N I N T H A N N U A L R E P O R T

N. C. State-Industry

Cooperative Tree Improvement Program

School of Forestry
North Carolina State University

Raleigh

June, 1965

N I N T H A N N U A L R E P O R T

N. C. State-Industry

Cooperative Tree Improvement Program

June, 1965

INTRODUCTION

Who says the spirit of cooperation and helpfulness is dead? We hear all about our selfish society, about people who care only for themselves. We hear especially of "self-seeking industry," of men and organizations whose only effort, only goal is to improve themselves, to make more profits. Now that the Cooperative Tree Improvement Program has come of age and commercial seed production is starting from the seed orchards and the wood studies are helping point the way to more efficient operations, one would expect that the members of the Cooperative Program would tend to go their own way, consolidate their gains and lose some of their helpful spirit.

But the past year has shown just the opposite; although working with the Cooperative Program has always been pleasant, this year has been a real joy. There has been more mutual aid, more trades of materials among organizations, more sharing of information than ever before. How can Bob Kellison and I help but show the real feeling of pride we have in working with this wonderful group of men and organizations?

For example:

1. One company was able to start a completely new 25-clone seed orchard, representing an area in which they do not yet own much land, by "loans" of trees from three neighboring companies on faith that the loans will be paid back when land is obtained and tree grading starts.

2. One company made a very large, expensive, complex wood study using their own facilities, relying on us only for limited advice. Throughout the study they kept us informed about their progress, and when it was completed sent us a summary page of their results, stating "Use this in any way it can be most helpful to others in the Cooperative."

3. Another company, in need of establishing a seed orchard rapidly, was not only given clones "on loan" from other organizations but received 1000 grafting stock and the use of a trained crew from another company to do the grafting. Only one year after joining the Tree Improvement Program this company has already established an orchard with over 700 grafts.

4. Several organizations have for the past five years grown progeny test seedlings for other members of the Cooperative, with never a question of payment for the considerable outlay of time, effort and cost in producing such planting stock. This has enabled our progeny testing to proceed rapidly and efficiently.

5. Several organizations have made land available for basic research undertaken as a part of the Cooperative Program. These studies consist of species and progenies that have no immediate use in an applied program, but which will be of help to all members of the Cooperative in the long run. When land had to be cleared for research on areas other than their own holdings, two companies donated their bulldozers and operators and prepared the land for planting, at no cost to the Cooperative.

6. Many, in fact nearly all, members of the Cooperative have sent pollen and seeds, have supplied cuttings from special trees, have made crosses additional to those needed for their progeny tests, and in other ways have helped to make possible research under way by students and faculty at N. C. State.

7. Often Bob's and my expenses, and sometimes those of the students who work with us, are partly or totally covered by companies with whom we work. Manpower, labor, even secretarial help is made available to us on occasion, thus stretching the limited funds of the Cooperative. No wonder so many outsiders will not believe such an extensive program can be carried on with so little direct cash. They cannot realize how valuable the "small things" done for us are in strengthening the Cooperative Tree Improvement Program.

8. Often company planes or cars are made available for our use. This is most helpful, since the greatest inefficiency of the Cooperative Program involves the many miles of travel and the thousands of hours spent "on the road." Meeting us at airports and helping with transportation has saved Bob and me weeks of work time during the past year.

9. Several organizations not only have given us permission to use data on costs, growth, techniques, yields of seed and other such information that would commonly be considered confidential and for internal organizational use only, but have suggested we make it available to others in the Program through the Annual Report, NEWSLETTER, or Contact Men's Meeting.

10. Several organizations - but, Oops! This is getting out of hand. Remember, however, the above nine are just a few examples of the marvelous cooperative spirit in the Tree Improvement Program, and we could easily expand the list manyfold.

We have been asked by groups throughout the United States and in a number of foreign countries to describe the organization of the Cooperative Tree Improvement Program. It is not unusual to have foreign visitors whose main objective in coming to Raleigh is to determine how the Cooperative Program operates. When we finish our description no one has yet called us liars to

our faces - but their expressions sometimes say it. It is just inconceivable to most people that a group of competitive organizations will band together and so unselfishly support a joint venture of the magnitude and with the degree of success of the Cooperative Tree Improvement Program.

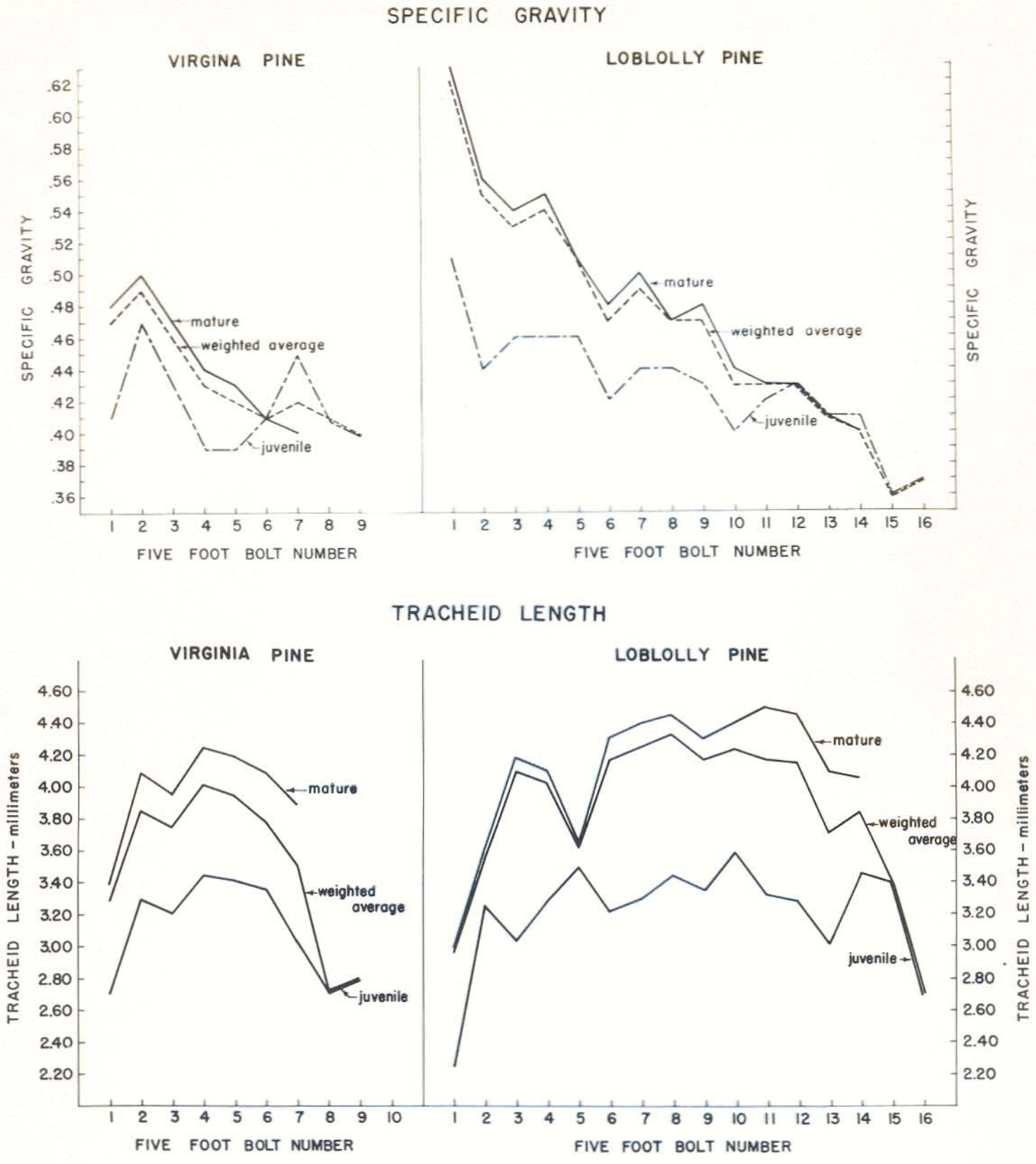
In each Annual Report we have had a central theme featuring some phase of our Cooperative Program. Before starting the Annual Report this year we decided not to have a theme - but after rereading the Introduction it appears the theme has automatically developed.

Yes, the theme is COOPERATION; this has been the best year ever!

SPECIAL FEATURE

What a year for Bob Kellison! He has graded more trees this year than ever before, a total of 298, representing eight species. He has been working on his research for the advanced degree. He has taken full charge of all bookkeeping phases of the Cooperative Program and continues to work with students on the Program.

But I guess all this activity wasn't enough - he was married March 28 to Miss Larita Umphlett, a music teacher in the Raleigh school system. When you receive this Annual Report he will be working and studying in Sweden. Bob was most fortunate to receive the Gunnar Nicholson Grant from the American-Scandinavian Foundation, which will enable him to work and study in Sweden for four months. Plans call for him to work with a number of research stations and several industries during his stay there. These four months will provide some most valuable experience and our Tree Improvement Program will be better for it. Bob returns the first of August, and a short time later I am hoping



Several times it has been necessary to cut select trees for some of the companies. Shown above are data for two of Kimberly-Clark's trees, one loblolly and one Virginia pine, separated into juvenile and mature wood. These trees were growing in the same general geographic area; the graphs allow a comparison of characteristics for these two species at different heights in the tree for juvenile and mature wood.

to make a trip to Australia and New Zealand, depending only on the availability of travel funds. Such a trip will also be most helpful to the Cooperative. (Ed. note: Just think of the potentials if we can combine the "innermost secrets" of tree improvement from Sweden, Australia and New Zealand with our own Cooperative Program.)

FLASH

At last you can relax..... After a battle, the name of our organization has been changed to North Carolina State University at Raleigh. This is a real relief after that "jawbreaker" under which we had to operate previously.

THE NEWSLETTER

At last June's Advisory Committee Meeting, Bob Kellison gave a short report on the first volume of the NEWSLETTER, published in February, 1964 at the suggestion of one member of the Tree Improvement Program. Two additional volumes have since been published. The NEWSLETTER is designed to be a very informal exchange of news and information, with emphasis on persons and small items of interest to members of the Cooperative Program.

The NEWSLETTER, thanks to the hard work and planning of editor Bob Kellison, has been an unqualified success. It was not designed to cover the same items as the Annual Report, but it touched on several items that will also be covered in the current Annual Report. The intended main objective of the NEWSLETTER - that of informally exchanging items of personal interest -

has, with each issue, contained more very solid technical information of real value to the members of the Cooperative. For example, costs, yields, methods and techniques of special value to the Program appear regularly in the NEWSLETTER, and requests for such information are increasing. Thus, though we intend to keep the NEWSLETTER more personal and informal than the Annual Report, there has been occasional overlapping of items covered. We regret this but will, hopefully, keep it within tolerable limits.

MASS PRODUCING IMPROVED SEED

No matter how many studies are made, no matter how basic the research undertaken, we must always remember that one of the primary objectives of the Tree Improvement Program is to produce improved pine seed on a mass basis as soon as possible for members of the Cooperative. Each year in the Annual Report we try to present the most up-to-date information on progress of the seed production program.

Seed Production in Seed Orchards and Seed Production Areas:

One objective of the Tree Improvement Program is in sight. Seed is becoming available in commercial quantities. In the fall of 1964, over 3,000,000 seeds were obtained from the seed orchards. This is, of course, only a "dribble" compared to what is expected in the next few years, but it is enough to plant several thousand acres and we can now consider several of the orchards in commercial production. Even though the crop was considerably reduced by the March 30, 1964 freeze which wiped out many thousands of conelets in several seed orchards, a large increase in seed from the orchards is expected in the fall of 1965. Barring unforeseen accidents, a major increase in seed yield will be obtained in 1966.

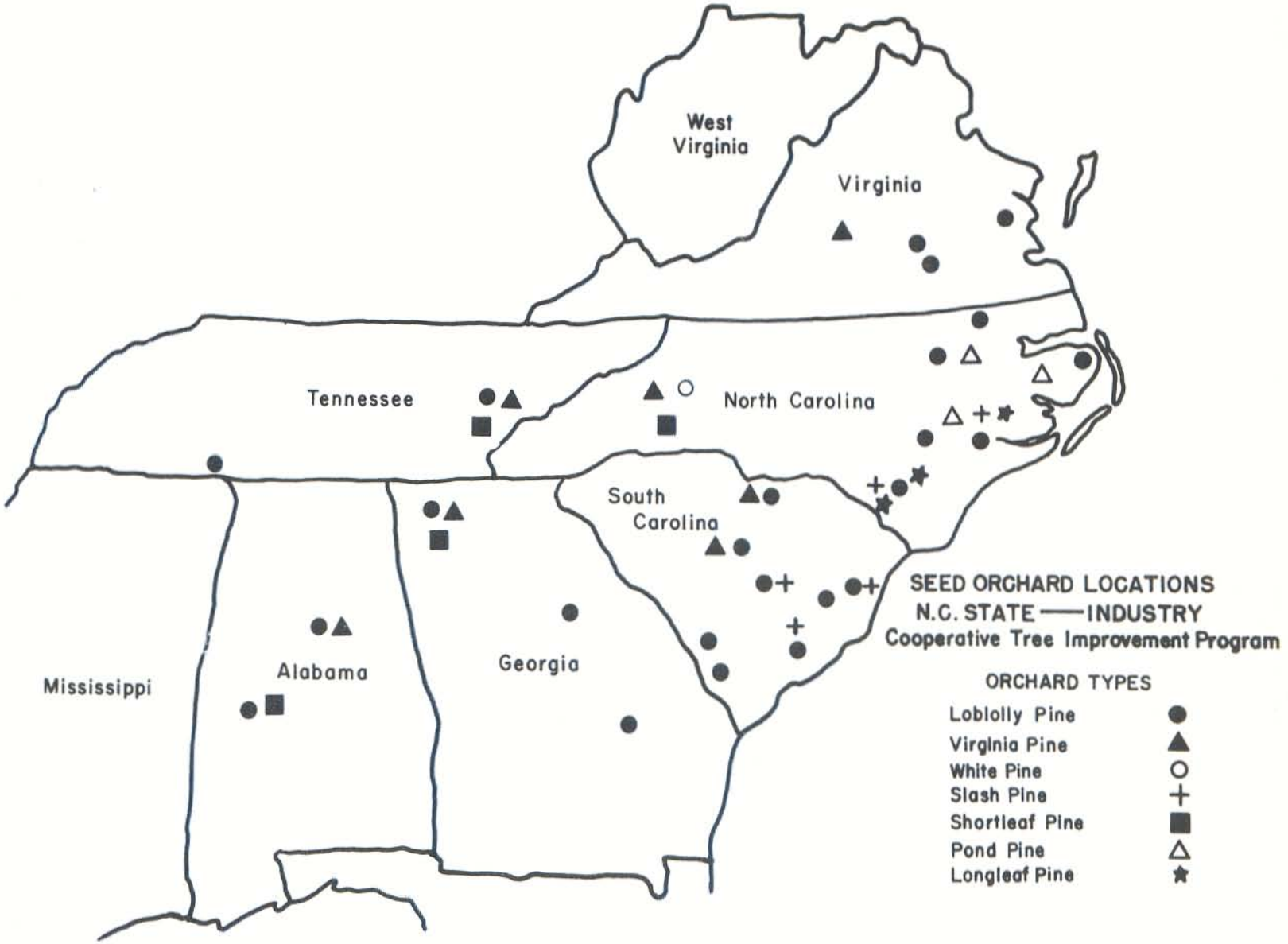
Several organizations are collecting seed from seed production areas. One company collected 17,000 pounds of seed from seed production areas in 1964, and three others collected several thousand pounds. Some of this is classified as certified seed. Good records on costs of seed collection in seed production areas have been kept and, on the average, loblolly pine seed collected by climbing the trees costs about $5 per pound in contrast to slightly less than $2 per pound for seed collected from felled trees in a seed production area. In both seed production areas and seed orchards the yields of seed per bushel have been considerably better than when collected from wild stands.

It is surely satisfying to see the first commercial improved seed becoming available; it represents the beginning of fulfillment of a major objective toward which so much of our collective time and effort has been expended and a solid realization of a result we have been anticipating since the Program was initiated.

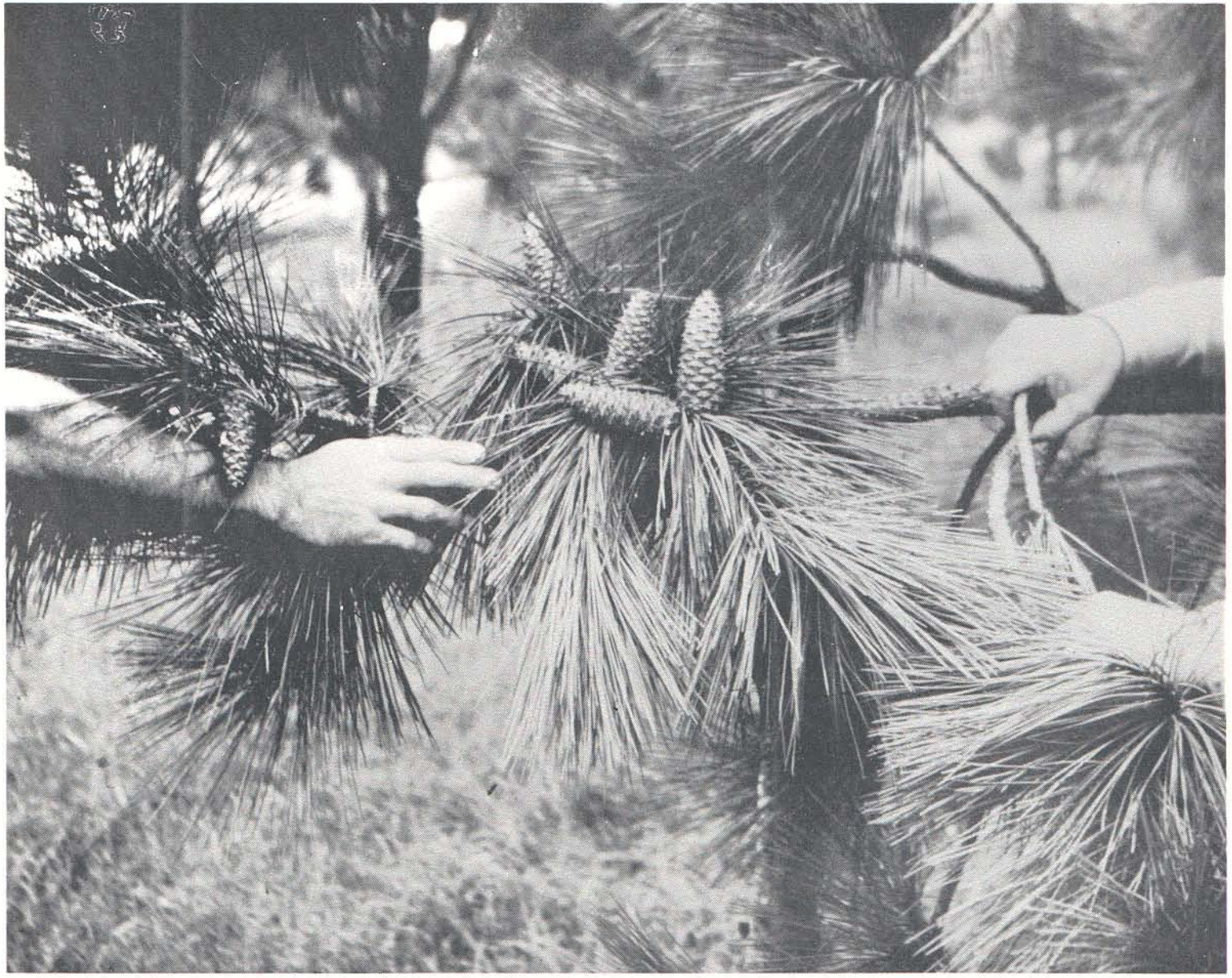
Tree Selection and Seed Orchard Establishment:

Last year maps were included in the Eighth Annual Report showing the location of selected trees for the 18 organizations in ten states which make up the Cooperative. This Annual Report includes a map showing the locations of the current seed orchards. Note that they are located in 24 areas, with 57 separate orchards when divided by species. Many more orchards could be tallied when broken down into geographic area or wood quality characteristics within species.

Below are included up-to-date facts and figures (Table 1) to indicate the current status of the seed orchards as of July 1, 1965. The last column on number of incompatible grafts was included to indicate the seriousness of our number one problem, with approximately eight per cent of the clones showing some degree of incompatibility. This percentage is lower than the actual value because a number of the younger grafts have not yet had the opportunity to develop this trouble. Importance and kinds of incompatibilities were discussed in last year's Annual Report.



General locations of the seed orchards in the Cooperative Tree Improvement Program are shown above, by species. When further divided into wood qualities and physiographic areas, there are over 70 separate seed orchards established. Although a number of these are small (really research orchards), nearly 40 of them are large productive orchards from 10 to 100 acres or more in extent.



Last fall the yields of seed from the seed orchard were good and for the first time could be considered to be in commercial quantities. Cones were large (note those on grafts from Champion's seed orchard) and one man from Albemarle Paper Company, who both fertilized and irrigated his orchard, told me over the phone "They are nearly as large as pumpkins." Tests are under way on yields, seed numbers and size and germination energy from the unusually healthy cones from the seed orchards.

Table 1. Status of Grafts and Seed Orchards as of June 1, 1965

Kind of Orchard	Grafts Made in 1965	Total Grafts to July, 1965	Total Acreage Seed Orchard to July, 1965	Total Trees Graded to July, 1965	No. of 1/ Incompatible Grafts
Loblolly Pine					
Coastal Plain					
High Sp. Gr.	10,947	36,500	308	342	42
Low Sp. Gr., long-fibered	1,274	1,644	38	43	-
Av. Sp. Gr.	2,500	4,900	26	38	-
Piedmont and Mountain					
High Sp. Gr.	11,070	27,720	245	372	35
Low Sp. Gr.	1,580	5,750	30	61	6
Av. Sp. Gr.	1,540	3,000	11	30	-
Total - Loblolly Pine	28,911	79,514	658	886	83
Virginia Pine	6,270	15,710	110	217	13
Slash Pine	5,550	8,743	104	174	20
Shortleaf Pine	955	1,905	18	55	3
Pond Pine	280	860	4	43	9
White Pine	1,775	2,450	26	44	-
Longleaf Pine	2,170	2,170	18	79	-
Total - All Pines	45,911	111,352	938	1,498	128
Fraser Fir (# plants instead of grafts)	36	36	1	36	-

1/ This value is not accurate because the younger grafts have not had time to show incompatibility.

A major problem faced by the cooperating industries is to develop equipment for use in the seed orchards. Some unique equipment has been designed, especially to enable the control-pollinations necessary for progeny testing. There are nearly as many kinds of equipment as there are organizations; one "home developed" rig is shown at the International Paper Company orchard in South Carolina. Several industries have completed the pollinations necessary for progeny testing the seed orchards.

Progeny Testing:

In 1962 approximately 57 control crosses were completed by the industries to test the genetic worth of the selected trees used in the seed orchards; seed of these crosses were planted in one nursery in 1963. In 1964, 204 control-pollinated crosses were planted in three nurseries, while 373 control-pollinated crosses were planted in seven nurseries in the spring of 1965. The necessary pollinations using a four-tester system have already been completed for several orchards of several companies, and the first measurements of the control-pollinated progeny were made in 1964.

In Vol. III of the NEWSLETTER, complete progeny test height data based on the "first year in the field" were reported for Weyerhaeuser's North Carolina "South Coastal Loblolly" seed orchard and also a summary of the results for the "North Coastal Loblolly" orchard. These are recapped again in Table 2, along with results for International Paper Company's Coastal Plains Loblolly Orchard at Georgetown, South Carolina.

Before the reader draws conclusions from the height data listed in Table 2, it is necessary to emphasize that height growth is only one of the characteristics in which we are interested and for which the select trees are chosen. In fact, in importance, it could be relegated into a class of lesser characteristics in tree grading. Improvement of adaptability, bole form, wood qualities and disease resistance are primary considerations in the N. C. State-Industry Tree Improvement production seed orchard activities. Good growth rate of the species concerned is essential, but securing growth rate increase, per se, in the selection program is not of paramount interest. Thus, from our seed orchards we hope to produce trees that grow somewhat faster than our present stands; but what we expect these select trees to have that is not available in abundance from unimproved stands are considerably straighter boles, better form, more

resistance to disease, and better wood. When it is recognized, then, that height growth has not been particularly emphasized, it is most gratifying to find the consistent height differences shown in Table 2. For example, in Weyerhaeuser's North Coastal Orchard, every one of the 22 crosses was taller than the average of the commercial and seed production area checks. This outcome held for both fertilized and non-fertilized tests, for the main and supplemental test. In the direct-seeded test all but two of 11 crosses were taller than the checks.

Such height superiority is especially surprising when it is known that height values at such a young age are easily affected by many environmental factors having little to do with genetics[1/]. In addition, it is known that different trees have different growth curves so an accurate measure of height potential to rotation age is not always evident at an early age. What the height differences and per cent superiorities in Table 2 will mean in future years we cannot say, but the consistent superiority already evident is certainly encouraging.

1/ Size of seed, density of seedlings in the seedbed, handling during planting, depth of planting, local competition from brush and weeds are just a few of the environmental factors affecting height growth at the end of the first year.

Most orchards have flowered well and consistently. Especially pleasing is the large amount of pollen produced in most orchards. However, several orchards have been slow to flower and rather drastic treatments were tried to see if flowering could be induced. Banding with a seedling "binder" was tried by Hiwassee Land Company (Bowaters) on several large, non-flowering grafts. As can be seen, the treatment was drastic - Only time will tell how successful it was.

Table 2. Height of seedlings after the first full growing season in the field, from control-pollinated seed orchard test progeny compared to the checks (the average of seed production area and commercial sources).

Type of Test	No. Lots Represented In Main Test	Fertilized Main Test	Non-Fertilized Main Test	Total[1] Main Test	Supplemental[1] Study	Direct-Seeded[1]
SOUTH COASTAL LOBLOLLY - WEYERHAEUSER						
Check lots	2	1.43	1.11	1.27	1.58	0.49
Control Crosses	22	1.69	1.28	1.49	1.79	0.58
% Super. of Crosses		19	15	18	14	19
NORTH COASTAL LOBLOLLY - WEYERHAEUSER						
Check Lots	2	1.63[2]	1.38	1.50[2]	1.51	0.37
Control Crosses	21	1.65	1.51	1.58	1.78	0.45
% Super. of Crosses		1	11	6	17	21
COASTAL LOBLOLLY - INTERNATIONAL						
Check Lots	3	-	1.21	1.21	1.34	-
Control Crosses	14	-	1.35	1.35	1.48	-
% Super. of Crosses		-	12	12	11	-

1/ Test design consists of six replications of ten trees each on the main tests, three replications of ten trees each in the supplemental and direct-seeded tests.

2/ One replication of the fertilized commercial checks was much larger than all other lots, but the other two replications were smaller than the control crosses. The reasons for this are not known.

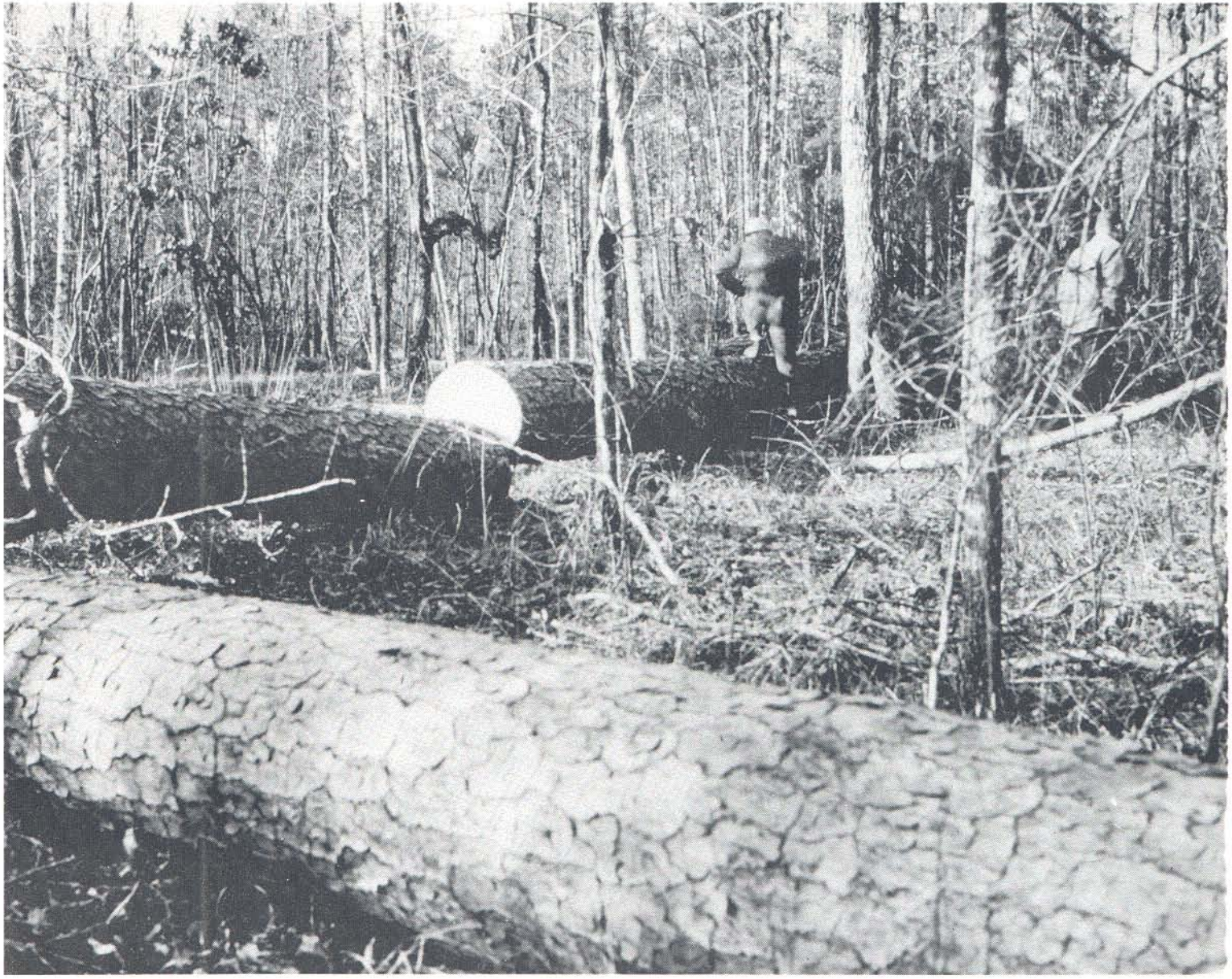
Species Emphasis:

Loblolly pine is the species on which our main activities continue to be centered, but the initially slow move toward greater emphasis on other species has speeded up sharply during the past year. This change in species emphasis has been centered on the following:

1. Longleaf pine. Last year we reported making a start on longleaf pine for two organizations. By now over 75 longleaf pine trees have been graded for three organizations, and two others will start longleaf programs in 1965. This species is fun to grade - Its form is good, and some very beautiful trees have been located[1/]. Last year's trials (several hundred grafts) show this species can be successfully grafted and establishment of several good-sized seed orchards is now under way.

2. Virginia pine. Interest in this species, often considered a weed by foresters, has been building steadily for the past several years. Seven companies have work under way with Virginia pine, and already nearly 150 trees have been graded. Several Virginia pine seed orchards are producing usable quantities of seed despite initial difficulties with some grafts, presumably caused by extreme or unusual cold. Virginia pine is a difficult species with which to work. Outstanding phenotypes are hard to find, although intensive search by the organizations of the Cooperative Program have turned up some genuine beauties. Grafting is difficult, both because of the size of scions and because the grafts mold easily. This species has one major advantage - it bears cones early and heavily, even as seedlings. This characteristic has made it possible for us to judiciously combine seedling and vegetative orchards to obtain the best results in the shortest period of time.

1/ I was startled to look at the grading sheet of one of the trees graded by Bob Kellison to find this comment in the "Remarks" column: "Use! Use! Use! The Mary Pickford (of trees) of 1965." I doubt if Bob ever really knew much about Mary Pickford (at least in her prime) but the meaning of the message got across.



Many people do not think of our southern pines as producing big timber. A few stands are even now being logged, such as the one shown in Southern Woodlands, American Can Company (the former Allison Lumber Company), that have beautiful timber. Replacements of such stands with improved seedlings is one of the main objectives of the Tree Improvement Program.

3. Pond pine. Two seed orchards of this species have been established, and two other organizations are initiating programs with it. Although few trees were graded during the past year, it is anticipated a number of select trees will be located next year. Wood qualities of this species have been more completely studied than in the past and appear to be quite suitable for pulpwood, being not too different from loblolly pine grown on similar sites.

4. Fraser fir. The first selections of this species were made this year, and 36 trees were accepted. The purchase of these from private landowners on whose land they were grown has been worked out and a seed orchard has been established near Hendersonville, North Carolina. The objective of establishing a seed orchard of this species is to provide a source of seed for Christmas trees as well as to help preserve the species from the balsam woolly aphid.

General Comments:

In last year's Eighth Annual Report we emphasized some of the difficulties encountered in the applied seed orchard program. These troubles are still with us and occasionally create considerable inefficiency. Cold damage has been bad in certain orchards, and incompatibility and the "unknown" fluting is ever present, although the fluting appears to be spreading little, if at all. Some reorientation in methods had to be made, especially when freeze damage occurred. For the second straight year we have escaped major disasters from tornadoes, hurricanes and ice storms. It does not seem possible that all sixty seed orchards, located in six states, could escape serious damage. But they have - Bob and I watched with disbelief as two hurricanes wound in and out around the seed orchards but never damaged any badly. A severe hailstorm came to within about one-half mile of one of the most productive orchards and stopped; similarly, ice storms started but the temperature rose just enough so the freezing stopped before serious damage occurred. We must expect an occasional disaster - the

scatter of so many seed orchards over such a wide geographic area makes it inevitable. But we watch, we worry and we hope, and so far we have been lucky. This watchful concern continues here; frequently I carry it home with me - so often, in fact, that my wife has started referring to the seed orchards as "your children."

STUDIES ON WOOD QUALITIES

In last year's Annual Report we stated "Investigations on wood properties have increased in tempo and depth, surpassing the activity in any preceding year." One year ago none of us had an idea just how much wood studies would be additionally intensified. A reasonably complete description of wood research carried on by us as a regular part of the Cooperative Program, and related studies done by the cooperative industries themselves with only minimal help from us, would easily make up a whole report ty itself. In addition to studies on wood variation, inheritance and the effects of environment, several additional projects have been started involving wood qualities as related to properties of the final product. These are investigations being done both by individual industrial groups and through cooperation of several industries joining together, working closely with the Wood Sciences Department of the School of Forestry at N. C. State.

Current research in which we are directly involved deals not only with specific gravity but also with tracheid length, moisture content, resin content, cellulose yields, and compression wood percentage. Relationship of these and actual pulp yield and quality are being determined in some cases directly by the industries or by means of industry-N. C. State cooperation. One study even involves the determination of knot volume, compression wood associated with

Large, intensive wood studies are under way by a number of industries. Pictured is a high sensitivity electric balance specially adapted to field studies by Continental Can Company. Also shown are the disks from one of their several hundred intensively sampled trees, used to determine the relationship between breast height and total tree values.

knots and fiber qualities of "typical" compression wood, moderate compression wood and compression-free wood at comparable locations in the same tree. Already, as a result of all the activity we have information enabling us to handle problems involving wood qualities more intelligently, but there still is a great need for more solid information. During 1965-66 several studies, now essentially completed, and in the calculation and manuscript stage, will be published. Some of these studies were described in detail in the preceding Annual Report.

Rather than repeat descriptions and objectives of the numerous individual research projects, we thought it would be of interest to summarize, as a group, the six general objectives of all the wood studies combined.

1. Most of the wood studies are designed to supply information necessary to maximize the dollar yield per acre of timber grown. Knowing maximum volumes of wood produced is not enough; as a result, the several studies have been so designed to give information on the maximum dry wood weight yields per acre, requiring the construction of dry wood weight yield tables. But even then a knowledge of the dry wood produced per acre is not sufficient because the quality of the wood must also be included. This information is then combined with economic considerations of interest rates and initial investments to determine the harvest or rotation age. To put it somewhat differently, the objective of most wood studies is to obtain the biological information necessary that will enable the company to obtain maximum dollar returns on their investment by proper harvesting.

2. A management decision of great practical importance is the allocation of the best species on available resources of soil-sites. Many such decisions in the past have been based simply on personal preference or, at best, on volume yields. Often wood yield considerations that might have been included in

the decision making were based on data obtained from trees of species grown under conditions not susceptible for making valid comparisons. This has led to some incongruous results and gross errors. Fortunately, current studies will soon be completed for several species growing on the same sites, of the same age, and about the same stocking, making valid comparisons possible. Some surprising and important results have been obtained.

3. There has been considerable effort to answer the questions as to the importance of certain wood qualities when related to the pulping conditions and product of the company concerned. Such tie of gross wood quality characteristics with pulping yields and qualities is one of the most significant developments during the life of our Cooperative Program. We in the Tree Improvement Program have neither the facilities, money, nor know-how to undertake such research directly but we cooperate by supplying trees and our growing backlog of information. Cooperative research with the Wood Science and Technology Department at N. C. State has made possible expanded studies in this most important area.

4. Information is necessary on the effect of age, site, spacing and geographic region on wood qualities and yields. Several studies under way will give such information, enabling more intelligent decisions on the part of the forest manager.

5. Data on intensity of inheritance on several wood qualities has been obtained. This information is vital in planning the wood quality criteria for trees to be used in the seed orchards. Tracheid length in pines appears to be the most strongly inherited, but specific gravity has a strong enough inheritance component to give gains of real economic value.

6. Determination of the relative yields and value of wood obtained from different parts of a tree is the objective of several studies. For example,

how good is top wood, how small in diameter can one go and still get a reasonable return on the cost of harvesting, what kind of paper is produced from young thinnings, etc. Each of these questions ties directly to rotation ages and utilization standards, which, in turn, affect planning in the Tree Improvement Program.

In summary, then, one of the most gratifying and useful developments related to the Cooperative Tree Improvement Program is the very great increase in interest in wood properties and the desire of the industry to take steps necessary to do something about it. Wood studies of any kind are expensive - this is particularly true when information is needed on species, stands and geographic areas, requiring analyses of a substantial number of individual trees. The cost further magnifies when the wood qualities are related to pulp qualities. With this final step the knowledge available about wood can then be translated into yield and economic return figures.

SPECIAL STUDIES

Many research projects in addition to those on wood are undertaken by the industries in cooperation with N. C. State or by graduate students at N. C. State, financed from industry or other grant funds. These studies are usually done on industry lands with the aid of the industrial foresters. The various research projects and resultant publications were listed in the Sixth Annual Report (1962), so only a few of the newer ones will be specially noted here.

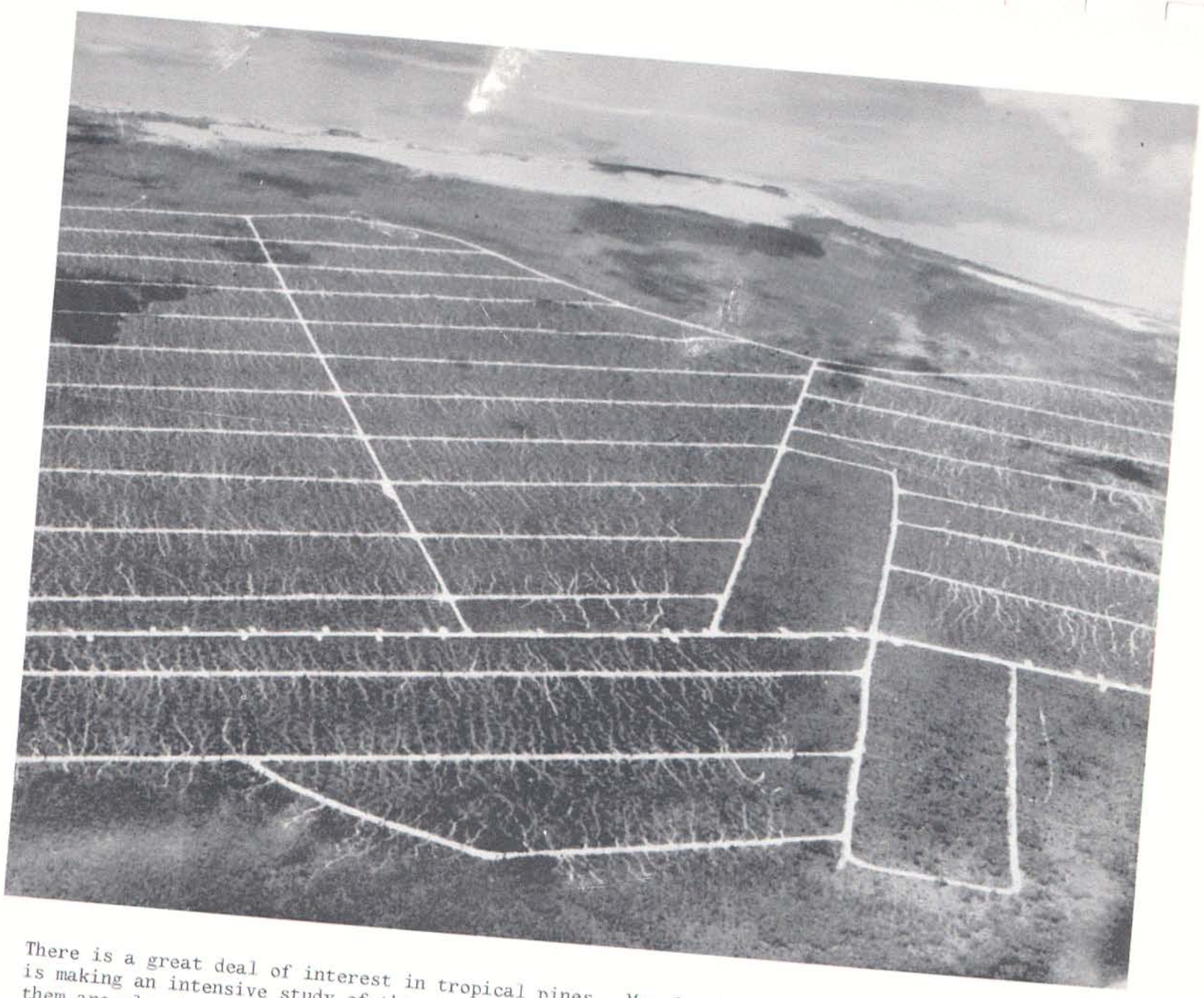
1. Mr. John Kundt has started a research project for his Master's and Ph. D. Degrees on geographic variation and inheritance patterns of selected characteristics of Virginia pine in the southern portion of its range. The variation phase will be in cooperation with several organizations working with

Virginia pine and the inheritance study will be done on trees from the Kimberly-Clark seed orchard. John's research will be closely related to the Tree Improvement Program and will be directed by Dr. Jack Duffield. Results of such research on Virginia pine will be of great value to the seven organizations who consider this of importance in their management operations.

2. A study of the genetic structure of a natural population of loblolly pine and the effects of selfing is under way by Mr. Carlyle Franklin working with the Cooperative Program and Dr. Gene Namkoong, a specialist in quantitative genetics and a U. S. Forest Service employee stationed at Raleigh. Part of the necessary crosses for Carlyle's research are being done on lands of Albemarle Paper Company, and the selfed and outcrossed material will be planted at their research area near Tillery, North Carolina.

3. A four-year research project on the extent and importance of natural hybridization between loblolly and pond pine will be completed within the next year. This study is being done as the Ph. D. research project of Mr. Ke Won Kang under the direction of Dr. Saylor. Natural hybridization between these two species is common and the hybrid and pond pine are much more widespread than previously reported, having been located on some of the driest sites in the Piedmont and Coastal Plains. It is rather startling to find this species, commonly considered to be restricted to wet sites, on such high, very dry sites. Results of this study will show differences and similarities among pond pine, loblolly pine and the hybrid when growing under the same environments. One of the characteristics to be studied is wood quality.

4. Within the next several months a thesis by Mr. Ron Woessner will report results of open-pollinated progeny tests for five of the industries. Ron's main effort is to determine how to measure form characteristics most efficiently, and his results will be used as a guide for measurements on the control-pollinated



There is a great deal of interest in tropical pines. Mr. Garth Nikles from Queensland, Australia is making an intensive study of the pines of the Caribbean. The logging roads and skid roads to them are clearly shown in this aerial view of logging Pinus caribaea from the Bahama Islands. Species grown under these tropical conditions have a lot of potential throughout conifer-poor areas of the tropics throughout the world.

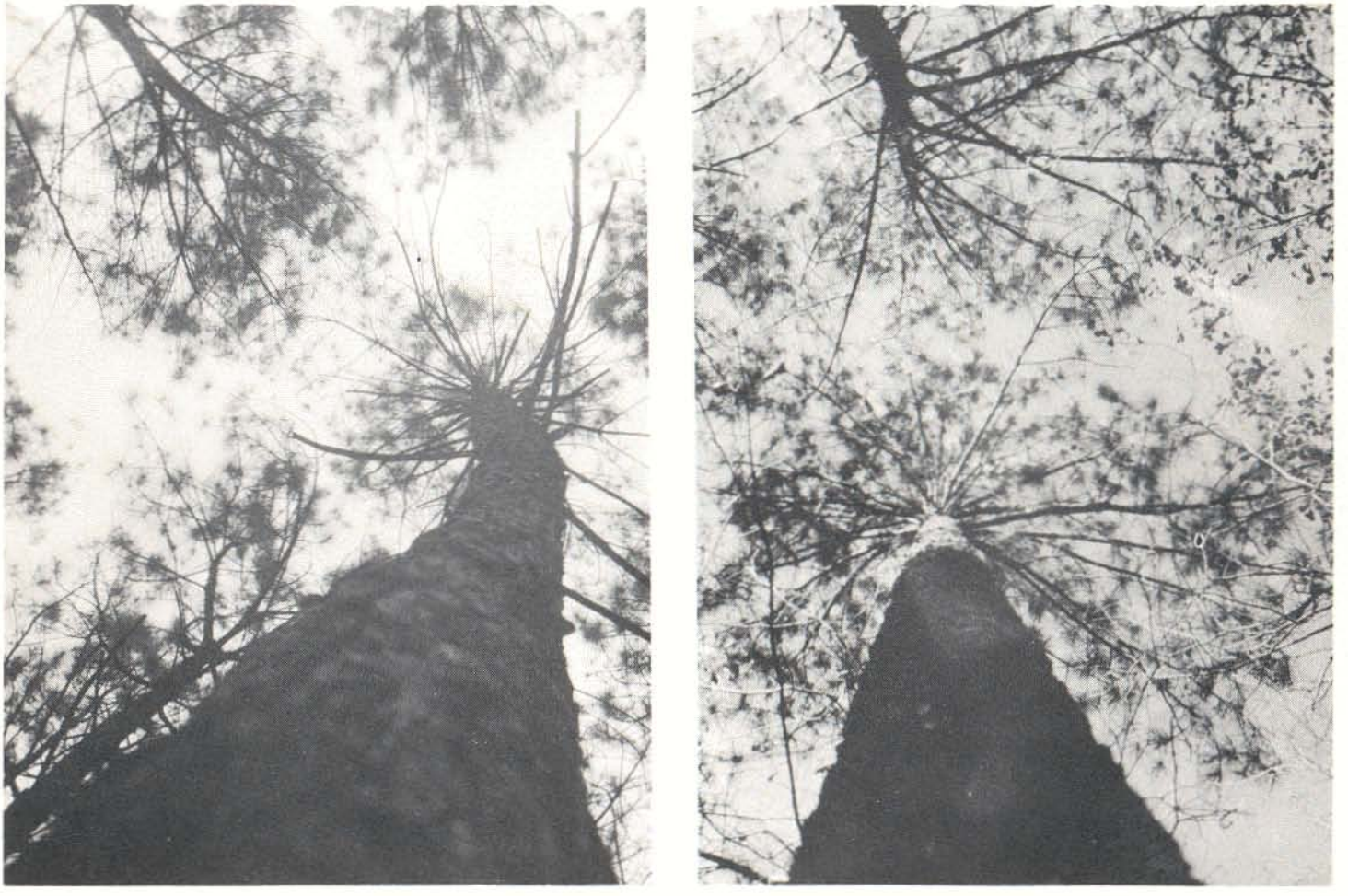
Studies on tropical and subtropical pines are becoming increasingly important. Above are shown a number of lots of Pinus caribaea from various islands in the Bahamas as well as South Florida slash and North Florida slash. Mr. Garth Nikles, who is undertaking a study of the pines of the Caribbean, has found considerable differences between the different islands. Since this material is susceptible to freezing it will be outplanted in South Central Florida.

progeny. He also has completed the necessary wide crosses among loblolly pine, such as the Virginia source crossed with North Carolina, Tennessee source crossed with North Carolina, Texas and Louisiana sources crossed with North Carolina, for his Ph. D. research. One objective of these studies, guided by Dr. Namkoong, is to determine if extra (hybrid) vigor might be found among such wide crosses and to develop a broad gene pool from which future selections will be made.

5. Both Dr. Saylor and I visited the Bahama Islands with Mr. Garth Nikles from Queensland, Australia to obtain specimens of Bahama slash pine (P. caribaea) for Garth's Ph. D. study of the Caribbean pines. This study will be completed in a little more than a year and includes wood properties among several other characteristics. Since P. caribaea is easily damaged by cold it was necessary to grow the progenies in the greenhouse at Raleigh and then outplant them in southern Florida. Other plantings of this material have been made in Queensland and in Brazil.

6. Accurately categorizing bole straightness of trees has been difficult and has usually been done by subjectively listing the trees as straightness class 1, 2, 3, 4, etc. Mr. Tony Shelbourne, who recently has been employed by the Forest Research Institute of New Zealand, has developed a unique and accurate method of measuring straightness. He will relate straightness to compression wood content of the tree, using trees harvested as part of the Continental Can wood study. He also is categorizing knot size, knot volume and compression wood volumes for a few trees as a guide to just how much effect knot size has on wood quality of a log for pulping.

7. One study on inheritance of resistance to fusiform rust has been completed by Mr. Bro Kinloch. A continuation of this research, part of his Ph. D. dissertation, should yield valuable data on how much gain can be expected by



The effect of crooked tree bole on wood qualities is of a great deal of importance. Preliminary studies have indicated considerable differences between the straight and crooked loblolly pines shown above. The effect of crook on compression wood formation and wood is being intensively studied. One of the graduate students, Mr. Tony Shelbourne, has developed a method to accurately measure the crook and sweep of the trees as shown. This will enable us to put more meaning to our subjective estimates of progeny straightness.

selecting for resistance to this disease, considered the most destructive on the southern pines. These studies are underwritten by the industry-financed Insect and Disease Research Council and are jointly directed through the School of Forestry and Department of Pathology.

8. For three years Mr. Sam Land has been investigating salt tolerance of loblolly and pond pines to determine if selection for this character is feasible. The preliminary studies, done under a National Science Undergraduate Research Participation Grant, were done while he was an undergraduate student at N. C. State. Sam was recently awarded a NASA fellowship and it is hoped he can continue and intensify this research for his graduate degree.

9. Variation patterns in natural stands of sweetgum and yellow poplar have been under investigation by Jim Roberds and Bob Kellison, respectively. These studies are both initial phases of their research projects for the Ph. D. Degree. Results on the first phases will be published within the next several months.

10. In July Mr. Hatakeyama from Japan will make a study on phases of quantitative genetics as related to population structure, in consultation with Dr. Namkoong and members of the quantitative genetics faculty at N. C. State. His grant, awarded by the National Institute of Health, will enable him to do research at N. C. State for a year. In addition we are in the "talking stage" about two other non-degree or postdoctoral students, financed by granting agencies or the home country of the man concerned. Such persons make a real contribution to the Tree Improvement Program because they are here to do research on problems of interest to us and they are not hampered by the requirement to take specified course work.

11. Two students from Mexico, Mr. Miguel Caballero and Mr. Jesus Jasso, financed by the Rockefeller Foundation and FAO, respectively, are working under

Studies of root development and inheritance of root characteristics are badly needed. Early results on inheritance of root characteristics will soon be published in the cooperative quantitative genetics studies jointly undertaken by N. C. State and International Paper Company, partially financed by the National Science Foundation and the National Institute of Health. Shown are 100-day-old seedlings of loblolly pine from different sources but grown under identical conditions. The tree with heavy roots is from a droughty Piedmont source; the one with poorer root development is from a moist, Coastal Plain source.

the direction of Dr. Saylor. Mike's research deals with the complex of pines including P. montezumae and P. pseudostrobus. An intensive study of these species is badly needed, both by foresters in Mexico and those using these species in a number of places throughout the world.

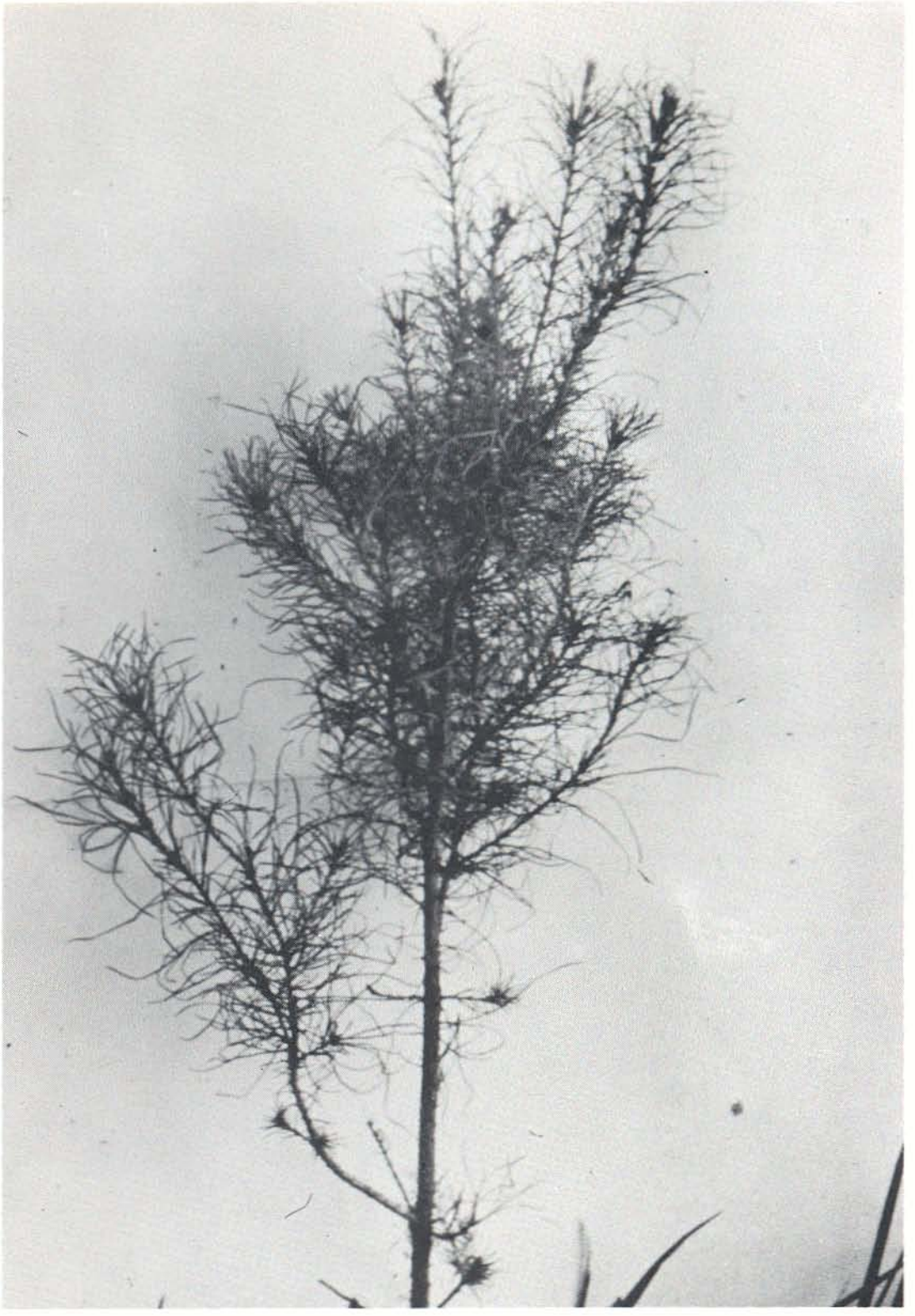
In addition to the studies specifically listed above, several Ph. D. students are in the final stages of developing their programs or have completed their research. These will be listed in the Publications section.

THE COOPERATIVE QUANTITATIVE GENETICS STUDIES

Each Annual Report has reported progress on the large basic studies on loblolly pine cooperatively undertaken by the International Paper Company and the Tree Improvement Program. For the past five years a portion of this research was financed by the National Science Foundation. As of January 1, 1965, financial support was underwritten by the National Institute of Health and the research is continuing as planned without any disruption.

The last field planting of the 55 male groups (control-pollinated seedlings) was made this year. The older male groups were measured - part of this was done by 13 faculty and graduate students from N. C. State going to Bainbridge for a week to help the IP personnel. The open-pollinated seedlings, now five years in the field and many of them 15 to 20 feet tall, have been measured and analyzed for certain characteristics. Grafting of the parent trees used in crosses for the heritability studies was started this spring, with 40 of the parent trees having been completed.

Several papers have been published based on the cooperative quantitative genetics studies. Four more will be completed within the next year. The first major results of this long-term basic research will be published as Mr. Roy



It is very important to locate genetic markers to make possible basic genetic studies. A number of loblolly pines with curly needles have been found by Roy Stonecypher in progeny of the Cooperative International Paper Company-N. C. State Heritability Study. Finds such as this may make possible a rapid speed-up in basic studies.

Stonecypher's Ph. D. dissertation, which will pull together the statistical methods and designs employed, the analyses used, the IBM program developed, and the inheritance patterns for several characteristics, setting the stage for future critical analyses of other characters. After finishing the requirements for the degree at N. C. State, Roy was employed at the Southland Experiment Forest of the International Paper Company, where the quantitative genetics research is being continued. In addition to Roy's major publication, another important one on the inheritance of cellulose, will be partially based on the cooperative quantitative genetics studies. A manuscript has been prepared on inheritance patterns in roots of seedlings, based on progeny from the quantitative genetics study. An additional paper is in preparation on resistance to fusiform rust, also based on trees under study in this project.

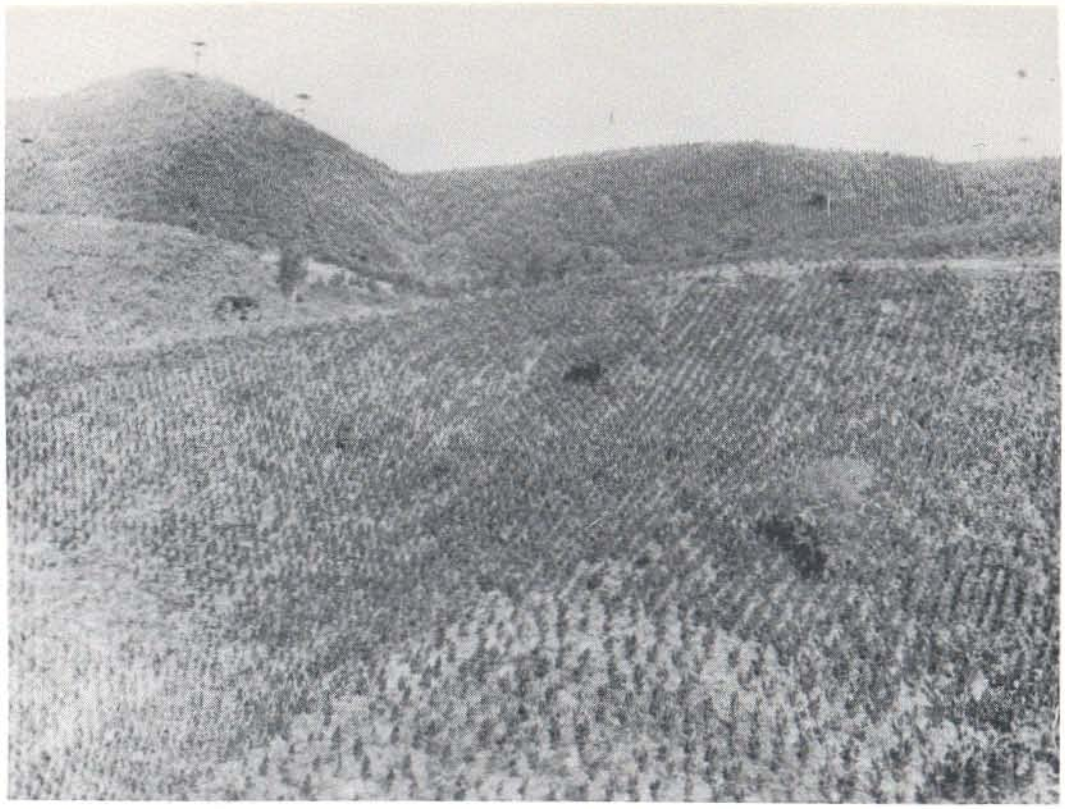
This basic research project on quantitative genetics has developed beautifully, and results have already had an impact on our planning of the industry programs. It has become recognized worldwide and is a "type" example of the theme of cooperation. Dr. Charles Driver and members of his staff at the Southland Experiment Forest at Bainbridge, Georgia, with the research and help of faculty and graduate students at N. C. State, and with the financial aid of the National Science Foundation and now the National Institute of Health, have under way research that will have a profound effect on forest genetics wherever it may be used.

PINES IN SÃO PAULO, BRAZIL

Last September I was asked to make a brief trip to Brazil to observe and advise on the use of southern pines in the State of São Paulo, Brazil. This proved to be a most interesting and informative trip. The growth rates were impressive indeed, and the current planting program is very large, with approximately 100,000,000 trees having been planted during the past three years. The need for conifer timber by industry is very great. It was my impression, based on this brief visit, that our southern pines will do well in the southern part of the state and in the higher elevations but must be used with caution in the winter drought areas in the low elevation, more northerly areas of the state. Some personal observations on the trip were given in Vol. III of the NEWSLETTER, and talks on growth potential in this area have been given to several groups of members of the Tree Improvement Program. There is absolutely no doubt about the productive capacity and bright future of this region as a major producer of pine and Eucalypt timber.

PERSONNEL

There has been one major addition to personnel working directly with the Tree Improvement Program. Mr. Jim Roberds, who has been doing graduate work on statistical and quantitative genetics phases of the Program, has been hired as full time liaison geneticist. Jim will thus work directly with Bob Kellison and me. He will be assigned mostly to statistical phases, designs and analysis, but will do some tree grading and will work closely with the progeny testing phase of the Program.



Planting of exotic pines is being done on a large scale in a number of tropical areas. Shown above is a large plantation of slash pine in the mountainous area of São Paulo, Brazil where the species grows beautifully. Also shown is a plantation of the same species in the drier, more northerly part of the same state, showing an unusually heavy development of side branches, causing rough, poorly formed trees. Growth rate in both areas is very rapid. Getting the correct species on the correct site presents a major problem.

The laboratory is really humming. Four full time employees are working on wood analyses; and along with the several graduate students, a number of temporary employees are being used. Two persons spend most of their time on secretarial and office work. The laboratory force is extra large at present because of the magnitude of the cooperative wood studies under way. Certain phases of the largest studies are being done in our laboratories on a cost basis but the smaller studies are being done as a part of our regular Tree Improvement Program.

Dr. T. E. Maki, under whose general administration the Program operates, and who makes recommendations when soil and fertilizer are involved, will be on leave from N. C. State for a year, working and studying in Finland on a Fulbright Fellowship. We wish him luck and look forward to his return.

We are very unhappy to report that Dr. Arthur Kelman will be leaving N. C. State. He has been a most loyal supporter of our Cooperative Program and has given us an untold amount of help and guidance. He leaves to become head of the Pathology Department at the University of Wisconsin. We wish him luck and give him a vote of thanks for all his help. He will be replaced by Dr. Ellis Cowling from Yale, and we look forward to continued close cooperation with Ellis and his staff.

Dr. H. F. Robinson, who has been such a staunch supporter of the Cooperative Tree Improvement Program, has moved up at N. C. State and is now Dean of Research, N. C. State University. We hope that despite this promotion we will still be able to call on him for his help and advice. Our working relations with the Agricultural Experiment Station, under which our program is administered, continue to be excellent.

Dr. H. A. Stewart continues to help guide the programs under way. We have had unusually good cooperation and a number of joint research programs with the Department of Genetics, headed by Dr. T. J. Mann.

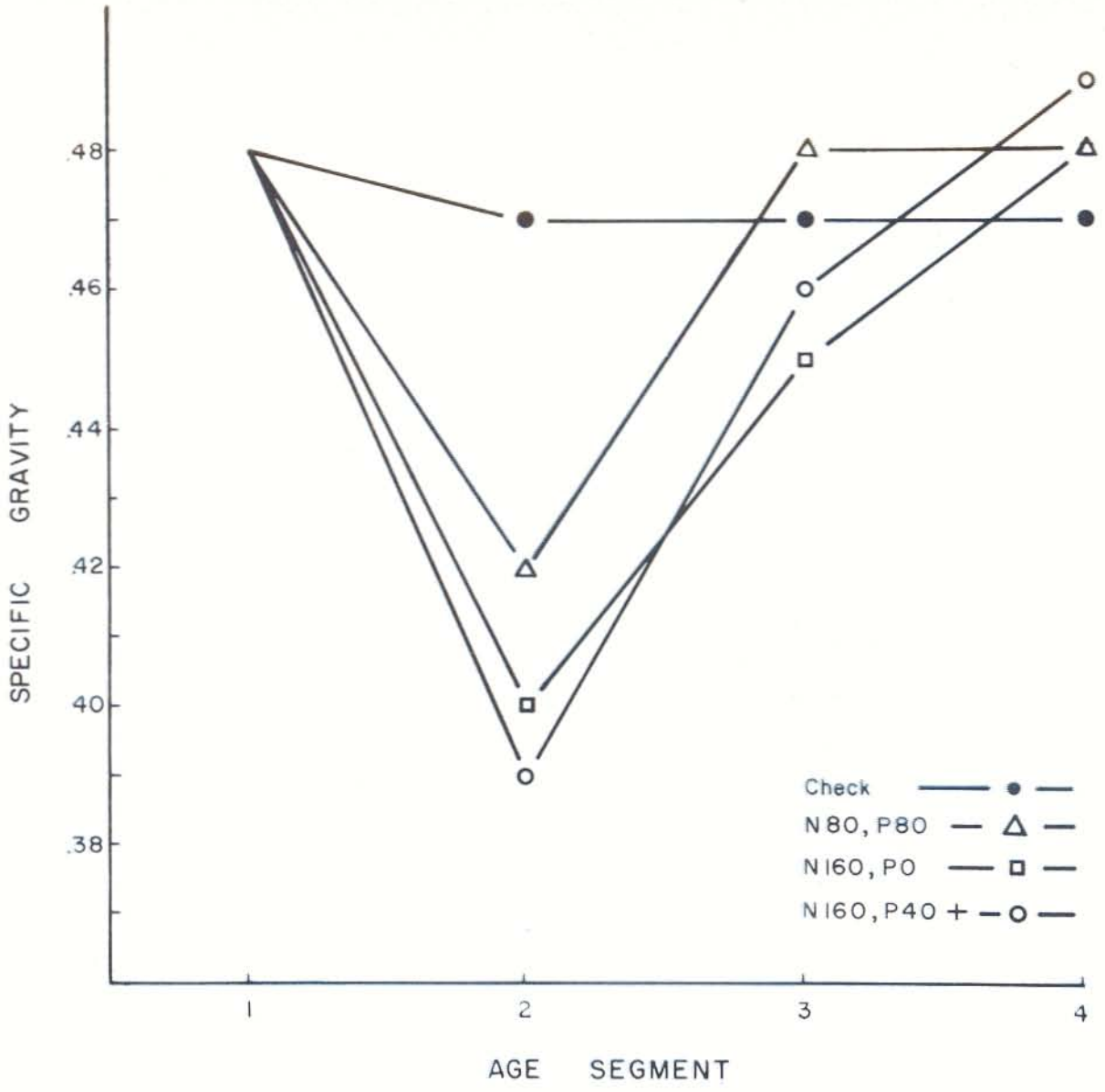
The whole organizational "setup" in the School of Forestry points up strongly the theme of cooperation. It is only through joint appointments that it has been possible to get the great depth into our Cooperative Program. For example, we can draw on (and do so liberally) the following men who hold joint appointments with the School of Forestry and departments in other schools at N. C. State:

Name	Joint appointment with
Dr. C. B. Davey	Soils
Dr. M. H. Farrier	Entomology
Dr. E. B. Cowling	Pathology
Dr. L. C. Saylor	Genetics
Dr. G. Namkoong	Genetics
Dr. A. W. Cooper	Botany
Dr. J. W. Hardin	Botany

PUBLICATIONS

Each annual report lists publications from the past year, either done by members of the Cooperative Program or of special interest to members of the Cooperative. Copies of these are either routed to members of the Program or are sent to each organization for their files. We feel one of our major services to the Tree Improvement Program is to help keep the members up to date on the newest and best publications, which we do via the medium of the Annual Reports and the NEWSLETTERS.

Below are listed publications made during the past year by faculty, students, or members of the Tree Improvement Program as a direct result of funding



Age Segment 1 = Before Treatment (1949 + 1950)
Age Segment 2 = During Treatment (1952 + 1953)
Age Segment 3 = After Treatment (1955 + 1956)
Age Segment 4 = After Treatment (1958 + 1959)

One of the more significant, recent publications is the one (Tech. Rept. #22) by Dr. Clayton Posey on the effect of fertilizer on wood quality. Note how drastically specific gravity was reduced by fertilizer (on 16-year-old loblolly pine) immediately following its application, but how, after eight years, the fertilized trees had higher specific gravities than the check trees.

by the Cooperative Program, or publications from N. C. State of special interest to members of the Cooperative Program although financed by funds outside the Cooperative Program.

PUBLICATIONS

1. Barefoot, A. C., Hitchings, R. G. and Ellwood, E. L. 1964. Wood characteristics and kraft paper properties of four selected loblolly pines. Tappi 47(6):343-356.

   This study, made by members of the Wood Sciences Department at N. C. State in a study financed by the International Paper Company, is of great interest to members of the Cooperative Program. In fact, the trees used for analysis were parents in the Cooperative International Paper Company-N. C. State Quantitative Genetics Program. Results indicated the importance of various wood and tracheid characters in the determination of pulp and paper qualities. They reported wall thickness of summerwood tracheids was of great importance.

2. Byrd, V. L. 1964. An investigation of the effect of wood chemical constituents on kraft paper properties of four selected loblolly pines. MS Thesis, N. C. State, School of Forestry. pp. 1-113.

   This is a companion study to the one of Barefoot, et al. listed above and deals with the chemical phase of the research. Byrd reported good relationship between chemical constituents of the wood and paper qualities, but these were not as good as those of certain tracheid morphological characters. He found a high degree of relationship between chemical and morphological characteristics of the tracheids of the wood.

3. Castillo-Z., Jaime. 1964. Analysis of the yield of some coffee varieties grown in Colombia and Brazil. MS Thesis, N. C. State. pp. 1-84.

   This study on coffee was made by a graduate student sent here by his government. Although the results are of little direct application to the Tree Improvement Program, the methods developed were very good and should prove helpful.

4. Duffield, J. W. 1965. Some influences of genetics on the thinking of foresters. Forestry in Science and Society, University of California, Berkeley. (In press)

   Dr. Duffield was asked to be the keynote speaker at the anniversary meeting at the University of California, to summarize the relationship of genetics to the field of forestry.

5. Duffield, J. W. 1965. An evolutionary view of wood. Seminar on genetics and wood quality. Oregon State University, Corvallis. (In press)

   At the seminar on genetics and wood quality, Dr. Duffield prepared a paper, philosophically oriented, on wood, its origin and why it has the properties it has. This was prepared as a background paper to the several papers presented at the wood seminar.

6. Franklin, C. 1963. Drought resistance in loblolly pine (Pinus taeda) seedlings at ages 0 to 3 months. Mimeographed student report. pp. 1-29.

   Mr. Franklin experimented for two years trying to determine a satisfactory method for testing drought resistance of newly germinated seedlings to see if there were differences between deep sand and clay sources, between Piedmont and Coastal Plain sources. Real differences were found, but the greatest differences were by individual tree within sources. A continuation of this most important research is not now under way but it should be continued. A study of this type will yield information of vital importance particularly to those companies practicing direct-seeding.

7. Kinloch, B. B., Jr. 1964. Evaluation of resistance to fusiform rust (Cronartium fusiforme) in loblolly pine (Pinus taeda). MS Thesis, N. C. State School of Forestry and Department of Pathology. pp. 1-62.

   Kinloch's study on Cronartium dealt mainly with techniques to effectively infect pines under test. His results showed a small difference, under conditions suitable for maximum infection, between open-pollinated families from infected and non-infected parent trees. A copy of his thesis has been routed to the cooperators in the Tree Improvement Program.

8. Ledig, F. T. 1965. Genetic differences in relative growth of shoot and root systems in Pinus taeda L. seedlings as measured by the shoot-root ratio and the allometric formula. MS Thesis, N. C. State School of Forestry.

   Ledig's study, under the direction of Dr. Perry, was an early step in the determination of genetic control of physiological characteristics. He is continuing work of this nature, using some crosses from the Cooperative Program as his experimental material.

9. Perry, T. O. 1964. Soil compaction and loblolly pine growth. Tree Planters Notes.

   Observations on the effect and importance of soil compaction on tree growth were listed and discussed.

10. Posey, C. E. 1965. The effects of fertilization upon wood properties of loblolly pine (Pinus taeda L.) Tech. Rept. 22, School of Forestry, N. C. State. pp. 1-59.

This study is a major contribution to our knowledge of wood and how it is changed by fertilization. It was done in cooperation with Dr. Maki, using trees and plots of his long-term study of the effect of fertilizers on growth of loblolly pine. Copies of this report, a summarization of his thesis, have been sent to each of the cooperating organizations.

11. Saylor, L. C. 1964. Karyotype analysis of Pines - Group Lariciones. Silvae Genetica 13(6):165-170.

For several years Dr. Saylor has had a continuing research project to determine information about the cytogenetics of the Genus Pinus. This is another paper in the series, which reports results for the Group Lariciones in which he found a variation from the "standard" karyotypes in the genus. This study is partially financed by a National Science Grant.

12. Saylor, L. C. 1965. Meiotic irregularity in the genus pinus. Submitted to Amer. Jour. Botany.

A survey of meiotic irregularity in a number of hybrids between species and the parents of the hybrids to get additional information on chromosomal structure is reported. This promises to be one of the classic papers on cytology of the pines.

13. Schmitt, D. & Perry, T. O. 1964. Self-sterility in sweetgum. For. Science 10:302-305.

This paper is a summarization of the Ph. D. research by Dr. Schmitt and studies by Dr. Perry and him. They found that sweetgum is relatively self-sterile or self-incompatible. They classified the reproductive stages in this species, making possible more intensive, complex genetic studies and breeding research.

14. Stonecypher, R., Cech, F. & Zobel, B. J. 1964. Inheritance of specific gravity in two- and three-year-old seedlings of loblolly pine. Tappi 47(7):405-407.

Results from the Cooperative International Paper Company-N. C. State Quantitative Genetics project are becoming available at more frequent intervals. This report, restricted to wood specific gravity and growth rate of young loblolly pines, shows inheritance of specific gravity to be quite strong. Although a small negative relationship was found between growth and specific gravity, it was pointed out that some of the fastest-growing families also had the highest specific gravities.

15. Taras, M. A. 1965. Some wood properties of slash pine (Pinus elliottii Engelm.) and their relationship to age and height within the stem. Ph. D. Thesis, N. C. State School of Forestry. pp. 1-157.

This Ph. D. thesis, done in the Department of Wood Sciences, makes a very important contribution to sampling procedures and variation patterns within a tree. It is basic to many of the wood variation and wood genetic studies. Dr. Taras has not yet announced plans for publication of this research but a copy has been routed to members of the Cooperative Tree Improvement Program.

16. Taylor, F. 1965. A study of the natural variation of certain properties of the wood of yellow poplar (Liriodendron tulipifera) within trees, between trees, and between geographic areas. Ph. D. Thesis, N. C. State, School of Forestry.

Dr. Taylor worked closely with the Tree Improvement Program in making this study in the Department of Wood Sciences. Like Taras' study, this is a real valuable contribution to variation patterns in wood of yellow poplar. His study also touched on geographic variation and reported, for example, that specific gravity of this species was highest in the Piedmont areas and lower on both the Coastal Plains and in the mountains.

17. Webb, C. D. 1965. Natural variation in specific gravity, fiber length and interlocked grain of sweetgum (Liquidambar styraciflua L.) Ph. D. Thesis, N. C. State, School of Forestry.

This is the third very important study on variation patterns in wood qualities to be completed during the past year. This study was financed by funds provided from the Cooperative Tree Improvement Program. Dr. Webb made an important contribution on variation patterns of sweetgum and included a good analysis of the effect of site and geographic area. He worked out a new method to assess interlocked grain. Like Dr. Taras and Dr. Taylor, Dr. Webb has as yet announced no plans for publication but a copy of his thesis has been routed to members of the Cooperative Program.

18. Whitesell, C. D., Zobel, B. J. & Roberds, J. 1965. Wood quality of loblolly pine in Maryland and Delaware. (In press)

This relatively small, concise study has been ready for publication for many months but has been held up by discrepancies in the IBM analysis. It should be published soon as a technical report from N. C. State.

19. Zobel, B. J. & McElwee, R. L. 1964. Seed orchards for the production of genetically improved seed. Silvae Genetica 13(1):4-11.

We have for a number of years been unhappy at the lack of understanding of the philosophy behind the production seed orchard concept. This paper was prepared especially to clarify what the policy and approach was in the N. C. State-Industry Cooperative Tree Improvement Program. It was published in a special issue of Silvae Genetica dealing with various phases of seed orchards. This issue of Silvae Genetica is a good one for the Cooperators' libraries - source and cost were listed in the NEWSLETTER.

20. Zobel, B. J. and Kellison, R. C. 1964. The Cooperative Industry-N. C. State Tree Improvement Program. Proceedings, Region 8, Forest Nurserymen's Conf. pp. 99-102.

21. Zobel, B. J. 1965. Variation in specific gravity and tracheid length for several species of Mexican pine. Silvae Genetica 14(1):1-12.

    During the Mexican collection trip, sponsored by six of the cooperating industries and N. C. State, wood samples were collected for all trees from which seed samples were obtained. These were analyzed and this report shows the large tree-to-tree variation and site-to-site variation within a species and differences between species. It pulls together a number of publications dealing with wood of the Mexican pines, both in Mexico and when planted as exotics.

22. Zobel, B. J. 1965. Inheritance of spiral grain. For IUFRO Conf. on Wood, Melbourne, Australia. (In press)

    A paper dealing with the genetics of spiral grain will be given at the IUFRO Meeting in Melbourne, Australia. It is a review of the literature on genetics of this most important wood characteristic.

23. Zobel, B. J. 1965. Inheritance of fiber characteristics in hardwoods - a review. For IUFRO Conf. on Wood, Melbourne, Australia. (In press)

    This paper also was prepared on request to summarize known information on genetics of fiber characteristics of hardwoods.

24. Zobel, B. J. & Kellison, R. C. 1965. Biological research by forest industries. Jour. of For. (In press)

    In response to a request by several persons, Bob and I wrote down our impressions on the contributions of industry to forestry research. Since these are often unknown or overlooked it seemed important to try to bring the contributions by the industries into the proper perspective. Our Cooperative Tree Improvement Program was used as an example of the contribution to research by industries in the past.

25. Zobel, B. J. & Kellison, R. C. 1965. Production seed orchards. Forest Farmer 24(6):6, 7, 18 & 19.

    An attempt was made to simplify and summarize the information given in the Silvae Genetica article on seed orchards (# 19, above) for readers of the Forest Farmer magazine.

26. Zobel, B. J., Ralston, J. & Roberds, J. 1965. Wood yields from loblolly pine stands of different age, site and stocking. (In press)

An intensive study of over 900 trees in 44 plots, with 22 trees per plot, enabled a determination of the effect of site, spacing and age on wood qualities and proportion of corewood in loblolly pine. Yield tables of weight of dry wood per acre were constructed which will enable an inventory of total pounds of dry wood per acre to be made and also an estimate of how much of this is corewood and how much is outerwood.

COOPERATING ORGANIZATIONS

Organization	Working Units and States
Albemarle Paper Mfg. Co. (Roanoke Rapids Div.)	N. C., Va.
Catawba Timber Company (Bowaters Carolina)	S. C., N. C.
Champion Papers, Inc.	S. C., N. C.
Chesapeake Corp. of Virginia	Va., Md., Del.
Continental Can Co.	Savannah Div. - S. C., Ga. Hopewell Div. - N. C., Va.
Georgia Kraft Company	Ga., Ala.
Hiwassee Land Company (Bowaters Southern)	Tenn., Ga., Ala., Miss.
International Paper Company	Coastal Plain - S. C., N. C. Piedmont - S. C., N. C.
Kimberly-Clark Corporation (Coosa River Div.)	Ala.
American Can Company, Inc. Southern Woodlands Department	Ala.
North Carolina Forest Service	N. C.
Riegel Paper Corp.	N. C., S. C.
South Carolina State Commission of Forestry	S. C.
Tennessee River Pulp & Paper Co.	Tenn., Ala., Miss.
Union Bag-Camp Paper Corp.	Savannah Div. - Ga., S. C., Ala. Franklin Div. - N. C., Va.
West Virginia Pulp & Paper Co.	South - N. C., S. C. North - Va., West Va., Ohio
Weyerhaeuser Co. (North Carolina Div.)	N. C., Va.