FOURTEENTH ANNUAL REPORT

N. C. State University
Cooperative Tree Improvement
and Hardwood Research Programs

School of Forest Resources
North Carolina State University
Raleigh

May, 1970

THE COOPERATIVE TREE IMPROVEMENT PROGRAM--PINE

General

In following the theme ACCOMPLISHMENTS it is difficult to know where to start because so much of significance has happened in both the application and research phases of the program. Results with most immediate economic gains will be emphasized first. This does not imply that they are always the most important, since continued future improvements can only be expected with a firm foundation of long-term basic information. It is more difficult than ever this year to restrict the size of the report because we want to give a representative sampling of results achieved. In all aspects we are years ahead of what had been hoped, with results more dramatic than we dared dream. It's none too soon, however, because of the constantly mounting pressures to obtain maximum production on each acre.

Putting Results to Work

The Pine Cooperative has as its main objective putting to use information obtained. Several major activities are now in the application category.

Improved Seed from Seed Orchards

The seed orchard program has developed rapidly, with 2,450 acres of orchard already established (See Table 12). Although much of the orchard acreage has been recently established and is not yet producing commercial quantities of cones, enough seed were obtained in 1970 to grow 40 million nursery seedlings, enough to plant approximately 60 thousand acres at the spacings commonly used in the Southeast. Seed are usually planted in the nursery to produce 25 plants per square foot, which results in few culls and a good seed-to-plantable seedling ratio.

Seed orchard establishment has developed well, and commercial production has started (enough seed was collected in 1970 to plant 40,000,000 trees). One of the largest orchards in the Cooperative is the 300-acre comples of the Virginia Forest Service in which establishment will be completed in the next two years.

Many of the older seed orchards have been thinned to reduce competition, promote flowering, and remove poor parents. Shown is the producing orchard of Union Camp Corporation in North Carolina which has been marked for thinning in 1970-71.

Table 12. Acreage and yields from conifer seed orchards[1/] established in the Cooperative

Species	Acres Established	Bushels of Cones (1969)	Pounds of Seed (1969)	Pounds of Seed/ Bushel of Cones
Coastal Source Loblolly pine	908	1467	1774	1.20
Piedmont source Loblolly pine	861	1299	1280	1.00[2/]
Slash pine	387	317	134	0.42[3/]
Virginia pine	115	212	133	0.63
White pine	73	---	19	---
Pond pine	48	20	21	1.00
Longleaf pine	43	---	---	---
Miscellaneous pine (pitch, sand, spruce)	10	---	---	---
Fraser fir	4	---	---	---
Totals	2449 acres	3315 bu.	3361 lbs.[4/]	

1/ Acreage of orchards established by June, 1970. Most of the 80 orchards are young and not producing commercial cone crops.

2/ Three of the producing orchards in the north had low yields of only 0.73 lbs./bushel; these offset the 1.26 lbs./bushel from the heavily producing southern orchards.

3/ Because of freezes and other factors, slash pine seed yields per bushel of cones were at an all-time low.

4/ Calculated to produce over 40,000,000 plantable seedlings

The yields of seed from the orchards continue to increase rapidly each year as the older orchards mature and the younger orchards come into production. Yields per acre are above predictions for Piedmont source loblolly but below expectations for Coastal Plain source loblolly orchards. Slash pine has been a real disappointment, while Virginia and pond pines are producing above expectations. In 1969 the first cones were obtained from longleaf and Fraser fir orchards.

Harvesting Seed from Seed Orchards

It is preferable to harvest seed from loblolly and Virginia pines because of the tenacious manner in which cones are attached to the limbs. Cones can be collected for longleaf and slash pines by tree shakers, but shaking loblolly and Virginia pine will destroy the tree before cones are detached from the limbs. The vacuum seed harvester being developed under the auspices of the Cooperative will be ready for operational use the fall of 1970. Testing under varied conditions in several seed orchards has proven the feasibility of vacuum seed collection from orchard surfaces and the suitability of the machine to do this.

In the tests, 65 to 80 percent of the seed on the ground has been collected by the harvester in one trip, and 90 percent or better collected in two trips over the orchard. For efficiency it is necessary to shake the seed from the cones prior to vacuum collection. Because of the time differential in maturity of individual clones it will be necessary to make several collections during the fall. Prior to seed fall, the close-mowed orchard is swept clean of needles, grass and other debris by the vacuum harvester, to facilitate seed pick-up. Separation of seed from remaining debris is partially accomplished within the cleaner but it is necessary to complete separation at the nursery site.

The Cooperative is indebted to the Seed Harvest Committee under the leadership of Harold Nelson for developing a seed collection system. Until now a seed collection technique not involving climbing was a major problem within the seed orchard program.

The classic concept of graft incompatibility is the scion overgrowing the stock. As exemplified by the loblolly graft in the International Paper Company seed orchard, however, a much less common type of incompatibility where the stock is outgrowing the scion is showing up in many of the older orchards.

The "proof of the pudding" is in the growth of trees from commercial stock versus seed orchards. Shown is the border between a plantation of seed orchard stock (left) and commercial stock (right) on l ands of Kimberly-Clark in Alabama. The trees have finished the fifth growing season--the seed orchard trees were 15.3' tall, the commercial check 11.5' tall; the orchard trees had 96 percent survival, the commercial lot 86 percent.

Disease-Resistant Seed Orchards

One of the most dramatic results from the Cooperative Program has been the amount and pattern of resistance to fusiform rust. This disease is of major concern to many members of the Cooperative, and an improvement in resistance will often spell the difference between a profitable and a nonprofitable forest operation.

Because much of their forest ownership lies within high hazard disease areas, three companies established special disease-resistant seed orchards. This use of known resistant clones in a specialty orchard was first proposed by Barry Malac of Union Camp Corporation; shortly thereafter U. S. Plywood-Champion Papers, Inc. and Continental Can Company decided to establish such specialty orchards during 1970. Other organizations will also establish disease-resistant orchards in 1971. Trees in control-pollinated progeny test plantations of six companies were examined for fusiform rust infections. In all, 33,811 trees of 199 crosses in 29 plantations two, three and four years old were examined. From the 49 parents that were represented with sufficient data for evaluation, seven were rated as extremely resistant, seven as very resistant, and four resistant enough to consider for use in the special orchards. Establishment of special disease-resistant seed orchards is a prime example of the value of the Cooperative approach. It would be difficult for an organization acting alone to establish such orchards. It also is an outstanding example of early use of information from progeny tests by members of the Cooperative.

Improved Seed Orchards

Now that many progeny tests are old enough to yield reliable information, it is possible to identify clones in the seed orchards that will produce desirable progeny. This enables the establishment of improved orchards in which all clones are compatible, good grafters, good seed producers, and which produce good progeny; for lack of a better name, these are called 1.5-generation orchards. To expand or to improve initial production seed orchards, ten members of the Cooperative have decided to establish the better 1.5-generation orchards by combining the very best clones of all orchards in the Cooperative for the same species from a given geographic area. Some new orchards of this type contain clones from seven or more Cooperators. An important goal of the Cooperative is to establish operational orchards of known heavy seed-producing clones that are compatible and that have outstanding progeny. Some really excellent clones such as 7-56, 8-33, 6-33, 12-12, 1-60, 6-9 and others will make a major contribution to improved plantations in the near future.

Progeny Tests

Establishment

Progeny testing is essential for these reasons:

1. To determine the worth of the mother trees used in the seed orchards. Data on progeny already available have enabled thinning of 15 established seed orchards.
2. To provide material for second-generation selections. The crossing design used in the Cooperative makes efficient second-generation selection possible; this use of progeny test data is perhaps the greatest long-term value obtained by progeny testing.
3. To assess the improvement in performance of stock obtained from seed orchards over that of commercial planting stock normally used.

Each year a generalized report of the progress in combined progeny testing for all members of the Cooperative is given. Data in Table 13 are current as of June, 1970.

We have found the most efficient seed orchard is one associated with a nursery location. Shown is Kimberly-Clark's nursery-orchard complex with nursery beds in the foreground, loblolly pine seed orchard behind that, Virginia pine seed orchard to the right, and in the background a longleaf pine seed orchard, a sycamore seed orchard and progeny tests of both pine and hardwood.

Table 13. Control-pollinated progeny crosses field planted in the Tree Improvement Program to June, 1970

	Number of Crosses[1/]	Acres Planted
Main Tests[2/]	2912	407.1
Supplementary Tests[3/]	2683	217.4
Total	5595	624.5

1/ Includes commercial and seed production area checks

2/ Each cross is planted in six 10-tree row plots for each of the three years, on an area considered representative of the lands of the organizations.

3/ Most crosses are planted in three 10-tree row plots for each of three years, on areas considerably different from those of the main test.

Special Tests (General)

In general the main progeny tests are established under conditions representative of planting methods and management used commercially, whereas supplementary tests are established under varying conditions to determine the reaction to special problems. Response to fertilizers is evaluated in one set of tests. As reported last year, some families react to fertilization differently than others, and it is essential to locate those that are especially responsive.

Special Tests (Overseas)

For a number of years members of the Cooperative have sent seed to persons making progeny tests overseas. Some results from these are now available and others will soon be in hand. For example, seed of special lots or special crosses from 75 select trees were obtained and are now outplanted in studies of loblolly pine in New South Wales. Overseas tests can be helpful in assessing the genetic worth of the clones used in orchards of the Cooperative. Several years ago some members of the Cooperative made seed from selected clones available to the Rhodesian Forest Service. Recently Mr. Peter Banks, who heads up forest research in Rhodesia, sent results of measurements on 48 families which had been grown in two locations. Although the data are only for three years' growth, results have been good, pointing up the necessity of using the proper geographic seed source. Mr. Banks stated, "For loblolly pine, the general superiority of the South Carolina seed lots at both sites is striking. I note that both lots of 7-56 performed well at both sites. The performance of 11-22, which is averaging nearly two feet taller at Stapleford than at Martin, and 8-7 (which is 1.3 feet taller) is interesting. The effect of site on form is most marked and there is not much agreement between seed lots. Clone 7-56 had better form at Martin than at Stapleford, whereas 8-35 was one of the best at Stapleford and nearly the worst at Martin. There appears to be little relationship between height and form. A relationship between crown width and straightness was not evident."

Several interesting comparisons can be made using five selected progenies from the southern Coastal Plain and two from the northern Coastal Plain of the southeastern United States (Table 14):

1. Geographic seed source is of vital importance, with best growth from the more southern sources.
2. There was little genotype-x-environment interaction for height growth. Most families performed relatively the same at both locations. For example, 7-56 rated first and second at the two locations, whereas 7-22 rated sixth at both, and 8-50 was sixteenth and nineteenth at the two locations.

Table 14. Performance of selected open-pollinated loblolly pine progeny of Cooperative clones grown in Rhodesia (Trees three years old)

Test Area	Clone	Source	Ht. (ft.)	Ht.[3/] Rank-ing	DBH (in.)	Straight-ness [3/] Ranking	Crown Width (ft.)	Branch Diam.
Stapleford	7-56[1/]	IP Co.,-S.C.	15.0	1	2.5	16	7.2	0.40
Martin	7-56	" "	15.2	2	2.4	4	5.0	0.40
Stapleford	11-61[1/]	Westvaco-S.C.	14.8	2	2.5	29	8.4	0.43
Martin	11-61	" "	14.4	4	2.2	20	4.4	0.47
Stapleford	7-56[1/]	IP Co.-S.C.	14.2	3	2.5	16	7.0	0.39
Martin	7-56	" "	15.1	3	2.5	1	4.3	0.40
Stapleford	11-22[1/]	Westvaco-S.C.	14.1	4	2.7	25	7.4	0.43
Martin	11-22	" "	12.2	8	2.1	8	4.5	0.56
Stapleford	7-29[1/]	IP Co.-S.C.	14.0	5	2.4	27	7.6	0.45
Martin	7-29	" "	15.5	1	2.3	13	4.4	0.49
Stapleford	7-22[1/]	" "	13.2	6	2.3	21	6.8	0.43
Martin	7-22	" "	12.8	6	2.1	17	4.6	0.50
Stapleford	8-29[2/]	Wyrhsr.-N.C.	9.5	16	1.4	3	5.0	0.43
Martin	8-29	" "	10.8	13	1.5	3	4.2	0.45
Stapleford	8-50[2/]	" "	8.9	19	1.2	9	4.6	0.39
Martin	8-50	" "	9.8	16	1.3	2	3.0	0.47

1/ Trees from southern Coastal Plain source. The two 7-56 lots are from the same mother tree.

2/ Trees from northern Coastal Plain source

3/ Rankings--1 best, 29 poorest

Stapleford--elevation 5400 feet, rainfall approximately 65 inches
Martin--elevation 4170 feet, rainfall approximately 45 inches

3. Bole straightness sometimes varied greatly between the two locations. Clone 7-56 produced progeny of only average straightness at one but straight trees at the other, indicating a strong genotype-x-environment interaction; however, progenies of 11-61 were exceptionally crooked at both locations, while those of 8-29 were exceptionally straight on both sites.
4. Crown width was always smaller at the Martin location but progenies of 8-50 were relatively short-limbed at both places. Tree 7-56 consistently produced trees with small branches, while 7-29 always produced trees with large branches.
5. Although trees at Stapleford had wider crowns, branches were usually smaller in diameter than those of trees grown at Martin.

Tests at other places have revealed that clone 7-56 produces vigorous, well-formed progeny while 11-61 progenies are vigorous, with wide crowns and thick limbs. These results indicate that relative family performance, for some traits at least, is similar for plantings on different continents. *It is, therefore, of importance to select the best parents to obtain maximum value from provenance tests.*

Progeny Performance (General)

The flow of progeny information from the progeny tests has become a flood. Results have been summarized for the four-year tests in Tables 15 and 16. Some results from older tests have been published; for example, one paper reported on the relationship between growth rate and specific gravity. At 7.5 years of age some families produced nearly three cords per acre per year while others yielded little over half as much. Dry wood weight yields were determined and the best family averaged nearly three tons of dry wood per acre per year.[1/]

1/ A good rule of thumb to convert volume to tonnages of dry wood of young loblolly pine is: one cord of wood equals approximately one ton of dry fiber.

As a species Virginia pine has increased in value to members of the Cooperative. Many fine select trees have been established in orchards, and progeny from these have developed very well. Shown (left) is a nice graft in Hiwassee Land Company's seed orchard of Virginia pine, and (right) 3-year-old progeny from it. Virginia pine progeny growth has been as good as loblolly in the high Piedmont and mountain areas.

As expected, a few crosses were outstandingly good while some of the others performed poorly. The improvement in bole and crown traits of trees from seed orchard parents over those of the commercial checks is pleasing. Although growth relationships may change as the trees become older, the height superiority of the selected parents (including both good and poor clones) is satisfactory, and volume comparisons will reveal more superiority. Roguing the poorest ten percent of the clones will considerably increase the superiority of orchard seed over commercial and seed production area checks.

Table 15. Height growth of 4-year-old control-pollinated progenies from seed orchards (Height in feet--loblolly pine)

	Coastal Plain 1/ Wet Site	Coastal Plain 2/ Well Drained Site	Piedmont 3/	All Combined 4/	% Superiority Over Commercial checks
Best 10%	7.01	9.00	8.74	8.02	33%
Poorest 10%	5.25	7.07	6.94	6.20	-8%
Plantation Avg. 5/	6.15	8.09	7.85	7.14	6%
Commercial Checks	5.54	7.99	7.48	6.74	-
Seed Prod. Area	5.68	7.67	7.77	6.78	1%

1/ Based on 190 crosses (test lots) in eight plantations with a total of 11,640 progeny test trees

2/ Based on 122 crosses (test lots) in eight plantations with a total of 4,120 progeny test trees

3/ Based on 92 crosses (test lots) in six plantations with a total of 4,350 progeny test trees

4/ Based on 404 test lots in 22 plantations with a total of 20,110 progeny test trees in 38 acres of test plantations

5/ Includes commercial checks and seed production area checks; the average from selected seed orchard parents is therefore greater than shown.

Table 16. Crown form, stem straightness, and disease resistance in 4-year-old control-pollinated progeny test plantations from seed orchards 1/ (loblolly pine)

	Straightness 2/	Crown 2/	Disease 3/
Best 10%	2.87	3.21	1.14
Poorest 10%	4.02	4.02	1.97
Plantation Average 4/	3.45	3.60	1.44
Commercial Checks	3.79	3.81	1.45
Seed Production Area	3.69	3.84	1.53

1/ Control-pollinated progeny tests from 404 test lots, totalling 20,110 individual trees planted in 22 test plantations

2/ Based on a subjective coding of 1 to 6, 1 being best, 6 poorest. The smaller values therefore indicate straighter trees or trees with better crowns.

3/ Values relate to a severity index involving severity and location of fusiform rust infection. The highest values indicate the most severe infection.

4/ Includes the commercial and seed production area checks

It is obvious that progeny from the selected trees have straighter boles and smaller crowns than do the commercial checks and seed production area lots. The difference in the plantation average for fusiform rust infection and that for the commercial checks is negligible; but when the more susceptible clones are removed from the orchard, seedlings produced will be considerably more resistant than the commercial planting stock. Several progeny test plantations were in areas of light infection, and many parent trees were selected from stands in which the incidence of fusiform rust was low.

In a special Virginia pine study, open-pollinated tests were established from seed collected from the select trees in natural stands (Table 17). All 13 parents produced progeny superior to the commercial check, several with marked superiority. Superiority over the commercial check lot should be interpreted with caution in this study because the check seedlings and those from select trees were grown in different nurseries. It appears from this and other tests that the superiority of progeny of selected Virginia pines over the commercial lots in height growth is greater than is found in loblolly pine.

Table 17. Performance of open-pollinated progeny of Virginia pine after three years' growth in the field 1/

Category	Height (ft.) after three years	Percent Superiority Over Commercial Check
Best 4 families	4.35	+28
Poorest 4 families	3.77	+11
All 13 families	4.07	+19
Commercial Check	3.41	0

1/ Ten rows of ten trees (100 trees from each parent) were planted under field conditions on lands of Westvaco Corporation near Charlottesville, Virginia. Thirteen parent trees were involved.

Special Tests (Maximum Yield)

To determine the maximum growth potential of seed orchard stock under ideal management conditions, including fertilizers, a number of organizations have established "maximum yield" progeny tests. In these the goal is to see how fast pine wood can be grown. Various combinations of intensive site preparation, fertilization, cultivation and insect and disease control have been applied.

One such test at the International Paper Company's Eight-Oaks seed orchard has developed well, having attained an average height of 16.7 feet and DBH of 3.2 inches at four years of age. Fertilization response has been large. Trees growing in plots which received the best fertilizer treatment produced an average of 47 percent more volume than those growing in the unfertilized area. The best fertilizer treatment was the moderate one; the heavily fertilized trees were less vigorous than the optimum treatment but better than the unfertilized plots. (Fertilizer levels are shown in Table 18.)

1. The superiority in height and diameter growth of the crosses was greater in the fertilized than in the unfertilized plots. The commercial check lot was essentially the same as the average of all crosses in the unfertilized plot. Differences between the Coastal Plain seed production area check and that of the control-pollinated crosses were greater on the fertilized plots than in the unfertilized one.
2. The superiority of the crosses in form and straightness was not large.
3. The Piedmont seed production area was always highly inferior to that from the Coastal Plain, no matter what category of Coastal Plain with which it was compared.
4. The mean of the upper 25 percent of the crosses was superior to the commercial check in almost all categories of form and growth. For example, in the optimum fertilizer plot these contained 77 percent more volume than did the commercial check, but on the unfertilized plot this superiority dropped to 29 percent.
5. Seed production area sources usually produced trees with small crowns and straight boles but volume growth was low.

This plantation (summarized in Table 18), and others like it, give useful information about how best to produce pine wood.

Special Tests--Fertilizer Response

There is often a differential response of certain families to fertilization, *i. e.*, some respond more favorably to fertilization than others. Nearly all such results have been observed on young plants, many in greenhouse

Table 18. Growth of the maximum yield progeny test plots in the Coastal Plain of South Carolina 1/

Category	Vol. (Cu.Ft.)	Height (Ft.)	Diam. (In.)	Straight-ness 3/	Crown 3/
			Optimum Fertilization 2/		
Avg.--upper 25% of crosses	.969	20.2	4.1	3.2	3.2
Avg.--all crosses	.687	17.9	3.5	3.6	3.4
Coastal Plain Seed Prod. Area	.477	16.0	3.1	3.4	3.1
Comm. Check	.547	17.0	3.6	4.0	3.4
Piedmont Seed Prod. Area	.329	14.8	3.1	3.6	4.0
			Heavy Fertilization 2/		
Avg.--upper 25% of crosses	.773	19.1	3.7	3.3	3.2
Avg.--all crosses	.593	17.0	3.3	3.6	3.5
Coastal Plain Seed Prod. Area	.523	15.5	3.4	4.3	3.6
Comm. Check	.519	15.7	3.1	3.6	3.2
Piedmont Seed Prod. Area	.328	11.7	2.4	3.8	3.6
			No Fertilization		
Avg.--upper 25% of crosses	.608	18.3	3.3	3.2	2.8
Avg.--all crosses	.462	15.9	3.0	3.4	3.3
Coastal Plain Seed Prod. Area	.427	15.4	3.1	3.2	2.6
Comm. Check	.473	15.9	3.1	3.3	3.4
Piedmont Seed Prod. Area	.170	11.4	1.9	3.2	3.4

1/ Eight-Oaks Seed Orchard of International Paper Company

2/ Optimum = 4 oz. of 5-10-10 per tree at year one.
Heavy = 12 oz. of 5-10-10 per tree at year one.

3/ Rated on a scale of 1 to 6, with the lower values indicating the straightest trees or narrowest-crown trees experiments. We have noted a similar response in our field progeny tests, and Jim Roberds and Gene Namkoong have established two studies (now three years old) to test such a response in the field. Results from these and other studies are being summarized by Bruce Zobel and Jim Roberds for presentation at the Forest Biology Workshop at Michigan State University in August, 1970.

In a progress report on his thesis research, Robert Simons, graduate student working for the Ph. D. Degree with Dr. Perry, presents results for crosses from the N. C. Coastal Plain orchards of Weyerhaeuser Company and from the Alabama Piedmont orchard of Kimberly-Clark. His generalized, tentative results were:

1. A definite interaction between nitrogen levels and family progenies was found; differences were at the one percent level of probability. This means that some families exhibited greater response to nitrogen levels than did others.
2. He found no differences in response for nitrogen supplied as ammonium or nitrate ions.
3. The North Carolina Coastal Plain crosses showed a greater response to nitrogen than those from the Piedmont Alabama source.

Studies involving genetic response to fertilizers will become more numerous as fertilization becomes a more accepted management practice.

Special Tests--Wet Sites

One of the major breeding problems in the South is to develop "strains" of trees that will grow on marginal sites. Large acreages of excessively wet, though otherwise good, sites should be reforested. Growth of standard commercial seed sources on these sites has not been satisfactory. To ascertain sources of seed that will grow best on these sites, Union Camp Corporation (Virginia) tested four different lots of trees. After four years the "wet site" loblolly pine source from Westvaco's seed orchard is doing well. Results are summarized in Table 19.

Table 19. Growth of four lots of pine on excessively wet sites,[1/] Union Camp Corporation, Virginia

Seed Source	Percent Survival	Ht. Growth (1 yr. in field)	Ht. Growth (3 yrs. in field)	Ht. Growth (4 yrs. in field)	Fusiform[6/] Rust Score
Seed Orchard[2/] Wet Site Loblolly Pine	89	1.3	5.4	8.5	1.00
Local Wet Site[3/] Loblolly Pine	92	1.3	4.9	7.5	1.07
Seed Orchard[4/] Pond Pine	100	1.5	5.3	7.5	1.06
Commercial Loblolly 5/	94	1.2	4.7	7.4	1.23

1/ Site is excessively wet, mineral soil, not bedded. There were four replications of 36-tree plots.

2/ From Westvaco's seed orchard, Dare County, wet site, deep peat source

3/ Collected from the wet land where test plantation is located

4/ From Westvaco's seed orchard, Dare County, wet site, deep peat source

5/ Commercial loblolly source, southern Virginia

6/ A severity index rating: 1.-- indicates no disease. The higher the score, the greater the infection.

The study shows (1) the value of selected material, (2) the value of well adapted sources, (3) the danger in making decisions too early. For example, the pond pine looked good for three years, but during the fourth year it fell back in height growth. There is no explanation for the disease-free condition of the loblolly from the selected deep peat seed source. When rated for straightness (data not shown) the seed orchard loblolly pine and seed orchard pond pine were much better than the commercial lots; the seed orchards also produced progeny somewhat better in crown form than the commercial sources.

Seed Orchards and Select Trees

Sizes and Numbers

Commercial production of large amounts of seed from seed orchards and seed production areas comes none too soon. Seed of any kind (especially slash pine) is becoming scarce, and a severe shortage may soon exist. As the older stands are harvested and the plantations cut at shorter rotations, seed of any kind will be in short supply. Seed orchards and seed production areas serve a major function as a continuing, reliable source of seed in addition to any genetic improvement realized.

When the established orchards become fully productive, the current reforestation requirement of members of the Cooperative for 300,000,000 trees each year can be met (2,449 acres in over 80 orchards, see Table 2). But as forest management practices intensify, and as additional land is placed under management with rotation ages shortened, the need for larger amounts of seed will grow. Many organizations have plans to expand their production orchards. In nearly all instances this will be done by using 1.5-generation orchards made possible by the exchange of the best clones among members of the Cooperative.

Ice storms hit every year somewhere in the Southeast. An especially severe storm hit in South-North Carolina, wrecking both pine and hardwoods. Shwon is a slash pine planting following the storm.

Ice storms are an ever-present threat to seed orchards. Shown is the slash pine orchard of the South Carolina Forestry Commission that was hit by ice in February, 1969. Inset is the Continental Can Company loblolly pine orchard in Virginia after an ice storm in January, 1970. In both instances damage was extensive but the trees are recovering rapidly.

The search for additional select trees goes on undiminished. This is desirable, since as broad a genetic base as possible is needed. The caliber of selections improves each year. Although loblolly pine receives the major emphasis, good selections have been made in minor species and placed in seed orchards. By March, 1970, trees graded for use in seed orchards numbered 2,386, and most were already established.

Seed Orchard Management

It is never safe to say that all answers are known--this never happens. But we can say that many problems inherent in clonal seed orchard management have been solved. We have workable spray schedules. We know that subsoiling is usually helpful for improving cone yields and vigor of the grafts. We have not solved the graft incompatibility problem but have learned to live with it. We know the effects of fertilization (although not the optimum formulations or concentrations) and, thanks to two dry years, can make some positive statements about the effects of irrigation on seed production. Results obtained by graduate student Steve Webster were summarized in Table 20 for the fertilizer-irrigation study in Hoerner-Waldorf's seed orchard. This study has been under way for five years.

Table 20. Cone counts on the Hoerner-Waldorf fertilizer-irrigation study in the Piedmont loblolly seed orchard--1969

Clone	Control	Irrigation	Fertilization	Irr. & Fert.	Mean
	Cones/Clone/Plot				(Cones/Tree)
6-7	55	55	52	35	12.3
6-20	53	26	109	209	26.4
6-8	94	102	224	84	33.6
6-9	59	174	275	737	77.8
Mean (Cones/ Tree)	17.4 1/	23.8 1/	41.2	66.6	

1/ Based on 15 trees; other means are based on 16 trees (4 ramets of each clone on each plot).

(Left) All kinds of oddities are found when a species is carefully studied. Shown is one of three "natural Christmas tree"-shaped white pines found by the North Carolina Forest Service. Tests are under way to see if these can be used to develop better Christmas trees.
(Right) Many hybrids have been graded and put into seed orchards. An outstandingly good loblolly-x-pond pine hybrid is shown in the Virginia seed orchard of Continental Can Company. The major difficulty with the hybrids is that they often flower out of phase with other trees in the orchard.

Things happen sometimes that we don't understand. For example, younger orchards are flowering earlier and more heavily than those that were established several years ago. We know better how to graft, how to establish the orchards, where to establish them, how to fertilize them, but we don't know why they are flowering better. The use of thimet and Di-Syston may be partially responsible--at least some think so. But regardless of the cause, the younger orchards are producing earlier and heavier cone crops than did the older orchards at the same age.

Seed Orchard Yields

Seed production from the orchards is summarized in Table 12. It remains true that Piedmont sources of loblolly always produce heavier and earlier cone crops than Coastal Plain sources, regardless of orchard location. Also, 20 percent of the clones are still contributing about 80 percent of the orchard seed yield.[1/] Management practices which increase seed production (including subsoiling, fertilizing and irrigating) result in larger increases in cone yields for the heavy producing clones than for the lighter ones, e. g., clone 6-9 in Table 20. Predicted yields of seed per acre have already been achieved in a few Piedmont source loblolly orchards but have not yet been realized in most Coastal Plain loblolly source orchards. Seed yields in the slash pine orchards have been below expected levels, and yields in Virginia pine orchards have been greater than anticipated.

1/ In his report, "Variation in Flowering and Its Effect on Seed Cost--A Study in Seed Orchards of Loblolly Pine," Bergman (1968) calculated that an exceptionally heavy cone- and pollen-producing clone in one seed orchard was a parent of roughly half the total seed produced in the orchard.

This series of photos illustrates how to construct an "instant seed orchard." Shown is the equipment used by Hiwassee Land Company (Bowaters) to move their 10- to 12-year-old orchard grafts to another location. The newly established orchard is shown below--already over 1,000 large trees have been moved.

Specialty Seed Orchards--Hybrids

Based on progeny performance, a number of specialty seed orchards have been established, as illustrated earlier for disease resistance. In addition, special orchards for production of hybrids have been established to obtain disease-resistant progeny (loblolly x shortleaf), hardy trees for planting on poor sites (loblolly x pitch), or fast growing, site tolerant trees (loblolly x pond). Although progenies of these crosses have been produced and are outplanted it is too early to assess results. However, some progenies of natural hybrid parents in seed orchards have performed well.

Second-Generation Selections

The long anticipated step in our Tree Improvement Program has begun, in which the best trees from parents in the production seed orchards are selected. Plans were formulated, changed, dropped, reformulated and changed by the staff of the Cooperative until an acceptable procedure was devised. The plan is simple in concept and consists of selecting the best trees in the progeny tests, on the basis of family as well as individual tree performance. On this basis the best individuals are selected, then checked on the ground to make sure they are outstanding. This first assessment is at four or five years of age; and if the tree meets specifications, three or four grafts are established in a clone bank where they remain for another five to seven years before being placed in a production orchard. At the end of this time (when the tree is about 12 years of age) we will:

1. know if the tree is graftable and compatible;
2. know if the initial estimate of the value of the selected tree is the same at age 12 as it was at age 4, based on another set of measurements and field check;

For years we have anticipated the selection of outstanding trees from progeny tests of the seed orchards to use in second-generation seed orchards. The extra work using crossing patterns such as a tester system or other single-cross systems is now paying off. Shown are initial second-generation selections: (Left) Riegel Paper Corporation--loblolly, five years old; (Center) International Paper Company--loblolly, five years old; (Right) Bowaters Corporation--loblolly, four years old.

Table 21. Height of some trees selected for second-generation seed orchards 1/

Source	No. Trees Selected/ 2nd-Gen. Seed Orch.	2nd-Gen. Selections Ht./4 Yrs. (ft.)	Avg. Fam. Ht. (ft.) from which Selected	Avg. Plant. Ht. (ft.) from which Selected	Avg. Ht. Comm. Cks. (ft.)	Sel. Tree Superiority Over Comm. Checks (ht.)	Sel. Tree Superiority Over Plantations (ht.)	Family Superiority Over Plantation Average
Coastal S. Car.	7	11.2	9.0	7.7	6.4	75%	45%	17%
Piedmont N. C.	4	9.8	7.5	6.9	6.5	51%	42%	9%
Coastal N. C.	10	10.6	8.2	7.9	6.3	68%	34%	4%
Piedmont S. C.	5	11.4	8.7	8.6	7.8	46%	33%	1%
Piedmont Alabama	6	11.7	8.5	8.3	7.1	65%	41%	2%

1/ Trees selected after four growing seasons in field

Harvesting cones from loblolly seed orchards is a difficult job. Shown above is the method now used by International Paper Company (South Carolina), which has proven to be efficient and rapid. In an attempt to do the seed collection even more efficiently, the Seed Harvest Committee of the Cooperative has developed a vacuum harvester. The operational model, now under test, is shown below.

3. perhaps know something about its flowering;
4. have a large supply of easy-to-obtain and healthy scions for grafting into a second-generation production orchard.

If the tree meets all specifications at this time, it is certified for use in second-generation production seed orchards. These will consist of the most outstanding second-generation trees plus the best trees from the previous orchards of a suitable geographic source. Trading of the best clones will be done among cooperators.

We have selected and accepted over 40 second-generation trees during the past year. A summary showing the superiority of those from five orchards is given in Table 21. Volume improvement is emphasized for the second-generation orchards but all trees must be disease-free, well adapted, have outstanding form and produce desirable wood.

Fusiform Rust Resistance

Variation in resistance to fusiform rust (Cronartium fusiforme) has been found to be large in loblolly pine. Results from many of the progeny tests of the Cooperative were reported last year. Results of two intensive studies by former graduate students, Dr. B. B. Kinloch and Dr. Roger Blair, helped to clarify the inheritance patterns of resistance to this disease. Results can be summarized roughly as follows:

1. There is great variation in susceptibility to fusiform rust among the offspring of clones and specific crosses. Some clones impart good resistance to their progeny, irrespective of the other parent in the mating. These good general combiners are being established in the special disease-resistant seed orchards.

2. Initial selection of disease-free parents is helpful in obtaining disease-free progeny. However, all control-pollinated progeny tests established to date (over 20,000 four-year-old plants) show progeny of crosses from selected parents have fusiform infection about equal to that of the commercial check lots. The best 10 percent of the selected families were essentially disease-free, while the most severely infected 10 percent of the families were one-third more severely infected than the plantation as a whole. Many of the selected parent trees were from essentially disease-free stands, and most of the progeny tests were in areas of only moderate disease incidence. Although the greatest single gain in resistance is obtained from using parents that produce disease-free progeny, a combination of initial parent selection followed by progeny tests gives a larger overall gain, if parents are from stands that have a high incidence of rust.
3. Percentage infection is dependent on the environment in which the trees are grown. However, the most susceptible families in one area are most susceptible in other areas, indicating little genotype-x-environment interaction.
4. Heritabilities are of such a magnitude that good gains in resistance can be achieved by including disease resistance in the Tree Improvement Program.

Roguing the seed orchards of the few clones producing the most susceptible progenies will result in a good improvement of disease resistance of overall orchard seed. This, combined with the specialized disease-resistant seed orchards, will make possible profitable forestry on hundreds of thousands of acres where severity of disease now makes forestry marginal. Resistance to fusiform rust becomes more necessary when infection levels are increased because of increased intensity of site preparation. More intensive forest management, combined with wide plantation spacing, makes it mandatory to keep disease incidence low.

Wood Studies

General

Work with wood still constitutes a large part of the activities of the Cooperative, as evidenced by the many projects completed during the year. One study was published in the Journal of Forestry[1/] and a number of talks have been given reporting results of wood studies (See publications section). Jim Roberds completed a report on dry wood weight and volume tables for three companies. The dry wood weight tables were based on large numbers of trees cut and sampled for wood quality determinations. Several other companies are in the process of constructing similar tables.

During the coming year a summary will be compiled of the mass of in-information we now have on wood qualities of many thousands of trees from throughout the Southeast. The publication will follow the same general format as Technical Report No. 37 on moisture content;[2/] it is being prepared at the request of members of the Cooperative.

Specialty Woods

For many years studies have been under way to develop pine trees with special qualities in juvenile wood that will supplement the hardwood furnish. Trials of this type of wood have been made in pilot runs in the mills and the results are satisfactory for certain quality papers and newsprint.

1/ Zobel, B. J., Roberds, J. H. and Ralston, J. 1969. Dry wood weight yields of loblolly pine. Jour. of For. 67(11):822-824.

2/ Zobel, B. J., Matthias, M., Roberds, J. H. and Kellison, R. C. 1968. Moisture content of southern pine trees. Tech. Rept. No. 37, School of Forest Resources, N. C. State University, Raleigh, N. C.

Maximizing cellulose yield in short rotations is of special interest to several companies. Of the nearly 1,000 trees sampled on lands of International Paper Company near Georgetown, South Carolina, approximately 40 were found that did not show great differences between juvenile and mature wood specific gravity. Cones were collected from these trees and seedlings were grown at the Eight-Oaks seed orchard. First harvest from these 34 families was made during 1969, when the seedlings were three years old. Further harvests will take place when the trees are five and ten years of age. It was found that parents with high gravity juvenile wood produced high gravity three-year-old seedlings ($r = .68$). For example, the eight parent trees with the highest juvenile wood produced three-year-old progeny with wood weighing 22.4 lbs./cu.ft., while parents with low juvenile wood produced progeny with three-year-old wood density of 21.1 lbs./cu.ft. Progeny of one tree had an average of 23.1 lbs./cu.ft. (dry wood), while another (the lowest) produced progeny with an average density of 20.6--a considerable difference for three-year-old trees. It is obvious from these results that parents selected for high juvenile wood density will produce young progeny with dense wood. No relationship was found between average growth rate of the family and specific gravity of juvenile wood.

In another study, Hammermill surveyed trees in a 12-year-old plantation for differences in juvenile wood specific gravity. Specific gravity varied from .350 (21.9 lbs./cu.ft.) to .503 (31.4 lbs./cu.ft.). Based on this survey, five high, six low and six average gravity trees were pulped to determine if differences in juvenile wood have enough effect on pulp yields and paper qualities to warrant a special breeding program. Results of the pulping tests are not yet available, but differences in paper quality and manufacturing techniques are expected for such large differences in juvenile wood specific gravity.

Table 22. Data on wood from select trees used in seed orchards of the Cooperative Tree Improvement Program 1/

Species and Source	Number Select Trees	Wood Density: Select Trees, Juv. Wood, Sp. Gr.	Select Trees, Juv. Wood, Lbs./Cu. Ft.	Select Trees, Mat. Wood, Sp. Gr.	Select Trees, Mat. Wood, Lbs./Cu. Ft.	Check Trees 2/, Mat. Wood, Sp. Gr.	Check Trees 2/, Mat. Wood, Lbs./Cu. Ft.	Tracheid Lengths 3/, 15-Yr.	Tracheid Lengths 3/, 30-Yr.
LOBLOLLY PINE									
Piedmont	487	.44	27.46	.52	32.46	.52	32.46	3.81	4.54
Coastal	606	.44	27.46	.55	34.34	.54	33.71	3.78	4.49
Fla. Coastal	37	.47	29.34	.58	36.20	.58	36.20	3.55	4.20
Deep Peat 4/	24	.49	30.59	.56	34.96	.56	34.96	3.62	4.60
Eastern Shore 5/	25	.43	26.84	.52	32.46	.53	33.09	3.38	4.35
Mountain	30	.44	27.46	.52	32.46	.53	33.09	3.77	4.56
Piedmont (Miss.-Ala.)	153	.44	27.46	.52	32.46	.53	33.09	3.85	4.63
Coastal (Miss.-Ala.)	83	.47	29.34	.54	33.71	.55	34.34	3.80	4.54
Avg. & Total	1445	.44	27.46	.54	33.71	.53	33.09	3.78	4.52
LONGLEAF PINE									
Ala. Piedmont	32	.50	31.22	.57	35.59	.57	35.59	4.05	4.69
Atlantic Coast.	136	.53	33.09	.58	36.21	.57	35.59	3.90	4.65
Avg. & Total	168	.52	32.46	.58	36.21	.57	35.59	3.93	4.66
SLASH PINE									
Gulf Coast	17	.50	31.22	.58	36.21	.58	36.21	3.66	4.54
Atlantic Coast.	129	.47	29.34	.56	34.96	.56	34.96	3.94	4.65
Avg. & Total	146	.47	29.34	.56	34.96	.56	34.96	3.91	4.64

(cont. next page)

1/ All wood measurements are at breast height (4.5' above ground).

2/ Average mature wood specific gravity of the five check trees used to compare with each select tree

3/ Measured uncut summerwood tracheids at the 15th and 30th annual ring

4/ Trees from deep peat (at least 4 feet to mineral soil) from Westvaco's lands in Dare and Tyrrell Counties, N. C.

5/ From the Eastern Shore, the peninsula in Virginia and Maryland that is along the Atlantic Coast

Table 22 (continued)

Species and Source	Number Select Trees	Wood Density: Select Trees, Juv. Wood, Sp. Gr.	Select Trees, Juv. Wood, Lbs./Cu. Ft.	Select Trees, Mat. Wood, Sp. Gr.	Select Trees, Mat. Wood, Lbs./Cu. Ft.	Check Trees[2/], Mat. Wood, Sp. Gr.	Check Trees[2/], Mat. Wood, Lbs./Cu. Ft.	Tracheid Lengths 3/, 15-Yr.	Tracheid Lengths 3/, 30-Yr.
VIRGINIA PINE									
Piedmont	144	.47	29.34	.52	32.46	.52	32.46	3.53	4.12
Ala. Piedmont	42	.45	28.09	.50	31.22	.51	31.84	3.48	4.03
Mountain	35	.46	28.72	.52	32.46	.52	32.46	3.52	4.08
Avg. & Total	221	.46	28.72	.52	32.46	.52	32.46	3.52	4.10
SHORTLEAF PINE									
Piedmont	58	.47	29.34	.52	32.46	.52	32.46	3.93	4.62
Ala. Coastal	29	.47	29.34	.55	34.34	.57	35.59	3.80	4.62
Mountain	24	.47	29.34	.54	33.71	.53	33.09	3.71	4.49
Avg. & Total	111	.47	29.34	.53	33.09	.54	33.71	3.85	4.59
POND PINE									
Coastal	84	.48	29.97	.54	33.71	.55	34.34	3.39	3.93
WHITE PINE									
Mountain	75	.32	19.98	.38	23.72	.39	24.35	3.47	4.17
PITCH PINE									
Mountain	19	.46	28.72	.52	32.46	.54	33.71	3.33	3.93
SPRUCE PINE									
Ala. Coastal	5	.44	27.46	.47	29.34	.48	29.97	3.87	4.82

Total number of pine trees graded and evaluated to March, 1970 = 2,386.

Wood of Progeny and of Select Trees

Considerable information about wood can be obtained from trees selected for seed orchards and the associated check trees. These data have been summarized by species and geographic source in Table 22. They give an indication of the variation in wood qualities of pine throughout the Southeast.

Several companies have planted excess progenies in supplemental tests for assessment of wood qualities. All analyses so far have shown great variation and strong inheritance of wood qualities. As an example, families of control-pollinated progeny of slash pine from Union Camp Corporation were harvested. The parental tree variation was large, as was variation among their progenies. The five families with the densest and lightest wood density are listed in Table 23.

Table 23. Wood density of control-pollinated slash pine progeny,[1/] Union Camp Corporation

Five Families With High Density Wood			Five Families With Low Density Wood		
Cross	Sp.Gr.	Lbs./ Cu.Ft.	Cross	Sp.Gr.	Lbs./ Cu.Ft.
97-56 x 08	.397	(24.78)	81-56 x A20	.346	(21.60)
89-56 x 08	.411	(25.66)	81-56 x 029	.353	(22.04)
89-56 x 028	.417	(26.03)	91-56 x A20	.350	(21.85)
100-56 x 028	.407	(25.10)	10-57 x 029	.349	(21.79)
100-56 x 029	.409	(25.53)	12-57 x 57	.348	(21.73)
Mean	.408	(25.42)		.349	(21.80)

Mean of all 50 families was 0.375 (23.41 Lbs./Cu.Ft.)

1/ Trees are in a three-year-old plantation near Savannah, Georgia.

The Heritability Study was initiated in 1958 when Dr. Charles Driver was director of Southlands Experiment Forest. Dr. Franklin Cech was responsible for setting up the study. In later years Mr. Darwin Fender ably took over Dr. Driver's duties when he went to Washington, and Dr. Roy Stonecypher replaced Dr. Cech when the latter went to West Virginia University. This year a major shift in personnel occurred when Dr. Stonecypher accepted a research and teaching position at Oklahoma State University. He was replaced by Dr. Roger Blair, who worked with Roy during the past year. It has been rewarding to be associated with excellent administrators and scientists in this program, and much credit for the success of the program must be given to the personnel involved.

Results of numerous separate studies from the Heritability Study have been published throughout the years. These have all been summarized in one paper and submitted to Forest Science for the Monograph Series. Therefore, further results will not be reported here. It must be emphasized that many activities, methods and plans used in the applied breeding programs of the Cooperative were based on experience and information gained in the Heritability Study.

Membership of the Pine Cooperative

Organization	Working Units and States
American Can Company (Southern Woodlands Division)	Ala., Miss.
Catawba Timber Company (Bowaters Carolina)	S. C., N. C., Va., Ga.
Chesapeake Corporation of Virginia	Va., Md., Del., N. C.
Container Corporation of America	Ala.
Continental Can Company, Inc.	Savannah Div.--S. C., Ga. Hopewell Div.--N. C., Va.
Georgia Kraft Company	Ga., Ala.
Georgia-Pacific Corporation	Va., N. C., S. C., Ga., Fla.
Hammermill Paper Company	Ala.
Hiwassee Land Company (Bowaters Southern)	Tenn., Ga., Ala., Miss.
Hoerner-Waldorf, Halifax Timber Div. (formerly Albemarle Paper Company)	N. C., Va.
International Paper Company	S. C., N. C.
Kimberly-Clark Corporation (Coosa River Division)	Ala.
Masonite Corporation	Miss.
North Carolina Forest Service	N. C.
Riegel Paper Corporation	N. C., S. C.
South Carolina State Commission of Forestry	S. C.
Tennessee River Pulp & Paper Company	Tenn., Ala., Miss.
U. S. Plywood-Champion Papers, Inc.	Alabama Div.--Ala., Tenn. Carolina Div.--S. C., N. C., Ga.
Union Camp Corporation	Savannah Div.--Ga., S. C., Ala. Franklin Div.--N. C., Va.
Virginia Division of Forestry	Va.
Westvaco Corporation	South--N. C., S. C. North--Va., West Va., Ohio
Weyerhaeuser Company	N. C. Div.--N. C., Va. Miss.-Ala Operations--Miss., Ala.

SPECIAL ACTIVITIES

Many special studies under way by the Cooperative and special problems that have not been mentioned earlier in this report are discussed briefly below:

1. Pollen flight characteristics using marked pollen has been the theme of the Ph. D. thesis by Bob McElwee. The research is completed so we will soon have another "doctor" on the staff of the Cooperative Programs.
2. A second Ph. D. will be added as Bob Kellison completes his work in 1970 on variation in yellow-poplar. Bob has already published on his early findings; current results make it clear that proper geographic source is essential to achieve success in planting this most valuable species.
3. To make it a clean sweep, Jim Roberds will have completed his Ph. D. in 1971, following a year's leave of absence starting May 1, 1970. Jim will bring the fourth doctorate to our Cooperative Program. Jim's work deals with theoretical aspects of design of progeny tests and will be a long-awaited guide to activities of the Cooperative as we get into advanced breeding generations.
4. Fertilizer and/or irrigation studies on seed production with five members of the Cooperative have produced tangible results, so recommendations in operating seed orchards can be more scientifically founded. A portion of these studies has been undertaken by Steve Webster, who will complete his Ph. D. in 1970.
5. Graft incompatibility studies by Clark Lantz, who recently completed his Ph. D. Degree, have outlined and pinpointed the problem. His studies gave some clues but few positive answers on how to lessen losses due to incompatibility although he made some suggestions to bypass this annoying problem. Clark has gone to Oklahoma State University to work with Roy Stonecypher.

6. A cooperative study with Dr. Tom Ledig of Yale University on wood characteristics of pond pine has been under way for a year. He is making a range-wide variation study on this species and we are working with him on wood quality aspects.
7. Drought resistance in loblolly pine, including studies in the phytotron, have been completed by Marcelino Quijada. He will return to his university post in Venezuela.
8. Introgression and speciation among pond, loblolly, pitch and shortleaf pines has been the research project by graduate student Peter Smouse. His work for the Ph. D. will be completed by mid-1970. Some of the hybrids produced in this study have been outplanted on industry lands.
9. A combined diallel analysis of Virginia pine and seedling seed orchard has been established jointly by John Kundt and Kimberly-Clark Corporation. John's analyses for the Ph. D. thesis will be completed during 1970. This study is a prime example of company-graduate student cooperation. John has accepted a position with the State University of New York at Geneseo, N. Y. where he is teaching dendrology.
10. All ten of the wide-cross loblolly pine plantings (part of Dr. Ron Woessner's thesis) have been successful, with good survival and growth. These will be remeasured after the fourth year in the field and will serve as a valuable source of material for advance-generation selections. The best crosses at present appear to be Piedmont North Carolina-x-Texas drought-resistant matings and Piedmont N. C.-x-wet site loblolly from coastal North Carolina.
11. Comparative growth, disease susceptibility and wood qualities of slash and loblolly pine is the nature of Don Cole's research work for the Ph. D. Degree. Don's work should be completed during the next year.

He found, for example, that loblolly nearly always outgrows slash pine and that slash pine tends to be more susceptible and more easily damaged by fusiform rust than loblolly. Don is now in the Amazon working as chief forester for Jari (Bulk Carriers Associates).

12. Dr. Leon Pederick completed a year's postdoctoral studies at N. C. State; results of his research while here have been published as Technical Report No. 41, "Variation and Inheritance of Stem Form and Bark Thickness in Young Loblolly Pine." He found a strong inheritance of bark thickness and related it to proper assessment of volume production in young plantations. He reported 34 percent bark by volume in young plantations and that the distribution of bark from the base to the top of trees (39 percent in first five-foot bolt, 30 percent in third bolt) has significant economic implications.

13. In a study of the comparison of yields from springwood and summerwood, former graduate student Dr. Bill Gladstone (now at Syracuse University) reported in the summary of his thesis research that a reduction in harvest age of loblolly pine will not only cause losses in yield of dry wood per unit volume but also losses per unit weight of dry wood. He speculated that the latter loss could be as high as 1.2 percent on a pulp basis for a reduction of rotation age from 30 to 20 years. Considerable differences in yield patterns were found between trees.

GRADUATE STUDENTS

The Cooperative has been fortunate in having a large, active group of graduate students numbering from 15 to 20 each year. Over 35 advanced degrees have been granted since the inception of the program. Approximately ten Ph. D. Degrees will be granted in 1970 to students associated with the Cooperative. Such a large student program has been made possible by monies from the Cooperative Programs as well as funds from outside agencies such as the National Science Foundation and the National Institute of Health. Especially helpful to graduate students have been the grants from the industrially sponsored Disease and Insect Research Council and the Hardwood Forestry Research Program, and special fellowship monies such as those granted by Union Camp Corporation for hardwood research and the Weyerhaeuser fellowship.

Reluctantly a change in policy must ensue regarding graduate student financing by the Cooperative. Costs are continually rising, and this, along with the long-anticipated termination of the NIH grant, forces sharp curtailment of student financial support. This is unfortunate because many more applications for study than can be accepted are received each year. Future students now must be primarily financed from funds outside those from the Cooperative.

Last year's annual report carried a complete listing of graduate students and their research projects. This list will not be repeated but is updated as shown below:

<u>Students Departing</u>

Roger Blair--Forest Geneticist, International Paper Company, Bainbridge, Georgia (Southlands Experiment Forest)

Don Cole--Chief Forester, Jari, Belem, Brasil (Bulk Carriers Association)

John Kundt--Assistant Professor, State University of New York, Geneseo, New York

Clark Lantz--Assistant Professor, Department of Forestry, Oklahoma State University, Stillwater, Oklahoma

Marcelino Quijada--Returned to his university position in Venezuela

Earl Sluder--Returned to his position with the U. S. Forest Service, Macon, Georgia

Peter Smouse--Plans to do postdoctoral studies

Steve Webster--Will finish work by end of 1970

Jim Barker--At Southlands Experiment Forest, International Paper Company, with Roger Blair. Target date to finish his Ph. D. is 1971.

Incoming Students

Lert Chuntanaparb from Thailand--To work on a Ph. D. Degree in applied tree improvement

Yves Lamontagne from Quebec, Canada--Studying variation in white pine, for M. S. Degree

Charles Lee from Westvaco Corporation--Studying variation in sycamore wood properties for Ph. D. Degree

Ralph Lewis from West Virginia University--Has under way research toward the Ph. D. on the physiological basis for resistance to fusiform rust, using electrophoretic and seriological techniques

Alan Long from the University of California--Studying for the Ph. D.; his research involves variation and response of pine families to mycorrhizal infection

Dimitrios Matziris from Greece--Major interest is applied tree breeding; working for M. S. Degree

Ibrahim Sheikh from Malaysia--Working on variation in wood properties of Pinus caribaea growing in Malaysia (for M. S. Degree)

There has been one change in graduate student training. At the request of a number of students, a teaching assistantship has been made available from state funds so that students who desire to do so can get one semester of teaching experience in botany, genetics or forestry.

INTERNATIONAL SHORT COURSE

From June 30 to July 25, 1969 faculty of the Cooperative Programs and other departments within the University, as well as instructors from other institutions, conducted a four-week Training Centre in Tree Improvement for forestry officers of 19 developing countries. Sponsored jointly by the Food and Agriculture Organization of the United Nations and North Carolina State University, the training session consisted of classroom lectures and discussions of topics relevant to forest genetics and tree improvement, beginning with basic genetics and statistics and covering plus-tree selection, seed orchard establishment and maintenance, progeny testing and the quantitative aspects of tree breeding. Forestry officers participating came from throughout the world, including Europe, the Near East, Africa, Central and South America, and the Far East.

In addition to the indoor sessions, field trips of varying lengths were made to the seed orchards, nurseries and forest operations of several members of the Cooperative. The success of the Training Centre, as expressed by all participants, was in large part due to the excellent demonstrations and the hospitality of those organizations which were visited. To those of us in the Cooperative Programs this once again demonstrated the outstanding spirit within the Cooperative.

Although it was somewhat hectic to prepare and present the Training Centre while maintaining the normal activities of the Cooperative, the end results justified the efforts. We made new friends, presented our programs to them, and in turn learned much that will be of benefit to members of the Cooperative.

One activity of the Cooperative Programs is training people in tree improvement. Shown are forestry officers from 19 developing nations who attended the FAO-sponsored Training Centre in Forest Tree Improvement held in Raleigh, North Carolina, July, 1969.

PERSONNEL

Unlike the 1968-1969 year when retirement, resignations and replacements resulted in a rather large change in personnel, few changes occurred within the Cooperative Programs during the past year. Jim Roberds will take a year's leave of absence to finish his Ph. D. studies. Mrs. Carol Jarman, laboratory technician, resigned to join her husband who is in service. Mrs. Jarman was replaced by Mrs. Becky Baker who is working on a half-time basis; Danny Isom resigned as a research assistant to go into business for himself and was replaced by Mrs. Sheryl Long. Other personnel remain the same as listed in the Thirteenth Annual Report.

Several people are employed part time, including Mrs. Norma Bergeron who is doing statistical typing, Miss Mary Alice Sherrill and Mrs. Joyce Dixon, typists, and Miss Donna Overby who helps in the laboratory.

THANKS AND WELCOME

Seldom are we privileged to recount a close association and pay tribute to a warm friend while still anticipating a continued close relationship in the future. Such is our happy task, however, in recognizing the immeasurable help we have received from Waldy Maki as he relinquishes the title of Department Head, Forestry, and returns to his first love of teaching and research.

Since the formative years of both the Tree Improvement and Hardwood Research Programs, Waldy has been the guiding hand behind the scene. It is to him that we have gone for suggestions; sound advice, editorial comment, policy decisions, humor (and <u>RAISES</u>). It is to him in his new position we hope we can continue to come for suggestions, sound advice, editorial comment, policy decisions, humor, with no thought of <u>RAISES</u>.

Waldy's interest in and dedication to the Cooperative Programs are known to all with whom we have worked. It was his keen intellect which helped conceive the basis of a highly successful cooperative relationship between industry and university. His loyalty to the Programs has been complete. His help in all phases of the program--administrative and technical--is deeply appreciated. For all the problems he has helped us with as Department Head, we say THANKS!

At the same time we welcome Dr. Charles Davey as the new Department Head. Chuck is no stranger to Cooperative members, having worked closely with us for many years. His has been the guiding hand in our fertilizer recommendations and studies to increase flowering in seed orchards. We look forward to a close working relationship with him.

PUBLICATIONS

Following is a list of publications directly from the Cooperative Programs, as well as other papers by members of the Cooperative. It also includes research results based upon materials made available by the Cooperative.

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Blair, R. L. 1970. Quantitative inheritance of resistance to fusiform rust in loblolly pine. Ph. D. Thesis, N. C. State University, Raleigh. 73 pp.

Franklin, E. C. 1969. Inbreeding depression in metrical traits of loblolly pine (*Pinus taeda* L.) as a result of self-pollination. Tech. Rept. No. 40, School of Forest Resources, N. C. State University, Raleigh. 19 pp.

Gladstone, W. T., Barefoot, A. C. and Zobel, B. J. 1970. Kraft pulping of earlywood and latewood from loblolly pine. For. Prod. Jour. 20(2):17-24.

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Kellison, R. C. 1969. Establishment and management of clonal seed orchards of pine. Second World Consultation on Forest Tree Breeding, Washington, D. C. 7 pp.

Kinloch, B. B., Jr. and Stonecypher, R. W. 1969. Genetic variation in susceptibility to fusiform rust in seedlings from a wild population of loblolly pine. Phytopathology 59(9):1246-1255.

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Lantz, C. W. 1970. Graft incompatibility in loblolly pine. Ph. D. Thesis, N. C. State University, Raleigh. 103 pp.

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McElwee, R. L., Tobias, R. and Gregory, A. H. 1970. Wood characteristics of three southern hardwood species and their relationship to pulping properties. Fifth TAPPI Forest Biology Conf., Raleigh, N. C. 21 pp.

Pederick, L. A. 1970. Variation and inheritance of stem form and bark thickness in young loblolly pine. Tech. Rept. No. 41, School of Forest Resources, N. C. State University, Raleigh. 44 pp.

Saylor, L. C. 1969. Chromosomal differentiation as a barrier to interspecific hybridization among pines. Second World Consul. on For. Tree Breeding, Washington, D. C. 6 pp.

Saylor, L. C. 1969. Provenance testing Mexican pines in the United States and Brazil. Proceedings of the Tenth Southern Conf. on For. Tree Improvement, Houston, Texas. pp. 155-164.

Shelbourne, C. J. A., Zobel, B. J. and Stonecypher, R. W. 1969. The inheritance of compression wood and its genetic and phenotypic correlations with six other traits in five-year-old loblolly pine. Sil. Gen. 18:43-47.

Sluder, E. R. 1970. Variation in wood specific gravity of yellow-poplar (Liriodendron tulipifera L.) and its relationship to environmental conditions in the southern Appalachians. Ph. D. Thesis, N. C. State University, Raleigh. 68 pp.

Webb, C. D. 1969. Variation of interlocked grain in sweetgum. For. Prod. Jour. 19(8):45-48.

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Zobel, B. J. 1969. Industrial tree improvement in the South--The need and results. Symposium, Canadian Pulp and Paper Research Institute of Canada. 3 pp.

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