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FOREST TREE IMPROVEMENT RESEARCH IN THE FOREST SERVICE

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Few aspects of forest research have expanded as rapidly as has forest tree improvement research in recent years. While to some this research may appear to be the fad of the day, yet the expansion is fully justified if only on the basis of progress in breeding crops in agriculture. But results in forestry support the anticipation that improved forest trees will be developed. The Forest Service shares this belief and has greatly expanded research to help provide these improved trees.

Tree improvement research in the Forest Service began about half a century ago, not long after the Forest Service was established and only about 10 years after Mendels papers on inheritance were rediscovered. This early work was concerned with racial differences within species, as an expression of adaptation to special environmental conditions. A study of seed sources of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) was started in 1912 by T. T. Munger (1936), who summarized the results in 1936 to show that racial differences did exist. Recently these old plots have been reexamined and the data are being summarized.

In 1911 the first plantings were made of seedlings representing 22 sources of ponderosa pine (Pinus L2ajerosa Laws.). Ponderosa pine was a suitable species for this early study of racial variation for its range extends about 28 degrees in latitude and 26 degrees in longitude. It is not surprising that differences in performance among the progeny were found, as reported by Weidman (1939. These old plots, with others established later, have lately been re-measured and the results prepared for publication.[1] These studies, together with later ones involving jack pine and the southern pines, were early expressions of a recognition of the role of genetics in forestry.

Today there are about 25 forest geneticists engaged in research in the Forest Service. They are employed at three institutes of Forest Genetics located at Placerville, Calif., Gulfport, Miss., and Rhinelander, Wisc., and at several other field centers. By contrast in 1950, there were less than 10 scientists engaged in forest tree improvement rsearch in the Forest Service and only one institute, at Placerville, had been established.

The Forest Service research program in tree improvement is divided, for administrative reasons, into four fields of work. These are racial variation and selection, inheritance, hybridization, and techniques. Although research does not fall clearly into any one of these categories, they are convenient to use in discussing the program.

[1] Squillace, A. E. and Silen, Roy R. Racial variation in ponderosa pine, 1960 manuscript on file at the Intermountain Forest and Range Experiment Station.

Variation and Selection

Much of the research effort currently is directed at determining the extent of ecotypic or clinal variation within a species. A practical result of such studies is the establishing of seed collection zones for planting. These studies now cover many of the important conifers and most of them involve numerous collections. The Southwide Pine Seed Source Study, started in 1952, involved 59 collections of seed in 16 states, with 46 progeny plantations. Standard progeny tests were employed and differences among collections are already apparent.

A similar study with eastern white pine has been started recently. This one includes seed collection in 11 states and in 3 provinces of Canada.

A unique approach to a study of variation was that used by Callahan in his recent study of variation in ponderosa pine. He has demonstrated differences among progeny from the various sources by growing them under conditions of controlled environment in the phytotron at the California Institute of Technology. Variation in response to day and night temperatures and to length of day were quickly apparent. This approach will probably become more widely used to screen progeny and cut down the cost of field testing.

Other studies concerned with racial variation include those with jack pine (*Pinus banksiana* Lamb.), with yellow poplar (*Liriodendron tulipifera* L.) and with eastern redcedar (*Juniperus virginiana* L.). Very conspicuous differences in foliage color, particularly of winter foliage, have been observed in the various collections of eastern red cedar. These color differences are of particular interest to growers of redcedar for Christmas trees.

Individual Tree Selection

Superior genotypes exist in the native population of forest trees. The problem of identifying them requires the selection from a mass of trees followed by careful progeny testing. Such a procedure has led to the finding of individual slash pines (*Pinus elliottii* Engelm.) whose yield of gum for naval stores in about twice that of the population average. The tendency for high gum yield was shown to be an inherited character by Mergen (1955). Propagules of these superior trees are sought for by the gum naval stores industry.

Blister rust resistant white pines have been found through extensive surveys of western white pine. Bingham et al. (1960) have demonstrated the existence of individual trees much more resistant to blister rust than the average. Seed orchards are now being established to make these superior genotypes available to forest managers.

Trees are being selected for crown size and for stem form. That these characteristics are under genetic control has been shown by Barber, and Dorman (1955) and by Mergen (1955).

Sugar maple trees (Acer saccharum Marsh.) yielding superior amounts of sugar have been found and progeny tests are being started to determine whether the trees are in fact superior genotypes.

The Forest Survey has provided the opportunity for mass selection of trees having superior growth rate or wood density. In the hundreds of thousands of trees measured on the Survey plots, outstanding phenotypes have been located, as for example a longleaf pine (Pinus palustris Mill.) with a specific gravity of more than 0.80.

Inheritance

Heritability determinations are basic to breeding programs and geneticists in the Forest Service are endeavoring to find out how strongly some characters are inherited. The Southern Institute of Forest Genetics has begun elaborate studies of inheritance of such characters as seed size, resistance to brown spot disease, vigor, etc. One study of polygenic inheritance in longleaf pine consists of about 10,000 trees in progeny outplanting.

In their studies of breeding blister rust resistant western white pine (Pinus monticola Dougl.), Bingham et al. (1960) found narrow-sense heritability of rust resistance to be 86 percent, with a 20 percent increase in resistance expected for the first few generations. In addition to rust resistance, the heritability of vigor and tree form of western white pine are also under study.

Although they did not compute heritability figures, Mergen et al (1955a) demonstrated by regression analysis that oleoresin yield and viscosity were under genetic control.

Reconnaissance Breeding

Much of the research effort has been directed at creating interspecific hybrids. The program indicates which species can be crossed and with what ease. It also provides information on the characters of the hybrids and on the inheritance of these characters.

The Western Institute of Forest Genetics pioneered in this field and first created many of the pine hybrids under study in other parts of the country. So far it has made about 80 species combinations in pine. Some of these have already been demonstrated to be of value in forest management, like the Knobcone x Monterey hybrid (P. attenuata Lemm. x P. radiata D. Don) and the Jeffrey x Coulter hybrid (P. jeffreyi Grev. & Balf P. coulteri Don.) which are being mass-produced for planting in'California. The shortleaf x loblolly hybrid (P0 echinata Mill. x P. taeda L0), now of interest in the South because of its resistance to fusiform rust was first produced in California. The Western Institute is now concentrating on hybrids, one parent of which is native to the western region. And it is intensifying its program of aimed breeding. An example is the current study of the knobcone pine progeny from various ecotypes. These will be grown for parental stock to create the vigorous hybrid with Monterey pine for a variety of sites below the ponderosa pine zone in California.

The Southern Institute of Forest Genetics has created all hybrid combinations of the four important southern pines. The latest creation is one which traces its parentage to all four of the southern pines. The most promising of the hybrids are the shortleaf x slash and shortleaf x loblolly hybrids, both of which appear to have inherited the fusiform rust resistance of shortleaf pine.

The determination of crossability patterns in the spruces with possible superior hybrids is one of the objectives of the Northern Institute of Forest Genetics. Some of the species combinations in spruce have been worked out already by the Northeastern Forest Experiment Station. Work here also included hybridization in maple, ash, oak and yellow poplar.

Techniques and Physiological Studies

Much effort in the past has been devoted to finding out how to do the job of tree breeding. Thus it was necessary to develop procedures for collecting and storing pollen, for determining when the flowers are receptive, and for pollinating the flowers. Even such commonplace procedures as how to get up in the trees have required some trial and error approaches.

Better information on the life processes of trees is often required to aid the tree breeding projects. For example the Western Institute has a broad study on the physiology of sexual reproduction. Current phases of it are concerned with pollen metabolism in an attempt to explain factors pro moting germination of the pollen grain and compatibility of the gametes.

At the Northern Institute there is a general study of the physiology of growth., At the present work is concentrated on the role of auxins in the production of springwood and summerwood. Larson (1960) recently demonstrated that the production of summerwood was related to activity of the terminal and to auxin production. It is conceivable that rate of auxin production might be a character to breed for instead of wood density, thus shortcutting the testing period.

Dormancy of the meristem of longleaf pine is a plaguing problem to southern foresters. Physiologists at the Southern Institute are trying to find whether longleaf pine has an inhibitor or lacks a growth-promoting substance. So far it appears that an unknown substance found in loblolly and slash pine, and growing longleaf pine, is lacking in dormant longleaf pine. Here again, breeding may be aimed at the presence or absence of a growth substance.

Increased use is being made of controlled environment chambers to study the reaction of progeny to various conditions. In addition to screening progeny for more extensive field plantings, these studies provide valuable information on how trees grow.

One of the most far-reaching studies related to tree breeding is the analysis of the terpenes of the pines by N. T. Mirov at the Western Institute. He has determined the terpene constituents of most of the pines of the world and hopes to be able to show species relationships.

In summary, the Forest Service is active in all phases of the tree improvement program and has an increasing program to further this research, hoping to cover many of the problems not now under study by state, university and industrial research groups.

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