SECOND ANNUAL REPORT

N. C. STATE - INDUSTRY COOPERATIVE

FOREST TREE IMPROVEMENT PROGRAM

School of Forestry
North Carolina State College
Raleigh
June, 1958

Second Annual Report
N. C. State - Industry Cooperative
Forest Tree Improvement Program

Introduction

The cooperative tree improvement program has expanded since last year's annual report was issued. Coosa River Newsprint Company and Georgia Kraft Company have joined the program, bringing the total number of participating companies to twelve (including mergers) and the total number of working units to sixteen. The complete list of participants is shown on the last page of this report. The active working area now comprises company lands in six states, including North Carolina, Virginia, South Carolina, Tennessee, Alabama, and Georgia.

Activities of this program are classed into three categories: (1) advice and assistance in the action program of the supporting industries; (2) basic research on problems common to the supporting industries; and (3) advice and guidance to graduate students in the forest genetics field enrolled at North Carolina State College.

This report will be devoted to elaborating in some detail on these three lines of activity.

Cooperative Activities with Industries

Selection. - The selection of trees for company seed orchards has progressed exceptionally well, with all but two of the cooperating industries having made initial selections of "superior" trees on their lands. A total of approximately 400 of these "superior" trees were select enough to warrant detailed grading. Of the trees graded, approximately 190 have

been judged acceptable (or "superior" enough) for use in the company seed orchards. Bob McElwee has personally graded all the trees to be used in the various seed orchards. Overall, a pleasingly large number of really good trees have been found. The grading system used is very selective and any tree that grades high is really good. Two or three trees located by company personnel and graded by Bob have approached the perfect tree.

Grafting Into Seed Orchards. - To insure an early start, and to obtain maximum results with minimum facilities, the use of field grafts was suggested for the early establishment of large scale seed orchards. For the early grafting, conditions could not have been worse, and the results show it. However, after the middle of February, grafting conditions were very good and the excellent results achieved by the late grafting have been most gratifying, in fact, much better than we had hoped or predicted. For most of the companies who really seriously attempted field grafting on healthy stock the results were about as follows: (1) Grafted in December and early January, before both freezes, 5% or less "takes"; (2) Grafted in late January, or early February, between the two freezes, from 10% to 40%; (3) Grafted from the middle of February until the end of March, from 30% to as high as 70% or 80% success.

This year's grafting was considered by most companies to be rather a "trial" period, so various methods were tried as suggested. Some methods were good, some were failures. The following results were obtained for approximately 13,000 grafts made between December and April, 1958.

Figure 1. Some excellent Virginia pine have been located that are tall, small limbed, and have fairly well pruned boles. The tree shown here is 36 years old, 69 feet tall and 10.5 inches in diameter. Its field grade was acceptable by the N. C. Tree Improvement Program's grading standards.

Field Grafting Results and Recommendations

Time	Success	Cover Used	Recommendations
December	Failure	All covers ineffective	Do not make early grafts
Early January	Failure to fair	Polyethylene bag alone	Use only foil covered by polyethylene
Late January	Fair	Foil alone	
Early February	Fair to good	Foil (loose) covered by polyethylene bag	
Middle February to end of season	Fair to excellent	Foil alone	Use polyethylene covered by kraft bags. In north use foil with polyethylene
	Good	Foil covered by polyethylene	
	Excellent	Polyethylene covered by kraft paper bags	
	Poor to fair	Polyethylene along	
	Excellent to Failure*	Bottle Grafts (all covers)	

General Recommendations for Future Field Grafting:

For Northern Companies (north of N.C. line except Dare County)	For Southern Companies (south of N.C. line and Dare County)
1. Start about middle of February	1. Start first of February
2. Use foil-polyethylene until March, then polyethylene-kraft bag.	2. Use foil-polyethylene until about February 20, then polyethylene-kraft bag.
3. Do not use plain polyethylene or plain foil anytime, except for north.	3. Do not use plain polyethylene or plain foil anytime.
4. Continue use of side graft.	4. Continue use of side graft.
5. Dust lightly with Malathion.	5. Dust lightly with Malathion.

This year's results make it obvious that cold temperatures are very hard on loblolly pine grafts. Temperatures below 15° Fahrenheit are known

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* Bottle grafts were a complete failure for one company, good for another, and excellent for a third.

to be injurious or fatal, depending on duration. This past winter temperatures fell as low as -10° F in one orchard, and around 5° F in several others.

The cold weather caused failure of grafting in any one of three ways, or a combination of them:

1. Actual killing of graft material. - Foliage material, not attached to roots, froze outright. This type of mortality was not common but was observed especially in the northern orchards. (In a Texas test it was found that foliage not connected to roots froze black at temperatures no lower than 10° F.)

2. Desiccation. - Mortality from drying probably is by far the most important. While the ground was frozen solid to a depth of several inches, very cold and clear days followed. Temperatures rose in the polyethylene bags but the trees cound not transpire because of the frozen soil moisture. Normally the graft bag is filled with moisture, creating a miniature humid greenhouse. Following the freeze the bags remained moisture-free for a period of three or four days. The scions simply dried out. This mortality was all the more discouraging because examination showed many of the grafts already had been developing some union with the stock plant when they died.

3. Actual killing of the plant or stock. - Some plants were killed outright in the more northern areas where in some situations many ordinary pine plantations suffered substantial mortality.

Although the field grafting appeared at first to be a "fiasco," it has not turned out too badly for those companies that had succeeded in doing

Figure 2. Although field grafting is more difficult than greenhouse grafting, the successful field grafts grow very rapidly with a minimum of care. Field grafting in 1957-58 was hard hit by the early unusual cold but the spring field grafting success was much better than our hopes and predictions

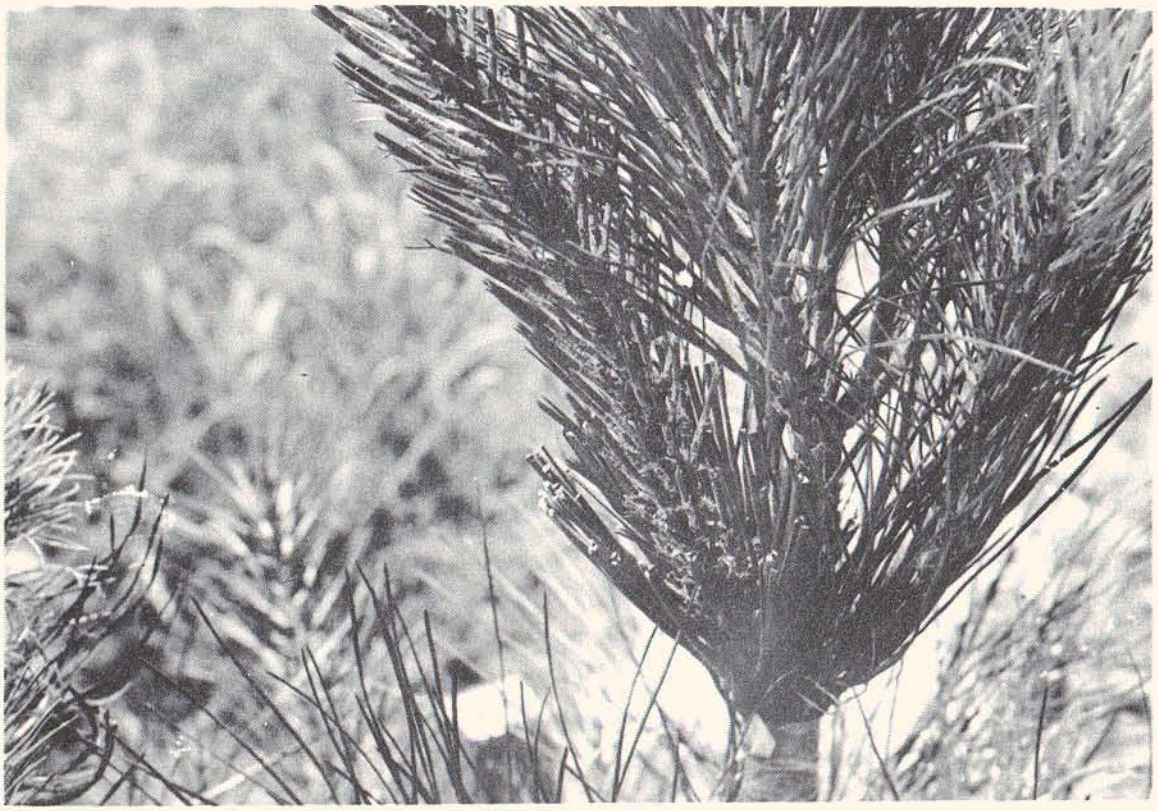

Figure 3. The short needled shoot on the left is a successful field graft rapidly elongating. Once having reached this stage, such a graft is seldom ever lost.

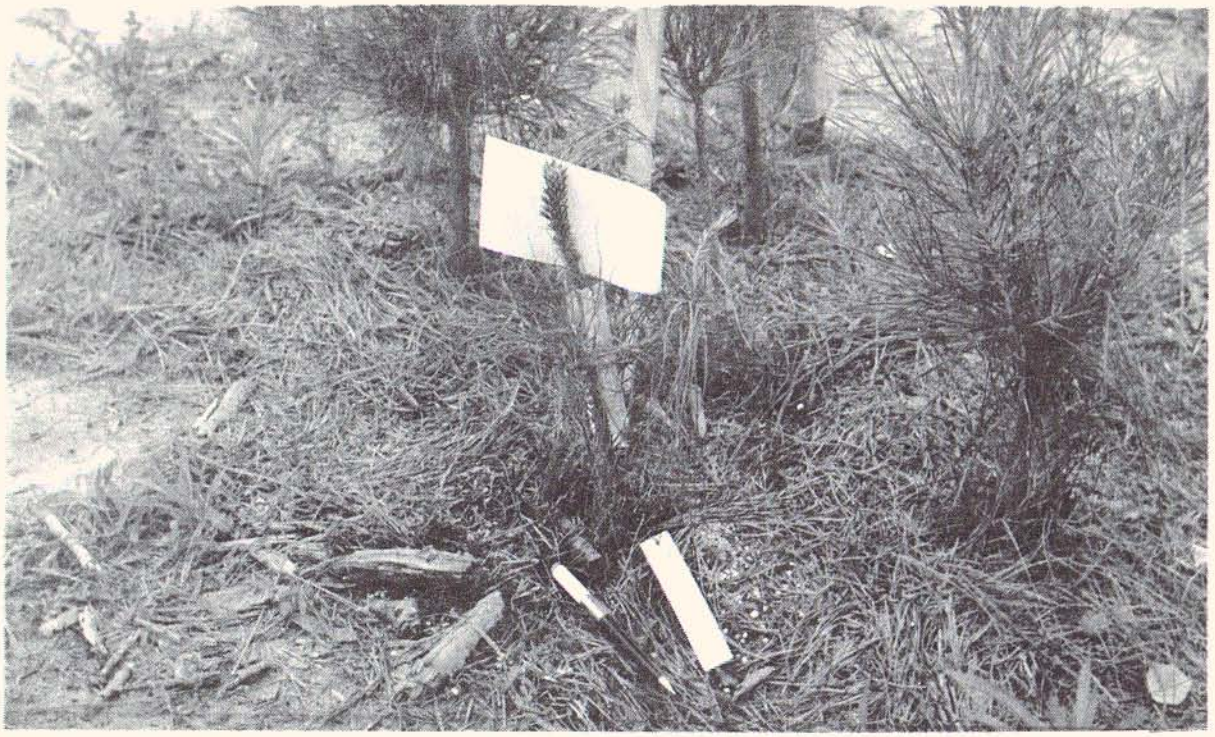

Figure 4. This young field graft is in the "pinfeather stage" that we consider necessary before removal of the protecting graft bag.

Figure 5. The graft in this picture has its needles half exserted and the stock has been cut back drastically.

a good initial job of grafting and had been able to follow through with adequate and timely care. A couple of orchards will be nearly completed. Other orchards have established in them individuals of each clone so that later expansion by inarching will be easy. This year's work again emphasizes that grafting must be carefully done and intensive after-care is necessary for success.

Several companies have sent in their survival patterns. In all but one case, those that followed instructions closely with proper "after care" were successful beyond our hopes. The data below are survivals obtained by Bowaters for three species. A total of about 1200 grafts were made, but less than 100 Virginia pine grafts were made. These results were based on an inventory made May 5 -- of course, a few additional grafts will succumb but mortality after this period should not be heavy.

	% Survival (May 5)
Loblolly - Southern Orchard	47%
- Northern Orchard	68%
Shortleaf	72%
Virginia Pine	84%

Schools. - During the year we held one-day schools for all but two of the companies. Forestry personnel, and in several cases, mill personnel attended. We feel that these schools are a great deal of help for all of us, -- we learn each other's problems and, in some cases, discover that there are mutual problems of interest to the forestry and mill people.

Research on Fundamental Problems

Studies on wood properties have progressed rapidly. However, certain fundamental studies have been restricted or deferred entirely because of lack of facilities, especially adequate greenhouse space. Until these facilities become available, the fundamental research program will lack proper balance.

Actual research accomplishments will be listed under individual projects. The whole research field of wood properties related to growth, environment and genetics is now very active and several organizations are now engaged in it. One of the most important events during the past year is that the Institute of Paper Chemistry is now starting research concerned with growth characteristics of fibers in relation to final product. They intend to concentrate at first on inherent fiber strength properties. This work of the IPC is financially supported by the Union Bag-Camp, Riegel, and West Virginia Pulp and Paper Companies which also support the N. C. State program.

Another significant development along the line of basic research on wood-genetic relationships has been an increased activity in the U. S. Forest Service. Work is now under way, both at the Madison Laboratory and at the experiment stations where men have been hired to work specifically on wood property studies related to tree improvement.

Graduate Students

General. - No general announcements were sent out this year to solicit graduate students, since we already had a number of good applicants in excess of funds available for assistantships.

For the coming year we will have five students working for the Ph. D. degree and two working towards the Masters degree. During the past year one of our doctoral students decided to go into the Ministry, relinquishing his

Figure 6. Illustrated here are the two most successful coverings for field grafting. The loose foil - polyethylene bag is illustrated in Figure 7. The graft to the right has a polyethylene bag and kraft bag cover. This combination was most successful late in the season and in the more southern areas.

assistantship, and one failed to appear last September. Funds thus made available will be used for additional assistantships in 1958-59.

Current Graduate Research. - One Masters candidate completing his plan of work is Mr. Earl Haught, who carried out an exploratory study on compression wood and its association with spiral crook, limb size, and limb numbers in loblolly pine. His findings will serve to guide us in our selection of trees for seed orchards, indicating how stringent we should be on selection for bole straightness, i.e., to what extent does the inherent spiral crook of loblolly pine reduce wood quality.

Haught found that trees appearing reasonably straight (on the lower limit of acceptibility we have set on selection) contained, on the average, 6.0 percent compression wood based on the total merchantable volume of the tree. Trees that were somewhat more crooked had 9.1 percent of the volume as compression wood. Still more crooked trees (those that are sometimes left as seed trees in ordinary silvicultural manipulations) had 15.8 percent or more of compression wood. One very crooked tree, (normally would be removed as a cull) had 67.1 percent of its total merchantable volume made up of compression wood.

Indications are that the amount of compression wood associated with knots occupy about the same volume as the actual knots in the bolt, i.e., if a knot system occupies 10% of the bole volume, the compression wood will also be about 10% of the volume; or if the tree has slender limbs and small knots occupying only about 5% of the bole volume, the compression wood associated with those knots also takes up about 5% of the volume.

Mr. Eyvind ("Thor") Thorbjornsen is well on his way to receiving the Ph. D. degree. In March he passed his comprehensive examinations and now needs only to complete his research study and prepare an acceptable thesis. His work should be completed within the year. Thor is working on seed variability both on selected and average trees. He is finding very large differences from tree to tree, in germination rates and other qualities, but so far no definite north-south geographic trends have become evident. He will supplement his north-south samples with seed collections along an east-west axis to the most westerly limit of the natural loblolly range in North Carolina. Thor is studying morphological characteristics such as seed color, seed coat thickness, seed wing characteristics, size and weight of seed as well as the effect of stratification on germination.

Thor's findings should be very valuable to the industries. For example, he has found one of the select trees in one of the seed orchards has 80% pops (unsound seed) while the neighboring trees have well filled seed. If such continues to happen, use of this tree in a seed orchard would be questionable.

Bob McElwee is carrying on studies of pollen flight, with emphasis on isolation distances. His results last year were rather "odd" since all the pollen was released within a few hours by a strong, drying wind. One of his major problems is to mark pollen from individual trees so that pollen from a single tree can be identified, thus enabling studies of tree to tree pollination such as in a seed orchard, as well as isolation distances.

Each of the new graduate students will undertake a research problem that will contribute to our over-all tree improvement project.

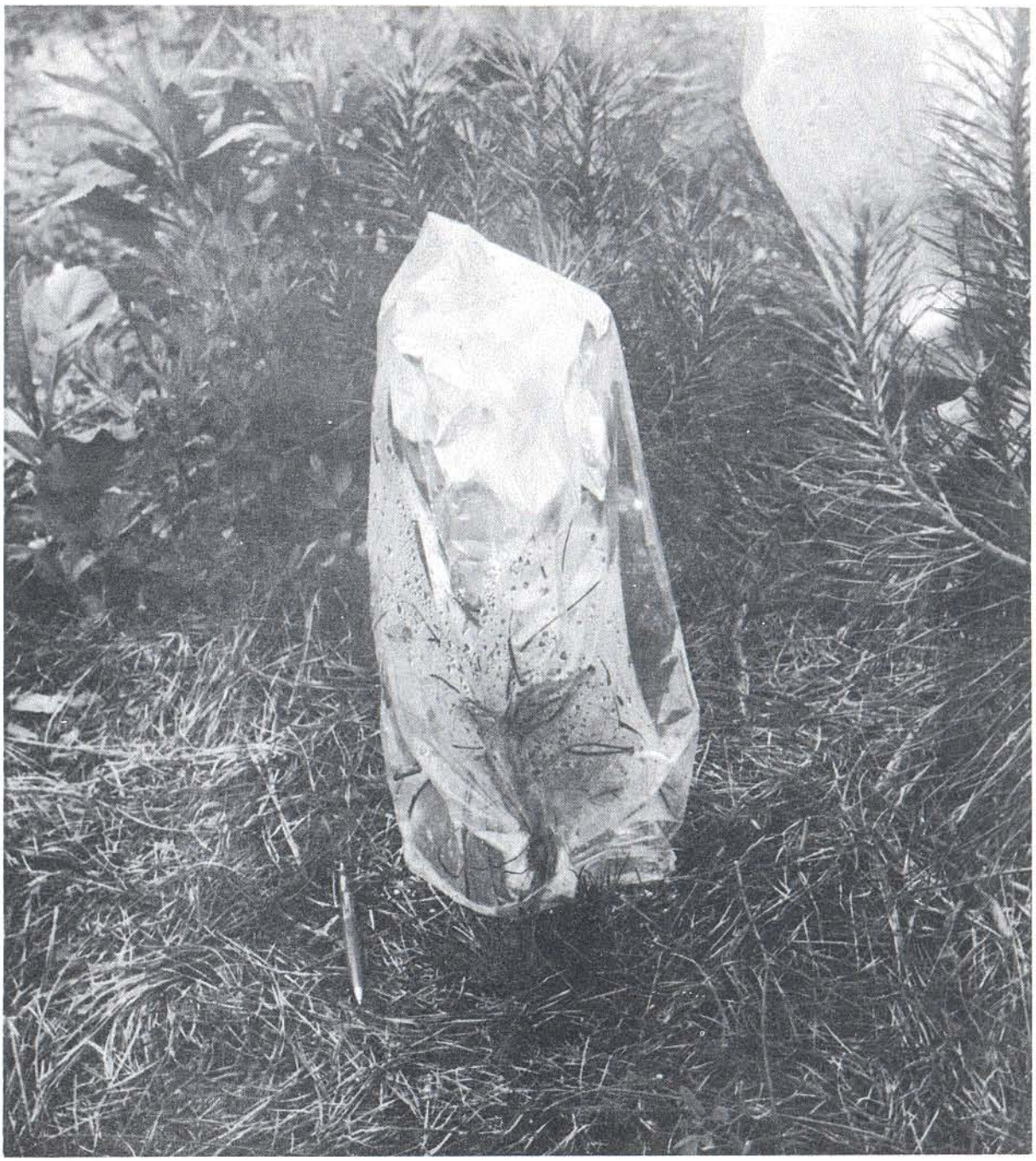

Figure 7. This field graft covering the loose foil covered by a polyethylene bag has proven to be one of the best for early grafting. Note the moisture on the inside of the bag showing the "greenhouse" effect in maintaining a high humidity.

Figure 8. A new seed orchard, started by field grafting. This loblolly (north) seed orchard of Bowaters will be complete for the clones grafted and there will probably be a few extras. Percentage take here (as of May 5) was 68.

Personnel

Bruce Zobel is the geneticist in charge of the program.

Bob McElwee, who has been acting as Liaison Geneticist, plans to attend school full time starting September, 1958 to take necessary formal course work leading to the Ph. D. degree. During his 9-month leave period the liaison job will be carried forward by Eyvind Thorbjornsen who has been working closely with Bob and can fill in without disruption of any of the liaison services.

Mrs. Peggy Houck has faithfully served as part-time secretary during most of the year. She has resigned to go with her husband who graduated from N. C. State College this spring. She is replaced by Mrs. Rachel Vogler.

We are indeed fortunate to be able to employ Mrs. Faye Henson as laboratory technician. Her employment was made possible by action taken in last year's Advisory Committee meeting with authorized additional money. Mrs. Henson does the routine laboratory analyses of wood specific gravity and cellulose yields, enabling Zobel to spend more time in the field, with the graduate students, and doing additional basic research. She is aided in her work by part time student labor.

Attempts have been made to hire a combination plant physiologist-soils man-geneticist who would devote half time to research. Funds for half of the salary of this man have been promised by the college, requiring him to teach two courses in the School of Forestry and to spend about two weeks in Summer Camp. His research assignment would depend on the

source of the other half of his salary and on his training. If industry funds were available, he would work on problems especially relevant to the tree improvement program. No matter what the source of funds, a man with the indicated training would be of inestimable help both to the program through his personal research and through his work with the graduate students.

Physical Facilities

Lack of adequate greenhouse facilities has already been mentioned. Although the General Assembly appropriated funds for greenhouse construction, there have been the usual administrative delays. An additional complication, not anticipated a year ago, was the College-wide long range planning, which further delayed decisions on location and related aspects. Limited greenhouse, cold-room, and headhouse facilities have been made available by the Horticulture Department, but lack of full control over these facilities restricts the amount and effectiveness of our research effort.

The laboratory is now partly out-fitted and equipped, at least sufficiently so that the necessary cellulose analyses can be made. Several test areas have been obtained near Raleigh. These areas are planted and already partly grafted. The ultimate plan is to have several grafts of each tree selected for each company present on the test area so that all necessary crosses can be made with ease. Considerable numbers of research seedlings have been outplanted on nearby company lands.

Since nursery facilities at Raleigh are very limited, and since earlier progeny tests will require considerable nursery space, Bowaters nursery

has graciously consented to grow this year's test progeny for us. Approximately 800 feet of nursery bed will be used. At the proper time the seedlings will be sent to each company for planting, thus starting the initial open pollination progeny tests of their seed orchards.

Research Projects

Discussion of details and objectives of the various research projects under way was made in the First Annual Report. The present report will summarize the present status of these projects.

Project O: Selection of Superior Trees. - This project has proceeded very satisfactorily with good efforts by most companies. To date, grading has been confined mostly to loblolly pine, but some pond pine, shortleaf pine and Virginia pine have also been selected, and some truly excellent trees have been found.

This project is a continuing one, since a minimum of 15 acceptable trees are needed for each company seed orchard. When it is recognized that each tree must meet rigid standards for eight (8) growth and form characters and, as of now, one wood character, it becomes evident how difficult it is to find trees that are satisfactory in all respects. As of now, 190 trees have been judged as satisfactory and are being used in seed orchards.

The field selection of trees is a truly huge task. It represents untold man hours and frustrations by the score (or in whatever manner frustrations are measured). In several of the companies' operational areas all of the good stands have been thoroughly examined and the best trees selected.

The following paragraph gives some indication on the time requirements to complete one seed orchard with 15 clones.

The first rough selection is made by company personnel, usually district personnel. The second selection is made by the company contact man who looks at the first group of trees. This first screening results in the rejection of about half the original selections. Then Bob McElwee screens those accepted by the contact man. Depending on the experience of the contact man, Bob then rejects from 25% to 90% of the contact man's trees as unworthy of grading. This percentage always drops after working with Bob on the grading of a number of trees. On the average, about 50% of the contact man's trees are graded by Bob. About 50% of these trees are further rejected in the office and laboratory, when they are found to grade too low against the standards for form, growth rate, and volume. Then, depending on wood property requirements, an additional group of trees are rejected. This final rejection varies from none for two companies (who are not now interested in the wood properties used as criteria) to about 80% by one company that wants only the trees with the very highest wood specific gravities. The average rejection rate due to wood properties is about 50%. Thus, if one starts with 100 trees selected by district personnel, on the average the following schedule of attrition takes place:

District personnel	100 trees
Contact Man (50% rejects)	50 trees
McElwee (50% rejects)	25 trees
Office rejects (form, growth, grade)	13 trees
Wood property rejects	6 or 7 trees

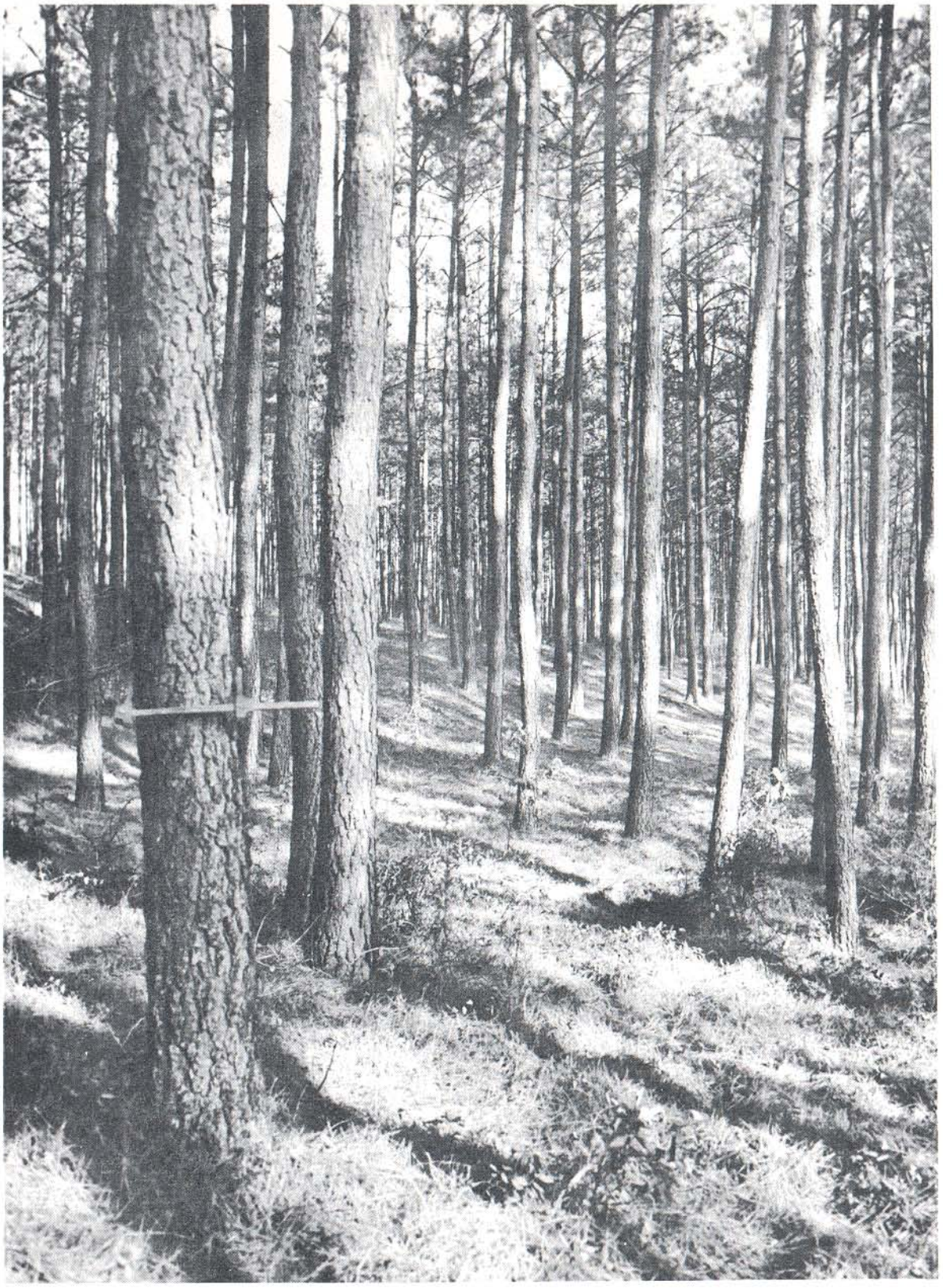

Figure 9. Stands such as this are ideal for selection of trees for the seed orchard. Such stands should be near the rotation age desired by the company.

Thus only 6 or 7 percent of the originally selected trees survive the screening process and find their way into the seed orchards. (Remember, a minimum of 15 trees are needed for each seed orchard.) This screening may appear to be too stringent, but the grading and selection job is exceedingly important and must be done right. It may seem a little costly now, but in the long run it is efficient if one remembers that the seed orchards will supply the companies' seed requirements for many years to come.

The selection work is the first big phase necessary by the cooperating companies. The next major phase is to get the selected trees established in seed orchards. The third phase will be the progeny testing of the individuals in the seed orchard. Most companies are well into phase one and also have started phase two. The third phase, progeny testing, will start for some companies next fall and winter, when we will send them seedlings from open-pollinated seed of trees in their seed orchards.

Last fall, cones were sent to us by most companies from select and check trees. This material is used for two purposes -- (1) an intensive seed study by student, Thorbjornsen, as discussed earlier, and (2) progeny tests of open-pollinated material from clones used in the seed orchard. These progeny tests will give some early indications of the worth of trees selected for the seed orchard. They will, of course, be followed by more intensive control-pollinated progeny tests.

The present early tests will consist of some 115 separate lots of seed to be tested by the companies concerned. This phase of the work will be stepped up the coming year so that as early an indication as possible will be gained of the worth of each clone in each seed orchard.

Project 1: Variation in Fiber Yield Among Individual Loblolly Pine Trees. - This project has received the bulk of our attention in the basic research. Preliminary results have been obtained and were reported at the TAPPI meeting in New York in February. Copies were sent with the Third Interim Progress Report and the papers were published in their entirety in the April issue of TAPPI.

The future of research on cellulose yield studies is uncertain and will be decided at the June, 1958, Advisory Committee meeting. The preliminary findings by our rather crude methods have shown there is considerable variation in cellulose yields among trees and between different parts of a tree. These results have stimulated considerable interest in cellulose variation studies; larger, better-equipped, better-staffed organizations have now started research on cellulose variation. At the present time, our data on cellulose yields on the select trees have been made available to each company. Our study enables us to put each select tree in the category of high-yielder, low-yielder or average-yielder. All the data collected to date is recorded on IBM cards.

Project 1-a: Specific Gravity. - In undertaking cellulose research, and in our tree selection program, a mass of data on specific gravity has been gathered and continues to be accumulated. Information on specific gravity has been made available in all our interim reports, annual reports, and publications. Some of the more recent findings were reported in one of the papers given at TAPPI in February in New York. A copy of this paper was sent with the Third Interim Progress Report.

Figure 10. Taking the oversize cores is a "man-sized" job. A special starter is helpful in getting the bit into the tree. Paul Otterbach is shown in the act of releasing the starter.

Figure 11. Bob McElwee here holds the oversize increment core used for samples of wood specific gravity and cellulose yield.

Part of the information on specific gravity deals with the so-called "juvenile wood." It was necessary to make this juvenile-mature wood subdivision in order to make routine specific gravity analyses. Enough information is now available on the importance of juvenile wood to justify summarizing in a paper which will be published next year bringing together all the information we have available on specific gravity, fiber characteristics, cellulose yields, occurrence, vertical distribution in the tree, etc. In future research, all studies will deal with specific gravities and properties of mature wood only, and the juvenile portion of the tree will be discarded unless there is a special reason to take it into account.

Project 2: Relationship Between Juvenile and Mature Characteristics on Morphological and Wood Properties. - Field work has been done on this project and further results await time for the trees to grow. Results of juvenile correlations on wood characters have been reported in several publications, and in certain instances these have been confirmed by work done by other research organizations.

Project 3: Progeny Testing for Special Purposes and Project 4: Breeding Arboreta. - Nothing new need be reported for these projects other than that considerable planting has been done. On the lands of N. C. Pulp Company several acres have been planted for the past two years, with selections of specific gravity material, southern pine hybrids, and Mexican pines. This same material has been planted on the School of Forestry research area near Raleigh.

Grafting into our "seed orchard" at Raleigh was done the past year and will be continued for several years.

Project 50: Seed from Superior Trees; Project 51: Pollen Flight Characteristics; and Project 52: Distribution and Extent of Compression Wood in Loblolly Pine. - These three studies are being done as the research work of several graduate students. They were discussed briefly earlier in this report.

Publications

Since the First Annual Report, several publications have been made:

1. Third Interim Progress Report

The Third Interim Progress Report summarizes and analyzes the recent research results and brings up the question, "where do we go from here?" This question will be discussed in detail at the 1958 annual Advisory Committee Meeting in June. In addition, an abstract of research results were included on the cellulose and specific gravity studies. These papers were later published in TAPPI as shown below.

2. Zobel, B. J. and R. L. McElwee 1958 Variation in Cellulose in Loblolly Pine. TAPPI 41(4): 167-170.

3. Zobel, B. J. and R. L. McElwee 1958 Natural Variation in Wood Specific Gravity of Loblolly Pine, and an Analysis of Contributing Factors. TAPPI 41(4): 158-161.

4. Zobel, B. J. 1957 Inheritance of Wood Properties in Pine. Proceedings Fourth Conference on Tree Imporvement, Tech. Paper 17, pp. 27-29.

This is a general report to the open meeting of the Southern Forest Tree Improvement Committee.

5. Zobel, B. J. 1957 Progeny Testing for Drought Resistance and Wood Properties. Der Zuchter 4:95-96.

At the request of Dr. Schmidt, this paper was prepared as a part of a symposium on early progeny testing in forest genetic material. Several other of the included papers are in English.

6. Zobel, B. J. 1958 The Tree Farmer of the Future will Plant Pine to Suit His Needs. Southern Planter, pp. 24.

This generalized article for The Tree Farmer was requested and published early in 1958.

7. Zobel, B. J. and F. C. Cech 1957 Pines from Nuevo Leon, Mexico. Madrono 14(4):133-144.

The results of two years' collection trips to Northern Mexico are summarized. The trips were made while the authors were in Texas, but the manuscript was completed during the past year.

8. Zobel, B. J. 1958 Forest Genetics -- Its Relation to the Wood Using Industries. The Wood Worker.

This very generalized paper was prepared on request. It summarizes the possible role of genetics for the various wood using industries, especially quality wood products.

9. Zobel, B. J. 1957 Results of Research on Genetic Phases of Wood Properties of Loblolly Pine. Lake States Tree Improvement Conference, September.

This paper was given upon request to the LSTIC and was intended as a summary of information on genetics of wood of loblolly pine.

Financial Support. - The N. C. State-Industry Cooperative program is made possible by financial assistance from the 12 cooperating pulp companies, the N. C. State Agricultural Experiment Station, the N. C. State College School of Forestry and individual contributions. Listed below are the companies (including mergers) and working units that are currently participating:

Company	Working Units
Bowater Southern Paper Corp.	one
Champion Paper & Fibre Co.	one
Chesapeake Corp. of Virginia	one
Coosa River Newsprint Co.	one
Continental Can Co.	Gair Division
	Continental (Eastern)
Georgia Kraft Co.	one
Halifax Paper Co., Inc.	one
International Paper Co.	Coastal Plain
	Piedmont
North Carolina Pulp Co. (Weyerhauser)	one
Riegel Paper Corp.	one
Union Bag-Camp Mfg. Corp.	Georgia
	Virginia
West Virginia Pulp & Paper Corp.	South Carolina
	North Carolina