ELEVENTH ANNUAL REPORT

N. C. STATE-INDUSTRY

COOPERATIVE TREE IMPROVEMENT PROGRAM

School of Forestry
North Carolina State University
Raleigh

June, 1967

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INTRODUCTION

The theme of this year's report reflects the need of an industry pressed to obtain sufficient raw material at a reasonable price. Mass expansion and new mills have greatly increased demand for pulpwood and plywood; labor shortages and transportation difficulties have made pulpwood more expensive and hard to obtain; reduction of farm surpluses and better prices, especially for soybeans, is causing widespread conversion of timberland to farmland; our "affluent" and expanding society, with its large construction projects, roads, suburban sprawl and government projects such as dam construction and emphasis on recreation and other "exclusive" uses for timberland, consume large acreages of productive forest lands. All these are compounding the problem of obtaining sufficient, reasonably priced wood.

The theme can be simply stated as "We must produce more on less area." This idea has been expressed to us by every industrial member of the Cooperative sometime during the past year. The Eleventh Annual Report will emphasize this theme, dealing with some of the ways the Cooperative Tree Improvement Program is involved in helping "produce more on less area." Four ways to increase production, all of which will result in greater dollar returns from an acre of forest land, are:

1. Improve volume production _per se_.
2. Improve quality, and thus dollar yields, for each unit volume of wood produced.
3. Reduce loss from pests.
4. Grow more productive forests on marginal sites.

In certain areas of the Southeast the economically available timber supply is becoming scarce, despite reports that growth exceeds drain. This is especially true for hardwoods. Two reasons for this apparent discrepancy are shown above: (1) Fine stands of hardwoods that are growing in swampy areas that are exceedingly difficult to log at a reasonable cost; (2) Low-grade upland hardwoods that add a lot of volume to the inventory but are so scattered that they can hardly be logged economically.

VOLUME IMPROVEMENT

Volume Production (Direct):

Improved volume yields can be obtained by developing faster growing strains of trees and by producing strains that will respond to improved cultural practices such as fertilization and intensive site preparation.

The Tree Improvement Program was developed with the idea that volume growth *per se* would be sought but not emphasized, and a 5 per cent improvement in volume yields was estimated. Although too early predictions are dangerous, it appears that we were much too conservative because first measurements of progeny tests from seed orchard trees show that many selected parent trees produce progeny growing 10 to 20 per cent faster than the standard commercial planting stock. Occasional parental combinations are doing even better, and the superiority appears to be increasing with age. Our limited data are compatible with other results from the South, as well as from Australia where specific crosses of southern pines have been reported with over 50 per cent superiority. We must interpret early results with caution, but it now appears that volume growth will be improved considerably over the 5 per cent estimated gain when the Program was started eleven years ago.

Yields from progeny from several selected trees are shown in Table 1. The data were obtained following thinning (50 per cent of the trees removed) of an open-pollinated progeny test on lands of West Virginia Pulp and Paper Company near Georgetown, South Carolina. One hundred trees of each family had been planted on a good site (about 95' S.I.), 7.5 years prior to thinning. Note the volume superiority of families 11-3 and 11-13 which at 7.5 years have produced an average of 2.7 cords per acre per year, compared to the poorest family (11-2) which produced 2.2 cords per acre per year. When dry wood production was determined, family 11-3, which combined fast growth with high wood specific gravity, produced over three tons per acre per year; and family 11-13, which combined fast growth with somewhat lower specific gravity, produced 2.8 tons per acre per year. In contrast, family 11-2 (the slowest-growing family) produced only 2.4 tons per acre per year. This difference was obtained even though 11-3 had three times more (19 per cent) bole cankers of fusiform rust than did the slower-growing family 11-2. Unfortunately, a commercial check usually used as a comparison was not included in this early progeny test. The point is made, however, that family-to-family differences of this magnitude have great economic importance.

Table 1. Wood Production by Open-pollinated Progenies from Seed Orchard Parents. West Virginia Pulp and Paper Company, Georgetown, South Carolina. (Planted 1959, thinned May, 1966)

Select Parent	Total Vol. Growth (cords/acre)	Sp. Gr.	Moist. %[1/] of Wood	Tracheid Lgth. (mm)	Dry Wood (Tons/Acre)
11-2	16.2 (2.16 cd/ac/yr)[2/]	.39	147	3.42	17.76 (2.37 T/A/yr)[2/]
11-3	20.7 (2.76 cd/ac/yr)	.39	159	3.58	22.68 (3.02 T/A/yr)
11-7	18.3	.38	166	3.63	19.56
11-11	19.3	.39	157	3.71	21.14
11-13	20.2 (2.69 cd/ac/yr)	.37	156	3.47	21.03 (2.80 T/A/yr)
11-16	16.9	.39	162	3.58	18.54
11-18	19.2	.39	157	3.71	21.00
11-20	16.3	.39	163	3.63	17.87
Ave., 8 families	18.4 (2.45 cds/ac/yr)	.39	158	3.59	19.95 (2.66 tons dry wood/acre/year)

1/ Moisture per cent calculated as the ratio of water removed to dry wood substance. Note the family-to-family differences which are of importance when buying by green weight.

2/ Calculated on 7.5-year basis, since thinning was done before summerwood production in 1966.

Seedling production from seed orchards is increasing rapidly, with many millions now being produced. Pictured above, at the Virginia Division of Forestry's New Kent Nursery, are seedbeds of seedlings from the Chesapeake Corporation's seed orchard. Over 650,000 seedlings were obtained from approximately four acres from the older section of the seed orchard.

Volume Production (Indirect):

The growth response from improved management practices and fertilizers has received considerable attention, and as a result it seems probable that fertilizing southern pines may become as accepted as site preparation. For example, Posey (N. C. State Univ. Technical Report 22) found that fertilizing 16-year-old loblolly pine resulted in an average increased volume production of one cord per acre per year for the ten years following the first fertilization, although by the tenth year the fertilizing effect had nearly disappeared. This test on a loblolly pine plantation on a good site (S. I. = 85) in the Piedmont of North Carolina indicated the increased yields available following fertilization but it left the important economic question still unknown, *i. e.*, how well does the increased volume, when balanced by the effects of the fertilizer which lowered tracheid length and specific gravity of the wood, offset the cost of the fertilizer?

If fertilization becomes a common practice it is mandatory to plant (or direct seed) strains of trees that will take best advantage of the improved culture. Little data are now available on large trees, but there are indications that an interaction between families and fertility levels exists, *i. e.*, some families respond well to fertilizers while others do not. In the progeny test of one company, several fertilized families have nearly twice as much height growth as the same families without fertilization. Clones from the seed orchards that do respond to improved culture will be used when planting areas to be intensively managed.

Numerous tests of fertilizer effect are included as part of the Cooperative Tree Improvement Program. For example, seven companies are dividing their progeny tests into fertilized and unfertilized sections. Several special tests are under way to determine the fertilizer-x-genotype (of seed orchard trees) interaction while other studies are designed to determine the most

Last year's annual report included a picture of Walt Chapman (Kimberly-Clark) with a fast-growing one-year-old seedling of a cross from their seed orchard. Rapid growth has continued as evidenced by the height of the same seedling one year later. Growth rate of seedlings from seed orchards has been more outstanding than anticipated.

efficient amounts and times of fertilizer applications. All fertilizer studies are done with the advice and guidance of Dr. T. E. Maki, Dr. C. Davey, or both, whose close and complete cooperation are essential for successes obtained in estimating the interrelationship between fertilizers and improved yields from seed orchard seeds.

Several companies have progeny tests under way to determine how rapidly pine from the seed orchards can be grown. Such maximum care areas, where fertilizers are used, competition is reduced and even spraying for tipmoth is done, have shown remarkable growth during the first several years. Soon growth and yield figures will be available to indicate the growth potential of pine under optimal conditions.

Our tentative opinions, as influenced by Maki and Davey, are summarized as follows:

1. On average to good sites, fertilizing of southern pines appears to increase growth significantly. Fertilizing the very poor or the very best sites is less promising, when viewed as an economic operation. The important unknowns to be determined are the net added value from fertilizing and a determination of time, quantity, and method of application.

2. There is a genotype-x-fertilizer (or management) interaction, and some families from the seed orchards respond to fertilizer and site preparation better than others. It is essential to determine the effect of these interactions if the full wood production potential is to be obtained from the genetic effort, the fertilizing effort, or the site preparation effort. Just as in agriculture, maximum yields will accrue when the type of plant and cultural practices are matched to take advantage of each other.

QUALITY IMPROVEMENT

Another way to increase returns per acre is to improve quality of the wood produced or to grow greater amounts of usable wood substance for a given volume of log. It is much harder to assess quality improvement than quantity improvement. Economic values are difficult to assign, although such values are very evident.

Tree straightness has been the most spectacular quality characteristic to show marked improvement. Nearly every select tree has produced progeny considerably straighter than commercial stock. Intensive studies by graduate students Shelbourne and Woessner have shown the high degree of inheritance of bole straightness. Effects of non-straightness on formation of severe compression wood are obvious for very crooked trees, but the relationship between compression wood and moderate non-straightness is not as clear-cut as formerly thought. It is not unusual to find as much or more moderate compression wood in a straight tree than in a crooked tree, with moderate compression wood sometimes comprising 30 to 40 per cent of the total merchantable volume. Formation of moderate compression wood is highly related to the individual parent trees; certain parental combinations produce families containing much more compression wood than others of similar bole straightness. Although the adverse effect of severe compression wood is known, a major unknown in dealing with bole straightness and moderate compression wood formation is the economic effect it has on the final product. After this has been determined it will be possible to assign much more meaningful values to bole straightness.

Other very evident quality characteristics are limb length and diameter. The most casual observation would indicate that progenies from some parents have much larger limbs than those from others but it is difficult to ascertain the economic importance of these differences. However, partial answers are being obtained from a study initiated by postdoctoral Kay von Wedel from Germany. He has dissected trees from large-limbed and small-limbed families to determine the per cent of the tree bole made up of knot wood. For young loblolly pine stands just becoming merchantable, total knot volume makes up only about 1 per cent of the total merchantable volume, but knots plus associated compression wood comprise up to 8 per cent of the total volume. A summary of some of his findings is shown in Table 2.

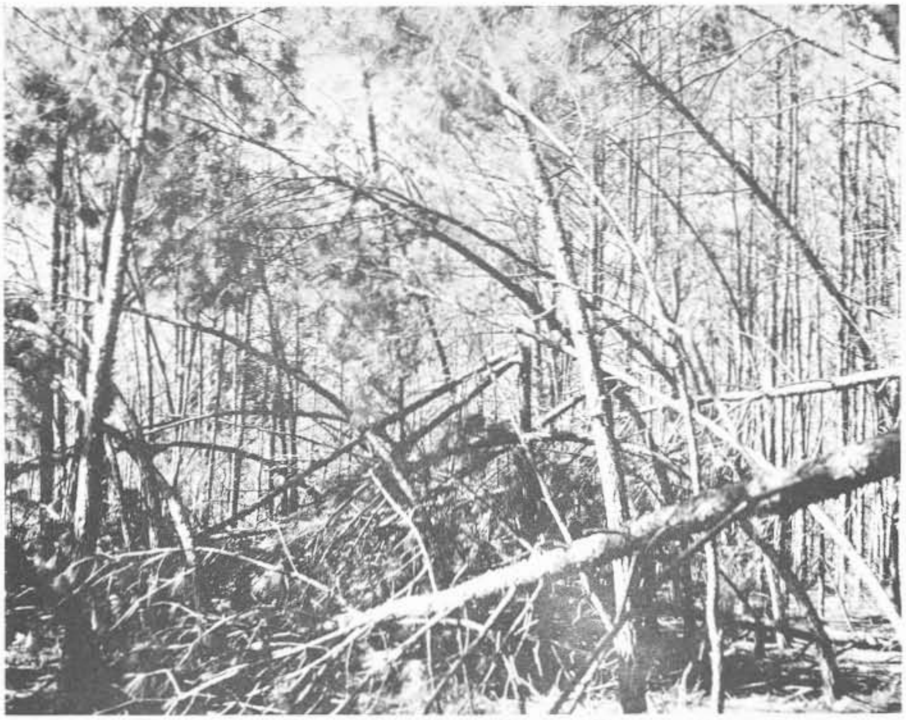
Table 2. Amount of Knotwood and Compression Wood Associated With Knots 1/

Bolt Number 2/	% Tree Vol. in Bolt 3/	Knot Diam. (inches)	Knot Vol. % of Total Bolt Volume	Comp. Wood Around Knot % Total Vol.	Knot & Comp. Wood - % Total Bolt Vol.
1	23	0.38	0.3	5.4	5.7
2	17	0.64	0.7	7.0	7.7
3	15	0.81	0.8	6.2	7.0
4	13	0.88	1.0	6.5	7.5
5	11	1.09	1.5	8.2	9.7
6	8	1.05	1.6	7.3	8.9
7	6	1.05	2.3	11.4	13.7
8	4	1.01	2.3	10.5	12.8
9	2	0.94	2.6	11.1	13.7
10	1	0.65	2.3	7.4	9.7
Weighted Average			1.05	6.97	8.02

1/ From a study by Kay von Wedel and Tony Shelbourne.

2/ Bolts are 5' long.

3/ Based on average values for 8 loblolly pine trees, 11 years old.



Ice is only one of the many hazards that face the seed orchards. Shown above is a young stand of timber that was severely damaged by a localized ice storm but a seed orchard nearby escaped serious injury when the storm stopped short. Many scares similar to this were encountered during the past year, but fortunately damage was light.

Fire is an always present danger in seed orchard maintenance and especially in progeny tests. Last year, parts of two control-pollinated progeny tests burned and there were several other "near misses." Maximum protection of such vital and expensive areas is essential. With over 70 test areas scattered throughout the South, the job of protection is a big one.

Another characteristic which affects yields from a given volume of timber is wood specific gravity. This has been one of the most spectacular improvements attained by the Cooperative, and dry wood yields are strongly influenced by specific gravity. For example, one 7.5-year-old family of loblolly pine from the West Virginia progeny test with both fast growth and high specific gravity produced over 1.5 tons more than a slightly slower-growing but lower-gravity family. Specific gravity improvements of yield are in the order of 4 per cent per unit volume. The increase of 200 to 300 pounds of wood per cord may appear to be small but it is consistent, and over large acreages it represents a lot of money.

Many other strictly quality characteristics will have a positive effect on the end product. One of those that has responded best and which has a high heritability is tracheid length. However, for any product in which fiber length is an important component of quality, we are faced with the almost impossible task of placing a monetary value on differences in lengths. For example, if the average fiber length is low, such as in juvenile wood, a 0.3 mm increase may have a substantial effect on quality of the final product, whereas a similar increase in much longer-fibered mature wood might hardly be detectable. Since tracheid length is strongly inherited and can be changed considerably through selection and breeding, the limitation in genetically improving this, as well as other, quality characteristics is one of economic justification.

LOSSES FROM PESTS

Every time a tree is killed or injured by pests so that growth or wood quality is impaired, a loss in productivity results. In many instances the losses per acre are subtle and may be barely discernible unless observed closely. A good example of this type of loss is caused by fusiform rust

Because of the unique appearance and the activity associated with seed orchards many questions are raised by the layman about the purpose of the operation. Most of the organizations in the Cooperative Program have erected signs similar to the two above, informing the public of the progress being made.

(Cronartium fusiforme). If only 5 per cent of the trees in a plantation have severe stem cankers there will be little reduction in yield. If, however, 15 per cent bole infection is present, excess mortality will be evident, especially if an early thinning is not made. Heavier infection results in a serious loss in volume and even a greater loss in quality if the stand is to be used for saw timber or plywood. Stands in which bole infection runs 70 to 100 per cent may be nearly complete losses, especially for quality log production. Thus, in areas of heavy infection, even a 20 per cent improvement in resistance may mean the difference between economically profitable and essentially useless stands of trees. Contrary to the opinions of some foresters, slash and loblolly pine exhibit heavy infection rates on large areas in parts of Alabama, Georgia and South Carolina. Tens of thousands of acres are so badly damaged by fusiform rust that economic forestry is not possible until the infected stands are removed and replaced by more resistant stock.

Inheritance of resistance to fusiform rust is high, and some families from seed orchards are twice or three times as resistant as others. (For example, infection rates of 18 families from one seed orchard varied from 30 to 80 per cent under conditions of severe infection.) In our heritability study some families are nearly free of stem cankers while others have one to several stem cankers on every tree. These results will be published soon as the Ph. D. theses of graduate students Bro Kinloch[1/] and Roger Blair[1/].

It is also known that certain hybrids such as the loblolly-x-shortleaf cross are relatively resistant to fusiform rust. Trials have been established within the Cooperative to determine the worth of these crosses on areas of

1/ Studies of disease resistance by these two students have been partially financed by the industry-sponsored Southern Insect and Disease Research Council.

heavy rust infection. American Can Company, for example, is completing a number of hybrid crosses from selected parents of shortleaf and loblolly and will test the material on some of their problem sites.

Although fusiform rust has been used as an example, it is evident that one of the best ways to improve yields on any given acre is to have trees as free from all pests as possible.

MARGINAL SITES

Forest land is becoming scarce and exceedingly expensive. Opposite to the trend during the past several decades, there is now a strong movement to convert forest land back to agricultural uses. Dams, recreation, roads and urban uses all seriously reduce the acreage of the most productive forest sites. The reduction in productive forest land is particularly troublesome for the producers of hardwood timber because the required best sites are disappearing most rapidly.

Considerable acreages belonging to organizations within the N. C. State Cooperative are on lands that must be classified as marginal for profitable forest production. These lands, often obtained as parts of large purchases, were not managed or at best only had minimal cultural practices applied. As long as timber was plentiful, land cheap and taxes low these lands could be ignored. This can no longer be done; in tune with our theme, these marginal lands must be made productive.

A number of the Cooperative members have activities under way to increase productivity of marginal sites. Of immediate importance and utility is the obtaining of proper strains and species for extreme sites. Virginia and loblolly pine have been intensively selected for poor, dry foothill sites, while longleaf pine is now widely established in orchards to produce seeds for the excessively dry, sandy sites. Loblolly and pond pine have been selected for excessively wet sites, and intensive selection has been made for slash pine to grow in more northerly climates. All of this work is beyond the theoretical or research stage, and seed orchards for selected species and strains have been established and in many cases seed are already being harvested.

Another approach for utilizing marginal sites is through hybridization. For example, hybrids between slash pine and longleaf pine and between slash pine and drought-resistant loblolly pine are being tried on droughty sites. Crosses with pond pine and several other species have been made for wet sites and the pitch-x-loblolly cross is under test for the very poor and severe sites in the foothills and mountains. These problem sites are areas where great improvement should be possible.

Converting nonproductive lands to productive lands can be the greatest benefit of a tree improvement program to many organizations. For others, pest resistance may offer the greatest contribution, while for others it will be increased growth on already productive lands. For all, improved quality and higher dollar returns per unit of wood produced will be a bonus resulting from the tree improvement program. All of this fits the theme "Produce more on less area."

WOOD STUDIES

Wood studies remain the "backbone" of our Cooperative Program, and this year has seen an all-time high in interest and activity. A number of companies have initiated studies dealing with dry wood weight production per acre, the relative value of saw timber versus pulpwood, the value of top logs, and the effect of wood properties on the final product. Many of the results of these studies are available to members of the Cooperative. For example,

During the past year the "traumatic" job of thinning the seed orchards has taken place for seven companies. Early thinning removes unhealthy and inferior trees whereas later thinnings are made on performance of crosses in the progeny tests. Members of Chesapeake Corporation have been accused of thinning for pulpwood production (above).

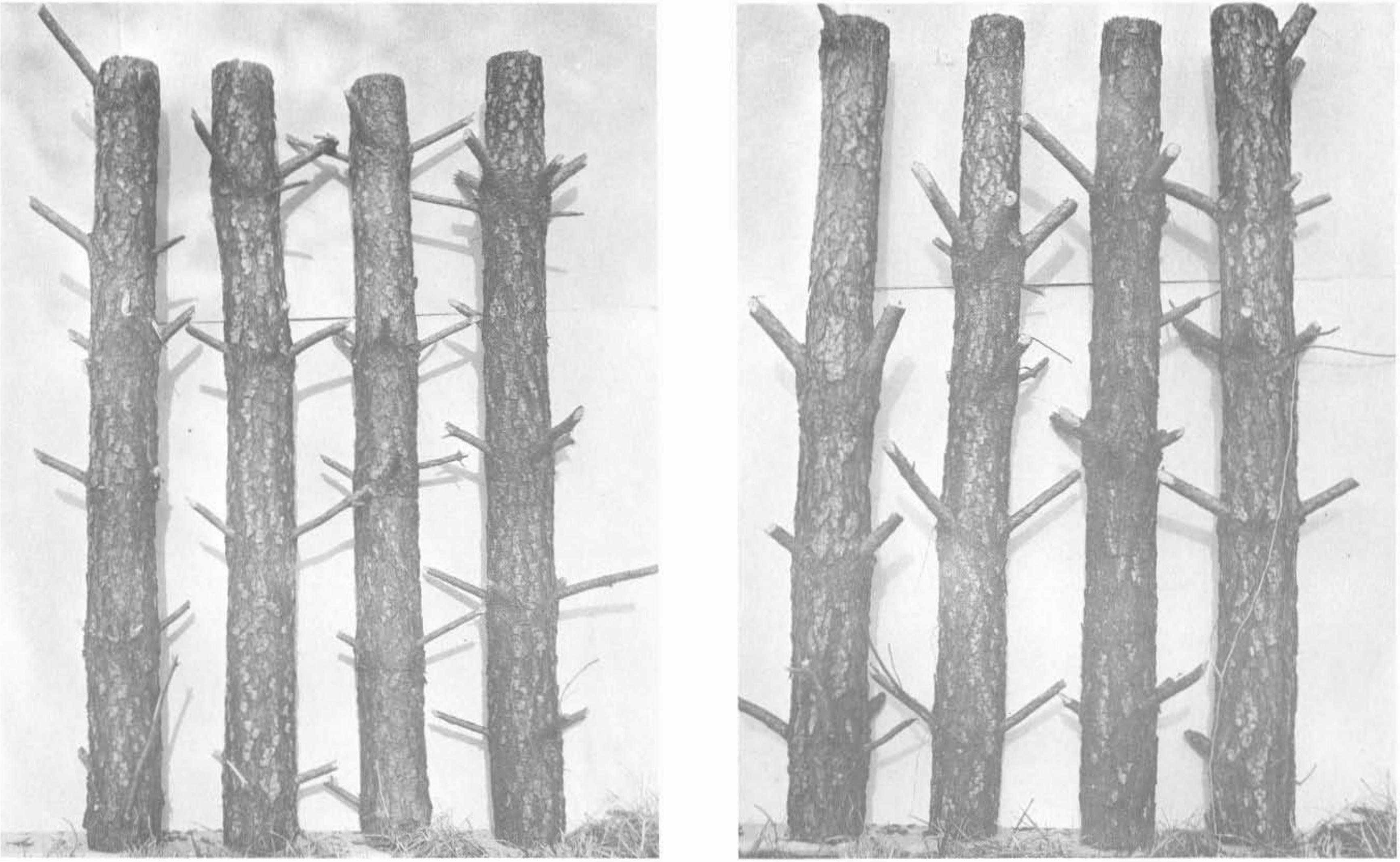
seven companies have made available their information on moisture content of wood or various species of various ages growing on diverse sites in different geographic areas. This tremendous mass of information will be brought together and published as a technical report, and a summary of the results will be given at the TAPPI Forest Biology Committee Meeting in Montreal and will be published in Tappi.

Our Cooperative Program is involved to various degrees with the special wood studies. Depending upon the desires of the organization, we help design the project, obtain laboratory determinations of wood characteristics and assist in analyzing and interpreting the results. For this service, we are reimbursed on a cost basis but, more important, pioneer information on wood properties is obtained and fed back to members of the Cooperative. At the present time, however, emphasis is shifting from these special and random variation studies of natural stands to assessment of progeny from the seed orchards. Two open-pollinated progeny tests have been thinned and analyzed; results for one were discussed earlier in this report.

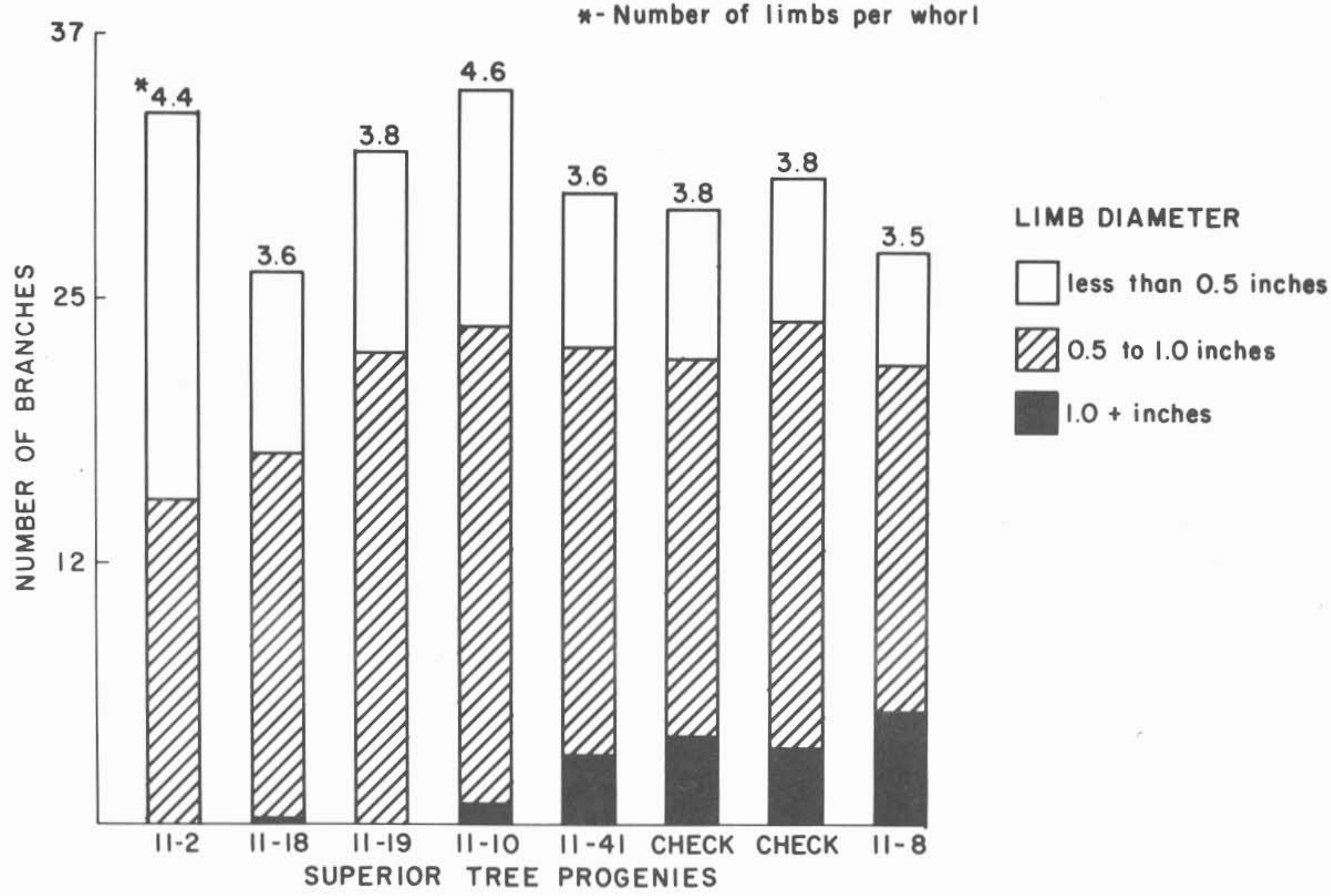
The opportunity was taken by Hiwassee Land Company, while conducting a thinning operation, to determine the variation in specific gravity of the wood of the grafts in their Rose Island Seed Orchards. Instead of sampling only at breast height, the thinned trees were sampled at the top of the first three five-foot bolts. Results are summarized in Table 3. Differences among clones were striking, especially since all trees had been grown under very similar environmental conditions. Note that the difference between the highest and the lowest specific gravity families is very large, with no overlap between the six ramets of each clone tested.

Table 3. Thinned Seed Orchard -- Hiwassee Land Company
Specific Gravity of a Number of Ramets from Several
Clones of Loblolly Pine

Clone No.	# Ramets Sampled	Weighted Sp. Gr.	Range	Bolt 1 Sp.Gr.	Bolt 1 Diam. (In.)	Bolt 2 Sp.Gr.	Bolt 2 Diam. (In.)	Bolt 3 Sp.Gr.	Bolt 3 Diam. (In.)
1-9	6	.308	.29-.34	.32	6.9	.29	5.8	.30	4.5
1-66	5	.338	.33-.36	.34	4.4	.34	3.8	.33	3.1
1-31	4	.342	.33-.36	.35	5.9	.34	5.4	.33	4.1
1-58	5	.342	.32-.37	.35	6.2	.33	5.2	.34	3.9
1-32	5	.344	.33-.36	.35	6.0	.33	4.9	.34	4.0
1-60	10	.344	.32-.38	.34	6.7	.34	5.1	.33	4.0
1-10	10	.345	.33-.40	.36	5.7	.33	4.5	.32	3.3
1-16	9	.356	.34-.38	.37	5.5	.34	4.7	.34	3.4
1-21	4	.362	.35-.38	.38	5.9	.35	5.0	.35	3.6
1-5	5	.362	.35-.39	.38	5.3	.35	4.8	.34	4.0
1-65	5	.364	.33-.39	.37	4.7	.36	3.7	.35	3.1
1-68	9	.365	.35-.39	.37	5.7	.37	4.9	.36	3.4
1-2	6	.365	.34-.39	.38	5.4	.36	4.8	.34	3.8
1-14	9	.380	.38-.40	.39	5.7	.38	4.9	.37	3.9
1-18	5	.380	.37-.41	.40	4.5	.37	3.5	.35	2.9
1-7	6	.383	.37-.40	.39	5.8	.38	4.8	.38	3.8
1-64	6	.387	.38-.40	.39	4.1	.38	3.6	.37	2.5



The importance and inheritance of limb diameter has long been questioned. Shown above are seven-year-old trees from open-pollinated seed orchard seed; one represents a small-limbed family (left), the other a large-limbed one (right). Inheritance appears fairly strong, and considerable differences in knot volume have been found.



An intensive study of branch size, number and volume has been made by Kay von Wedel, a German postdoctoral student at North Carolina State University. Results illustrated are from eight-year-old progeny from Westvaco's seed orchard, showing branch diameter for small-limbed and large-limbed families. Note that total branches are quite similar but relative numbers of large and small branches are very different by families.

HERITABILITY STUDY

The heritability study is yielding information so rapidly that the published results cannot keep up with the data available. The uniqueness of this cooperative research program, supported by International Paper Company, N. C. State University, National Institute of Health, and the National Science Foundation, is exemplified by the annual trip made in January. Twenty-five professors and graduate students from N. C. State spent a week at Southlands Experiment Forest recording measurements and collecting wood samples. Their efforts and those of the staff of the Southlands Experiment Forest resulted in a complete measurement of both the open-pollinated progeny tests, which have completed their sixth year of growth, and the control-pollinated progeny, oldest of which are three years in the field. In addition, talks, seminars and demonstrations were held, making the week an educational experience as well as accomplishing a considerable amount of work.

Family differences in growth, crown form, bole straightness, resistance to fusiform rust and wood properties have been outstanding. Dr. Roy Stonecypher, in charge of the work for International Paper Company, has developed all the necessary statistics and computer programs to analyze the mass of data being accumulated; this was reported in International Paper Company Technical Bulletin No. 5. Other results have been published and several articles are in print; in addition, two Ph. D. theses are in preparation. A special paper on inheritance of spiral grain, co-authored by Roy Stonecypher and Bruce Zobel, will be given at the IUFRO meeting in Munich in 1967.

Roy, who has worked with the heritability program for many years, and who has greatly helped the students working on the project, has been appointed an adjunct assistant professor at N. C. State. This will enable him to officially serve on graduate student committees and to participate more fully in activities of the faculty at N. C. State.

The establishment phase of the heritability study is completed and plans for its continuance are firmly established; the major problem now is to analyze and publish the mass of data available. Use of the information obtained is already under way and has helped greatly in the operation of the applied tree improvement program. Many of the operations are more efficient because of the experience gained in the heritability program.

IMPROVED SEED -- PRODUCTION, TESTING AND USE

Each year we report progress on production of seed from the seed orchards. Two years ago it was possible to state that commercial seed production was under way. Last year's annual report emphasized seed production and progeny testing, with a description of yields and conditions under which testing is being made. Therefore, this section will be brief, with just enough details to bring the reader up to date.

Currently there are 73 separate seed orchards at 34 locations in the Cooperative Program. About 1300 acres of orchard have been established, with plans to expand this to 2000 acres within the next 3 years.

Last year approximately 450 pounds of seed were obtained from seed orchards (enough for 3,000,000 plants), whereas this past fall approximately 1200 pounds were collected (enough for 12 to 15 million plants). These will plant about 20,000 acres at the relatively wide spacings and with the conservative nursery techniques usually used by members of the Cooperative. Next year's yields will be considerably larger. In addition to loblolly pine, "commercial" amounts of Virginia and pond pine were collected.

A major problem in seed orchard operation is the ability to harvest the cone crop in the limited time available while holding damage to the tree and to the yearling cones to a minimum. The Cooperative Program seed harvesting

To use seed from seed orchards more effectively it is necessary to prolong the planting season. One method that may be feasible is to produce planting stock properly hardened off but "out of phase" with field-grown nursery seedlings, by use of plastic greenhouses such as those shown above. These structures have gained wide acceptance in the Scandinavian countries to speed up production of plantable seedlings.

committee, headed by Harold Nelson,[1/] has been very active. Many methods of cone and seed harvesting have been tried, some quite unique; these are to be reported by Harold Nelson at the Advisory Committee Meeting. The high-frequency tree shaker seems to be successful on slash and longleaf pine but not on loblolly. Power clippers and mechanical ladders have been the best combination found for collecting loblolly cones. The important problem of efficient and rapid cone harvesting needs much attention.

Table 4. Seed Yields in Pounds per Bushel from Loblolly Seed Orchards in Commercial Production

Location	Pounds per Bushel
Virginia -- Coastal Plain	1.3
Virginia -- Piedmont	1.7
N. C. -- Piedmont	2.1
N. C. -- Coastal Plain	1.5
N. C. -- Piedmont	0.8 (Injured by late freeze?)
S. C. -- Coastal Plain	1.2
Ala. -- Piedmont	0.7 (Injured by late freeze?)
Ga. -- Coastal Plain	1.5
Ga. -- Piedmont	1.2

Yield of seed per bushel (and per cone) continues to be surprisingly high in loblolly pine. Overall yields were poor in slash pine in 1966, averaging less than 0.3 pounds per bushel while loblolly varied from a low of 0.6 pounds per bushel to over 2.0 pounds per bushel, and the overall average was an excellent 1.5 pounds per bushel. In order to compare yields per bushel from a wide

1/ Members are Barry Malac (Union Camp), Ray Marler (Va. Div. For.), Martin Fox (Riegel), Walt Chapman (Kimberly-Clark), J. G. Hofmann (Albemarle).

Seed orchard expansion continues. Nearly 1300 acres are already established and 2000 acres will be completed within the next three years. Shown is the start of one of the newer expansions, the "average specific gravity" orchard of Champion Paper Company.

There have been questions about the root development of grafted trees. When the seed orchard of West Virginia Pulp and Paper Company at Manteo, North Carolina was thinned, the trees were removed in a way so as to prevent infection by Fomes annosus. The trees removed revealed roots with vigorous development, as shown above.

area from seed orchard trees of loblolly pine Table 4 is presented. No particular importance should be attached to yields from any one area because they are affected by age of grafts, spacing of clones within the orchard, and especially by late freezing weather. All collections listed are commercial size.

As reported last year, seed from orchards are larger (thus fewer per pound) but have a higher germination percentage than usual commercial collections. The number of cones per bushel also varies greatly, as does the number of seed per pound. For example, Coastal Plain (N. C.) seed averaged 12,000 to the pound while Coastal Plain (Va.) averaged well over 18,000 to the pound. Pond pine from Coastal North Carolina ranged from 29,400 to 78,400 seeds per pound (average, 40,000) whereas loblolly clones of Piedmont and Coastal Virginia ranged from 10,110 to 19,230 seeds per pound (average, 15,573). Within an orchard, loblolly pine varies from 230 cones per bushel to as much as 700 cones per bushel; differences are obviously clonal.

We have always calculated seed yield on an average of 30 sound seed per cone. Clonal differences in number of seeds per cone are large for both control- and open-pollinated cones. For example, Riegel's Piedmont loblolly yielded from 0 to 130 seeds per cone whereas Westvaco obtained from 20 to 110 seeds per cone by clones from their orchard. As the orchards mature and as management methods improve, it looks as if 30 seed per cone is too conservative and yields will be in the order of 40 to 50 seeds per cone.

As indicated last year, the control-pollinated progeny tests are proceeding beautifully. The summary (Table 5) shows over 200 acres have been established. The first really meaningful measurements (end of 4th year) will be taken in 1967.

Much has been said about the special cooperative heritability study, with combined efforts of International Paper Company, National Science Foundation, National Institute of Health and North Carolina State University. Shown are some of the six-year-old open-pollinated progeny and a group of parent trees (with bands) used in the study.

Table 5. Inventory of Control-pollinated Progeny Crosses in the Cooperative Program, Field Planted (to spring of 1967)

	Seed Lots	Acres
Main Tests	1160	144.2
Supplementary Tests	808	62.7
Total	1968	206.9
Number seed lots planted in nursery, 1967	612	
Number crosses completed, 1966[1/]	605	

1/ Enough seed available for all three years' planting.

MEMBERSHIP IN THE COOPERATIVE

Although solicitation of new members into the Tree Improvement Program is not being made, the Cooperative continues to grow and several valuable additions have been made during the past year. Newest members, all of whom have been very active, are the Hammermill Paper Company (Selma, Ala.), Georgia-Pacific Corporation (Augusta, Ga.), and the Mississippi-Alabama operations of Weyerhaeuser Company. We welcome these new members to our group. Lands of the new companies "block in" the portion of the Southeast where our program is very active and are intermingled with those of the older members.

When asked the number of members of the Cooperative it is always difficult to answer because one never knows how to count "mergers." In actuality we have 25 separate working units, but because of company policy and organizational structure we consider we have 20 separate industrial units and 3 state units. We try very hard to keep up the level of services to each unit and have been able to do this, with the exception of certain rush periods, despite the increase of membership. This means many more hours on the road for Bob,

One of the most dramatic results from the Tree Improvement efforts has been resistance to fusiform rust. Shown are two rows of control-pollinated progeny growing side by side in the heritability study. Seedlings from one cross have nearly 100 per cent infection; those from another, practically no infection. These results, repeated over and over in the cooperative study with International Paper Company, give evidence of the possibility for breeding for disease resistance.

Jim and me with some reorientation of research and student activities at Raleigh. Working with the Cooperative is never tiresome and never dull, although at times it seems to become rather frantic. We suspect our families suffer most of all. To work with a group of organizations which are dedicated to doing something, to work with them as partners who are jointly working out problems together is always a pleasure; in fact, it is an inspiration.

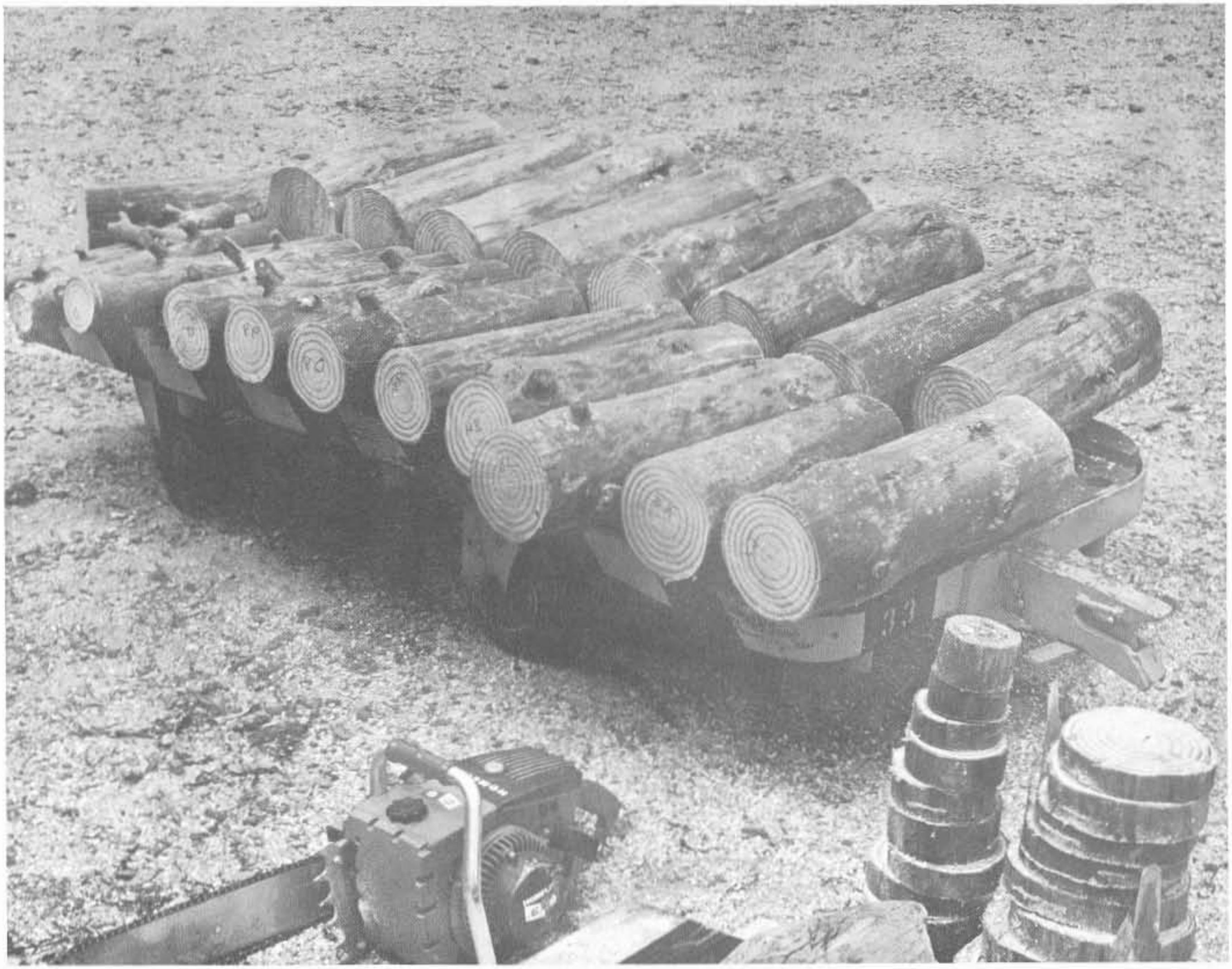
PERSONNEL AND FACILITIES

The long-awaited new Forestry building in which we can have space to move, breathe, and keep records is still not a reality but it is closer. Rumor has it that bids will be let soon. Maybe, some day, when several of you come to visit in our offices, you won't have to sit on tables and bookcases and we will have space to store records and samples.

Dr. Thomas Perry, associate professor of Forest Genetics at N. C. State, has been awarded a Charles Bullard Research Fellowship at Harvard University. The fellowship will allow Tom to write the book for which he has long had aspirations but never the time. He will depart from Raleigh about September 1 on a one-year's leave of absence from N. C. State.

Mr. Vernon Johnson has taken over the duties of field technician to the Cooperative Program, the position previously held by Alvis Walker. Vernon is a delight to work with; he has had a number of years' experience with the Department of Plant Pathology and is mechanically inclined. Vernon fully fills the needs for someone to help on the progeny tests, seed cleaning and dispersal, care of equipment, and the hundred-and-one other jobs we have in conjunction with the Cooperative Program.

Some of the progeny tests are old enough to be thinned. Illustrated is a seven-year-old plantation of International Paper Company at Georgetown, South Carolina, prior to thinning. Shown as an inset is a cross-section of one of the faster grown trees removed in the thinning. It was 37.3 feet tall and 7.8 inches in diameter. Growth of the progeny from the seed orchards has usually been excellent.



Wood studies still take a large portion of our time and effort in the Cooperative Program. Shown here are sections of trees from Continental Can Company used by Tony Shelbourne in his study on tree straightness and its effect on compression wood.

Mrs. Sheila Ferrari resigned when her husband graduated and went north to continue graduate work. Sheila carried a great deal of the load on the wood studies in the laboratory and her careful work is missed.

Bob Kellison is now back in the harness after being "out" one semester to try to complete the course work for his Ph. D. He is on his last course now -- then only study and research stand between him and the Ph. D. Jim Roberds is also working hard on his research. It will ease things in the Cooperative when these two have completed their degrees.

Bruce Zobel has just returned from a "quickie" trip to Brazil, a follow-up of the trip two and one-half years ago. This time he was sponsored by Champion, Brazil and spent a most interesting week visiting their operations near Campinos in São Paulo. Just before returning, Steve Chase, Earl Stephens and Bruce, along with Mrs. Chase and Mrs. Zobel, had the chance to visit in the states of Santa Catarina and Parana. This trip was especially interesting, since it is in the area where slash and loblolly pines grow outstandingly well.

There is great interest in obtaining supplemental sources of fiber among many industries in the Cooperative Tree Improvement Program. One plant tried by several organizations is kenaf (a hibiscus). Shown are Earl Stephens (Champion) and Al Folweiler (Texas Forest Service) examining trial plots of kenaf in which several species and cultural methods were tested.

Many ingenious methods have been developed by members of the Cooperative to speed up their operations and to make them more efficient. This mechanized transplanter, developed at Tennessee River Pulp and Paper Company, has made transplanting of grafts faster and more economical. Similar systems have been developed at many of the Cooperative's seed orchards.

COOPERATING ORGANIZATIONS

Organization	Working Units and States
Albemarle Paper Manufacturing Company (Roanoke Rapids Division)	N. C., Va.
American Can Company (Southern Woodlands Division)	Ala., Miss.
Catawba Timber Company (Bowaters Carolina)	S. C., N. C., Va., Ga.
Champion Papers, Inc.	S. C., N. C., Ala., Ga.
Chesapeake Corporation of Virginia	Va., Md., Del.
Continental Can Company, Inc.	Savannah Div. - S. C., Ga. Hopewell Div. - N. C., Va.
Georgia Kraft Company	Ga., Ala.
Georgia-Pacific Corporation	Va., N. C., S. C., Ga., Fla.
Hammermill Paper Company	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 Division)	Ala.
North Carolina Division of Forestry	N. C.
Riegel Paper Corporation	N. C., S. C.
South Carolina State Commission of Forestry	S. C.
Tennessee River Pulp and Paper Company	Tenn., Ala., Miss.
Union Camp Corporation	Savannah Div. - Ga., S. C., Ala. Franklin Div. - N. C., Va.
Virginia Division of Forestry	Va.
West Virginia Pulp and Paper Company	South - N. C., S. C. North - Va., West Va., Ohio
Weyerhaeuser Company	N. C. Div. - N. C., Va. Miss.-Ala. Operations - Miss., Ala.

PUBLICATIONS

Publications are coming from the Cooperative in increasing numbers, yet we are falling behind in this endeavor. Large amounts of data have not been summarized and incorporated into formal publications. This is especially true of the heritability study, for which plans are being made to prepare a comprehensive monograph on results to date.

Below are listed publications directly from, or of interest to, the Cooperative Tree Improvement Program.

1. Cole, D. E., Zobel, B. J. and Roberds, J. H., 1966. Slash, loblolly and longleaf pine in a mixed natural stand; a comparison of their wood properties, pulp yields and paper properties. Tappi 49(4):161-166.

   Comparative yields of three different species of the same age growing intermixed on the same site were reported. The study included pulp yields and paper strengths of trees selected as having special wood properties.

2. Franklin, E. C., 1966. Photoelectric seed counter for forestry research. For. Sci. 12(3):362-364.

   Carlyle developed a simple and inexpensive seed counter which has been vital to our cooperative program. It has made possible precise inventories and seed counts so necessary in the progeny tests. This article was published as a guide for anyone who desires to construct a similar machine.

3. Kang, Ke Won, 1966. Relationship between loblolly and pond pine in North Carolina. Ph. D. Thesis, N. C. State University, School of Forestry, Raleigh, N. C.

   Kang's study showed that pond pine has a much wider range than originally believed, with many trees being found on the drier areas of the Piedmont. Hybridization between loblolly and pond pine commonly takes place but most of the gene movement is from pond to loblolly pine and not in the other direction. From the tables and summary of Kang's thesis sent to members of the Cooperative, it is possible to compare the wood of pond and loblolly pine from the same age trees growing on the same site.

4. Kellison, R. C., 1967. Geographic variation of yellow-poplar within North Carolina. Tech. Rept. No. 33, pp. 1-41.

   Bob has under way a continuing study of the differences among yellow-poplar. The first phase, consisting of a study of variation within parent trees and stands is summarized in this report, which is a condensation of his M. S. thesis.

5. Ledig, F. T., 1967. Variation in photosynthesis and respiration in loblolly pine progenies. Ph. D. Thesis, N. C. State University, School of Forestry, Raleigh, N. C.

This thesis is part of the continuing studies on why trees grow at different rates. Fred found differences in growth rates between families and tried to relate these to photosynthetic differences. One cross between a select loblolly in the Piedmont and one in coastal Georgia showed an unusually high photosynthetic rate. This research again points up the difficulty of such physiological studies and our inability to ascribe growth differences to any single factor.

6. Nikles, D. G., 1966. Comparative variability and relationships of Caribbean pine (Pinus caribaea) and slash pine (P. elliottii). Ph. D. Thesis, N. C. State University, School of Forestry, Raleigh, N. C.

Garth made a comprehensive study of pines from the Bahamas as well as those from southern Florida. He made collections from a number of different islands, both from stands and from selected trees. These are planted in Florida, Australia and Brazil and seem to be growing well. He studied wood as well as other characteristics. Interesting relationships and island-to-island differences were found. (Surprisingly, some sources survived temperatures as low as 6° F.; P. caribaea is commonly considered to be frost sensitive.) A summary of Nikles' thesis will soon be sent to members of the Cooperative.

7. Perry, T. O. and Baldwin, G., 1966. Genetic variation in winter breakdown of the photosynthetic apparatus of evergreens. For. Sci. 12(3):298-300.

It has been known for some time that winter yellowing is related to a breakdown of organized chloroplasts in the needles. This study looks into variation in this phenomenon.

8. Perry, T. O., Wang, Chi-Wu and Schmitt, D. M., 1966. Height growth for loblolly pine provenances in relation to photoperiod and growing season. Sil. Gen. 15(3):61-64.

Comprehensive studies are under way at N. C. State for reasons why some trees grow faster than others. Reasons include provenance differences and their reaction to photoperiod. The study reported here deals with this phenomenon.

9. Roberds, J. H., Zobel, B. J. and Kellison, R. C., 1967. Progeny testing in the N. C. State University-Industry Tree Improvement Program. IUFRO Meeting, Munich. (In press)

This paper will be presented at the meeting of International Union of Forest Research Organizations at Munich, Germany. We have had many requests to describe our crossing pattern and progeny test design. This paper attempts to fulfill this need.

10. Saylor, L. C. and Koenig, R. L., 1967. The slash and sand pine hybrid. Sil. Gen. (In press)

This cross is one of the few successful intergroup crosses and represents the first well documented hybrid between a species of Australes and a species from another group. It was made as part of Union Camp's effort to breed trees especially suitable for certain problem sites.

11. Saylor, L. C. and Smith, B. W., 1966. Meiotic irregularity in species and interspecific hybrids of pinus. Amer. Jour. Bot. 53(5):453-468.

Bud Saylor has a continuing project on the cytology of pines. This paper summarizes much of his work done over the past four years, based on 61 trees representing 21 species and 22 hybrid combinations.

12. Shelbourne, C. J. A., 1966. Studies on the inheritance and relationships of bole straightness and compression wood in southern pines. Ph. D. Thesis, N. C. State University, School of Forestry, Raleigh, N. C.

Portions of this comprehensive study are being prepared for publication. Tony found many interesting facts, some quite unexpected. For example, severe compression wood was related to nonstraightness, as expected, but moderate compression wood was found to be independent of bole straightness. No tree was found with more than 10 per cent of its total volume severe compression wood, but it was not unusual to find trees with over 30 per cent of moderate compression wood. He found moderate compression wood was strongly inherited. Crook of tree bole was strongly inherited while sweep, as expected, was weakly inherited. A summary of Tony's thesis was sent to the members of the Cooperative.

13. Stonecypher, R. W., 1966. Estimates of genetic and environmental variances and covariances in a natural population of loblolly pine (Pinus taeda L.). Tech. Bull. No. 5, Southlands Experiment Forest, International Paper Company. pp. 1-128.

Technical Bulletin No. 5 is essentially Roy's Ph. D. thesis, edited to some extent. It is the most comprehensive paper to come from the heritability study and presents the background methods of analyses that will be used as the study progresses. Data used in this publication are from both open- and control-pollinated progeny and are mostly for second- and third-year characteristics. The statistical methods used and their genetic and biological interpretations are clearly outlined.

14. Heritability - research today for tomorrow's forests. Kraft Messenger (Panama City Mill, International Paper Company).

This is a short, popularized handout given to interested visitors that come to the Southlands Experiment Forest. It gives a good layman's description of the Cooperative Heritability Project.

15. Stonecypher, R., Cech, F. and Zobel, B., 1965. Estimates of components of variance and covariance in root and shoot characteristics of loblolly pine after one growing season. Proc., Eighth South. Conf. on Forest Tree Improvement. Pub. #24, Comm. on South. For. Tree Impr. pp. 86-95.

Most root characteristics showed low inheritance, with the exception of degree of fibrousness. This characteristic showed considerable differences among crosses.

16. Stonecypher, R. W. and Zobel, B. J., 1966. Inheritance of specific gravity in five-year-old seedlings of loblolly pine. Tappi 49(7):303-305.

A close agreement was found between heritability estimates of specific gravity for three- and five-year-old material. There was a negative relationship between growth rate and specific gravity. Removal of extractives from this young wood did not change results. If such a high inheritance of specific gravity continues, genetic gains will be large.

17. Wheeler, E. Y., Zobel, B. J. and Weeks, D. L., 1966. Tracheid length and diameter variation in the bole of loblolly pine. Tappi 49(11):484-490.

Remarkably close relationships were found to exist between tracheid dimensions at breast height and the average values for the total tree bole. Twenty trees were sampled from five different stands. As expected, tracheids from juvenile wood are shorter and narrower than mature wood tracheids, but there is a relationship between length and width of juvenile and mature tracheids from the same tree. Large tree-to-tree differences were found; however, trees with longest tracheids do not necessarily have the widest tracheids.

18. Zobel, B. J., 1965. Inheritance of fiber characteristics in hardwoods -- a review. Vol. 2, Proc., Meeting of Section 41, IUFRO, Melbourne, Victoria, Australia. pp. 1-14.

This paper deals with the relatively little that is known about inheritance of fiber characteristics in hardwoods.

19. Zobel, B. J., 1965. Inheritance of spiral grain. Vol. 1, Proc., Meeting of Section 41, IUFRO, Melbourne, Victoria, Australia. pp. 1-9.

This paper summarizes what is known on inheritance of spiral grain.

20. Zobel, B. J., 1966. Tree improvement and economics: a neglected interrelationship. Sixth World Forestry Congress, Madrid, Spain. (In press)

This article was mimeographed and sent to members of the Cooperative and other interested persons. It pulls together ideas and contributions of over 30 persons. It will be published as part of the proceedings of the Forestry Congress, probably in 1967.

21. Zobel, B. J. and Kellison, R. C., 1966. The future of southern hardwoods. Proc., 45th Annual Meeting, S. A. F., Appalachian Section, Raleigh, N. C. pp. 35-37.

A discussion of the difficulty of continued high production of hardwoods on good lands was made. Reduction of suitable lands by conversion to farms, high land values, and recreation use all were cited as holding down the potential for hardwood production on the Coastal Plain and Piedmont of the Southeast.

22. Zobel, B., Matthias, M., Roberds, J. and Kellison, R., 1967. Moisture content of southern pine trees. (In press)

This major publication summarizes results from moisture content measurements of several thousand trees sampled by seven different companies during intensive wood studies. A detailed report will be published as a technical report, and a summary of the study will be given at the TAPPI meeting in Montreal. This paper is full of well-documented information about moisture content within trees, between species, between trees, within species, and between geographic areas.

23. Zobel, B. J., Stonecypher, R., Browne, C. and Kellison, R. C., 1966. Variation and inheritance of cellulose in southern pines. Tappi 49(9): 383-387.

Ten years' results are summarized involving both variation and inheritance patterns. Tree-to-tree differences were found to be large but inheritance values so small that improvement through selection does not appear to be feasible.

24. Zobel, B. J., Stonecypher, R. W. and Browne, C., 1967. Inheritance of spiral grain in young loblolly pine (Pinus taeda). IUFRO Meeting, Munich. (In press)

This paper summarizes the inheritance of spiral grain in 52 control-pollinated families in the heritability study. Assessment was made at four years of age when grain spirality is often maximum. Considerable family differences in grain spirality were found but the inheritance pattern shows these won't respond too well to selection. Overall, spirality in loblolly pine was relatively small compared to other species.