TWENTY-FOURTH ANNUAL REPORT

N. C. State University-Industry Cooperative
Tree Improvement Program

School of Forest Resources
North Carolina State University
Raleigh

June, 1980

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EXECUTIVE SUMMARY

1. Record loblolly pine cone and seed production was acheived by members of the Cooperative in 1979. A total of 27.7 tons of improved loblolly pine seed was harvested.
   a. Seed orchards of all conifer species in the Cooperative produced 63,266 lbs. of improved seed from 3705 acres of orchard.
   b. The Cooperative averaged 1.43 lbs. of seed per bushel of cones for loblolly pine. One orchard realized a yield of 2.10 lbs. per bushel.
   c. A previously innocuous coneworm Dioryctria disclusa did extensive damage to second year conelets in several orchards throughout the eastern portion of the loblolly range.
2. A total of 1060 progeny tests have been established on 3892 acres. The first tests were planted in 1964 and the last tests for the first generation program will be outplanted in 1983.
   a. Dramatic differences between offspring of trees selected for rust resistance were found in plantings of the "rust diallel."
   b. Comparison of three sources of Virginia pine in north Alabama and south-central Tennessee indicates few important source differences. Tentative results suggest broadening the geographic base from which selections for this region are drawn is feasible.

3. The Cooperative graded 638 new loblolly plantation selections in 1979 for a total of 2360. More than 3000 total trees are anticipated by the end of this intensive program in 1981.

   a. Average volume superority over the check trees is 17.8% for the 2360 trees graded to date.

   b. Twenty five cooperators have established 457 acres of second generation seed orchard to date. Breeding of advanced generation selections has just begun.

   c. Good general combiner tests indicate that improved seed sources from the Atlantic coastal region, ranging from north-east Georgia to the central North Carolina coastal plain, do well regardless of the geographic region in which they are planted.

   d. We expect to make acceptable gains with wood specific gravity in the second generation of breeding by selecting on midparent values. Such a procedure will eliminate the need for expensive and extensive wood sampling from thinned tests.

4. The Cooperative has 17 graduate students working toward masters and Ph.D. degrees.

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INTRODUCTION

As this report was written a year ago we anticipated a favorable economic climate for the year. The industry was not disappointed; a satisfactory year was experienced by most. The year ahead is, however, viewed with less optimism. The nation is experiencing soaring interest and inflation rates that have seriously depressed home building markets and thus the solid wood products industry. However at this time short inventories and strong demand have bolstered pulp and paper prices. All told there is at best a mixed economic climate for the forest products industry.

This unsettled economic atmosphere occurs partly as a result of increasing energy costs. Rapidly escalating costs for doing business are being experienced by all. There are intense pressures to maintain site preparation/planting costs at reasonable levels. For most this means some reduction in site preparation intensity coupled with increased consideration of herbicide potentials and opportunities for more complete utilization of the wood produced on each acre. Environmental consciousness works adversely to cost and energy saving alternatives such as herbicides or site preparation with fire. There is also concern about nutrient drain and site degradation that could be associated with more complete utilization, yet no one seems to doubt the positive aspects derived from use of heretofore wasted wood. An underlying theme throughout is to increase production per acre per year of useable wood on each acre of managed forest land.

The tree improvement program continues to play an increasingly positive role with respect to production increases on forest land. Members of the Cooperative produced record amounts of improved loblolly pine seed in 1979; the total was 27.7 tons of seed. In 1980 it is expected that 55% of the land regenerated by the Cooperative members will be planted with genetically improved seedlings. These improved trees have been shown through twelve years of age to produce 10 to 15 percent more wood per acre.

Overall statistics for land management, regeneration and tree improvement activities are shown for the Cooperative membership in Table 1. These statistics were accurate for the 27 members of the Cooperative as of April 1, 1980. While not shown in Table 1, a net gain for membership planting programs of 45,600 acres or a 10 percent increase over current planting is anticipated by 1985. State forestry organizations in the Cooperative also anticipate increased demand for the seedlings produced in their nurseries. With their current production at 140 million seedlings (30% improved) they anticipate demand in 1985 to reach 192 million seedlings with approximately 45 percent of that production being improved seedlings. As both the industries and state organizations experience increased use of genetically improved seed, the benefits and gains south wide will be enormous. It is indeed an exciting era for all of those involved with the Cooperative Tree Improvement Program.

Table 1. Summary statistics for land management, regeneration and tree improvement activities for the Cooperative members.

General For The Industries	
Acres of forest land operated	17.9 million
Percentage of holdings classified as pine land	73 percent
Pine Regeneration	
Acres of plantations established	6.9 million
Acres planted annually	466 thousand
Number of seedlings planted annually	336 million
Number of acres direct-seeded annually	10 thousand
Three State Forestry Organizations	
Number of conifers produced annually in nurseries	140 million
Number of improved seedlings produced annually in nurseries	42 million
Combined Tree Improvement Activities	
Acres of seed orchard established	3705
Acres planted annually with improved seedlings	256 thousand
Number of improved seedlings planted annually	184.5 million

CONE AND SEED PRODUCTION

Seed Orchard Acreage

We have once again surveyed Cooperative members to determine seed orchard acreage statistics by species and type. A summary of these statistics is presented in Table 2. It is from these 3705 acres of seed orchard that the cone and seed yields described in the next section were derived.

During the decade of the 1960's we reported seed orchard statistics annually, for that was a time of rapid establishment. Seed orchard establishment activities tapered off noticeably during the early 1970's. Most of the additional acreage was established by new members of the Cooperative and consisted primarily of 1.5 generation orchards. The 1970's also saw the first significant second generation orchard acreage established, mostly by members with older improvement programs located in the eastern portion of the loblolly range. Since 1976 we have recorded 278 new acres of second generation orchard for a current total of 457 acres. It is estimated that an additional 2500 acres of second generation loblolly pine seed orchard will be developed in the next decade.

It is interesting to note a 266 acre reduction for slash and Virginia pine orchards since 1976. This reflects a substantial surplus in seed production for these species. The Cooperative has realized a net gain of 127 coniferous seed orchard acres since 1976 for a total of 3705 acres.

Table 2. Coniferous seed orchard acreage in the N. C. State Tree Improvement Cooperative as of June, 1980.

Species and Source	First-Gen.	1.5-Gen.	Second-Gen.	Disease-Resistant	Other Specialty	Total
Grafted Orchards						
Coastal loblolly	1204	450	295	84	54	2087
Piedmont and Mountain loblolly	542	203	146	26	7	924
Slash	320	50	16	18	-	404
Longleaf	72	-	-	-	-	72
Virginia	79	-	-	-	-	79
White Pine	61	-	-	-	-	61
Sand Pine	1	-	-	-	-	1
Pond Pine	29	-	-	-	-	29
Shortleaf Pine	23	-	-	-	-	23
Pitch Pine	4	-	-	-	-	4
Spruce Pine	4	-	-	-	-	4
Seedling Orchards						
Fraser Fir	5	-	-	-	-	5
Virginia Pine	12	-	-	-	-	12
Total	2356	703	457	128	61	3705

3011

Cone and Seed Yields

Surprise, surprise!! The cone crop harvested in 1979 was the largest ever, surpassing the 1978 crop by more than 3000 bushels (Table 3). It is also a delight to report that the loblolly pine cone crop was an all-time record for Cooperative members. A total of 38,693 bushels of loblolly cones were harvested which resulted in 27.7 tons of improved seed. This is the largest harvest of improved loblolly pine seed ever for the Cooperative, surpassing the previous record set in 1977 by 2.9 tons.

Table 3. A comparison of total cone and seed yields for all conifers and loblolly pine in the Cooperative's three best production years.

Harvest Year	All Conifers		Loblolly Pine	
	Bushels of Cones	Tons of Seed	Bushels of Cones	Tons of Seed
1977	46,041	32.8	32,152	24.8
1978	46,258	25.6	37,977	23.5
1979	49,415	31.6	38,693	27.7

This record cone and seed crop was truly a surprise--few individual Cooperators experienced super production but many had very good crops. In fact, several Cooperators with older orchards along the Atlantic Coast region suffered a substantial drop in production in comparison to previous record years. This drop was apparently more than offset by the simultaneous realization of full production by many seed orchards in the western portion of the Cooperative (Alabama, Tennessee, Mississippi). This has resulted in distribution of improved seed among a greater number of the Cooperative's member organizations.

Record cone harvests are realized in 1979. Shown is the heavy cone crop on Westvaco's eight year old Virginia Piedmont orchard, in South Carolina.

The total bushels produced and yield per bushel for loblolly and slash pine for the last eleven years are shown in Table 4. It is evident from this table that cone production levels in each of the last three years have more than doubled anything experienced prior to 1977. However, the ultimate production capacity of the approximately 2500 acres of first and 1.5 generation orchards are much greater than experienced to-date. In producing 38,693 bushels of cones in 1979, these 2500 acres averaged about 15.5 bushels per acre. Since many of these acres are young and not yet in full production, significant increases are inevitable in the years ahead. In fact, if one assumes a rather conservative average of 35 bushels of cones per acre, we could more than double the current production for the Cooperative. The Cooperative would appear to have the capacity to produce in excess of 85,000 bushels of cones per year. Whether or not this production potential is ever realized is quite another matter. Never the less, the apparent seed production capacity of the Cooperative is tremendous.

Table 4. Cone and seed yields of the Cooperative orchards for the last eleven years.

	Loblolly Pine		Slash Pine	
Year	Bushels of Cones	Lbs. Seed/ Bushel	Bushels of Cones	Lbs. Seed/ Bushel
1969	1769	1.10	317	0.42
1970	5146	1.36	1744	0.88
1971	6478	1.14	3795	0.80
1972	6807	0.98	1684	0.60
1973	11853	1.09	2779	0.58
1974	8816	0.99	4088	0.74
1975	16348	1.31	5516	0.93
1976	14656	1.21	5233	0.79
1977	32152	1.54	12880	1.17
1978	37977	1.24	4789	0.54
1979	38693	1.43	7460	0.62

As young orchards, such as the Weyerhaeuser 1.5 generation orchard at Belgrade, North Carolina, come into full production we expect even greater records to be set for cone and seed yields.

A comparison of cone and seed yields for 1978 and 1979 for all coniferous species is given in Table 5. Of particular note is the second successive year of low yield per bushel for slash pine orchards. This is not surprising since following the record slash pine harvest in 1977 (see Table 4) many cooperators relaxed, and in some cases terminated intensive management, including insect control, on extensive portions of their slash pine orchards. Inventories for many organizations show a sufficient seed supply to meet regeneration needs for the next 10 years. Reduced management intensity for slash pine orchards may be temporary--if the apparent markets for sale of improved slash pine seed continue to develop rapidly.

The 1979 harvest of white pine seed (Table 5) was nearly identical to the 1978 production. It is important to note, however, that the same amount of seed came from only about half the bushels of cones. Seed yields per bushel in 1979 were nearly double (0.63 vs. 0.35) those experienced for white pine a year earlier. This is due partially to better pollen production, which has been a historical problem in all white pine orchards. It is also reflective of better insect control in these orchards.

Table 5. Comparison of the cone and seed yields for 1978 and 1979.

	Bushels of Cones		Pounds of Seeds		Pounds of Seed/ Bushel of Cones	
	1978	1979	1978	1979	1978	1979
Loblolly Pine Coastal Source	25443	26186	31156	35982	1.22	1.37
Loblolly Pine Piedmont & Mountain Source	12534	12507	15810	19529	1.26	1.56
Slash Pine	4789	7460	2571	4608	0.54	0.62
White Pine	2429	1341	856	850	0.35	0.63
Virginia Pine	669	562	418	412	0.62	0.73
Longleaf Pine	260	1226	146	1694	0.56	1.38
Fraser Fir	66	59	156	134	2.36	2.27
Shortleaf Pine	46	74	35	57	0.76	0.77
Total	46236	49415	51148	63266		

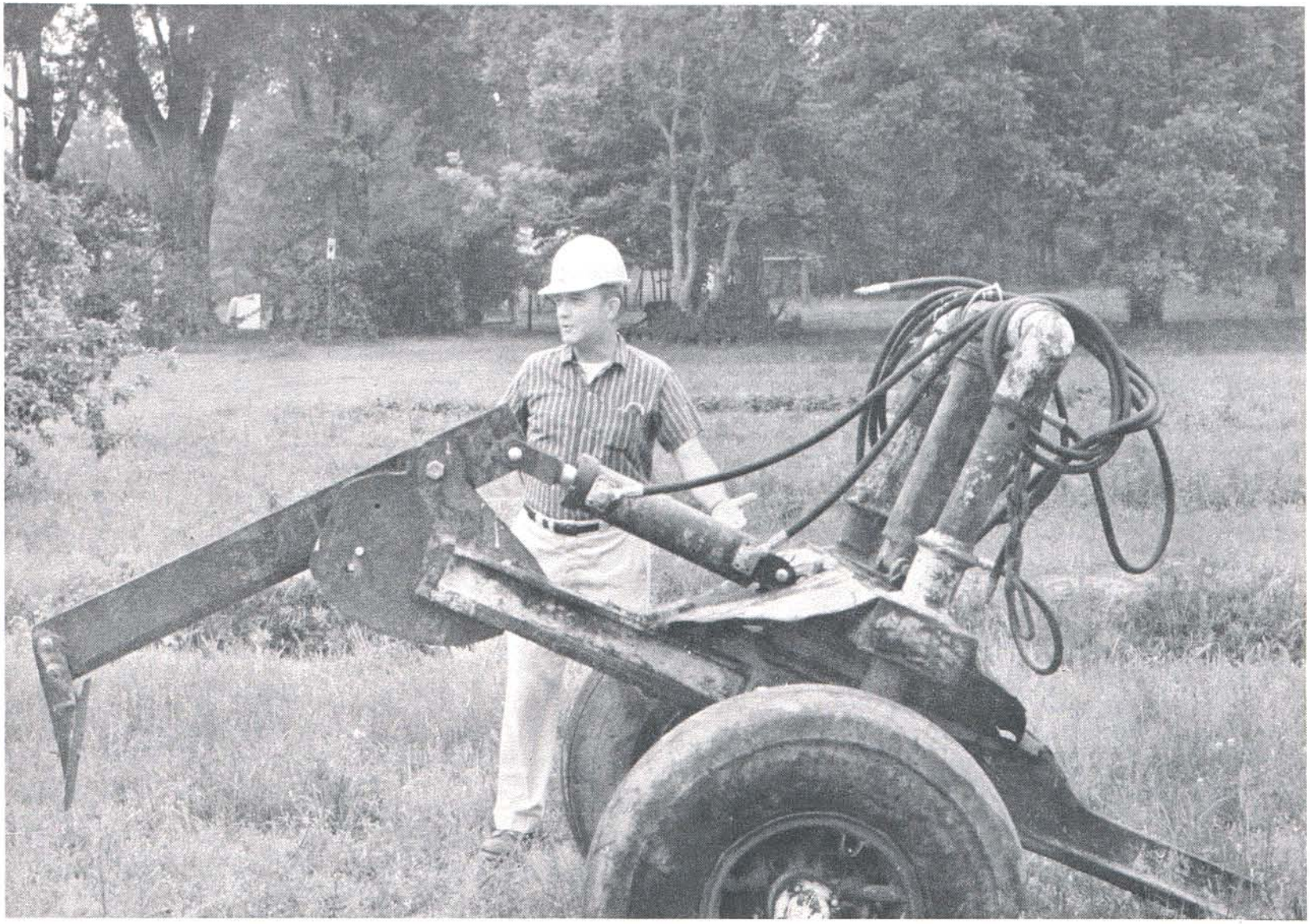
Individual Production Records

In addition to the noteworthy production records set in 1979 for the Cooperative as a whole, several individual organizations enjoyed record production in 1979 against which all outstanding performances in the future will no doubt be judged. Catawba Timber Company produced 156 bushels of cones from a 5-acre block of low gravity-long fiber piedmont loblolly orchard. The remarkable statistic, however, is that 328 pounds of seed were extracted from the 156 bushel crop for an unbelievable 2.10 pounds per bushel yield. Only one other Cooperator, the N. C. Forest Service, has exceeded 2 lbs/bu. yield on an orchard-wide collection.

The seed orchard for Champion International near Newberry, South Carolina, holds the record for sustained production excellence. Beginning in 1975, their 10-acre loblolly pine orchard has produced in excess of 100 pounds of seed per acre for five successive years. No other orchard in the Cooperative has enjoyed such high yields year after year. This string began when the orchard was approximately 15 years old.

The record for seed production per acre at a young age is, we believe, now held by Hammermill Paper Company. Their 37.5 acre loblolly orchard near Selma, Alabama, which averages about 11 years in age, produced 3791 pounds of seed. This is the youngest orchard ever to produce over 100 lbs. of seed per acre, 101.1 lbs/acre to be precise. Congratulations to Catawba, Champion and Hammermill for setting such high standards of excellence.

Production records such as the one set by Hammermill are the result of a number of factors. Among them are proper choice of seed orchard site, excellent and intensive orchard management and to a degree fortuitous weather conditions.



A converted fire plow makes an excellent subsoiler for International Paper Company. The coulter which cuts heavy roots is hidden by the tires. Beneficial effects of subsoiling include root pruning, and reduced soil compaction.

The early, heavy production experienced by Hammermill is a phenomenon which is more widely experienced today than previously because our understanding of orchard site suitability and management is improved. Hammermill moved from no improved seed in 1974 to self-sufficiency in 1980 (Table 6).

Table 6. A record of Hammermill Paper Company's progress towards self-sufficiency in improved seedling production.

Year	Improved Seedlings %	Wild Seedlings %
1974	0	100
1975	17	83
1976	57	43
1977	91	9
1978	52	48
1979	89	11
1980	100	0

Seed and Cone Insects

While we bask in the pleasure of all-time production records, we must also come to grips with the reality of unrealized production potential resulting from damage by seed and cone insects. Nowhere was the reality of insect damage more heavily felt than among a number of orchards from Virginia to Georgia. These orchards suffered from a heretofore unknown epidemic outbreak of Dioryctria disclusa, the webbing coneworm. A combined report on this rather new problem was prepared by Dr. Gary DeBarr and Dr. Larry Barber and is reprinted below in its entirety.

> "In the spring of 1979, we observed the webbing coneworm, Diorctria disclusa, causing extensive damage at Georgia Kraft's Briar Patch Seed Orchard, Greensboro, Georgia. Losses at this orchard averaged 20 to 25 percent in the piedmont orchard, while less damage occurred in the south

coastal orchard. The cone crop was completely destroyed on certain individual trees. Damage evaluations at Greensboro and observations at several other locations showed that Furadan did little to control the webbing coneworm. Average damage on 13 treated and 12 unprotected trees at Greensboro is shown in Table 7.

Table 7. Diorctria (coneworm) damage in Georgia Kraft's Briar Patch Seed Orchard near Greensboro, Georgia.

Treatment [1]	Total Cones [2]	Sound Cones	Disclusa Damage #	Disclusa Damage %	Other Dioryctria #	Other Dioryctria %	Total %
Furadan 6 oz.	1608	1220	302	18.8	96	6	24.8
Untreated Check	1059	694	268	25.3	97	9.1	34.5

[1] Applied March 5, 1979.

[2] Cones on 4 randomly selected branches in the south quadrant of each tree crown.

Damage was also reported in loblolly pine orchards in New Kent, Virginia, Lumberton, North Carolina, Washington, North Carolina, and Georgetown, South Carolina. More than 80 percent of the 1979 loblolly pine cone crop was destroyed by this coneworm in one industry orchard located in eastern North Carolina. Although this insect is found as far west as east Texas, serious infestations appeared to be confined to the eastern part of the loblolly pine range. Throughout this area, the outbreak appeared to be widespread and damage was found in natural stands as well as orchards.

This is the first year that we have observed this coneworm causing significant damage in orchards. Apparently, unknown biological and/or climatic factors failed to keep populations of this insect at low levels. Larval and pupal parasitism in the Greensboro orchard was less than 5 percent. The heavy cone crops of the past several years have probably contributed to the outbreak. Dr. William Mattson concluded that on red pine in the North Central States, the highest webbing coneworm survival and population densities occur when annual cone production remains good for several years."

Seed orchard roguing at International Paper's 8 oaks orchard. The top photo shows them on the ground. The poor parents are removed and the orchard is opened up for full sun which is a must for cone production. The bottom photo shows a very expensive load of pulpwood.

Recommendations have been made for early insecticide applications which we hope will control this pest. Last year the damage done was in many cases complete before the orchard manager discovered the problem.

Seed orchard managers have never been totally satisfied with the control of coneworms (Dioryctria sp.) achieved with currently registered pesticides. Quite typically, the registered pesticides, if used properly, will only reduce coneworm losses by approximately 50%. That is to say, if a control plot sustains a 30% loss, a treated plot will likely have as much as 15% damage. Available pesticides, particularly Furadan (R), control seed bugs but do not satisfactorly control coneworms. We are, however, optimistic about some recent work by Dr. Gary DeBarr and his colleagues with synthetic pyrethroids. Several synthetic pyrethroid compounds have been tested, and while there are differences, the pesticides as a group seem to offer 1) greater persistance and residual activity than currently registered chemicals; 2) remarkably low toxicity for mammals and 3) almost instantaneous "knock-down" on contact with insects. Dr. DeBarr has coordinated field tests with several of these chemicals in Georgia, Mississippi, Louisiana, Arkansas, and Texas. More tests are planned for this year. The goal is to register one or more of these pyrethroids for seed bug and/or coneworm (Dioryctria sp.) control if the field test results warrant such action. We are hopeful.

PROGENY TESTING

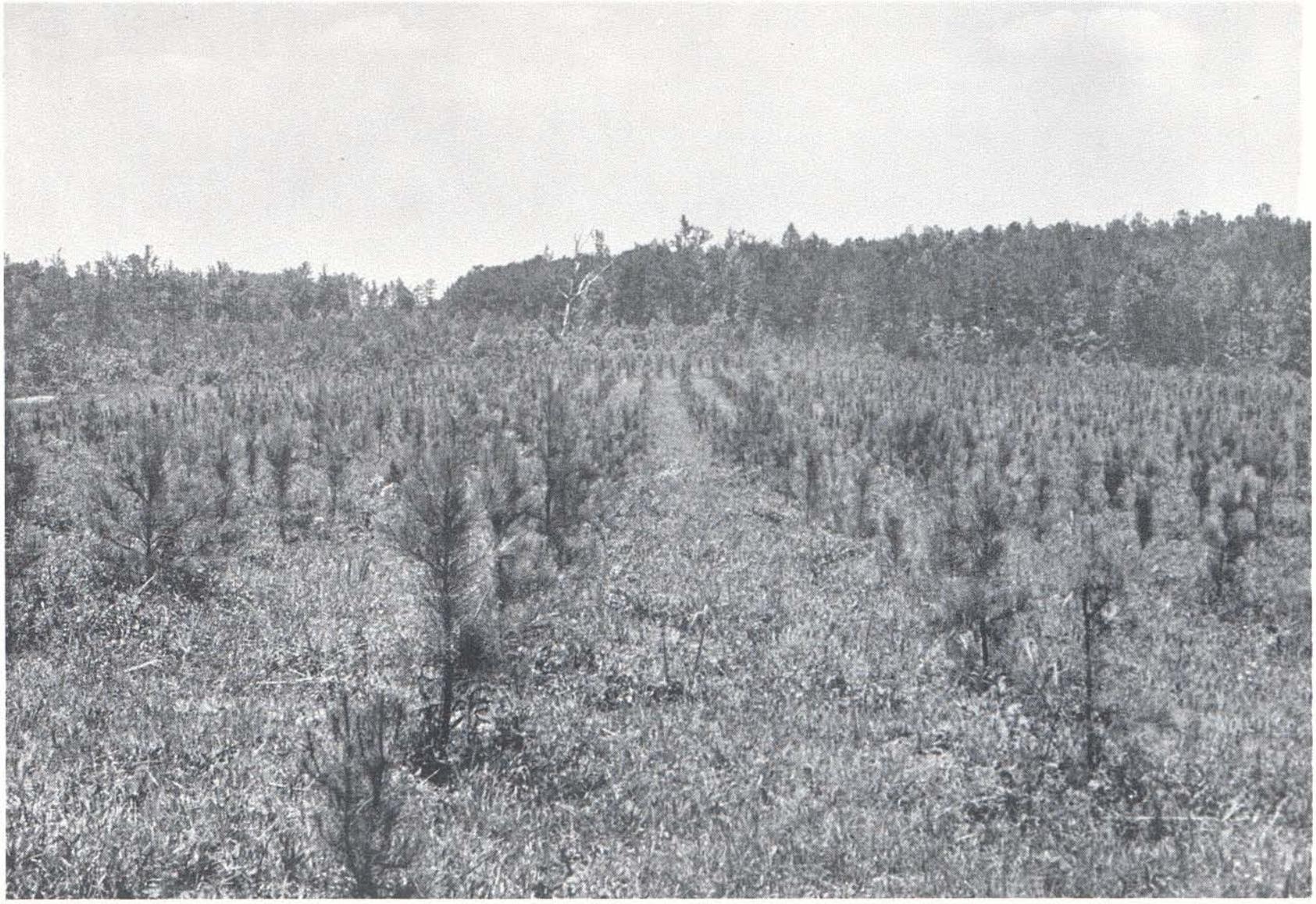
Progress to Date

The progeny test program has been a major activity of the Cooperative members since control pollinations were started in the early 1960's. The first outplantings occurred in 1964 with the establishment of six progeny tests. With the 1980 outplantings Cooperative members have established 1060 progeny tests occupying 3892 acres (Table 8).

Table 8. Acreages planted and number of progeny tests by species and type test in the N. C. State Cooperative as of May 1, 1980.

Species or Type Test	Acreage	Number of Tests
Coastal Loblolly	1437	413
Piedmont Loblolly	922	276
Slash Pine	546	105
Virginia Pine	230	75
Shortleaf Pine	33	9
Pond Pine	42	14
Other (Mountain, Longleaf, Hybrids, etc.)	165	50
Good General Combiner (Open-pollinated)	360	80
Disease Diallel	113	28
Good General Combiner (Control-pollinated)	44	10
Total	3892	1060

The first age four progeny test data were received in 1968 and consisted of measurements on the six 1964 tests. By comparison, the 1980 schedule called for the assessment of 116 age 4 (or age 5) tests, 70 age 8 tests and 81 tests 12 years of age or older.



A two year old Loblolly Pine progeny test of Georgia Kraft Company. Growth and survival are excellent - the test has been maintained well. This is one of 1060 progeny tests in the Cooperative.

The measurement status of Piedmont and Coastal loblolly tests shown in Table 9, indicates that 80% have received their age four assessment and 42% have been measured at age 8. In addition, approximately 13% of the tests have been assessed at age 12. With few exceptions, some data are currently available on every first generation orchard in the Cooperative. Many orchards have a substantial accumulation of progeny test data.

Table 9. Measurement status of Coastal and Piedmont loblolly tests as of May 1, 1980.

	Number of Tests	
	Piedmont	Coastal
Not measured to-date	53	84
Fourth-year measurements only	108	158
Eighth-year measurements completed	115	171
Total	276	413

Future Measurements

The current measurement schedule recommended for progeny tests is as follows:

1. All tests are to be assessed at age four with measurements to be taken for height, cronartium, crown and straightness. In exceptional cases, when a test has developed slowly, the first assessment may be delayed until age 5.
2. All tests are to be assessed a second time at age 8. The same traits are measured as at age 4 plus diameter which allows volume calculations.
3. All tests are to be measured at age 12 with assessment of all five traits. If a test must be thinned prior to age 12, the test is to be measured at the time of thinning. This measurement will take the place of the age 12 assessment.

4. A selected number of tests will continue to be measured at four year intervals through an entire rotation. The tests selected for measurement until rotation will provide the data needed to verify the validity of the information obtained at early ages. On the basis of this information, optimum assessment and selection ages will be determined for future generations.

During the past year an extensive evaluation of existing tests was undertaken to select a subset of the tests for retention until rotation age which would provide the maximum amount of information. The primary factor in selection was the number of control crosses and clones represented in a given subset. Such a subset will allow for the validation of clonal performance as well as specific cross performance. Tests which would provide information of special interest were also given strong consideration for retention. For example, some of the paired plantings of Coastal and Piedmont sources were retained for future comparison. Special plantings, such as the wide cross tests established in 1968, were also designated for retention. Throughout the selection process, we strived to minimize the work load for any given cooperator by restricting the tests selected for retention from a single cooperator to a maximum of five.

Ultimately, 101 tests were tentatively selected for retention. Of the 101, 33 are Piedmont loblolly tests, 26 are Coastal loblolly tests, 24 are good general combiner open pollinated tests, 12 are rust diallel plantings and 6 are wide cross studies. The tests are well distributed throughout the operating region of the Cooperative. The final acceptance of these tests awaits field review. If on field inspection a test is deemed unsuitable, an alternative will be selected.

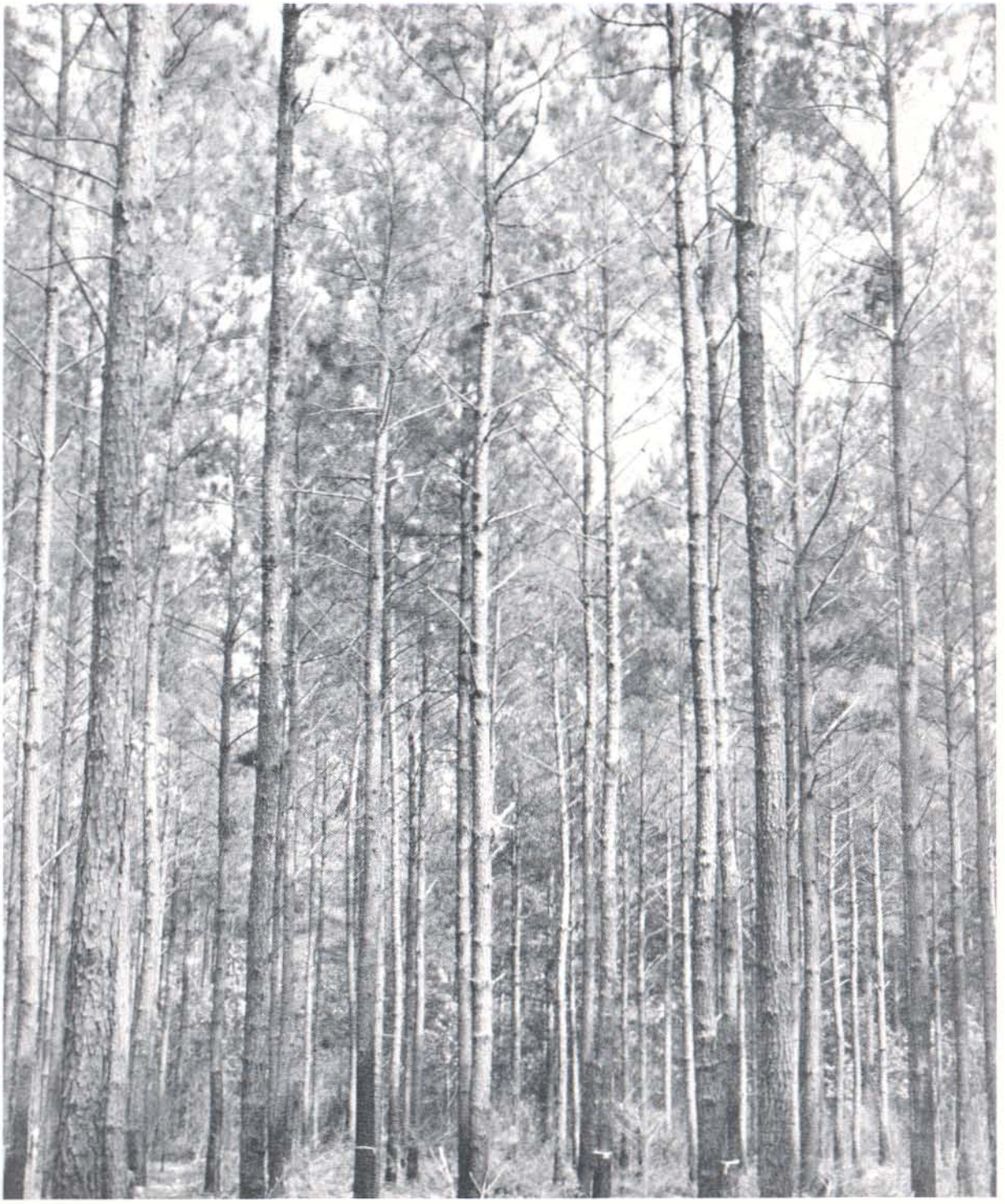
Floods and hurricanes impeded progress during the last year. Shown is a progeny test seedling in MacMillan-Bloedel's test which was wilted when the 10 day spring flood receded.

First Generation Wrap-Up

As is obvious from the number of progeny tests and associated acreage reported, a tremendous amount of effort has been put forth in breeding and testing first generation orchards. We can gladly say that this phase of tree improvement work is nearly complete.

A status report prepared last winter on the first generation program indicated that the breeding and outplanting had been completed for 20 Piedmont and Coastal loblolly orchards. Control pollinations had been completed for an additional 21 orchards. Twelve of these orchards required two additional years of outplanting, while outplanting will be complete for the remaining nine after one more year. There are 6 orchard programs that will require additional control pollinations in order to complete the testing program. Four of these orchards were expected to complete the needed control pollinations this past spring, the other two orchards were just beginning control pollination work. Rather than delay the completion of the first generation testing program, it has been decided that the clones in these two orchards will be tested under the breeding scheme for plantation selections. Finally after all of this is completed, if there are any totally untested clones, they will be included with the plantation breeding program.

Why the rush to complete the first generation program? The next generation will involve two distinct lines of breeding and testing; one will include second generation selections from progeny tests of first generation clones and the other breeding line will be composed of plantation selections. As outlined in the long range breeding plans, these two breeding programs must move forward simultaneously so that selections derived from both programs can be incorporated into a single program for the third generation. With the plantation



This beautiful stand of timber is a 17 year old open pollinated progeny test on lands of International Paper Company. The quality improvement is evident.

selection effort scheduled to conclude in 1981, we expect the last of these selections to be ready for breeding in the late 1980's or early 1990's. For first generation progeny tests to contribute second generation selections to the combined third generation improvement effort in a timely manner, the progeny tests must be established no later than 1983. For this reason, it is essential that the first generation breeding and testing program be wrapped up promptly. Time delays now will cause time and dollar losses in the third generation.

In summary, the last control pollinations for the first generation breeding program were made this past spring. Outplantings will continue through 1983. It is anticipated that 31 plantings will be established in 1981 and 24 in 1982. The final 14 outplantings will occur in 1983. Cooperative members will have established approximately 1150 progeny tests on about 4200 acres. This represents a tremendous effort and accomplishment. It is certainly one in which every Cooperative member can take great pride.

Rust Diallel Plantings

In the early 1970's control crossing was started on a half-diallel of 22 rust resistant clones. The selection of clones for the diallel was based on progeny performance in tests having high rust incidence. Clonal assessment was based primarily on age 4 data. In addition to the clones chosen for resistance, four crosses involving six clones which appeared to be highly susceptible to fusiform rust were selected for inclusion in each planting for comparison purposes. Twenty-eight outplantings of these seedlots were made over a three year period beginning in 1975.

Table 10. Performance Levels for Rust Diallel Clones Based on Four Tests Planted in 1975.

Clone	Performance Levels		
	Rust	Height	Form
10-5	78	100	61
10-25	76	63	49
11-10	72	69	67
7-2	68	74	66
7-56	64	72	78
11-20	64	42	52
7-34	62	77	70
3-7	62	36	45
12-12	60	36	49
12-13	59	48	48
3-36	59	47	45
3-17	59	36	29
1-64	55	34	37
1-14	55	40	39
1-11	55	45	48
3-2	52	34	43
5-5	51	31	39
3-34	50	48	50
12-9	50	44	42
10-37	49	77	56
CC	48	48	36
3-8	47	49	58
5-33	45	67	72
10-8	19	64	56
3-20	13	26	48
3-13	13	26	48
11-23	6	73	65
10-18	6	73	65
10-39	0	57	55

Four of the 1975 plantings were assessed in 1979, and although the information is tentative at this point, the results were very encouraging. The performance levels for all the clones represented in these four tests are given in Table 10. The six susceptible clones, 3-13, 3-20, 10-18, 10-8, 10-39, and 11-23, are all at the very bottom of the list with performance levels ranging from 0 to 19. The clones selected for their rust resistance performed much better

The outstanding three year old tree above was found in the Rust Diallel planting established by Container Corporation near Fort Deposit, Alabama.

with performance levels ranging from 45 to 78. The difference between the best of the susceptible (performance level = 19), and the poorest of the resistant (performance level = 45) is to say the least dramatic. As stated earlier, these results although very tentative are quite encouraging, particularly considering the limited information available on the clones at the time of selection.

Virginia Pine Seed Source Trial

While the major progeny testing effort in the Cooperative has been with loblolly pine, many organizations are working with other species as well. Virginia pine is one species receiving attention from several cooperators with lands in the northern sections of the Cooperative's working area.

In a comparison of three diverse seed sources of improved Virginia pine planted at two locations on Champion's land in north Alabama and south-central Tennessee, only stem straightness differences were shown to be important at six years of age. Families and seed sources tended to maintain the same ranking relative to each other at both locations. A majority of families performed significantly better than a Virginia pine commercial check lot, indicating substantial improvement in growth and straightness characteristics in one generation of selection. Also included in the tests were two improved loblolly pine seed orchard mixes from the South Carolina Piedmont which showed a 27% height advantage over the Virginia pine at age 6.

It is concluded from these early results that successful Virginia pine plantations can be established in the north Alabama, south-central Tennessee areas using improved seed from orchards representing three rather diverse provenances. If the results continue as shown then the genetic base of Virginia pine improvement programs in that area can be broadened by inclusion of selections developed in other regions.

Table 11. Average height, dbh and straightness from a Virginia pine source trial. Study was planted at two locations, Jackson County, Alabama and Wayne County, Tennessee, and measured at 6 years of age.

	Height	DBH	Straightness
Plantation Average	12.5	2.4	2.4
Seed Source			
Alabama	12.4	2.4	2.6
Tennessee-Kentucky	12.4	2.4	2.4
North Carolina-South Carolina	11.8	2.4	2.2
Virginia Pine Comm. Check	11.2	2.0	2.7
Average Loblolly Pine Check	15.7	3.1	-

*Straightness is measured on a 1 to 6 scale (1 = excellent; 6 = poor).

ADVANCED-GENERATION PROGRAM

Once again a discussion of activities and progress related to "advanced-generation" efforts is included in this report. We use the terminology "advanced-generation program" to broadly describe a number of distinct activities such as second-generation selections, plantation selections, establishment of second-generation orchards, good general combiner testing, etc. Much of the work described here is developmental in nature. Often, results of the work will be realized in the second generation; in other cases the payoff is even farther down the road. For example, the real benefit to be derived from plantation selection work is in the third generation of improvement. We cannot stress enough the importance of such developmental work if the Cooperative Tree Improvement Program is to have a sound base on which to build for the long term. Yet, we are ever mindful of the requirement that the program pay a return on investment at each and every stage. Currently, the large effort by Cooperative members on second-generation orchard establishment is expected to produce the next major increment of genetic improvement.

Plantation Selection

As of April 1, 1979, there were 1722 new plantation selections graded by the Cooperative staff. During the period from April 1, 1979 until April 1, 1980, an additional 638 trees were graded. This is the largest number of trees graded in a single year since the plantation selection program was initiated in 1975. It indicates that the membership is intensifying efforts to reach the goal of 100 new selections per orchard program. This increased effort is gratifying as this project moves into the last full year of intensive activity. We now have a total of 2360 graded plantation selections. It is expected that with one

last push in the coming year the Cooperative will surpass the 3000 tree mark before the formal end of the program, now scheduled for April 1, 1981. It is important to meet this time schedule if significant delays in developing third generation production orchards are to be avoided.

A hypothetical "average" loblolly pine plantation selection is described on the selected tree grade sheet shown on page 33. The superiority of this "average tree" is most impressive. Ranging in age from 10 to 45 years and geographically from Maryland to Mississippi, the average superiority of all plantation select trees over the check trees is 4.8% for diameter and 4.8% for height resulting in 17.8% volume advantage. This volume superiority is quite striking when it is noted that the check trees are the five best crop trees in the stand after the candidate tree. The average superiority of select trees over their respective stand averages would be even more dramatic. The average select tree scores for quality traits implies that this size advantage has been realized with a simultaneous improvement in quality.

Second Generation

Selection of new second-generation trees from progeny tests continues at a steady pace. In 1979, 176 new selections were identified bringing the total number of loblolly second-generation selections to 1783. Table 12 shows a current list of the number of second-generation selections by cooperator.

For the past several years, the total number of selections has been increasing by approximately 175 each year. We anticipate that the annual increase will remain at this level through the early 1980's. About 1984 or 1985, when the majority of first generation tests have received their second and/or third assessment, we expect the annual increase to decline rapidly.

SELECTED TREE GRADE SHEET
N. C. STATE COOPERATIVE TREE IMPROVEMENT PROGRAM

COMPANY:	NCSU Cooperative	NC STATE NO.:	Average of 2360 trees
STATE:	Maryland to Miss.	CO. NO./BORROWED:	
COUNTY:	???	SPECIES:	Loblolly
GRADER:	Jett & clone	TYPE SELECTION:	Plantation
DATE:	Through March, 1980	AGE:	10-45

	SELECT TREE	AVERAGE CROP TREE
VOLUME	0.238	0.202
HEIGHT	66.0	63.0
DIAMETER	10.9	10.4
FORM CLASS	72.0	71.0

REMARKS: Superiority of select trees over checks is:
Volume: 17.8%
Height: 4.8%
Diameter: 4.8%

LOCATION: Somewhere in the S. E. United States

SELECT TREE SCORES

HEIGHT	0.3
VOLUME	1.5
CROWN	3.6
FORM CLASS	0.4
STRAIGHTNESS	3.4
PRUNING ABILITY	1.5
BRANCH DIAM.	1.0
BRANCH ANGLE	0.7
TOTAL	12.4

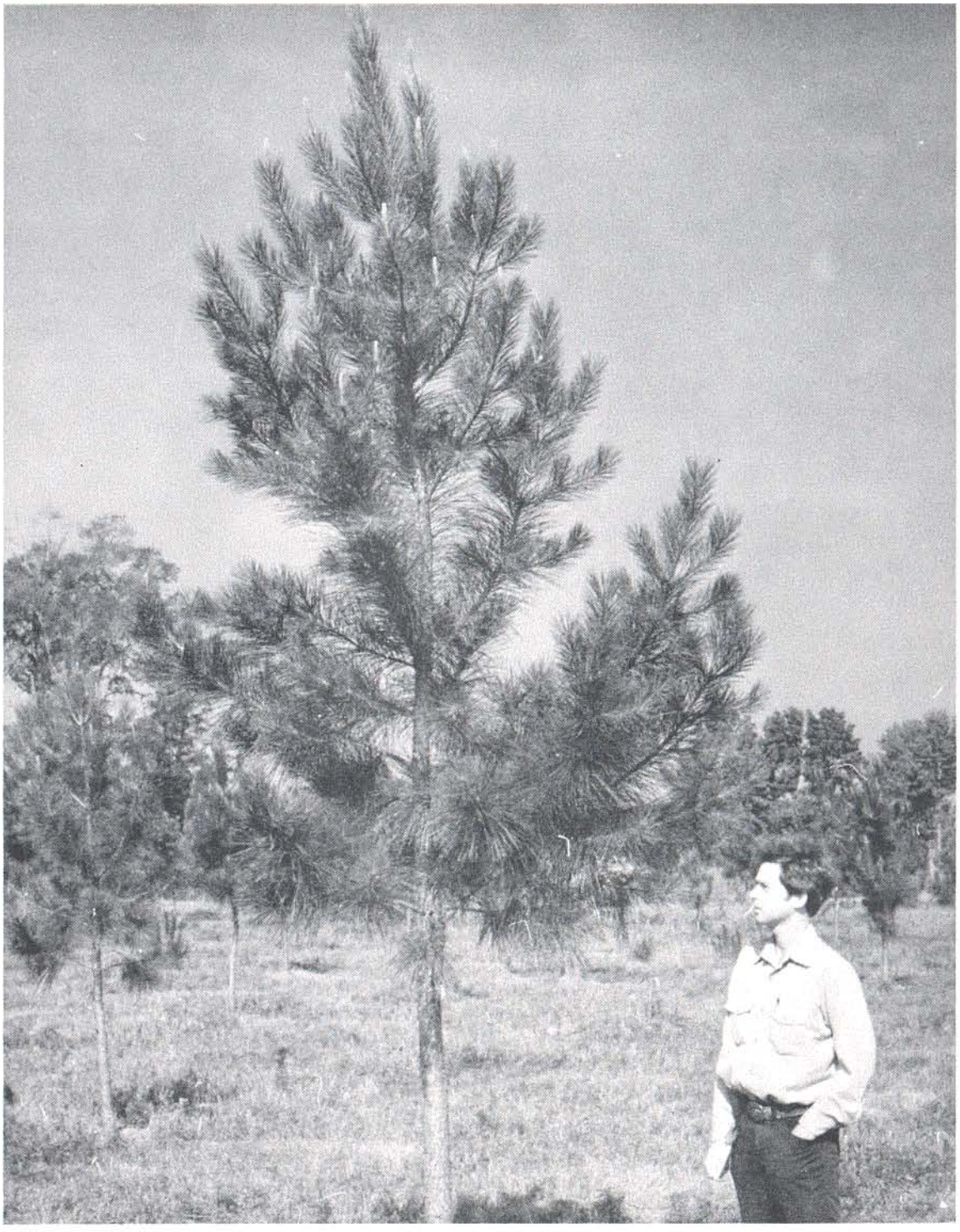
RECOMMENDATION FOR USE: BREED ASAP:

An outstanding 15 year old second generation selection from a progeny test of Hiwassee Land Company. The Cooperative selects about 175 new second generation selections each year.

Establishment of second-generation selections in breeding orchards has progressed well in the past couple of years. From information we received this past year on the status of second-generation breeding orchards, we estimate that 60% of the selections are now established in a breeding orchard/clone bank. Following this spring's grafting, we expect that 75% of the selections will be established in a clone bank. If this progress continues, we should experience little difficulty in providing the scion material needed for completion of second-generation orchards and we should be able to commence with the second-generation breeding program on schedule.

Table 12. A listing of second-generation selections of loblolly pine in the Cooperative.

	Number of Selections
Hiwassee	147
Catawba	60
Union Camp (Va.)	96
Champion--Western Carolina Division	68
Chesapeake	89
Continental Forest Industries (Ga.)	80
Champion--Eastern Carolina Division	115
International Paper	98
Weyerhaeuser (N. C.)	210
Weyerhaeuser (Miss.-Ala.)	33
Federal	97
Union Camp (Ga.)--Loblolly Only	51
Westvaco	131
Kimberly-Clark	121
Continental Forest Industries (Va.)	85
Georgia Kraft	67
N. C. Forest Service	4
American Can	36
S. C. Commission of Forestry	42
Tennessee River	60
Virginia Division of Forestry	76
Georgia-Pacific	7
Masonite	4
Brunswick	5
MacMillan-Bloedel	1
Total	1783



Georgia Pacific's second generation seed orchard is developing nicely as shown by this 4 year old graft. Twenty-five Cooperators have now begun their second generation orchard.

The establishment of second-generation orchards is progressing well. Twenty-five cooperators are now involved in orchard establishment. In 1980, grafting was underway for 32 loblolly orchards--18 of which were for the Coastal plain and 14 for Piedmont lands. Following this year's grafting, three second-generation orchards will be essentially complete.

Shown for each orchard in Table 13 are the number of clones recommended and the subsequent rejection rate. The rejection rates currently range from 0% to 33%, with an overall rejection rate of 15.6%. We believe that the rejection rates are quite tolerable. With the larger number of trees and clones on each orchard acre, rejected trees can be rogued, leaving a satisfactory orchard of good quality trees.

Table 13. Summary of second-generation orchard clonal recommendations and rejection rates, 1972 to 1980.

	Number of Clones Recommended for Orchard	Percent Rejected
Hiwassee	76	25.0
Catawba	94	22.3
Union Camp (Va.)	78	28.2
Champion	97	31.9
Chesapeake	86	30.2
Continental Forest Industries (Ga.)	62	24.2
Champion International--		
Eastern Carolina Division		
Coastal	54	11.1
Piedmont	58	6.9
International Paper		
Coastal	79	21.5
Piedmont	36	8.3
Weyerhaeuser		
N. C. Coastal	111	28.8
Miss. - Ala. Coastal	35	5.7
Federal		
Coastal	63	17.5
Piedmont	99	33.3
Union Camp (Ga.)	89	28.1
Westvaco	83	26.5
Kimberly-Clark	51	29.4
Continental Forest Industries (Va.)	67	14.9
Georgia Kraft	49	8.2
American Can	59	10.2
S. C. Commission of Forestry		
Coastal	37	0.0
Piedmont	64	7.8
Tennessee River	58	18.9
Va. Division of Forestry	35	0.0
Georgia-Pacific	69	18.8
Masonite	48	12.5
Container	49	10.2
Rayonier	71	14.1
Brunswick		
Piedmont	63	6.3
Coastal	34	0.0
Boise Cascade		
Piedmont	32	0.0
Coastal	32	0.0

The importance of a pollen isolation/dilution zone increases for advanced generation seed orchards. The greater the expected gain from an orchard, the greater is the loss from an influx of wild pollen. Shown in the foreground above is an ideal isolation zone managed by Catawba Timber Company.

Good General Combiner Tests

During the winter of 1978-1979, fourth year measurements were taken on a number of good general combiner tests established in 1975 at locations throughout the South. The tests were designed to assess the potential for long-distance geographic movement of genetic material which had been proven superior in its original testing area. If superior families should prove to be adaptable over a wide geographic area, then the genetic base with which the Cooperative has to work will be substantially broadened.

Good general combiner tests were established by Cooperative members during 1975, 1976 and 1977. Altogether, more than 50 tests have been established; twenty-three were measured during 1979. A distinction should be made between the good general combiner tests, which consist of open-pollinated families, and the good general combiner crosses which many Cooperative members have been making in recent years. The good general combiner crossing is being conducted to create a new base population of superior families from which improved second-generation selections can be made. Selections made in tests of progeny resulting from the crossing of good general combiners will be genetically superior to those currently being made in Cooperative progeny tests, and may provide selections for the establishment of improved second-generation orchards. There are no plans to make selections in the open-pollinated good general combiner tests, since there is no ancestral control on the male side of the pedigree. The open pollinated tests were designed specifically to assess the potential for wide movement of superior families.

Although fourth-year measurements must be considered preliminary, the tests measured to-date indicate that there is potential for movement of certain families

across breeding regions. Progeny of some clones appear to be quite adaptable throughout much of the loblolly pine range. Other families do well only in certain areas, usually those regions in which the parent tree was selected.

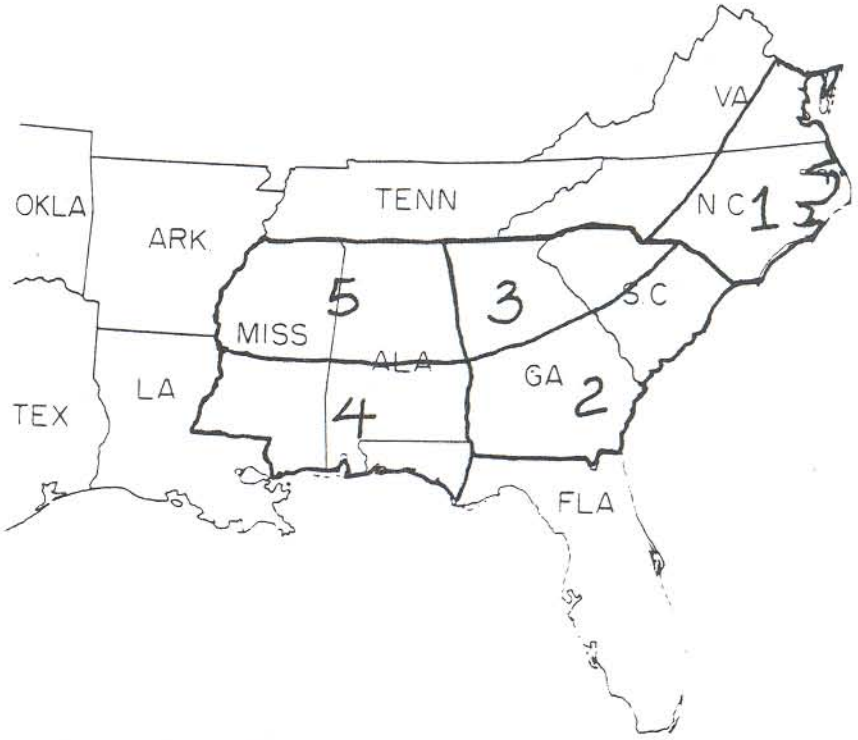
The general adaptability of families can be determined by comparing performance levels of families tested together in different geographic regions. To do this, we divided the area covered by the good general combiner tests measured last year into five geographic regions, as shown in Figure 1. These regions do not exactly correspond to the breeding regions being used by the Cooperative[1/], but were drawn to follow general physiographic bounderies and to coincide with the locations of the good general combiner tests. Four to six tests were measured in each region.

Height performance level values for a number of families, which were represented in tests in each of the regions, are given in Table 14. One trend that can be detected in the results is that many families originating in the Atlantic Coastal region from northern Georgia to central North Carolina do well regardless of the geographic region in which they are planted. For example, families 7-56, 7-34, 11-9, and 8-61 have superior performance level values in all of the geographic regions. Although family 5-5 was not planted in any test in the Southern Piedmont region, it does extremely well elsewhere.

Seedlots which represent the southern extreme of the loblolly pine natural range generally do well in southerly locations, but perform poorly in the colder environments. The Marion County, Florida and the Gulf Hammock, Florida sources are typical of this trend. These two sources have superior height performance level values in the Lower Gulf region, and also do well in tests located in South Coastal areas. In North Coastal and Upper Gulf tests, they show poor height growth.

[1/] Weir, Robert J. and Bruce J. Zobel. 1975. Managing Genetic Resources for the future: A plan for the N. C. State-Industry Tree Improvement Cooperative. Proc. 13th Southern Forest Tree Improvement Conference. pp. 73-82.

Figure 1. Geographic Regions for Good General Combiner Tests.



Region 1. North Carolina - Virginia

Region 2. Coastal Plain Georgia, South Carolina

Region 3. Piedmont Georgia, South Carolina

Region 4. Lower Gulf Coast

Region 5. Upper Gulf Coast

Table 14. Height Performance Levels of Selected Clones Across Five Geographic Regions

Seedlot	Ortet. Location	Performance Levels				
		Lower Gulf	Upper Gulf	S. Coastal	S. Piedmont	No. Coastal
Maryland-East. Shore	-	17	71	26	25	42
17-16	Sumter, AL	22	31	21	40	44
3-36	Newberry, SC	25	27	9	41	38
4-6	Gloucestor, VA	31	40	22	22	43
2-40	Sussex, VA	33	33	31	18	36
6-9	Warren, NC	37	50	54	44	54
3-7	Newberry, SC	43	46	56	52	31
1-14	Barron, GA	43	34	40	44	46
2-8	Southampton, VA	46	53	39	47	51
6-20	Chatham, NC	48	59	44	53	58
8-68	Craven, NC	49	58	38	38	57
8-76	Onslow, NC	56	70	47	59	57
8-59	Hertford, NC	60	71	60	50	55
Gulf Hammock, FL	-	62	42	60	21	21
8-61	Bertie, NC	64	69	59	78	82
11-16	Georgetown, SC	64	44	95	81	57
8-1	Beaufort, NC	65	80	46	77	61
Livingston Parish, LA	-	67	48	59	90	43
Marion Co., FL	-	70	27	53	51	30
10-14	Liberty, GA	70	83	67	55	52
11-9	Georgetown, SC	77	79	66	61	60
7-34	Georgetown, SC	78	84	70	78	65
7-56	Williamsburg, SC	88	66	90	82	65
5-5	Barnwell, SC	100	87	100	-	73
19-17	Monroe, MS	25	53	-	68	46
17-4	Marengo, AL	31	48	-	56	35
4-18	New Kent, VA	18	68	-	43	45

Sources which originated in the northern portion of the loblolly pine range show the opposite trend. Family 6-20, for example, is a good grower in North Coastal and Upper Gulf tests, but is somewhat below average in Lower Gulf and South Coastal regions. Many of the northern families did not perform well even in the North Coastal area, but the most northerly test measured (south-eastern Virginia) was south of the northern limits of where loblolly pine is planted. Several tests planted in northern locations have been measured this past winter, and results will likely be different at these locations. Preliminary analyses of tests planted in areas such as the high Piedmont of North Carolina and in West Virginia show the Atlantic Coastal Plain sources perform poorly or are killed outright by cold, while northern sources grow and survive well.

Correlation of family performances in the various geographic regions are given in Table 15. The correlation coefficients measure the consistency of family performance from region to region. A quite high correlation (r=.87) was obtained for the Lower Gulf and South Coastal areas. This means that families tended to rank the same in both regions. Family performances in the North Coastal region and the Upper Gulf regions also correlated well (r=.69). Correlation for some regional comparisons were much lower. The correlation coefficients for the North Coastal region and the South Coastal region was only .47, which indicates some change in family ranking between these two regions. Correlation coefficients given in Table 15 should be used with caution, since tests measured were only four years of age, and performance levels for any region were based on a limited number of tests. With many more tests being measured this year, future correlations will be much more precise.

The trends mentioned above are of interest from a theoretical and practical standpoint. First, the data fit well with evolutionary genetics theory which states that populations in the center of a species' range are more highly buffered to an array of environments than those which occur on the extreme edge of the range. Location in the center of the range facilitates gene flow from surrounding populations, increasing the genetic diversity and ability to adapt to a number of environments. Populations on the edge of the range are subject to limited gene flow and are under severe natural selection pressure resulting from extreme environmental conditions. These two factors would operate to make an "edge" population well adapted to local conditions but often poorly adapted to other environments. Families originating in the South Coastal area are from the central portion of the loblolly pine range, and many appear to be generally adaptable. Families representing "edge" populations (e.g. Marion County, Florida, Gulf Hammock, Florida, 6-20, Maryland-Eastern Shore) on the other hand do well only in environments similar to those in which they evolved.

Table 15. Correlations of Height Performance Levels For Select Families in Five Geographic Regions

	Lower Gulf	Upper Gulf	S. Coastal	S. Piedmont	N. Coastal
Lower Gulf		.50	.87	.61	.51
Upper Gulf			.51	.41	.69
S. Coastal				.67	.47
S. Piedmont					.59
N. Coastal					

Families from more western locations in Alabama and Mississippi could also be considered as coming from "central" populations, but have not performed as

well as families from the South Coastal area. This may be in part due to the fact that when families were chosen for inclusion in the tests, progeny test information was much better for organizations in the eastern portion of the Cooperative working area. It is likely that, with the more complete progeny test information currently available, many families from Alabama and Mississippi could be chosen which would also perform well across a wide geographic area.

The results also have important practical implications. The potential for expanding the genetic base through wide geographic movement of superior families appears to be good. Fourth-year measurements indicate that the greatest opportunities for movement lie with families from the South Atlantic Coastal Plain, while opportunities are limited for material from extreme northern or southern areas. If results hold through later ages, the genetic base of breeding regions in the North or South can be enriched by inclusion of families from more central locations. Breeding regions which are centrally located will have a particularly broad genetic base with which to work.

Thinning Progeny Tests for Wood Density Data: Is There a Need?

Currently 1060 progeny tests (3892 acres) have been established by Cooperative members! The original thinking was that as these tests matured and competition became a factor, each test would be thinned. At the time of thinning each test would be measured and wood samples taken to develop family wood specific gravity data.

As the actual process began to take place, it became apparent that an alternate approach was needed. Some of the facts contributing to this conclusion were:

1. The sheer number of tests involved was awesome.

2. Costs in time and money to the Cooperators were going to be quite high.
3. Cooperative laboratory facilities and personnel would eventually be unable to cope with the deluge of samples.
4. What was the value of having a complete wood data set for many of the crosses?
5. Was there a better way to arrive at the information?

It was this last thought that led us to analyze the data already in hand from thinnings of several progeny tests.

Data were obtained for 11 thinned progeny tests with an average age of 10 years, located in Georgia, North Carolina and South Carolina. A total of 128 crosses were included in these tests. The mature wood specific gravities were obtained for the parents in each cross from the original select tree records. Correlation coefficients were determined for parental and progeny specific gravities. With the parent-progeny correlations in hand it was possible to estimate the heritability of wood specific gravity.

An additional source of wood specific gravity was also evaluated to strengthen the information gleaned from the progeny test thinnings. Wood specific gravity is determined for each 8-year-old second-generation selection from a breast high increment core. Correlations were determined for parental specific gravity and the specific gravities of 364 second-generation selections. As in the case of the thinning data, the heritability for wood specific gravity was estimated from these parent-progeny correlations.

Results from the correlations of progeny specific gravity with the mid-parent mature wood specific gravity yielded a highly significant correlation coefficient of 0.55 for the progeny test thinning data. Utilizing the parent-progeny correlation, a heritability value of .42 for wood specific gravity was

calculated. This high value is right in line with values cited in numerous references and strengthened our confidence in the 0.55 correlation coefficient.

The correlation coefficient for mid-parent mature wood specific gravity and specific gravities of the second-generation selections was r = 0.41. Although this value is not as large as that obtained from the thinning studies, it was highly significant. The fact that it was lower is to be expected since in this case the specific gravity representing a progeny family is based on one value--that of the second-generation selection. Conversely, in the thinning studies, each family is represented by multiple values and this yields a higher precision when estimating the correlations. Importantly, the heritability value for specific gravity, based on the mid-parent second-generation selection correlation, was .57. Again this value is very comparable to previously published values.

The efficiency of selection for a trait based upon the performance of relatives can be determined and centers on the degree of co-ancestry. These studies indicate that a very acceptable job of selection for wood specific gravity can be done by simply utilizing mid-parent specific gravity values. Selection for specific gravity based on mid-parent specific gravity was found to be 71 percent as efficient as selection, based on physically sampling progeny specific gravity. This high level of efficiency becomes extremely important when one considers that second-generation orchards are often established with some trees less than 8 years of age. Such selections are too young to reliably or safely sample progeny specific gravity. However, excellent gains in specific gravity can be made in second-generation orchards by selections on mid-parent values when progeny values are not available.

Based on the foregoing results, it is concluded that we have made good gains by selecting for wood specific gravity in the first generation. Further, we should be able to make very acceptable gains for specific gravity in the second-generation of breeding with selection based on mid-parent values. Savings to Cooperative members and Cooperative laboratory operations will be considerable.

A first! Champion has set aside a tract of land for their third generation seed orchard. It will be farmed until needed. When we concluded that worn out farm land made a productive orchard site, they believed!

MISCELLANEOUS

Supportive Research/Special Projects

Work on a number of special projects is progressing well. These projects have often been collectively referred to as supportive research, i.e. that research activity which is done so that the applied program can move forward on a sound technological basis. Since there is a substantial number of these projects only the highlights of a few will be reported.

A study of the effects of varying levels of inbreeding or related mating is now underway. Losses in growth and vigor resulting from selfing in loblolly are now well documented, but the effects of lesser degrees of inbreeding are not known. This work is supported by the generosity of Weyerhaeuser Company and a grant from the U. S. Forest Service. Two small breeding orchards have been established in large pots and the trees are being subjected to special treatments to promote flowering. Control crossing began this year. Weyerhaeuser is managing a major portion of the Coastal plain replicate of the study and the N. C. State Cooperative staff is working on the portion with Piedmont source selections. A distinct, but parallel, study of inbreeding effects with Virginia pine is being done by Union Camp. Virginia pine was used in this pilot trial largely because the trees flower profusely at a very young age.

Jerry Sprague has initiated a study to evaluate what seems to be an improved method of testing pollen germination. The method originally used by Fred Mathews of the U.S.F.S. would seem to offer better repeatability and a more finely tuned estimate of pollen germinability. Use of such an improved method could make our advanced generation breeding work much more efficient.

John Talbert, with senior student Rob Wilson, has initiated a study of the value of first-generation pollen parents in second-generation orchards. To-date, approximately 16% of the trees established in second-generation orchards have been outstanding first-generation parents. The expectation has been that because of their advanced physiological age (50 + years), these trees would produce pollen earlier and more heavily than the more juvenile second-generation selections (5 to 15 years). Whether or not this is true should be objectively determined by this special project.

A study of intergenotypic competition effects has been undertaken by several cooperators along the Gulf Coast. The project designed by John Talbert seeks to determine if there are yield differences in stands comprised entirely of a single family and stands grown from a random mixture of families. St. Regis is the Cooperative member taking the lead in this research effort. Others cooperating are Rayonier, Scott, Container, and MacMillan-Bloedel. The first plantings were established in the field during the last year with additional plantings to be done in the year ahead.

Super intensive roguing of seed orchards is now being considered by some organizations as a means to capture greater genetic gains from first-generation seed orchards. Many organizations are soon to have this opportunity, but we do not yet know the extent of biological constraints on such practices. J. B. Jett has been working with graduate research assistants Steve McKeand and Rich Sniezko on an extensive work plan involving many distinct, but related, aspects of this question. In addition to the study plan, we have begun to acquire the equipment and expertise for electrophoresis analysis in our laboratory. Electrophoresis can be a very powerful

In the top photo is shown recently cleared forest land now growing food. Each year more of the most productive land is converted from forests to farms. It is imperative therefore to make each of the remaining acres more productive. The nursery full of genetically improved tree seedlings (bottom photo) is a step toward that end.

tool in this project, as well as having application to several other Cooperative projects such as identifying mislabeled seed orchard trees.

In the past year a number of other study plans have been developed by the Cooperative staff. These include: 1) a study of seed orchard irrigation methods; 2) a revised seed orchard gains work plan; 3) a study plan for assessing the inheritance of mature wood specific gravity and moisture content, and 4) a work plan to compare seed orchards from several geographic sources. Work on a number of these projects is now underway.

Students

The Cooperative continues to work with over 15 graduate students at the Master's and Ph.D. level. This work is largely the responsibility of Bruce Zobel, Bob Weir, and Floyd Bridgwater. However, other staff members of the Cooperative spend some time assisting students and guiding their research program. Floyd Bridgwater, John Talbert, and Bob Weir enjoyed conducting a special Monday evening seminar during the last year. Seminar topics included many aspects of quantitative genetics and advanced generation breeding.

Financial support for students comes from a variety of sources--the Tree Improvement Program, the School of Forest Resources, the N. C. State University Agricultural Research Service, the U. S. Forest Service, and special industry-sponsored fellowships. Students working with the Tree Improvement Program during the last year are listed on the following page with their respective degree and research topic.

Student	Degree	Research Project
Tim Adams	Masters(complete)	Correlation of rust resistance in the field tests with rust test center results.
Mike Carson	Ph.D.	Variation in rust virulence on loblolly pine.
Bill Dvorak	Masters	Genetic studies of Eucalyptus.
Teo Equiluz	Ph.D.	Genetic variation of Pinus tecumumani.
Bruce Emery	Masters	Intensive roguing of seed orchards.
Albert Garlo	Masters	Vegetative propagation of Fraser fir.
Mike Harbin	Masters	Aspects of seed orchard management.
Dave Harcharik	Ph.D.	Seed orchard irrigation.
James Hodges	Masters	Genotype-Fertilizer Interaction studies on slash pine.
Susan Hubbard	Ph.D.	Host-Pathogen interaction with Fusiform rust.
Clem Lambeth	Ph.D.(complete)	Genotype-Environment Interaction studies of Douglas fir.
Steve McKeand	Ph.D.	Natural inbreeding levels in loblolly pine stands.
Larry Miller	Masters(complete)	Genetic studies of seed orchard Fraser fir.
Reungchai Pousujja	Ph.D.	Vegetative propagation of loblolly pine.
Richard Sniezko	Ph.D.	Inbreeding studies with S_1 loblolly pines.
Joe Weber	Ph.D.	Natural variation of Fraser fir.
Claire Williams	Masters	Wet site loblolly pine source differences.

Staffing

Several new faces are visible in and around the program offices and laboratory. Personnel changes during the last year have resulted from retirement, resignations, and reorganization. However, at this time we are fully staffed with capable people that are working well together.

One new position has been filled in the last year that brings the 18-month term appointment of Bob Towe as a full-time tree grader. Bob is seldom seen in our offices since he spends virtually all of his time with cooperators grading plantation selections. He has averaged less than 2 to 3 days per month in Raleigh.

Faculty-level staff are well-known to cooperators because of their nearly constant travel to work with Cooperative members in the field. Laboratory, secretarial and data-processing staff are not nearly so visible, yet their work is of equal importance and they contribute vitally to the smooth and effective operation of the Cooperative. Our complete staff is currently as follows:

Faculty-level staff

Bob Weir, Director
J. B. Jett, Associate Director
Jerry Sprague, Liaison Geneticist
John Talbert, Liaison Geneticist
Bob Towe, Tree Selection Specialist
Bruce Zobel, Professor Emeritus
Part time with Cooperative

Support staff

*Vernon Johnson - Coordinator
Laboratory & Field Technicians
*Addie Byrd
*Steve Russell
*Dan Barker
Rob Wilson (part-time student)

Alice Hatcher - Coordinator
Data Processing & Secretarial
*Nancy Wills
*Vernedia Hunter
Karen Dwornik
Margaret Funderburg

*Individuals's time and financial support shared by Tree Improvement and one or more other cooperative programs.

MEMBERSHIP OF TREE IMPROVEMENT COOPERATIVE

Organization	States Where Operating
American Can Company	Ala., Miss.
Brunswick Pulp Land Company	S.C., Ga., Tenn.
Bowaters	Catawba Timber Co.--S.C., N.C., Va., Ga. Hiwassee Land Co.--Tenn., Ga., Ala., N.C., Miss.
Boise Cascade Corporation	S.C., N.C.
Champion International	Alabama Region--Ala., Tenn., Miss. East Carolina Region--N.C., Va. West Carolina Region--S.C., N.C., Ga.
Chesapeake Corporation of Virginia	Va., Md., Del., N.C.
Container Corporation of America	Ala.
Continental Forest Industries	Savannah Div.--S.C., Ga. Hopewell Div.--N.C., Va.
Federal Paper Board Co., Inc.	N.C., S.C.
Georgia Kraft Company	Ga., Ala.
Georgia-Pacific Corporation	Va., N.C., S.C., Ga.
Great Southern Paper Company	Ga., Ala., Fla.
Hammermill Paper Company	Ala.
International Paper Company	Atlantic Region--N.C., S.C., Ga. Gulf Region--Miss., Ala.
Kimberly-Clark Corporation	Ala.
MacMillan-Bloedel Corporation	Ala., Miss.
Masonite Corporation	Ala., Miss.
North Carolina Forest Service	N.C.
Rayonier, Inc.	Fla., Ga., S.C.
Scott Paper Company	Ala., Fla., Miss.
South Carolina State Commission of Forestry	S.C.
St. Regis Paper Company	Ala., Miss., Fla., Ga.
Tennessee River Pulp and Paper Co.	Tenn., Ala., Miss.
Union Camp Corporation	Savannah Div.--Ga., S.C., Ala. Franklin Div.--N.C., Va.
Virginia Division of Forestry	Va.
Westvaco Corporation	South--S.C. North--Va., W.Va., Ohio
Weyerhaeuser Company	N.C. Region--N.C., Va. Miss. Region--Miss., Ala.

PUBLICATIONS BY OR OF SPECIAL INTEREST TO MEMBERS OF THE COOPERATIVE

Adams, Tim. 1980. A determination of the predictive value of the Bent Creek Screening Center. M. S. Thesis, Dept. of Forestry, N. C. State University, Raleigh. (In Press).

Bridgwater, F.E., and R.W. Stonecypher. 1978. Genotype x Environment interaction: Implications in tree breeding programs. In: Proc. Fifth N. American For. Bio. Workshop. pp. 46-63.

Bridgwater, F.E., and R.W. Stonecypher. 1979. Index selection for volume and straightness in a loblolly pine population. Proc. 15th Southern Forest Tree Improvement Conf. pp. 132-139.

Bridgwater, F.E., and I.F. Trew. 1980. Supplemental Mass Pollination. In: Pollen Management Handbook. USDA Agricultural Handbook. (In Press).

Brotschol, J.V., L. Nunnally, G. Namkoong and H.A. Thomas. 1978. Studies on enzyme variation in the Southern pine beetle. The Journal of the Elisha Mitchell Scientific Society 93(2):91.

Cannell, M.G.R., F.E. Bridgwater, and M.S. Greenwood. 1978. Seedling growth rates, water stress response, and root-shoot relationships related to eight year volumes among families of Pinus taeda L. Silvae Genetica 27:237-247.

Cretcher, G. 1980. Natural variation of willow oak (Quercus phellos) among four river systems along the East Coast. M. S. Thesis, Dept. of Forestry, N. C. State University, Raleigh. (In Press).

Franklin, Carlyle. (Ed.) 1980. Pollen Management Handbook. USDA Agricultural Handbook. (In Press).

Foster, G.F., and F.E. Bridgwater. 1979. Viability tests to evaluate pollen reliability in loblolly pine controlled pollinations. Forest Science, 25:270-274.

Frederick, D.J. 1979. Biomass production in intensively cultured energy plantations. Paper presented at West Virginia Chapter Meeting - Society of American Foresters, Beckley, WV, November.

Frederick, D.J., W.E. Gardner, A. Clark., D. Phillips., and M. Williford. 1979. Biomass estimation of mixed southern hardwoods using an area sampling technique. Proc. Forest Resources Inventory Workshop, Fort Collins, CO pp. 782-791.

Frederick, D.J., W.E. Gardner., A. Clark., D. Phillips., and M. Williford. 1979. Biomass and nutrient distribution in hardwood forest of the Southern Coastal Plain. Proc. Symposium on Impact of Intensive Harvesting on Forests Nutrient Recycling. Syracuse, NY p. 394.

Frederick, D.J.., W.E. Gardner., R.C. Kellison., and P. Marsh. 1979. Area sampling predicts weight yields in West Virginia mountain hardwood stands. J. For. 77:762-764.

Frederick, D.J., W.E. Gardner., R.C. Kellison., and M. Williford. 1980. Energy plantations - a future source of biomass. Paper to be presented at 1980 Annual Meeting of the International Solar Energy Society, Phoenix, Arizona, June 2-6, 1980.

Frederick, D.J., R.C. Kellison., W.E. Gardner., M. Williford., and T.K. Slichter. 1979. Species selection and silvicultural systems for producing fuels from woody biomass in the Southeastern United States. Proc. 3rd Annual Biomass Energy Systems Conf. Colorado School of Mines, Golden Colorado. pp. 387-392.

Goldstein, I. 1980. New technology for new uses of wood. Tappi 63:105-108.

Goncalves, P. De S., and R.C. Kellison. 1980. Potential of black alder in the South. Technical Report No. 62, School of Forest Resources, N. C. State University, Raleigh. 31pp.

Greenwood, M.S. 1978. Flowering induced on young loblolly pine grafts by out of phase dormancy. Science 201:433-444.

Hunt, R. and B. Zobel. 1978. Frost-hardy Eucalyptus grows well in the Southeast. South. Jour. Applied For. 2(1):6-10.

Hunter, S. 1978. An electrophoretic analysis of isoenzyme variation in a Piedmont loblolly pine seed orchard. M. S. Thesis, School of Forest Resources, N. C. State Univ., Raleigh. 47pp.

Kang, H-C. 1978. Limits of artificial selection under various mating systems. (Under the direction of G. Namkoong and B.J. Zobel) Ph.D. Thesis, School of Forest Resources, N. C. State Univ., Raleigh. 140 pp.

Kellison, R.C. 1978. Genetic manipulation of southern hardwoods. Proc. Eighth Forestry and Wildlife Forum: Productivity of Southern Forests. April 13-14. Virginia Polytechnic Institute and State Univ. pp. 111-120.

Kellison, R.C. 1979. The making of a cooperative forestry program. Paper presented at Canadian Tree Improvement Association, Gander, New Foundland, Sept. 30, 1979.

Kellison, R.C. 1979. Advances in tropical tree improvement. Paper presented at the International Symposium on Forest Sciences and their Contribution to the Development of Tropical America. San Jose, Coasta Rica, Oct. 1979.

Kellison, R.C. 1980. Early natural stand growth in hardwoods. Paper presented to the Southeastern Lumber Manufacturer's Assoc. Hardwood Symposium, Atlanta, GA, Jan. 29, 1980.

Kellison, R.C., T.K. Slichter and D.J. Frederick. 1979. Increased wood production from matching species to site. Tappi 62:77-79.

Kellison, R.C. and R.J. Weir. 1980. How forest genetics is helping grow better trees for tomorrow. Tappi 63:57-61.

Kelly, C.W. 1978. Intra-clonal variation in tissue clutured loblolly pine (Pinus taeda L.) M. S. Thesis. Dept. of Forestry, N. C. State Univ., Raleigh. 46pp.

Lambeth, C.C. 1979. Interaction of Douglas fir full-sib families with field and phytotron environments. Ph.D. Thesis, School of Forest Resources, N. C. State Univ., Raleigh.

Lambeth, C.C. 1979. Some problems in the traditional expression of genetic gain in forestry. (In Press).

Leach, G.N. 1978. Early growth of tissue culture-produced loblolly pine (Pinus taeda L.) plantlets in soil. M. S. Thesis, Dept. of Forestry, N. C. State Univ., Raleigh. 50 pp.

Lewis, C. 1980. The effect of cultivation on the root development of American Sycamore (Platanus occidentalis L.). M. S. Thesis, Dept. of Forestry, N. C. State Univ., Raleigh. (In Press).

Lowerts, G.A. 1980. Genetically controlled resistance to discoloration and decay in wounded trees of yellow-poplar. M. S. Thesis, Dept. of Forestry, N. C. State Univ., Raleigh. (In Press).

McCall, E. 1980. Conelet abortion in longleaf pine. M. S. Thesis, School of Forest Resources, N. C. State Univ., Raleigh.

McKeand, S.E. and W.F. Beineke. 1980. Sublining for half-sib breeding populations of forest trees. (In Press).

Makoui, K.B. 1980. An experimental study of the relationship between kraft pulp strength properties and wood morphological characteristics of several families of sweetgum (Liquidambar styraflua L.) Ph.D. dissertation. Dept. of Forestry, N. C. State Univ., Raleigh. (In Press).

Messina, M.G., D.J. Frederick, W.E. Gardner, A. Clark, D. Phillips, and M. Williford. 1980. Biomass, energy and nutrient estimation of mixed southern hardwoods. Paper submitted to the Bio-Energy Council for publication in their Resource Book, (Paul Bente, Ed.)

Miller, L.K. 1980. A genetic study of seed orchard Fraser fir. M. S. Thesis, Dept. of Forestry, N. C. State Univ., Raleigh. 59 pp.

Mott, R.L., R.H. Smeltzer, A. Mehra-Palta, and B.J. Zobel. 1977. Production of forest trees by tissue culture. Tappi 60(6):62-64.

Namkoong, G. 1978. Choosing strategies for the future. Unasylva 30(119-120): 38-41.

Otegbeye, G.O. 1979. Estimate of heritability of some wood and fiber characteristics in Eucalyptus viminalis Lambill. M. S. Thesis, Dept. of Forestry. N. C. State Univ., Raleigh. 59 pp.

Otegbeye, G.O. and R.C. Kellison. 1980. Genetics of wood and bark characteristics of Eucalyptus viminalis. Silvae Genetica. (In Press).

Paschke, J.L. 1979. Age-age relationships in loblolly pine (Pinus taeda L.). M. S. Thesis, Dept. of Forestry, N. C. State Univ., Raleigh. 47 pp.

Pearson, R.G., R.J. Weir, and W.D. Smith. 1980. Utilization of pine thinnings. Paper prepared for Southern Forest Economics Workers Conf. 27 pp.

Powers, Jr., H.R. and B.J. Zobel. 1978. Progeny specific loblolly pine clones vary in fusiform rust resistance according to seed orchard of origin. For. Sci. 24(2):227-230.

Rose, R. 1980. Association of mycorrhizal fungi and Eucalyptus species. Ph.D. dissertation, Dept. of Forestry. N. C. State Univ., Raleigh. (In Press).

Schoenhofen, L.H. 1978. The distribution of biomass in selected Appalachian hardwood species and stands, and the economic feasibility of separating sawlogs in conjunction with full tree chipping. M. S. Thesis, N. C. State Univ., Raleigh. 57 pp.

Schultz, Emily Butler. 1979. Artificial cold-hardiness testing of Eucalyptus. M. S. Thesis. Dept. of Forestry, N. C. State University, Raleigh, 56 pp.

Slichter, T.K., D.J. Frederick, R.C. Kellison, W.E. Gardner, and M. Williford. 1980. Energy plantation research in the southeastern United States. Paper submitted to the Bio-Energy Council for publication in their Resource Book, (Paul Bente, Ed.)

Sprague, J., J.B. Jett, and B.J. Zobel. 1978. The management of southern pine orchards to increase seed production. Symp. on Forest Tree Seeds. IUFRO Workshop, Starkville, Miss. May. 17 pp.

Sprague, J. and E.B. Snyder. 1980. Extraction and drying of southern pine pollen. In: Pollen Management Handbook. USDA Agricultural Handbook. (In Press).

Stahl, P.H. 1978. Interfamily competition in loblolly pine (Pinus taeda L.). Ph.D. Thesis; School of Forest Resources, N. C. State Univ., Raleigh. 127 pp.

Talbert, J.T. 1979. An advanced-generation breeding plan for the N. C. State University-Industry Pine Tree Improvement Cooperative. Silvae Genetica 37:72-75.

Talbert, J.T. and R.D. Heeren. 1979. Sex differences in green ash. South. Jour. of Applied Forestry. 3:173-174.

Talbert, J.T. and R.J. Weir. 1979. Improved loblolly pine of northern Piedmont - source does well in the northern Coastal Plain. Tree Planters Notes. 30:33-35.

Talbert, J.T., G. White, and C. Webb. 1980. Analysis of a Virginia pine seed source trial in the interior South. South. Jour. of Applied Forestry (In Press).

Wearstler, Jr. K.A. 1979. Competition-density effects and genetic improvement in loblolly pine (Pinus taeda L.) Ph.D. dissertation. Dept. of Forestry, N. C. State University, Raleigh. 64 pp.

Weber, J. and J.T. Talbert. 1980. Response of open-pollinated Fraser fir families to several stratification treatments. (In Press).

Williford, M., R.C. Kellison, D.J. Frederick, and W.E. Gardner. 1979. The use and selection of trees for energy and chemicals. Proc. Fifteenth Southern Forest Tree Improvement Conf., Mississippi State Univ., Starksville, MS, pp. 149-155.

Zobel, B. 1978. The challenges facing forestry in the South. Forest Farmer. 38(2). 3 pp.

Zobel, B. 1978. Gene conservation--as viewed by an applied forest tree breeder. Ecology and Forest Management 1:339-344.

Zobel, B. 1978. The good life or subsistence--how tree breeding can help. Third World Consul. on Forest Tree Breeding. Unasylva 30(119-120):5-9.

Zobel, B. 1978. The influence of forestry trends on nursery operations. Paper presented at Nurseryman's Conf., VA.

Zobel, B. 1978. Production of quality hardwoods by the large forest industries. Southern Lumberman, Logging and Sawmilling. pp. 11-16.

Zobel, B. 1978. Recent and future pressures and trends on forestry in the South. 5 pp. (In Press).

Zobel, B. 1978. World timber supplies and effect on the southern pine region. Mimeo Rept. 25 pp.

Zobel, B. 1979. The ecological impact of industrial forest management. Paper given at CICEPLA - Cartegena, Columbia. Nov. 1979. 11 pp.

Zobel, B. 1979. Florestas baseadas em exoticas (Forestry based on exotics). Boletim Technico 2(3):22-30.

Zobel, B. 1979. Growing More Timber on Less Land: Forest genetics can provide a means. For. Farmer. 38(9) 3 pp.

Zobel, B. 1979. Making the forest resource more productive. Paper presented at the 50th Anniversary of the School of Forest Resources, Raleigh, NC Sept.

Zobel, B. 1979. Panel introductory comments - PBS II. Given at the Plant Breeding Symposium #2, March 16, 1979, Ames, Iowa. 55 pp.

Zobel, B. 1979. Resource renewability. Presented at the International Materials Congress, Reston, VA, March 27, 1979. Part of a panel on Materials Aspects of the Worlds Energy Needs. 2 pp.

Zobel, B. 1979. The Southeast timber supply: how it will be affected by changing forestry in South America, Canada, and the Northeast. Sou. J. App. For. 3:37-42.

Zobel, B. 1979. Timber Supply Trends in South America. Given at CICEPLA in Cartegena, Columbia, Nov. 19, 1979, to pulp mill presidents of South America.

Zobel, B. 1980. Fast Growth Plantations in the Tropics and Subtropics of South America. (In Press-Forest Farmer).

Zobel, B. 1980. Genetic improvement of forest trees for biomass production. Preparation for book on biomass.

Zobel, B. 1980. Inherent differences affecting wood quality in fast grown plantations. Presented at IUFRO Conference in England, April. 17 pp.

Zobel, B. 1980. Special report: Imbalance in the world's conifer timber supply. Tappi 63:95-98.

Zobel, B., J.B. Jett, and R. Hutto. 1978. Improving wood density of short-rotation southern pine. Tappi 61(3):41-44.

Zobel, B. and R.C. Kellison. 1978. The importance of genotype-x-environment interaction in southern pine forestry. Paper delivered at Eigth World Forestry Congress in Indonesia. Oct. 9 pp.

Zobel, B., and R.C. Kellison. 1978. The rate of growth syndrome. Silvae Genetica. 27(3-4):123-124.