ONE-QUARTER CENTURY OF TREE IMPROVEMENT ON NATIONAL FORESTS IN THE SOUTHERN REGION

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Abstract.--In 1983, the Southern Region of USDA Forest Service Harvested over 15 tons of first generation orchard seed from six seed orchards. This represented a milestone for a tree improvement program that began in 1959. That was the year researchers and foresters made plans for breeding improved trees for restocking National Forest lands. The program is large and complex, encompassing some 13 species and 52 geographic sources, and serves a land base of about 10 million acres. Some tough seed orchard management problems were solved along the way - examples, Net Retrieval system for seed harvest and aerial application of pesticides. Payoffs are impressive by any measure. Early progeny test results indicate that large gains in volume and other traits can be expected through genetic tree improvement. Over 400 acres of progeny tests have been planted mainly to provide a source of selections for another generation of breeding. The Second Generation Plan has been developed and is being implemented.

Additional keywords: Seed production, progeny testing, hardwood tree improvement, net retrieval system.

The Southern Region's Tree Improvement Program is one of the really great success stories of the USDA Forest Service. In the last 2 years, 47,000 pounds of first generation orchard seeds were harvested. Through the 1985 planting season, approximately 325,000 acres of improved trees have been planted on National Forests in the South. This acreage is increasing at the rate of about 50,000 acres per year.

Payoffs are great by any measure. These trees will produce 10 to 20 percent more volume than average wild trees. They are also bred to be straighter, more disease-resistant, and to have better wood qualities than their wild cousins.

It took 25 years of hard work by many people to get to this point, but the most important phase lies just ahead--that of second generation superior trees. These trees are expected to grow a whopping 35 to 45 percent faster than the wild population:

First Generation Program

In 1959, under the guidance of Thomas F. Swofford, the first Regional Geneticist, planning for the program was started. He consulted many people and organizations in developing the program. The following is a list of some who contributed and deserve recognition: John Kraus, Bruce Zobel, Hans Van

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Buijtenen and Ray Goddard, Southern, Southeastern and Southwestern Forest Experiment Stations, and Tree Improvement Cooperatives at North Carolina State University, University of Florida, and Texas A & M University. Programs already underway in Portugal, Sweden and England were also examined. Swofford retired in 1975 and was replaced by Jim McConnell, the present Regional Geneticist.

The pine program was started first. Actual selections begun in 1961 and were essentially completed by 1967. Thirty-eight species-geographic source combinations were recognized in the original selection program; consisting of shortleaf ¦Pinus echinata Mill.), loblolly (P. taeda L.),__longleaf (P. palustris Mill.), slash (P. elliottii Englem.), eastern white (P. strobus L.), Virginia (P. virginiana Mill.), and Ocala sand pines (P. clausa var. clausa D.B. Ward) [McConnell 1978). All original orchard sites and species were successful except for sand pine. It *was* first included as part of the Erambert Seed Orchard in south Mississippi. Survival and growth was poor so the sand pine orchard was moved to central Florida, which is in the native range of the species.

Approximately 6 million acres of National Forest pinelands were intensively searched for the very best trees as candidate parent trees for first generation orchards. After a candidate was found, it had to pass several screens before it was finally accepted. Faster growth, pruning ability, straightness, disease resistance, and specific gravity were the traits sought after in the superior tree selections. About 50 selections for each species-geographic source were approved. Then the selections were grafted into clonal orchards. The Ocala sand pine orchard has both a clonal orchard and a 120-family seedling seed orchard. The Region now has 2,177 pine selections in 1,256 acres of pine seed orchards at 6 orchard sites.

The first collectible crop of seed was harvested in 1970; through 1984, collections have totalled 81,000 pounds. Most pine sources in the program are now producing enough seeds for total planting requirements.

The hardwood program started in 1968. Six species are in the program--black ¦Quercus velutina Lam.), white (Q. alba L.),__northern red (Q. rubra L.),__and chestnut oaks (P. prinus L.),__cherry ¦Prunus serotina Ehrh.) and yellow-poplar ¦Liriodendron tulipifera L.).__To-date, 382 selections have been made for clonal orchards and 29 acres of clonal orchards have been established. A 220-family, 16 acre, northern red oak seedling seed orchard was established, which was originally a Tennessee Valley Authority progeny test on National Forest land.

Of the hardwood clonal orchards, only yellow-poplar and black cherry are producing enough seed for operational plantings. Sure-fire techniques for successful oak seeding or planting are still not developed; however, within a few years, crops will be harvested from the orchard and attempts at using them for reforestation will be made.

Managing first generation orchards presented some unique problems that had to be solved. Foremost was how to harvest all the cones or seeds without harming the trees. During regular woods cone collection, trees were usually

cut down and the cones picked; however, since cutting trees was not possible in a seed orchard, various methods were used to place people in the trees, including ladders and bucket trucks. Besides being expensive and slow, these methods were somewhat hazardous.

With the cooperation of the Georgia Forestry Commission, a new system was developed, called the Net Retrieval System. Netting was placed on the ground where the seeds fell, and a combine-type machine was used to roll the net and separate the seeds. The Net Retrieval System is now in operation on all or part of 4 Forest Service orchards (Edwards and McConnell 1983, McConnell and Edwards 1985), and other organizations are considering using this system.

Because a seed orchard has many trees of the same age, it is an attractive home for insects--especially those that like to eat cones and seeds. Safe and effective ways had to be found to control these seed-destroying insects. Entomologists worked closely with orchard managers on pesticide formulation, application, and timing for effective control. With the help of several organizations, technology for the aerial application of insecticide was developed. Now an orchard can be treated in hours instead of weeks that were required for ground application methods. In addition, aerial applications place the insecticide in the top portion of the crown, where the cones are. This means less insecticide is necessary to do an effective job.

Progeny Testing

In 1974, controlled crosses among orchard trees began according to a plan that employed disconnected half-diallels for all species except sand pine. Individual matings were made to match desirable characteristics as indicated by the original scoring sheets, fusiform rust disease resistance screening tests, and progeny performance (McConnell 1983). Over 9,500 individual crosses will have been made when the plan is completed.

Progeny testing was done to; (1) measure gains, (2) test worth of parents, and most importantly, (3) as a source of selections for second generation orchards. A few open-pollinated tests were installed, mainly for demonstration purposes. To date, over 250 tests have been planted representing about 6,500 families. About 20 percent of the tests are 5 years old or older. Early results have been quite surprising. Of course, early results must be used with a great degree of caution. Nevertheless, they indicate that large genetic gains can be made.

A white pine open-pollinated test at the Cradle of Foresty, on the Pisgah National Forest in North Carolina, showed orchard trees to have a 25 percent superiority in diameter growth (dbh) and a 15 percent superiority in height growth over general forest area stock at age 5. The 10-year results for the same test showed an accelerating difference--28 percent in height and 36 percent in diameter. The 10-year mean for orchard stock was 24.75 feet tall and diamater of 4.97 inches; for general forest area stock the respective means were 19.25 feet and 3.65 inches.

Another important result, and one expected by geneticists, was that the range of trait variation for height and diameter was the same for seed orchard material as general forest area stock. Only the mean of the two populations was different. This is evidence that orchard populations will continue to have large amounts of variation for some traits.

One of the largest actual heights and diameters occurred in a loblolly pine test in Southern Mississippi. At age 5, the average of all orchard families was 16.6 feet, the tallest family was 18.2 feet, and the tallest individual tree was 29.1 feet.

Other early results are quite impressive. However, the number of tests analyzed is small relative to the total number planned. During the next few years many more tests will be analyzed so that greater confidence can be placed in the gain percentages.

Plans are to use 8- to 10-year test results to begin making selections for second generation orchards. That time is almost here.

Second Generation Breeding

The second generation plan for pines has been developed. Actually, it goes beyond the second generation because selection of new genetic material to infuse into second and successive generation breeding is also planned.

As stated earlier, since second generation gains are expected to double first generation gains, full speed ahead is in order.

Orchard site selection has already begun. In general, second generation sites will be near first generation sites in order to efficiently utilize present personnel, facilities, and equipment.

The 38 pine geographic source-species combinations used in the first generation were streamlined into 20 breeding populations for the second generation. The breeding populations are based on seed movement and planting zones as defined by research results in most cases, but a few were designed using a combination of intuition and/or administrative necessity (Wells and McConnell 1983). Reducing the breeding population to 20 will increase program efficiency. It also gives a broader genetic base for second generation selections since some first generation populations were combined.

The 20 breeding populations for the second generation have been prioritized based on the species importance in National Forest reforestation and on progress of first generation progeny tests. The highest priorities will be developed first and others will be done as timing and budgets allow. Other flexibilities have also been built into the plan so that developing technology can be incorporated along the way.

Guiding Principles

Several guiding principles have been used which contributed greatly to the success of the program.

Knowledge and experience of a large part of the tree improvement community have been drawn upon in formulating strategic plans and critiquing the program. The Regional Geneticist and a small staff are responsible for strategic planning, but they consult frequently with many others. John Kraus and Ozzie Wells, Southeastern and Southern Forest Experiment Stations respectively, are constant advisors. The interchange of tree improvement information under the umbrella of the Southern Forest Tree Improvement Committee is used. One almost has to be a part of tree improvement in the South to fully realize the spirit and degree of cooperation within this community.

Maximum involvement of Forest and District personnel is fostered. There is no tree improvement organization as such below the Regional level. Forest Supervisors are responsible for the program on their respective forests. Orchard Managers and workers who do actual test plantings and measurements are on the District Ranger's staff. By having this type of involvement, ownership of the program is vested in all levels of the organization and each level takes pride in program accomplishments. Work is accomplished in a timely fashion and the quality of work is high.

The Tree Improvement Program is continually evaluated with respect to current silvicultural practices used on National Forest lands. Greater productivity is the goal of tree improvement. Greater productivity cannot take place without the proper integration of genetics and silviculture. In fact, on the National Forests, tree improvement is viewed as an integral part of silviculture.

Closing

A quarter-century has brought the Southern Region's program a long way, but the challenge to breed another generation of trees to reach higher production goals is great and exciting. The next 25 years will no doubt bring accomplishments unimaginable today.

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