles (5 needles from 10 trees at each of 5 stands) averaged 2.1 resin canals per leaf, which is not significantly different from Inverness (2.1 canals), Sonoma Co. (1.8), or Mendocino Co. (2.3) populations, but is significantly different from population averages south of Inverness (Millar 1985). In general, the central Marin trees grow slowly and have poor bole and crown forms. In these traits, they resemble bishop pines in southern populations, which were shown by common-garden studies to have genetically slow growth, sparse crowns, and poor form.

Cone shape varies among trees within stands, from symmetric and thin-scaled to asymmetric and heavy-scaled. This polymorphism also occurs in most populations from Inverness southward, but not farther north in California. In populations north of Marin Co., cones are mostly asymmetric and heavy-scaled.

Striking features of all the inland Marin stands are the prolific cone production and extreme cone serotiny. Cones not only persist on the trees for many years, but remain closed much longer than the cones of the northern populations. At all five stands, 25–35 whorls of cones occur commonly. Because more than one cone whorl may be produced annually, the exact duration in years of cone serotiny is difficult to assess. Within the south-to-north cline in decreasing cone production and decreasing serotiny that occurs in bishop pine (Duffield 1951), the inland Marin Co. pines resemble southern California and Baja California populations.

DISCUSSION

Although fire undoubtedly has been important in the evolution of all bishop pine populations, fire frequencies differ along the California–Mexico coast, and the extant populations are affected differentially by fire. Fires are least common in the cool, damp parts of the species' range north of Marin Co. Cones in those populations usually open after several years, and seedling regeneration in the absence of fire is common. Although natural and man-related fires have affected bishop pine on Inverness Ridge (Sugnet and Martin 1984), high relative humidities throughout the year lessen the chance for ignition.

With increasing distance from the coast, however, fires become more common (Jacobs et al. 1985). For coast redwood forests near Muir Woods, Jacobs et al. estimate a fire interval of 27 years on the first ridge inland, and an interval of 22 years on a third ridge inland. At the inland site, the distribution of fire intervals was highly skewed toward shorter than average intervals. This indicated a pattern of several short intervals followed by one or a few long intervals. Jacobs et al. also documented a significantly lower average weekly fog drip during the fire season at the inland site than at the coastal site. Because pine forests are more fire-prone than redwood forests, they undoubtedly burn more often. Fire-charred bark on trees at all pine stands indicates the occurrence of fires. A higher fire frequency in interior Marin Co. compared to Pt. Reyes may, in part, account for the long cone serotiny and prolific cone production of the inland trees.

The origin and relationship of the inland Marin Co. stands to other bishop pine populations remain enigmatic, although the "green" foliage excludes a close affinity to the "blue" race north of Sea Ranch

and east of the fault. The general appearance of the trees (form and size, cone serotiny and abundance, and attributes of their location and ecological situation) resembles bishop pine stands of southern California and Mexico, but, due to distance and genetically distinct intervening populations, the inland stands are unlikely to be closely related to those populations. More likely, these pines are remnants of a formerly large bishop pine population in Marin Co. A western group evolved under mesic conditions on Inverness Ridge and Pt. Reyes, and an eastern group evolved under xeric conditions inland. Pleistocene fossils of bishop pine from the east side of Tomales Bay near Millerton, where bishop pine does not grow now (Mason 1934), indicate a formerly more extensive Marin Co. population. The Pt. Reyes population, whose present southernmost extent at Mt. Wittenberg is 13 km from the closest inland stand, may once have extended farther south on Inverness Ridge. Sugnet and Martin (1984) suggest that fire exclusion practices on Pt. Reyes have encouraged Douglas-fir growth on the southern peninsula, and have prevented bishop pines from growing where they otherwise might have flourished. If bishop pine formerly grew farther south on Pt. Reyes, it would have been close to the two Bolinas Ridge stands. The size and extent of the inland population undoubtedly has been restructured often by fire, which may have further obscured links to the Pt. Reyes pines. Additional ecological and genetic studies would clarify the origin and relationship of these trees to other bishop pines.

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