THIRTY-FIRST ANNUAL REPORT

N.C. STATE UNIVERSITY-INDUSTRY

COOPERATIVE TREE IMPROVEMENT PROGRAM

SCHOOL OF FOREST RESOURCES
N.C. STATE UNIVERSITY
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THIRTY-FIRST ANNUAL REPORT

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

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EXECUTIVE SUMMARY

1. Information from annual measurements of early advanced generation diallel tests will be used to:

   a. Evaluate and optimize two-stage selection.

   b. Verify whether the single measurement/selection age of six years is optimum.

   c. Assess stem diameter as a selection criterion in addition to, or in lieu of, height.

2. A progress report on advanced generation breeding reveals that:

   a. Through the 1986 pollination season, regional completion rates for second generation breeding ranged from 55 to 75 percent.

   b. Twenty to 56 percent of the breeding is complete for the plantation selections through the 1986 season.

   c. Only four pollination seasons remain to complete breeding work if the Cooperative is to fulfill its 12-year objective.

3. Second generation selection work with loblolly will soon be completed. All Virginia pine second generation selections have been clone-banked by Westvaco.

4. The 1986 harvest of cones and seeds was the second largest in program history.

   a. Cooperative members harvested 70.1 tons of improved loblolly pine seeds.

   b. Second generation loblolly seed orchards produced 7.3 tons of seeds or slightly more than 10% of the total harvest.

   c. Incredibly, 17 seed orchards in the Cooperative exceeded two pounds of seed per bushel of cones harvested.

5. Cooperative program research initiatives are providing supportive information from a number of studies.

   a. A grafted tree in a breeding clone bank or production seed orchard can be heavily pruned for 2-3 years to produce well over a hundred scions for orchard expansion.

b. Quick seed stratification methods for loblolly pine do not work as well as a 45 day moist stratification.

c. Age two results are reported for a study comparing intensive versus standard culture of genetic tests.

d. A geographic variation study for plantation selections is proposed.

e. A loblolly pine rooting study reveals that season of the year is more important to rooting success than various chemical rooting treatments.

6. The Cooperative hosted an IUFRO Conference on Breeding Theory, Progeny Testing, and Seed Orchards. Over 160 scientists from 34 nations attended.

7. A total of 14 graduate students are working in association with the Cooperative on M.S. and Ph.D. programs.

INTRODUCTION

The N. C. State University-Industry Cooperative Tree Improvement Program has completed 31 years of activity. Starting with only a hope that "trees could be genetically improved," we are now entering our fourth decade of continuous operation with confidence that it not only works, but works well. Success through the years has resulted from firm commitments to goals, continuous financial support and true cooperation in genetic resource development. As we enter our fourth decade, we face new and perhaps greater challenges in accomplishing our breeding objectives while operating in a climate characterized by rapid change.

The changes are not only rapid, but vary widely in their cause and subsequent impact on the tree improvement program. Corporate mergers have been frequent in recent years and are likely to continue in the future. While some mergers occur with smooth transitions and minimal impact, others can be very disruptive of technical programs such as tree improvement. In some cases, progress can be delayed two to three years before organizational structures and personnel exist to continue the breeding effort.

A second change, now prevalent throughout the industry, could likewise have a major effect on technical programs. Many organizations are re-evaluating forest land ownership and management since they are viewed as investments yielding only modest returns. In this climate, tree improvement activities are, more than ever before, being evaluated with respect to the "bottomline."

A potentially strong force for change is the emerging pressure from foreign competition in the raw material or wood supply arena. Mr. Gene Cartlege, Chairman and CEO of Union Camp was quoted in the April 1987 Tappi

Journal as follows: "We've got to learn to grow more trees, more quickly, closer to our mills, and use less wood to produce a ton of our product. Brazilians are growing eucalyptus at the rate of six cords per acre per year on a six to seven year rotation."

One industrial leader has predicted that changes between now and the year 2000 will be greater than all the changes seen in the last 60 years. How do we, as tree breeders engaged in a long term breeding program, respond in such a rapidly changing environment?

Underlying all these changes is the common goal of increasing productivity and product quality while employing less capital. Tree improvement is a powerful tool with tremendous potential for positively impacting this goal. We are, however, a long-term program whose benefits are in the future. To insure our continued success in the short-term, we must strengthen our resolve to achieve the breeding and testing goals established. We must investigate all opportunities for reducing the time required for generation cycling in the future. We must improve our breeding methods so that more can be accomplished with less. We must prepare to accommodate technology improvements, such as vegetative propagation and biotechnology, at the earliest opportunity.

We can not, however, be deterred because the rate of progress is deliberate. Our situation is not unlike the conversation recently overheard between a landowner and a forester. It went like this: Question: How long will it take to grow this beech forest? Answer: About 80 years. Response: Well, sir, it seems we ought to begin today! We must likewise begin today if we are to accomplish our goals and thus significantly impact forest productivity in the future.

SELECTION, BREEDING AND TESTING

Annual Measurement of Early Diallel Tests

At the Cooperative's 1986 Advisory Meeting, recommendations for the measurement of advanced generation tests were presented (see the 1986 Annual Report, pp. 11-23) and adopted by the Cooperative. The recommendations were based on analyses of data from first generation tests. These analyses indicated that a single measurement at age six followed by selection at age seven would maximize the gains per year in our loblolly breeding program.

During discussion and debate on this issue, alternative strategies worthy of further consideration were identified. These included:

1) Utilization of a two-stage selection scheme with early selection at age three or four followed by final selection at about age eight. It has been suggested that a two-stage selection system would be more profitable than our conventional selection system. However, we do not at present have data available which allows us to evaluate or design an optimal two-stage selection scheme.

2) A suggestion was made that maximum gains per year could be achieved through selection at an age earlier than six. Again, data to justify such a modification of selection age are not currently available.

3) A proposal was made to consider tree diameter in addition to, or instead of, height as a criterion for selection for mature tree volume. Once again, the lack of appropriate data prevented a final decision on this suggestion.

In recognition of an information shortage, the Advisory Committee adopted the recommendation for a single measurement at age six, but also authorized the collection of data to provide the basis for modifying plans in the future. As a result, a study was initiated this past winter to measure annually a number of early diallel tests through age eight and periodically through age 25. The objectives of the study are to determine:

1. Time trends in genetic variance components, heritabilities, and genetic correlations among traits in young tests.

2. The optimal ages and relative merits of single-stage and two-stage selection.

3. The value of diameter in addition to, or instead of, height as a selection criterion.

For this study, 33 of the earliest advanced generation test series were identified for annual measurement through age eight. These 33 test series (each series = 4 tests) are well distributed throughout the working area of the Cooperative (Table 1). While the number of tests selected may seem large, they are necessary to precisely estimate the genetic variances and to determine if geographic differences exist in heritabilities and genetic correlations.

Each of the tests in the study has been or will be visited to verify their suitability for inclusion in the study. Tests included in the study that were field planted in or before 1986 were measured for the first time during the 1986-87 measurement season.

This is a major undertaking for the Cooperative, yet the effort is necessary if we are to optimize measurement and selection strategies in the future. By the mid 1990's, results will provide information that could enhance the efficiency of selection for establishment of third generation seed orchards and for the development of an optimum two-stage selection system for utilization in the later half of our current breeding cycle. In addition, the data base will provide a long term guide to determine appropriate improvement strategies in future generations.

Table 1. Diallel test series identified for annual measurement.

NCSU Test Area	Cooperators	Test Series Established
1. Virginia	Chesapeake	1984 & 1985
	Union Camp	1988 & 1989
	Virginia Dept. of Forestry	1987 & 1988
	Westvaco	1990 & 1991
2. NC Coastal	Champion	1990 & 1991
	Federal	1989 & 1990
	N. C. Forest Service	1988 & 1989
	Weyerhaeuser	1984 & 1985
3. SC Coastal	Boise Cascade	1988 & 1989
	Georgia Pacific	1988 & 1989
	International Paper	1984 & 1985
	S. C. Commission of Forestry	1988 & 1989
	Westvaco	1986 & 1987
4. GA-FL Coastal	Brunswick	1987 & 1988
	Georgia-Kraft	1988 & 1989
	Rayonier	1986 & 1987
	Union Camp	1986 & 1987
5. Lower Gulf	James River	1989 & 1990
	Container	1988 & 1989
	Great Southern (AFC material)	1988 & 1989
	International Paper	1985 & 1986
	Leaf River	1990 & 1991
	MacMillan-Bloedel	1987 & 1988
	Scott	1986 & 1987
6. Upper Gulf	Alabama Forestry Commission	1988 & 1989
	Champion	1984 & 1985
	International Paper Co.	1988 & 1989
	Kimberly-Clark	1986 & 1987
	Packaging Corp. of American	1988 & 1989
7. GA-SC Piedmont	Buckeye Cellulose (Ga. Kraft material)	1987 & 1988
	Hiwassee	1989 & 1990
	Catawba	1987 & 1988
	Continental	1987 & 1988

Breeding Progress

In October of 1981, the Cooperative held a special Advisory Committee Meeting in Hot Springs, Arkansas. The purpose of the meeting was to examine available technologies for stimulating flower production on young grafts, to consider the impact of this technology on the Cooperative's breeding plans, and to adopt a realistic but aggressive schedule for completing the current breeding cycle. Clearly recognizing the increased benefits from turning generations over rapidly, program members adopted a twelve year schedule for completion of breeding and test establishment in the current cycle of improvement. We are currently six years or half way into the twelve year plan as shown below.

BREEDING AND TESTING STATUS OF 12 YEAR PLAN

1981	-	**START**
1982		
1983		
1984		
1985		
1986		
1987	-	**WE ARE HALF WAY**
1988		
1989	]	*FOUR SEASONS LEFT TO COMPLETE POLLINATIONS*
1990		
1991		
1992	-	**HARVEST LAST SEEDS**
1993	-	**PLANT LAST TESTS**

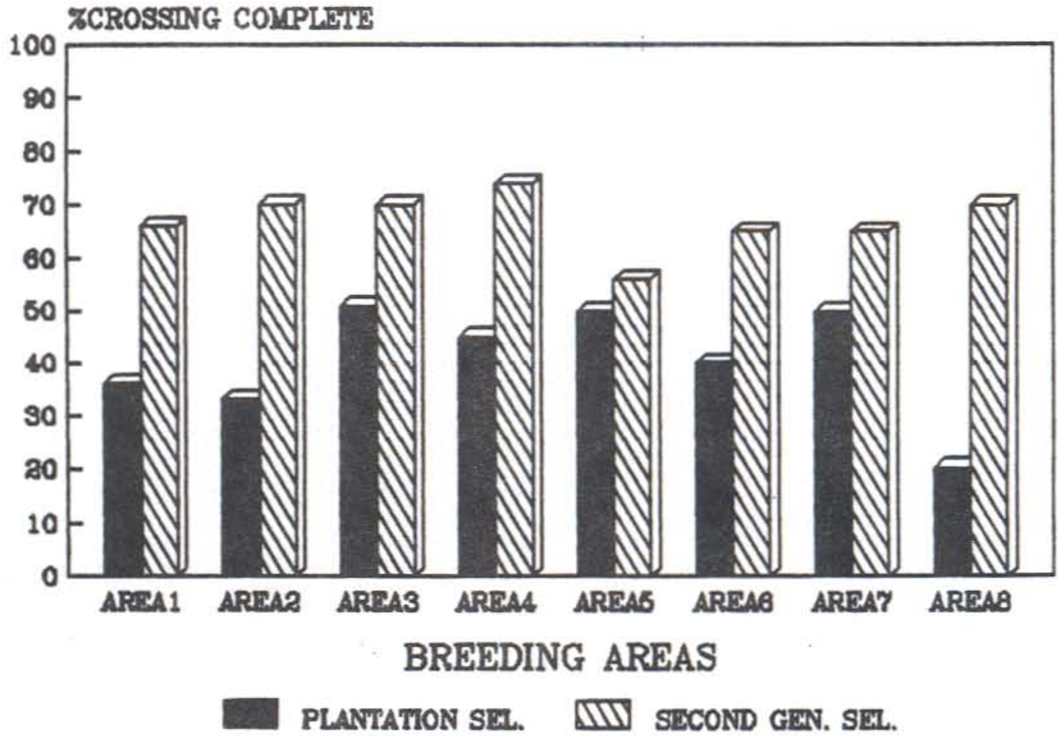
During the first few years, efforts have focused on development of trees in the breeding clone banks and the subsequent stimulation of male and female flower production. Breeding greenhouses have, in most cases, been very effective for this purpose. Outside potted breeding trees have worked well, and field breeding clone banks have been satisfactory when managed very intensively. Most members have benefited from wire girdling of lower limbs to produce the needed pollen. The use of GA $_{4/7}$ to stimulate development of female flower primordia has been widespread, both in the breeding greenhouses and in the outside environment. An extraordinary effort has been made to efficiently exploit the flowers that have been produced through these methods.

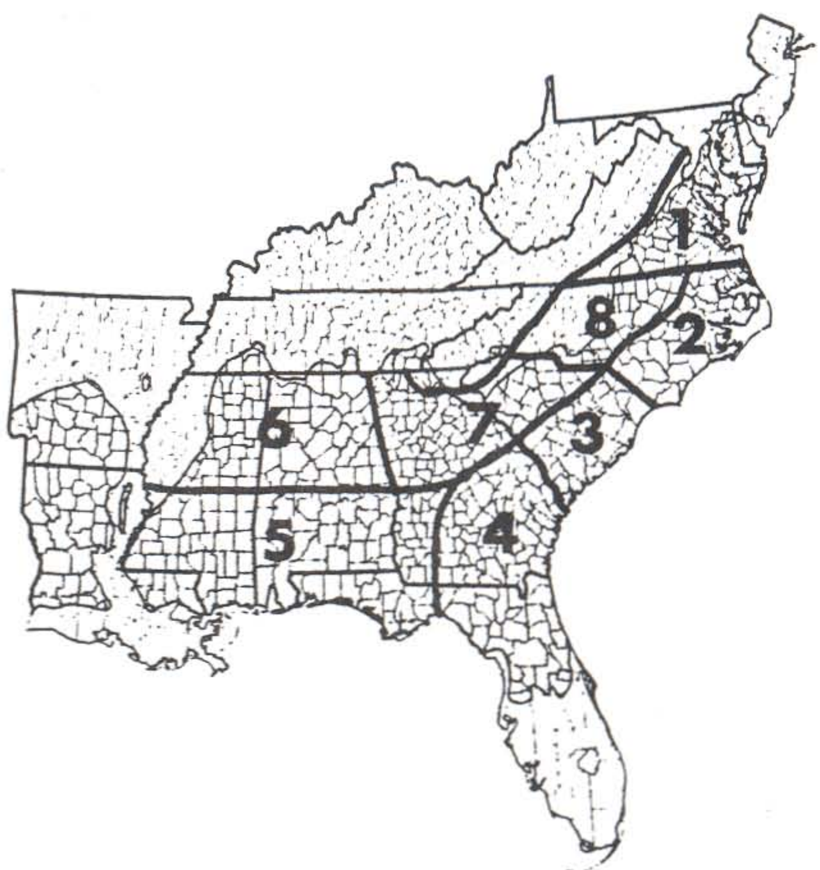
Having reached the halfway point of the twelve year plan, there are only four pollination seasons remaining between now and the target date for completion of the breeding. The chart on the following page plots the accomplishments through the 1986 breeding season for each breeding area. While we expect additional progress was made in 1987, it was undoubtedly impeded by the severe cold weather in early April throughout much of the southeast. Reports of freeze damage to flowers resulting in losses ranging from 25 to 50 percent have been received.

Breeding progress with second generation selections has been outstanding. Through the 1986 breeding season, completion rates in the eight breeding regions ranges from a low of 55 percent to a high of 75 percent. Cooperative members should have no major difficulty completing the breeding and testing of second generation selections on schedule.

Progress has been more deliberate in the plantation selection breeding program which comprises 85% of the Cooperative's total breeding effort.

BREEDING STATUS REPORT
PLANTATION AND SECOND GENERATION





The Cooperative members have aggressively pursued the huge job of breeding and testing for the future. Shown above is the greenhouse breeding facility belonging to Boise Cascade Corporation.

For this segment of the program, the completion rate by breeding region ranges from 20 percent to 56 percent. The slower progress in breeding plantation diallels can be partly explained by the large number of trees involved (nearly 3300 in total). Many of the plantation selections were acquired late in the selection process and only now have enough flowers where breeding can commence. It is now essential that every effort be made to utilize all available flowers if the breeding work is to be completed on schedule. For some cooperators, a redoubling of effort during the remaining four pollination seasons will be required. We have witnessed one cooperator with a large breeding obligation complete 35 percent of their work in a single pollination season. This was done with extraordinary effort, careful planning, and use of sound methodology. It can be done, and we are confident that it will be done! With such effort and commitment, the 12 year plan adopted in 1981 can be met and the productivity of the South's Fourth Forest enhanced by our success.

Selection

In 1984, the Cooperative adopted a schedule for completing first generation progeny testing and second generation selection. At that time, it was decided that all remaining tests would receive a final assessment at age 4 (age 5 in some northern areas). Following collection of all data, final clone evaluations would be prepared to identify the best families within each testing program. In the absence of previous selections, the best trees in the best families would be chosen as second generation selections. This would complete the testing, measurement and selection from the first generation program, except for the few tests that are to be assessed to rotation age.

The progeny testing program of the Cooperative has progressed well this year. Intensive test management has resulted in excellent growth as illustrated by the three year-old test of Weyerhaeuser Company in North Carolina.

At the time this plan was adopted, there were 21 testing programs with one or more tests yet to be measured. Seven of these testing programs completed measurements in 1984 and 1985. Measurements were completed for six additional programs in 1986. During the last year we have completed the second generation selection work in four testing programs and have selection work pending in two more programs. Selection work will be completed in the final eight testing programs following completion of progeny test measurements between 1987 and 1989.

As test measurements are completed, a final clone evaluation is being prepared for each of these testing programs as planned. However, we are omitting selection work in some programs because they will contribute no "new" selections. In a number of cases, the last two or three progeny tests are repeat (2nd and 3rd year) plantings of families established in earlier tests. In most of these situations, selections from the best parents have already been identified. In other instances, such as the Lower Gulf orchard of Champion International, a number of new families were represented in the later tests, thus creating an opportunity to add to the breeding population in a significant way. While these selections are too late for the current breeding efforts, they are being grafted into breeding clone banks for eventual inclusion in the base population.

Virginia Pine Second Generation Selections Archived

Most members of the Cooperative who were actively involved in the improvement of Virginia pine have relegated these programs to a low maintenance status. There is minimal demand for seed production and essentially no justification for advanced generation orchard establishment. Progeny test data have been used to rogue the poor parents from existing orchards which are being maintained to meet the modest seed needs.

A number of the original first generation Virginia pine seed orchards were progeny tested using a control pollinated mating design. Second generation selections from the best parents in these programs have been identified. Recently, Westvaco volunteered to archive these second generation selections in a clone bank established near Summerville, South Carolina. In March of 1987, five Cooperators collected scions from approximately 57 second generation selections which Westvaco has subsequently grafted into the clone bank. The Cooperative is most appreciative to Westvaco for their contribution to this effort. It is a very appropriate strategy for preserving the progress accomplished to date with a species that is now of secondary importance. Should second generation orchards be needed in the future, rapid development with scions from the clone bank would be possible.

SEED ORCHARD PRODUCTION

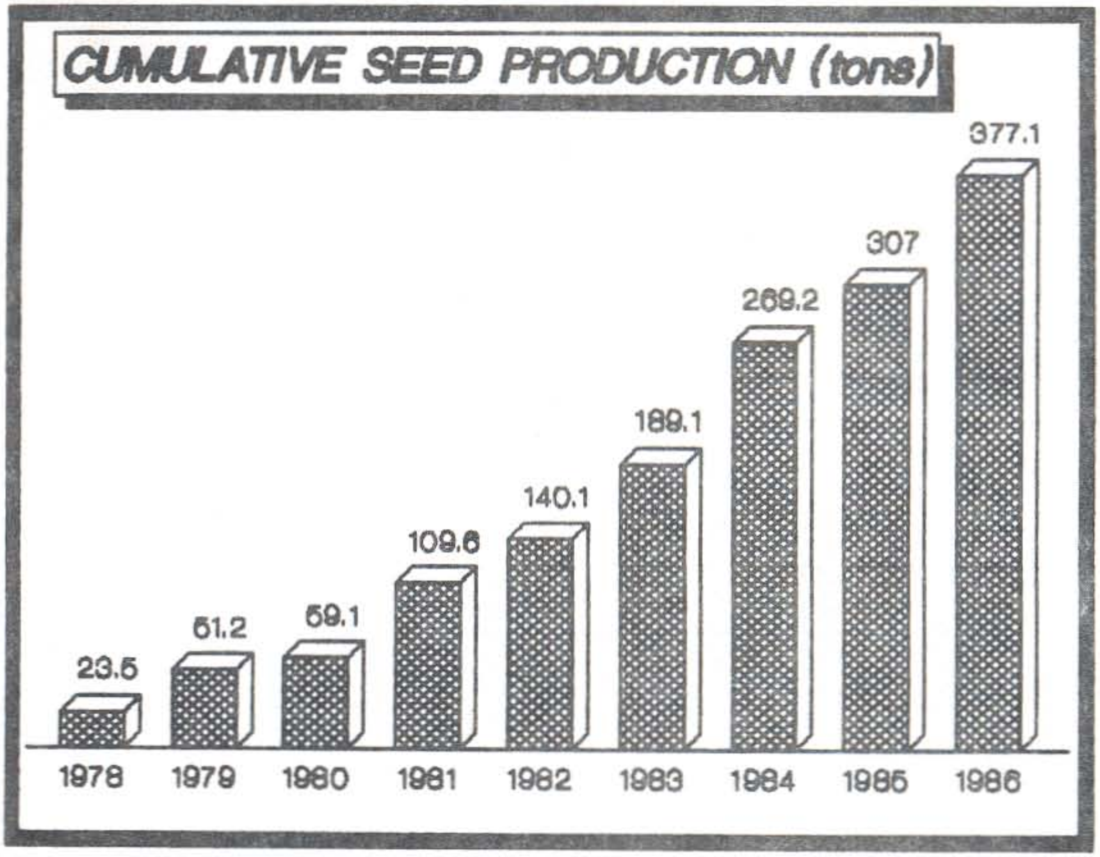
Cone and Seed Yields

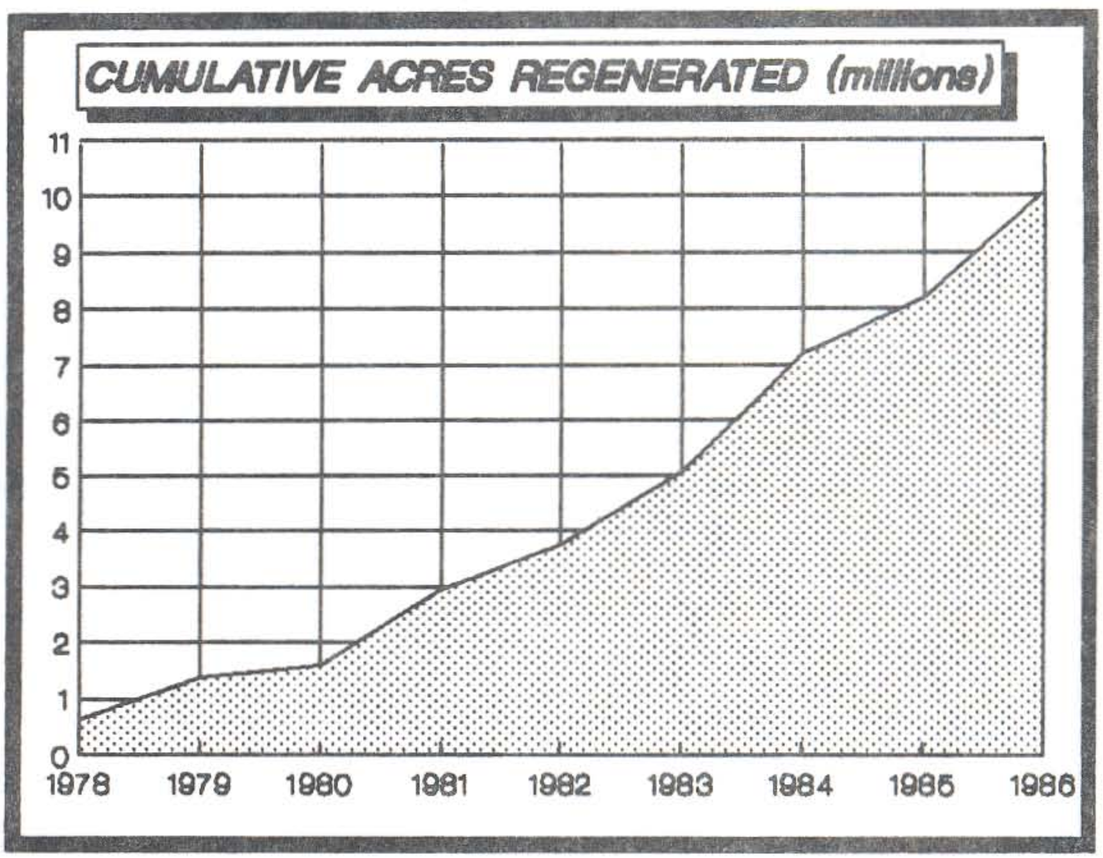
The 1986 harvest of cones and seeds from loblolly pine orchards was the second largest in program history (Table 2). Nearly 85,000 bushels of cones were harvested from which 70.1 tons of genetically improved seeds were extracted. This harvest is sufficient to produce an estimated 1.12 billion plantable seedlings, nearly twice the annual seedling need (600 million) of the Cooperative membership. If all of these seedlings were used in regeneration programs, approximately 1.87 million acres could be planted with genetically improved loblolly pine.

The cumulative production profile depicted on page 17 illustrates that Cooperative program members are impacting the forests of the south, and indeed the nation, in a major way through the genetic improvement of loblolly pine.

Table 2. Production of cones, seeds and seedlings from Cooperative members' loblolly pine seed orchards over the last 9 years, including an estimate of acres that could be regenerated with improved seedlings if all seed were used.

Harvest Year	Bushels of Cones	Tons of Seeds	Millions of Seedlings	Millions of Acres Regenerated
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
1985	52,155	37.8	605	1.01
1986	84,953	70.1	1,122	1.87
Totals	512,332	377.1	6,034	10.08


CUMULATIVE SEED PRODUCTION (tons)
23.5
51.2
59.1
109.6
140.1
189.1
269.2
307
377.1
1978
1979
1980
1981
1982
1983
1984
1985
1986


CUMULATIVE ACRES REGENERATED (millions)
0
1
2
3
4
5
6
7
8
9
10
11
1978
1979
1980
1981
1982
1983
1984
1985
1986

Seed production by Cooperative members has been successful in recent years to the point that an overproduction of genetically improved loblolly pine seed has resulted. This is detrimental to those organizations striving to defray program costs and/or to profit from seed sales. The market for genetically improved seed has fallen considerably in recent years. However, we never have an over abundance of the very best genetically improved seed. In rare instances where a surplus of seed from the best parents in fully rogued seed orchards exist, the market value of the seed remains high. To expand production of high quality, high value seed, many organizations are roguing first generation orchards extensively, leaving only the best 9 to 12 parents. This type of roguing has a two-fold benefit. Genetic quality is increased by as much as 4 to 5 percent and operating costs are substantially reduced. Intensive management of heavily rogued orchards remains essential, however, if production is to remain at an acceptable level.

In Table 3, the 1986 cone harvest statistics are contrasted with those of 1985 for all conifers in the Cooperative program. Seed yields from first generation loblolly pine orchards increased an average of 66 percent over last year's levels. While the Cooperative is not heavily involved in slash pine improvement, we routinely show slash seed orchard production statistics (Table 3) to illustrate total activities of the membership. Slash pine seed production for 1986 was essentially the same as in 1985. Five cooperators contributed to the excellent longleaf pine harvest in 1986. Bushels of cones harvested and pounds of seed per bushel were double the 1985 level. The increase in Virginia pine seed harvest reflects the demand for this seed by the Christmas tree industry. The North Carolina Division of Forest Resources' Fraser fir seed orchard, which is exclusively for

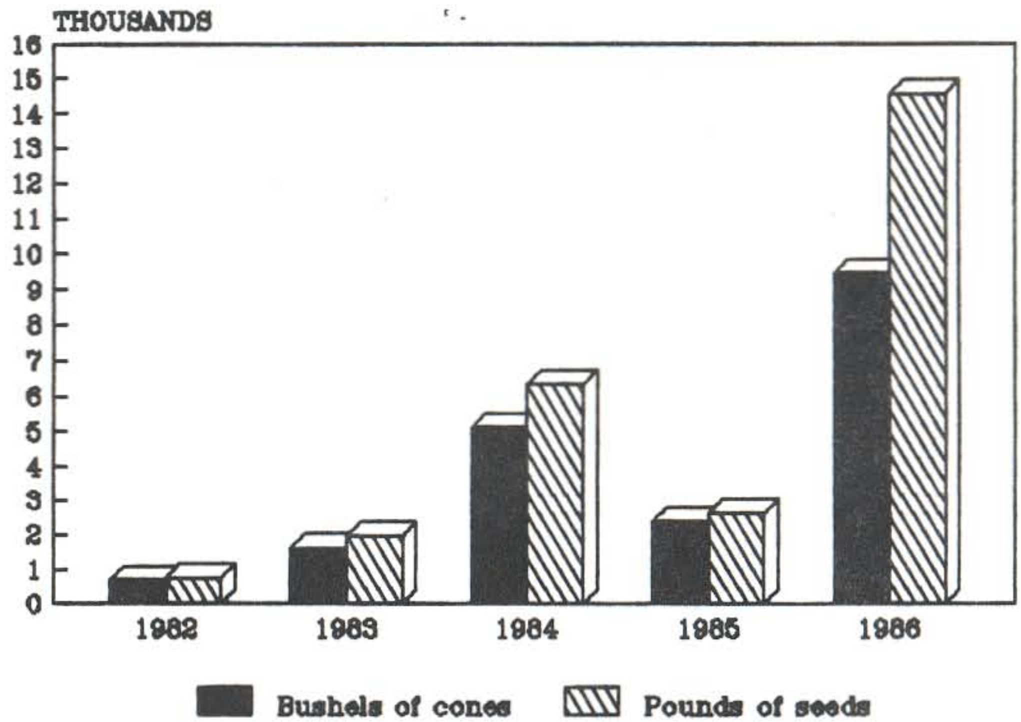
Table 3. Cone and seed yield comparisons for 1986 and 1985.

	Bushels of Cones		Pounds of Seeds		Pounds of Seed per Bushel of Cones	
Species	1986	1985	1986	1985	1986	1985
Loblolly Pine:						
Coastal 1st gen.	54,075	34,798	90,363	49,462	1.67	1.42
Piedmont 1st gen.	21,412	14,962	35,335	23,467	1.65	1.57
Coastal 2nd gen.	6,594	2,024	10,136	2,325	1.54	1.15
Piedmont 2nd gen.	2,872	371	4,425	294	1.54	0.79
Slash Pine:						
1st gen.	8,256	7,898	7,546	6,311	0.91	0.80
2nd gen.	204	20	105	2	0.51	0.12
Longleaf	2,111	1,022	2,444	535	1.16	0.52
Virginia	462	175	376	96	0.81	0.55
Sand	84	30	32	21	0.38	0.70
Shortleaf	52	21	41	16	0.79	0.76
White Pine	3,557	-	2,294	-	0.64	
Fraser Fir	144	16	389	54	2.70	3.37
Total All Conifers	99,823	61,337	153,486	82,583		

Christmas trees, showed a large increase in production. Over a ton of white pine seed was produced by the states of Virgina and North Carolina. The total harvest of conifer cones increased 63%, and total seed produced was up 86% over the 1985 crop.

Second generation loblolly orchards produced four to fifteen times more seed than in the previous year. This reflects the ingrowth of many young second generation orchard acres to full production status. In 1986, 7.3 tons of second-generation seed were harvested representing approximately 10% of the total 1986 loblolly pine seed harvest. In fact, this year's harvest of second generation seed was more than all previous years combined (chart below). In the last five years, second generation orchards in the Cooperative have produced enough seed to grow 210 million seedlings and to regenerate 350 thousand acres of plantations.

SECOND GENERATION SEED ORCHARD YIELDS



In eight of the last nine years, Cooperative members have experienced outstanding seed crops; only the crop in 1980 was considered poor. This is a record of consistent and high production for which all member organizations can be proud. These seed production accomplishments would not have been possible without excellent management know-how and the commitment to implement these practices properly. Without seed production success, the very best selection, breeding and testing program is of no value.

Production Leaders

Each year, we enjoy recognizing those cooperators who set standards for excellence in seed production. Orchard production measured in terms of pounds of seed per acre is the bottomline. However, we continue to take interest in seed yield per bushel statistics since they reflect seed orchard efficiency. Incredibly, there were 17 seed orchards in the Cooperative that exceeded two pounds of seed per bushel of cones in 1986. Congratulations are in order to the ten seed orchard managers who achieved membership in the "Two Pound Club" for 1986. It is remarkable that this high level of orchard efficiency was achieved by so many in one single year. The orchards exceeding the two pound production level and their yield statistics are presented in Table 4.

Table 4. Seed orchards exceeding two pounds of seed per bushel of cones harvested in 1986.

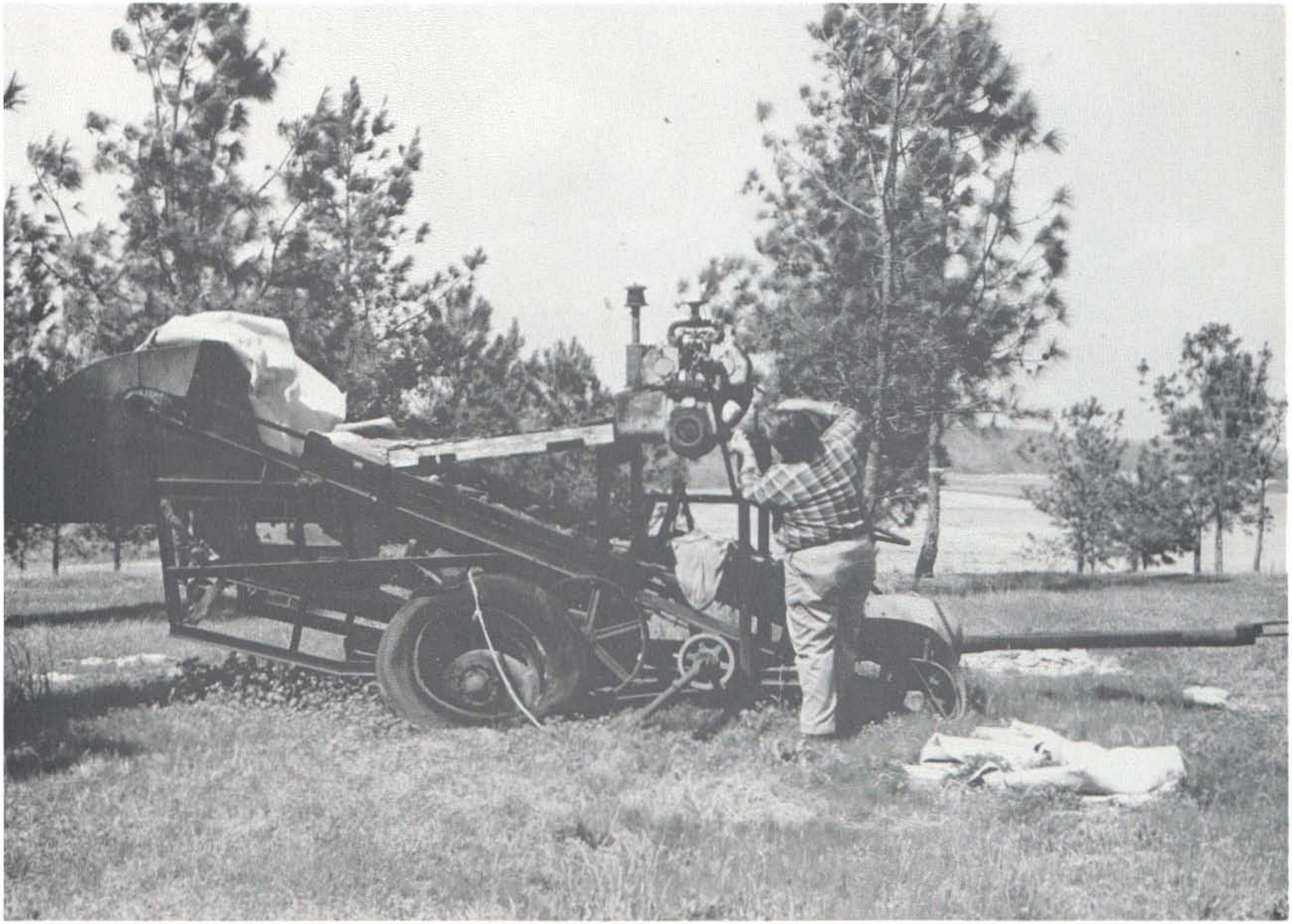
Cooperator	Orchard Type	Generation	Acres	Age	Lbs./Bu.
International Paper(SC)	North Coastal	1.0	11	23	2.42
S. C. Comm. of Forestry	Coastal	1.0	31	20	2.39
Great Southern	Coastal	1.5	40	11	2.34
Westvaco	Coastal	1.0	12	22	2.34
Weyerhaeuser(NC)	Piedmont	1.0	11	25	2.30
Westvaco	Coastal	1.0	6	17	2.29
Westvaco	Coastal	2.0	8	13	2.27
Westvaco	Coastal	1.5	10	15	2.24
International Paper(SC)	South Coastal	1.0	26	23	2.23
Continental For. Inv.	Virginia Coastal	2.0	16	8	2.15
Hammermill	Disease Resistant	1.0	7	14	2.14
Brunswick	Coastal	1.5	8	12	2.12
International Paper(SC)	Coastal	1.5	25	11	2.10
Weyerhaeuser(NC)	North Coastal	1.0	64	26	2.06
Catawba	Coastal	1.5	25	11	2.04
MacMillan Bloedel	Coastal	1.5	38	11	2.02
S. C. Comm. of For.	Piedmont	1.0	40	20	2.01

Optimization of seed yields depends upon careful timing of cone collection to ensure that mature cones are harvested.

The best yield in the Cooperative during 1986 was International Paper Company's first-generation north coastal orchard under the capable management of Marvin Cribb. This eleven acre, 26 year-old orchard located near Georgetown, South Carolina produced 504 bushels of cones from which 1,218 pounds of seeds were extracted. This sets a new Cooperative record of 2.42 pounds of seed per bushel of cones. Congratulations to Marvin and International Paper Company. Surpassing the previous record of 2.36 pounds per bushel, and coming in a close second this year at 2.39 pounds per bushel, was the South Carolina Commission of Forestry's coastal orchard managed by Booth Chilcutt. Congratulations to Booth and The South Carolina Commission of Forestry.

Congratulations are also extended to Dave Gerwig of Westvaco for placing four orchards in the more than two pounds per bushel class. International Paper Company (Marvin Cribb) had a total of three orchards above two pounds per bushel, while South Carolina Commission of Forestry (Booth Chilcutt) and Weyerhaeuser (Gary Oppenheimer) each had two orchards in this select group. The 1986 harvest also provided the first second generation orchards to exceed two pounds per bushel in yields. The two second generation orchards were Westvaco's, near Summerville, South Carolina (Dave Gerwig again), and Continental Forest Investments' Virginia orchard growing near Statesboro, Georgia and managed by Pete Ranalet.

Obviously, effective orchard management practices, especially insect control, have allowed Cooperative members to frequently realize production efficiencies that were previously a rare event. Congratulations to all the Cooperative's production leaders.



It may not be pretty, but Gary Cannon, Great Southern Paper Company, says his old peanut combiner really does an excellent job separating pine needles from the cones. Gary averaged 2.34 pounds of seed per bushel this year!

The South Carolina State Commission of Forstry will finish the 450 acre second generation loblolly Niederhof Seed Orchard at Tillman, South Carolina. Approximately 9,000 grafts were made this year to complete the orchard.

Insect Control

Efforts to maximize seed production from the highest valued orchards requires intensive management and insect control. Recently, Brunswick Pulp Land Company conducted an operational comparison of insect control methods. They compared spraying Guthion® and Pyrdrin® (two sprays of each) to a standard spring application of the granular systemic Furadan®. As illustrated in Table 5, the results were dramatic. The spray treatments yielded over twice the seed per bushel of cones harvested when compared to the Furadan® treatment. While some differences in yield are to be expected between piedmont and coastal sources, differences of the magnitude shown undoubtedly reflect a genuine treatment response. These results reflect the ineffectiveness of the soil applied granular systemic during the severe drought of 1986.

Table 5. Differences in seed yields per bushel of cones between sprayed (Guthion® and Pydrin®) and Furadan® treated orchards. Data provided by James Hodges, Brunswick Pulp and Land Company.

Orchard	Treatment*	Pounds of Seed Per Bushel
Coastal Loblolly - 1st gen.	sprayed	1.83
Coastal Loblolly - 1.5 gen.	sprayed	2.13
Florida Loblolly - 1st gen.	sprayed	1.91
Piedmont Loblolly - 1.5 gen.	Furadan®	0.72
Piedmont Loblolly - 2nd gen.	Furadan®	0.87

*Sprayed - 2 sprays of Guthion® and 2 sprays of Pydrin® at recommended label rates.

Furadan® - Applied in early spring at label rates.

RESEARCH AND ASSOCIATED ACTIVITIES

Management of Clone Banks for Scion Production

Second generation seed orchard establishment has been a major activity in the Cooperative in the past few years. Too often, scion supply has been a limiting factor in orchard establishment, especially when new selections were used or when large orchard acreages were being developed at one time.

Seed orchard managers, fearing reduced tree growth and flower production, have been reluctant to cut scions out of breeding clone banks or production orchards. The collection of scions from ortets scattered over a broad geographic region are time consuming and expensive. Repeated removal of scions from ortets can also severely impact our ability to assess selections' performance in subsequent years.

As we progress with advanced generation breeding and testing, third cycle seed orchards are but a few years away. Better methods of scion multiplication are necessary if previous problems in scion availability are to be avoided. Establishment of scion banks, solely for the production of scions for use in developing breeding and production orchards, is one possible solution to alleviate the problem of limited grafting material.

Several methods exist to increase the production of scions from young ramets (1-5 years). Hedging has been effective in increasing the number of cuttings available from loblolly pine. However, there is a risk of increased graft incompatibility with severe hedging. Less severe pruning may reduce the risk of graft incompatibility, yet still produce more scions. Cytokinin spray (BAP) which causes fascicular and lateral buds to elongate may also increase the number of shoots available.

In 1984, a study was initiated to determine how to best increase the number of scions produced from grafted selections of loblolly pine. Twelve second generation and six first generation select trees were used in the study. Five successful grafts of each tree were established in a field trial at the NCSU Genetics Garden in May 1984. The following treatments were imposed on the grafts:

1. Hedging

   (Year 1) - After planting in May, the terminal bud was pinched out to force elongation of lateral and fascicular buds. In August, all terminal buds were pinched again.

   (Year 2 and 3) - As many acceptable scions as possible were clipped in March for dormant grafting and again in June for succulent tissue grafting.

2. BAP Spray

   Same treatment as hedging, except a BAP solution (100 mg/l) plus 1 mg/l of DMSO was sprayed on the trees once a week for 4 weeks in June and 4 weeks in August 1984. Because of apparent BAP damage in 1984, the BAP solution was reduced to 50 mg/l. This solution was sprayed once a week for 4 weeks in the following months: March 1985, June 1985, March 1986 and June 1986.

3. Heavy Pruning

   (Year 1) - No removal of scions.

   (Year 2 and 3) - As many scions as possible were clipped in March and again in June. Although most of the lateral shoots were removed, the terminal bud was left intact.

4. Light Pruning

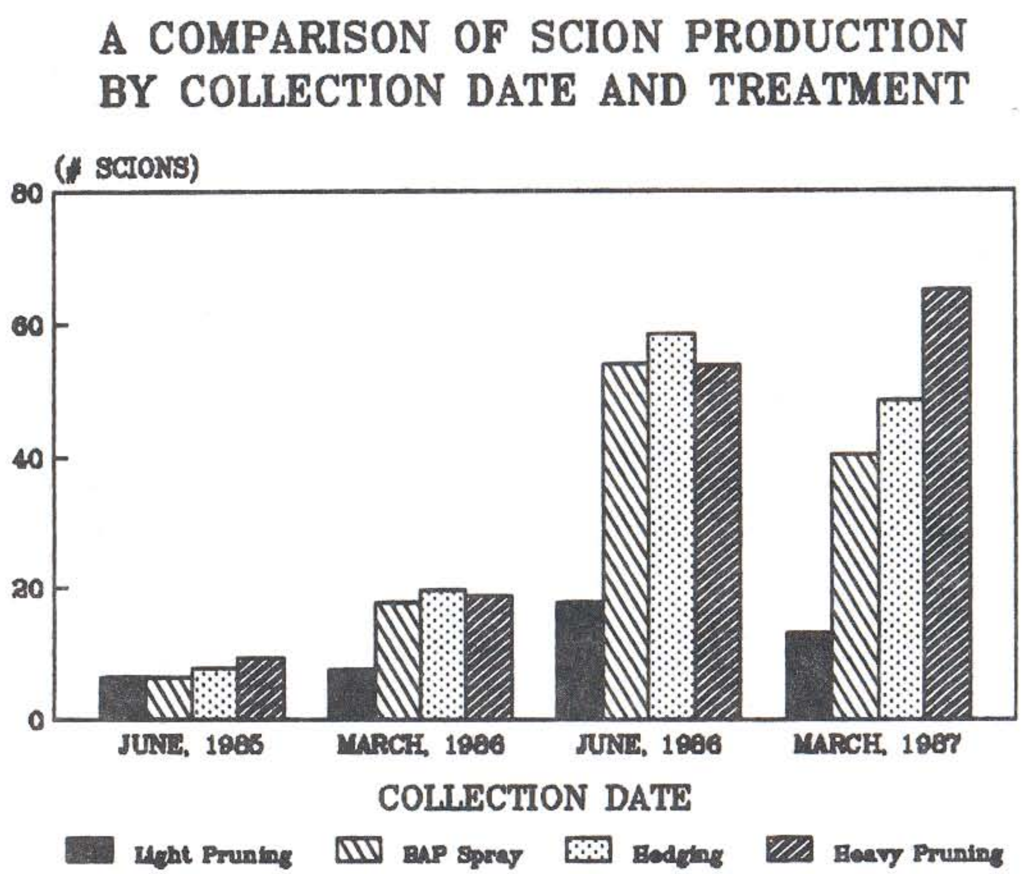
   (Year 1) - No removal of scions.

   (Year 2 and 3) - Clipped scions from lateral branches only in March and June. No dominant lateral shoots were removed. If two or more shoots were present in a lateral position, one was removed.

5. Control

   No removal of any scions.

Results of the scion multiplication study are shown in the graph below. Maximum scion production per graft over the period of the study was obtained from the heavy pruning treatment (147). Hedging (134) and BAP (119) treatments also resulted in excellent scion production. Even with very light pruning, an average of 46 scions were produced per graft.



Effects of the different treatments on tree growth (Table 6) were evaluated using height, rootstock caliper and crown diameter. The hedged and BAP sprayed trees were intentionally kept short (< 5') so height was not measured on these treatments. There was no significant difference in tree height between the control, the light pruning or the heavy pruning.

Table 6. Characteristics of scions and grafts for different treatments in scion production study at conclusion of study - March 1987.

	Treatments				
Traits	Control	Light Prune	Heavy Prune	Hedge	BAP
Average # scions collected per graft from June 1985 - March 1987	-	45.7 b	147.5a	134.0a	118.9a
Scion Diam. (in.)	-	.212 b	.223ab	.232a	.213 b
Rootstock caliper (in.)	2.88a	2.60 b	2.69ab	1.94 c	1.74 c
Height (ft.)	10.7a	10.6a	11.4a	-	-
Crown Diam. (ft.)	6.0a	4.4 b	3.7 c	-	-

Means within a row followed by the same letter are not significantly different (p = .05) from each other.

Scion production was maximized in the heavy pruning treatment (tree being measured) as compared to other treatments such as the hedged tree to the right.

Crown diameter was reduced with increased pruning. Rootstock diameter, the best trait for evaluation of the pruning treatments' effects on growth, showed a tendency to decrease as the severity of the treatment increased. Fewer needles for photosynthate production was probably responsible for the growth reductions.

Heavy pruning produced the greatest average number of scions per tree with only minimal effect on tree growth. Based on the results from this study, little justification exists for using more severe treatments, such as hedging or the use of cytokinins to stimulate bud production. In fact, the BAP spray had a detrimental effect on tree growth. Likewise, no justification exists for the establishment of clone banks solely for the production of scion material. A grafted tree in a breeding clone bank or production seed orchard can be heavily pruned for 2-3 years to produce well over a hundred scions for use in orchard expansion without detrimental effect to the tree.

Quick Stratification Methods for Loblolly Pine Seeds

After harvesting the seed from control pollinations in the breeding program, seed from completed diallels must be processed and sown quickly if a one year delay in testing is to be avoided. Following cone harvest in October, the seed must be extracted, stratified, and sown in the greenhouse by late December if the genetic tests are to be established during May. Tests planted after May often grow very little during the first year resulting in a delay of one year in test development. A frequent obstacle to meeting this schedule has been the recommended 45+ days of moist seed statification at approximately 36°F.

There are numerous reports in the literature of successful seed germination following quick stratification methods. A study was designed to evaluate a number of these methods and determine their usefulness in a genetics testing program. In February 1987, a study with six different seedlots was initiated to compare the following seed stratification treatments:

1. No stratification
2. 45 day moist stratification
3. Seven day aerated cold water (40°F) soak - air from an aquarium pump was bubbled through air stones in a refrigerator
4. Seven day aerated room temperature (65°F) - air from an aquarium pump was bubbled through air stones on the lab bench
5. 3% H_2O_2 at room temperature (65°F) for 72 hours
6. 3% H_2O_2 at 86°F with continuous light for 72 hours
7. 3% H_2O_2 at 86°F with no light for 72 hours

Treatments were compared for their effectiveness on the basis of total germination at 36 days and the speed of germination. A graph of the results typically obtained from the six seedlots is shown in Figure 1, page 34.

After 20 days, seed germination in the 45 day moist stratification treatment was essentially complete. With the quick treatments, only half of the final germination was completed in 20 days (only two of the five quick treatments are displayed on the graph since results from the other treatments were similar).

This study clearly indicates that for genetic testing, where rapid germination is essential to achieve desired test uniformity, these treatments were not beneficial shortcuts. Seeds must be extracted quickly from the control-pollinated cones harvested in October to allow time for the recommended 30 to 45 day stratification period. Seeds processed in this manner can then be sown in late December with the expectation of rapid and uniform germination.

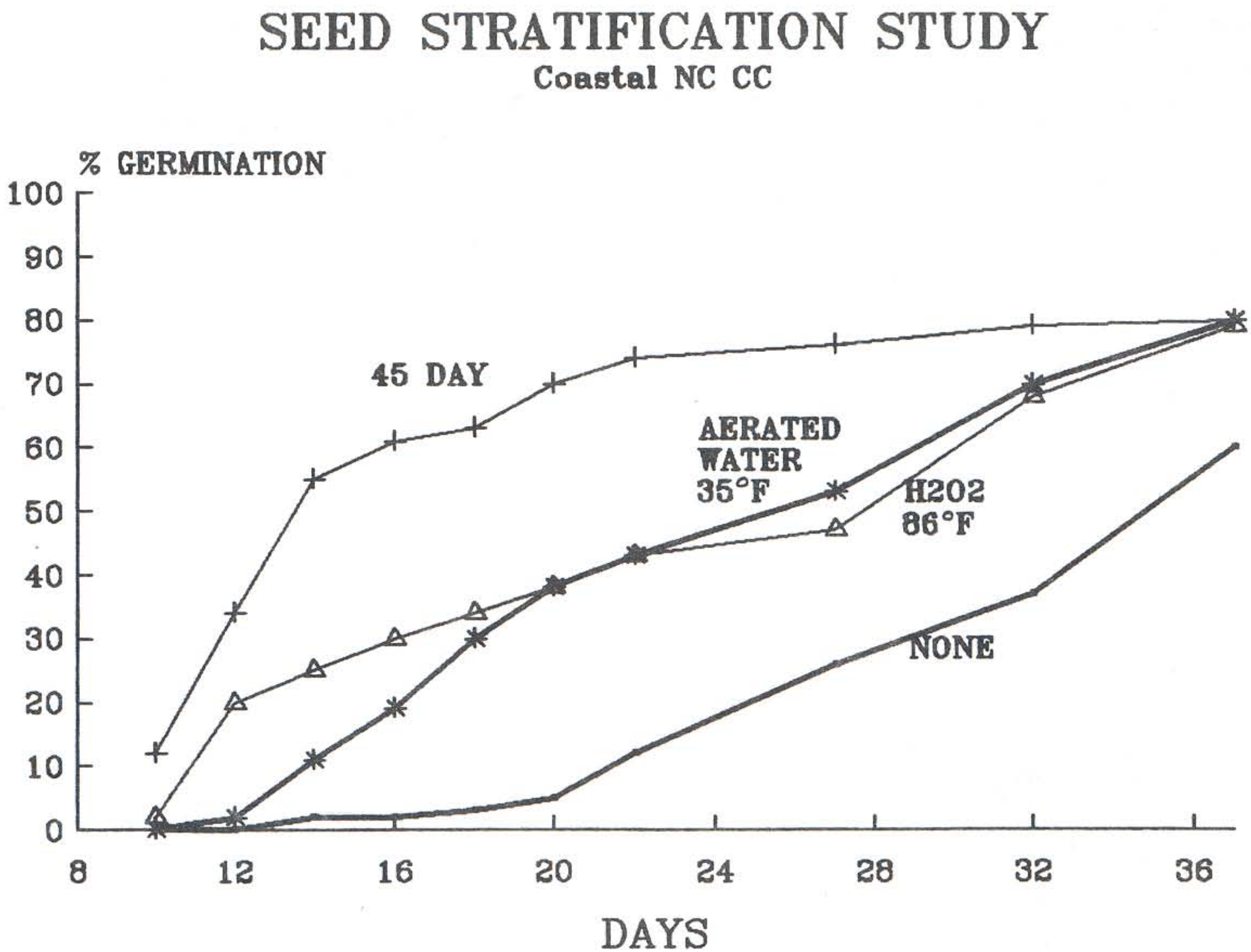
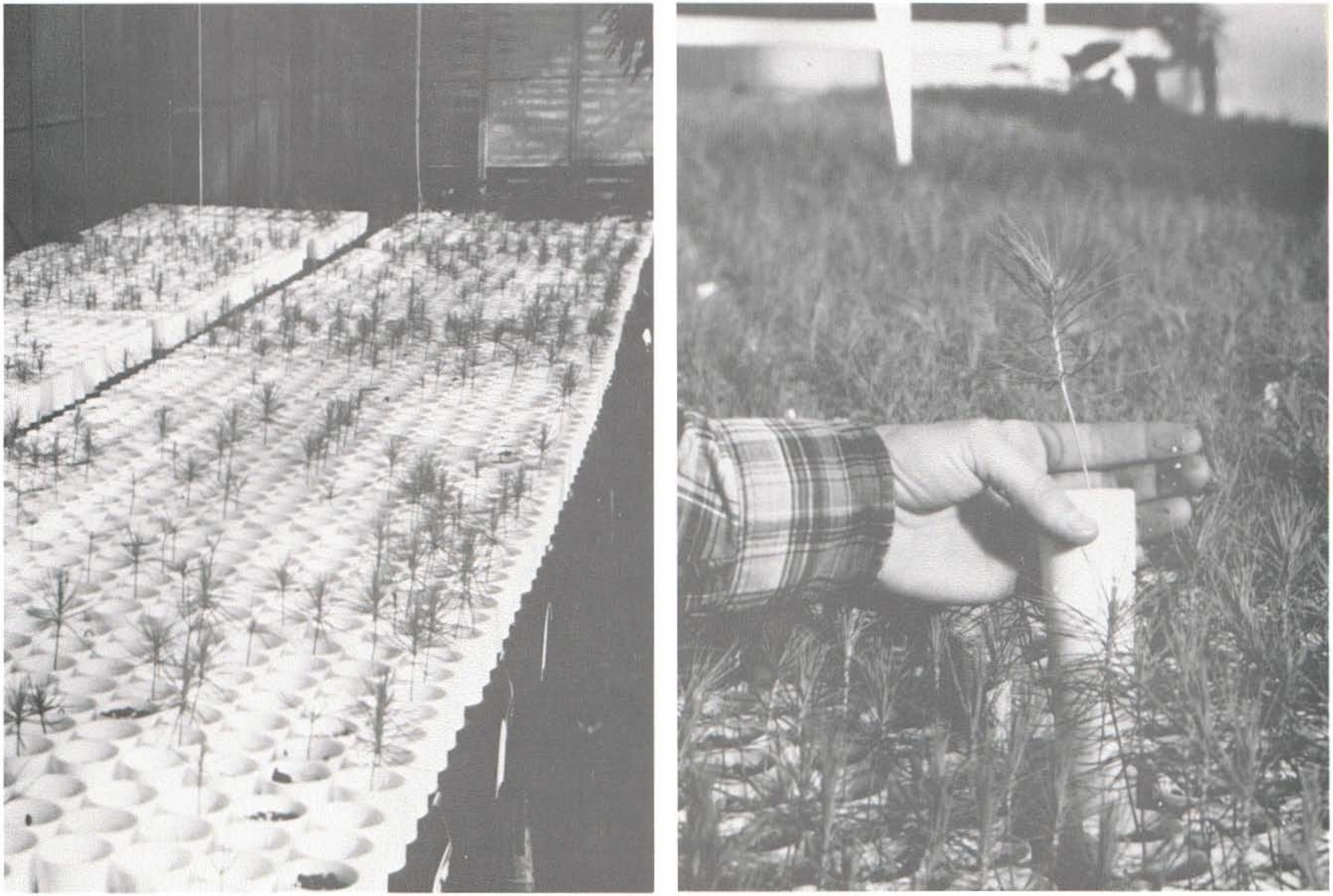


Figure 1. Results from a seed stratification study comparing traditional long term seed stratification procedures with quick stratification techniques on loblolly pine seed. Only four treatments are shown. Seed source is a coastal N. C. loblolly pine commercial check.



Short cut stratification procedures can produce extremely erratic germination as shown in the picture on the left. The seeds for this progeny test were treated with hydrogen peroxide. The production of high quality progeny test seedlings as depicted on the right is vital to the Cooperative's advanced generation testing program.

Intensive Culture of Loblolly Genetic Tests

The consequence of accelerated growth resulting from intensive culture in genetic tests remains controversial among tree breeders. Some believe that intensive culture improves the quality of genetic information and, therefore, genetic and economic gains are increased. Others argue that intensive cultural practices may result in selections that are poorly adapted to less intensively managed operational forest lands.

Interactions between cultural practices and loblolly pine families have been reported, but usually are significant only when cultural practices are extreme. It is hypothesized that under intensive culture, trees can be measured earlier and heritability estimates are higher resulting in a more accurate assessment of family performance at a younger age. If accelerated growth resulting from intensive culture on productive sites can improve the quality of early information, then the cost of such practices can likely be offset by greater genetic gain per unit time.

The Cooperative staff, in conjunction with several members, have discussed this issue for some time. In early 1985, a study was initiated to determine the effect of intensive culture practices in loblolly pine. The objectives of the study are to:

1. Assess performance when progeny are grown under intensive culture and "standard" culture regimes, including:

    a. Correlation and interaction analyses of families grown in two quite different cultural regimes.

    b. Influence of cultural regimes on selection reliability.

2. Determine the juvenile-mature correlations for families in these tests (both for standard and intensive culture) with the performance of the same families in the Cooperative's good general combiner tests at ages 12 and/or 16.

Open-pollinated seed from 15 families were used in the study. These same families, originally selected in the upper coastal region of Alabama and Mississippi, are widely planted in the Cooperative's Good General Combiner tests. In June 1985, intensive culture tests were established at three locations in Alabama and Georgia on lands of Weyerhaeuser, Union Camp and Buckeye Cellulose. The cultural treatments used are shown in Table 7.

Table 7. Cultural treatments for intensive culture genetic test study.

Year	1 Standard Culture	2 Intensive Culture
1	1 application of Furadan® No additional herbicide to site preparation dose No fertilizer	2 applications of Furadan® Additional herbicide Fertilizer (10-10-10)
2	No application of Furadan® Reduce growth of hardwood sprouts only No fertilizer	2 applications of Furadan® No competing vegetation throughout growing season Application of fertilizer as recommended
3	No Furadan® No herbicide No fertilizer	2 applications of Furadan® No herbicides Application of fertilizer
4	No Furadan® No herbicide No fertilizer	No Furadan® No herbicides Application of fertilizer
5	No Furadan® No herbicide Fertilizer prescription	2 applications of Furadan® No herbicides Application of fertilizer

Two of the three locations showed little to no development during the first growing season due to very hot and dry conditions. The first measurements were postponed until the winter of 1986-87 after the second season in the field. The results are reported in Table 8.

Table 8. Intensive Culture of Genetic Tests--results after two seasons in the field.

Study	Average Height (ft)		Survival (%)	
	Intensive Culture	Standard Culture	Intensive Culture	Standard Culture
Weyerhaeuser	4.6	3.1	99	91
Union Camp	3.0	2.1	88	83
Buckeye	2.8	2.6	95	97
Overall	3.5	2.6	94	90

The growth in response to intensive culture was greatest in Weyerhaeuser's planting where there was ample rainfall during the first growing season. The Buckeye Cellulose planting showed only a small difference in growth between cultural regimes, probably the result of the extreme drought stress the trees experienced in both growing seasons. Two of the three tests showed slightly higher survival when competing vegetation was completely controlled under the intensive culture treatment. Survival differences in the Buckeye planting are masked to a degree by interplanting of extra seedlings following early mortality from the intense hot and dry conditions at the time of planting.

Geographic Source Variation of Plantation Selections - A Study Proposal

Between 1975 and 1981, the Cooperative conducted an intensive selection effort in unimproved loblolly pine plantations. The plantation selections were intensively screened for growth, form, and disease resistance. The nearly 3300 trees selected during this period comprise more than 85% of the base population for future cycles of improvement by the Cooperative.

Virtually nothing is known about the genetic structure and geographic variation of the plantation selection populations. Additionally, there are some important distinctions between the new plantation selections and the original selections from natural stands:

1. It is known that a substantial number of stands in which selections were made originated from non-local seed sources. Movement of seed (up to 300 miles) was common in early plantations of loblolly pine. Thus, the patterns of geographic variation (source movement results) could be different than those reported for locally adapted natural stands.

2. It is suspected that the plantation selections may constitute a "land race" or a population that has become adapted to the environment in which it was planted. The patterns of variation among and within suspected land races of loblolly pine have never been studied in the South. The presence or absence of a land race effect could greatly influence our tree improvement strategy.

3. The intensity of selection for plantation selections was high. The intensity of selection for commercially important traits for trees used in past source trials was relatively low. Recent studies (the Good General Combiner trials) have shown that intensively selected families tend to be stable and perform well over a broad range of sites. If intensively selected plantation selections behave differently from non-selected trees when tested over wide areas, results from earlier provenance trials will not be applicable to the plantation selection populations.

A thorough understanding of the genetic structure and geographic variation of the plantation selection populations can have a major impact on the management of breeding programs in the Cooperative. If certain "exotic" sources prove better than local sources in a given area, then gain can be made by replacing the local source with a better performing source. If the exotic source is equal to the local source, then gain can be made by having a larger population from which to select. Selecting from a combination of two or more sources would allow us to increase selection intensity and thus gain. The opportunity to combine two or more sources could offer an opportunity for reduced costs in some areas.

While source variation is important, a need also exists to evaluate individual families from each source with respect to stability of performance when planted in different regions of the South. If a source is acceptable in an area, and the families do not significantly change rank between the local and exotic areas, then testing individual families in both regions prior to movement would not be required. If, however, family instability between regions is high, then the testing of each family in the exotic region would be necessary before any movement could occur. Such a result might make source movement prohibitively expensive in the immediate future.

Recognizing the importance of the plantation selections to the future of our breeding programs, a research study designed to obtain the needed source information for these trees has been proposed. The objectives of the study are to determine:

1. The performance, adaptability, and patterns of variation among the geographic sources of plantation selections.

2. The stability of families from each geographic source when they are planted in different regions.

The program staff firmly believes that this study is of major importance to the Cooperative and its members. The need to thoroughly describe and understand these patterns of geographic variation and the stability of family performance is essential to the effective and efficient use of our loblolly pine genetic resources in the future. We hope that work on this study can commence during the 1988 breeding season.

Rooting Study with Loblolly Pine Cuttings from Six Year-Old Clones Using IBA-DMSO Treatments

Previous observations of positive rooting response with mature cuttings of Pinus spp. treated with indole-3-butyric acid (IBA) and dimethyl sulfoxide (DMSO) led to this investigation (special project by graduate assistant Mary Frances Mahalovich). IBA, an exogenous auxin, is routinely used in the propagation of many species in forestry and horticulture. DMSO is effective in aiding the movement of compounds across plant tissues. The objective of this study was to test the effectiveness of IBA and DMSO treatments at different times of the year compared to other rooting treatments.

The seven loblolly pine clones used in the study were six year-old clones used in past rooting studies. Ramets of each clone were planted at the NCSU Genetics Gardens in the spring of 1983 and were annually hedged to a height of two to three feet.

Seasonal rooting response in loblolly pine is a common and large source of variation in rooting trials. Thus, the clone-by-treatment and season-by-treatment interactions were examined for three rooting periods. Winter dormant cuttings were collected on February 21, 1986. Succulent shoots were available from the ortets for a May 19 collection period. A tipmoth infestation limited the number of cuttings collected from shoots that had already set bud for a September 26.

Approximately 105 cuttings were collected per clone, per season. All cuttings were treated with a benomyl soak and then randomly assigned to five treatments applied to basal tips:

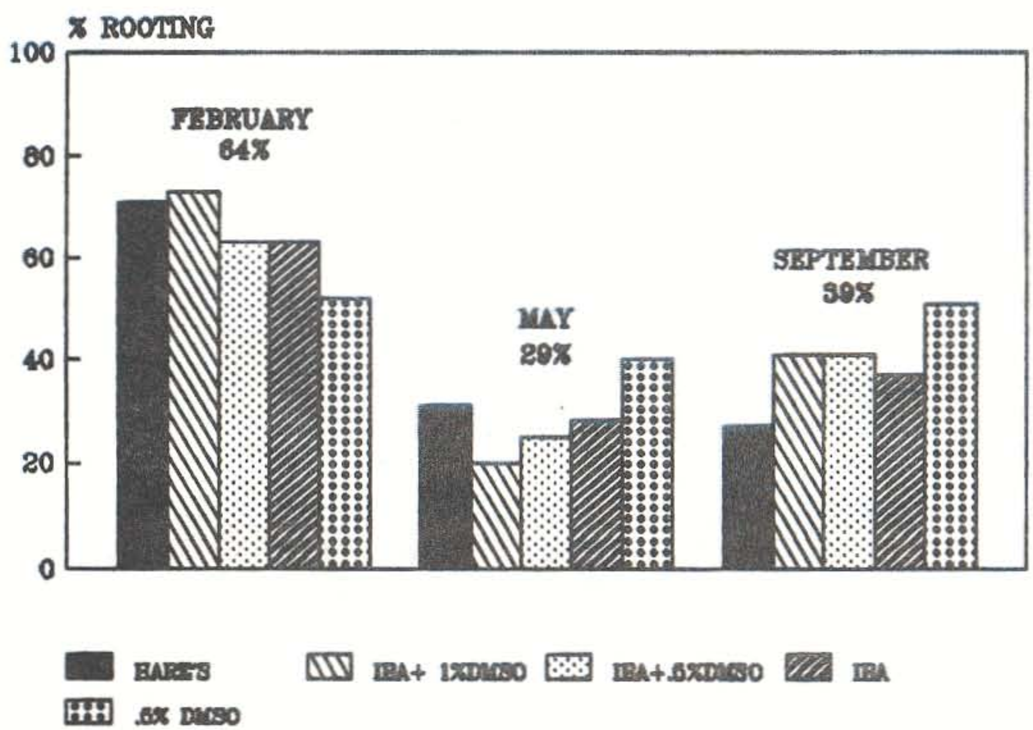
(1) Hare's powder - see Hare, 1974.
Can. J. For. Res. 4:101-106
(2) 4000 ppm IBA + 1% DMSO
(3) 4000 ppm IBA + 0.5% DMSO
(4) 4000 ppm IBA
(5) 0.5% DMSO

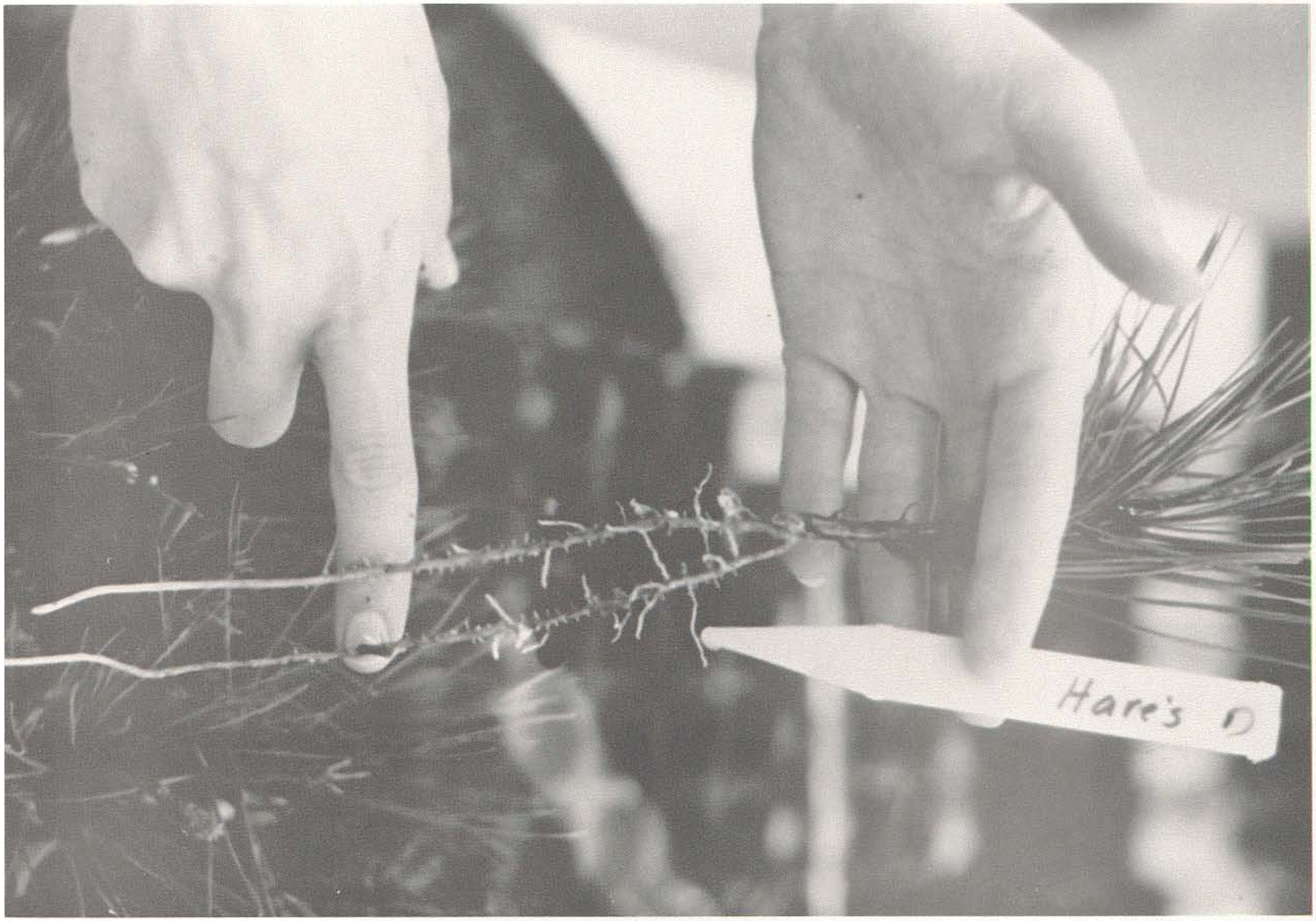
(NOTE: Treatments two through five were mixed in 50% ethyl alcohol.)

Cuttings were set in Leach® tubes filled with 2 parts perlite, 2 parts vermiculite, and 1 part peat, and then placed in a fog room. Rooting data were collected at seven and 12 weeks. Callus development was assessed at week seven.

Rooting percentages varied by clone, by treatment and by season of collection. The highest rooting percentages were observed in February (64%), followed by September (39%), and May (29%). There were significant differences in percent rooting among clones ($p < 0.01$) for all three rooting periods. Treatment-by-clone interactions and treatment-by-season interactions were statistically detectable in several instances, but were of minimal biological importance. It was of some interest that the best rooting treatments generally did not have the largest callus development. However, no cuttings rooted in the absence of callus formation. Results of the rooting study are displayed below.

ROOTING TRENDS WITH 6 YEAR OLD LOBLOLLY CUTTINGS





Differences among hormone treatments were not large in
a rooting study with six year-old loblolly cuttings.

These preliminary results offer added insight into the appropriate schedules and rooting treatments that may be used to root field cuttings of loblolly pine collected in environments matching those of Raleigh, NC. Similar seasonal trends have been noted among loblolly pine in Georgia. Though there were treatment differences in percent rooting and callus development reported here, the treatment effects were not nearly as large as the variation attributed to clonal and seasonal differences.

IUFRO Conference

In October of 1986, the Cooperative hosted an International Union of Forest Research Organizations (IUFRO) Conference on Breeding Theory, Progeny Testing and Seed Orchards. The Conference, held in Williamsburg, Virginia, seemed to be very successful.

The Conference theme was: Tree improvement - Theory and Practice. A total of 160 scientists from 34 nations met to contribute and discuss papers detailing recent discoveries relating to these three distinct but related areas of tree improvement work. Three invited papers (one for each working party) were presented at the Conference.

- Dr. Paul Cotterill (CSIRO, Australia) in his paper on Breeding Theory developed arguments for the value of simplicity.

- Dr. Clements Lambeth (Carton de Columbia, Columbia) pointed out the many and often conflicting considerations required for effective progeny testing. Compromise is a necessary ingredient of successful progeny test planning.

- Dr. J. B. Jett (North Carolina State University) reviewed the significant factors contributing to full production of seed orchards in the southeastern USA. Intensive management of seed orchards is required.

Mr. Barry Malac of Union Camp Corporation presented the Key Note Address entitled "So You Want to Be a Tree Breeder!" Barry's thought provoking address summarized 30 years of outstanding program accomplishment and

The Cooperative Program hosted an IUFRO Conference on breeding theory, progeny testing and seed orchards, October 13-17, 1986 at Williamsburg, Virginia. The group is shown visiting the Virginia Department of Forestry seed orchards at Providence Forge, Virginia.

challenged us to intensify our commitment to future research and development so that we may fully realize the immense potential of genetic improvement.

The balance of the five day Conference involved the presentation of over 60 volunteer papers covering a wide range of topics. Visits to seed orchards, progeny tests, breeding orchards and historic sites of interest in southeastern Virginia were successful, despite the occurrence of a damaging tornado nearby.

A post-conference tour of the commercial forest region of eastern Virginia, North Carolina and South Carolina was conducted from October 18 through October 22, 1986. The tour included forestry operations, genetics and silvicultural research installations, as well as visits to areas of scenic and cultural interest. Sixty conference attendees participated in the post-conference tour.

Scientific papers and/or abstracts presented at the Conference were reproduced in a proceedings. A limited number of proceedings are available at cost. Requests for reprints of individual papers should be directed to the individual authors.

The Cooperative staff wishes to extend their appreciation to those Cooperative members who contributed to the success of the Conference by hosting field tours. They are as follows:

Conference Tours	Post-Conference Tours
Virginia Department of Forestry	Union Camp Corporation
Chesapeake Corporation	Weyerhaueser Company
	Federal Paper Board Company
	Westvaco Corporation

Hosting the Conference was a major undertaking, yet very worthwhile. The contacts, interactions and information exchange that was generated by this effort will pay dividends to the Cooperative for many years into the future.

Graduate Student Research and Education

The education of graduate students and the research they conduct as part of their degree program continues to be an important activity of the Cooperative. During the past year, 14 students have been involved in graduate studies in association with the Tree Improvement Cooperative. Eight have been pursuing Masters degrees and six were involved in Ph.D. programs. Of special note is the completion of degree programs by three students in 1986-1987: Gary Hodge, Karen Miller and Lisa Wisniewski.

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. Student research projects encompass a wide range of subject matter related to tree improvement. Financial support for students comes from a variety of sources--The Tree Improvement Cooperative, the School of Forest Resources - Department of Forestry, the North Carolina State University Agricultural Research Service, the U. S. Forest Service, industry-sponsored fellowships, and foreign governments.

The Cooperative staff served during the past year as host for the technical activities of two visiting scientists from India. Dr. Jambulingham and Dr. Khajuria have been working with us to increase their tree breeding knowledge. Upon their return to India, they and others currently studying in the United States will serve on the faculty of forestry programs being initiated in several universities in India. Support for Dr. Jambulingham and Dr. Khajuria has been provided by the Winrock Foundation. For all of us, working with Jambu and Hira has been a very enjoyable experience.

Student	Degree	Research Project
Roger Arnold	Masters	An evaluation of the DRIS approach for identifying mineral nutrient limitations on flowering and cone production in Fraser fir
Claudio Balocchi	Masters	Efficiency of genetic test designs for *Pinus radiata* in Chile
Gary Hodge	Ph.D.	Cold tolerant loblolly pine - completed 1986
Ann Margaret Hughes	Masters	Seed quality studies in Fraser fir
Ruy Lima	Masters	Family stability for wood properties of *Pinus oocarpa*
Karen Miller	Masters	Histological response of shortleaf and shortleaf loblolly hybrids to *in vitro* innoculation with fusiform rust fungus - completed 1987
Mary Frances Mahalovich	Ph.D.	Modeling the genetic consequences of positive assortative mating
Ray Moody	Masters	Pollen vigor studies
Bailian Li	Ph.D.	Genetic variation of nitrogen use in loblolly pine
Kyung-Whan Pak	Masters	Patterns of growth cycle phenology between loblolly pine tissue culture plantlets and seedlings
David Porterfield	Masters	An evaluation of interspecific hybrids of *P. Clausa* x *P. virginiana* and *P. rigida* x *P. Clausa*
Jim Richmond	Ph.D.	Genetic variation among populations of pine cone worms
Lisa Wisniewski	Ph.D.	Physiological studies of maturation and rejuvenation in loblolly pine - completed 1987
Lan Zheng	Masters	The stability of wood specific gravity of loblolly pine in diverse geographic areas

Program Staff

Cooperative program staff members and their primary responsibilities are depicted in the organizational chart on the following page. The Cooperative staff work full time on Cooperative activities, except for limited teaching commitments by Drs. J. B. Jett and Steve McKeand; Mr. Charles Echerd has split responsibility as a research technician with the Tree Improvement Cooperative and the Tissue Culture Research Program. Not shown on the organization chart are the following associated appointments:

Dr. Floyd Bridgwater	- U. S. Forest Service Research
Dr. John Frampton	- Tissue Culture Program
Dr. Bruce Zobel	- Professor Emeritus

During the last year, one change in the program staff occurred. Mr. Mark Hubbard resigned to accept employment with the South Carolina Commission of Forestry. Mark has been replaced by Mr. Charles Echerd. Charles is a 1982 graduate of North Carolina State University's Forestry Department and has experience working in the NCSU phytotron. We are pleased to welcome Charles to the program.

COOPERATIVE TREE IMPROVEMENT PROGRAM
ORGANIZATIONAL CHART - JUNE 1, 1987

DR. ROBERT J. WEIR
DIRECTOR

DR. J. B. JETT
ASSOCIATE DIRECTOR

- **MR. VERNON JOHNSON**
  AGRI. RES. TECH. II
- **MS. ADDIE BYRD**
  RESEARCH TECHNICIAN II
- **MR. CHARLES ECHERD**
  AGRI. RES. TECH. I

Activities:

-Seed Orchard research and operations

-Lab. and field research and management

DR. STEVEN E. MCKEAND
GENETICIST

- **MR. JERRY SPRAGUE**
  RESEARCH ASSISTANT
  (1/2 TIME)

Activities:

-Breeding and testing research and development

MS. ALICE V. HATCHER
MANAGER, INFO. SRVS.

- **MR. JERRY SPRAGUE**
  RESEARCH ASSISTANT
  (1/2 TIME)
- **MS. JUDY STALLINGS**
  SECRETARY IV
- **MS. JACKIE EVANS**
  SECRETARY
  (HOURLY)

Activities:

-Data Processing

-Office Management

-Budget Management

MEMBERSHIP OF THE TREE IMPROVEMENT COOPERATIVE

Organization	States Where Operating
Alabama Forestry Commission	Ala.
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. Florida Region--Ala., Fla., Ga.
Chesapeake Corporation of Virginia	Va., Md., N.C.
Container Corporation of America	Brewton--Ala., Fla. Fernandina Beach--Fla., Ga.
Continental Forest Investments	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.
James River Corporation	Ala., Miss.
International Forest Seed Company	Miss., Ala., Fla., Ga., S.C.
International Paper Company	Atlantic Region--N.C., S.C., Ga. Gulf Region--Miss., Ala. Hammermill Acquisition--Ala.
Kimberly-Clark Corporation	Ala.
Leaf River Forest Products Co.	Ala., Miss.
MacMillan-Bloedel Corporation	Ala., Miss.
N. C. Divison of Forest Resources	N.C.

Organization	States Where Operating
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 Department of Forestry	Va.
Westvaco Corporation	South--S.C. North--Va., W.Va.
Weyerhaeuser Company	N.C. Region--N.C., Va. Miss. Region--Miss., Ala.

Membership in the Tree Improvement Cooperative now totals 28 organizations. The 28 member organizations operate 28 base units and 13 supplemental units for a total of 41 active tree improvement programs. During the last year, James River Corporation acquired a majority of the American Can land base, including the seed orchards and tree improvement program. We welcome James River to the Cooperative. Hammermill Paper Company was purchased by International Paper Company and has become a third working unit for International Paper. The Virginia Division of Forestry has become the Virginia Department of Forestry. While this may appear to be a subtle change, it does mean that the Virginia State Forester now reports directly to the Governor of Virginia. This is a very positive change for forestry in Virginia. Container Corporation of America was purchased by Jefferson Smurfit Corporation during the last year. John Pait continues to be the Tree Improvement Manager while Tim McElwain was named R & D Director in the new organization.

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. 1985. Loblolly pine tissue culture: laboratory, greenhouse and field studies. p. 271-287. In: R. R. Henke, K. W. Hughes, M. J. Constantin and A. Hollaender (eds.). Tissue culture in forestry and agriculture. Plenum Press, NY. 390 p.

Bramlett, D. L. and F. E. Bridgwater. 1986. Segregation of recessive embroyonic lethal alleles in a F_1 population of Virgina pine. pp. 401-409. In: Proc. IUFRO Conf. Joint Mtg. of Working Parties on Breeding Theory, Progeny Testing and Seed Orchard. Williamsburg, Va.

Bramlett, D. L., F. E. Bridgwater, J. B. Jett and F. R. Matthews. 1985. Theoretical impact of pollen viability and distribution on the number of strobili to use for controlled pollinations in loblolly pine. Proc. 18th South. For. Tree Impr. Conf., Long Beach, MS. May 21-23, 1985. p. 194-203.

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