TWENTY-NINTH ANNUAL REPORT

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

School of Forest Resources
North Carolina State University
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EXECUTIVE SUMMARY

1. The 1984 cone and seed crop broke all previous production records by a wide margin.
   a. Members of the Cooperative harvested 105,239 bushels of loblolly cones from which 80.1 tons of seed were extracted.
   b. Second generation orchards of the Cooperative produced 6,321 pounds of seed.
   c. A monitoring system for second generation seed orchard yields has been established to provide information needed to develop orchard yield over age curves.
   d. The loblolly pine planted each year by the membership comprises 40% of the nation's annual tree planting.
2. Plans have been adopted to conclude the first generation progeny test measurement and second generation selection work by 1988.
   a. Breeding work has been initiated on 73% of the second generation diallels, and is complete for 20% of these diallels.
   b. Breeding is underway on 40% of the 500+ plantation selection diallels.
   c. Procedures are outlined for open-pollinated tests of second generation seed orchard parents for purposes of roguing.
3. Cooperative program research initiatives are providing supportive information from a wide array of studies.

a. Growth and yield modeling research concludes that genetic improvement affects the rate at which stands develop, but does not fundamentally change the pattern of forest stand development.

b. Preliminary results from a seed orchard subsoiling study including frequency and intensity treatments have shown no changes in tree growth rate. However, a marked increase in cone production from the multiple ripping treatment is suggested at this time.

c. Full season irrigation and supplemental nitrogen fertilizer treatments in a young second generation orchard increased tree size, crown volume and potential flowering sites. However, full season irrigation suppressed flower production while supplemental nitrogen increased the number of cones produced per tree.

d. Eight year results from the good general combiner test series indicate that for a major portion of our work area, families performing well in one test area also do well in others. Family performance in cold climates has no relationship to performance in more mild southerly areas.

e. Plans have been developed to test the performance of plantation selections over a wide geographic area--a plantation selection seed source study.

4. A total of 13 graduate students are working in association with the Cooperative on M.S., and Ph.D. programs.

5. The program has been delighted to have a Fullbright Scholar from Turkey work and study with us in the last year.

6. A total of 29 members operate 41 working units in the Cooperative program.

INTRODUCTION

The North Carolina State University-Industry Cooperative Tree Improvement Program has completed its 29^{th} year of operation. Program activities have been conducted in an operating environment characterized by intense scrutiny of forest management investments, including tree improvement. Increased accountability for resource allocation decisions is very prevalent. However, the individual and collective efforts of the Cooperative members has produced an impressive track record of accomplishment that is a model for tree improvement programs throughout the nation and the world. We can be confident our improvement efforts are contributing to increased forest land productivity and helping to ensure a continued supply of highly valued raw materials at a reasonable cost.

Reflection upon activities of the past year make it evident that our Cooperative is a balanced tree improvement program with substantial efforts in production, development and research. Seed orchards of member organizations produced over 88 tons of genetically improved seed in 1984. Enough seed has been produced from developing second generation loblolly orchards to regenerate 100,000 acres of forest land. Breeding progress has been initiated on 70 percent of the second generation diallels and 40 percent of the plantation selection diallels. Accelerated breeding technologies have been implemented successfully with over 20% of the second generation breeding now completed. We have participated in research targeted at understanding how to model growth and yield of genetically improved stands. Research is being conducted to gain a better understanding and thus more effective use of various seed orchard management techniques such as subsoiling, irrigation, fertilization, supplemental mass pollination, and genetic roguing. We are studying opportunities to exploit genetic gain more effectively through seed source trials, early selection and vegetative propagation. While more could be enumerated, it is clear that the Tree Improvement Cooperative is an action program with clear objectives and well understood priorities.

The Cooperative Tree Improvement Program has been both successful and dynamic. Member organizations, their personnel, and the program staff are working effectively together to meet the important challenge of developing the genetic potential of our forest resource. It is a major task, yet a tremendously rewarding activity. We are eager to continue our success and to maintain the pace of progress in the year ahead.

American Can's 1980 block of second generation seed orchard. The 1976 and 1977 blocks in this orchard produced 37 and 23 pounds of seed per acre in 1984.

SEED ORCHARD PRODUCTION

Cone and Seed Yields

The 1984 cone and seed crop broke all previous production records by a wide margin. Cooperative members harvested 105,239 bushels of cones from their loblolly pine seed orchards last fall. A total of 80.1 tons of genetically improved seed were extracted, an all time record crop. This is sufficient seed to produce 1.28 billion seedlings, which in turn would regenerate approximately 2.14 million acres of forest land with genetically improved trees.

In the 25th Annual Report (1980), it was suggested that the Cooperative members' seed orchards "might have the capacity to produce 85,000 bushels of cones". This year we surpassed that projection by 20,000 bushels. The 1984 harvest for loblolly surpassed the previous record cone crop (1983) by 54%, and the seed crop exceeded the previous production record (1981) by 59%. Cone and seed production statistics spanning the last eight years are shown in Table 1 for the Cooperative's loblolly pine

Table 1. Production of cones, seed and seedlings from Cooperative members' loblolly pine seed orchards over the last 8 years including an estimate of acres that could be regenerated with improved seedlings if all the seed were used.

Harvest Year	Bushels of Cones	Tons of Seeds	Millions of Seedlings	Millions of Acres Regenerated
1977	32,152	24.8	396	0.66
1978	37,977	23.5	376	0.63
1979	38,693	27.7	443	0.74
1980	15,296	7.9	127	0.22
1981	64,811	50.5	808	1.35
1982	44,761	30.5	488	0.81
1983	68,447	49.0	784	1.31
1984	105,239	80.1	1,281	2.14
Totals	407,376	294.0	4,703	7.86

orchards. We have experienced seven large cone and seed crops in this eight year period, a period of "full production".

A recent survey of the Cooperative shows that the members are growing 600 million loblolly pine seedlings annually. The seed produced in 1984 is equivalent to a two year supply for the entire program. Combining the information on tree planting of Cooperative members with information from a recently published nationwide survey of forest tree nurseries, it was determined that Cooperative program members produce 40 percent of the trees planted in the nation each year. Virtually all of the seedlings used in this tremendous tree planting program are now produced in Cooperative members' seed orchards. The impact of the tree improvement program is very large in the southeastern region and significant for the nation as a whole.

Loblolly pine cone and seed production in 1984 comprised about 90 percent of the total conifer cone and seed harvest for the Cooperative. Seed orchards of seven other conifer species produced an additional 17,000 bushels of cones and approximately 17,000 pounds of seed. The production for all conifer orchards is shown in Table 2 along with the 1981 harvest statistics, the previous record year. Particularly noteworthy is the harvest of 5,004 bushels of white pine cones, all by the North Carolina Forest Service, which yielded 3,634 pounds of seed. The North Carolina Forest Service also produced 702 pounds of Fraser fir seed from their "Christmas tree" seed orchard in the mountains. This is a welcome event since seed of any type has been in short supply for Fraser fir. Several Cooperators contributed to the increased crop of longleaf cones (3,018 bushels) which produced 2,494 pounds of seed. We are uncertain why the longleaf seed yields per bushel for 1984 were way below the excellent yields of 1981. Only a limited part of the shortleaf and Virginia pine seed orchard crops are harvested most years. Cones from the one or two pond pine orchards in the Cooperative are harvested infrequently. These sporadic harvests are the result of very limited demand for seed from these species.

Table 2. Comparison of cone and seed yields for 1981 and 1984, respectively, the previous best production year and the best yet.

Species	Bushels of Cones		Pounds of Seeds		Pounds of Seed per Bushel of Cones	
	1981	1984	1981	1984	1981	1984
Loblolly Pine:						
Coastal 1st gen.	43,819	77,686	66,579	114,113	1.52	1.47
Coastal 2nd gen.	0	4,308	0	5,374	0	1.25
Piedmont 1st gen.	20,326	22,431	34,454	39,734	1.70	1.77
Piedmont 2nd gen.	0	814	0	947	0	1.16
Slash Pine						
1st gen.	4,880	8,711	4,701	9,909	0.96	1.14
2nd gen.	0	96	0	93	0	0.97
Longleaf Pine	1,457	3,018	2,039	2,494	1.40	0.83
White Pine	658	5,004	298	3,634	0.45	0.73
Virginia Pine	591	364	480	283	0.81	0.78
Pond Pine	46	0	14	0	0.30	0
Shortleaf Pine	39	76	35	64	0.90	0.84
Sand Pine	0	30	0	24	0	0.80
Fraser Fir	148	218	336	702	2.27	3.22
Total All Conifers	71,964	122,756	108,936	177,371		

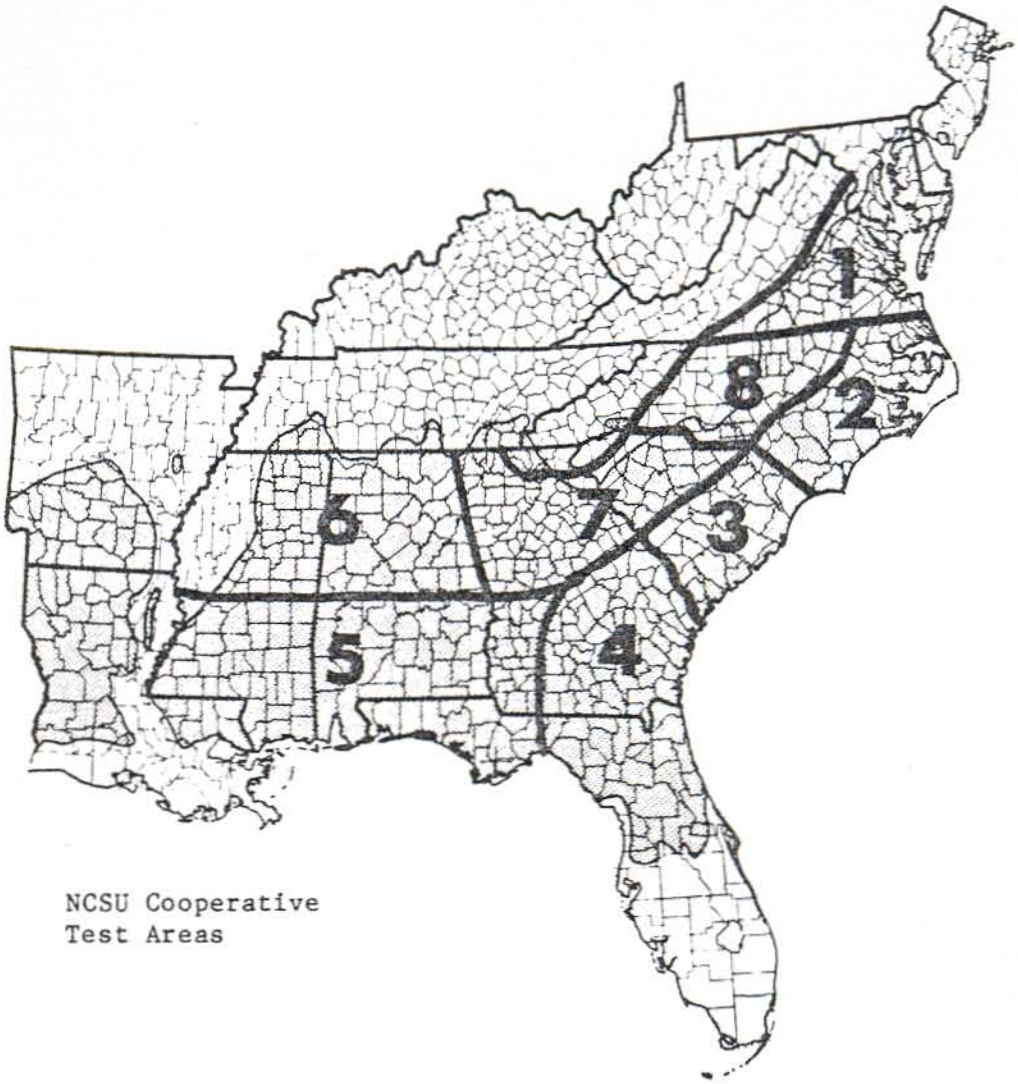
A dramatic increase in second generation seed orchard production has been experienced in each of the last three harvest years. Over 6,300 pounds of second generation seed orchard seed were produced in 1984 which represents over a 300% increase from the previous year (Table 3). Second generation loblolly seed orchards are producing large seed crops at relatively young ages. This reflects better orchard site selection and vastly improved management regimes. The second generation orchards produced enough seed in the last three years to grow 72 million seedlings and regenerate slightly over 100,000 acres of forest land. The first meaningful second generation slash pine seed orchard harvest occurred in 1984. Union Camp Corporation collected 96 bushels of second generation slash cones and extracted 93 pounds of seed.

Table 3. Second Generation Seed Orchard Yields.

	Loblolly Pine		Slash Pine	
Year	Bushels of Cones	Pounds of Seed	Bushels of Cones	Pounds of Seed
1982	692	763	---	---
1983	1,611	1,966	---	---
1984	5,122	6,321	96	93

Regional Distribution of Seed Production

Large cone and seed crops have been produced several years in succession. These production levels have provided most members with seed inventories equal to a two to three year supply. In addition, a considerable amount of first generation genetically improved seed has been offered for sale in recent years and especially following the 1984 bumper crop. In this seed surplus environment, it is of interest to note where the largest quantities of seed are being produced. Shown in Table 4 is a listing of the total 1984 harvest of loblolly pine seed for each testing area along with an estimate of the plantation acres that could be regenerated from this record crop. The largest amount of seed was produced for use in the Georgia-South Carolina Piedmont area followed closely by the Georgia-Florida Coastal area. While these statistics are of interest, one must interpret the information with caution. Substantial quantities of seed were produced for the Georgia-Florida Coastal area (29,013 pounds) and the Lower Gulf region (23,162 pounds), however, both these areas have a high concentration of industry and have extremely high demands for improved seed. It is expected that there might be considerably more surplus of the North Carolina Coastal seed than there would be for Lower Gulf seed, despite the relatively equal amounts produced. The difference reflects the variation in regional demand. The regional distribution was well balanced despite the fact that there are large regional differences in orchard acreage and the average age of orchards.



NCSU Cooperative
Test Areas

Table 4. Seed produced in 1984 for each area of the Cooperative and an estimate of the potential regeneration acreage by area.

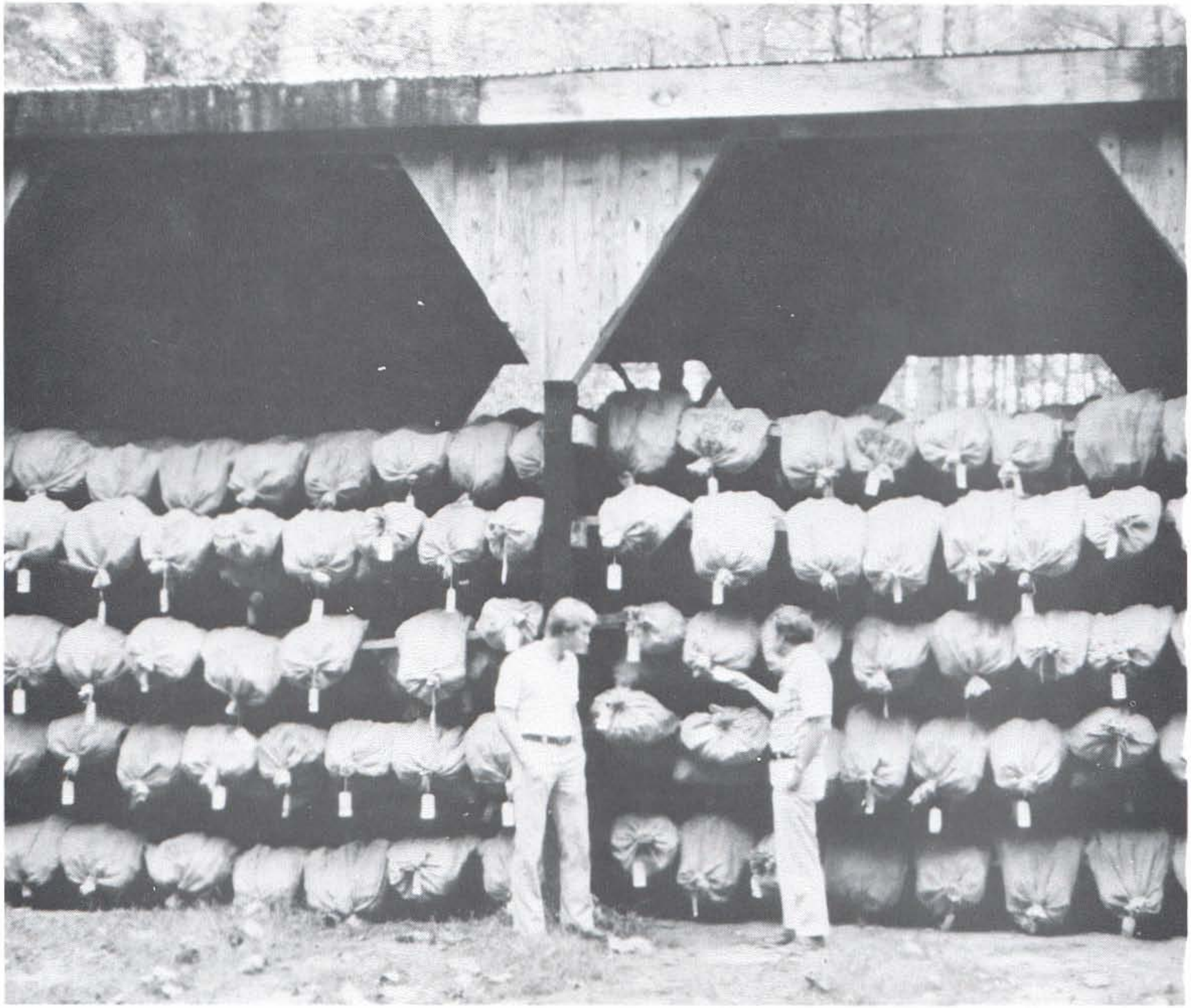
Area	Pounds of Seed	Acres that can be regenerated
1. Virginia Coastal & Piedmont	16,031	230 M
2. North Carolina Coastal	22,360	320 M
3. South Carolina Coastal	15,689	224 M
4. Georgia-Florida Coastal	29,013	415 M
5. Lower Gulf	23,162	331 M
6. Upper Gulf	17,232	246 M
7. Georgia-South Carolina Piedmont	30,372	434 M
8. North Carolina Piedmont	6,307	90 M

Production Leaders

It is with pleasure each year that we recognize those Cooperators who have the best producing seed orchards. This year we are happy to congratulate Marvin Zoerb and The Union Camp Corporation for the orchard having the highest yield per acre. Marvin and his capable staff produced 297 pounds of loblolly seed per acre in a 5 acre, 25 year-old Georgia Coastal first generation orchard. This is the highest yield ever recorded in the Cooperative -- Congratulations to Marvin and to Union Camp. The second place honor is awarded to Adlai Platt of Champion International for producing 242 pounds of seed per acre in a 5 acre, 26 year-old Piedmont orchard located near Newberry, South Carolina. Adlai's orchard has been noted previously for production excellence at or near the best in the Cooperative. Congratulations to Adlai and Champion International for continued excellence.

Excellent per acre yields were realized by Mark Steigerwalt with KMI Land Resources, Inc. (formerly Continental Forest Industries) using the ground cloth-net retrieval system. Mark collected 5,510 pounds of seed from 34.1 acres of orchard. One 7.7 acre, 26 year-old Piedmont orchard near Statesville, Georgia produced 206 pounds of loblolly seed per acre using the net harvest system. We commend Mark, his staff and KMI for maintaining such high standards of production while converting to a new harvest system.

While pounds of seed per acre is the "bottom line" measure of seed orchard production, we continue to take interest in the pounds of seed per bushel statistics because they reflect seed orchard efficiency levels. Leading the way for the 1984 crop was the Weyerhaeuser North Carolina Piedmont orchard managed by Gary Oppenheimer with 1.89 pounds of seed per



Proper cone handling after harvest has a pronounced impact on seed yields. Shown is Champion International's set up in Eastern North Carolina, a program with consistently high pounds per bushel yields.

bushel. Several other Piedmont orchards had excellent yields as noted below:

Catawba Timber Co.	- 1.87 lbs./bu.
South Carolina Comm. of Forestry	- 1.81 lbs./bu.
Champion International, NC	- 1.70 lbs./bu.

Seed yields per bushel were generally lower for Coastal Plain orchards in 1984. No explanation for the phenomena is readily apparent. The leader again in the Coastal Plain is the Champion International orchard at Tillery, N. C. managed by Ray Brown. Ray extracted 874 pounds of seed from 495 bushels of cones for a yield of 1.77 pounds per bushel. Honorable mention in the Coastal orchard category goes to Great Southern Paper Company. The orchard manager, Gary Cannon extracted 1,050 pounds of seed from 600 bushels of cones in his nine year-old 1.5 generation coastal orchard for a yield of 1.75 pounds per bushel. Congratulations to all of these organizations and managers for setting the standards of excellence in 1984.

Second Generation Seed Orchard Yield Monitoring System

The Cooperative program staff has begun an effort to monitor second generation seed orchard yields per acre by age class. Working in conjunction with the seed orchard managers, we are identifying at each second generation orchard site at least one orchard block that is uniform, even-aged, and well stocked to be monitored over the life of the orchard. We plan to record the bushels of cones and pounds of seed produced annually from each of these orchard blocks. The objective is to derive curves of per acre yield over age. This information is essential to properly plan the required acreage for new or expansion seed orchards.

Accurate seed yield information is important for financial planning. How many acres of orchard are needed to meet projected seed needs? What is the economic life of an orchard? When do we phase out one orchard and replace it with a new and genetically better orchard? Answers to these economic optimization problems are in part a function of orchard yields at various ages. The information we now possess with respect to yield-age relationships is incomplete and perhaps obsolete given the dramatic changes in seed orchard management regimes in recent years. We are now able to produce more seed at younger orchard ages than ever before. New yield relationships must be well documented to improve planning in the future. We are delighted by the outstanding cooperation of the membership as they move the project forward.

Care in orchard site selection, site preparation and establishment will pay off in well stocked, uniform and very productive orchards as typified by Westvaco's efforts above.

SELECTION, BREEDING AND TESTING

First Generation Testing and Second Generation Selection

Appropriate allocation of Cooperative member's resources to the highest value activities is an important component of Cooperative Program planning efforts. Resource allocation became a critical issue in the last several years as we continued to manage a very large first generation testing program and simultaneously initiated efforts to aggressively pursue an advanced generation breeding and testing program. The result was a major increase in activity with no commensurate increase in resources. In response to this challenge, the Cooperative staff conducted detailed analyses of the first generation test measurement and second generation selection activities to determine if planned assessments through age 12 were justified. Tests are measured and data are summarized for two purposes:

1) The determination of breeding values or genetic worth of parent trees in first generation orchards.
2) The development of a base population from which second generation selections can be drawn.

Results of the correlation analyses shown in Table 5 indicate that age four data are rather reliable for determining parental breeding values. If we were to make decisions (e.g. rogue orchards) using age four data, only rarely would we choose a parent that would be passed over on the basis of age 12 data. Only rarely are age 12 winners missed if we select on the basis of age four data. In all cases, the parent tree that is inappropriately included or omitted using four year data has intermediate values at age 12. The impact on genetic gain is inconsequential in either case.

Table 5. Average correlation coefficients for height, rust and form performance levels at ages 4, 8, and 12.

	Height	
	Age 8	Age 12
Age 4	0.84	0.75
Age 8		0.93

n = 7 programs

	Rust	
	Age 8	Age 12
Age 4	0.96	0.94
Age 8		0.97

n = 5 programs

	Form	
	Age 8	Age 12
Age 4	0.84	0.63
Age 8		0.86

n = 7 programs

- Evaluations were based on the same tests for each age.
- Only half-sib families composed of 3 or more crosses were used in the analyses.
- Two programs were not included in the rust analyses because of low infection levels.
- Form is a combined crown-straightness trait that weights straightness twice as much as crown.

With respect to second generation selection, the results of the correlation analyses suggest that the best families can be identified with high regularity using four year measurements. This is significant because with traits having relatively low heritabilities, the greatest gain results from correctly selecting the best families. Given therefore that early selection is appropriate, the decision became one of simply determining whether continued selection was needed to enhance the genetic base. Following a review of the available selections, it was concluded that "mature" breeding and testing programs had in nearly all cases one or more second generation selections from each of the better testers and females. Additional selections from these "mature" programs would contribute little to breeding or orchard establishment efforts because of relatedness. The Cooperative can still benefit from additional second generation selections in a number of breeding and testing programs that began later and have yet to reach maturity.

These conclusions, based on the reliability of early test results, led to a series of revised recommendations for first generation progeny test measurement and second generation selection. In the last year, these recommendations were unanimously accepted by the membership of the Cooperative and were thus established as program policy. The new policies are as follows:

Measurement -

1. All control-pollinated first generation progeny tests will be measured at age four (or five if slow to develop).
2. Only the previously designated 100+ progeny tests to be retained through rotation will be remeasured at four year intervals.

Selection -

1. Selection will be discontinued in programs where the best half-sib families are well represented in current selections.
2. Additional selections will be made in programs where the best half-sib families are not represented or are poorly represented in current selections.
3. The additional selections to be made will be identified after all tests in a program have been assessed at age four.

Selection Process -

1. Once all tests in a program have been measured at age four, a final clone evaluation will be prepared and those families identified from which selections are desired.
2. These families will be screened to determine the best individual(s) available. Acceptable individuals will be selected for use in the breeding program and, in some cases, for use in production seed orchards.
3. It is projected that the final first generation test measurements and selection will be completed in 1988.

The changes in the measurement and selection policies apply only to the first generation breeding and testing activities. Work is currently underway to develop measurement and selection procedures for the second generation breeding and testing program. We hope to finalize these plans in the near future. The value of the above decisions is significant. Policies have been established that reduce current workloads and allow reallocation of limited resources to breeding and testing for the future. This has been accomplished at no cost in progeny information or genetic gains.

An outstanding candidate for eventual selection in a three year-old, well managed genetic test established by MacMillan-Bloedel Corporation near Pine Hill, Alabama.

Advanced Generation Breeding Progress

Second generation and plantation breeding continues to gain momentum. More clones begin flowering each year, allowing more crosses to be made. Through 1984, breeding work was underway for 57 percent of the second generation diallels. Following the spring of 1985, work has been initiated on 73 percent of the 123 diallels. Control-pollinated crosses have been completed for 20% of the second generation diallels.

The logistics of coordinating the breeding work for the second generation diallels are quite complex. We seek to complete the breeding rapidly, yet distribute the workload as evenly as possible. This is all being attempted with limited flower production and a short supply of pollen. For the first time this year, the decisions on breeding assignments were computer aided. This has been a great aid to the timely completion of this work.

Approximately 40% of the 500 plantation selection diallels have been started. A generally excellent flower crop this year provided a good opportunity for breeding work. We fear, however, that flower damage from the April cold (freeze?) may have been extensive in certain areas. One Cooperator reported 99% flower kill in their breeding orchard.

Early results indicate that accelerated breeding efforts have been successful. In one instance, average seed yields of 51 seed per cone were reported and several individual cones produced as many as 110 seed per cone. This is more than twice the 20 seed per cone average of the first generation control-cross breeding program. These higher seed yields reflect greater care in pollen storage, better pollination techniques and improved insect control. The more seed per cone, the greater the efficiency and the lower the cost of the breeding program.

Breeding orchards/clone banks that have been established in a timely manner and are well managed are now contributing to advanced generation breeding progress. Shown is one of the best in the Cooperative.

Accelerated breeding in greenhouses is working extremely well. Thousands of flowers are produced for control-pollination three to four years after grafting. Flowers are produced earlier, in greater abundance and more consistently in such facilities.

Open Pollinated Tests of Second Generation Seed Orchard Parents

Second generation seed orchards are now beginning to produce significant quantities of seed. Members of the Cooperative harvested over 6,000 pounds of second generation seed in 1984. Many of the older blocks of second generation orchards have been rogued once and much more roguing will be done in these orchards over the next 10 to 12 years. Plans were recently developed to obtain the information needed to make better roguing decisions in the future.

The roguing done to date in second generation orchards has utilized family performance from the first generation testing programs. This information has allowed the removal of the obvious losers--the "real dogs". In the future, it will be necessary to identify the best 10 to 12 parents in the orchard--the winners we want to keep. To do this properly, information is needed from open-pollinated tests of each orchard. The family data from first generation tests is useful for early roguing, but will not allow us to compare the relative value of selections taken from different testing programs. Second generation diallels include only a subset of the selections used in production orchards so these tests will not help orchard roguing much.

The procedures described below are recommended for open-pollinated tests of second generation orchards. Only selections that have enough healthy ramets in the orchard to contribute substantially to orchard seed crops are to be tested. In some orchards as many as 60 to 80 selections will require testing. This is certainly true for orchards established over a six to eight year period. To maintain manageable test size under these conditions, one test series will be established with open-pollinated seed from the 30-40 parents well represented in the oldest three or four year blocks. A second follow up test series can include 30-40 selections from the youngest three to four year blocks.

The second generation open-pollinated testing program will be conducted using the same field test procedures described in the Cooperative's Genetic Testing Manual. A single test will be planted in each of two locations in each of two consecutive years. Each test will consist of six replications of six tree family row plots. The same check lot series used in the diallel tests will be used. Two plots of each of four checks will be established in each test. Containerized seedlings should be used to save time and to increase the liklihood of producing enough plantable seedlings for each seedlot attempted.

Pollen availability must be considered in this open-pollinated testing program. If ample pollen is being produced, the seed harvesting and testing can commence promptly. If pollen availability is restricted to only a few parents in the orchard, then use of supplemental mass pollination techniques should be used to accelerate the testing schedule. A mix of 20 pollens from first generation parents can be used for supplementing the natural pollen. Cone collections for open-pollinated tests of second generation orchards should come from three or more ramets scattered over the orchard. It is essential that the second generation orchard testing program begin as soon as flower and pollen availablity permits. The information will soon be needed.

Virginia Pine Second Generation Selections

The Cooperative at one time was involved in a full scale improvement program for Virginia pine. This effort included making wild selections, grafting production orchards, and subsequently control-pollinated breeding and testing work. In recent years, the interest in Virginia pine tree improvement work has diminished substantially. Regeneration programs have been curtailed since the species does not offer the potential for the high value solid wood stumpage market. The largest seed and seedling use of Virginia Pine at this time is for the production of Christmas Trees.

Concerns have arisen about the future of selection work for this species. Numerous tests are in place that could be assessed and screened for selections. However, given the interest in Virginia pine regeneration, little reason exists to advocate investment in advanced generation improvement. Yet, if some selection is not done in the near future, a lot of the foundation work will be lost. The question has been how to accomplish this with a minimum effort.

We are delighted to report that Westvaco Corporation has recently offered to graft and maintain a clone bank of all the Cooperative's second generation Virginia pine selections. Westvaco will preserve these trees for possible future use by any member of the Cooperative. The program staff is planning to coordinate the screening and grading of the selections from progeny tests during the next two to three years. The offer by Westvaco is very timely and is the kind of cooperative effort that has been the mark of success for the program over the years. We will, through Westvaco's initiative, maintain our progress with Virginia pine improvement at current levels. Should an incentive for further investment in the genetics of this species arise in the future, we will have a foundation on which to build.

RESEARCH RESULTS AND ASSOCIATED ACTIVITIES

Modeling the Growth and Yield of Genetically Improved Loblolly Pine [1/]

For the past 15 years, an increasing proportion of the acres planted with loblolly pine have been established with genetically improved stock. It is expected that essentially all loblolly pine planted in the future will be from selected genotypes. As more acres of improved stock come into production, crucial management decisions are being made for these stands. While percentage increases in volume production have been projected, little work has been done to determine the distribution of the expected volume increase or to study the dynamics of stands of genetically improved loblolly pine stock. An understanding of the growth and dynamics of genetically improved stands relative to unimproved stands is important for decisions regarding selection and breeding as well as forest management. To address the fundamental questions of dynamics and growth for genetically improved stands, a research project was started at Virginia Tech in September, 1983. Using data from diverse sources, the work has primarily involved the development and testing of hypotheses concerning stand dynamics and growth patterns in stands of improved stock, and devising ways of incorporating the implications of these test results into growth and yield models.

1/ It is a pleasure to acknowledge that this subsection of the 29th Annual Report is authored by Dr. Marilyn A. Buford, Champion International Postdoctoral Fellow, School of Forestry and Wildlife Resources, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. The research described is sponsored by Champion International Corporation and the Loblolly Pine Growth and Yield Research Cooperative, School of Forestry and Wildlife Resources, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

The data base used was comprised mainly of three components: 1) the loblolly phase of the Southwide Pine Seed Source Study; 2) a block plot half-sib progeny test, planted near Bogalusa, Louisiana, belonging to Crown Zellerbach; and 3) selected progeny test data released to this project by the North Carolina State University-Industry Cooperative Tree Improvement Program. Analysis of the Seed Source Study allowed hypotheses to be tested regarding similarity or difference of growth patterns of different seed sources at the same location and at different locations. Analysis of the half-sib block plot progeny test allowed hypotheses to be tested regarding growth patterns of half-sib families at the same location. The row-plot progeny test data from the NCSU-Industry Tree Improvement Cooperative were used to further test hypotheses which were accepted using the Seed Source Study and the half-sib block plot progeny test.

Results of the hypothesis testing done to date indicate: 1) at the seed source and family levels, the shape or slope of the height-age curve is dictated by the site, while the level or intercept of the height-age curve is dictated by the seed source or family; 2) at the seed source and family levels, the shape or slope of the height-diameter relationship at a given age is determined by site and initial stand density while the level or intercept of the height-diameter relationship is determined by the seed source or family and is directly related to the dominant height of the seed source or family at that age; and 3) given that silvicultural treatments are the same, are equally intense and successful, the variances of height and diameter in stands originating from selected genotypes are not different than those in genetically unimproved stands.

Implications for modeling growth of stands originating from selected genotypes are: 1) genetic improvement affects the rate at which stands develop, but does not fundamentally alter the pattern of stand development from that of unimproved stands; 2) changes in genetic material on a given site will likely affect the level, but not the shape, of such basic relationships as the height-age and height-diameter curves; and 3) correctly characterizing the height-age profile will be very important.

Future work will include further comparisons of basic stand dynamics relationships for unimproved and improved stands, growth and yield model modification to reflect hypothesized growth changes, and model validation using data collected from operational plantations of genetically improved loblolly pine stock.

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The Tree Improvement Cooperative is extremely pleased to have contributed to this valuable work through the release of data and by advising Dr. Buford concerning the conduct of tree improvement programs. On occasion, simply explaining to the growth and yield specialists the confusing terminology used in genetics seemed to be helpful. We are certainly not competent in growth and yield modeling and Dr. Buford has limited understanding of the principles of tree improvement, however, together much progress has been made.

The results of this work to date suggest that no fundamental changes in methods are needed to correctly model growth and yield of genetically improved loblolly pine. This is indeed good news! Validation of these hypotheses in operational plantings of improved trees and in block plot comparison studies such as the "seed orchard gain" trials will be useful.

Data from this and eight other plantings of the South Wide Seed Source Study established in 1952 and 1953 were used to examine aspects of growth and yield predictions for genetically improved stands.

Seed Orchard Subsoiling - Frequency and Intensity

The use of subsoiling in southern pine seed orchards dates back to the 1959-60 period and has been done to alleviate what was considered to be adversely high soil compaction. Positive responses to early subsoiling efforts resulted in increasingly wide use until subsoiling became generally accepted as a standard management practice. Despite wide acceptance, little is actually known about which types of subsoiling practices are most effective.

In August of 1981, a study was initiated in cooperation with Great Southern Paper Company to evaluate the impact of the frequency and intensity of subsoiling on the development and seed production of a six year-old loblolly pine seed orchard. The project involved five treatments:

1. Multiple ripping every other year. This treatment consisted of three parallel cuts on two (opposite) sides of a tree in year one. The next set of cuts was made in the third year at right angles to the first series of cuts. Therefore, it took three years to complete a cycle of cuts around a tree.
2. Multiple ripping each year. This treatment consisted of the same subsoiling cuts as in treatment one. However, rather than skipping a year between successive sets of cuts, subsoiling was done each year. In this treatment two years are required to complete a cycle of cuts around each of the trees.
3. Single ripping every other year. A single subsoiling cut was made on two (opposite) sides of a tree in year one. The second year was skipped and another set of cuts made in the third year at right angles to the first set. This treatment essentially

duplicates current operational subsoiling practices. Three years were required to complete a full cycle of cuts around a tree.

4. Single ripping each year. Subsoiling is done each year on two sides of a tree. Each successive cut is made at right angles to the previous cuts. Two years were required to fulfill a complete cycle of cuts around a tree.
5. Control. No subsoiling.

Results through the 1984 growing season indicate that none of the treatments have significantly influenced total tree height (see Figure 1), d.b.h. or crown size. Through luck of the draw, the trees assigned to the multiple rip - two year cycle were the smallest trees. Analyses of percent growth from year to year failed to identify significant differences attributable to the treatments at this point in the study. This means that trees in all treatments exhibit a very similar rate of growth. These lack of differences can be viewed as being quite positive in nature. While treatments have apparently failed to enhance tree development, subsoiling treatments which are more intense and more frequently applied than is currently operational have also failed to suppress tree growth.

In contrast to the lack of response in tree growth variables, analyses of the 1984 cone crop indicate a significant response to treatments. As can be seen in Table 6, the multiple ripping treatments resulted in a substantially greater number of cones per tree than did the control. The increase of about 40 cones per tree in the multiple rip plot as compared to the control is substantial. One of the hypotheses regarding the increased fruitfulness resulting from previous subsoiling experience has been the stress associated with root pruning. However, if some type of stress, NOTE: After printing the 1985 Annual Report, it came to our attention that the symbols were left off of the legend on Figure 1. The appropriate symbols are listed below.

Treatments

○ Multiple rip - 3 year cycle

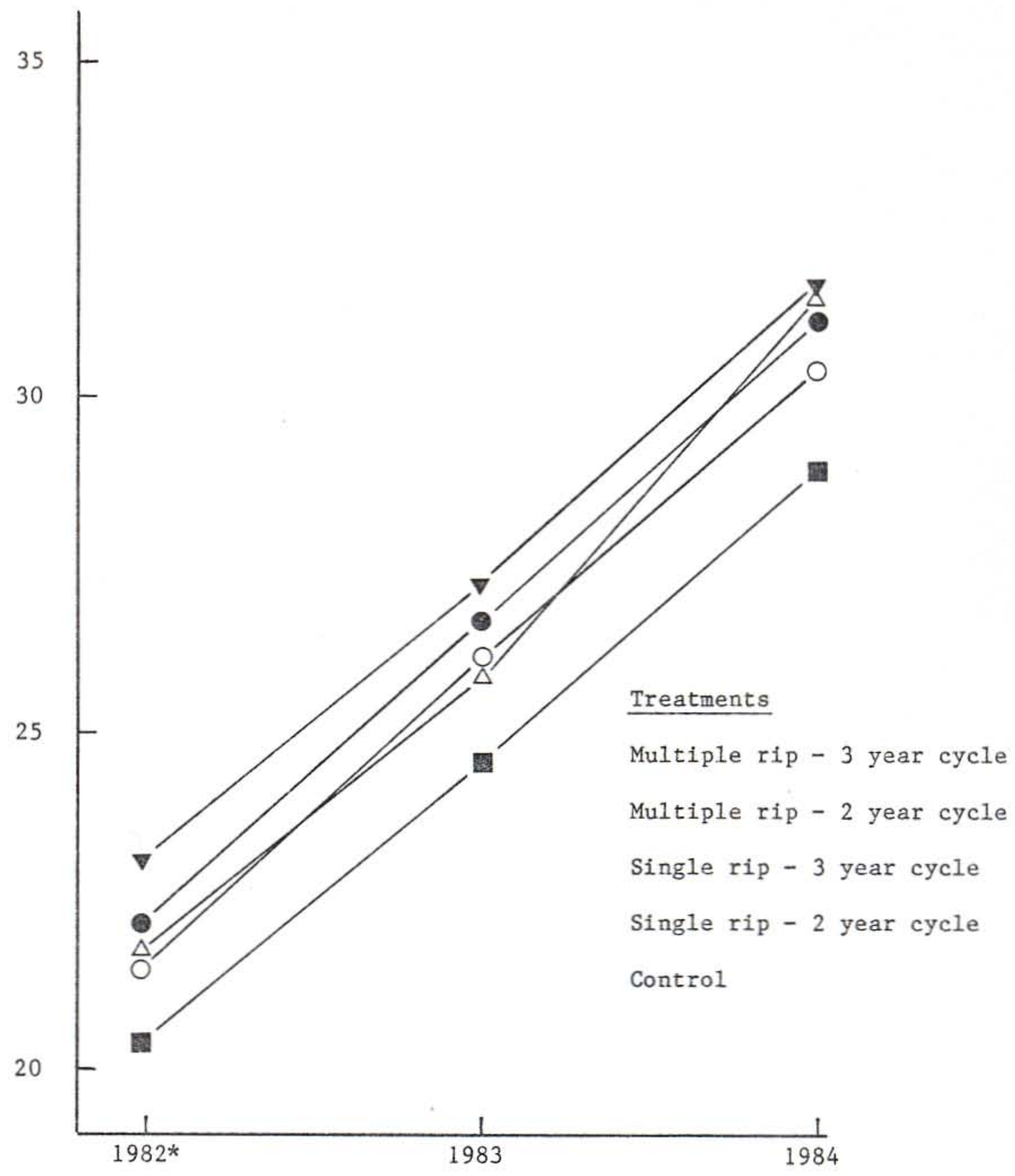
■ Multiple rip - 2 year cycle

▼ Single rip - 3 year cycle

● Single rip - 2 year cycle

△ Control

Figure 1. Mean total tree height by treatment for the Great Southern subsoiling study.



* Initial height taken 1982.

either for nutrients or moisture, is contributing to the enhanced flowering, it is apparently not impacting growth. Another hypothesis suggests that subsoiling promotes health in trees through amelioration of soil compaction and healthy trees in turn produce more flowers. It seems reasonable to assume that if this is true, healthy trees should also evidence improved growth. In this study, the multiple ripping treatments showed increased cone production and lower bulk density (compaction) of the soil. However, none of the treatments affected tree growth up to this point.

All of this leaves us with a need for much more work to understand the action of subsoiling. As intriguing as these early results are, it is premature to draw final conclusions. We will continue to monitor development of orchard tree growth and cone production in order to establish long term trends. As in any orchard research, results must be viewed over several years before conclusions are warranted.

Table 6. Mean number of cones per tree for the 1984 cone harvest.

Treatment	Mean [1/]
Multiple rip - 3 year cycle	143.5 a
Multiple rip - 2 year cycle	139.7 a
Single rip - 3 year cycle	117.4 a b
Single rip - 2 year cycle	107.5 b
Control	97.3 b

[1/] Means followed by the same letter are not significantly different.

A multiple ripping subsoiling treatment is being studied in Great Southern Paper Company's 1.5 generation seed orchard near Cedar Springs, Georgia.

Seed Orchard Irrigation and Supplemental Nitrogen

In 1980, an irrigation-fertilization research project was initiated in a one year-old second generation loblolly pine seed orchard belonging to the Weyerhaeuser Company in Lyons, Georgia. The purpose of this study was to quantify crown development and tree growth in response to irrigation and supplemental nitrogen fertilization applied only during the early years of an orchard's development. It was speculated that enhanced tree growth during the developmental years would result in larger cone crops when the orchards reached the production stage.

The four treatments consisted of a control, irrigation, supplemental nitrogen fertilization, irrigation plus supplemental nitrogen. Irrigation spanned the entire growing season each year from April through September. In addition to an annual broadcast application of 10-10-10 applied to all plots in March at the rate of 300 lbs./ac., 5.5 oz. of ammonium nitrate were applied to each tree each month from June through August in treatment plots receiving the supplemental ammonium nitrate. Treatments were continued four years through the growing season of 1983.

Analyses of fifth year data following the 1984 growing season reveal that early differences in total tree height, d.b.h. and crown volume associated with treatments receiving irrigation were persistent through the 1984 growing season. Irrigated trees were on the average 1.8 feet taller than non-irrigated trees. At the end of the fifth year, the irrigated trees averaged 1.3 inches greater diameter than non-irrigated trees (Table 7).

While these responses in total tree height and d.b.h. to irrigation are interesting, the more meaningful responses were observed in crown size. In an attempt to evaluate crown size, crown volume was calculated on the basis of a simple cone shape. As for height and d.b.h., the only significant differences were those due to irrigation effects (Table 7). The difference of 412 $ft.^3$ in crown volume between irrigation and no irrigation represents a striking 32.5 percent increase in the crown size of irrigated trees.

One of the theories supporting irrigation of young seed orchards is that irrigation will produce a larger crown which in turn will support larger cone crops by providing more potential flowering sites. Evaluations at the end of the 1982 growing season did in fact indicate that irrigated trees averaged two more potential flowering sites per primary branch than non-irrigated trees. However, early "flower" counts through the spring of 1982 indicated that full-season irrigation was suppressing female flower initiation.

Table 7. Significant main treatment effect means for total height, d.b.h. and crown volume following the fifth growing season (1984) and for cones per tree resulting from the 1984 harvest for the Weyerhaeuser irrigation-fertilization study.

Variable	Main Effect Mean: Irrigation	Main Effect Mean: No Irrigation	
Total height (ft.)	23.7	21.9	$LSD_{.05} = 1.3$
D.b.h. (in.)	6.9	5.6	$LSD_{.05} = .41$
Crown volume ($ft.^3$)	1679.8	1267.8	$LSD_{.05} = 283$

	Supplemental Nitrogen	No Supplemental Nitrogen	
Cones/tree	161	101	$LSD_{.05} = 48$

Analyses of the 1984 cone crop which was initiated under irrigation, flowered and developed the first year with irrigation and the second summer without irrigation, indicate that there were significant differences due to application of supplemental nitrogen. There was a 60 cone per tree difference between those treatments receiving the supplemental ammonium nitrate and those that did not (Table 7). Differences of this magnitude on a per tree basis are very important and serve to re-enforce our emphasis on the value of nitrogenous fertilizers in enhancing cone production. However, it should be remembered that the supplemental ammonium nitrate was applied monthly June through August rather than the late-July, early-August timing that is currently operational.

The first opportunity that the influence of the larger crown size on cone production can be evaluated completely free of full season irrigation will be the harvest of 1986. The 1986 cone crop will have been initiated, developed and matured without irrigation. In the interim, interest in and installation of irrigation systems continues. To many orchard managers, enchanced orchard development is only one of several reasons to irrigate.

Good General Combiner Tests - 8 Year Results

Good General Combiner (GGC) Tests were established throughout the Southeast by Cooperators in 1975-1977. The objectives of these open-pollinated tests were:

1. To determine the adaptability of good general combiners when planted outside their natural physiographic area.
2. To test a few sources, such as Livingston Parish, LA; Marion County, FL; Gulf Hammock, FL, and Eastern Shore, VA and MD loblolly for potential superiority in areas outside their natural range.

Eight year measurements from 50 of these tests have been analyzed during the last three years, and some interesting results and trends have been observed. Family and seed source means were calculated for each of the eight NCSU Test Areas, as well as for a combination of three cold site[1/] tests (Figure 2), in order to compare the relative performance of the different families in these nine Areas.

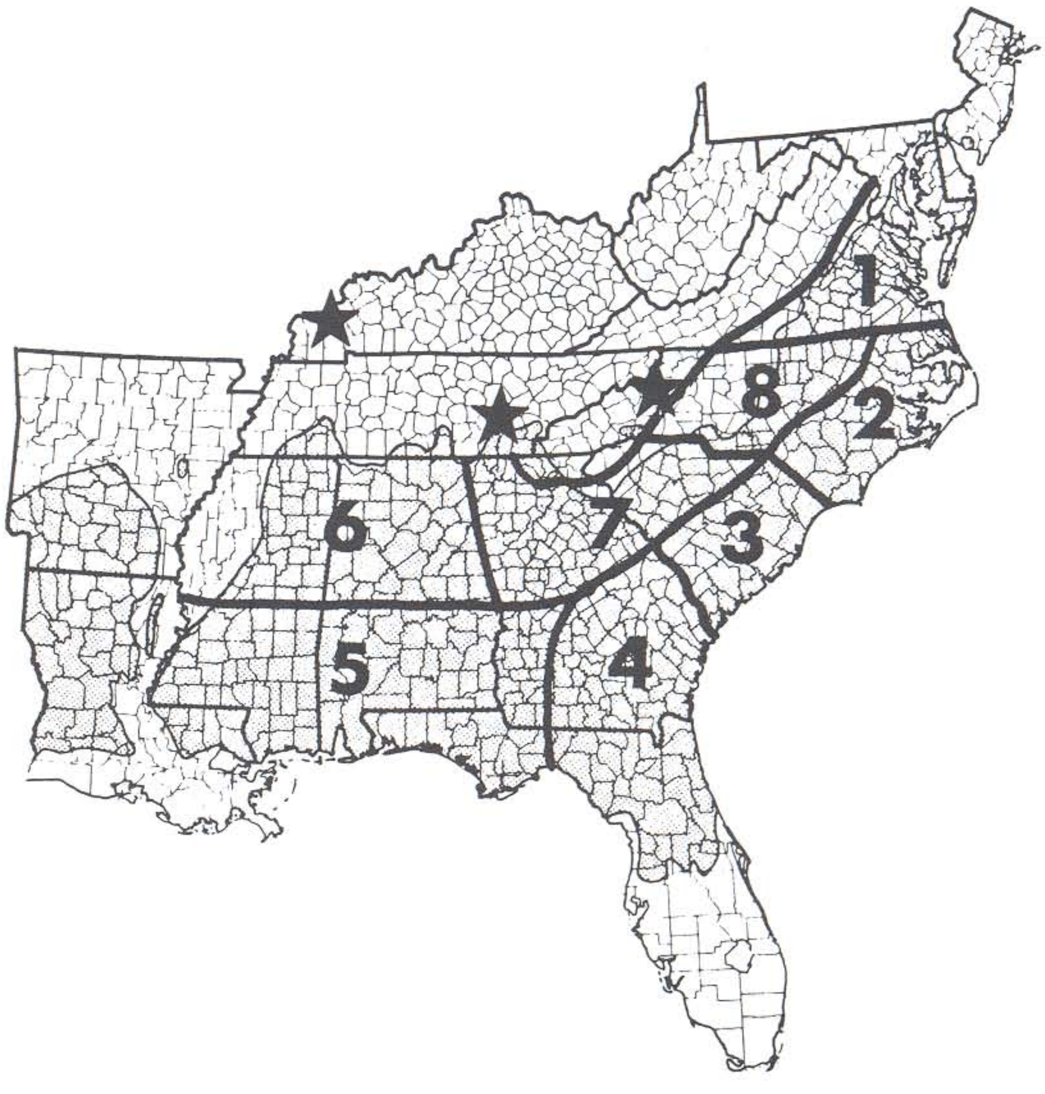


Figure 2. Partial range of loblolly pine showing the eight NCSU Test Areas and the location[1/] of the three cold site tests(★) of the Good General Combiner Test series.

[1/]Cold site test locations are Burke Co., NC; Rhea Co., TN; and Livingston Co., KY.

Caution must be used when interpreting the results of the GGC Test series. The small number of families which originate from different Areas, limit the usefulness of these data for seed source information (Table 8). Most of the 32 families which were planted in the nine different Areas originated from the Coastal Plain and Piedmont of Virginia, North Carolina, South Carolina, and Georgia. Very few good general combiners originating from the Lower and Upper Gulf regions were tested outside of Areas five and six.

The performance levels for height at age eight for the 32 families and four sources are shown in Table 9. The families are ranked in order of their performance in Coastal South Carolina. The results are similar to the four year results which were reported in the Cooperative's 1980 Annual Report. Generally, the relative performance of families in the Coastal Areas of NC, SC, GA-FL, Piedmont GA-SC and the Lower Gulf is stable. A good family or source tested in one of these Areas will usually be good in

Table 8. Number of families originating from the eight different NCSU Test Areas used in the analyses of the Good General Combiner Tests.

Source		Number of Families Represented
1 - Virginia		4
2 - Coastal NC		6
3 - Coastal SC		7
4 - Coastal GA-FL		1
5 - Lower Gulf		1
6 - Upper Gulf		2
7 - Piedmont GA-SC		7
8 - Piedmont NC		4
	Total	32

Table 9. Summary of family and source performance levels[1/] for height at age eight in the eight NCSU Test Areas and the three cold site tests of the Good General Combiner Test series.

Family or Source	Origin of Ortet (Area, County, State)	Ht. PL Area 3	Ht. PL Area 2	Ht. PL Area 4	Ht. PL Area 7	Ht. PL Area 5	Ht. PL Area 6	Ht. PL Area 8	Ht. PL Area 1	Ht. PL Cold Site Tests
1-14	7 - Barrow, GA	–	–	38	42	–	34	68	52	58
1-60	6 - Marshall, AL	–	–	–	36	–	24	40	47	51
1-64	7 - Cherokee, GA	–	–	–	27	2	21	18	34	55
1-66	7 - Bartow, GA	–	–	–	–	26	53	38	66	71
1-523	7 - Fairfield, SC	–	–	40	43	–	46	46	48	54
2-8	1 - Southampton, VA	–	56	44	–	51	63	–	52	70
3-7	7 - Newberry, SC	–	28	44	48	35	38	32	37	43
3-36	7 - Newberry, SC	–	–	21	23	19	19	12	44	43
6-9	8 - Warren, NC	–	53	26	51	45	57	80	57	55
6-22	2 - Northampton, NC	–	–	21	52	–	53	66	63	60
8-127	8 - Franklin, NC	–	–	–	63	40	61	–	59	56
9-17	8 - Anson, NC	–	60	43	62	43	50	50	64	–
15-42	7 - Morgan, GA	–	–	42	55	38	50	–	43	50
4-18	1 - New Kent, VA	15	35	36	58	34	59	39	55	69
ES	Eastern Shore, MD	19	10	32	35	28	40	55	58	60
4-6	1 - Gloucester, VA	20	29	25	48	19	42	30	58	64
17-4	5 - Marengo, AL	20	–	–	45	36	52	–	–	–
2-40	1 - Sussex, VA	23	27	14	26	27	24	42	54	74
17-16	6 - Sumter, AL	36	51	25	31	41	57	38	48	36
18-102	3 - Orangeburg, SC	37	–	59	39	67	51	–	31	–
8-68	2 - Craven, NC	40	63	54	52	50	39	57	37	40
6-20	8 - Chatham, NC	41	54	51	64	48	69	68	63	70
MC	Marion Co., FL	54	26	51	32	65	20	5	6	0
8-59	2 - Hertford, NC	55	52	53	70	55	74	82	59	71
GH	Gulf Hammock, FL	56	22	68	36	50	29	0	0	0
8-01	2 - Beaufort, NC	57	58	53	89	67	82	89	73	67
LP	Livingston Parish, LA	64	83	68	77	72	74	67	52	28
8-76	2 - Onslow, NC	65	62	55	77	62	71	51	68	–
10-5	3 - Jasper, SC	65	49	69	41	63	–	–	20	–
11-9	3 - Georgetown, SC	66	–	78	75	71	–	60	42	–
10-14	4 - Liberty, GA	68	46	67	36	69	75	30	17	–
8-61	2 - Bertie, NC	72	83	62	87	69	73	81	81	67
7-34	3 - Georgetown, SC	74	77	80	–	94	98	75	64	–
11-16	3 - Georgetown, SC	75	52	82	81	72	52	65	48	20
5-5	3 - Barnwell, SC	76	–	–	–	77	60	85	–	–
7-56	3 - Williamsburg, SC	99	94	97	90	92	84	90	63	36

[1/] Performance level is an index of relative performance of families with 0 = poor, 100 = good, 50 = average. Averages based on at least two tests in a Test Area.

the others. The performance of families in the Upper Gulf and Piedmont NC relates less well to the warmer, more southerly and Coastal Areas. When Virginia and the three cold site tests are included, the performance of a family in the Coastal and southern Piedmont regions has little or no relationship to the family's performance in these more extreme cold Areas.

The correlations of family and source performance in these nine different Areas are shown in Table 10. The correlations among family means in Areas 2, 3, 4, 5 and 7 are all high (0.58 to 0.91). The family means in Virginia and the cold sites have a low or even negative relationship to the family means in Coastal Areas and the southern Piedmont.

Table 10. Correlation of family and source performance levels for height at age eight in the eight NCSU Test Areas and the three cold site tests of the Good General Combiner Test series.

	Area 2 Coastal NC	Area 3 Coastal SC	Area 4 Coastal GA-FL	Area 5 Lower Gulf	Area 6 Upper Gulf	Area 7 Piedmont GA-SC	Area 8 Piedmont NC	Cold Site Tests
Area 1	0.49	0.01^{NS}	-0.16^{NS}	0.02^{NS}	0.53	0.59	0.74	0.78
Area 2		0.72	0.58	0.73	0.76	0.77	0.71	0.06^{NS}
Area 3			0.89	0.91	0.56	0.60	0.45	-0.42^{NS}
Area 4				0.90	0.56	0.59	0.30	-0.45
Area 5					0.70	0.64	0.59	-0.36^{NS}
Area 6						0.80	0.71	0.30^{NS}
Area 7							0.76	0.13^{NS}
Area 8								0.43

NS = not statistically significant at $p = 0.05$; all other correlations are statistically significant at $p \leq 0.05$.

Several of the families and sources are poorly adapted when planted in some of the extreme Areas of the Cooperative. For instance, 7-56 is the best or nearly the best family in all Areas except cold site tests, where its performance level is 36. The survival of 7-56 is extremely poor in the cold site tests and moderately poor in Virginia (Table 11). The two Florida seed sources (Marion County and Gulf Hammock) do reasonably well in the Lower Gulf, Coastal GA-FL and Coastal SC but are very poor when moved north any distance at all. The best family in the cold tests, 2-40 does reasonably well in Virginia but very poorly in all other Areas. The poor adaptability of several families and sources to extreme environments is also demonstrated by the poor survival of some families and sources in some extreme environments. The most southern sources and families survive poorly in Virginia and other cold site tests Areas. Survival of more northern families planted in the South (i.e. Area 4) is generally good, but growth is poor (Table 11).

The results of these GGC studies have some important implications for future breeding work in the Cooperative. The stability of many tested families over a relatively broad range of environments suggests that these families can be moved to certain geographic areas. Unfortunately, because only a few families were tested for each source, little can be said about different sources of loblolly pine, except that many families from Coastal South Carolina and North Carolina tend to perform well in several different Areas. How they compare to the best families from the Gulf Areas, for example, is not known.

Table 11. Deviation from average test survival for families and sources at age eight in selected Areas of the Good General Combiner Test series.

Family or Source	Area of Origin	Survival Deviation (%) in Area 1 (Virginia)	Survival Deviation (%) in Area 9 (Cold Site Tests)	Survival Deviation (%) in Area 4 (Coastal GA-FL)
Gulf Hammock, FL	-	-29	-59	5
Marion Co., FL	-	-29	-59	-1
Livingston Parish, LA	-	-16	-12	2
10-14	4	-14	-	-9
10-5	3	-12	-	1
11-16	3	-12	-30	4
7-34	3	-10	-	-1
7-56	3	-9	-27	4
3-7	7	-8	5	5
3-36	7	-7	8	8
8-68	2	-7	-9	-4
11-9	3	-7	-	-1
18-102	3	-4	-	3
8-61	2	-3	-1	-5
9-17	8	-1	-	0
8-76	2	1	-	1
15-42	7	1	9	6
17-16	6	1	8	3
6-22	2	2	14	-11
6-9	8	3	12	-7
6-20	8	3	8	-4
8-1	2	3	5	-2
4-18	1	4	12	1
1-14	7	5	-9	4
2-40	1	6	9	-5
1-60	6	7	3	-
2-8	1	7	12	5
4-6	1	7	16	0
8-59	2	9	2	1
1-64	7	10	13	-
8-127	8	12	10	-
1-66	7	13	21	-
Eastern Shore, MD	-	14	14	7
1-523	7	17	7	-3
Test Averages		78%	72%	84%

A device used in fruit orchards has been modified and is being tested for supplemental mass pollination of pines by Tom Blush of Westvaco Corporation.

Graduate Student Research and Education

The education of graduate students and the research they conduct in conjunction with their degree program is an important activity of the Cooperative. During the past year, 13 students have been involved in graduate studies in close association with the Tree Improvement Cooperative. Six have been pursuing Masters degrees and seven were involved in Ph.D programs. Of special note is the completion of degree programs by two students in the last year.

In addition to the work with students on their respective research programs, Cooperative staff members were invited to lecture in a variety of graduate and undergraduate courses during the year. Numerous lectures on aspects of tree improvement were conducted by members of the staff in conjunction with an International Short Course on Fast Grown Tropical Plantations conducted in March, 1985.

The graduate students working in association with the Cooperative, the degree to which each aspires and the subject of their research project are listed on the following page. The student research projects encompass a wide range of subject matter but, in each case, the work is supportive of the overall program research goals. Financial support for students comes from a variety of sources--The Tree Improvement Cooperative, the School of Forest Resources - Department of Forestry, the N. C. State University Agricultural Research Service, the U. S. Forest Service, industry-sponsored fellowships, and foreign governments.

Student	Degree	Research Project
Bruce Emery	Ph.D.	Intensive roguing of seed orchards
Greg Ferguson	Masters	Undecided
Diana Hartwell	Masters	Undecided
Gary Hodge	Ph.D.	Cold tolerant loblolly pine
James Hodges	Masters	Genotype-fertilizer interaction studies of slash pine
Randy Johnson	Ph.D.	Genetic variation in nitrogen uptake and utilization in loblolly pine (joint student with Fertilizer Coop - completed)
Karen Miller	Masters	Histological response of shortleaf and shortleaf loblolly hybrids to in vitro innoculation with fusiform rust fungus
Bialian Li	Masters	Geographic variation of Fraser fir
Kyung-Whon Pak	Masters	Undecided
Jim Richmond	Ph.D.	Genetic variations among populations of pine cone worms
Jarbas Shimizu	Ph.D.	Genotypic competitive effects in loblolly pine (completed)
Claire Williams	Ph.D.	Early selection in loblolly pine
Lisa Wisniewski	Ph.D.	Physiological studies of maturation and rejuvenation in loblolly pine

Program Staff

Listed below are Cooperative program staff members. The program is fortunate to have such a dedicated and capable group working as a team. The faculty level staff and those listed under support staff work full time on Cooperative activities except in the case of Greg Ferguson who has joint responsibility as a technician to the Tree Improvement Cooperative and the Tissue Culture Research Program.

Faculty-Level Staff

Bob Weir - Director
J. B. Jett - Associate Director
Steve McKeand - Geneticist
Jerry Sprague - Liaison Geneticist

Associated Appointments

Floyd Bridgwater - U. S. Forest Service
John Frampton - Tissue Culture
Bruce Zobel - Professor Emeritus
Kani Isik - Fullbright Post Doctoral Scholar

Support Staff

Alice Hatcher - Manager of Data Processing & Office Personnel
Rosina Rubes
Judy Stallings
Jackie Evans

Vernon Johnson - Coordinator Laboratory & Field Technicians
Addie Byrd
Greg Ferguson

There has been essentially no change in program personnel in the last year. Vernon Johnson and Addie Byrd previously were responsible to both the Tree Improvement and Hardwood Research programs but as of January 1, 1985, they report solely to the Tree Improvement Program.

Dr. Kani Isik is a visiting Fullbright Scholar from the Middle East Technical University in Ankara, Turkey. Dr. Isik received his Ph.D. from the University of California at Berkeley in the early 1970's and has been for some time an Associate Professor in the Biology Department of his home University. While with us, Dr. Isik has done data analysis and written two manuscripts on a Geographic Variation Study of Pinus brutia in Turkey. More recently, we have enjoyed his contribution to the Tissue Culture Program where Dr. Isik has been working with Dr. John Frampton on certain aspects of the field trials of tissue culture plantlets. We are honored to note that of some 850 Fullbright Scholars now studying in the United States, only Dr. Isik is working in forestry. It is a credit to the Cooperative Program and N. C. State University that Dr. Isik chose to study and work with us.

A solar powered electric fence is being used by Champion International to "discourage" deer from damaging a young seed orchard near Newberry, South Carolina.

MEMBERSHIP OF THE TREE IMPROVEMENT COOPERATIVE

Organization	States Where Operating
Alabama Forestry Commission	Ala.
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.
Boise Cascade Corporation	S.C., N.C.
Buckeye Cellulose Corp.	Ga.
Champion International Corp.	Alabama Region--Ala., Tenn., Miss. East Carolina Region--N.C., Va. West Carolina Region--S.C., N.C., Ga. St. Regis Acquisition--Ala., Fla., Ga.
Chesapeake Corporation of Virginia	Va., Md., N.C.
Container Corporation of America	Brewton--Ala., Fla. Fernandian Beach--Fla., Ga.
KMI Land Resources, Inc.	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	Northern Region--Va., N.C. Southern Region--S.C., Ga.
Great Southern Paper Company	Ga., Ala., Fla.
Hammermill Paper Company	Ala.
International Forest Seed Company	Miss., Ala., Fla., Ga., S.C.
International Paper Company	Atlantic Region--N.C., S.C., Ga. Gulf Region--Miss., Ala.
Kimberly-Clark Corporation	Ala.
Leaf River Forest Products Co.	Ala., Miss.

MEMBERSHIP OF THE TREE IMPROVEMENT COOPERATIVE (CON'T)

Organization	States Where Operating
MacMillan-Bloedel Corporation	Ala., Miss.
North Carolina Forest Service	N.C.
Packaging Corporation of America	Tenn., Ala., Miss.
Rayonier, Inc.	Fla., Ga., S.C.
Scott Paper Company	Ala., Fla., Miss.
South Carolina State Commission of Forestry	S.C.
Union Camp Corporation	Savannah Div.--Ga., S.C., Franklin Div.--N.C., Va. Alabama Div.--Ala.
Virginia Division of Forestry	Va.
Westvaco Corporation	South--S.C. North--Va., W.Va.
Weyerhaeuser Company	N.C. Region--N.C., Va. Miss. Region--Miss., Ala.

Three changes in Cooperative membership occurred in 1984. First, the Cooperative is pleased to welcome the Alabama Forestry Commission (AFC) as the program's newest member. While new to the Cooperative, AFC is not new to tree improvement; they have a large and very active program. The AFC has established over 150 acres of first generation loblolly orchard as well as slash and longleaf pine seed orchards. With their membership, the AFC brings to the Cooperative over 200 "new" loblolly selections which will substantially expand the genetic base in the Lower Gulf and Upper Gulf regions. The AFC began their first block of second generation loblolly orchard this year on a site chosen just north of Montgomery, Alabama. The Cooperative members and staff look forward to a long and mutually rewarding association with the Alabama Forstry Commission.

The second change in membership occurred as the result of corporate merger. Champion International Corporation bought St. Regis Paper Co. in late 1984. The very active tree improvement program of St. Regis will continue with the Cooperative as a supplemental working unit of Champion International. We look forward to continued interaction with this very fine program.

Finally, The Continental Forest Industries membership has changed in name as a result of changes in corporate ownership. Continental is now known as KMI Land Resources, Inc.. While the name has changed, the strong, progressive tree improvement program managed by Mark Steigerwalt continues to move forward without interruption.

We also note that Tennessee River Pulp and Paper Co. has changed their name to Packaging Corporation of America. This is a name change that occurred during corporate restructuring, it does not indicate a change in ownership.

These changes bring our total membership to 29 organizations. These 29 members operate 29 base units and 12 supplemental units for a grand total of 41 active programs in the Cooperative.

PUBLICATIONS OF SPECIAL INTEREST TO MEMBERS OF THE COOPERATIVE

Amerson, H. V., L. J. Frampton, Jr., S. E. McKeand, R. L. Mott, and R. J. Weir. 1984. Loblolly pine tissue culture: laboratory, greenhouse and field studies. Symp. Propagation of Higher Plants Through Tissue Culture: III Development and Variation. Univ. Tennessee. Sept. 9-13, 1984 (In press).

Amerson, H. V., L. J. Frampton, Jr. and R. L. Mott. 1984. In vitro methods for the study of fusiform rust in association with loblolly pine. p. 103-123. In: J. Barrow-Broaddus and H. R. Powers (eds.). Proc. of the Rusts of Hard Pines Working Party Conf., S2.06-10. Sponsored by IUFRO and Southeastern For. Expt. Sta., USFS. 331 p.

Bramlett, D. L., F. E. Bridgwater, J. B. Jett and F. R. Matthews. 1985. The theoretical impact of pollen viability, timing and numbers of applications, and pollen amount on seed yields in loblolly pine. Proc. 18th South. For. Tree Impr. Conf., Long Beach, MS. May 21-23, 1985. (In press).

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