

FOURTH ANNUAL REPORT

N. C. STATE - INDUSTRY COOPERATIVE  
FOREST TREE IMPROVEMENT PROGRAM

School of Forestry  
North Carolina State College  
Raleigh

June , 1960

## FOURTH ANNUAL REPORT

### Introduction

Overall, the cooperative tree improvement program has progressed at a rate exceeding all expectation when it was actively initiated in 1956. Seed orchard establishment and tree selection have progressed well. The basic research has been greatly enhanced by the large number of graduate students now affiliated with the program and the full cooperation of the various industries when called upon.

The Second Annual Report emphasized progress made in seed orchard establishment and tree selection, and the Third Annual Report dealt mainly with progress in basic research and the contribution made by the students. This Fourth Annual Report will emphasize several changes in objectives and aims brought about by expansion and other causes.

Events of particular interest during the past year have been:

(1) The obtaining of a sizeable National Science Research Grant which supplements the current research on loblolly pine and makes possible the first steps in basic studies of sweetgum. (2) The exceptional flowering year for pines. Many of the grafts in the seed orchards are flowering profusely. (3) The addition of Dr. Perry to the staff of the School of Forestry. Although he is not primarily supported by industrial funds, his research and consultation will be invaluable in furthering certain phases of the cooperative research program. (4) The change of primary emphasis in basic research of wood properties from cellulose yields to

tracheid characteristics. This changeover has taken place over the past year and is now virtually complete.

#### Significant Events Occurring during 1959-1960

##### National Science Grant

In November, a grant totaling \$65,300 was obtained from the National Science Foundation to cover a five-year period. It was given specifically for heritability studies in loblolly pine and sweetgum. These funds are to be used in basic aspects of the heritability studies.

The overall heritability study in loblolly pine is well advanced. As described in the Third Annual Report, this study was initiated as a joint project with the Southland Experiment Forest of the International Paper Company. Its objective is to determine the heritability (Variance components) of economically important characteristics of loblolly pine. With information on inheritance patterns, selection indices (grading systems) can be constructed that are much more accurate and useful than the present ones. In addition, parent-progeny and juvenile-mature correlations will be determined.

The National Science Foundation grant makes possible the inclusion of many non-economic characteristics, such as needle, seed, seedling, and bud characters, in the present heritability study. Since an equal amount of work is involved in making the crosses in studying heritabilities for the economically important and the non-important characteristics, effort of the N. S. F. grant will be mainly in analysis of characteristics of



One of the services to the cooperating industries is to hold "schools" for company personnel, discussing how genetics can be used in the program for forest management. Such schools have been held for most of the cooperating companies. The above photo was taken at a school on the lands of the West Virginia Pulp and Paper Company near Walterboro, S. C. Note the remains of hurricane damage that occurred in this very nice loblolly pine stand.

the parents and crosses used in the study. First crosses were made last year, and Dr. Franklin Cech, of Southland, in charge of the field work, reports that most of the crosses will be completed this year. Thus, the bulk of the seed needed for the heritability study will be available two years hence.

The N. S. F. grant has made possible the awarding of three additional assistantships to students working on the heritability study, as well as providing funds for a laboratory assistant to aid in analyzing data in the laboratory.

Open-pollinated seed were collected last fall and are now growing in the nursery at the Southland Experiment Forest. This seedling crop will enable an early estimate of heritability and a comparison of the efficiency of open-pollinated versus control-pollinated progeny tests. First results on seedling characteristics will be available one year from now.

#### Dr. Perry on the Staff

Dr. Perry came to us from the California Institute of Technology at Pasadena, where he did research in the phytotron on various phases of physiological variation in loblolly pine and sweetgum. Prior to this, he was in charge of the industry-sponsored Tree Improvement Program in Florida. Tom's appointment at N. C. State consists of half-time teaching, half-time research. Although he is not supported by industry funds, his basic physiological studies will be most valuable in supporting the present industry-sponsored research program. His research will deal with

phases of physiology such as growth, photosynthetic efficiency and respiration that are related to growth rate and wood production. Many of his studies will be made on the select trees in the company orchards. In addition, Tom will guide students in studies related to the genetics of southern hardwoods.

The problems undertaken by several students deal with studies that Tom is best qualified to guide. Thus, he has already taken on a considerable share of the teaching load concerned with guidance of graduate programs.

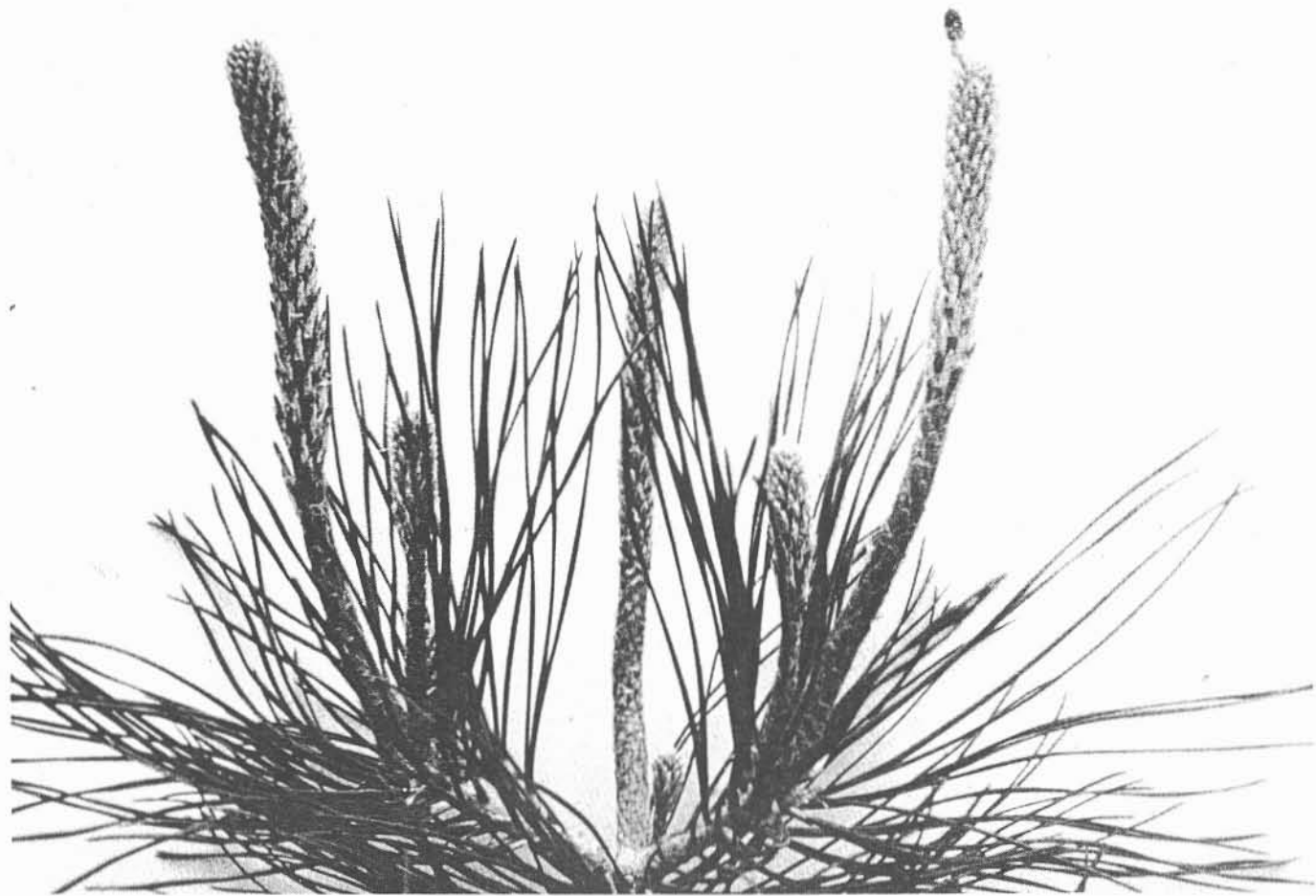
#### Exceptional Flowering Year

This spring, most seed orchards, both one and two year old, produced some female "flowers", and several produced flowers in large numbers. This situation is an unusual one, since normally several years must elapse following grafting before any significant amount of flowering occurs. This year most of the flowers are female, though in two orchards a considerable number of male catkins were observed.

Such heavy, early flowering provides a unique opportunity to get control-pollinated progeny tests established soon. Each company was urged to make control crosses with individual testers on a minimum of 40 female flowers per clone. In most instances, this crossing was done, and a total of several thousand bags have been pollinated. This abundant early flowering not only enables the probable harvest of control-pollinated seed, but also provides an opportunity for the company personnel

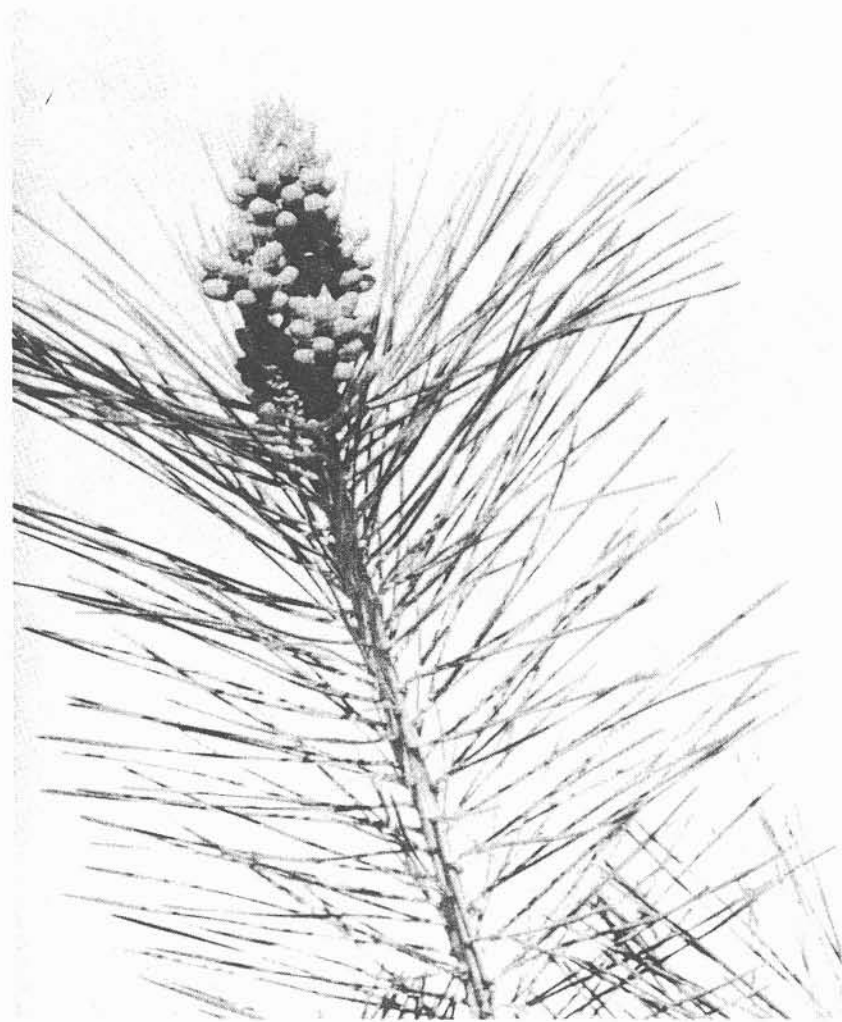
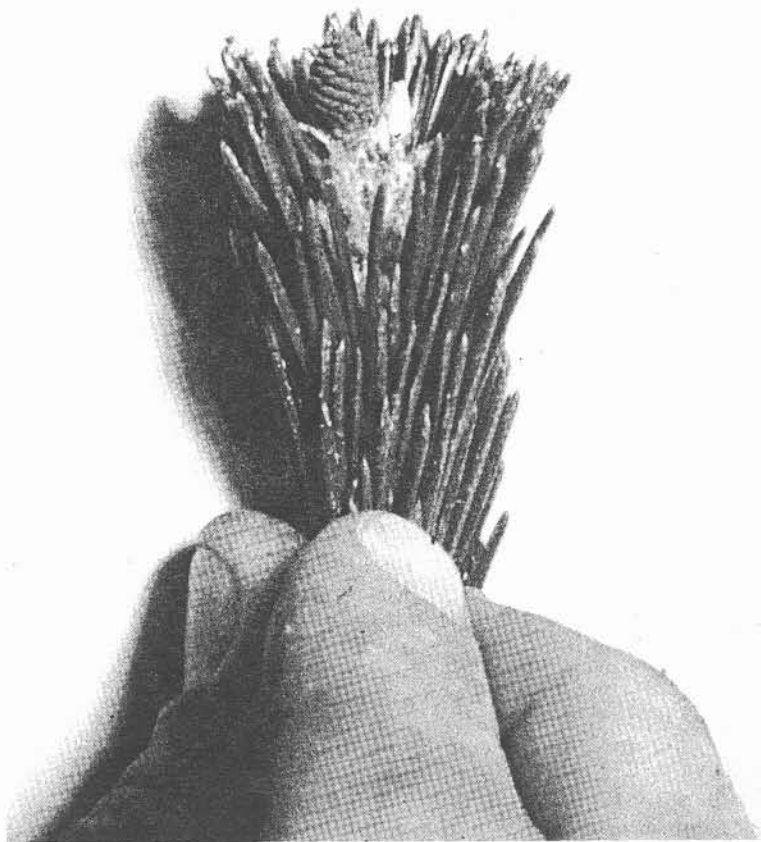


Most of the field grafts have grown at a very rapid rate. Here Bob Dorward of Bowaters shows the union where this very vigorous field graft was made. Grafts such as these flowered heavily, especially in the Eight-Oaks seed orchard of International Paper Company and at the Washington seed orchard of North Carolina Pulp Company. As many as 45 flowers were found on grafts of this size, though the average was much lower.



During the past year several second-year seedlings produced "flowers" in the greenhouse. One loblolly seedling produced considerable pollen. Most of the Japanese black pines had female flowers, as shown by the seedling, above.





Early flowering of grafts has been unusually heavy during the past year. Most of the "flowers" were female (left, above) but some of the grafts produced "male flowers" (right, above). Such early flowering will greatly speed up making progeny tests, although it will be some years before seed in commercial quantities will be obtained.

to learn the pollination technique, so that in future years crossing can be done efficiently. The heavy flowering this year was unexpected, but welcome. Several years may pass before a heavy flower crop is again produced. At that time, the grafted trees will be large and we may expect a very considerable number of cones to mature on them.

#### Change of Emphasis in Basic Research

During the Annual Meeting in 1959, a substantial portion of the discussion was directed toward the value and importance of the cellulose determinations in contrast to other basic studies emphasizing tracheid characteristics. The ensuing poll indicated that currently the greatest company interest lay in tracheid characteristics such as length, wall thickness, and tracheid diameter. Thus, the basic studies on cellulose have been gradually terminated and several active projects on tracheid characteristics were initiated.

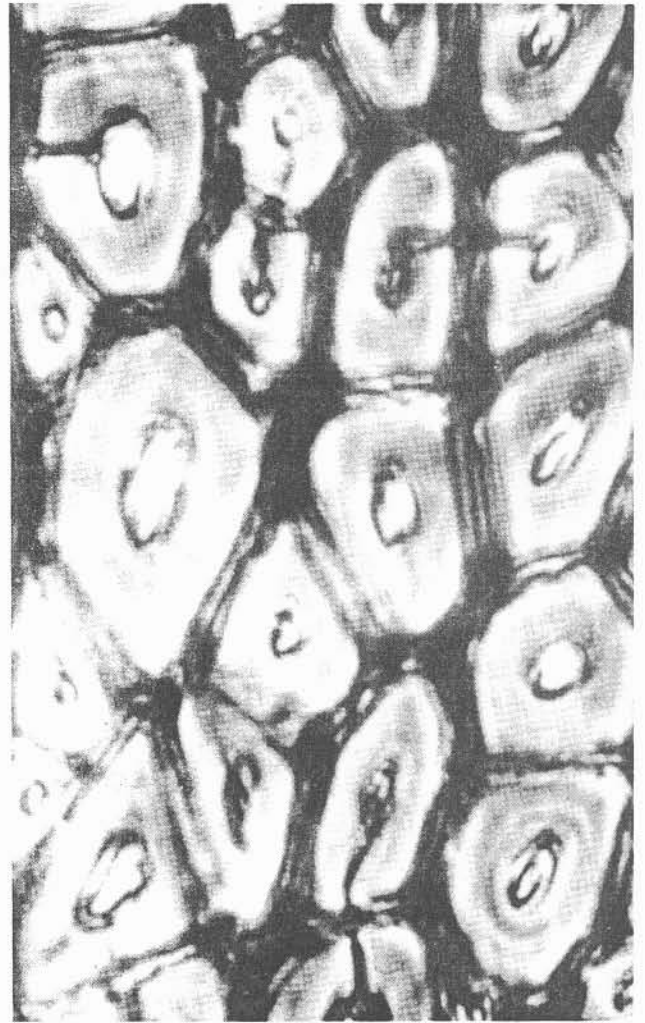
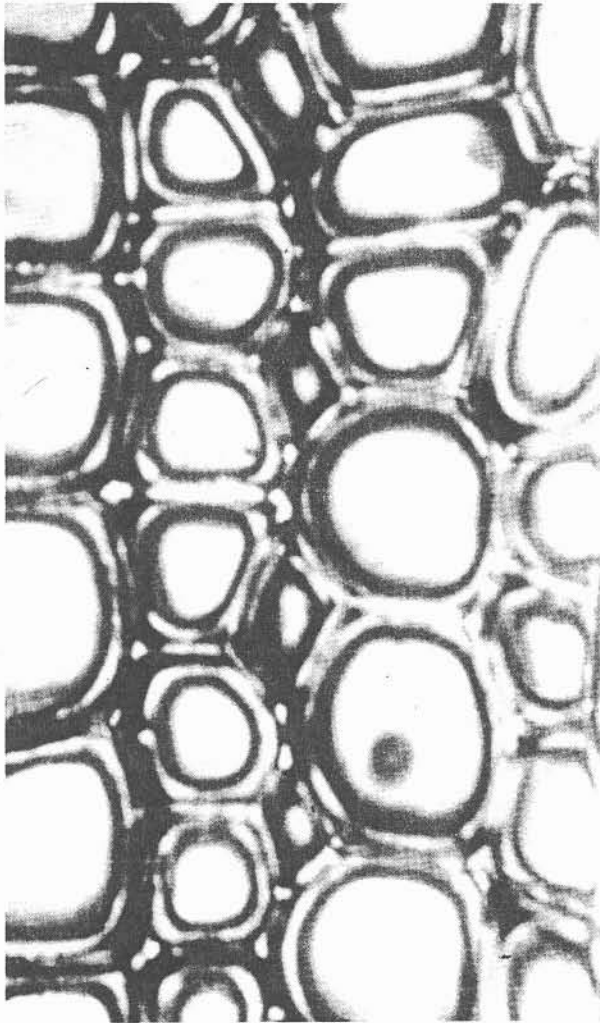
Mr. Floyd Goggans has as his Ph. D. problem the variation and inheritance of tracheid length, tracheid width and tracheid wall thickness. Mr. Mike Taras, working in the Department of Wood Technology, has under way an intensive study of the variation in wood characteristics up the tree from the stump and outward from the pith. We have submitted for publication two manuscripts dealing with tracheid characteristics, one on variation of tracheid length with geographic source of seed, and one on the effects of fertilizer on tracheid lengths.

The present studies under way, corroborated by several previous good studies on tracheid length by others, have indicated that there is much variation in tree-to-tree tracheid characteristics. We do not yet know whether this variation is strongly or weakly controlled genetically, although studies by others have indicated that tracheid length may be strongly influenced by tracheid length of the parent trees.

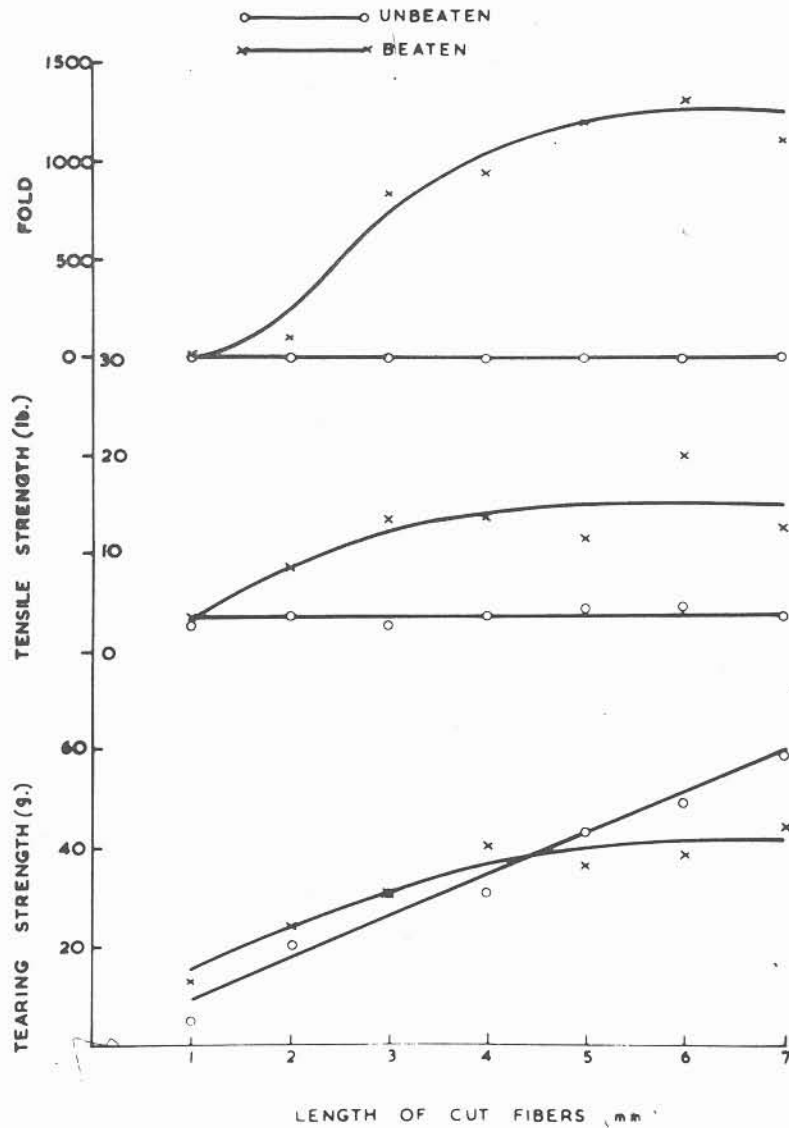
Much interest and speculation have been aroused concerning the possibility that such characteristics as specific gravity, tracheid length, and tracheid width are related. We now have data, as yet unpublished, which permit determining the interrelationships between tracheid length, tracheid width, wall thickness and specific gravity. These data will be subjected to a rigorous analysis, and published as time becomes available for completing the assessments and interpretations. From preliminary inspection, it appears that tracheid length, specific gravity and tracheid width are not strongly related, so that it seems possible for a tree with long tracheids to have either high or low specific gravity, or a tree with large or small tracheid diameters to have short or long tracheids, etc.

### The Graduate Program

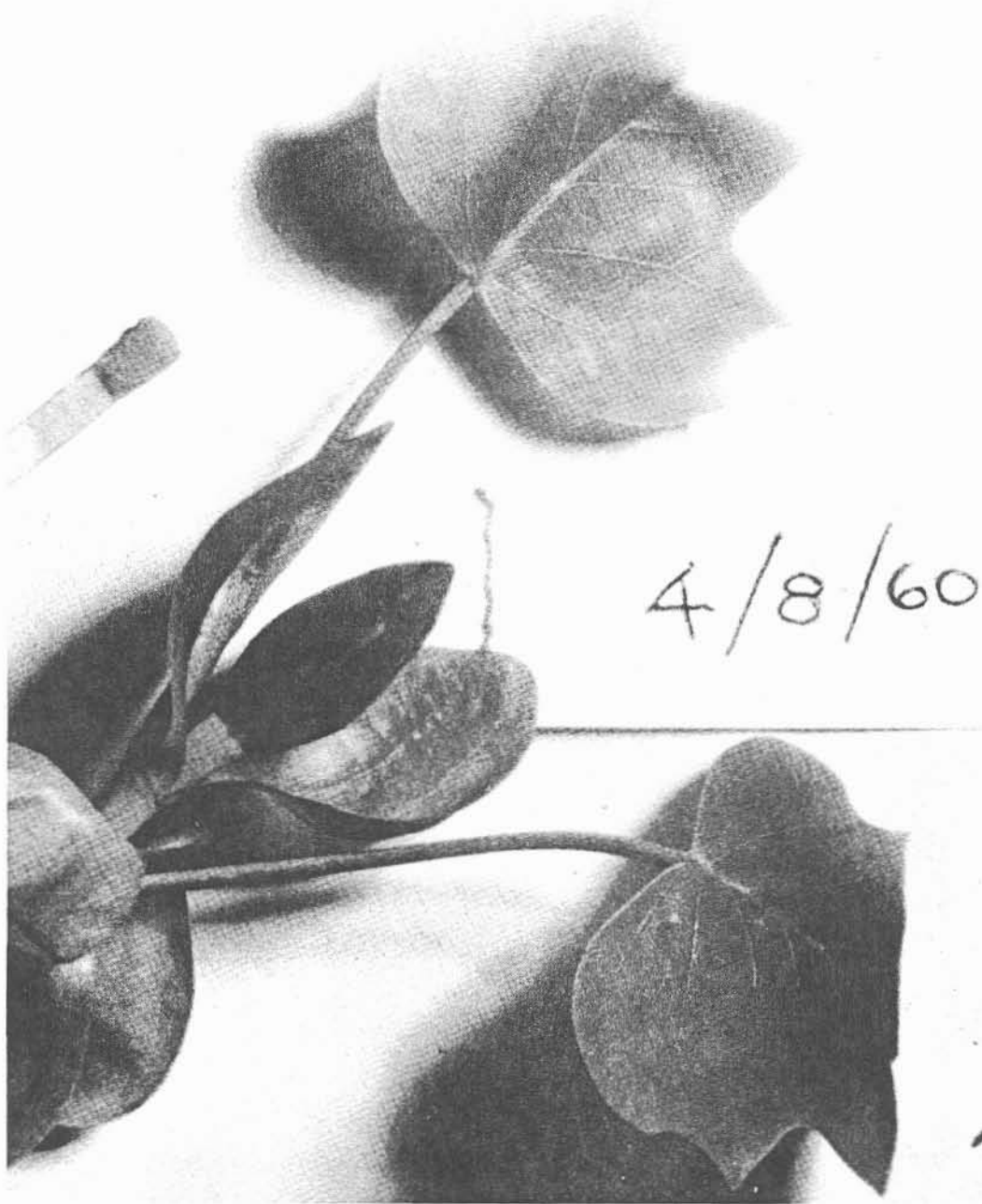
The graduate program in forest genetics and closely related fields has expanded far beyond all expectations. As of September, 1960, we shall have sixteen men, most of them studying for the Ph. D. degree, directly concerned with the field of forest genetics. In addition, several



Cell wall thickness may have a very great effect on paper properties. The above photograph, supplied through the courtesy of Dr. H. E. Dadswell from Australia, illustrates differences in wall thickness between two species of Eucalyptus, where fiber lengths are the same. Similar differences, though of lower magnitude, occur within a species. Research now under way will determine the magnitude and extent of such variation within a species.



One of the "unknowns" most needing study is the effects of different tracheid characters on the paper produced. Several organizations are working on this to help guide us in our decision as to what type wood properties to strive for in our breeding programs. The above graph, used through the courtesy of Dr. H. E. Dadswell from Australia, indicates the effects of tracheid length on certain paper properties. (Reference is made to the publication: Dadswell, H. E.; Watson, A. J.; and Nicholls, J. W. 1959. Tappi 42(7):521-526)



To do genetic studies successfully, many basic facts need to be determined. Kingsley Taft, a graduate student working to determine ways to increase viable seed set in yellow poplar, has found it necessary to make a series of studies on the flower and its development. Pictured above is the bud of a yellow poplar flower just about to open.

other students at N. C. State College are working on research projects related to forest genetics. Members of the School Staff have an active part in guidance of these students, and are members of their graduate committees.

Below are listed the names of students who are now actively engaged in research related to forest genetic studies, and their research problems:

Tom Conkle	Progeny testing of seed orchards
Floyd Goggans	Variation and inheritance of tracheid characteristics in loblolly pine
Fred Mathews	Cone rust of slash pine (completed in the Plant Pathology Dept. for the M. S. degree)
Bob McElwee <sup>(1)</sup>	Pollen flight characteristics and germination with horizontal and vertical samples (completed for the M. S. degree)
Gene Namkoong <sup>(2)</sup>	Hybridization in southern pines
Brooks Polk <sup>(3)</sup>	Pollination problems and techniques in pines
Jim Roberds	Variation patterns in the heritability study
Mahmoud Salem	Eccentric growth in hardwoods
Leroy Saylor	Cytogenetics of pines
Dan Schmitt	Crossability and compatability in sweetgum
Earl Sluder	Geographic variation in yellow poplar (completed for the M. S. degree)

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<sup>(1)</sup>Full time staff member, Liaison Geneticist

<sup>(2)</sup>Arrives Sept. from Southern Institute of Forest Genetics

<sup>(3)</sup>Staff member, School of Forestry, Univ. of Missouri

Don Smith	Wood quality of the bole, as predicted from limb sections of pine
Ray Steinhoff	Soil-foliage nutrient studies on loblolly pine
Roy Stonecypher	Variation and correlation of wood characters, soil, foliage, seed, etc., in the pine heritability study
Kingsley Taft	Flowering characteristics and effect of bees on seed set in yellow poplar
Michael Taras (1)	Patterns of wood characteristics within trees of slash pine
Fred Taylor (2)	Geographic variation in wood of yellow poplar
Eyvind Thorbjornsen (3)	Variation patterns in loblolly pine (completed for the Ph. D degree)
Ray Varnell (4)	Variation in root characteristics of southern pines
Charles Webb	Technique of field grafting (completed for the M. S. degree). Variation in sweetgum, especially wood characteristics (started for Ph. D. degree)
Craig Whitesell (5)	Geographic variation of Virginia pine

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- (1) Technologist, Southeastern Forest Experiment Station, and Affiliate Staff Member, School of Forestry
- (2) Department of Wood Technology, School of Forestry
- (3) Now geneticist, Tennessee Agricultural Experiment Station, Univ. of Tennessee
- (4) Called into service, to return in October
- (5) Arrives September from Solomons, Maryland





To make a heritability study such as the cooperative one with International Paper Company, it is necessary to have much land area and many stands on which to work. Pictured above is one of the stands of loblolly pine on the Southland Experimental Forest in which crosses have been made for the heritability study.



The biggest difficulty in control pollinating pine is the physical problem of getting to the "flowers". These photographs, taken on the lands of the Southland Experiment Forest, International Paper Company, show two methods of getting up the tree. At the left is the standard Swedish ladder. To the right is shown the mechanical, trailer mounted ladder developed and used by personnel of the Southland Experiment Forest. It increased the speed of crossings necessary for the heritability study under way.

## The Cooperative Program

Twelve (12) pulp and paper companies are continuing to support the program, just as they did last year. A larger share of the operating funds <sup>(1)</sup> however, is coming from non-industrial sources than was formerly the case. The National Science Grant, Experiment Station Funds, and fellowships from various sources such as N. S. F. and H. E. W. have helped the program to expand both in size and scope of operation.

The many services which are provided by the industries, in addition to the direct financial contributions, have made several additional studies possible. Previous mention has been made of the cooperative heritability study with International Paper Co., a study that would be impossible to undertake without the personnel, facilities and land at the Southland Experiment Forest. Progeny test seedlings have been grown by the Bowaters Southern Paper Corporation and the Riegel Paper Corporation, in their nurseries. Land for a special geographic and site variation test, and labor to plant the test material, have been donated by the North Carolina Pulp Co. and Halifax Paper Co. All the industries have helped a great deal by supplying equipment and supplies, plant materials, land and labor in making progeny tests, as well as being hosts for the several meetings of the cooperative program. The size of the budget is, then, in a sense misleading; a much more intensive research program than the size of the budget would indicate is actually under way.

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<sup>(1)</sup>A detailed breakdown of source of funds will be supplied to the supporting industries.

## The Seed Orchard and Tree Selection Program

Personnel from N. C. State College operate in a consultant capacity in the tree selection and seed orchard programs, in addition to the final grading of the select trees, which is done by Liaison Geneticist McElwee. At the present time, over 700 trees have been graded in 9 states, all but about 150 of which are loblolly pine. The remainder are slash, shortleaf, pond and Virginia pines. Approximately 400 of these have been grafted into one or more of 29 different seed orchards that are established in 15 locations in 6 states.

During the past year a grading system was developed for use on yellow poplar, and 23 selections have been made on the Coastal Plain of North Carolina for the North Carolina Pulp Company. Also, during the past year, more general interest has been evidenced for Virginia and pond pines, and a number of selections were made in these species.

Several seed orchards have been completed. Plans for a number of others have been expanded because of the increased interest in direct seeding and the need for larger quantities of seed. One potential danger to the orchards was the heavy ice and winds, but we were extremely fortunate in that there was no appreciable damage to any of the orchards by ice or hurricanes, although nearby forest stands were badly damaged. Field grafting results were excellent this year, despite the extremely cold winter in most of the area which we serve; several companies report takes in excess of 85 percent.



The seed orchards had a number of "near misses" from ice and snow and from hurricane winds. Luckily no major damage resulted. Here Bud Johnson is inspecting the Chesapeake seed orchard in West Point, Virginia. In one orchard the cold weather killed outright many grafts of several clones. Such hazards are always present in seed orchard management.

Interest in wood properties of trees used in seed orchards still is high. All parent trees used in the seed orchards are now being analyzed for tracheid length, as well as specific gravity and cellulose yields. This fiber analysis should be completed during the next year. Several of the industries have indicated that they desire to take this characteristic into account in recommendations for trees to use in the orchards. Already over 10,000 tracheid measurements have been made on the select trees, showing a large tree-to-tree fluctuation at both the 15-year ring and the 30-year ring.

Progeny tests are well under way. At present, in excess of 12,500 open-pollinated progeny from select trees grafted into the seed orchards have been outplanted. Many of the necessary control pollinations have been made; thus, in three years a large number of progeny will have been planted to test the genetic worth of the trees grafted into the seed orchards.

## Publications

During the past year a number of publications have been made or are currently in press. Considerable data on wood is now available for publication, and will be worked up as soon as time can be found to do so amid the very heavy demands for travel and student guidance. Some of the more pertinent publications are listed below:

1. Barber, J. C., and Zobel, B. J. 1959. Comments on "Genetic variation within geographic ecotypes of forest trees, and its role in tree improvement." Jour. For. 57(6):439-441.

These comments were made in an attempt to clarify and present a more realistic and practical view of the use of genetics in forestry than were presented in the original article.

2. Cech, F. C., and Zobel, B. J. 1960. What is inherited - how we can tell. Forest Farmer (in press)

A description of the heritability study under way at Southland Experiment Forest was prepared in simple language.

3. McElwee, R. L., and Zobel, B. J. 1960. Characteristics of loblolly pine in six southeastern states. (in press)

This article does not deal with genetics, but with silvicultural and mensurational information gathered during the past three years on some 700 select and 3500 check trees.

4. Zobel, B. J., Henson, F., and Webb, C. 1960. Estimation of wood properties of trees from breast height measurements. For. Science (in press)

This study indicated the feasibility of using breast height measurements to classify wood properties of the total tree bole. Results are shown graphically.

5. Zobel, B. J., Webb, C., and Henson, F. 1959. Core or juvenile wood of loblolly and slash pine trees. Tappi 42(5):345-356.

This was in the form of a "monograph", including a comprehensive review of the literature, as well as pulling together all of our

findings on core wood for these two pine species. It was fortunate that this was done at this time, because considerable confusion seems evident on the properties and location of core or juvenile wood.

6. Zobel, B. J., Goggans, F., Maki, T.E., and Henson, F. 1960. Effect of fertilizers on wood properties of loblolly pine.

This paper is to be presented at the annual meeting of the Biology Committee of TAPPI in August, 1960, in Seattle. It reports the effects of high, medium and no fertilizer treatment on a 16-year-old stand of loblolly pine. The trees are now 25 years of age, and the analysis deals with tracheid length, specific gravity, and cellulose yields seven years prior to and seven years following first application of fertilizer.

7. Zobel, B. J., Thorbjornsen, E., and Henson, F. 1960. Geographic, site, and individual tree variation in wood properties of loblolly pine. Submitted to *Silvae Genetica*, April 1960.

This is a comprehensive report of the variation of specific gravity, cellulose yield and tracheid length among trees, sites and geographic areas in seven states. It is the culmination of 2 1/2 years' intensive analysis. The complex interrelationships have been clarified by use of IBM methods of analysis, and show some very interesting trends for tracheid length and specific gravity.

8. Zobel, B. J. 1960. Seed sources for direct seeding. Direct Seeding in the South - a Symposium. Duke University. pp 27-30.

This was prepared upon request for the symposium and stressed how seed source may be even more important in direct seeding than in planting. The first year, when establishment takes place, is the critical one for survival--this first critical year is by-passed by watering and care in the nursery bed, but may spell the difference between success and failure if the wrong seed source is used in direct seeding.

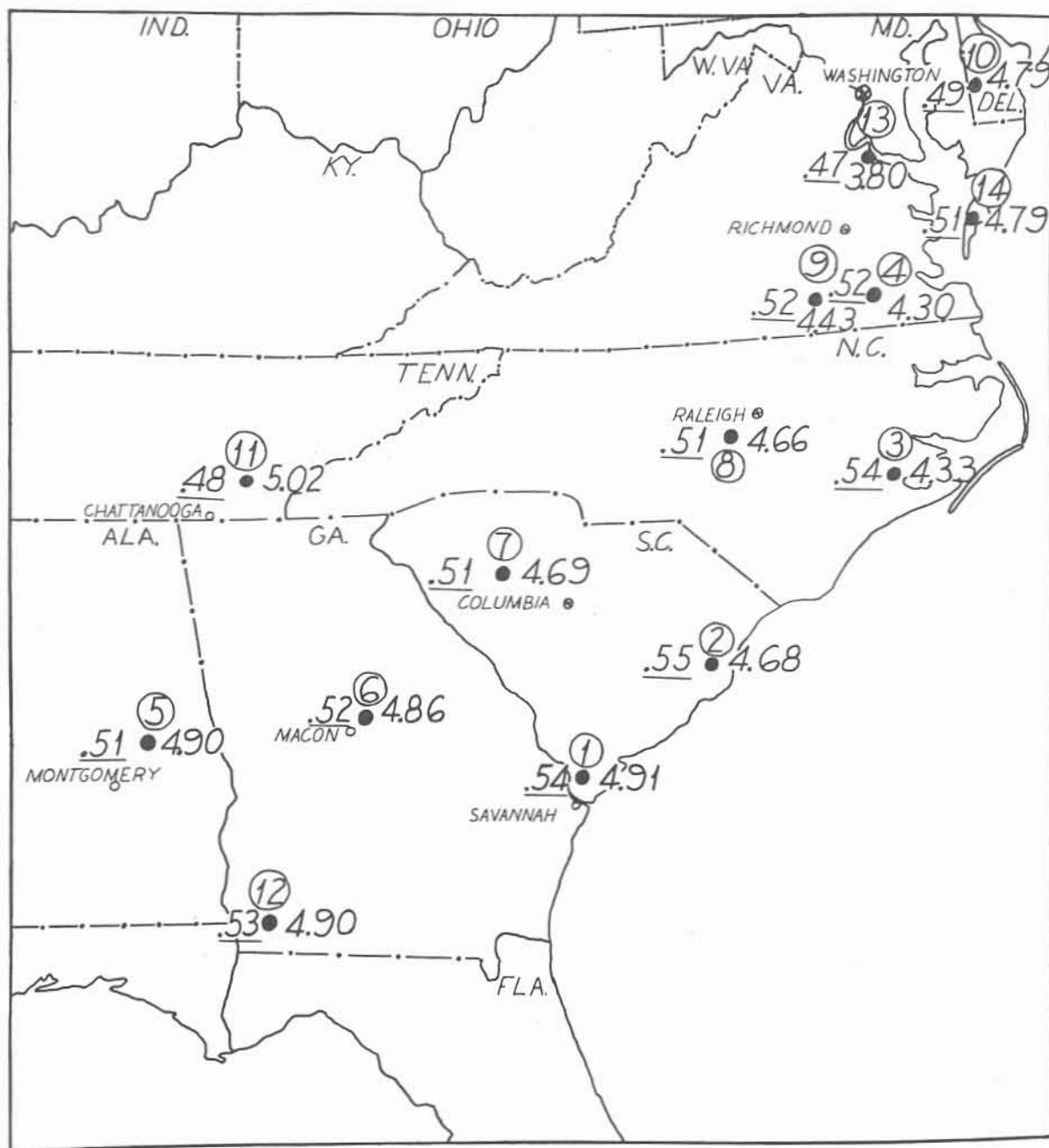
9. Zobel, B. J. 1960. Selection and breeding of coniferous trees with superior wood characteristics. Fifth World Forestry Congress.

This is a request paper to be presented at the Fifth World Forestry Congress in Seattle, August, 1960. It summarizes information on inheritance of wood properties.

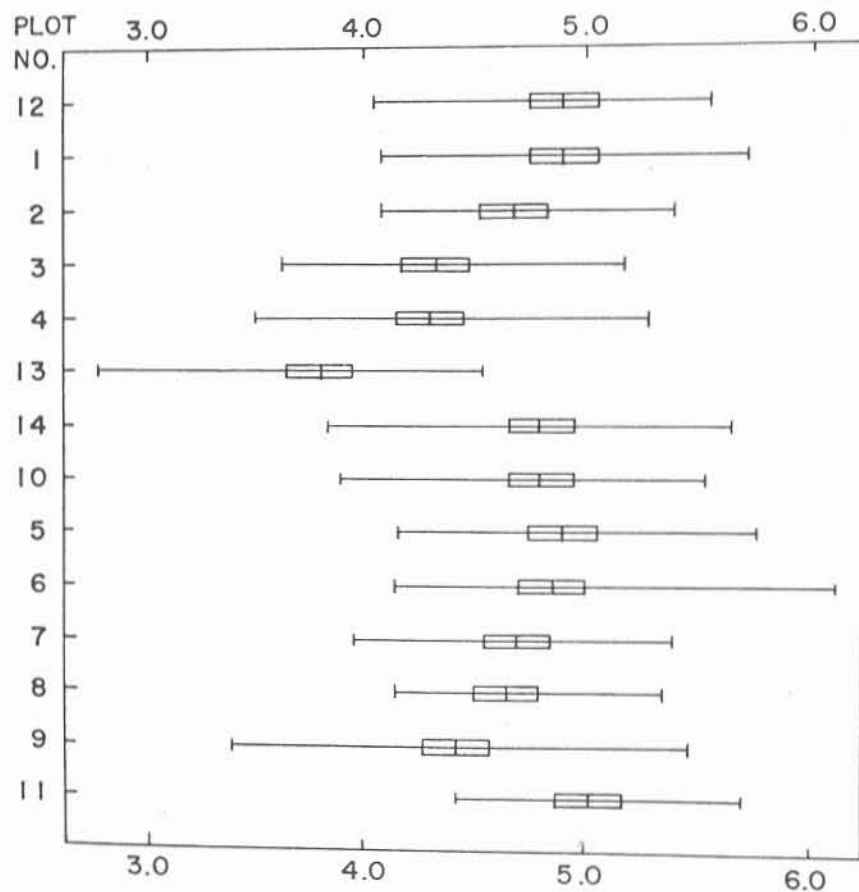
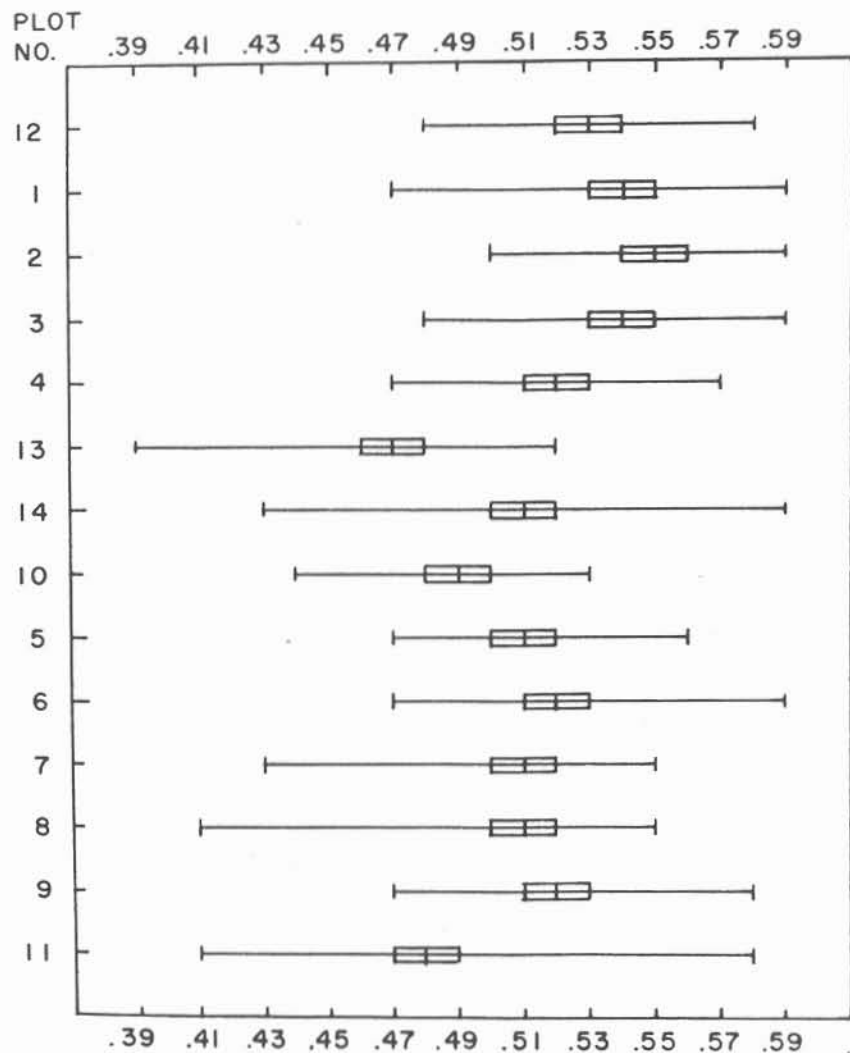


Cooperating Companies

<u>Company</u>	<u>Working Units and States</u>
Bowaters Southern Paper Corp.	One - Tenn., Ga., Ala., Miss., N. C.
Champion Paper & Fibre Co.	One - S. C.
Chesapeake Corp. of Virginia	One - Va.
Coosa River Newsprint Co.	One - Ala.
Continental Can Co.	One (Gair) - S. C., Ga., Ala. One (East) - N. C., Va.
Georgia Kraft Co.	One - Ga.
Halifax Paper Co.	One - N. C., Va.
International Paper Co.	One - S. C., N. C. (Coastal Plain) One - S. C., N. C. (Piedmont)
North Carolina Pulp Co. (Weyerhaeuser)	One - N. C., Va.
Riegel Paper Corp.	One - N. C.
Union Bag-Camp Mfg. Co.	One - Ga., S. C. One - N. C., Va.
West Virginia Pulp & Paper Co.	One - N. C. One - S. C., Ga.

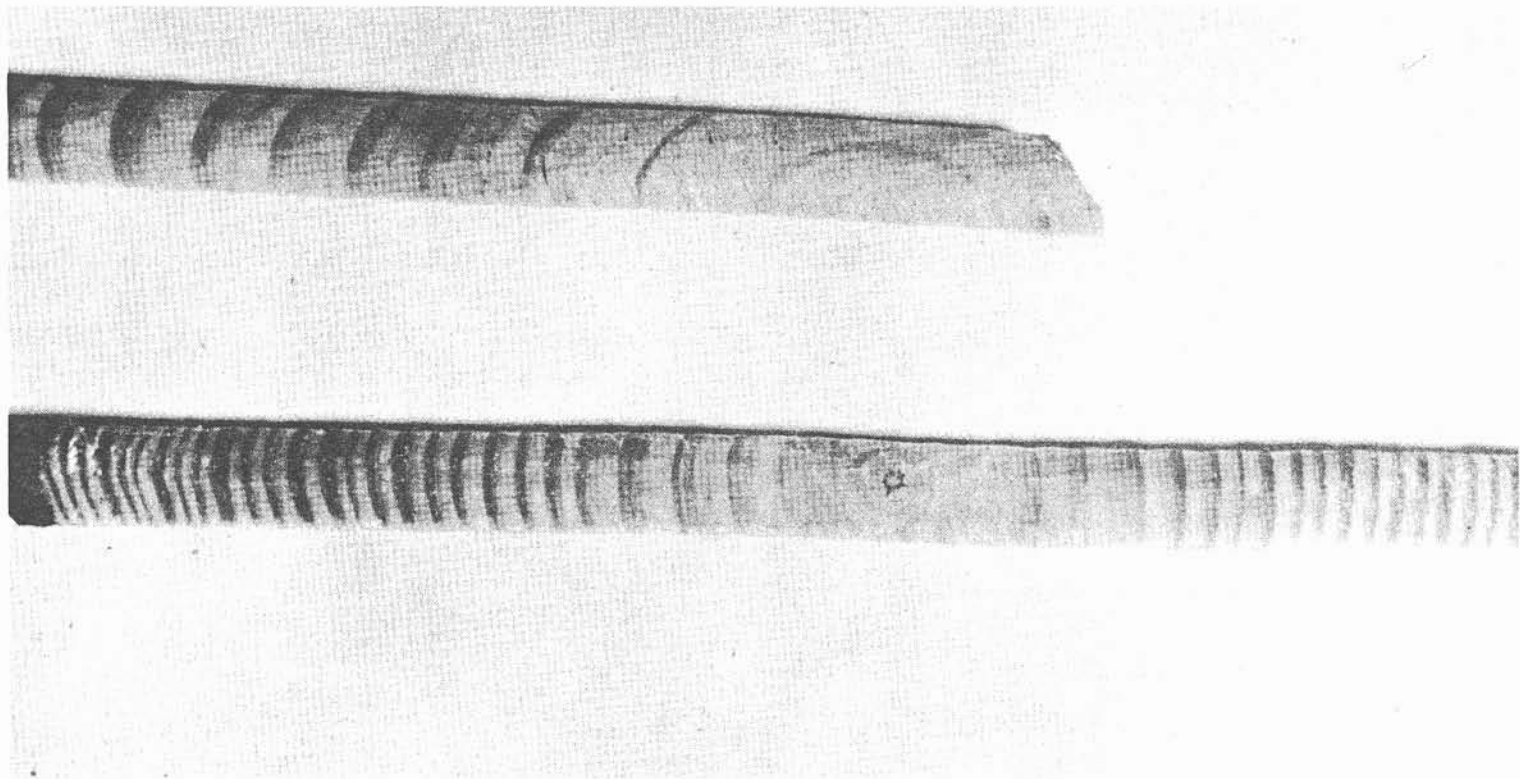


The map indicates location of plots in the geographic wood variation study of loblolly pine. Underlined numbers refer to specific gravity, circled numbers to plot number, and the three digit numbers to tracheid lengths. See the next page for graphical presentation of results.

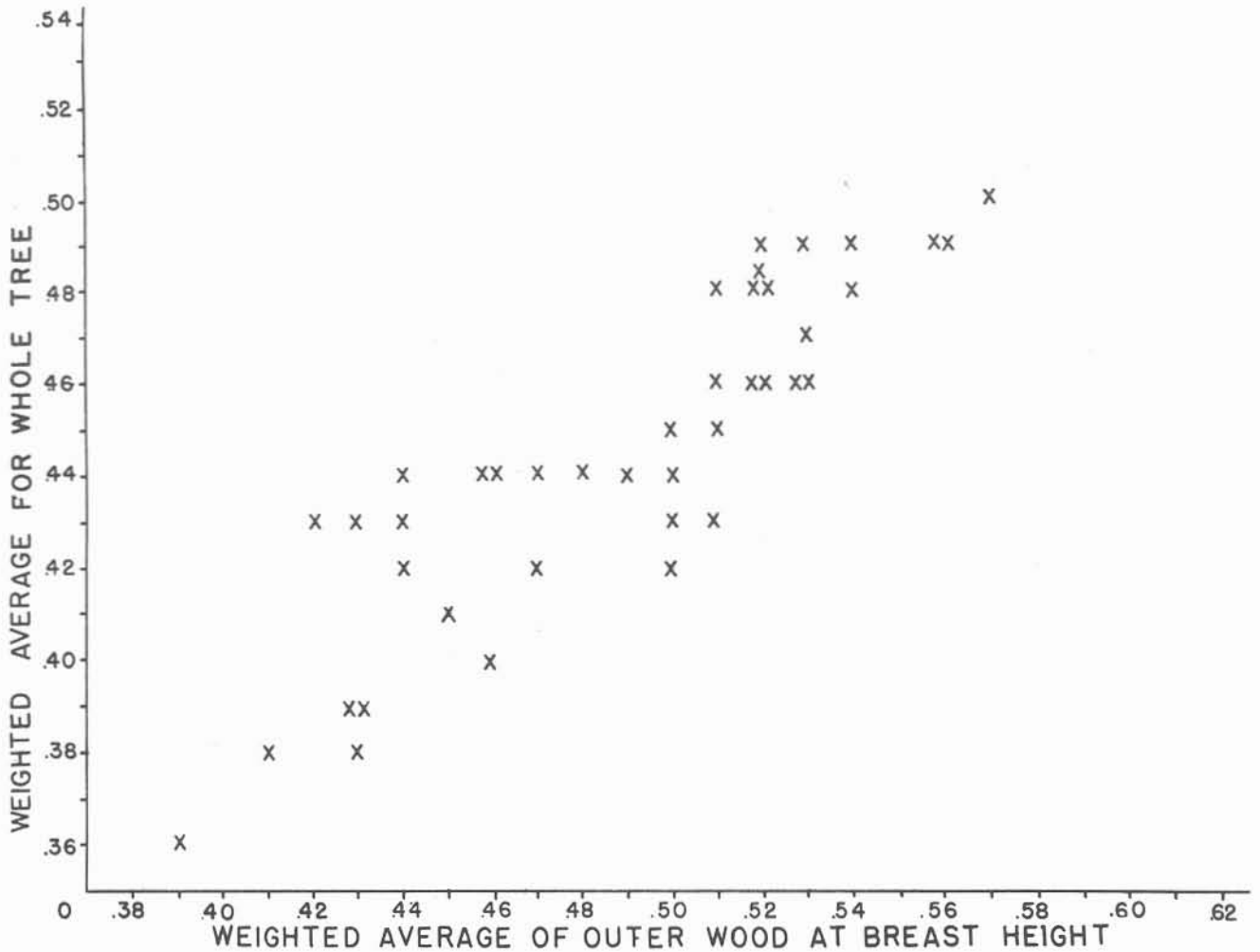


Recently a manuscript was completed showing variation in wood of loblolly pine among trees, among sites and among different geographic areas.

The above pictorial graphs indicate variations in specific gravity and tracheid length. The heavy vertical line is the average for the 23 tree plots, the box represents two standard errors and the horizontal lines show the total range in values for individual trees. Plot numbers and locations were indicated on the map, previous page. A trend for lower specific gravity and shorter tracheids is evident from south to north in the Coastal Plain, while much less change is found from south to north in the Piedmont.



During the past year, a summary or "monograph" on core wood in loblolly and slash pine was published in Tappi. The above "oversize" increment core illustrates the different appearance of the wood near the pith of the tree (the small dark-rimmed target in the center of the core in the photograph). Presence of this core must be taken into account in all studies of wood properties, especially from trees of different ages.



All researchers working with wood properties have been concerned about the feasibility of using wood properties from the breast-height position to categorize the whole tree. A recent publication has been completed clarifying this relationship. As indicated above, there is a good relationship between specific gravity at breast height and specific gravity of the whole tree. All studies to date indicate that breast-height values are related to the values of the whole tree.