FIRST ANNUAL REPORT

N. C. STATE - INDUSTRY COOPERATIVE

FOREST TREE IMPROVEMENT PROGRAM

School of Forestry
North Carolina State College
Raleigh
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First Annual Report
N. C. State -- Industry Cooperative
Forest Tree Improvement Program

Introduction

At the June 1956 meeting of the advisory committee, a decision was made to publish annual Progress Reports. The objectives of these reports are to keep the supporting industries informed as to what is being done and results achieved.

As might be expected, in tree improvement work the first year progress report cannot be filled with a listing of finished projects. To date, however, the N. C. State-Industry program has made rapid progress. Many studies currently underway will show definite results within the next year or two, and considerable research data are summarized in this first report.

Activities of the forest tree improvement program can be arbitrarily divided into three parts; (1) help, advice, and consultation with the supporting industries on management problems relating to tree improvement (2) basic research on problems common to the supporting industries, (3) working with and guiding graduate students in the forest genetics field. These parts will be discussed under separate headings below.

Cooperation with Industries

This phase of the program has, for the most part, progressed very well. Most of the cooperating industries have initiated active programs, and results can already be seen. A few of the industries have been

somewhat slow in getting underway, having as yet done little on their own lands.

Chief among the industry activities are the selection of trees for seed orchards, and seed orchard establishment. The selection phase is well underway and Bob McElwee is now spending full time grading the selected trees. Some excellent trees have already been located.

In brief, the plan for selection consists of (1) Preliminary selection by company personnel (2) Re-selection based on information gained by company personnel working with McElwee while grading. The re-selection is done by one competent company representative. (3) Final selection and grading by McElwee. Most companies have underway, or have completed, step 1 above, and several are undertaking step 2 at the present time. McElwee will soon be spending full time on the third step.

A word of explanation regarding step 3, the final grading, is appropriate here. Final grading by Bob McElwee of every tree to be used in the seed orchards is a time consuming, expensive operation, but we feel it is warranted. Selection and grading is the most critical phase of seed orchard establishment and must receive intensive attention. The objective is to get the very best trees possible into the seed orchard as the future seed source. This phase requires considerable work, skill, and uniformity in grading by a highly-trained man. McElwee fills that need, and after he has finished grading, all trees used in the seed orchard will represent the fastest growing, best formed trees with desirable wood that could be located. It must be remembered that one or two inferior

individual clones included in a seed orchard, unless detected early, can quite effectively nullify gains from the other desirable selections, so skill and care in selection are essential.

McElwee has graded several hundred trees to date, and has rejected as unsuitable an even larger number. Even after he grades a tree it will not necessarily be used in the seed orchard. We will study all the graded trees for each company and select from them those that we consider to have the best genetic potentials. These trees will then be recommended as trees for each company to use in its seed orchard.

Before final recommendations are made, each company will need to make a decision concerning wood specific gravity, or wood density. As previously found for loblolly pine in Texas, we are finding a very large variation in specific gravities from tree to tree, independent of site. Some of the selected trees will run over .65 specific gravity while others will be as low as .45. Which tree does your company want? Do you want to emphasize the trees on the upper or lower end of the specific gravity scale? Before we make final recommendations it will be necessary for each company to supply us with this information.*

Actual grafting of the selected trees into the seed orchards will begin in December. Most companies have already selected areas for seed orchards and have the grafting stock planted. Since field grafting

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* This decision must be made on type, quality, and specifications of product manufactured, taking into account the increased tonnage yield from trees with higher specific gravity, and the difference in fiber quality with high specific gravity wood.

techniques will be used, a relatively low graft survival is anticipated. Don't expect the high survivals reported in the literature. We are working with loblolly pine, a difficult grafter; with old material, in some cases up to 60 years of age (young material grafts much easier); and we are working with hard to control field grafts. Each company will have a different set of conditions to contend with, and will have to make adjustments as problems are encountered. As an over-all goal we are hoping for 25% success, although some of the more southern and eastern companies may well top this. The northern and western companies can anticipate difficulties due to fluctuating relative humidities.

As suggested, most companies are planning to start grafting on a moderate scale the first year. From experience thus gained on local problems, the second year should see an increased degree of successes.

Two companies have asked for "schools" for their forestry personnel. At these meetings tree selection, seed orchard management and establishment, pine flowering habits, wood properties, management problems relating to genetics and other questions and problems are discussed. We welcome additional requests for "schools" because following such meetings we always notice a more realistic, sympathetic attitude of foresters towards genetics.

Research on Fundamental Problems

As a part of the tree improvement program, research on basic problems of mutual interest to all companies has been undertaken. We are concentrating on wood properties and related problems. Already some

very interesting results regarding specific gravity have been found; these will be summarized under specific project discussions later in this report.

Please note that it is necessary, under the plan of organization and finances of this cooperative program, to do a portion of the basic research on company lands. Cooperation along this line has been very good and every company contacted has made available field help, equipment, and land for testing as needed.

Graduate Students

There are at present three graduate students enrolled, and three more will enroll in the coming fall semester.

Mr. Eyvind Thorbjornsen, from Norway, is working on his Ph. D. degree. He received his MS from the University of Washington and had forestry training in Europe and in this country. His thesis problem deals with the seed producing ability of trees selected for seed orchards; the quality of seed produced, and the quantity of the seed produced, etc. He hopes to find out something about seed characters of the better trees, and to see why they usually are considered as being light seed producers. Thorbjornsen will spend the coming summer working on his thesis and related problems on the lands of one of the cooperating companies.

Mr. Earl Haught, formerly a forester for Bowaters, is working for his Masters degree in forest genetics. His problem deals with the presence of compression wood (abnormal wood) in spiral and crooked

loblolly pines. Much has been said about not using crooked trees for seed orchard material. Haught is trying to find out just how much compression wood accompanies the spiral, (a genetic character), how it is distributed, and how much is associated with knots. Since compression wood is abnormal and has qualities very unfavorable in the manufacture of paper, his findings should be of considerable interest to the cooperating industries.

Bob McElwee, in his "spare" time, is working on the Ph. D. degree. His problem is vital for seed orchard management, i. e., how large an isolation strip is necessary to keep the seed orchard from being contaminated by unwanted pollen. Several incomplete studies have previously been made on this subject. McElwee's will be a complete study and he will overcome several difficulties by using radioactive pollen. His technique will enable him to determine pollen flight under many different conditions, and when the research is complete, it should be possible to state definitely what isolation distance must be left to obtain a certain degree of seed purity in the seed orchard.

Personnel

The present personnel connected with the tree improvement program consists of Bruce Zobel, geneticist, Bob McElwee, liaison geneticist, T. E. Maki, silviculturist, and Peggy Houck, part time secretary. In addition, the graduate students do many jobs and as money is available, students are hired to perform routine tasks.

Bob McElwee arrived on the job in August, 1956, and had as his

first objective the contacting of the supporting industries. He worked out plans for a grading system and is now grading many of the selected trees. His specific job is to work between the College and Industry on a liaison basis. He was formerly employed by Gaylord Container Corporation of Bogalusa, Louisiana, where he worked on management research, including genetics.

Dr. Bruce Zobel arrived on the job January 1, 1957, having come from the Forest Genetics Laboratory, College Station, Texas. He is heading up the program, and has as his special interest the guidance of graduate students and the basic research program on wood properties. His basic research in Texas largely centered on inheritance of wood specific gravity and this continues in North Carolina in addition to intensive work on cellulose yield variation.

Dr. T. E. Maki heads the management group under which the genetics work comes. Although he does no direct work on the project, his work on nursery, soils, fertility, and related problems will contribute to the program, and his aid is frequently sought and obtained.

Mrs. Houck does the secretarial work involved, keeps up the card and reprint files, and helps in the compilation of research data.

Physical Facilities

The slowest phase of the program has been in the obtaining, developing, and outfitting laboratory and greenhouse facilities. The request to the State Legislature for a greenhouse and headhouse has been favorably passed on by the budget bureau. Construction of these facilities will be

started as soon as the money is appropriated for them

Field equipment has been obtained. Transportation, the Swedish ladder, and other items are being used. Certain pieces of field equipment are being constructed by cooperating industries. The laboratory is partly equipped, sufficiently so that cellulose analysis has been started. Certain key pieces of equipment have been borrowed from the Utilization and Pulp groups of the N. C. State School of Forestry.

Research Projects

Several research projects are underway at present. They are briefly described below:

Project O -- Selection of Superior Trees

This project deals with the selection and grading of the superior trees to be used in seed orchards. Each tree is carefully graded by Bob McElwee for several characteristics. In addition, wood samples are taken to get wood properties of the select tree. This tree is then either used in the seed orchard or rejected, depending on its grade and the overall relationship of its various characteristics. About 200 trees have been graded so far. The trees are graded in a very strict manner; i.e., they are compared with the 5 nearest crop trees in the stand. Any tree that grades high is really good. Some of the characteristics considered in the grading are volume, and growth rate, height, pruning ability, limb form, competitive ability, wood specific gravity, bole straightness, crown size, and others.

After seed is collected from these trees, progeny tests will be made

to see if they are genetically better. If the trees produce good progeny, they are retained in the seed orchard; if not, they are removed. These tests consitute a long term project.

Project 1 -- Variation in Fiber Yield Among Individual Loblolly Pine Trees

These studies form the "meat" project of the basic research on wood properties. The project covers many things including compression wood, specific gravity, and fiber yield (cellulose-lignin ratio). For the latter, hollocellulose and alpha cellulose will be determined.

A copy of the project outline for this study has been previously sent to the cooperators so the details will not be repeated here. To date some 250 king-sized increment borings have been made on 3 separate areas, in several different stands to study variation in specific gravity and fiber yield, and to locate high yield individuals for use in seed orchards.

The yield studies are now underway. Dr. Yundt and Dr. Bradway, of Camp-Union Bag, along with Professor Libby of the N. C. Pulp Laboratory, have worked out a method of small-sample analysis which is now in use. At the time of this writing, however, no comparative yield results are available.

For the material under study, considerable information has been obtained on specific gravity. This information will be published as a summary report, when all the data are analyzed. In brief, to date we find:

(1) Variation in specific gravity between trees growing on the same site, same age, dominant trees only, is very great. Table I lists some of the variations found.

Table 1 -- Specific Gravity Data for Several Stands

Stand No.	Type of Stand	#Specimens	Age	Site	Highest Sp. G.	Lowest Sp. G.	Ave.* Sp. G.
9-1-25	Loblolly plantation (Same site as 9-1-50)	47	18	flat-woods	.58	.43	.50
9-1-50	Loblolly natural Even aged. (Same site as 9-1-25)	47	18	flat-woods	.56	.41	.48
9-2 L	Loblolly plantation	49	6	deep sand	.41	.31	.36
9-2 S	Slash plantation	48	6	deep sand	.46	.32	.37
8-1-25	Loblolly plantation	48	17	flat-woods	.55	.44	.50
8-1-50	Loblolly, even aged stand	48	37	flat-woods	.61	.45	.54

The above data show that the same thing holds true for loblolly pine in the east as it did in the western end of its range, i.e., that trees of the same age, growing on the same site, have considerable variation in specific gravity. In other words, no one site, or combination of environmental conditions, can be said to produce a uniform or predictable specific gravity. It would appear some of the variation is genetic in nature.

(2) It was found that the so-called juvenile wood has a much lower specific gravity than the mature wood. All specific gravity deter-

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* Average specific gravity is a weighted specific gravity based on volume growth, not radial growth.

minations were made separately for juvenile and mature wood. The separation was made by appearance. It was found that, as in Texas, the break from juvenile to mature wood comes between the 6th and 10thyear.

The following gives comparisons between juvenile and mature wood for 200 samples.

Table II -- Comparison of Juvenile and Mature Wood

Stand No.	Years of Juvenile Wood	Sp. G. Juvenile Wood	Sp. G. Mature Wood
9-1-25	7	.41	.54
9-1-50	8	.41	.52
8-1-25	6	.41	.55
8-1-50	8	.45	.56

These figures are rather important, showing that in the shorter rotations, a higher proportion of very low specific gravity wood (juvenile wood) is produced. Juvenile wood also has poor pulping qualities. Note from Table I, stands 9-2 L and 9-2 S (all juvenile wood) how low the specific gravities were for both slash and loblolly pine.

The work on yield (cellulose-lignin) ratio is now underway but results are not yet available.

Project 2 - Relationships Between Juvenile and Mature Characters

Some significant results have been found here concerning wood properties. It is found that there is a very strong relationship between the specific gravity of a tree when young (juvenile wood) and the specific gravity of that three when mature. All tests have shown this relationship

to be highly significant, i.e., a tree that will yield high specific gravity wood starts out when young with "high" specific gravity juvenile wood and vice versa. This relationship had been indicated in previous studies farther west and is now being confirmed as equally true here.

This fact is very significant. It indicates genetic control; it makes possible the assessment of selections for specific gravity and crossings at an early age; it permits selection and wood analysis of relatively young trees with considerable accuracy of predicting what their later performance might be.

A second test was made, enabling analysis of juvenile wood by limbs without destroying the tree selected. Previous studies showed a correlation between the specific gravity of the limb and the tree bole from which it grew. To check this relationship, plantations 9-2 L and 9-2 S had both bole and limb sections obtained. The correlation between bole and limb specific gravities was highly significant, though somewhat better for the loblolly than for the slash pine. At any rate, it now appears that one can get an estimation of the juvenile wood of a young tree from its limb, and from the juvenile wood one can predict the specific gravity of the mature tree.

Note that in the test (9-2 L and 9-2 S) of interplanted slash and loblolly (source unknown) the difference in average specific gravity between the two species is very small. Each species showed about the same range of variation in specific gravities. The commonly accepted statement that slash has higher specific gravity than loblolly was not borne

out here, where both species (interplanted) were grown on the same site under the same environmental conditions.

Project 3 - Progeny Testing for Special Purposes

One plantation has already been established to test the inheritance of wood specific gravity. Others will be made as seed become available. Such tests allow an assessment of the selections and aid in determining the genetic worth of the tree under study.

Project 4 - Breeding Arboreta

As selections, hybrids or exotics become available, they are planted out in special areas on which crosses may be made. Such arboreta will be made on the lands of several companies who desire them. One is already established and contains hybrids such as loblolly x slash, loblolly x longleaf, slash x longleaf, sonderegger x slash, rigida x loblolly, etc. Also several species of Mexican pines have been planted and many more are presently in the nursery beds.

At Raleigh a breeding arboretum is being established where a few specimens of every selected tree will be established. This material will bring together selections from the southeast and will enable intensive studies and hybridizations to be made.

Project 50 - Seed from Superior Trees

This is the job discussed as graduate student Thorbjornsen's research project.

Project 51 - Pollen Flight Characteristics

This has been discussed as McElwee's Ph D research project.

Project 52 - Distribution and Extent of Compression Wood in Loblolly Pine

This is student Haught's study as outlined.

In addition, information on compression wood was found in conjunction with project 1. A great deal of compression wood was found, averaging about 42% by volume for juvenile wood, and 7% by volume for mature wood. Surprisingly, though similar to Texas findings, the presence of compression wood had little effect on the specific gravity. It does have an effect on pulp yield and quality of product, however. Therefore, it can be seen that if 42% of the juvenile wood volume is compression wood, (juvenile wood also has a low specific gravity) the yield from such wood is low. Low yields would, thus, result from the hearts of basal logs and of the top cuts of the tree. Less than 10% of the trees were found free of compression wood, even though the trees studied were only the best dominants and codominants that could be found in the stand. Compression wood is affected by straightness of tree. Because of its prevalence and deletereous effect, it is important in selection work to know how much abnormal wood is produced by spiral or crooked trees, a characteristic suspected of being strongly inherited. In addition, knot volume and compression wood associated with knots is important and will be studied in this project.

Publications

No formal publications have yet been made. It is planned to summarize and make public the current findings on specific gravity and cellulose

Financial Support

This cooperative program has been made possible by financial assistance from cooperating pulp companies, the N. C. State Experiment Station, The N. C. State College School of Forestry and individual contributions. Listed below are the companies and individual who made contributions during the past year.

Bowater Southern Paper Corporation, Calhoun, Tennessee

Camp Manufacturing Division of Union Bag Corporation, Franklin Virginia.

Champion Paper & Fibre Co., Canton, N. C.

The Chesapeake Corporation of Virginia, West Point, Virginia

Gair Woodlands Corporation, Savannah, Georgia

Halifax Paper Company, Inc., Roanoke Rapids, N. C.

International Paper Company, Georgetown, S. C.

North Carolina Pulp & Paper Co., Plymouth, N. C.

Riegel Paper Corporation, Acme, N. C.

Union Bag & Paper Corporation, Savannah, Georgia

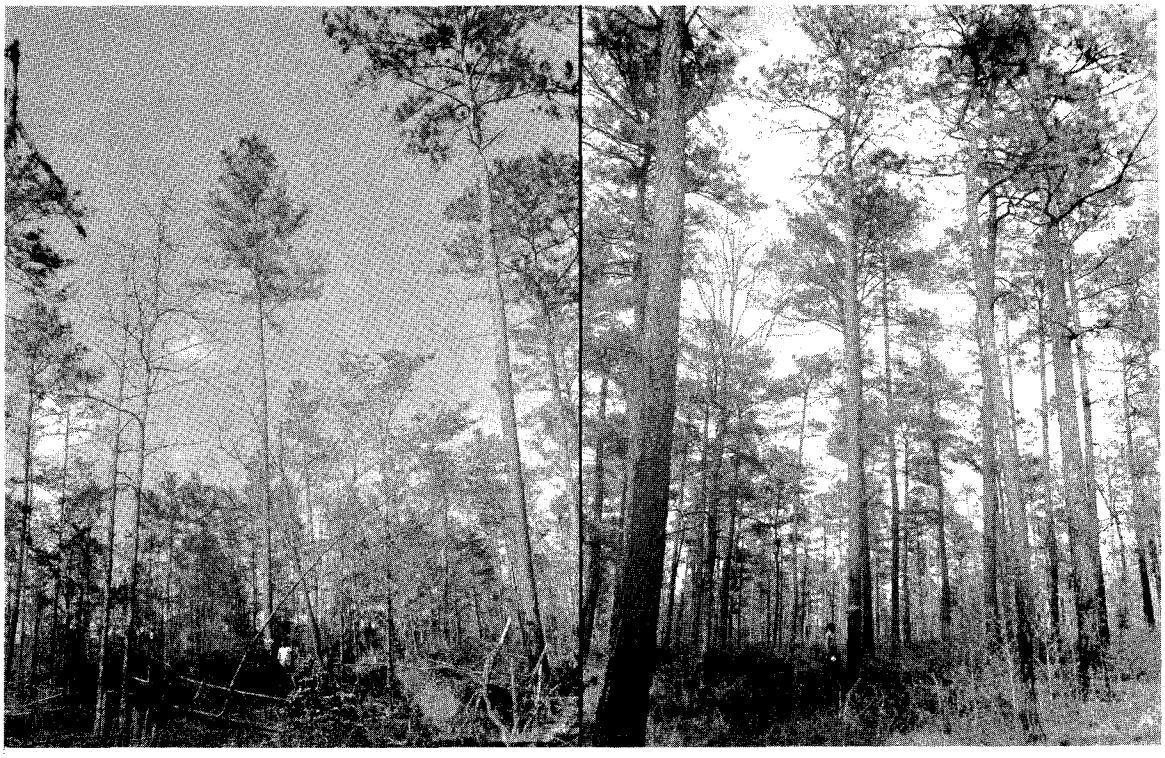
West Virginia Pulp & Paper Corporation, Georgetown, S. C.

Mr. Richard W. Lloyd, Camden, S. C.

Grateful acknowledgement is made to all of those who have contributed to this project.

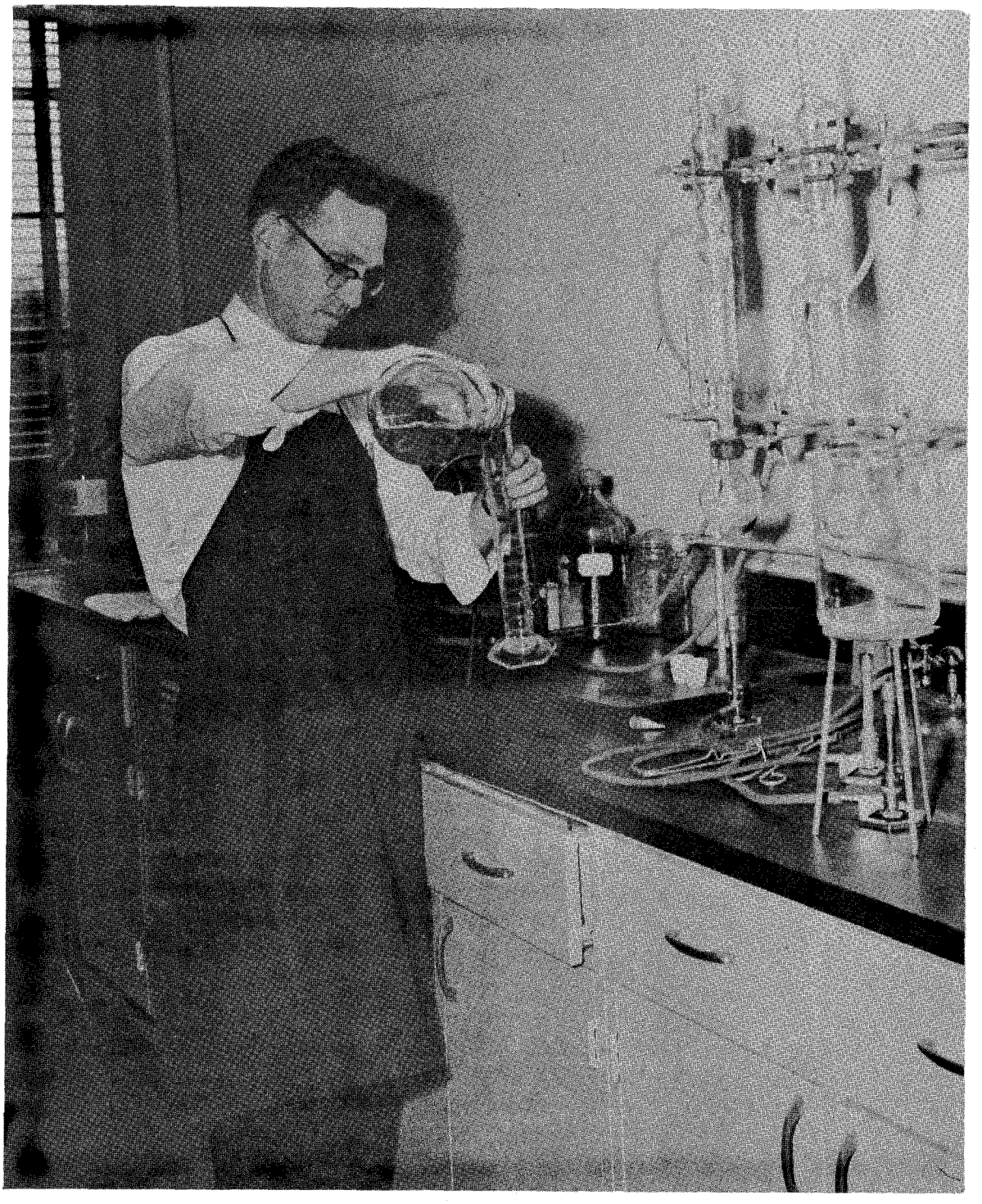
This isolated stand is used by Bob McElwee in certain parts of his study on pollen dispersal. He is studying vertical as well as horizontal distribution, and pollen viability.

Selections must sometimes be made for special conditions. The stand of loblolly pine pictured above is growing on 9.5 feet of peat before mineral soil is encountered. Growth rate is rapid, and some of the selected trees were nearly 100 feet tall at 50 years of age.

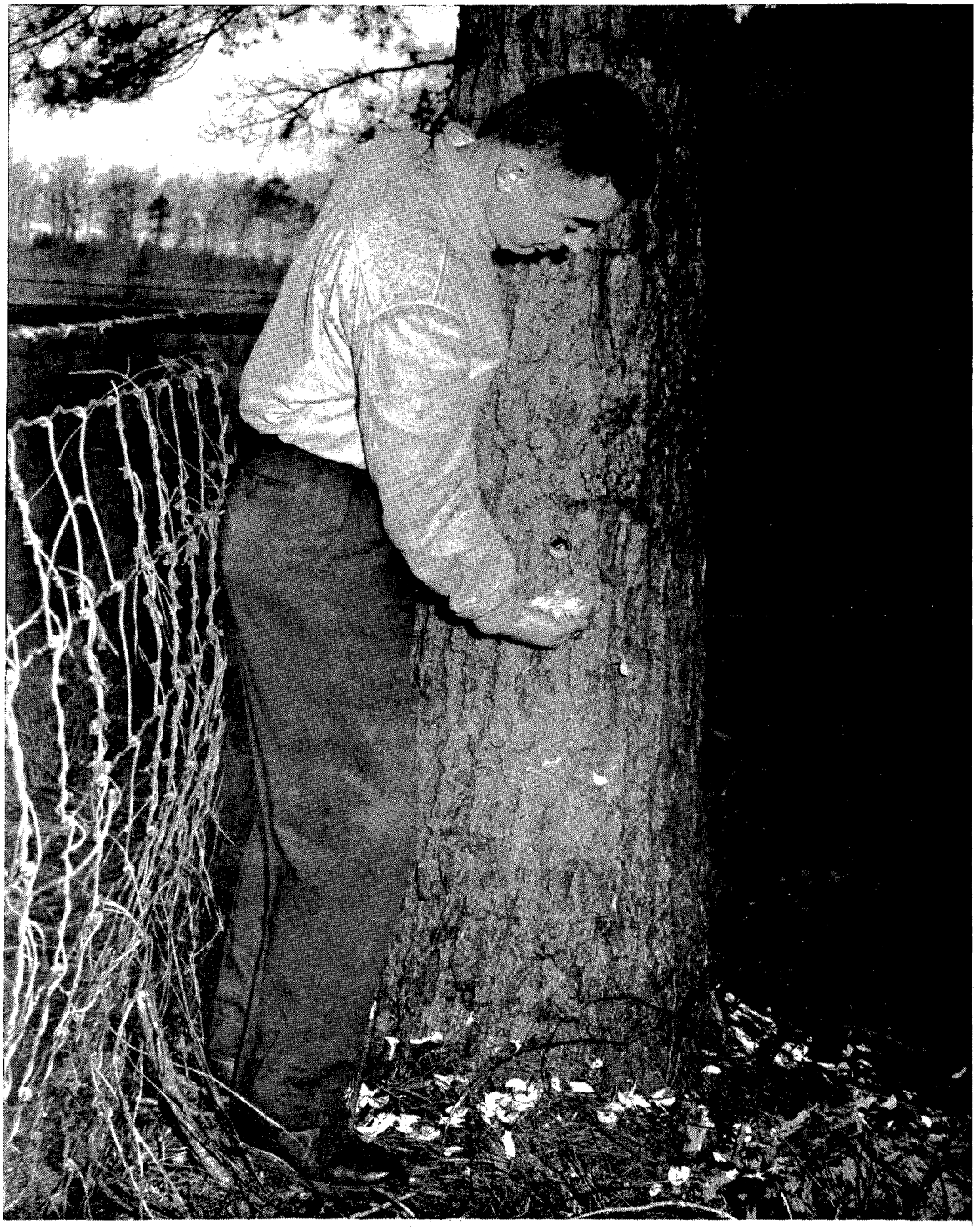


The above tree on the left is one of the relatively young trees selected to be used in the seed orchards. Such trees are chosen for straightness, fast growth, good pruning, good crown, wood properties and other things. The tree on the right is one of the older trees selected.

Field grafting will be used in the establishment of the seed orchards. Here Zobel and McElwee examine some preliminary tests on field grafting. This type of grafting is difficult to do but has many advantages over greenhouse grafting.



The analysis of yield (cellulose-lignin) requires a great deal of equipment and technical know-how. Cal Reis, a graduate student at the N.C. State Pulp Laboratory, is helping iron out the techniques used in making yield studies. (Photo - courtesy D. Davis, Champion Paper Co..)



Special tools are needed to obtain specimens from living trees. Bob McElwee shows the kind of chips obtained with the Little Beaver attachment that will be used on tests of variation in pulp yields. (Photo - courtesy D. Davis, Champion Paper Co.)

Bob McElwee and Bruce Zobel examine one of the "king-size" increment cores that have been used in all studies of specific gravity, compression wood and cellulose yield. About 400 of these large cores have been obtained so far. (Photo - courtesy D. Davis, Champion Paper Co.)