Reprinted with kind permission from the University of Washington Arboretum Bulletin, Seattle, Volume XXX No.4, Winter 1967.

Crossing the Western Pines at Placerville, California

W. B. CRITCHFIELD and S. L. KRUGMAN*

ABSTRACT

The results of hybridizing the western pine species by the Institute of Forest Genetics are described and discussed. It has been found that the hard (yellow) pines can generally be crossed successfully only with similar species native to the same part of the world. In contrast, the soft (white) pines of the Western Hemisphere have been crossed successfully with soft pines of the Eastern Hemisphere. The hybrids produced by the Institute have been found to have value in both the field of forestry and in improving man's environment.

In the forests of the Pacific Slope grows one of the world's great concentrations of conifers—matched in number of species only by the forests of western China. The pines in the dense forests of the Pacific Northwest are not as well represented, but their diversity in the drier forests of California is unrivalled by any stands elsewhere.

This distinction can be illustrated by the number of species of *Pinus* in the three Pacific Coast States: 4 in Washington, 8 in Oregon, and 19 or 20 in California. Central Mexico, another center of diversity in this group, exceeds California in number of species, but most of the Mexican pines (unlike those of California) belong to a few closely related species complexes. Of the 15 subgroups in this genus, 8 are represented in California compared to 5 in central Mexico.

Ever since the Institute of Forest Genetics, originally called the Eddy Tree Breeding Station, was established in 1925 at Placerville, California, most of our research has been concentrated on the pines.* Species hybridization has been an important part of this program. It has been directed toward the improvement of pines by producing superior hybrids and by transferring desirable characteristics, such as insect resistance, from one species to another. About a dozen pines are native to our operating area, and this has greatly facilitated work on species-crossing.

The two main subdivisions of this genus —the soft (or white) pines and the hard (or yellow) pines differ widely in their crossing behavior. The hard pines can generally be hybridzed only with similar species native to the same part of the world. On the other hand, among the soft pines, successful crosses between species of the Western and Eastern Hemispheres are common.

Western white pine (*P. monticola*) is a good example. This species can be crossed most readily with its very similar relative, eastern white pine (*P. strobus*), which is native to the eastern United States and Canada. But it has been crossed also with (among others) blue pine of the Himalayas (*P. griffithii*), Balkan pine (*P. peuce*), and Japanese white pine (*P. parviflora*).

Not all the white pines, however, can be crossed with each other so easily. One conspicuous exception is sugar pine (*P. lambertiana*). All our efforts to cross it with western white pine and the other North American white pines have failed. Strangely enough, we have succeeded in crossing it with two white pines native to eastern Asia—Korean pine (*P. koraiensis*) and Armand pine (*P. armandii*), the latter a very widely distributed species of China and bordering regions. Both Korean pine and Armand pine—unlike sugar pine and most

*Geneticist and Plant Physiologist, respectively, Institute of Forest Genetics, Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, P. O. Box 245, Berkeley, California.

*The Institute and its collection of pines in the Eddy Arboretum have been described by J. W. Duffield in the Winter 1949 issue of this bulletin, Vol. XII, No. 4: 17-20, 40-41. "Pines of the Eddy Arboretum."

other white pines—have wingless seeds, but otherwise they are not very similar. Our single *P. lambertiana* x *koraiensis* hybrid has not yet flowered, but one of the *P. lambertiana* x *armandii* hybrids growing at Placerville began producing cones a few years ago at the age of 12—much earlier than sugar pine ordinarily begins to flower. This tree is the first seed-producing hybrid between parents having winged and wingless seeds. Its seed wings are remarkably varied in shape; they are mostly ragged in appearance and range from rudimentary to fairly well developed (fig. 15).

One of the more interesting white pines of the West is bristlecone pine (*P. aristata*), well publicized in recent years as the oldest known living organism. In California it grows at high elevations on a few desert ranges. Its only close relative is foxtail pine (*P. balfouriana*), which grows in fairly inaccessible parts of the southern Sierra Nevada and the northern Coast Ranges of California. We have never succeeded in crossing these two pines with other species. Recent attempts to cross them with each other, though, have been highly successful; in fact, there seems to be little if any crossing barrier between the two. In this they are unique among the pines—crosses between different pine species ordinarily yield far fewer offspring than crosses between two trees of the same species.

Among the hard pines, the most important in the West are the western yellow pines. This group includes ponderosa pine (*P. ponderosa*), Jeffrey pine (*P. jeffreyi*), and many of the Mexican pines. Most of the western yellow pines that we have worked with can be crossed with each other. But none of them has been successfully crossed with the rather similar yellow pines that make up the extensive pine forests of the southeastern United States. Nor have any of the western yellow pines been crossed successfully with the numerous hard pines of Europe and Asia.

Of the many western yellow pines, we have investigated most thoroughly the crossing behavior of ponderosa pine. It is one of the most readily hybridized species in the western United States. To date we have crossed it with both of its California relatives—Jeffrey pine and Washoe pine (*P. washoensis*)—and with several species centering in Mexico—*P. montezumae*, *P. hartwegii*, *P. engelmannii*, *P. durangensis*, and *P. pseudostrobus*.

Jeffrey pine resembles ponderosa pine and grows with it in many areas, but it behaves quite differently from ponderosa in crosses with other species. We have succeeded in crossing it with ponderosa and several of ponderosa's close relatives, but Jeffrey pine does not cross readily with any other species. Jeffrey pine also differs from ponderosa in its ability to cross with Coulter pine, one of the big-cone pines of California. This last hybrid, Jeffrey x Coulter, has shown a high resistance to a weevil that often destroys young pine plantations in California. Because of its resistance to this

---

Below—
Sugar Pine × Armand Pine—18-year-old, 40-foot hybrids of a cross between one of our most important commercial western soft pines and a soft pine from eastern Asia.

Photo: Courtesy Institute of Forest Genetics, Placerville, Calif.
Fig. 15

insect this hybrid has potential as a forest tree.

The big-cone pines—Coulter (*P. coulteri*) Digger (*P. sabiniana*), and Torrey (*P. torreyana*)—differ from other western pines in their large cones and long needles. Digger pine is one of the few pines that characteristically develops a multistemmed crown. The heavy spiny cones of Coulter pine are the most massive cones produced by any of the pines. Torrey pine's five needles per bundle make it the only hard pine in the United States with more than three needles in a bundle. It is also exceptional in its extremely restricted range: a few miles of coastal bluffs north of San Diego and one small grove on Santa Rosa Island, off the coast of southern California.

The three big-cone species have proved to be among the most difficult to cross of any of the pines. Coulter and Jeffrey pines were first crossed more than two decades ago, but for years we were unsuccessful in crossing Coulter with the other big-cone species. Only recently have we produced a single Digger x Coulter hybrid. Digger pine can also be crossed (and somewhat more easily) with Torrey pine. The hybrids, which have not yet reached cone-bearing age, are nearly indistinguishable from Digger pines of the same age. They can easily be identified as hybrids, however, by the chemical composition of their wood resin. The turpentine fraction of Digger pine's resin is mostly limonene; in Torrey pine it is nearly all heptane; and in the hybrids the proportions of these two compounds range from 1:1 to 1:2.4.

One of the most variable and wide-ranging of the western pines is *P. contorta.* Its coastal race, which extends from Alaska to California, is commonly called shore pine. Another race—generally known as lodgepole pine—grows in the upper-elevation forests of the Cascade Range and the Sierra Nevada. These two races are so different in morphology that they are sometimes considered different species. The hybrid between shore and lodgepole pines has possibilities as a Christmas tree. It combines some of the desirable features of both parents. It has shore pine's thick green foliage, persistent cones, and multinodal growth. In addition, it has the well-formed sturdy crown of mountain lodgepole pine. During the past few years we have crossed the two on a large scale. Despite the differences between them, we have found no indication of any barrier to crossing them. Shore pines cross as readily with lodgepole pines as they do with other shore pines, and this is true of lodgepole as well. The complete absence of crossing barrier has reinforced our view that these two forms should be considered races of the same species.

The first hybrid produced at the Institute of Forest Genetics was the cross between knobcone (*P. attenuata*) and Monterey (*P. radiata*) pines. It combined two of the three closed-cone pines that grow in California. Planted in 1929, these hybrids are still growing at Placerville and have now reached a height of about 80 feet. Their pollen parent, Monterey pine, is one of the most widely planted trees in the world. It plays a major role in the forest economies of New Zealand, Australia, and other countries. The other parent, knobcone pine, is of no importance as a timber tree, but it grows on a much wider range of soils and in much colder and drier climates than Monterey pine. The cross between knobcone and Monterey pines yields quantities of hybrid seed, so the production of large numbers of first-generation hybrids is biologically feasible. This hybrid is being produced and tested on a large scale in California and elsewhere, with the object of combining knobcone pine's tolerance of poor sites and cold climate with Monterey pine's desirable characteristics as a wood producer.

The third closed-cone species of California is bishop pine (*P. muricata*). This pine grows along the Pacific Coast in a string of isolated stands extending from northern California to Lower California. Within this range several well-defined geographic races have evolved. These races, unlike those of

P. contorta referred to above, are not always easy to cross, and some of them cannot be crossed at all. For example, we have been completely unable to cross a blue-foliaged race that grows along the coast of northern California with some of the green-foliaged southern races. Bishop pine is highly unusual in this respect; crosses between races of other pines—and most other plants—generally yield large numbers of offspring.

The closed-cone pines are not confined to California; there are several species native to Mexico. We have not been very successful in crossing the California species with the Mexican species. The sole product of these crosses so far is a single young hybrid of Mexecan weeping pine *(P. patula)* and Monterey pine. It seems that these two groups of closed-cone pines are not nearly as closely related as are the yellow pines of the western United States and those of Mexico.

These are but some of the many interesting aspects of breeding and crossing of our western pines. Additional information on these and other pine hybrids at the Institute of Forest Genetics can be found in the following publications:

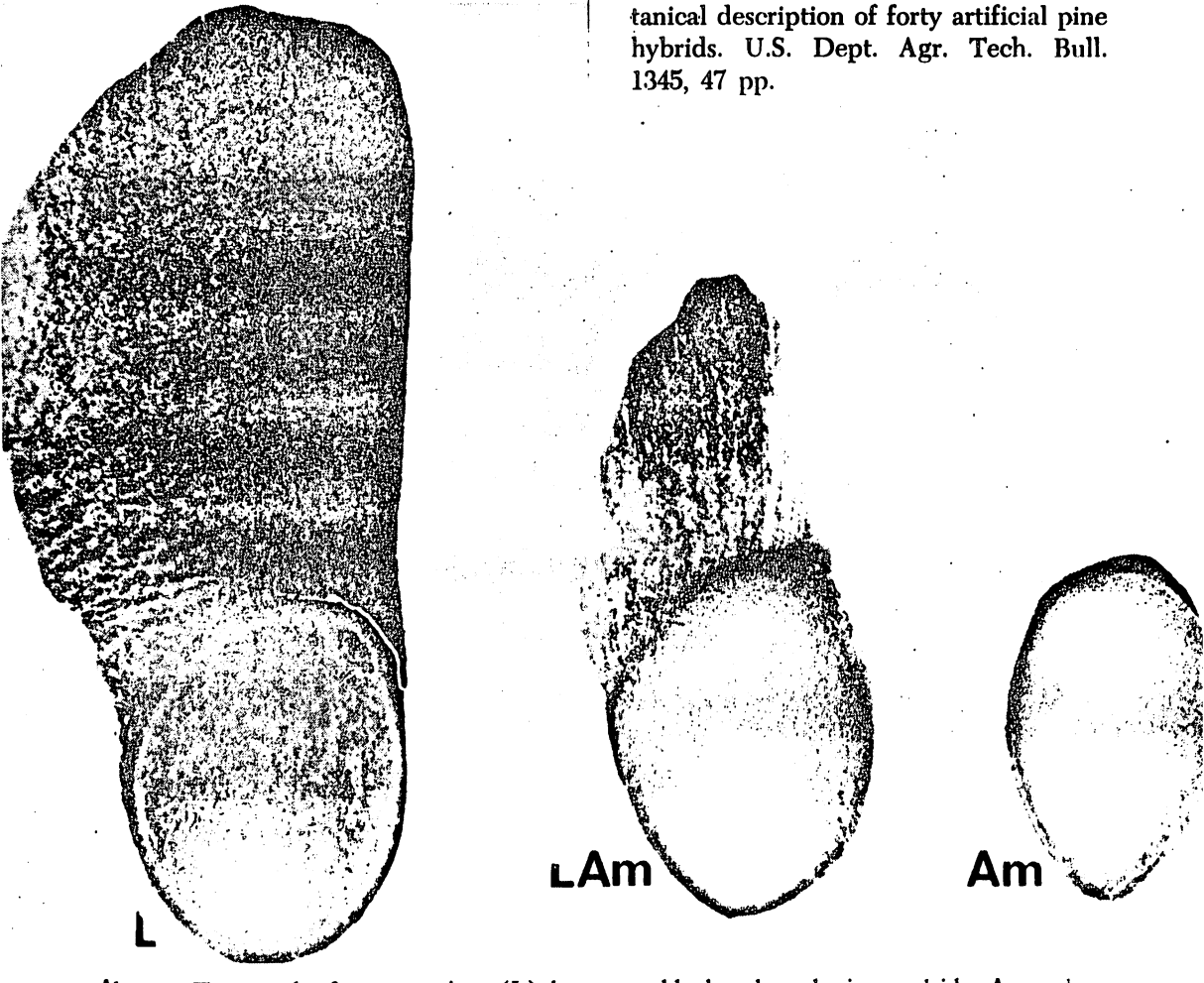
Critchfield, William B. 1963. Hybridization of the southern pines in California. Forest Genetics Workshop, Proc. 1962: 40-48. (So. Forest Tree Improvement Com. Pub. 22, Macon, Ga.)

1966. Crossability and relationships of the California big-cone pines. U.S. Forest Serv. Res. Paper NC-6, N. Central Forest Exp. Sta., St. Paul, Minn. pp. 36-44.

1967. Crossability and relationships of the closed-cone pines. Silvae Genetica 16(3): 89-97.

Duffield, J. W. 1952. Relationships and species hybridization in genus *Pinus.* Ztschr. f. Forstg. u. Forst pflanzena. 1 (4): 93-97.

Little, E. L., Jr. and F. I. Righter 1965. Botanical description of forty artificial pine hybrids. U.S. Dept. Agr. Tech. Bull. 1345, 47 pp.



Above--The seed of sugar pine (L) has a well-developed wing, while Armand pine (Am) has an essentially wingless seed. The hybrid (LAm) however, has a seed wing mostly ragged in appearance and highly varied in shape.

Photo: Courtesy Institute of Forest Genetics, Placerville, Calif. Fig. 16.