SUGAR PINE OUTPERFORMS PONDEROSA PINE ON A HOT, DRY SITE

William W. Oliver, Silviculturist, Forest Service, U.S. Department of Agriculture, Pacific Southwest Range and Experiment Station, Redding, Calif.

Sugar pine grew 20 percent more in diameter, and in basal area and volume per acre than did ponderosa pine 40 years after planting on a hot, dry, eroded site.

Sugar pine (*Pinus lambertiana* Dougl.)—prized for its beauty, lumber, and rapid growth to great size—would seem to be an ideal species for plantations in interior California. Yet its potential has remained unrealized because of its susceptibility to white pine blister rust (*Cronartium ribicola*), and poor survival after planting. Because it lacks these drawbacks, ponderosa pine (*Pinus ponderosa* Laws.) is planted more often than sugar pine.

Another attribute of sugar pine (not as widely recognized) is its ability to grow well on hot, dry sites. This ability was demonstrated in a test in which plantations of sugar pine and of ponderosa pine, on a severely eroded slope, were compared for survival and growth.

Kennett Smelter-Fume Area

Between 1905 and 1919, a copper smelter at Kennett, Shasta County, Calif., 3 miles up the Sacramento River from where Shasta Dam now stands, belched sulphuric fumes. These poisonous fumes, merging with those of two other downstream smelters, completely killed the cover of mixed conifers, oak, and chaparral on more than 100 square miles of land.[1] Gully and sheet erosion was so severe in what had become known as the "Kennett smelter-fume area" that an estimated 40 million cubic yards of soil had washed away by 1932.

Between 1932 and 1938 the California Forest and Range Experiment Station (now the Pacific Southwest Forest and Range Experiment Station), studied the feasibility of reforestation and other erosion control measures in the denuded area. In one experiment two 0.1-acre plots were planted, one with sugar pine and one with ponderosa pine.

The plots lie on a steep south-facing slope at 1,300-feet elevation, about 300 feet above the high-water mark of Shasta Lake. The severely eroded soil is a gravelly, sandy loam which, in many places, is less than 2 feet deep to metamorphosed rhyolite. Annual precipitation averages 60 inches, but summers are hot and dry. In July, maximum temperatures average 96° F and, usually, only 3.4 inches of rain fall between June and October.

A site index of 40 feet at 50 years (*1*), as estimated from dominant ponderosa pines within the plantation, may be a low estimate. Naturally established ponderosa pines nearby suggest a higher site index: 50 feet at 50 years. Whether reduced height growth of the planted trees is the result of a poor seed source or severe intertree competition cannot be determined.

Plantation History

In April 1936, 2-year-old sugar and ponderosa pines were hand planted at about a 2- by 2-foot spacing between gullies or about a 3- by 3-foot spacing overall, equivalent to 4,840 trees per acre (fig. 1A). Unfortunately, the seed source of neither species is known. Most likely, however, sources were from areas dissimilar to the planting site because stands producing seed abundantly are rare on south slopes at this elevation.

Early survival was higher for ponderosa pine than it was for sugar pine. By August 1939, after nearly four growing seasons, 89 percent of the ponderosa pines and 67 percent of the sugar pines had survived. Long before 1950, tree crowns on both plantations had closed (fig. 1B), and a thick carpet of needle litter covered the gullies beneath the stands.

Methods

in fall 1976, 40 years after planting (fig. 2), I measured the following on a single 0.05-acre circular plot within each plantation: diameter at breast height of all trees; height to live crown, stem diameter at 1 foot, total height, and upper stem diameters on 10 percent of the trees selected randomly. The crown class of

[1] Kraebel, C. J., Memorandum on erosion control in Shasta Dam Area, California. Feb. 15, 1951. Calif. Forest and Range Exp. Stn. (Copy on file at Shasta-Trinity National Forest, Shasta Lake Ranger District, Redding, Calif.).

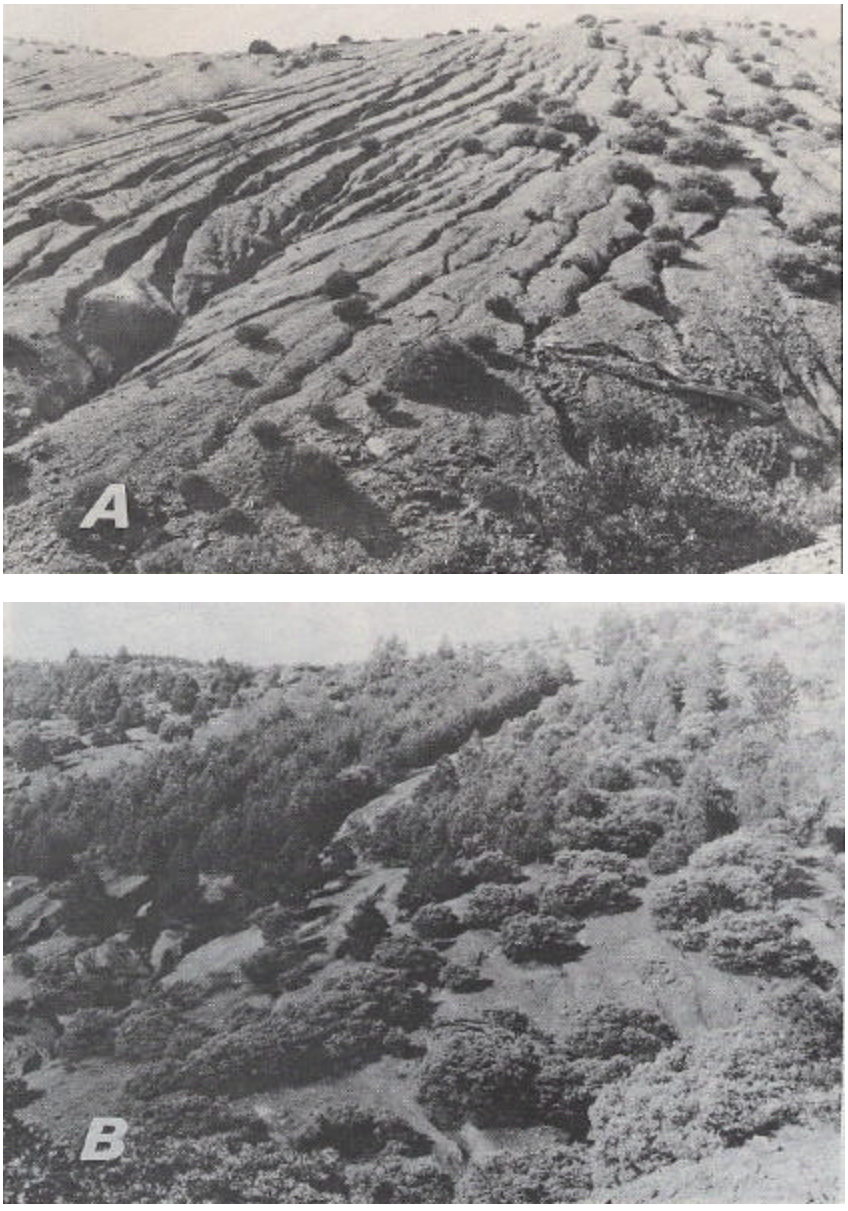

Figure 1.—*Site of the sugar pine and ponderosa pine plantations was severely gullied after Kennett smelter fumes killed existing vegetation. (A) In 1937, 1 year after planting. (B) In 1950, 15 years after planting.*

each tree was also recorded. Stem volumes inside bark were calculated as the sum of a series of conic frustums.

Results and Discussion

Since 1939 more than twice as many ponderosa pines as sugar pines have died—1,468 as opposed to 728 trees per acre. Nevertheless, the higher early survival of ponderosa pine is still evident. After 40 years, 13 percent more ponderosa pines are surviving per acre than are sugar pines—2,840 against 2,515 (table 1).

Basal area and cubic-foot volume per acre, and average breast height diameter are all about 20 percent greater for the sugar pine plantation than for the ponderosa pine plantation. But average heights and live crown ratios are about equal (table 1).

The difference in diameter distribution between the two stands is impressive (fig. 3). Most of the sugar pine stems are about evenly divided among the 2- through 5-inch diameter classes, but nearly half of the ponderosa pine stems are concentrated in the 2-inch class.

Sugar pine is generally considered to be intermediate in tolerance to shade, and ponderosa pine as intolerant (*2*). In the plantations sugar pine's greater tolerance has retarded its differ-

entiation into crown classes as indicated by: (a) a more uniform diameter distribution; (b) less recent mortality; and (c) more uniform heights of individuals. For instance, dominant sugar pines are 6 feet taller, whereas, dominant ponderosa pines are 10 feet taller, on the average, than their respective mean stand heights (table 1).

Conclusion

Forty years after planting, sugar pine appears to have outperformed ponderosa pine on this hot, dry, eroded site. But because only a single observation was possible in each small plantation, the results cannot be statistically validated. Another weakness of the research is the unknown effect of seed source. To be valid, a comparison of local seed sources for both plantations would be required.

Nevertheless, the plantations indicate that sugar pine may have promise as an alternative to ponderosa pine on low-elevation, droughty sites. Under these conditions, white pine blister rust is not a hazard. Early survival is still a problem, but research now in progress on nursery and outplanting techniques may provide solutions soon. A general recommendation, however, must await test results from similar sites elsewhere.

Figure 2.—*Sugar pines had completely occupied the site and covered the gullies with a thick blanket of needles when the plantation was examined in 1976.*

Table 1.—*Sugar pine outperformed ponderosa pine in many characteristics 40 years after planting in the Kennett smelter-fume area*

Species	Trees per acre	Av. d.b.h.	Average height		Live crown ratio	Basal area	Total volume
			All trees	Dominants only			
		(inches)	*(ft)*	*(ft)*	*(percent)*	*(ft^2/acre)*	*(ft^2/acre)*
Sugar pine	2515	3.9	20	26	45	207	1916
Ponderosa pine	2840	3.3	21	31	46	168	1590

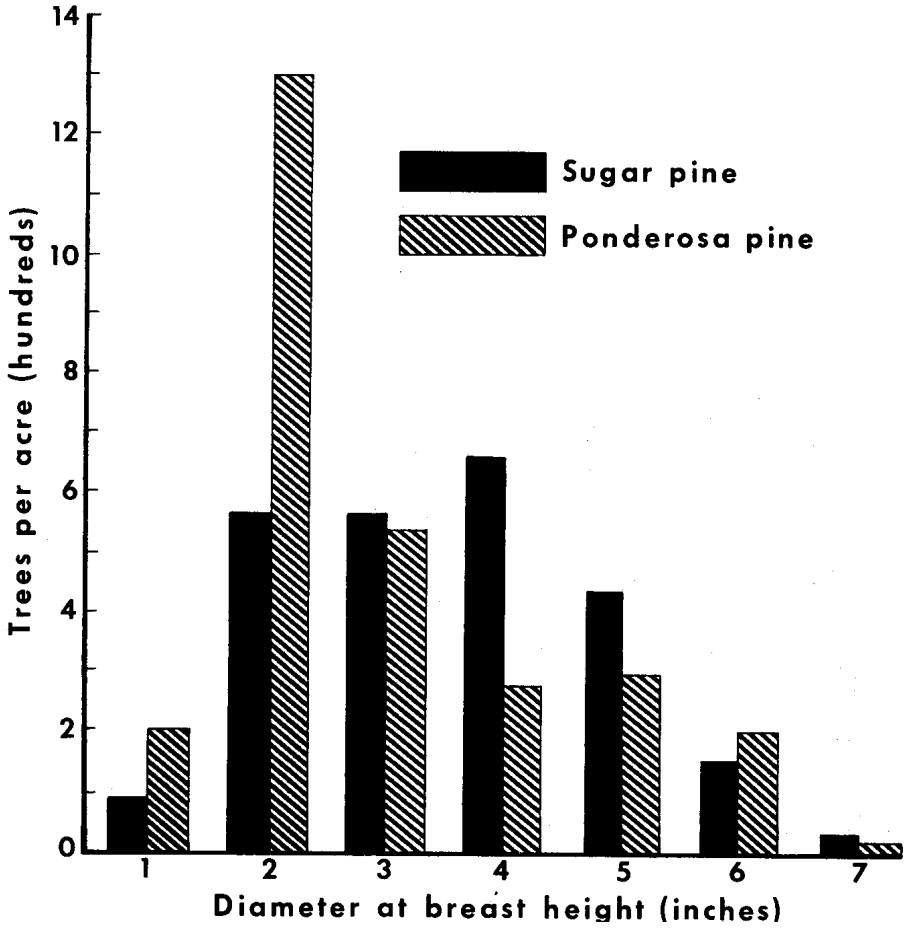

Figure 3.—*Difference in diameter distribution between the two stands.*

Literature Cited

1. Powers, Robert F., and William W. Oliver.
1978. Site classification of ponderosa pine stands under stocking control in California. USDA For. Serv. Res. Paper PSW-128, 9 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.
2. Baker, Frederick S.
1949. A revised tolerance table. J. For. 47(3) :179-181.