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PROCEEDINGS

Third Lake States Forest Tree Improvement Conference

SEPTEMBER 17, 18, 1957

Station Paper No. 58
FEBRUARY 1958

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE — FOREST SERVICE

The Lake States Forest Tree Improvement Committee and similar groups in other regions are playing an important role in encouraging and coordinating research and other activities in forest genetics. This new field of work is expanding; so too is the need for close liaison among the agencies active in it. Our Station is glad, therefore, to participate in and to further the work of this Committee. Accordingly we are happy to publish this Proceedings of the Third Lake States Forest Tree Improvement Conference, as we did for the preceding two conferences in 1953 and 1955.

M. B. Dickerman, Director

Lake States Forest Experiment Station*

* Maintained at St. Paul 1, Minn., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Minnesota.

PREFACE

The Third Lake States Forest Tree Improvement Conference culminated the activities of the Lake States Forest Tree Improvement Committee and offered an opportunity to report on committee work for the past biennium. It also provided an important means for the Committee to meet its major objective--the encouraging and coordinating of forest tree improvement activities in the region. The Proceedings makes the Conference a matter of record available to all who are interested in reading it, and the Committee is indeed grateful to the Lake States Forest Experiment Station for publishing it.

A conference such as this one always entails a great deal of work for many people. We should like, therefore, to acknowledge some of the major contributions made toward the success of our meeting. The conference was arranged largely by Paul O. Rudolf, Scott Pauley, Z. A. Zasada, and your Chairman. The University of Minnesota's North Central School and Experiment Station provided the meeting place. Finally, our special appreciation is extended to those who participated in the program, especially those who came from other regions to meet with us. In a large measure, the success of the conference rested on their cooperation in preparing and presenting papers and in leading discussions.

The Lake States Forest Tree Improvement Committee

Earl J. Adams, Chairman

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September 17-18, 1957

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Forest Tree Improvement--First the Seed

by R. G. Hitt[1/]

The idea of using good quality seed as the source of stock for reforestation has long been advocated. European forestry is replete with examples of the desirability of carefully selecting the seed source for plantation forestry. Sweden has a vast forest industry dependent upon maximum volume production. As such, Sweden is utilizing, wherever possible, seed of the highest quality to furnish the stock for reforestation work. These practices are not advocated, they are a must and are strictly enforced. Similar programs exist in Germany, Denmark, Norway, etc.

In this country too, prominent foresters, conservationists, plant breeders, and others have advocated the use of seed of known and desirable origin in reforestation programs. Failure to heed their warnings has resulted in losses of both time and money to the forest industry. Concurrent with these losses have been the additional losses resulting from continued exploitation of natural stands which represented potential reservoirs of both seed and germ plasm.

In the South, a number of forest tree seed production areas have been established. State, Federal, and private industrial areas have been set aside for seed production in Texas, Mississippi, Georgia, Florida, Alabama, and North Carolina. Undoubtedly there are other areas which are contemplated or which have been established recently.

In considering the situation in the Lake States, it can be said that the best stands of many of our indigenous species are now probably gone. We must be satisfied for the present with having to labor, in most cases, with remnants. Further, not all of the remaining virgin or good second-growth stands are in the public domain. Generally these areas do not

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involve large acreages. They are not all of the best type, do not form pure stands, and often lack proper isolation for seed production. Many of the plantations now attaining the age for seed productions can be used only as a last resort as seed sources because of their unknown seed origin.

Recognizing these facts and the need for immediate action to insure that our future forests will be of the best genetic quality possible, the Genetics Department of the University of Wisconsin in 1952 recommended to the Wisconsin Conservation Department that a program for the Certification of Forest Tree Seed be established. This proposal was not acted upon until 1956 when, in November, the Wisconsin Conservation Department in cooperation with the University of Wisconsin undertook a program for the Verification of Forest Tree Seed in Wisconsin. I would like to discuss briefly with you this general plan.

The program was set up under the following three general objectives: (1) An adequate number of forest stands and plantations should be selected, reserved, and managed as seed production areas. (2) Seed derived from these seed tree reservations should be separately collected, extracted, and grown in nurseries, and the resulting stock distributed for planting. (3) An adequate system of seed orchards of the more important forest tree species should be established to provide seed of proven genetic value for future reforestation.

Let us consider each of these objectives in a little greater detail.

(1) An adequate number of forest stands and plantations should be selected, reserved, and managed as seed production areas

Scattered sparingly throughout central and northern Wisconsin as well as in other parts of the Lake States are stands of virgin and good second-growth forest tree species. These stands are both privately and publicly owned. On the publicly owned stands full cooperation regarding measures to be taken to convert certain of these areas to seed tree reservations is expected. It is hoped that purchase, lease, or harvest rights can be obtained on private lands to utilize their seed crops. The locations of some of these areas are known already to us, and undoubtedly additional areas will be brought into the program as they are found. The assistance of Federal, State, and industrial foresters in locating and recording these additional areas is sought. University of Wisconsin Tree Improvement Project personnel will arrange to meet with the foresters on the proposed areas. The work to be carried out for the conversion of each area would be discussed on the spot in order to properly appraise and prepare each area.

Let us consider a hypothetical case for each type of ownership. The boundary of a desirable stand on State or Federal lands would be clearly marked. In some cases an isolation strip would be necessary around the desired area. This too would be designated. Then the trees to be removed would be carefully marked. Crooked or misshapen trees would be removed. Insect infested or diseased trees would be marked for cutting. Tree form, rate of growth, fecundity, spacing, etc., would also be considered in selecting the individuals to be left as seed trees.

In plantations of known seed origin essentially the same procedures would be followed. Here, however, we may experience greater ease in management because of even age, spacing, and favorable crown types. Only as a last resort should plantations of unknown seed source be used! These plantations should all have attained the age which would allow for the first cut of a merchantable product (pulp, box bolts, posts, poles, etc.). This gives some assurance that the particular seed source is adapted to local growing conditions and that offspring arising from this seed source probably would produce sufficient high-quality plantation growing stock in the future to warrant its use.

Following the selection and preparation of the area, management practices would be conducted to encourage increased and sustained seed production. Such procedures as growth retardation by mechanical means and fertilization would be used.

On privately owned lands the area either would be purchased or leased, or cone harvesting rights would be obtained. In the latter case it would be necessary also to obtain permission to prepare the area for seed production according to prescribed standards. In addition, management practices would have to be clearly defined. It is recognized that these arrangements might be difficult to make in some cases; however, there are a number of such areas that have seed tree reservation potentials and as such should be utilized.

Another possibility exists for the use of privately owned areas. Owners of these areas could be contacted and the program outlined to them. Should they feel that they would not want to lease the area or grant harvest rights, they might instead be induced to carry out on their lands the necessary cultural operations to qualify their stand for inclusion as a privately owned and managed seed tree reservation. Cones derived under supervision from these areas then might be brought into the program.

(2) <u>Seed derived from these seed reservations should be separately collected, extracted, and grown in nurseries, and the resulting stock distributed for planting</u>

The procedure to be followed in the collection of cones in the seed-tree reservations undoubtedly would vary. Procedures used in mature stands might well vary from those used in plantations and, eventually, seed orchards. It will be necessary to test various methods and equipment before deciding on any procedure. Trained cone-picking crews might be employed on an hourly or piecework basis. They would be under the supervision of a local supervisor or would be provided with a full-time supervisor to travel with them during the cone-picking season. Cones should be bagged and properly sealed at the collection site. They should then be delivered to one of the extractories for processing. Again caution should be exercised in the handling of the cones by lots so that their identity is maintained and that contamination does not occur. The seed thus obtained would be designated "Verified Forest Tree Seed", the term "verified" indicating that the seed is of known origin. In addition, the seed would be tested for germination percent and purity.

Much of the Verified Forest Tree Seed thus obtained would be used by our State forest nurseries. The identity of these seed lots must be maintained throughout their nursery culture. As the program develops, sufficient seed might be obtained to devote the entire facilities of one forest nursery to the production of "Verified stock". The increased cost of procurement and production of such stock could be offset by a higher price for the stock when marketed.

It should be pointed out that this stock will be "Verified" as to origin and purity only. Eventual introduction of "Certified Forest Tree Seed" will follow adequate progeny testing of selected parent trees. This certified seed will be derived from seed orchards established for that purpose from grafts of the selected and field-tested parent trees. The genetic value of certified seed will be known.

The distribution of verified stock should correspond to seed origin in so far as possible. That is to say, stock should be furnished for planting on areas near the source of the seed. If this is not possible, other stock should be furnished from nearby sources or from sources within the general seed zone where the planting is to be done. Since the actual operation of certain phases of this work is without precedent, the best procedures to be followed will have to be worked out in practice.

(3) An adequate system of seed orchards of the more important forest tree species should be established to provide seed of proven genetic value for future reforestation

Simultaneous with the development of the seed-tree reservation program should be another program directed toward the establishment of a system of seed orchards. These seed orchards will be composed of cloned, selected forest trees of various species. For Wisconsin, the areas for these orchards should be in the central and southern parts of the State. They should have isolation from other trees of the same species of at least $\frac{1}{4}$ to $\frac{1}{2}$ mile with greater distances of isolation more desirable. Spacing in the orchards should be wide (20x20 or 24x24 feet) to allow for good crown development and ease in managing the stand and harvesting the cone crop. Cultural practices to insure abundant and continuous flowering will be carried out on these areas.

Success to date with field grafting of red pine lends optimism to the plans which call for the establishment in Wisconsin of an adequate system of seed orchards of red pine within 5 to 10 years. We have been able to graft scion material from old trees (40 years and older) onto plantation stock ranging in age from 7 to 10 years with successful graft take for individual lots running from 5 to 100 percent and an average success of 50 to 65 percent.

The details of seed orchard establishment as well as the development of seed tree reservations have been omitted from this discussion. Each area as it is developed will have special merits or requirements and must be handled accordingly. Further, many of the details will have to be worked out on the area inasmuch as there are no patterns to follow.

Your attention is directed to the map which shows the seed zones to be used in Wisconsin in the designation of seed collected under the Verified Seed Program (fig. 1).

There you have it, gentlemen. On paper it looks good! This fall we tried to make it work. Here are some of the results to date--all very hurriedly assembled and quite incomplete.

Four good second-growth stands of Norway or red pine ranging in age from 40 to 75 years were selected as seed-tree reservations. Three areas were in northeastern Wisconsin and one was in the northwestern part of the State. Seed trees were marked, consideration being given to spacing, tree form, crown development, stand density after undesirable trees were removed, general tree vigor, branching, etc.

Next our efforts were directed toward finding collecting crews. It was anticipated that this might prove to be somewhat of a problem and it was. Certain state regulations prevented hiring anyone less than 16 years of age. We could not pay on a piecework basis because of the lack of satisfactory insurance coverage on that basis. Summer jobs today are plentiful, hence many teen-agers are relatively "wealthy" by the end of the summer. Why then should they work for us picking cones for $7.50 a bushel when they could wait 2 weeks longer and let the squirrels do the cutting after which they could collect these squirrel-cut cones and still get $6 a bushel! In reality we did get some cones. High school boys did not work out satisfactorily for cone collecting this year. Undoubtedly some of their poor performance, however, was due to inexperience, lack of sufficient climbing equipment, and trees which did not contain 6 bushels of cones each!

Briefly, here are a few of the statistics at the end of the sixth inning. We still have a few men collecting; consequently the score will change. Five experienced pickers worked for a total of 116 hours climbing 70 trees to harvest 754 pounds of cones. Figuring 35 pounds of cones to the bushel in the early season, they collected 21.5 bushels at a cost of $9.12 a bushel. Undoubtedly their harvest rate would have been greater had we not insisted that they pick cones from some excellent phenotypes which were not flowering as abundantly as certain other trees in the stand.

Most of the trees from which the cones were harvested ranged in height from 60 to 75 feet. Three to five 10-foot sections of a Swedish Cone Picking ladder were needed to enter the trees. The men were instructed to pick in their trees until such time as they felt they could no longer pick cones profitably. They harvested for the most part in the upper

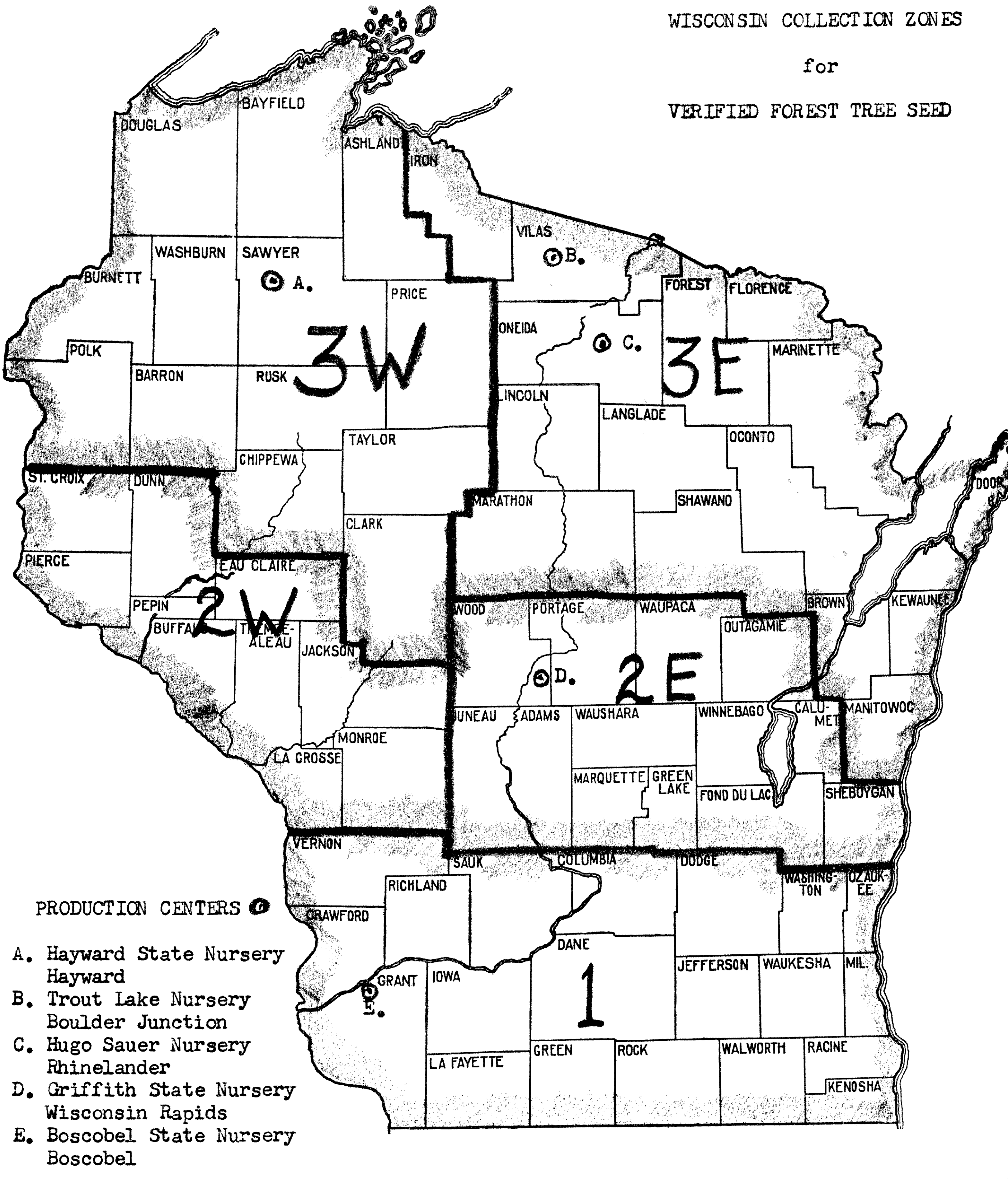

Figure 1.--Wisconsin collection zones for verified forest tree seed.

one-third of the tree's crown, where picking is generally good. A man can remain in one position in the upper crown often for 5 or 10 minutes and be kept busy picking all that time. I have charged travel time, ladder erection time, climbing time, etc., against the per-bushel cost.

Let us contrast this situation. Five high school boys, inexperienced in cone picking but presumably willing workers, climbed 28 trees in a total of 30 hours to collect 80 pounds or 2 1/3 bushels of cones. These cones cost $24.20 a bushel. They harvested their cones from the middle one-third of the crown and obtained very few cones per tree. They put in their time that day going up and down, getting situated, breaking off branch tips, and comparing ideas on how they were going to spend all the money they made collecting cones for us. Needless to say, their services were terminated at the end of the day.

I do not wish to infer by these remarks that we are discouraged by the results of our first attempt to harvest Verified Forest Tree Seed! Actually, we did not expect to have the operation go smoothly. We anticipated that we would learn a great deal but that we would do so at some expense. We also recognize, however, that the most insignificant cost item in the total unit production cost of forest tree planting stock is the cost of the seed. Even a doubling or tripling of the initial cost of the seed would not greatly increase the cost of the final planting stock. In fact, the improved quality of the seedling stock derived from the Verified Seed might result in more vigorous seedlings with less cull, thereby reducing the per-unit cost of production. The information which we will obtain from this season's collecting will be of great value in planning future cone collections in Wisconsin. Our Verified Forest Tree Seed Program, although now started on a rather meager scale, is a reality and will continue to grow.

Viewing the situation in the Lake States, there is at the present time a large tree planting program in progress. Nursery facilities are being expanded and utilized to full capacity. There is a great demand for forest tree seed, and unfortunately a high percentage of this seed is being harvested from genetically undesirable sources. We may expect that the quality of the trees in many of tomorrow's forest plantations will be inferior. Fortunately, enough interest has been generated by tree improvement research activities nationwide to insure that this situation will not continue indefinitely. Locally, steps are being taken to overcome this problem through the introduction and use of Verified Forest Tree Seed. Even though we in Wisconsin have had to pay an average price (at the end of the sixth inning) of $10.50 per bushel for our Verified Forest Tree Seed, this cost is insignificant in the overall unit cost of production of forest tree planting stock. I am confident that we have turned the corner and are now on the right road!

Improvement of Stock Quality in the Forest Nursery

by J. H. Stoeckeler[1/]

The application of forest tree improvement will be largely through tree planting. Consequently much of the seed developed in seed production areas and seed orchards, or from special selections, hybrids, or other controlled pollinations, will be used to grow nursery stock. It will be especially important, therefore, to use nursery practices that will produce the largest feasible proportion of high-quality planting stock.

It is possible, too, that seedlings of inherently high vigor can be selected in the nursery and thus provide a shortcut in forest tree improvement. Such selection must be based on comparison with other seedlings growing under similar uniform conditions. This implies good nursery management.

For these reasons there is given here a brief resume of nursery practices that are known to foster the production of high-quality planting stock. Included also is some evidence of the effectiveness of these practices.

Grading

The culling out of small, runty, infested, or otherwise defective stock in the nursery is in reality an early genetic rogueing of the plant material and invariably results in better field survival and growth and some reduction in the disease and insect potential. In a trial in Wisconsin (17) involving large, medium, and small sizes of 2-0 red pine, all from the same bed, the large trees had 12.4 percent better survival and 1.3 feet (35.1 percent) greater average height than the small size after 10 years in the field. The medium-sized trees had an advantage of 8.6 percent in survival and 1.0 foot (27.0 percent) in height over the small trees.

Even more contrasting results were noted in survival of 1-0 jack pine graded into 4 size classes (7). Plantings were made in the droughty mid-thirties. At end of the 13th year, field survivals were about 53, 35, 27, and 12 percent for good, fair, poor, and cull classes respectively. The largest class had an advantage of 1.25 feet or 9.1 percent in average height over the cull group.

For white spruce, studies by Consolidated Water Power and Paper Company (3) revealed a 48.3 percent advantage in height growth (43 versus 29 inches) at the end of 6 years in the field for "super" seedlings representing the very best of stock, selected for outstanding growth in the nursery.

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Apparently inherent genetic vigor exhibits itself at a rather early stage, identifiable even in the nursery. Hence, some grading in the nursery for quality, based on size, would seem to be warranted. Grading that removes the poorest 5 to 15 percent of seedling stock and 2 to 3 percent of the transplants would certainly seem to be a "must."

As seed orchards of superior or plus trees are established by rogueing of existing natural stands, and plantings are made of "elite" seed orchards of superior strains, it is believed that the percent of cull in nursery stock--now rather high in some of the run-of-the-mill collections--can be substantially reduced.

Age Classes of Stock

Age class of stock is a controlling factor in stock quality and field survival. Age class, of course, must be geared to species and to planting site conditions. Transplants have shown rather consistently better survival than seedlings, especially in white spruce (14) and to some extent in pine (6, 11, 17). The margin in favor of transplants over seedlings was 29 percent for white spruce and 20 percent for red pine in a series of tests run in Wisconsin and Michigan (17). In a number of plantations averaging 23 years of age, Rudolf (11) found average survival of 2-2 stock to be 60 percent compared to only 31 percent in 2-0 stock.

Contrast in survival by age classes is most likely to be large in drought years or on difficult sites. The age class of stock to be used should be dictated by long-range performance in the field and by the gains attained by older age classes or transplants when balanced against the additional costs.

Season of Sowing

Season of sowing has an effect on ultimate size of nursery stock. It can be adapted as a control technique on tree size in several ways. For instance, in one test of some 2-0 jack pine at Hugo Sauer Nursery at Rhinelander, Wis., fall-sown trees had an average fresh weight of 8.2 grams as compared with 5.3 grams per spring-sown tree seeded under comparable conditions; this was an increase of 54.7 percent (16). Second-year red pine shows similar results.

On the other hand where soils are of a high fertility level or the growing season is long, excessive top growth of jack pine may be prevented by seeding in June, thus in effect reducing the period of growth. This results in a 1½-0 age class, which is in better balance than 2-0 stock from such nurseries and rather consistently gives better survival, especially for fall planting.

The adverse effect of poor top-root ratio on field survival has shown up repeatedly, especially in fall-planted 2-0 jack pine and 3-0 red and 3-0 white pine (17).

Fertilization

An extensive series of experiments on fertilization of stock in Lake States nurseries (16) led to these conclusions.

1. The most important value of fertilization in the nursery is the increase of plantable stock. This may be as much as 27 to 40 percent; such increases in percent of plantable stock are easily worth $400 to $600 per acre of nursery.

2. Proper fertilization in the nursery gives a slight but rather consistent improvement in survival of field planted stock; the advantage over unfertilized trees may be 5 to 10 percent.

3. Proper fertilization improves color, vigor, needle length, and bud length.

4. Fertilized trees showed greater drought resistance than unfertilized stock.

5. Vigorous trees show more rapid juvenile growth.

Trees treated with balanced commercial fertilizers involving nitrogen, phosphorus, and potash usually show excellent growth response when from 50 to 100 units of each are used per acre.

Composts and hardwood duff (16, 20) applied at around 20 to 30 tons per acre have resulted in excellent response by both coniferous and broad-leaved species.

Occasionally, dolomitic limestone is necessary to reduce soil acidity (13) and to correct deficiency of calcium and magnesium (1, 21).

Mycorrhizae

Lack of mycorrhizae has, on occasion, been a bottleneck in the production of good conifer stock, particularly in prairie soils. The mycorrhizae are beneficial fungi that aid in assimilation of phosphate, potash, nitrogen, and perhaps other nutrients.

In experiments run in the mid-1930's at Oakes and Towner, N. D., striking improvements were noted in beds of jack pine, Scotch pine, and spruces which had been inoculated with mycorrhizae either as pure cultures grown on boiled wheat or by means of mycorrhiza-rich soil brought in from an old established nursery. Our experience with the beneficial effect of mycorrhizae on growth of conifers in prairie soils was later verified by McComb (5) and Rosendahl (9). Our experience also indicated that the soil pH had to be slightly to moderately acid to permit good growth of the mycorrhizae. The soil was treated with at least 1/4 to 3/8 fluid ounce of sulphuric acid per square foot of seedbed applied in a 2-percent solution with water, or with at least 1/4 avoirdupois ounce of commercial grade sulphur per square foot worked into the top 4 inches of soil.

Seedbed Density

Seedbed density is an important factor in stock quality. Dense seeding tends toward spindly, undersized trees of poor caliper and poor root system. They survive poorly when field planted. The general practice in most publicly owned nurseries for trees scheduled for field planting is to seed so as to attain a density of around 40 trees per square foot for 3-0 pines and spruces and about 50 trees per square foot for 2-0 pines. When scheduled for transplanting, these species are grown at 65 to 75 per square foot. Even lower densities may be desirable, especially for 2-0 or 3-0 age classes scheduled for field planting.

Field survivals are often 10 to 25 percent better for stock grown at low (50) rather than at high (100-150) density. In fall-planted stock of 3-0 red pine, over-winter mortality was doubled by increasing seedbed density from 25 to 80 per square foot, i.e., mortality was 25 and 50 percent respectively for the two densities. High densities increase the top-root ratios of 3-0 red and white pine, producing trees poorly adapted to withstand over-winter as well as summer desiccation.

An increase in density of 3-0 red pine from 33 to 101 trees per square foot resulted in a drop in green weight from 9.3 grams per seedling for the former to 5.0 for the latter; for 3-0 white pine grown at 26 and 81 trees per square foot respectively, the average green weight per plant dropped from 6.2 grams for the former to 3.5 grams for the latter (16). Stem caliper--an important factor in ability of recently planted trees to resist flattening or lodging by wind, rain, snow, or weeds--is also adversely affected by high densities.

Watering

Proper watering affects not only stock size but also, and more important, its field survival. Experiments by the Lake States Forest Experiment Station (12, 15) indicate that for second-year jack pine a moderate water supply involving addition of 2.25 inches of water in 3 applications as a supplement to 15.11 inches of precipitation that fell in the period June 1 to September 30 inclusive, gave better drought hardiness than trees receiving no irrigation, or those receiving 4.75 to 7.00 inches of irrigation water.

The amount of water that nursery plants will require varies, of course, by nursery location, soil, tree species, age class, normality of rainfall, and its distribution.

Soil moisture content can be gauged by a number of methods, and among these the newly designed tensiometers used extensively in California show promise for use in irrigation control in forest nurseries where the tension is generally held below one-half atmosphere.

These tensiometers have a vacuum gauge dial and hence are more compact than the early experimental models developed in the late thirties, which used a U-tube mercury manometer.

Weed Control

Good control of weeds is an absolute essential in producing high quality nursery stock. This problem has been greatly simplified by the use of the right kind of cultivation equipment such as rotary hoes (16) and the use of selective herbicides such as mineral spirits (8, 14) and Dalapon. Pre-seeding treatments with herbicides such as allyl alcohol (18) and methyl bromide gas (4, 15) have been used to some extent for weed control; these same treatments also have some fungicidal value.

Root and Top Pruning

Root pruning or top pruning, alone or in combination, has been used as a means of producing nursery stock that is shorter, better-balanced, and more likely to survive the late fall and early spring desiccation.

In a series of experiments involving various depths and methods of root pruning and top pruning of seedbeds during 1937-41 in several Wisconsin and Michigan nurseries, the best survival increases in field plantings were 16 and 23 percent respectively for fall-planted red and white pine. In the spring of the third year these had been root pruned horizontally at a depth of about 3 to 5 inches, and also vertically between each of the 10 drills in the seedbed.

Cone Quality and Ripeness

Since some nurserymen are charged with the responsibility for cone purchasing, the quality of cones deserves some mention. Cone quality, specifically size, can affect seed yield. In an experiment at Rhinelander, Wis., in 1938, red pine cones sorted into three sizes showed definitely that the small cones yielded less seed than medium- to large-sized cones, as noted in the table below.

Cone size	Average volume per cone cc	Total seeds per cone
Small	9.5	19.6
Medium	15.5	34.1
Large	18.1	43.1

In terms of number of seedlings produced, small cones were also at a disadvantage as shown by the following table.

Volume of fresh cone	Seedlings produced per cone
cc.	No.
6	0
8	0.7
10	2.2
12	3.6
14	5.0
16	6.3
18	7.9
20	9.3

Eliason and Heit (2) found similar results in Scotch pine and concluded that cones of this species less than 1.5 inches long produced smaller seed and smaller seedlings than three larger grades of cones, ranging from 1.50 to 2.25 inches in length.

Cones, of course, must be ripe to realize their full seed value. Rudolf (10) found differential specific gravity a good means of determining ripeness of freshly collected red and white pine cones, using kerosene for the former and linseed oil for the latter.

Seed Treatment

Certain seeds with embryo or seed-coat dormancy or both often germinate late or poorly, producing under-sized seedlings or under-stocked beds. Standard references on the subject (16, 19) give recommended treatments to assure prompt and complete germination.

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Applying Forest Tree Improvement Practices in Silviculture

by Zigmond A. Zasada[1/]

Two statements from recent publications indicate the lack of tree improvement guidelines available to the forest manager. One is from the preface of the publication "Guide for Selecting Superior Forest Trees in the Lake States",[2/] "Trees especially desirable silviculturally usually will be desirable for tree improvement purposes." Another from a report given at the Northeast Tree Improvement Conference in 1956 states, "'Genetical marking' at present can be hardly more than the best silvicultural marking." Silviculturists need more detailed information than this from the forest geneticists if we are to make more rapid progress in the improvement of our present forest stands.

1/ Forester, Lake States Forest Experiment Station, Grand Rapids, Minn.

2/ Prepared by Paul O. Rudolf with the assistance of the Subcommittee on Tree and Stand Selection, and published by the Lake States Station (Sta. Paper 40, 1956).

Silviculture is the art of producing and tending a forest. Forest tree improvement, genetics, tree breeding, whichever term is used, should be considered an auxiliary science to silviculture as are soil science, entomology, botany, and economics. Geneticists should present their material as it relates to silvicultural practice.

To my knowledge forest tree improvement work to date has emphasized improvement through reforestation. The studies have dealt with seed origin, seed-tree selection, delineation of races and strains of species, and adaptability of exotics. The emphasis on these studies and the approach through reforestation lead foresters to think that progress will be exceedingly slow, and there is little enthusiasm for the tree improvement program.

Actually forest tree improvement practices can begin right now. In carrying out their program the geneticists have developed information which can be applied by silviculturists now in managing our present stands. However, it needs to be presented in a manner that points up its application in obtaining natural regeneration, in the silvicultural improvement of young stands, and in the management of older stands.

It is the job of the geneticist to define and describe good and poor tree characteristics. When he has done so, the silviculturist can apply the knowledge in managing the timber stands. An example of what can be done is the change in thinking on the qualities of a good seed tree. Seed trees have been selected primarily for their large bushy crowns, indicating a large capacity for seed production. On the basis of information developed by the forest geneticist, however, seed trees should be selected on form, growth rate, and branching habits. This type of information should be pointed out more specifically.

Studies of seed origin show that locally grown seed generally produce the best forest plantations. Geneticists have also found that distinct races and strains develop within species on the basis of environment. This information points up the importance of getting the best stands reproduced naturally; yet nowhere are these recommendations made specifically. We have not been too successful in getting natural regeneration in our conifers even though we know many of the basic requirements. When the silviculturist understands the importance of local origin, the job of natural reproduction becomes even more important, especially where high quality stands are involved. Any time we permit our good stands to be replaced by brush or off-site species we are adding to an already difficult problem of forest improvement.

Forest improvement through silviculture can begin in very young stands. Release cuttings, weedings, and thinnings can be used to control stand composition and, in some cases, tree quality. These practices can in many instances maintain the right species on the right site, which is very important in forest tree improvement. Selective and partial cutting during the middle life of the stand allow us to rogue out the poor trees before they become effective seeders. Theoretically, intensive forest practices should permit us to end up with the best quality trees in the stand for a seed source and stand regeneration. But the ability to recognize good and poor tree qualities that are hereditary is necessary.

Forest management systems have never been analyzed or studied in relation to tree or stand improvement. Forest management studies show that good growth can be maintained over a wide range of stocking and cutting conditions. For example, pine, aspen, and black spruce are adapted to even-aged management. Partial cutting during intermediate ages is often practicable. There is some indication that cutting from above (taking out trees in the upper part of the crown canopy) during this period has little effect on total wood production. What effect does this cutting method have genetically? Can we get by with this system and not hurt future crops? These questions need answering. They can be answered best by the forest geneticist.

We must recognize that many conditions exist which do not permit intensive management or the retaining of the biggest and best trees in the stand. Foresters are faced with the problem of getting the highest wood volume of a specific product such as pulpwood or logs from present stands. The economics of logging require the cutting of a specific volume per acre or certain size trees to meet merchantability requirements. Extensive management is applied in these instances. Large areas are clear cut, leaving cull trees and suppressed unmerchantable trees as a seed source. Cutting systems such as stick limits and diameter limits are applied, which in most cases leave the poorest trees in the stands. How much future forest degrading is being done by these practices? No concrete evidence is available for or against these practices. Here the genetic appraisal must be on a stand basis and not a tree basis.

Summing up on the subject of applying tree improvement in silviculture:

1. Forest genetics should be considered an auxiliary science to silviculture.

2. The forest geneticist has developed a considerable volume of information valuable to the forester. A job remains to present this information in such a way that it will be usable to the fieldman.

3. Silviculture has the tools, such as release cuttings and thinnings, to get tree improvement information applied.

4. Where stands are marked for cutting and intensive management is applied, we are getting forest stand improvement and tree improvement, but in an indirect way; most foresters do not have genetic information to guide their marking. A better job of tree improvement work could be done if the forest geneticist would define tree qualities so that they can be identified and measured.

5. In the field of extensive management it is probable that no forest improvement will take place until it is shown that damage is being done. Studies are needed to get the answers.

6. Management studies do show that good growth can be maintained over a wide range of stocking and by several methods of cutting. But we need a genetic appraisal of management practices: It is highly possible that we can maintain good growth but would be degrading the quality of present and future stands.

These are important questions and should receive the attention of the forest geneticist soon.

Applying Forest Tree Improvement Practices in the Lake States: Production of Quality Wood

by Harold L. Mitchell[1]

We do not have any high-powered forest geneticists at the Forest Products Laboratory. Our job, as we see it, is somewhat different; it is to work closely with the geneticists, so that wood quality receives the consideration it deserves in the whole field of forest genetics. We take the position that there is no justification for spending a lot of time and money to develop "elite" trees that produce wood which may have little or no value in the market place.

In past selection and breeding research, there has been a tendency to overlook or take wood quality for granted, and to place most or all of the emphasis on such desirable silvical characteristics as growth rate, form, branching habit, adaptability to site, resistance to pests, and the like. Some silviculturists, probably a minority of the discipline that spawned most of our present crop of researchers in forest tree improvement, still hold the extreme view that trees which are superior according to their concept of quality will, under proper management, automatically yield the maximum of high-quality products.

Perhaps this should be generally true, as it is in many cases, but there are too many exceptions to justify acceptance of such a philosophy. It is too easy to find trees that are superior according to the silviculturist's requirements as to size, form, straightness of bole, and the like, but that contain wood so poor in intrinsic quality that it is unfit for any of the more demanding uses. In such trees the wood may be poor because of low specific gravity, unevenness of growth, occurrence of compression wood or tension wood, severe cross grain, or any combination of the various physical and structural factors that determine mechanical strength, pulp yields, the tendency to warp, machining characteristics, and other important properties.

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This raises the question of what is meant by wood quality. Obviously, we all need an adequate concept of quality if we are to work effectively in the field of forest tree improvement.

Because of important differences within and between species and the great variety of products made from wood, it is difficult to develop a single, all-inclusive definition of wood quality. From a technological standpoint, wood quality can be defined and given a relative rating according to how well it meets the technical requirements for a particular product or end use. Thus, all high-density wood could be considered as of high quality for charcoal, the low-value product of a woods-scavenging industry that prefers high-density species but can economically process odds and ends of most any sort of wood. One objection to using this basis alone for a wood-quality rating system is that it disregards monetary values and leads to some unrealistic groupings.

A more realistic approach would be a rating system based on how well a bolt, log, or tree meets the technical specifications for the highest value products or uses for which it will qualify. Thus, a high-quality tree could be defined as one with a high proportion of its net volume in wood suitable for conversion into the higher grades of the more valuable end products and in sufficient quantity ordinarily to justify its economical harvest for such products.

Now, what are the characteristics of wood, in addition to size, clearness, and the like, that determine its suitability for various end uses? Wood density, usually expressed as specific gravity, is perhaps the simplest and most useful single index to the suitability of wood for many important uses. In southern yellow pines, for example, for every 2-pound increase in wood density, there is produced about 1 pound more of kraft pulp (fig. 1). Stated another way, a cord of high-density southern pine wood will yield about twice as much kraft pulp as a cord of low-density wood of the same species. The same general relationship between wood density and pulp yields holds for all species.

There is also a high degree of correlation between specific gravity and the mechanical strength of all woods. Specific gravity is therefore a primary factor in the segregation of structural-grade timbers that command premium prices in the lumber market, and also in the selection of material for high-grade piling, transmission poles, and other uses where strength is of major importance.

Another key feature is the proportion of summerwood to springwood in the annual growth ring. Springwood is composed of relatively large-diameter, thin-walled cells, and summerwood of smaller, thicker-walled cells. Springwood is lighter in weight, softer, generally weaker, and shrinks more along the grain than summerwood. Thus, the greater the proportion of summerwood to springwood in the annual growth rings, the greater the strength of the wood and the yield of pulp therefrom, and the less the longitudinal shrinkage. On the other hand, it is known that pulp sheets made experimentally of practically pure springwood from southern pines

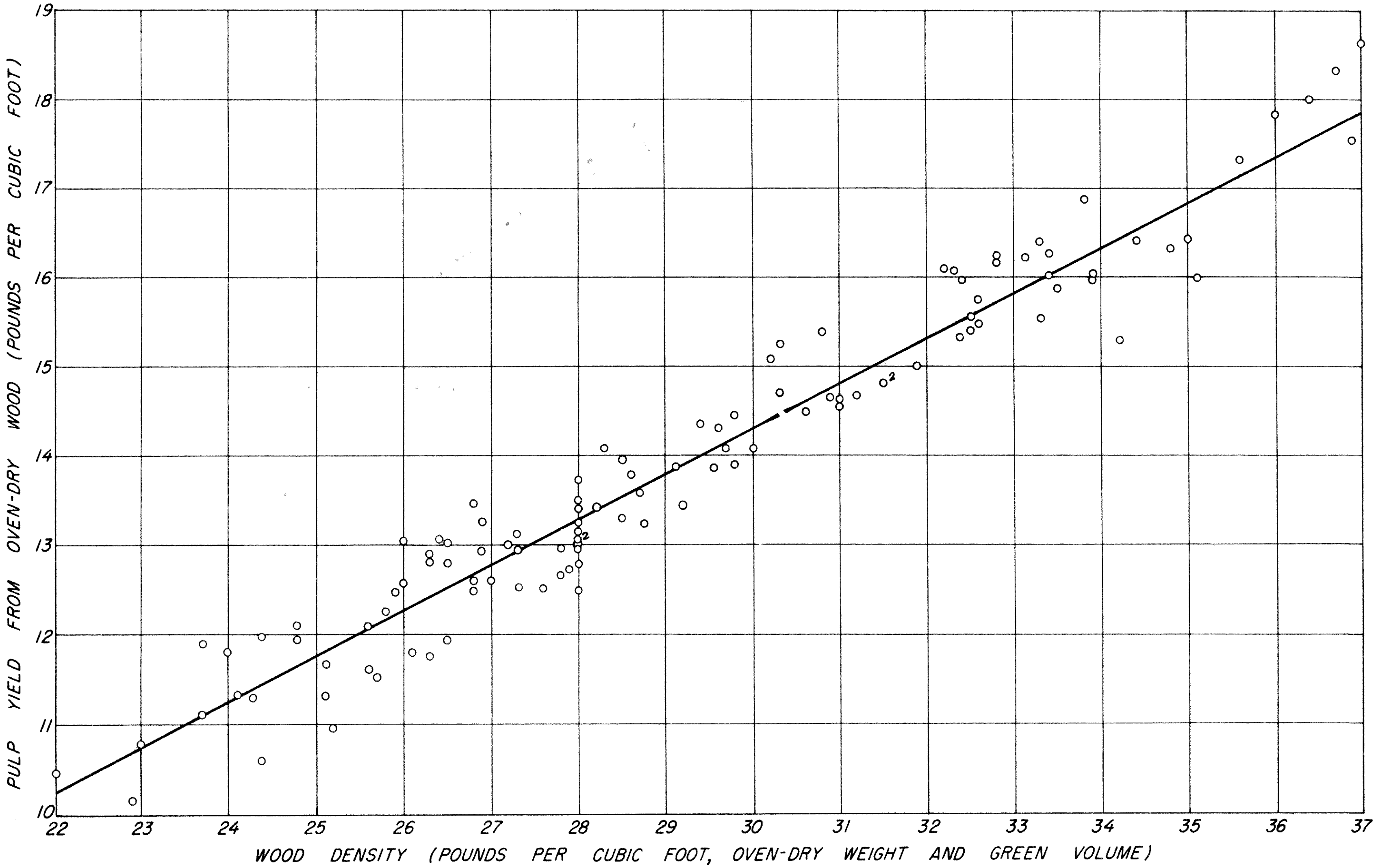

Figure 1.--Relationship between wood density and kraft pulp yields of southern yellow pine pulpwood.

felt better than those made of summerwood;[2] also, that the bursting strength and tensile strength of paper tend to increase with increases in the proportion of springwood to summerwood. In contrast, the stiffer summerwood fibers make paper whose resistance to tearing--a highly essential property for kraft paper--increases with the proportion of summerwood.

The significance of another feature--fibril angle--looms larger as we learn more about it.[3] Fibrils, which are believed to be composed of strands of cellulose chains, make up the layers of the secondary wall of the wood fibers. Their orientation with respect to the long axis of the fibers is termed the fibril angle. Large fibril angles are the rule in compression wood, an abnormal wood that has extremely poor strength and shrinkage properties, and in normal wood of low density and low mechanical strength. Small fibril angles, in some cases practically parallel to the axis of the fibers, are typical of high-density, strong wood of low shrinkage along the grain.

What happens when low-density, high-shrinkage wood is combined in the same board with higher density, more stable wood (fig. 2)? In early life, say up to 10 or 12 years, many softwoods tend to make excessive diameter increment when grown on good sites relatively free of competition. During this period wood density tends to decrease and shrinkage to increase with the rate of diameter growth. The warping which results from combining such wide-ringed juvenile wood with more mature wood formed later in life is an important cause of degrade in southern pine, and is common in many other second-growth softwoods.

Nonuniform growth is equally undesirable in hardwoods. In hardwoods, however, both wide- and narrow-ringed wood are well suited to important, although quite different, uses. Most hardwoods, unlike the majority of softwoods, tend to increase in density with increases in growth rate. Uniformly dense, wide-ringed, "second-growth" hickory and ash, for example, are preferred for tool handles, athletic equipment, and other products requiring high mechanical strength and shock resistance. On the other hand, the furniture industry prefers "soft-textured" wood of moderate, even growth because of its lower weight, greater stability, and superior machining and finishing properties (fig. 3).

Compression wood (fig. 4) is abnormal wood formed largely on the under side of leaning softwoods. Trees that lean 4 degrees or more from the vertical usually contain large amounts of this abnormal structure that is characterized by large fibril angles, excessive shrinkage, and low mechanical strength. In certain combinations with normal wood in the same board, the greater shrinkage of the compression wood causes the piece to twist, crook, or bow on drying.

2/ Chidester, G. H. 1954. Maximum growth of pulp fiber per acre. Amer. Pulpwood Assn. Pulpwood Annual, pp. 50-52.

3/ Pillow, Maxon Y. 1953. Patterns of variation in fibril angles in loblolly pine. Forest Prod. Lab. Rpt. No. D1935. 11 pp., illus.

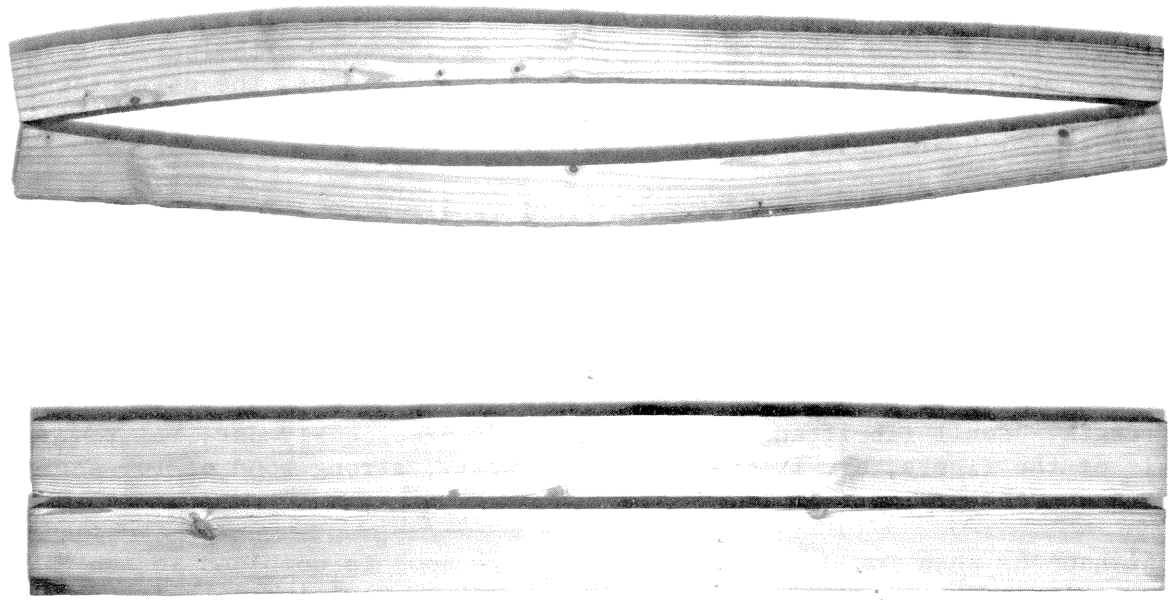

Figure 2.--Top: Two 2 by 4's ripped from a 2 by 8 sawed approximately through the pith of slash pine which grew very rapidly in the juvenile stage and then at more moderate rate. Warp is due to greater longitudinal shrinkage of the wide-ringed, low-density, juvenile wood, as compared to the older, more stable wood grown at more moderate rate. Bottom: Two 2 by 4's from a 2 by 8 sawed approximately through pith of slash pine grown at an even, moderate rate. Here there is little or no stress due to differential shrinkage, hence no warp.

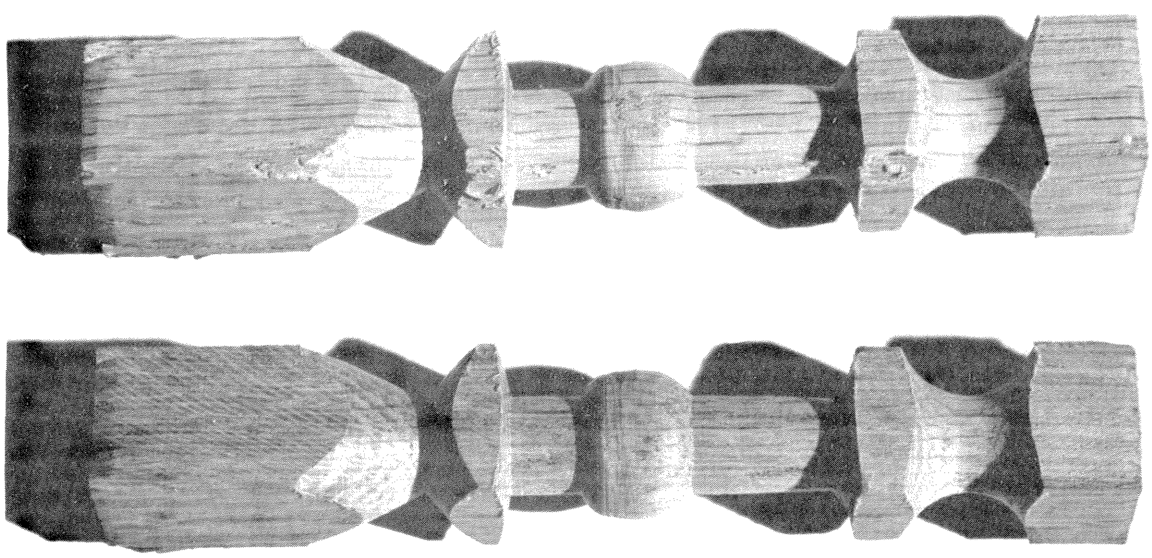

Figure 3.--Standard machining-test turnings of samples of red oak from two different trees. Top: Wide-ringed, high-density wood; note numerous machining imperfections. Bottom: More moderate, even growth; lower density; almost perfect machining properties.

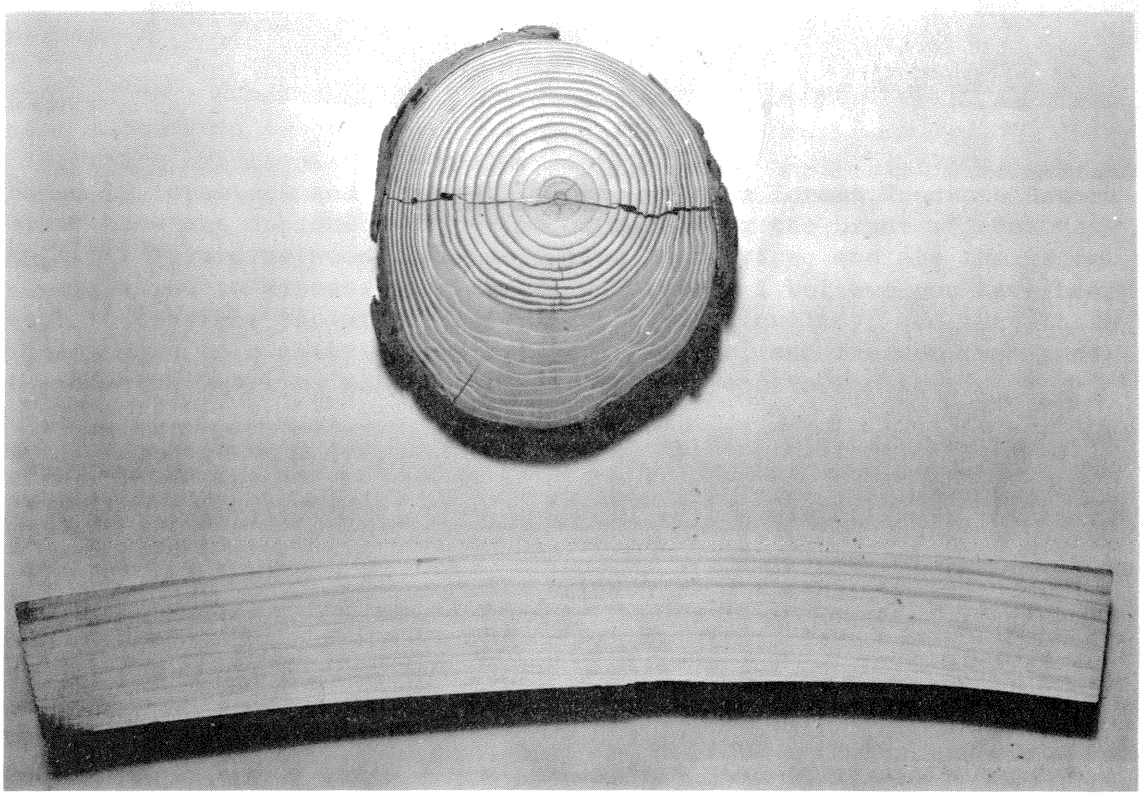

Figure 4.--Cross section of young slash pine showing eccentricity typical of compression wood formed on under side of leaning tree. Below is 1-inch board that has warped because of greater longitudinal shrinkage of compression wood as compared to normal wood.

Tension wood (fig. 5) is an abnormal structure that usually occurs in serious amounts on the upper side of leaning hardwoods. Sweep and crook, common in leaning trees, also favor tension-wood formation. Tension wood is made up of a large number of gelatinous fibers that cause serious warping and torn grain in lumber and fuzzy surfaces and buckling of veneer, and make machining and finishing difficult or impossible.

Compression failures (fig. 6), which should not be confused with compression wood, are minute fractures or short, locally deformed areas along the cell walls of fibers, that are caused by excessive endwise forces, as during severe windstorms, careless felling, or rough handling of logs and lumber. These localized areas of damaged fibers, each of which extends across at least several annual rings, constitute an important cause of brashness, which permits wood to break suddenly and completely across the grain with the application of relatively small loads. The wood of certain trees, because of inherent physical or structural weakness, may be more prone to develop compression failures than others. Failure of many of the broken ladder rails and helicopter rotor blades sent to the Forest

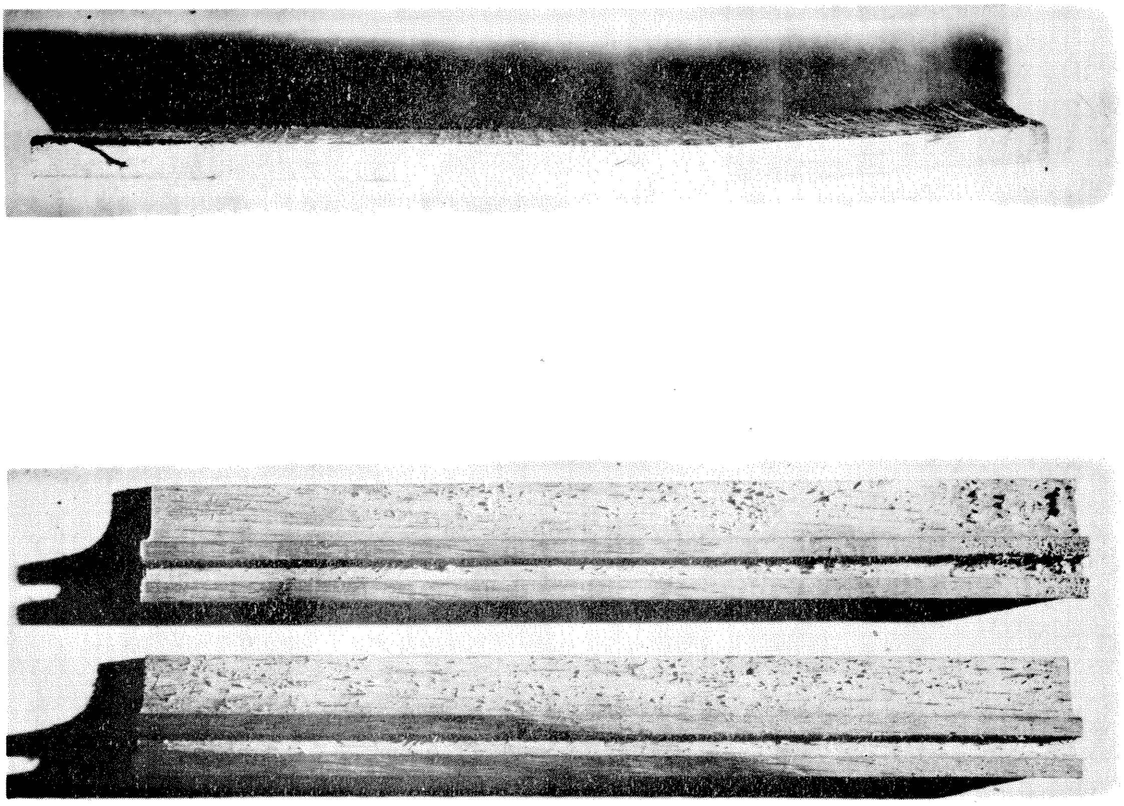

Figure 5.--Elm board (top) that has warped due to serious tension wood. Moldings (bottom) made from cativo, showing torn grain and fuzziness in spots containing large number of gelatinous fibers.

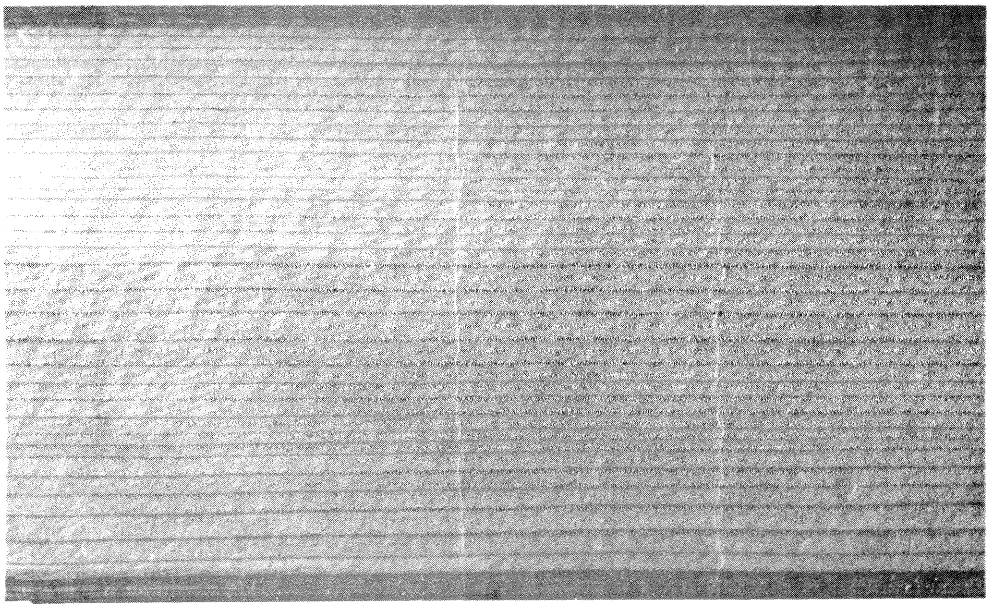

Figure 6.--Clearly visible compression failures found in Sitka spruce ladder rail. If used, this ladder would have broken abruptly, along lines of compression failures, with the application of even relatively light load.

Products Laboratory for diagnosis can be attributed to compression failures that in most cases should have been detected by inspection of lumber destined for such uses.

I could spend the remainder of my time citing other examples of waste, degrade, failure in service, and loss of life, limb, and property due largely to ignorance or disregard of basic wood-quality factors that are normally ignored by foresters and lumbermen alike. At the Forest Products Laboratory we have the dubious distinction of receiving the brunt of consumer complaints regarding wood that has failed in service, and are therefore well qualified to discuss the subject. However, I believe you have heard enough to convince you of the importance of wood quality, and that there is a lot more to quality than size, straightness, and freedom from knots, rot, and other obvious defects with which everyone is familiar.

Fortunately, the wood-quality factors we have been discussing are, unlike the weather, something we can do much about. They can be modified, controlled, or minimized to a considerable extent through forest management and careful selection and breeding aimed at attaining specific wood-quality objectives.

Some of the more important quality characteristics, like specific gravity, are known to be heritable in certain species. Many others, including tension wood and compression wood, can be controlled indirectly by selection and breeding to eliminate certain physical features--crook, lean, sweep--that favor the formation of serious reaction wood.

What some workers in forest genetics have overlooked, or failed to take advantage of, is the fact that trees differ as much in wood-quality characteristics as they do in form, growth rate, and other features that have received most of the emphasis to date. In this connection, I would like to show you some data on the specific gravity of southern pines just obtained in connection with the second resurvey of the State of Mississippi. I am sure you are all generally familiar with the design of the sample plot technique used by the Forest Survey in obtaining forest resource data. Suffice it to say that in this case the Southern Forest Experiment Station and its cooperators obtained, in addition to the usual measurements, complete increment cores (to pith) from all pines tallied on all of the semipermanent plots established in Mississippi during the second resurvey, the fieldwork for which is about completed. The cores, which will eventually exceed 12,000 in number, were sent to the Forest Products Laboratory for the determination of specific gravity, age, growth rate, percent summerwood, and other quality characteristics.

The objective of this cooperative study was twofold: (1) to identify living trees having exceptionally high or low specific gravity for use as breeding stock or scion material for seed orchards; and (2) to provide more complete data on the quality of the forest resources of Mississippi.

The frequency distribution curves (fig. 7) show, for each of the five species, the variation in specific gravity and age of trees 3 inches in diameter at breast height and over. The magnitude of the differences found in specific gravity was from 0.25 to about 0.8 in this unbiased sample of the pine population of an entire State. Among other important findings, it was learned that specific gravity is strongly correlated with and increases with age; that there are significant differences in specific gravity between species; and that within species specific gravity increases significantly from the northern to the southern part of the State.

What we are looking for, of course, are individuals that combine exceptionally high specific gravity with superior growth rate, good form, and other desirable characteristics. Such trees will give the greatest yields of kraft pulp--the chief product of southern pine pulpwood--and the high-strength structural lumber, timbers, poles, and piling for which dense southern pines are so well suited.

With the white pines, on the other hand, we would be less concerned with high specific gravity than with characteristics--machining properties and dimensional stability, for example--that determine the suitability of these species for their more important uses--millwork, pattern stock, and the like.

In "hard" hardwoods destined for uses requiring high mechanical strength--tool handles, wood type, athletic equipment--we would aim for rapid growth and high density. In cabinet hardwoods used chiefly for furniture, paneling, flush doors, and interior trim, the emphasis would be on machining and finishing properties, dimensional stability, and appearance. There is no reason why geneticists should not select and breed for distinctive figure in fine hardwoods, including bird's-eye and fiddleback, and possibly even for the deformities--crotches, burls, and swollen butts--that produce the highest value fancy veneers.

In this connection, I would like again to call your attention to the distinctive and highly attractive figure found in the Sherrill hybrid poplar that I discussed with you at our last meeting, and that is reported on in a recent issue of Forest Science.[4/] This is a fine example of how a normally low-value pulpwood tree can be upgraded from the "beaver-fodder" category into the fancy face veneer class.

Now, at the risk of introducing a slightly sour note into this otherwise happy gathering, I would like to make a comment on the emphasis the majority of speakers, especially in our lively discussions, have placed on the development of better pulpwood trees. I doubt if I will get any serious arguments if I say that an unbiased but uninitiated observer sitting with us today could easily get the idea that the primary objective of most forest genetics research in this country is to supply more and better raw material for the booming pulp and paper industry.

4/ Little, Elbert L., Jr., Kenneth A. Brinkman, and A. L. McComb. 1957. Two natural Iowa hybrid poplars. Forest Sci. 3(3): 253-262, illus. Sept.

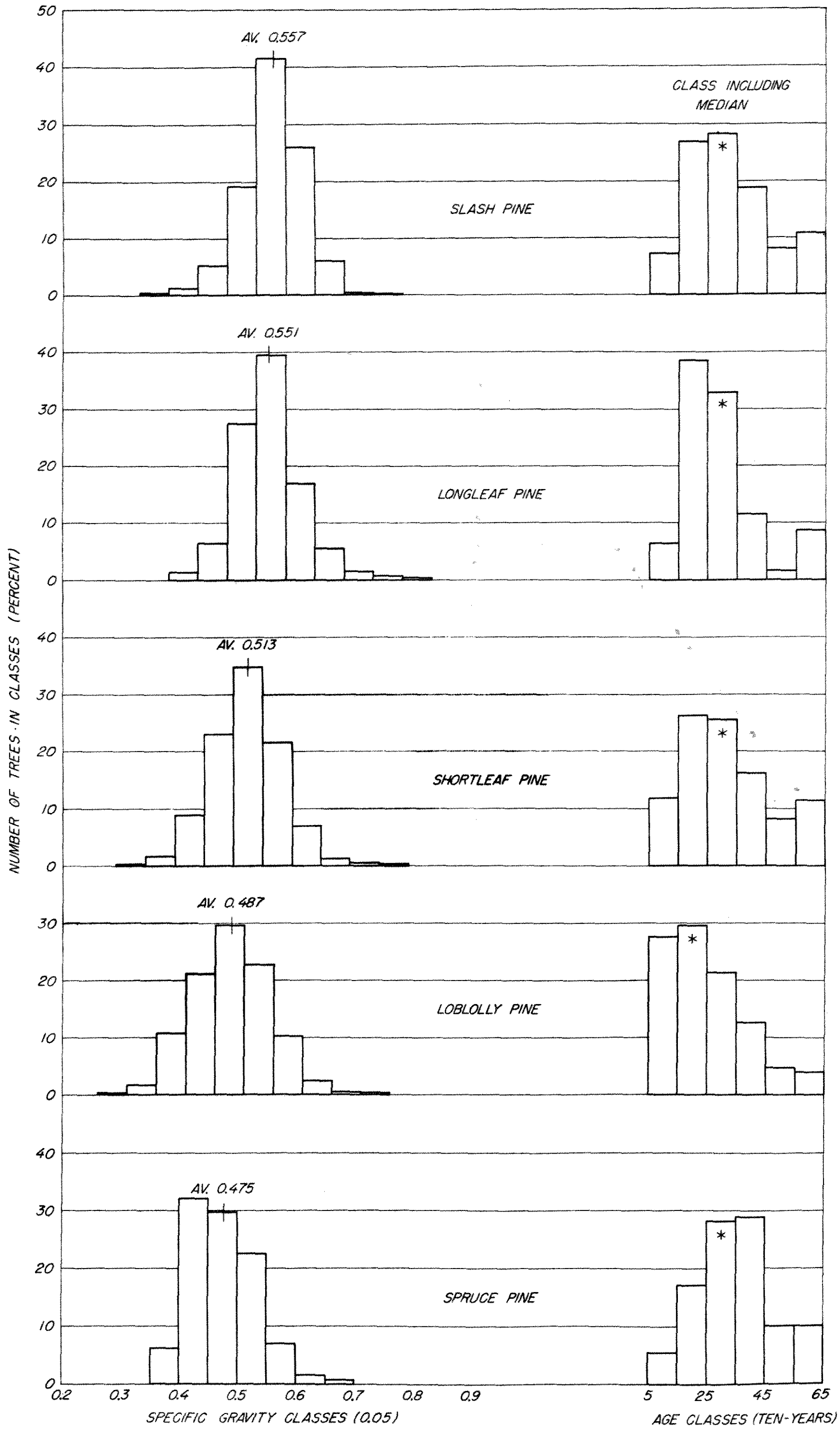

Figure 7.--Frequency distribution of specific gravity values (at diameter at breast height) and age for five species of southern pine in Mississippi. Based on data from trees on all permanent plots sampled in the third Forest Survey of Mississippi. Field sampling by Southern Forest Experiment Station and cooperators; laboratory determinations by Forest Products Laboratory.

I am not suggesting that there be less research oriented in this direction. On the contrary, the pulp and paper people should be commended for their long-range viewpoint, their acknowledged leadership in tree planting, the strides they are making in the management of their rapidly expanding forest properties, and especially on their interest in and support of research, including tree improvement research. More power to them! They are setting a fine example which, if attendance at this particular meeting is any indication, is not being followed to any great extent by other segments of the wood-using industry.

However this may be, I feel obligated, as a member of an organization interested in the improvement and efficient utilization of all forest products, to say a few words on the present and future requirements of some rather important wood-using industries not represented here today. According to the Timber Resource Review, our Nation consumes annually some 12.2 billion cubic feet of wood. Of this total, sawlogs account for 52 percent, pulpwood 22 percent, fuel wood 16 percent, veneer logs and bolts 3 percent, and all other products 7 percent. The requirements for both pulpwood and veneer logs and bolts are expected to increase more rapidly than for sawlogs, and fuelwood is on the decline. But for the present, and in the furthest published projections into the future, by far the greatest proportion of the volume of wood required is and will continue to be in the form of lumber and allied products.

These are economic facts that shouldn't be overlooked by genetics researchers not committed to the improvement of any particular forest product. We must also remember that there are in the Lake States some important industries, including furniture, that are dependent on a continuing supply of high-quality hardwood lumber and veneer. A greater proportion of their raw material needs could and should be supplied from local sources. We have some of the world's finest cabinet hardwoods--yellow birch, sugar maple, cherry, red and white oaks, ash--with which to work toward this objective.

Although the Lake States softwood lumber industry is currently at a low ebb, for reasons with which we are all familiar, much of the land that once produced some of the Nation's finest softwood sawtimber is still available, although in a rather sorry state from the standpoint of stocking and species composition. But enough progress has been made to demonstrate that, with time and effort, these lands can be rehabilitated. In the planting, including reinforcement planting, that will be an important part of the rehabilitation job, let us not think solely of the quality of the pulpwood that will be removed in thinnings, or in such premature clear cutting as may be done, but also of the quality and value of the final crop when harvested at maturity.

Discussion on Applying Forest Tree Improvement Practices in the Lake States[1/]

Discussion centered first on the training of crews for seed collection. It was stated that the trained crew used in the first year's work on the Wisconsin verified seed program consisted of college men who had previously worked for the State on jobs requiring tree climbing. One problem was to keep local collectors out of the areas designated for verified seed collection. It was pointed out that the Davey Tree Company will train tree climbers.

There was considerable discussion on the general topic of wood specific gravity. The statement was made that there is no correlation between growth rate and specific gravity in southern pine, and that the southern pulpwood companies know that coastal plain loblolly pine has high specific gravity while that found in the Piedmont has lower specific gravity. It was pointed out also that specific gravity must be based on basal area increment, not on radial increment. For example, in comparing 100 selected southern pines with 100 average trees it was found that although the selected trees grew faster, there was no significant difference in specific gravity based on basal area increment.

It was brought out, however, that there are places where we don't want dense wood. Dense fibers contribute to poor penetrability of paper, and summerwood contributes dense fibers. Springwood on the other hand contributes to paper strength by bonding better than denser summerwood fibers.

Concluding the discussion was a plea that we remember that the greatest use of wood still is as wood, and not as pulp, important as that may be.

1/ This report on the discussion for this section and those for succeeding sections are based on notes made by Roland E. Schoenike, graduate student at the University of Minnesota.

RECENT ADVANCES IN FOREST TREE IMPROVEMENT IN THE LAKE STATES

Forest Tree Improvement Activities at the Lake States Station During the Past Two Years

by Robert D. McCulley[1/]

The genetics work at the Lake States Station comes in several different packages. During the past 2 years laboratory and greenhouse facilities have been completed at the Hugo Sauer State Forest Nursery near Rhinelander, Wis., and our geneticist, Hans Nienstaedt, has moved there from St. Paul. This Northern Institute of Forest Genetics is the current location of a part of the work to be reported. Progeny tests dating back as much as 25 years are maintained by the Station's centers for research at East Lansing, Mich., Marquette, Mich., Wausau, Wis., and Grand Rapids, Minn. The work at these field stations is included. Also included is the work of the Forest Diseases Division in St. Paul on races of white pine blister rust.

Research Under Way During Past Two Years

I'll begin by outlining the physiological studies now being made as the most recent component of the Station's program. From there I'll move on to the white spruce project, the species currently receiving the most emphasis. Then there are several items in connection with seed source tests and other outplantings. And finally brief mention will be made of the study of races of white pine blister rust.

Physiology

The emphasis in this phase of the program is on auxin metabolism. In the preliminary stages of the initial studies, problems developed in applying standard procedures of bio-assay. Resin contamination proved more serious than expected. Work on new or different techniques therefore is a necessary prerequisite to advancement in this project. Studies under way that are dependent on auxin assay are:

1. A study of the role of an auxin inhibitor (TIBA) on root formation and elongation. Work was begun on this problem because vegetative propagation is at present a limiting factor in studies of many species. A better understanding of the mechanism of rooting should lead to more effective use of the various means of stimulating root development that now show promise or have been effective with some of the less difficult species.

1/ Chief, Division of Forest Management Research, Lake States Forest Experiment Station, St. Paul 1, Minn.

2. A study of the role of auxin in the initiation of flowers and in sex expression of forest trees.

3. A study of the role of auxin in the transition from springwood to summerwood. Collections at intervals during the growing season will relate auxin concentration to the type of wood being formed.

White Spruce

We have a 1936 planting that includes seven sources from the Lake States, Ontario, and the Black Hills. Collections for a more comprehensive study of racial variation in white spruce have been completed with the exception of three Canadian and one U. S. source. Twenty-eight sources are involved, covering the botanical range of the species. Seed will be sown in the nursery in spring, 1958. Tests of seven collections made in 1955 showed marked differences in seed dormancy between sources.

Studies of the characteristics of spruce and of the techniques that are well adapted to use in genetics research on spruce have been made to provide the basis for future work on this species group. One of these has to do with fall grafting of material obtained at the time of seed collection. Aids to success at this season were studied in 1956. Black spruce and Norway spruce were included in addition to white spruce. Day length and temperature for the stock plants were varied both before and after grafting. Results:

1. Pretreatment seemed to have little effect on survival of the grafts provided the stock plants were maintained in good growing condition throughout the summer.

2. Treatment after grafting had a marked effect on survival. Radical changes in the physiology of the plant brought on by treatment were associated with low scion survival.

3. Growth of the scions was little affected by pretreatment but markedly affected by post-grafting treatment. Chilling for about 8 weeks is necessary to break dormancy and produce maximum growth. Long day compensates in part for lack of chilling.

A similar study with more vigorous root stock showed better overall results. Tests of the uses of day length variations and low temperature to stimulate early and long-sustained growth of white spruce seedlings were made in 1956. If successful, such treatments could make it possible for seedlings to go through 2 or more normal growth cycles in 1 year's time and thus hasten their development to certain desired stages. Preliminary results indicate that 4 to 6 weeks' chilling at 36° F. is sufficient to overcome dormancy completely. Long-day treatment (20 hrs.) compensates for chilling but the breaking of dormancy is considerably delayed.

In 1956 the Station began a study of white spruce with the threefold objective of determining and describing (1) the first appearance of primordial male and female flowers and their development through one complete cycle, (2) determining and describing the developmental stages in flower formation during the period of pollination, and (3) the time interval between pollination and fertilization. Observations were made and material collected at specified intervals from early spring to late fall. Microscopic examination of this material has given some basis for early identification of male flowers, female flowers, and vegetative buds. Observations are being continued during 1957 and more complete analyses of material will be made.

A study of the effect of gross climatic changes over short geographic distances on the development of ecotypes in white spruce is under way. In the Upper Peninsula of Michigan there is a range of average frost-free season from 80 to 140 days within a distance of 40 miles. Nineteen seed sources have been collected within this area and these are undergoing preliminary testing under controlled conditions in the greenhouse.

A study of controlled pollination was made in 1956:

1. To determine the most effective bag type or combination.

2. To determine the developmental stage at which female strobili show greatest receptivity.

3. To make preliminary observations on species and self-compatibility.

4. To develop techniques for overcoming species incompatibility.

5. To work out control methods for cone insects.

Results showed that:

1. A combination of sausage casing and kraft bags was best.

2. Female flowers were receptive to pollination for a maximum of 5 days beginning at the first pollen shedding.

3. Several interspecies crosses yielded seed.

4. None of the hormones tested overcame species incompatibility.

5. Lindane gave partial control of cone insects.

A modified repetition of the study was made in 1957 but was limited by poor flower production.

A part of the white spruce project but also bearing on work with other species is the selection of superior trees on the national forests. After the publication of the Guide for Selecting Superior Forest Trees and

Stands in the Lake States,[2] the national forests in the region were asked by the Regional Forester to supply data on trees that they believed were in the superior category. Two forests have sent in these descriptions and the trees have been checked in the field. Continued and widespread participation by management foresters is required and requested to make this phase of the program fully successful. The selected trees will be used in studies of variation, the inheritance of tree characteristics, and seed orchard and breeding techniques.

Progeny Tests and Other Miscellaneous Studies

As noted before, some of the outplantings now under observation were made in the early thirties. Among these are seed source installations for red pine with plots remaining in two areas of northern Minnesota. The problems of thinning, accentuated by a row-by-row arrangement of sources, have been argued back and forth in connection with one of these tests. In general, it is a reminder to us that progeny testing needs thorough planning, wise decisions on the necessary compromises on objectives, and a fair measure of good fortune.

The regional seed source study of jack pine seems to be off to a good start. The plantings the Station is maintaining close check on have had good survival with one exception. No attempt has been made to compare sources at this early date and no differences have been so prominent that they excited comment from field examiners. A few minor insect attacks have been reported.

Sixteen sources of white pine seed have been assembled from throughout the botanical range of the species as part of an inter-regional seed source study in cooperation with the Southeastern, Northeastern, and Central States Forest Experiment Stations, and the Ontario Department of Lands and Forests. Seeding in the nursery is scheduled for next spring.

The Station succeeded in obtaining a number of Russian and Siberian sources of Scotch pine, Norway spruce, and a number of other species in a recent seed exchange. They were sown in the spring of 1957 and are developing well in the nursery. The sources of Norway spruce will help to round out an older study of this species.

Older plantings that are remeasured periodically include:

a. Scotch pine seed sources

b. Norway spruce seed sources - International Union

c. European and Siberian larch sources

2/ Prepared by Paul O. Rudolf of the Lake States Forest Experiment Station with the assistance of the Subcommittee on Tree and Stand Selection, and published by the Lake States Station (Station Paper No. 40, 1956).

d. Hybrid poplars

e. Eastern x western white pine hybrids

f. Jack pine x lodgepole pine hybrids

g. Some 65 exotic tree species from random sources

Blister Rust Races

Research on blister rust races was begun informally at the University of Minnesota in 1950. Limited financing was furnished by the U. S. Department of Agriculture in 1951. The Station entered the picture in 1952 when Ralph L. Anderson joined the staff. In 1955 evidence of racial difference was found on a species of Ribes.

Subsequent research has confirmed the initial evidence of racial differences. Preliminary evidence of possible racial variation has been noted on other Ribes species.

The next step is to determine whether racial differences also show up on the pine host. For this purpose clonal lines are being built up through grafting. A good start has been made with: Eastern white pine of a Lake States source, Korean pine, limber pine, and Balkan pine. We hope to add clonal lines of the following: A northeastern source of eastern white pine, a rust-resistant selection of eastern white pine, a normal western source of western white pine, and a rust-resistant selection of western white pine. Tests on pine hosts will begin in the immediate future.

Plans

The outlook for genetics research at the Lake States Station in the period just ahead includes considerable development work. However present facilities are good and there are only the normal problems lying in the way of improving them.

The emphasis on spruce will continue for a number of years. Problems in connection with other species are enticing and cannot all be taken care of by other research agencies in the region. No doubt variety will creep in more rapidly than the financing to take care of it.

There is a feeling of optimism on our part due to the quality and not the quantity of our research staff and because of a formally recognized program established in a field that received only sporadic attention in the past.

Forest Tree Improvement at the University of Minnesota

by Scott S. Pauley[1]

Principal initial effort in the establishment of the tree improvement project at the University of Minnesota continues to be directed to the accumulation and propagation of experimental materials at the University's North Central School and Experiment Station (NCSES) and in a new nursery established on the St. Paul campus. Additional test and demonstration outplantings were also established and new studies initiated by several graduate students in 1956-57. A summarized description and report of progress on these activities follows.

Nursery Propagation

Through cooperation of the Knife River Nursery (Kimberly-Clark of Minnesota, Inc.) and the Willow River and Badoura nurseries (Minnesota Conservation Department), several thousand seedlings and transplants of white spruce, black spruce, red pine, jack pine, and white pine have been lined-out for use as rootstocks in the NCSES nursery and in the St. Paul nursery. Additional rootstocks of the following species have been propagated from seed: Yellow-poplar, black willow, quaking aspen, cottonwood, silver poplar, grey birch, river birch, paper birch, American elm, Siberian elm, slippery elm, rock elm, red maple, silver maple, and black locust.

In addition to the new nursery site made available to the Tree Improvement Project on the St. Paul campus in the spring of 1957, three new rodent-proof seedbeds and a heeling-in bed adjacent to the Green Hall (School of Forestry) greenhouse have been constructed. These facilities will materially improve our ability to handle seedling progenies.

Outplantings

Tree Improvement Arboretum.--Through cooperation of the Blandin Foundation, initial outplanting in a Tree Improvement Arboretum at the D. M. Gunn Memorial Park, Prairie Lake, was made in the spring of 1956. The planting consisted of various cottonwood, balsam poplar, and aspen ecotypes and hybrids.

In May 1957, 100 4-tree plots of paper birch seed sources were established in the arboretum area. The seed sources represented cover most of the range of this species in North America. Seed of this material was assembled by Dr. Chi-Wu Wang in 1953 while on the staff of the Harvard Forest. (Dr. Wang is now on the staff of the School of Forestry, University of Florida.)

1/ Professor, School of Forestry, Institute of Agriculture, University of Minnesota, St. Paul 1, Minnesota.

In addition, 28 4-tree plots of various paper and yellow birch seed sources, and putative natural hybrids of these species with bog birch, were planted. Seed of this material was assembled by A. G. Johnson while on the staff of the Arnold Arboretum, Harvard University, in 1953 and 1954. (Mr. Johnson is now on the staff of the Horticulture Department, University of Minnesota.)

Cook outplanting.--The Cook outplanting area, established through cooperation of the Diamond Match Company on the Pete Trygg farm near Cook, Minn., in the spring of 1956, was increased in the spring of 1957 by the addition of a portion of the birch sources described above. Twenty-one of the Wang seed source collections and 12 of the Johnson collections, in various plot sizes, were outplanted in the spring of 1957.

Five F_2 and backcross progenies of quaking aspen were also outplanted in the Cook test area.

Highway 33 outplanting.--Through cooperation of the Diamond Match Company another test site for birch was made available to the Tree Improvement Project in the spring of 1957. This area comprises a piece of newly cleared land on the west side of Highway 33, about 10 miles north of Cloquet. Forth-five of the Wang birch sources were outplanted here in the spring of 1957.

Waseca, Austin, and St. Paul outplantings.--One hundred cottonwood and balsam poplar clonal lines were established in hardiness tests in north, central, and southern Minnesota in the spring of 1956. Marked variation in frost damage of certain clones between plantings was recorded in 1956-57. The plots will be maintained with cooperating agencies for several years.

Studies in Progress

Mode of inheritance in aspen.--Several F_2 and backcross progenies derived from crosses of F_1 hybrid aspen populations were produced in the greenhouse during late winter 1956 and 1957. The F_1 populations utilized were derived from controlled crosses of selected quaking aspen and European aspen parents made by the Cabot Foundation in 1950.

Hermaphroditism in quaking aspen.--An analysis of female, male, and hermaphroditic (bisexual) trees in a 206-tree sample of sexually mature quaking aspens, all of seedling origin, was made in 1956. Results of this study are summarized in Minnesota Forestry Notes No. 55.

Certain aspects of this initial study (e.g. actual ratio of male or female flowers to bisexual flowers in a single tree, self fertility studies of bisexual plants, genetic sex mechanisms involved, etc.) will be continued by Mr. Soon Chul Hong, a Korean graduate student now in residence.

Birch studies.--In addition to the Wang and Johnson birch collections described above, further studies of ecotypic diversity and natural hybridization in the native birches have been initiated:

(1) In cooperation with Raymond J. Wood, Manager of the Diamond Match Company's Land and Timber Department, open pollinated seed collections from 11 selected birch stands were made in late August 1957.

(2) Studies of natural hybridization involving paper birch and bog birch were initiated during the past year by Knud E. Clausen, a graduate student in the School of Forestry. Initial effort has been directed to the location and mapping of hybrid swarms throughout the State and collection of herbarium material and seed for morphological and cytological studies.

Forest genetics survey.--A report on the Minnesota forest genetics survey conducted by Thomas O. Rudolph and William J. Libby during the summer of 1956 has been completed. This report was not intended for publication, but as a reference for more detailed investigations. Three copies have been prepared and are available on loan. A portion of the data collected, concerned with jack pine variation and distribution in Minnesota, has been published as Minnesota Forestry Notes No. 58.

Jack pine variation.--As an outgrowth of the above report, a detailed investigation of jack pine diversity has been undertaken by Thomas O. Rudolph and Roland E. Schoenike, both graduate students in the School of Forestry. These students are presently engaged in a study of the jack pine seed source plantations established by Dr. Schantz-Hansen at the Cloquet Experimental Forest in the early 1940's, and the more recently established seed source plantings made cooperatively by the Lake States Forest Experiment Station and the University of Minnesota. If feasible, fieldwork will be undertaken outside the State throughout the range of jack pine, and especially in western Canada where the natural range of jack pine and its western counterpart, lodgepole pine, overlaps.

Toxin tests for Dutch elm disease.--Tests of a toxin screening method for the isolation of American elm seedlings resistant to the Dutch elm disease were undertaken by Frank S. Santamour, a graduate student in the School of Forestry, during the past winter. Results of these tests did not support the feasibility of such a screening method nor support the hypothesis that a toxin, produced by the causal fungus, is the prime disease-causing factor in infected trees.

Grafting and hybridization of elm.--The grafting and hybridization studies undertaken by Paul E. Collins while a graduate student in residence at the School of Forestry in the spring of 1956 are being continued at South Dakota State College.

Yellow-poplar ecotypes.--Adaptability tests of four open-pollinated seed sources (New York, Tennessee, North Carolina, Michigan) of Liriodendron tulipifera were initiated in 1956. Other such tests of southern species, designed to isolate possibly adapted individuals, are planned.

Jack pine and lodgepole F_2 population.--Through cooperation of the Institute of Forest Genetics, Placerville, Calif., we have been supplied samples of seed from F_1 hybrids of the cross lodgepole x jack pine--a controlled cross that was made at the Institute a number of years ago. Several samples of lodgepole pine seed from the same locality of origin as the female parent of the original cross have also been supplied. These samples, together with samples of Minnesota jack pine, are currently being propagated.

Progeny test analysis.--Mr. John C. Barber, on leave from the Southeastern Forest Experiment Station, U. S. Forest Service, was in residence as a graduate student in the School of Forestry during the 1956-57 academic year. Mr. Barber's research problem is concerned with the 6-year evaluation of several slash pine progeny tests growing in the State of Georgia.

Basswood propagation.--Studies of basswood propagation from stem and root cuttings have recently been undertaken by William J. Peters, a graduate student in the School of Forestry. Basswood is given high ranking by Minnesota farmers as a desirable farm woodlot tree. Other hardwoods of high preferential rating by the State's farmers are: rock elm, red (slippery) elm, red oak, white oak, butternut, walnut, and green ash.

Growing northern planting stock in the South.--Richard Watt, a member of the Lake States Forest Experiment Station, will be in residence as a graduate student in the School of Forestry during the current academic year. Mr. Watt plans to initiate a research problem which will be designed to assess the feasibility of growing certain native northern conifers in nurseries of the deep South. In the long growing seasons of such areas, and under an artificially lengthened photoperiod designed to increase the period of active growth, high-quality planting stock may be produced in a shorter time.

Forest Tree Improvement in the Department of Genetics at the University of Wisconsin

by R. G. Hitt[1/]

The University of Wisconsin in cooperation with the Wisconsin Conservation Department undertook a program in forest tree improvement in July of 1948. The general objective of the program was for the improvement of the genetic quality of the forest tree planting stock used in Wisconsin reforestation. The program has been developed along three general lines. They are:

1. Selections and testing of superior forest tree species

1/ Forester-in-Charge, Forest Genetics Research, University of Wisconsin, Madison, Wis.

2. Hybridization studies

3. Specialized studies on such problems as vegetative propagation, flower induction, establishment and maintenance of forest tree seed orchards, etc.

To date, over 360 individual tree selections have been made. Not all of these, however, represent plus-tree selections. Many of the individual tree selections have been used to provide stock for progeny tests and as parent stock for forest tree seed orchards to be established.

Species of interest include red, white, and jack pines, white and black spruces, and some balsam fir. In addition, some individual tree selections have been made for quaking and bigtooth aspen, and several birch population collections have been acquired.

An attempt has been made to build up a collection of breeding material for future research. Included in the collection are some 20 species of Pinus, 5 species of Larix, 6 species of Picea, 3 species of Abies, and 3 species of Betula. Representative samples of all this material are being grown in breeding collection areas in several locations throughout the State.

Approximately 100,000 trees from open-pollinated seed from individual trees or selected areas are now involved in progeny and provenance tests. The trials are composed of 36- and 64-tree plots replicated 2 or 3 times within a trial. The trials are then replicated on 2 or 3 different sites in central and northern Wisconsin. Periodic survival counts, growth records, and other observations will be made on the areas. Certain provenances or individual tree selections which prove to be superior to others in the test will be used as seed sources for future reforestation work and as parent stock for seed orchards.

Controlled pollinations have been performed during the years as time, personnel, and flowering on the pines permitted. The majority of these pollinations have been made on red pine, although some work has also been done with jack pine, Austrian pine, and white and Norway spruces. Both intra- and interspecific crosses have been attempted. Results to date have been rather poor. Many cones have been lost through insect damage. To date no interspecific crosses have yielded seed. A small scale self-compatibility test with red pine has been in progress for several years.

The object of several of the specialized studies is to provide information of value for the systematic development and management of a network of forest tree seed orchards. In addition, a number of the studies will yield data of value in the pursuit of other phases of the tree breeding research.

All of the flower induction studies to date have involved the use of mechanical means. Girdling (both semi-circular and spiral), strangling, root pruning, defoliation, and phloem inversions have been used on different age classes of red pine. The results have been variable. The spiral girdle gave the greatest immediate response in number of both male and female flowers. This treatment also caused the greatest damage to the treated trees, resulting in the death of the terminal portions of branch tips. The semi-circular girdle gave increased flowering and did not noticeably injure the growing crown.

Response to strangulation was slow, but as the trees grew and began to strangle themselves, flowering increased.

Root pruning did cause increased flowering on already flowering material and initiated flowering on non-flowering trees.

Most phloem inversions failed to grow; however the few inversions which did take did not stimulate or initiate flowering on 8- to 12-year-old red pine. The number of trees which survived was small; hence these results should not be considered conclusive.

The techniques for field grafting of red pine have been developed sufficiently to allow for their widespread application in the establishment of a network of forest tree seed orchards in Wisconsin.

The grafting is done in the early spring before new shoot growth begins. Stored or freshly collected scions are used. Prior to grafting, the scions are dipped in a 25-percent solution of liquid latex and allowed to dry. This anti-desiccant helps to carry the scion over the first few weeks while the callus tissues are formed. A veneer graft is used. Grafting success ranged from 5 to 100 percent depending on scion lots. The average percent of grafts to "take", however, was about 65.

Greenhouse grafting has been continued. The percent of successful grafts here, however, was about 35. Various species of Pinus were used as understocks to determine graftability as well as for studies to determine understock influence on the stimulation of precocious flowering.

Vegetative propagation by means of rooted cuttings has been attempted. Spring "planted" cuttings taken from 2-2 red pines several weeks prior to "planting" gave as high as 25 percent rooting. The American Chemical Company's experimental powder Rootone #104 gave rooting of 25 percent after 17 weeks in out-of-doors cutting beds. When a second replicated bed of cuttings was allowed to over-winter and the trial was read after 64 weeks, rooting had dropped to 19 percent.

Air layering of red, white, jack, and Scots pines yielded no rooted branches. The treatments were applied in late June and early July. This undoubtedly was too late in the growing season, and better results would certainly be expected provided the treatments could be applied earlier in the spring prior to bud break.

Dormant vegetative bud primordia, formed at the base of each needle fascicle in Pinus, can be stimulated into growth by injury or removal of the distal portion of the branch. When the tip is removed or injured, an abundance of small branches or scions are produced by growth of the latent buds. Thus it is possible to produce large numbers of scions for increasing selected genotypes by grafting.

Branch-tip clipping trials were carried out in northern Wisconsin on 9-year-old plantation red pine. When the treatment was applied prior to the third week in July, the bud primordia were sufficiently stimulated and had enough growing season remaining after treatment to form good scions. These scions were large enough at the end of the growing season to be used for grafting the following April. As few as one and as many as 40 buds were stimulated into growth on a single clipped terminal.

The first of the forest tree seed orchards to be established in Wisconsin was set out on an abandoned field in the Kettle Moraine State Forest near Eagle, Wis., in April 1955. Rabbit damage to many of the trees considerably reduced the number of live stems. More trees were added to the original planting in the spring of 1957. Measures have been taken to protect the trees from further animal damage. Field grafting also was carried out for seed orchard purposes during the spring of 1957.

Cone-crop prediction surveys as well as cone-picking time studies have been conducted. The information gathered has been made available to the Wisconsin Conservation Department to assist them in planning their cone-buying programs. Data are also being accumulated relative to the cyclic nature of flowering of red pine.

The Verified Forest Tree Seed program which was initiated in November 1956 by the Wisconsin Conservation Department in cooperation with the forest tree improvement program has already been discussed.

A new investigation has been undertaken for several populations of red pine which show a high degree of basal forking. Several mutant red pines have been found including a prostrate bushy type, a "snake" type which has a tendency to form very few side branches, and a fastigate type which has short, fine, acutely angled branches. These types are being vegetatively propagated, and studies to determine their genetic makeup are planned.

Forest Tree Improvement in the Department of Plant Pathology at the University of Wisconsin

by J. G. Berbee[1/]

For a number of years the University of Wisconsin and the Wisconsin Conservation Department have cooperated on programs aimed at the development of superior disease- and insect-resistant trees. Two major projects have been carried out in the Department of Plant Pathology. One is concerned with the blister rust resistance in white pine and the other with poplar improvement.

Blister Rust Resistance in White Pine

Progress in the development of blister-rust-resistant white pines has continued along several main lines, including selection, testing, breeding, and vegetative propagation. The investigations have been made by R. F. Patton and A. J. Riker.

Resistance of parent selections in the form of grafts has been tested in the Blister Rust Nursery and also in outplantings in a number of different places in this country and abroad. Of the original 163 selections, 40 have been rated highly resistant and many of these have been used in the breeding program. Additional selections have been made and tested for resistance, and others will be, to encompass a wider range of climate and genotypes.

To determine the inheritance pattern of resistance, the progeny from resistant trees have been tested. Seedlings from open-pollinated resistant trees had little, if any, more resistance than ordinary seedlings. Thus, emphasis has been placed on controlled crosses between resistant trees.

A total of 263 different controlled crosses have been made. Artificial inoculations of 900 seedlings from the first crosses have indicated that, on the average, a low percentage of the first-generation seedlings had resistance to blister rust. Some parents appeared to have greater ability than others to pass their resistance on to their offspring. The single self-pollination included among these first crosses produced stunted seedlings, but these had much less infection than the checks. In further tests in the Blister Rust Nursery, over 8,000 seedlings, including those from crosses between resistant eastern white pine and resistant western white pine have been inoculated and results will be available soon. To introduce additional resistance factors from naturally resistant species, a number of other interspecific crosses have been made. Sound seed has been obtained on eastern white pine from controlled pollinations with Mexican white pine, Himalayan pine, Japanese white pine, and Balkan pine. Pollen from eastern white pine yielded some seed on Balkan pine. From these and other progenies under test, selections of F_1 individuals will be made for further screening and for the production of F_2 generations through F_1 intercrosses or backcrosses to the parents. If a useful

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1/ Forest Pathologist, University of Wisconsin, Madison, Wis.

percentage of resistance can be transmitted through the seed from certain combinations, the eventual establishment of a seed orchard is contempleted.

Methods of vegetative propagation have continued under investigation. Apparently, top grafting field trees may speed up the establishment of seed orchards. In trials designed to promote early flowering, F_1 seedlings were grafted into the crowns of large flowering white pine trees. However, pollen has not yet been secured from grafts made as early as 1953. Rooting cuttings has proved cheaper than grafting. With 4-year-old trees and suitable treatments it has been successful. With 15- to 60-year-old trees the results have been variable; at best 25 to 30 percent of the cuttings have rooted. Ten years after establishment in plantations, trees from rooted cuttings have proved indistinguishable from trees of seedling origin.

Poplar Improvement

The aim of this project has been to develop a number of poplar clones resistant to diseases and insects, capable of rapid growth on several different sites, and suitable for a variety of uses. The program has included selection, introduction, breeding, and testing. It has been carried on by J. E. Kuntz and K. R. Shea, A. J. Riker, and, more recently, by J. G. Berbee.

Through the cooperation of various agencies, clones have been obtained from many different places, including South Dakota, Minnesota, Pennsylvania, Maine, Canada, and Holland. In cooperation with the Harvard Forest, 400 other clones from various parts of the United States have been obtained. About 50 clones have been supplied by the Northeastern Forest Experiment Station. Approximately 200 Wisconsin poplar trees have been selected as superior. In all, over 750 clones have been set out for study.

To evaluate this material, cuttings from the various clones were set out in replicated blocks. In these tests, most of the hybrid poplars developed elsewhere have proved unsatisfactory in Wisconsin. However, a few of the native and introduced selections have been found resistant to one or several of the diseases and insect pests of poplar, and have desirable growth characteristics.

In further trials, these promising clones will be used in small plantations on a variety of soils in Wisconsin.

A large number of trees also has been obtained by controlled pollinations using elite Wisconsin trees as parents. The following crosses have yielded progeny: A monoecious quaking aspen selfed; quaking aspen (female) with bigtooth aspen*, eastern cottonwood*, and white poplar*; bigtooth aspen (female) with eastern cottonwood and white poplar*; white poplar (female) with balsam poplar and eastern cottonwood; and balsam poplar (female) with eastern cottonwood and quaking aspen. For those species indicated by the asterisks, the reciprocal crosses also have been successful. In addition, progeny have been obtained from intraspecific crosses with all of the above species.

Approximately 10,000 seedlings obtained from these crosses have been planted near Madison and near Wausau. Their resistance to cankers incited by *Hypoxylon pruinatum* (Klotzsch) Cke., *Septoria musiva* Pk., and *Cytospora chrysosperma* (P.) ex Fr. is being tested by artificial inoculation. Continued evaluation of the seedlings over a period of years will be necessary.

Recent Advances in Forest Tree Improvement at the University of Michigan

by Burton V. Barnes[1/]

Forest tree improvement research at the School of Natural Resources of the University of Michigan centers in the Silviculture-Silvics and Pathology divisions of the Forestry department. The Botany department of the University has also assisted by giving space for some limited aspen flowering and pollination experiments. At present, however, there are no facilities for intensive breeding experiments or large-scale progeny tests. Research in forest tree improvement is stressed from the silvicultural point of view and it continues along the lines of variation and selection.

The initiative in tree improvement research is taken by Professor Stephen H. Spurr, Professor Dow V. Baxter, and graduate students who choose this field of specialization. Professor Baxter is continuing his research in the selection of individual trees of the Chinese chestnut that have proved satisfactory for culture in Michigan. The trees that have demonstrated their hardiness to approximately 30 Michigan winters are being selected for yield, size, and quality of nuts they produce. In cooperation with the Lake States Forest Tree Improvement Committee the annotated bibliography: "Forest Genetics in the Lake States" was published in June 1956.

The University owns an 800-acre tract northwest of Ann Arbor where several seed sources of Scots pine are planted. These plantings have been the subject of past research investigations and are presently used for student instruction in silviculture. A larch provenance experiment was begun in the spring of 1957 when seedlings representing several origins of European and Japanese larch were planted. Seedlings of the Dunkeld hybrid larch are now in the forest nursery. In a separate larch project, the University is cooperating with Professor Dr. R. Schober of the Lower

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1/ Instructor, School of Natural Resources, University of Michigan, Ann Arbor, Mich.

Saxony Forest Research Station in undertaking the American trials of a mass collection of European larch seed. The larch seed was collected by Professor Schober from the best larch stands and phenotypically superior individuals throughout the range of European larch in Europe.

Another part of current research centers upon the genus Populus and is primarily concerned with the two native North American members of the section Leuce: Populus tremuloides (quaking aspen), and Populus grandidentata (bigtooth aspen). The initial phase of this work is a fundamental study of the natural variation of these aspen species in northern Michigan by Burton V. Barnes of the Forestry department. The University owns a 9,000-acre tract in Emmet and Cheboygan Counties near the tip of the Lower Peninsula, which is the home of the University Biological Station. In the summer of 1956, fieldwork was initiated by identifying and mapping 35 geographically isolated quaking aspen and bigtooth aspen clones on poor-quality glacial outwash sand soils. Differences within and between clones will be demonstrated by showing the morphological diversity of the leaves, bark, buds, flower parts, seeds, and seedlings. Branch diameter, branch angle, fall leaf coloration, time of leaf fall, and flushing time will further illustrate the clonal variation. Besides the detailed biological study, data have been collected to assess the growth performance and rate of spread for each clone. The clones will continue as permanent plots of the Biological Station and will afford future opportunities to analyze clonal development.

The purpose of the study is to give a clearer picture of clonal growth and development of aspen and to portray accurately the wide range of individual variation even when site conditions are uniform. It is felt that this type of information will help American and European tree breeders in understanding these highly variable species. It should give them valuable assistance in the selection of desirable parent material for future hybridization experiments. Succeeding studies planned to follow are: (1) The selection of superior clones on sandy sites in northern Michigan, and (2) the vegetative propagation of aspen by root and green cuttings. Seed from several selected and open-pollinated female clones will be germinated and seedlings out-planted on a variety of sites in Michigan and Europe.

Some work has already been started for the future Michigan progeny trials of the quaking aspen x European aspen hybrid. A small population of this hybrid was produced in the spring of 1957 and the seedlings will be transplanted in the spring of 1958. This year more breeding experiments are planned in order to have material in future years for comparison with the large quantities of the European aspen x quaking aspen hybrid produced in Europe. In Europe this hybrid is receiving more attention and seems more promising than diploid and triploid forms of the native European aspen.

In the spring of 1956, several spontaneous clones of the white poplar x bigtooth aspen and bigtooth aspen x quaking aspen hybrids were found in lower Michigan. Several clones of perfect flowered quaking aspen were also discovered. Again this year foresters and botanists of the University will be searching in lower Michigan for these infrequently occurring genetic types and also for natural triploids of both bigtooth aspen and quaking aspen.

Tree Improvement Activities at Michigan State University

by Jonathan W. Wright[1/]

In other years Prof. P. W. Robbins has covered the various forest genetic experiments that have been started at Michigan State University. Instead of trying to bring you up to date on these experiments--after all trees don't grow too much in 2 years--I'd like to speak about some of our plans for the future.

The teaching program at Michigan State University will include forest genetics instruction at both the undergraduate and graduate levels. In addition, I will be able to spend about half time on research. The research program has not yet been crystallized. However, I can be sure of one thing. It will include a minimum of short-term studies which are put in because they will make convenient class demonstrations. Long-term studies designed to produce the best trees for Michigan planters will make even better class demonstrations and thesis projects.

Last year Michigan nurseries produced about 88,000,000 red pine, about 66,000,000 Scotch pine, and smaller amounts of other species. Therefore, red pine is Michigan's most planted tree, and will get the greatest emphasis in our program. Our initial efforts will be aimed at producing better red pine, or at producing improved strains of other species which will outperform red pine on the ground and be as valuable as that species in the sawmill.

The European pine shoot moth is the number one problem of red pine in Michigan. It is still not serious in the Upper Peninsula or in the northern portion of the Lower Peninsula. However, it is enough of a problem in southern Michigan to make it likely that a shoot moth-resistant strain would be appreciated more by foresters than almost anything else we could produce.

A quick glance around the Lansing area indicates that the exotic field is promising. Ponderosa pine, Austrian pine, and Scotch pine are all doing well. One or more of them might be more than a satisfactory replacement for red pine in certain areas, although probably not over the range as a whole. They are considerably more resistant to the shoot moth than is red pine. But we need to know much more about those species. In particular we need to know more about their climatic adaptability and their geographic races. The small racial tests now in existence are quite inadequate. Range-wide, well-replicated, and statistically analyzable provenance tests of red pine and of those three exotics are high on our must-do list for the next few years. I suspect that those same species will loom

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1/ Associate Professor, Department of Forestry, Michigan State University, East Lansing, Mich.

large in the programs of other agencies, too. We will hope to carry along as much as possible of this provenance testing work on a cooperative basis, provided that the cooperative work plans call for the best possible experimental design.

Michigan State University has quite a number of statisticians and geneticists on its staff. I like that. There will be opportunities to work with them on studies to determine the best possible experimental designs for forest genetics experiments. Take the field of provenance testing. We know from past experiments on forest tree species that growth rate differences of up to 25 percent are often meaningless if based on unreplicated experiments. Therefore we must replicate. And we know from experiments on herbaceous plants that many 1-, 2-, and 4-plant plots give 50 or 100 percent more information than two or three 100-plant plots. Also, they are much cheaper to install and measure. But there are several things we don't know. We can't calculate beforehand whether a given experimental design will permit valid conclusions as to 5-percent, 10-percent, or 15-percent differences between origins. Every provenance test we establish obligates our employers to $25,000, $100,000, or even $500,000 worth of future work. Therefore it seems only right that we should try to eliminate all possible guesswork in planning those tests. I am hopeful that during the next year we can complete two experimental design studies, using data from existing commercial plantations, to help us in planning all our subsequent tests.

So far I've talked only about provenance testing. It may well be that an individual tree selection and selective breeding program in red pine holds more promise. We're going to find out. The first step, of course, will be to select the plus trees. That will take a little time. There should be about 500 of those plus trees--selected for apparent resistance to the shoot moth or apparent rapid growth--to provide the basis for a new strain. With too small a number of initial selections we can get only theoretical information showing what can be done. We'd like the actual improved strain.

During the course of this preliminary phenotypic selection work we will get clues as to whether or not red pine is genetically variable in resistance to shoot moth attack. Clues, not proof. If those clues point in the right direction, we will go ahead with the next step--a seedling progeny test of the selected parents.

My thoughts on by-passing the traditional clonal seed orchard ran something like this. (1) A good-sized clonal orchard would be expensive. (2) The clonal test, if properly designed, would give information on the genetic variability of red pine with regard to shoot moth resistance. However, that is not the information we need. For a seed-propagated species we have to know whether superior trees give superior seedlings. (3) The clonal test can serve as a tested seed orchard only if every clone is progeny tested. It is the progeny testing--not the grafting--that will prove the superiority of certain parents. (4) At the end of one progeny-testing rotation--say 15 years from now--the clonal test could be thinned to become a tested seed orchard. But what would happen if we thinned our F_1 seedling progeny test, leaving the best progenies? Fifteen years from now they will start to produce seed. The seed they produce will be genetically more variable than the seed produced by the clonal seed orchard, but it will have the same average productivity. (5) If our original assumption that the best parents give the best seedlings is correct--the entire project will fall apart after 15 years if it isn't--seed harvested from the best individual trees of the best F_1 progenies will produce even better F_2 trees. The selection cycle can be repeated for at least 5 or 6 generations (if we are to judge by the results on lower plants), with a constant genetic increase per generation. On the other hand a clonal test does not offer any opportunities for further selection work.

Those five points can be summarized as follows. A seedling progeny test is cheaper and far superior to a clonal progeny test for a species that is usually propagated by seed.

In these remarks I have attempted to give--not a complete summary of all our future plans--but some of the major projects that I feel reasonably certain will be started in the next biennium or at least in the next 5 years. We may start off rather slowly, but I think it's better that way. Then we can be sure that every project will furnish good theoretical information for the science of forest genetics, and improved strains which will be usable on sizable Michigan areas.

Progress Report, Forest Genetics Work at the Institute of Paper Chemistry

by Dean Einspahr[1/]

The genetics program of The Institute of Paper Chemistry is supported in part by several pulp and paper companies and in part by the research funds of the Institute. Major emphasis has centered on the genetic improvement of aspen with particular attention being given to genetic effects upon pulping and papermaking characteristics and to the use of polyploidy in hardwood tree improvement.

Since the last meeting of this conference in August 1955, we have, in addition to the previously described test area on Rhinelander Paper Company land, purchased a 38-acre nursery and test site near Appleton. We also have established test areas in cooperation with the Kimberly-Clark Corporation on a site near Marenisco in Upper Michigan and are fencing a test area near Cornucopia in Northeastern Wisconsin on Cornell Paperboard Company land. Also, we are to have additional laboratory space for cytological and fiber anatomy work when the new wing of the research building is completed.

1/ Physiologist, Institute of Paper Chemistry, Appleton, Wis.

Our staff has undergone several changes since our last meeting. Dr. Peter Hyypio, who was handling the cytological work, is now with the Botany Department of the University of Michigan and was replaced by Dr. J. P. van Buijtenen in January 1956. The staff includes, in addition to Dr. Joranson and myself, a greenhouse man and a young lady who assists Dr. van Buijtenen with fiber studies and cytological work.

Work on the improvement of aspen has evolved into three phases: (1) securing of polyploid and desirable diploid experimental material, (2) field testing of experimental material, and (3) determining the relative usefulness of the various experimental materials for pulp and papermaking.

Polyploid materials have been obtained by the treatment of seedlings with colchicine, by hybridization using polyploids as one of the parents, by grafting of material obtained through cooperative exchanges, and by the detection of naturally occurring triploid aspen. Although we have been successful in securing polyploid material <u>via</u> the first three described methods, the location of four clones of naturally occurring triploid quaking aspen has done the most to speed up our progress in investigating the usefulness of polyploidy. One of the triploid clones occurred in northeastern Minnesota, one in Colorado, and two in Upper Michigan. The latter two clones were located about 1.5 miles apart and contained a total of 19 large mature stems which have proven extremely useful in comparing volume growth and pulping characteristics with nearby diploid trees of similar age and site.

Hybridization also received considerable emphasis, with 41 crosses being made in 1956 involving 27 selected parent trees ranging in location from northern Ontario to central Illinois. Quaking aspen crosses were stressed in 1956 but in 1957 bigtooth aspen work predominated, with 23 crosses involving 19 parent trees being made.

Field testing is well under way with 3 major experimental trials having been established and with plans for 3 or possibly 4 new trials to be established the coming spring. Test materials presently in experimental trials include white poplar, European aspen, a diploid hybrid between European aspen and quaking aspen, a hybrid between a tetraploid European aspen and a diploid quaking aspen, and several quaking aspen crosses with parents which are widely separated geographically.

Pulping studies, fiber measurements, and work on variability of specific gravity are also in progress. The major concentration in this phase of the program is a study in which the pulping characteristics, paper properties, chemical properties, and fiber dimensions of diploid and triploid aspen are being compared. The wood used in this investigation was obtained by cutting 5 of the naturally occurring triploids (near Bruce Crossing in Upper Michigan) and 5 near-by diploid trees growing under similar environmental conditions. This study is very near completion and results are to be presented at the National TAPPI meeting this winter. Two additional articles dealing with triploids are soon to be released. One article is a project progress report and describes the characteristics of natural aspen triploids and their recognition in the forest. The second article is a field guide and discusses methods of recognizing triploid aspen in the field.

In addition to the previously described studies, work is in progress on: (1) Inheritance of wood characteristics in aspen, (2) physiology of flowering and rooting of Populus, (3) the effect of irradiation on aspen, (4) the comparative performance of male and female aspen and their sex ratio in nature, (5) the soils of an exceptional stand of aspen having cubic volumes from 40.8 to 93.0 cords per acre, (6) a tree selection index for aspen, (7) the possible existence of an unequal chromosome pair and its relation to the sex of the tree, and (8) a method of fumigation for the control of flower bud larvae.

Report on Research at the Forest Products Laboratory of Interest to Forest Geneticists

by Harold L. Mitchell[1/]

Since the question usually arises, I might begin by explaining why it is that we do not do more work on Lake States species. It is largely a matter of economics. The Lake States combined have only 4.8 percent of the Nation's total growing stock and only 2.4 percent of the total sawtimber. When you start breaking these figures down by species, or even species groups, the contribution of any one to the national woodpile becomes infinitesimal. Thus, as an organization with national and international interests and responsibilities, we can't logically justify much more than we are now doing on local species--and certainly not on the basis of the fact that our physical plant happens to be located in Wisconsin.

On the other hand, we have by no means neglected Lake States species, as this brief report will show. Moreover, practically all of our research on the improvement of both methods and equipment for determining wood-quality factors is as applicable to Lake States species as to any others.

As I indicated in my previous talk, a good part of our work during the past year or so was in connection with making laboratory determinations on increment cores from the Mississippi Forest Survey. Next year this work will be extended to Arkansas, again in cooperation with the Southern Forest Experiment Station, and, we hope, into Missouri in cooperation with the Lake States and Central States Stations. The new work, together with the Mississippi data, will provide good information on the wood

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1/ Chief, Division of Timber Growth and Utilization Relations, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture. The Laboratory is maintained at Madison, Wis., in cooperation with the University of Wisconsin.

quality of shortleaf pine and also loblolly, all the way from the Gulf to the northern limits of their respective natural ranges.

Another major activity was our cooperation with the California Station on a study of racial variation of ponderosa pine over its entire natural range. The sampling in this case was less intensive than in the Mississippi Survey but covered a much greater area, extending from Mexico to British Columbia and east to the Black Hills and Nebraska sandhills. Wood-quality determinations were made of increment cores taken from selected trees on many of the sample plots.

In cooperation with various Universities and Forest Experiment Stations, we continued long-range basic studies of the influence of various environmental factors and silvicultural practices on wood quality, and of the heritability of fibril angle, specific gravity, and other quality indicators. The species studied included southern pines, various pine hybrids, Douglas-fir, ponderosa pine, red pine, aspen, hybrid poplars, cottonwood, and red oak.

Substantial progress was also made in the development of new methods and equipment. Important contributions in this field include: (1) A taper gage for calibrating standard increment borers; (2) Smith's maximum moisture technique for making precise specific gravity determinations on increment cores, including separated springwood and summerwood specimens from single annual rings; (3) Mart's fluorescence microscopy technique for making direct measurements of fibril angle; and (4) a new design traversing microscope for making fast accurate measurements of summerwood.

Recent Advances in Forest Tree Improvement by Industry in the Lake States

by B. L. Berklund[1/]

This is a report of progress since that presented at the 1955 Conference in Wisconsin Rapids, Wis. For convenience it has been classified into four categories: Seed and nursery practices, field trials, silviculture, and scholarship and related activities.

Seed Collecting and Nursery Practices

The Blandin Paper Company has established a tree nursery and experimental plantings of various aged stock as a guide in planning future nursery production.

1/ Forester, Nekoosa-Edwards Paper Co., representing Lake States Council of Industrial Foresters.

The Rhinelander Paper Company also has established its own nursery.

The Blandin, Kimberly-Clark, Nekoosa-Edwards, Northwest, and Rhinelander Paper Companies report an emphasis on controlled seed collections. Some no longer buy "open market cones" and all eventually hope to have established controlled-supply sources.

Cooperative or Independent Field Trials of Forest Stock

The Diamond Match Company is working closely with Dr. Scott Pauley of the University of Minnesota in field-testing aspen and birch stock. Plots were established in 1952 at Orr, in 1956 at Cook, and in 1957 at both Cook and Cloquet, Minn.

In 1956 the Kimberly-Clark Company established hybrid poplar plantings at Loretto, Mich., from 22 different clone origins, and in 1957 they set out a poplar hybrid planting at Marenisco, Mich.

The Mosinee Paper Mills Company reports second-year survival of 98.5 percent and total height of 0.98 foot in their cooperative Lake States jack pine study, with a remeasurement due in 1958.

In 1956 the Nekoosa-Edwards Paper Company established 3 replicates of red pine seed source studies at both Nekoosa and Minocqua, Wis., and 3 black spruce replicates in northern Wisconsin. In 1957 they set out 3 white spruce seed source replicates at Minocqua. All replicates are being examined this fall, with the 1954 jack pine replicates (reported as established at the previous Conference) showing considerable insect problems, primarily the jack-pine shoot moth.

Silvicultural Practices

The Cliffs-Dow Company is working closely with the Upper Peninsula Forest Research Center of the Lake States Forest Experiment Station, the Chatham Branch of the Michigan Agricultural Experiment Station, and the Munising Ranger District of the Upper Michigan National Forest in hardwood genetic stand improvement.

In 1957 the Rhinelander Paper Company began a large-scale project, the purpose of which is to promote and favor sprouting from the best aspen trees of the stand. In timber-marking coniferous stands, emphasis of genetic improvement has gone beyond general marking practices.

Scholarships and Other Activities

The Blandin Paper Company provided a Tree Improvement Arboretum and a 5-year grant of $25,000 for use in forest genetics work by the School of Forestry, University of Minnesota.

The Kimberly-Clark, Marathon, and Rhinelander Companies contribute financial support to the aspen polyploidy program of the Institute of Paper Chemistry, Appleton, Wis.

It is gratifying to observe a growing awareness of the need for application of genetic principles in the general forestry program as exemplified by wide participation of industry, particularly the pulp and paper segment. There are, no doubt, other items of progress which, because of their continuing nature, have not been reported by the various industry members at this time.

Tree Improvement Work in Progress at the Quetico-Superior Wilderness Research Center

by Clifford E. Ahlgren[1]

During the past 9 years, this Center has been engaged in tree improvement work which has emphasized the working out of field techniques for putting the results of geneticists into practical application in this region. The work was first begun because the area provided an ideal place for testing the resistance of white pine to blister rust. Later, it developed that the climatic conditions and the humidity afforded by the large body of water are also advantageous for field grafting. Because of the uniqueness of these conditions, we have been advised to continue and expand the work. As previously reported, 5-year results show that our field grafting of white pine selections being tested for blister rust resistance has been successful in over 60 percent of some 700 grafts, so we have accepted the technique as practical wherever needed in future work in our area. Consequently, our emphasis has shifted to other aspects of the pine breeding problem.

Controlled pollinations have been continued, as the amount of flower producing wood increases on the grafts. To date, approximately 54 cones have been pollinated with pollen from resistant selections. Seed from the crosses is extracted and grown for us at the Griffith State Nursery at Wisconsin Rapids by Dr. Patton of the University of Wisconsin.

In 1955 a new area was established for testing the resistance of hybrids and root grafts. It is located on a very good white pine site, bordered on three sides by a swamp which provides abundant Ribes for inoculum as well as supplying proper microclimatic conditions for the development of the disease. Incidence of rust is very high on natural reproduction, and the Ribes bushes under observation show a consistently high infection rate. The hybrids under test include some developed by Drs. Riker and

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1/ Director, Quetico-Superior Wilderness Research Center, Ely, Minn.

Patton of the University of Wisconsin and some from our own parent selections on the test site. In this same area we also have a test plot for root grafts, also developed by Drs. Riker and Patton. The area now supports 1,100 seedlings and 150 grafts. Our test area for root grafts established 9 years ago continues to show a very low infection rate on the root grafts, while the controls have shown 100 percent infection and have been replaced.

To investigate the possibilities of flower induction by combining different species in grafting, over 200 interspecific grafts involving eastern white, Norway, Balkan, Swiss stone, and Korean pine in various combinations have been made. Average survival has been 80 percent, and there have been very striking differences in the vegetative growth patterns among the different combinations of species. Some of the combinations produce reduced primary growth and yet flower more abundantly than those which grow vigorously. For example, of the 30 Swiss stone pine scions on Norway pine rootstocks (a slow-growing combination), 20 have flowered while of the Swiss stone pine scions on white pine (a very vigorous vegetative combination), one out of 50 have flowered. Differences among the other combinations are equally significant, and the work is being continued. Some of this work is in cooperation with the Minnesota Iron Range Resources and Rehabilitation Commission, with whom we are also engaged in intraspecific Norway pine grafting for the establishment of seed orchards. This latter problem has continued along the same lines as previously reported.

The attempts to induce flowering by bark inversion as reported at the last meeting have been continued. To date, there has been a reduction in primary growth on the trees with inversions. However, there is as yet no indication of flowering. Since superficial examination of the callus tissue revealed cell orientations difficult to interpret in terms of normal cambial development, an anatomical study of the disturbed tissues is being conducted by Dr. John Carlson of the biology department of the University of Minnesota, Duluth Branch. In connection with this, annual samples of bark inversions have been made, in addition to bark grafts and inversions in which the xylem and phloem have been separated by a plastic strip to determine the effect of each tissue on the differentiation of young cells.

In an effort to speed up the process of testing for resistance to blister rust, attempts have been made to supplement natural inoculation by artificial methods. In our first attempts last year, 30 diamond-shaped pieces of infected bark have been grafted onto healthy trees. These patch grafts, however, did not survive, for they were drowned out by pitch. This past spring, entire rings of diseased bark were grafted onto healthy trees, in the same manner as done in our bark inversion trials. Some of these inoculations appear to be transmitting the disease, although results are still preliminary.

These preliminary attempts at flower induction, pollination, seed orchard establishment, and artificial inoculation offer enough promise, we feel, so that we plan to continue our work along these lines for the immediate future.

Discussion on Recent Advances in Forest Tree Improvement in the Lake States

Discussion centered chiefly around flower induction. It was pointed out that we must distinguish between induction of flowering and stimulation of flowers, since they are two different processes. Concerning bark inversion it was pointed out (1) that we should study inversion unions under the microscope to determine whether there has been a real inversion or a mere bridging of the gap by regular tissue, and (2) that Dr. Sax of Harvard obtained flower stimulation from bark inversions on grafted material but not on seedlings. (This may, of course, have reflected merely the fact that the grafted material was physiologically ready to flower whereas the seedlings were not.)

RECENT ADVANCES IN FOREST TREE IMPROVEMENT IN OTHER REGIONS

Progress Report for Shelterbelt Tree Improvement and Nursery Problems in Prairie Canada

by W. H. Cram1/

Mr. Mark Holst has previously given you a bird's-eye view of tree breeding work in Canada (Proc. 2nd Conf. pp. 41-42. 1955), so we shall confine this report to our activities at Indian Head. The Indian Head Forest Nursery Station was established by the Canada Forestry Branch in 1903 for the express purpose of supplying shelterbelt material to prairie farmers. Since then the station has produced and distributed some 250 million broadleaf seedlings and since 1910 some 8 million conifer seedlings for shelterbelt plantings. From 1935 on, increasing attention has been given to field shelterbelts for farms, and afforestation on submarginal land. (A few copies of the Station's 1947-52 Progress Report are available for those desiring further details.)

Research in tree improvement was initiated at the Station in 1947. While the professional staff for this work has not increased, the technician staff has grown from 1 in 1949 to 6 in 1957. In addition, our facilities and equipment have been greatly improved, especially by the construction of a new headerhouse and greenhouse in 1957. Research work from 1947 to 1949 was of an exploratory nature, which resulted in the formulation of improvement projects for caragana, pine, spruce, and poplar. Investigations were also initiated to resolve problems in seed viability, storage,

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1/ Plant Breeder, Forest Nursery Station, Canada Department of Agriculture, Indian Head, Saskatchewan.

vegetative propagation, and disease and insect control. Solutions to these problems are essential prerequisites to our tree improvement work.

Caragana Projects

The Siberian peashrub has proven an important and versatile tree species for shelterbelt purposes in the Canadian prairies. Favorable results in the control of wind erosion by the use of this species created a demand for increased height growth. This was one objective of the improvement program initiated in 1949.

The species was found to be naturally cross-pollinated, with Hymenoptera insects being the principal pollinating agents. Cheesecloth proved superior to paper or plastic bags for isolation of the bloom. Self-compatibility of 218 open-pollination plants, which were selected on the basis of vigor, seed set, etc., ranged from 0 to 100 percent. To date, we have identified 13 self-incompatible (or sterile) vigorous selections. Cross-compatibility results for self-fertile and self-sterile selections appear to be conditioned by the action of several compatibility (S) factors. Regrettably, all self-steriles apparently have the same genotype and hence are cross-incompatible. To overcome this problem we have collected accession material from all possible sources, which should ensure genetic diversity of the growth and compatibility factors.

Inbred and hybrid progenies, which resulted from self- and cross-determinations since 1948, have been planted in performance tests. Results to date suggest that the vigor potential of progenies may be estimated with reasonable accuracy from the height of 4-year-old seedlings. The fact that some highly self-fertile selections carry good growth factors has been substantiated by the superior vigor of their inbred (S_1) progenies. Tests are in progress to evaluate the combining ability of these vigorous self-fertile selections with existing self-sterile selections.

Softwood cuttings were superior to hardwood cuttings, budding, or grafting as a means of propagating selections. Maximum rooting of softwood cuttings was obtained if collected before moisture content of the wood fell below 71 percent. Malathion treatments gave good control of aphids within isolation bags. Satisfactory means of controlling the seed chalcid have not been determined.

Spruce Improvement Projects

Spruce improvement work was delayed awaiting solutions of problems relating to seed viability, disease, procedures, and personnel. Indices for cone maturity, seed stratification treatments, and controls for damping-off diseases have now been resolved. Through the courtesy of Dr. T. O. Perry of the University of Florida, we have adopted sausage casings for the isolation of spruce bloom. Paper, cotton, and polyethylene materials proved unsatisfactory.

The prime objective of the spruce breeding project is the production of "True-blue" seedlings of Colorado spruce, which appear to be immune to the pine needle scale (Phenacaspis pinifoliae). Selections have been rated from 0 to 5 on the basis of the intensity and distribution of the blue coloration of their needles. Depending on the seedtree, from 12 to 97 percent of the open-pollination seedlings were found to display some degree of blue needle coloration.

Controlled pollinations were started in 1955 to determine the self- and cross-compatibility of selections. The results were seriously distorted by insects in both 1955 and 1956. Male flowers were attacked by larvae of the owlet moth (Epizeuxis sp.) in late May, female flowers were destroyed by larvae of the spruce budworm (Choristoneura fumiferana) in early June, while mature cones were damaged or destroyed by larvae of the spruce coneworm (Dioryctria abietella) and of the spruce seedworm (Laspeyresia youngana). Nevertheless, our results suggest that self- and cross-incompatibilities exist within Colorado spruce.

Control measures for flower and cone insects are under investigation with Mr. L. O. T. Peterson, entomologist. Current tests involve dusts and sprays of DDT, Malathion, Lindane, and Dieldrin.

Grafting methods for Colorado spruce were investigated in 1956. Grafts were made in April on 3-year-old seedlings which were potted a year earlier. The average catch for cleft, side, and bottle grafts was 45, 27, and 9 percent, respectively.

The improvement of white spruce is a major project of Mr. M. Holst at the Petawawa Forest Experiment Station. For this reason we have utilized white spruce only for exploratory studies and tests, such as controlled pollinations, insect control, seed viability, etc.

Pine Studies

Open-pollination progenies from 88 selections of 7 Scotch pine races were field planted in 1952 and 1953. Records for needle-burn and vigor in 1956 revealed that outstanding seedlings were produced by seedtrees of each race. Eighty-five seedlings were selected for grafting and retest. A slight relationship (r = .55) was found to exist between the height of the seedlings at 4 and 8 years.

Poplar Improvement

On the basis of performance and rooting, 17 poplar clones were selected from 80 hybrids and 40 species in test station plantings. A test for these 17 clones was planted in 1951, and records were taken in 1956 on survival, disease, and vigor. One clone, FNS 44-52 (a selection of eastern cottonwood), proved outstanding for survival (94 percent), vigor (25 feet), and absence of cankers.

Seed Viability

Problems pertaining to tree seed maturity, storage, dormancy, etc., are being investigated as prerequisites to our breeding program.

Indices for determining the stage of maturity for harvesting spruce cones and peashrub pods have been evolved. Size, yield, and germination of spruce seed were found to increase with maturity of the seed. Viability of mature peashrub seed was double that of immature seed after common storage for 5 years. Dormancy of spruce seed appeared to increase or decrease with maturity depending on the seedtree and seedyear. Dormancy of peashrub seed seemed to decrease with maturation on the tree and decreased further under storage.

Hybrid Seed Production

Hybrid progenies, which have been produced to date by hand pollinations, are now in performance tests to identify the superior combinations. It is proposed to mass-produce seed for such superior hybrids in the future by means of natural crossing blocks. The two parental selections of each superior hybrid will be propagated vegetatively and planted as alternate rows in such blocks in an isolated location. It will be essential that one (and preferably both) of the parents be self-incompatible. If only one of the parental selections is self-incompatible the hybrid seed will only be produced on clonal material of this selection in a natural crossing block.

Other Studies

Studies are in progress to resolve the photoperiodic requirements of tree seedlings for progeny tests. Results to date suggest a 16-hour photoperiod is required for peashrub and a 20-hour period for spruce.

Cooperative studies, with Dr. O. Vaartaja, pathologist, have indicated that soil drenches are effective for controlling damping-off diseases. Pre- and post-sowing applications (soil drenches) of Tersan or Captan at 0.6 and 0.2 gram per square foot are recommended.

The Forest Tree Improvement Program at the University of Florida

by T. O. Perry and Chi-Wu Wang[1]

Forestry in the South is blessed with an especially favorable environment. Fast growth rates prevail throughout the area, with trees achieving breast height in 3 years. Seedlings are transplanted after 1 year in the seedbed as 1-0 stock. The terrain is level, and mechanized planting and land clearing are economically feasible operations. Major pestilences, like those that sweep through northern United States and Canada, are uncommon. Thus there is no pestilence of a severity corresponding to that of the white pine weevil, the white pine blister rust, or the bronze birch borer that seem to sweep across entire states and provinces. Our pestilences, such as the turpentine beetle and the ips engraver beetle, strike individual trees or clusters of trees in stand, and only rarely sweep through a whole forest. Usually forest stands are even-aged and of a single species, making selection of promising phenotypes a relatively easy task.

In this favorable economic and biological environment the support of forestry research, particularly forest genetics, is unusually strong. Forest industries, especially the pulp and paper industry, take an active role in supporting forest genetics research. Industry cooperators are assisting tree improvement work by providing planting sites and taking measurements of the racial variation studies of the Committee on Southern Forest Tree Improvement and other agencies. The pulp and paper industries, through direct financial support, are aiding three genetics research programs: The Texas ForestService Program, the University of Florida Program, and the North Carolina State College Program. The author is most familiar with the University of Florida Program and will describe it briefly.

The Cooperative Forest Genetics Research Program at the University of Florida is completing its third year of operation. The Program is supported by the University of Florida and 11 pulp and paper companies which have holdings in the Southeast Coastal Plain. The Program is administered by the University of Florida School of Forestry and is supported by annual contributions from the cooperating industries. Dr. T. O. Perry and Dr. Chi-Wu Wang supervise the research work at the University and make regular visits to the forest holdings of the cooperating companies. At the University, three assistants supervise the record keeping and nursery operations. A temporary crew is hired annually to assist in propagating work.

The Program is further aided by the contact men of the cooperating industries. The contact men are appointed to serve as liaison between Dr. Wang and Dr. Perry in the tree improvement work for each company. These men are specially trained in tree selection techniques and in the methods of marking stands for genetic improvement.

1/ Associate Professors, School of Forestry, University of Florida, Gainesville, Fla.

Practical research, basic research, and teaching comprise the threefold objective of the Program as supported by the industries.

One of the major projects of the Program is the selection of superior phenotypes for use in the establishment of seed orchards for cooperating industries. These selected trees are propagated by grafting and then serve as breeding stocks for many basic studies. The best will provide the breeding lines of the future.

All selected trees are being tested to see if their phenotypic superiority has a genetic basis. Past experience in selecting superior southern pine phenotypes permits the prediction that most of these trees will prove to be genetically superior. The plantations from the initial seed orchards will produce a significantly greater return than the plantations established by current seed collection practices. The few selected trees that are proved genetically average or inferior will be rogued from the cooperator's seed orchards. At the start of the Program, each cooperating company was visited and a 2-day training session was held for the field foresters. At these training sessions the theories and techniques of tree selection were explained and demonstrated to over 175 foresters.

During the past 3 years over 6,000 trees were examined by these foresters and their assistants. The best of these were reported to the company contact men. This contact man examined each tree again and with the aid of a special scoring system selected the best for propagation and use in the Genetics Program. Over 500 trees have been selected to date. Most of these trees are growing over $2\frac{1}{2}$ times as fast as the surrounding trees of the same age and are outstanding in straightness, height growth, disease resistance, and other characteristics of importance to the cooperator's production goods.

Cuttings from these selected trees are shot down with a high-powered rifle and shipped to the University for grafting. The grafts are planted in a central test area here at Gainesville and in the seed orchards of the cooperating companies. Two grafted plants from each tree are kept by the University and the remainder are sent back to the cooperators.

In addition to the practical activities of selection of superior trees and seed orchard establishment, companies are becoming increasingly seed-quality conscious. Logging operations in good timber stands are being deferred until the time of seed ripening when a double crop of seed and timber is being harvested from the land. Nearly every contact man is engaged in the task of thinning exceptional stands of trees to stimulate seed production. In many instances these "seed production areas" are sprayed with insecticides from the air and fertilized to improve seed crops. These are stop-gap measures being instigated to provide vital seed during the years when the seed orchards are growing to full production capacity.

A large area of practical research evolves directly from the problems of seed-orchard and seed-production area establishment and management. What spacings, what fertilizers, what cultivation, and what pruning practices should be used to obtain maximum production and efficiency in these areas? These practical research demands must be and are being met.

Basic research studies, too, form an essential part of the Program. Weekly measurements of height and diameter growth are revealing much information regarding the phenology and genetic variation in photoperiod requirements of the southern pine species. A nearly completed study reveals a clinal pattern of genetic variation and the winter chilling requirement for red maple. Several research projects are aimed at elucidation of the pattern of genetic variation in forest trees.

A comprehensive description of the activities of the Cooperative Forest Genetics Research Program may be obtained by writing for the Second Progress Report published by the University of Florida in June 1957.

Results of Research on Genetic Phases of Wood Properties of Loblolly Pine

by Bruce J. Zobel[1/]

As many of you know, the pulp and paper industry in the South is very interested in forest tree improvement. You have heard Dr. Perry tell of his work with a group of companies--we at North Carolina State also obtain the bulk of our financial support from the pulp and paper industry. There is not sufficient time to discuss with you our program and its relationship to the industry. It is sufficient to say that we expend our funds and energies in the three following ways:

1. Consultation services for the cooperating companies, with special emphasis now on the selection of material and its incorporation into the extensive seed orchards being established. Our operating area covers the States of Virginia, Tennessee, North and South Carolina, Georgia, and Alabama.

2. Basic research on problems of general interest to all cooperating companies. We have specialized on wood properties such as specific gravity, fiber length, cellulose content, and compression wood.

3. Work with graduate students majoring in forest genetics. The past year we had 3 students; this fall we will have 7 or 8 working either for the Master's or Doctor's degree in forest genetics or as special students concentrating their studies in this field.

I wish to discuss with you one portion of our basic research, and how it applies to the company seed orchards. These orchards are not a small

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1/ Associate Professor of Forest Genetics, School of Forestry, North Carolina State College, Raleigh, N. C.

thing. The companies with which we work have established or are establishing about 250 acres of seed orchards. Dr. Perry's companies probably are establishing considerably more. This acreage is planned to supply the seed for all the planting to be done by these companies for many years in the future. Thus, for our companies alone, we will have a potential seedling production of 100 million annually of one species. The size of the seed orchard operations should answer your questions as to how important it is to make sure the best trees are used for establishment of the seed orchards.

Mr. R. L. McElwee, the liaison geneticist who works with me, makes the final selection and grading of every tree to be used in each company's seed orchard. In the field he selects for rapid growth, good limb form, straight boles, and other usual criteria used in selection of superior trees. Additionally, however, he obtains wood specimens from all selected and check trees so that they can also be evaluated on wood properties. Before this can be done intelligently, we must first gain some knowledge of the genetics of wood properties.

I have been working on wood genetics since early 1951, i.e., for 5 years in Texas and now in North Carolina. The comments to follow are based on work done during that period. Some of them have been published and will be familiar to you; some are in press; and many are in the form of data now in my files or in experiments now being pursued. Please be absolutely clear on one point--I'm speaking only about loblolly pine. However, I am speaking about it from two extreme portions of its range, from Texas with its droughts and severe weather to places in North Carolina where loblolly pine sometimes grows on 8 to 12 feet or more of water-saturated peat overlying the mineral soil. Of great interest is the fact that our Texas studies and the studies on the eastern loblolly have yielded the same results.

It will not be possible for me to do more than mention some of the chief points of interest. They are as follows:

1. For over 30 years it has been constantly repeated that there is a close relationship between growth rate and specific gravity. Intensive studies show that there is very little correlation between specific gravity and rate of growth (as expressed in rings per inch) for wood of the same age outside of the central core of juvenile wood. Perhaps all of you have read or been taught that for conifers, fast growth results in low specific gravity and slow growth results in high specific gravity. For loblolly pine, within the framework of commercial rotation age, this just isn't so. Not only our work, but many other recent studies have shown that this relationship is nonexistent. Dr. Perry and Dr. Wang plotted the specific gravities of selected trees that had a volume superiority 2.5 to over 4 times the check trees against the specific gravities of the check trees and found the curves nearly coincided. They did this partially in self defense, because their companies were afraid that by selecting the fast growers they would be propagating trees with low specific-gravity wood.

2. Nearly every stand has a normal curve of specific gravities, from relatively high to relatively low. Stand averages may differ, but all the trees on a uniform site grown under uniform environment do not have the same specific gravities. It is usual to find trees the same age, growing on the same site within a few feet of each other, the same diameter, and same height, that possess opposite extremes of specific gravity.

3. I have been unable to find any relation between site characters (including moistness of site) and specific gravity. Such relationships may exist but they have not yet come to light. For example, the loblolly pine growing on the deep peat, excessively wet sites in coastal North Carolina has wood whose specific gravity is similar to that growing in the "Lost Pines" of Texas under conditions of very low rainfall and high temperature. Under both of these conditions high and low specific-gravity trees were found.

   In slash pine, there appears to be a geographic trend for higher specific gravities in the regions of highest summer rainfall. Although we have not analyzed our data yet, they appear to show a higher average specific gravity in the Coastal Plain than in the Piedmont sites. In spite of this general trend, however, the very highest specific-gravity trees we have located so far are in the Piedmont. Although it would not be too hard to explain a summer rainfall-specific gravity trend from a physiological standpoint, the important fact from a genetic standpoint is that, for all environmental conditions, both high and low specific-gravity trees are found growing together. Do not interpret my comments to mean that environment has no effect on specific gravity. It obviously does as shown by samples of loblolly pine grown in California; the wood of the samples I have observed from the Far West is similar to Virginia pine. However, the variation present, which occurs no matter what the environment, and the inability to tie specific gravity to any individual or to any group of environmental or growth factors leads one to suspect inheritance is of importance.

4. Genetic proof of specific-gravity inheritance is very meager. Research underway has just not been in progress long enough. However, my exploratory observations, as well as those of others, suggest that specific gravity tendencies are quite strongly inherited. In Texas we tested open-pollinated progeny from five trees with known specific gravities. In every case the progeny tended toward the specific gravity of the parent, i.e., parents with high specific gravities have progeny with high specific gravities and vice versa. In Texas there is considerable research material available which can be used to follow up these preliminary observations.

5. We find an extremely high correlation between specific gravity of juvenile wood and mature wood of the same tree. In addition, on young trees, there is a high correlation between the limb specific gravity and juvenile-wood specific gravity. This double relation enables assessment of selection and breeding results at 3 or 4 years instead

of waiting for the full rotation age, without destroying the test material.

6. We are developing relationships on the characteristics of juvenile wood, mature wood, and compression wood as affected by growth and environmental conditions.

7. According to Kramer in Texas, and others, the fiber length of mature wood is related to wood laid down near the end of the juvenile period, i.e., about 10 years. His work, as well as other work in Georgia and elsewhere, all points to the genetic control of fiber length. Just as for specific gravity, fiber length tends towards constancy outside the core of juvenile wood.

8. Yield studies (or lignin-cellulose ratios) make up the bulk of our current basic research. It appears to date that some trees will yield more usable fiber than others, weight for weight. Very preliminary results based on only a few samples show some trees yielding between 4 and 10 percent more holocellulose and alphacellulose than others. These results are "hot off the press" and the analysis of the bulk of the material awaits my return to the laboratory. We will have samples from the best stands in six States, from many sites from the Tennessee mountains to the Carolina swamps, and latitudinally from Savannah, Ga., to Richmond, Va. We are studying (a) variation from tree to tree within a site (b) variation between sites within a geographic region and (c) variation between geographic regions. For each of the thousands of sample trees we will have recorded on IBM cards complete growth and environmental data, as well as wood property information including holocellulose, alphacellulose, specific gravity, compression growth, percent summerwood, and fiber length.

In my talking about the various wood properties, some of you may have lost sight of the objectives of this research. One of the major ones is to establish seed orchards for the industries, so they will have trees that are not only taller, faster growing, better formed, etc., but also that have the type of wood they most desire for their product. To do so we need to know all we can about the particular wood character and how it: (a) is affected by the environment (b) is affected by the tree's parentage (c) affects the product the industry makes. We can help on the first two. It is a tremendously interesting research challenge.

Summary of Forest Tree Improvement Work in the South

by Philip C. Wakeley[1/]

Since 1950, tree improvement activity in the South has increased to such an extent that a mere listing of the agencies and individuals engaged in research or constructive application would require most of the time allotted for this paper. More than 30 organizations are engaged in such activities--not counting 5 geographically distinct Research Centers at the Southeastern and 5 more at the Southern Forest Experiment Station. Probably 80 or more individuals are devoting part or full time to tree improvement research, basic or applied. Their publications and releases are beginning to appear at the rate of one or more a week. Any summary of these activities, to be grasped, must be in very general terms.

What follows is a sketch of recent and current work by types of agencies, drawn largely from Wright's "Directory of Forest Genetics and Education in the United States and Canada, 1955", but supplemented as far as possible from the more recent literature and from personal acquaintance with workers and their projects.

Educational Institutions

At least 12 southern colleges and universities are taking part in tree improvement work.

The schools of forestry at North Carolina State College, the University of Georgia, and the University of Florida have two men apiece devoting full time to forest genetics research, teaching, or both. North Carolina State and Texas A & M College have industry-supported graduate fellowships in the subject, those at Texas A & M in cooperation with the Texas Forest Service. North Carolina State and the University of Florida have ambitious seed orchard projects in cooperation with, and financed by, industry; in the past 2 years, T. O. Perry and Chi-Wu Wang of the University of Florida have helped establish 15 seed orchards with approximately 10,000 grafts from selected slash and loblolly pine trees. All four of the institutions mentioned stress basic as well as applied research. Two forest genetics short courses for Federal, State, and private foresters have been given at the University of Florida, and one each at the University of Georgia and at Texas A & M College, with a total attendance of about 180.

1/ Forester, Southern Forest Experiment Station, New Orleans, La. This paper was prepared by Dr. Wakeley for the Committee on Southern Forest Tree Improvement and was presented by him at the Fifth Northeastern Forest Tree Improvement Conference at Orono, Me., in August 1957. Because this is such a comprehensive, yet brief, summary of current activities in the South, we are glad to include it in this Proceedings.

In addition to other tree improvement research, Alabama Polytechnic Institute, Louisiana State University, and the University of Tennessee have research projects in forest genetics under the federal Agricultural Marketing Research Act, in cooperation with their respective State Agricultural Experiment Stations. The project at Alabama Polytechnic Institute includes relative nutrient requirements and efficiency of progenies of "plus" pines and of their checks, and has recently been expanded to permit work on hardwood genetics.

R. M. Allen, of the Southern Institute of Forest Genetics, has just completed 2 years' graduate work at Duke University, under Drs. Kramer and Naylor, on the contrasting growth-substance complexes of longleaf pine, its hybrids, and loblolly and slash pines. This bears directly on one of the most challenging genetics problems in the South--shortening or eliminating the notorious stemless or "grass" stage of juvenile longleaf pine.

At Newcomb College of Tulane University, Dr. Willis A. Eggler has completed 2 years' work, in cooperation with A. J. Hodges Industries, Inc., and the Southern Institute of Forest Genetics, on the anatomy and phenology of pine reproductive processes, including the date of formation of the primordia of female and male strobili. Under a recent grant from the National Science Foundation, he is extending this study to slash and shortleaf pines. The Biophysics Laboratory at Tulane University is cooperating with the Southern Institute of Forest Genetics in studies of the effects of irradiation on pine seed.

The University of Arkansas is cooperating with the Crossett Research Center of the Southern Forest Experiment Station, and with the Crossett Company, in tests of local races of loblolly pine seed. Mississippi State College is cooperating with the Station in tests of hybrids made at Placerville.

The University of Tennessee is cooperating with the Tennessee Valley Authority on several seed source tests (including a study on Virginia pine sponsored by the Maryland Board of Natural Resources), improved nut tree variety tests, and pine propagation investigations.

Federal Agencies

The very considerable activities of the Southeastern and Southern Forest Experiment Stations may be dismissed briefly, as they have been adequately described in annual reports and other publications.

At the Southeastern Station, the major tree improvement programs are at the Lake City and Athens-Macon Research Centers, in Florida and Georgia, respectively, the latter in cooperation with the Ida Cason Callaway Foundation, the University of Georgia, the Georgia Forestry Commission, and the Georgia Forest Research Council. Less extensive programs are under way at the Franklin, Va. (single-parent loblolly progeny tests), Asheville, N. C. (yellow-poplar, red oak, and white pine racial variation tests, and hybrid poplar and blight-resistant chestnut studies), Santee, S. C.

(edaphic races of longleaf adapted to the sandhills), and Cordele, Ga., Research Centers (selection in slash pine plantations).

The Lake City and Athens-Macon programs have included some interspecific hybridization, but have stressed mainly selection of slash and longleaf pines for high gum yield, of slash and loblolly pines for form and growth rate, of slash pine for resistance to black turpentine beetle and fusiform rust, and of shortleaf pine for resistance to little leaf disease. Local geographic races of slash and loblolly pines, nursery selection of slash and loblolly pines, and seed orchard management have been or are being emphasized, and both Centers have made notable contributions to techniques of vegetative propagation.

At the Southern Forest Experiment Station the main program, including such basic work as pollen handling, is concentrated at the Southern Institute of Forest Genetics, Gulfport, Miss. The Institute has a technical staff of six (a geneticist, a pathologist, a geneticist-pathologist, a physiologist, a wood technician, and a silviculturist), plus an entomologist detailed full-time. There is also a full-time man at the Crossett, Ark., Research Center, financed cooperatively by industry. Some work on interspecific hybridization and racial variation is done at the Alexandria La., Research Center, and some on hardwood selection, vegetative propagation, and breeding at the Delta Research Center, Stoneville, Miss. The Station has a small but highly effective cooperative project, industry financed, with A. J. Hodges Industries, Inc., at Many, La., which has greatly advanced its work in interspecific hybridization.

The Southern Station has done less work than the Southeastern in vegetative propagation, and none in selection for high gum yield. Its selection for growth and form is more recent and less extensive than the Southeastern's--except that it possesses an invaluable legacy of experimental plantations more than 30 years old in which outstanding phenotypes were marked as potential breeders in 1928 through 1931. It has done considerably more hybridizing, with special attention to longleaf hybrids and to slash-shortleaf crosses. (It has several score four-way or "quarter-horse" hybrids made by applying pollen of the Placerville shortleaf x slash hybrid to sonderegger pine.) At Crossett, it has 17 separate tests of nursery selections of slash, loblolly, and shortleaf pines, established in 4 different years, many of them with stock from size-graded seed. In cooperation with the Forest Products Laboratory at Madison, Wis., and with the Southern Forest Survey, the Institute is exploring the wood quality of pines throughout Mississippi. The Station's racial-variation studies go back to the loblolly pine seed crop of 1925, and the Station is the Chairman organization of the Southwide Pine Seed Source Study sponsored by the Committee on Southern Forest Tree Improvement.

The Tennessee Valley Authority has a large and varied tree improvement program dating from before 1948. It includes, or has included, much work on racial variation of pines and on vegetative propagation, individual-tree and nursery selection of pines and eastern redcedar, and related work such as development of thornless honeylocust, selection of honeylocust with pods suitable for cattle feed, selection of black walnut for nut production, and some work on figured grain of wood. Most of this work has been done in cooperation with various State Agricultural Experiment Stations, Federal Forest Experiment Stations, and other organizations, including the University of the South, Tennessee State Department of Conservation, Tennessee Fish and Game Commission, Maryland Board of Natural Resources, and Coosa River Paper Company. The TVA was one of the principal promoters of the First Southern Conference on Tree Improvement in 1951, and E. G. Wiesehuegel of its Division of Forestry Relations is the present Chairman of the Committee on Southern Forest Tree Improvement.

Region 8 of the U. S. Forest Service has established a number of seed production areas on national forests throughout the South. Its outstanding contributions in the field of tree improvement, however, have been the organization of the First and Second Southern Tree Improvement Conferences in Atlanta in 1951 and 1953, and its unremitting campaign to get State and industrial nurserymen to procure seed from suitable geographic sources.

State Departments or Commissions of Forestry

At least three State Forest Service programs of forest tree improvement deserve special mention.

The Texas Forest Service started active research in tree improvement about 1950, and established its Forest Genetics Laboratory in 1951, with strong industrial support and in close cooperation with Texas A & M College. The Laboratory has a professional staff of 3, plus 2 graduate fellows; a fine laboratory building and greenhouse; space in the State forest nursery; a large outplanting area, with residence, at Fastrill, Tex.; and other experimental areas. A. J. Hodges Industries, Inc., at Many, La., with whom the Laboratory has a cooperative contract, built its greenhouses especially to fit the needs of the Texas program, and has done much work in vegetative propagation and outplanting in cooperation with the Texas group. Bruce Zobel was in charge of the work from 1951 until his move to North Carolina State College in 1957, when he was succeeded by Claud Brown.

The research in Texas has been concentrated upon selection and breeding of loblolly pine for form, growth rate, drought resistance, and wood qualities--especially high and low specific gravity. Outstanding use has been made of loblolly from the so-called "Lost Pines" area in a region of low rainfall and high evaporation rate some 120 miles west of the main loblolly pine belt. Important basic contributions have been made to the problem of inheritance of specific gravity. Vegetative propagation has led the way to active work in seed orchard management. Another important phase has been introduction of exotic pines from Mexico. Some work has been done in hybridization, racial variation, and nursery selection.

The Georgia Forestry Commission's program is one of financial and organizational assistance and support rather than of direct research. In cooperation with the Southeastern Forest Experiment Station, the Georgia School of Forestry, and the Georgia Forest Research Council, it has greatly advanced work on selection of superior slash and loblolly pines and on large-scale seed orchard establishment.

The Mississippi Forestry Commission had for several years a program of forest tree improvement with one full-time man and ample support. It stressed selection of both pines and hardwoods and did considerable work in vegetative propagation. A by-product of the work was the remarkable documentary film, "Developing Pedigreed Trees," on possibilities and means of forest tree improvement. Financial difficulties terminated the program at the end of 1956, but steps are being taken to preserve and use its data and plant material.

Industry

Industrial interest and participation in, and generous financial support of, the various tree improvement programs have been one of the outstanding features of work in the South.

The North Carolina State College, University of Florida, and Texas Forest Service programs have been made possible in large part by contributions from 26 pulp, lumber, and land companies, 1 endowed foundation, and 3 individuals. Several corporations have contributed annually to 2 of these 3 programs, and 2 corporations have contributed to all 3. About 20 companies not only support financially the North Carolina State and University of Florida seed orchard projects, but participate in the technical work. Many of these concerns also have additional tree improvement projects of their own, of greater or less extent.

The tree improvement programs of at least 5 industrial and other organizations (3 of which are not included among the 26 just mentioned) deserve special mention.

The West Virginia Pulp and Paper Company's Westvaco Experimental Forest, at Georgetown, S. C., devotes part time of three technical men to tree improvement research. The staff has pioneered in the development of "seed-producing areas" (as an interim substitute for planted seed orchards). Other lines of work include selection, interracial and interspecific hybridization, studies of racial variation, and testing of exotics.

The Ida Cason Callaway Foundation, at Hamilton, Ga., has furnished outstanding facilities in trees, land, and labor to the Southeastern Forest Experiment Station, and has augmented the Station's tree improvement work with the full- or part-time efforts of two of its own technical men. Emphasis has been on selection of the four principal southern pines for growth rate, form, and disease resistance.

The Gaylord Container Division of Crown-Zellerbach Corporation, at Bogalusa, La., has a research staff of more than a dozen men. Its program includes considerable work on racial variation and on selection, and a small but important study of growth and disease resistance of shortleaf pine hybrids. The Southern Forest Experiment Station's original 1925 study of racial variation in loblolly pine and its "documented" plantations, now being converted to "breeding blocks" with the company's help, are on Gaylord lands. The company is starting active work on seed orchards, with nearly 150,000 acres of plantations and thousands of acres of even-aged natural stands from which to select superior trees. (The plantations include 12,700 acres older than any other extensive plantations in the South; the natural stands include a 10,000-acre block of longleaf pine from the 1920 seed crop from virgin timber.) Gaylord has been the largest single cooperator in the Southwide Pine Seed Source Study, and T. E. Bercaw, Chief of the company's Forest Management Section, was Wiesehuegel's predecessor as Chairman of the Committee on Southern Forest Tree Improvement.

A. J. Hodges Industries, Inc., at Many, La., has a forester working nearly full-time on tree improvement research, with a field assistant and ample labor. In addition to an adequate research budget, facilities include a 4,000-acre fenced area, access to thousands of acres of plantations and natural stands, a 25- by 25- by 25-foot air-conditioned greenhouse with an 18-foot loblolly pine established in it (for grafting experiments), a smaller greenhouse that can be held at 65° F. even in midsummer (for vegetative propagation), extensive progeny-testing areas, and a remarkable 10-acre longleaf-loblolly pine hybrid swarm. As previously noted, A. J. Hodges Industries have cooperative research agreements with the Texas Forest Service, Louisiana State University, and the Southern Forest Experiment Station. Main lines of work have included interspecific hybridization, vegetative propagation, racial variation, and the establishment of an 80-acre arboretum of native and exotic pines and hardwoods. Game management research and ornamental gardens are included in the experimental tract, which often draws 1,500 to 2,000 visitors on a Sunday.

The Crossett Company, at Crossett, Ark., in addition to financing a full-time researcher in cooperation with the Southern Forest Experiment Station, has a tree improvement program of its own, with emphasis on loblolly pine and ultimately on shortleaf pine seed orchards.

Committee on Southern Forest Tree Improvement

Although much of the research and other tree improvement activity just outlined arose through the initiative of the organizations and individuals engaged in it, some at least owes its start to the Committee on Southern Forest Tree Improvement. The Committee definitely has served a useful function in coordinating the work.

The Committee was an outgrowth of the First Southern Conference on Forest Tree Improvement, held in 1951. It has 18 members. Seven of these represent the Southeastern Forest Experiment Station, the Southern Forest Experiment Station and its Southern Institute of Forest Genetics, Region 8 of the U. S. Forest Service, the Tennessee Valley Authority, and the professions of forest pathology and forest entomology, and are appointed for indefinite terms. The remaining 11 serve 6-year terms, beginning at staggered intervals; 3 represent schools of forestry, 3 represent State forestry organizations, 3 the pulp and paper industry, and 1 each the softwood and hardwood lumber industries. Geographic coverage coincides with Region 8 of the U. S. Forest Service. The Committee meets every summer, and also in conjunction with the Southern Conferences on Forest Tree Improvement that are held in January of each odd-numbered year.

The Committee sponsors and arranges the biennial Southern Conferences, and has produced, prompted, or approved a total of 17 publications by personnel of its member agencies.

Perhaps the most ambitious direct research undertaking of the Committee is the Southwide Pine Seed Source Study, coordinated by its Subcommittee on Geographic Source of Seed, of which I have the somewhat arduous honor of being Chairman. Over and above all the tree improvement activities previously mentioned, the organizations already listed and many other organizations and individuals have been cooperating since 1951 in a 16-state provenance test of longleaf, slash, loblolly, and shortleaf pines. The study extends from Pennsylvania and New Jersey south almost to Lake Okeechobee in Florida, and west to Missouri, Arkansas, Oklahoma, and Texas. Literally hundreds of individuals cooperated in collecting seed throughout this territory in 1951, 1952, and 1955. Nineteen nurseries cooperated in producing and shipping nursery stock. Fifteen Research Centers of 4 Forest Experiment Stations, 3 national forests, 4 schools of forestry, 5 State forestry commissions and 1 State wildlife service, 1 State agricultural experiment station, 4 pulp companies, 2 lumber companies, an oil company, and a fertilizer company have established 125 test plantations with the stock, ranging in size from 2.4 to 3.6 acres apiece, and totaling 490,000 trees. Routine measurements by the cooperators have been supplemented over a wide area by special "pest" examinations by pathologists and entomologists of the Southeastern and Southern Forest Experiment Stations. Fifth-year reexaminations of nearly half the plantations will be made this coming winter.

The Committee has stressed this research on geographic sources of seed not only for the obvious benefit to the southern pine planting program, but also from a conviction that virtually all tree improvement research must, for best effect, be carried out within the framework of geographic race.

Summary of Forest Tree Improvement Work in the Northeast

by W. J. Gabriel[1/]

This report on the recent advances in forest tree improvement in the Northeast is based on 40 replies to questionnaires sent to northeastern State forestry organizations, agricultural experiment stations, forestry extension services, private industry, foundations, institutions, forestry schools, and research centers of the Northeastern Forest Experiment Station. The various types of studies reported have been segregated into classes such as provenance, propagation, and progeny tests, and a summary of the work in each class is presented.[2/]

Stand and Individual Tree Selection

There are 16 projects now in progress, involving 13 different organizations and 9 species. Seven projects have as their objective the development of seed orchards established from selected phenotypes of Scotch pine, white pine, white spruce, and Norway spruce. About half of these seed orchards will be used for production of improved Christmas tree planting stock.

The remaining projects are concerned with selection for improving tree quality and timber-growing potentialities in larch, white pine, loblolly pine, Norway spruce, chestnut, and sugar maple, presumably through the establishment of seed orchards of superior trees and through hybridization of selected individuals.

Progeny Tests

The bulk of the progeny testing of control-pollinated hybrids in our region is being done by two organizations, the Hartford Foundation at the Yale School of Forestry and the Northeastern Forest Experiment Station. The majority of these hybrids are of hard pine, spruce, and 5-needled white pine parentages, and were developed mainly by the Experiment Station. Several other organizations are engaged in control-pollinated progeny tests on a cooperative basis.

One-parent progeny tests of selected phenotypes of black cherry, Scotch pine, sugar maple, oak, Norway spruce, and several species of 5-needled white pines have been listed by several organizations.

1/ Geneticist, Northeastern Forest Experiment Station, Burlington, Vt.

2/ A list (originally accompanying this report) of the forest tree improvement studies in the Northeast and cooperating organizations may be obtained from the Lake States Forest Experiment Station, St. Paul Campus, St. Paul 1, Minn.

Provenance Tests

There have been 17 provenance tests reported by 9 organizations in the Northeast. Three tests each are listed for Douglas-fir, Scotch pine, red pine, and Norway spruce; 2 in white pine; and 1 each in paper birch, white ash, and larch. Several organizations have cooperative provenance test plantings.

Hybridization

Hybridization programs are being conducted by 6 organizations on at least 28 species. With the exception of 5 hardwood species, all are conifers.

The large part of the hybridization work in conifers has been done by the Northeastern Forest Experiment Station, where a total of 17 pine species have been used in determining crossability patterns in the hard pines and white pines.

Propagation

There are 10 organizations working on 12 propagation projects covering 37 species.

Rooting of cuttings of white pine, Virginia pine, poplar, black locust, larch, and sugar maple is being investigated for, or is in use as, a means of vegetatively propagating selected trees for clonal tests. One of the largest of these investigations is a sugar maple rooting experiment now in progress at the Burlington, Vt., unit of the Northeastern Forest Experiment Station. Here nearly 8,000 cuttings from 46 selected sugar-producing trees are being tested for effect of clone and rooting medium on rootability in cooperation with the Vermont Agricultural Experiment Station. This study is preliminary to a more extensive one designed to clonally test phenotypically high sugar producing sugar maples.

Most of the grafting work at present appears to be centered at the State University of New York, College of Forestry. The work has been primarily in the genus Acer, where scion wood of 23 species of maple has been grafted on sugar maple root stocks for purposes of studying floral morphology and ecology.

Seed storage by freezing methods has been investigated in ponderosa pine, Sitka spruce, western hemlock, western redcedar, and Douglas-fir, at the Boyce Thompson Institute. Seed germination studies have been reported in black cherry by the Armstrong Forest Company.

Physiology and Morphology

Nine organizations list 14 physiological projects, nearly half of which are related to growth studies in the following species: Norway spruce, Scotch pine, white pine, aspen, and hybrid poplars. The remaining projects are concerned with sap flow mechanisms, seed studies, bud resin color variation, flower induction, and development of flower primordia.

Five studies have been reported in morphology. An example of one of the more outstanding of these is the identification of putative pine hybrids by means of stomates; this work has been done by the Hartford Foundation.

Cytology

A large part of the work in cytology is being done at the Hartford Foundation. Here a study of chromosome behavior during fertilization is in progress in Austrian pine. Studies in induction of polyploidy in slash pine and in staining techniques are also reported. The Boyce Thompson Institute for Plant Research is studying polyploidy induction in larch.

Soil-Site Studies

Six soil-site studies are now in progress in the Northeast. The Cornell University Agricultural Experiment Station is studying the soil and climatic requirements for optimum growth in red pine. It is also investigating the degree to which known geographic races maintain desired characteristics in a range of soil and climatic conditions. A somewhat similar study, also in red pine, has been listed by the New York Department of Conservation, Division of Lands and Forests.

The first year's fieldwork of a hardwood soil-site study, conducted jointly by the Northeastern Forest Experiment Station and the Vermont Agricultural Experiment Station, is nearly complete. The study has as its objective the determination of factors which control site productivity of northern hardwood species.

The Northeastern Forest Experiment Station also has a soil-site study in progress in white pine, and the University of Maine Department of Forestry has a similar study in spruce.

Miscellaneous Studies

Nursery Work.--A program of nursery and outplanting studies designed to investigate seeding and planting techniques suitable for commercially important northern hardwoods is in progress at the Burlington, Vt., unit of the Northeastern Forest Experiment Station.

Arboreta Establishment.--Two arboreta are now being established. The Hartford Foundation is building an arboretum of all species which they feel would be of importance in their future tree breeding programs. The Northeastern Forest Experiment Station is beginning to build a birch breeding arboretum of native and exotic species near its Burlington unit.

Forest Tree Improvement Work in the Central States

by H. B. Kriebel[1/]

At your meeting 2 years ago, G. A. Limstrom gave a report on current research in forest tree improvement in the Central States, in which he discussed the various species on which work was being done. Most of the research was and still is at the present time being conducted by two agencies, the Central States Forest Experiment Station and the Ohio Agricultural Experiment Station. Recently, however, other State organizations in the region have taken an increased interest in this type of research, and it is probable that activity will be expanded within the next 2 years. Some consideration is being given at the present time to regional planning and cooperation.

Rather than discuss current research by species, I will attempt to review briefly progress in each of several phases of forest tree improvement.

Racial Tests and Seed Source Tests

A comprehensive study of geographical variation in sugar maple is now in its fourth year at the Ohio Agricultural Experiment Station. Fifty sources are included. Two permanent plantings have been made at Wooster, and another will be made in extreme southern Ohio in the spring of 1958. To date it has been possible to identify patterns of variation in drought resistance, winter hardiness, tree form, and time of leafing-out and of onset of winter dormancy. Little information has yet been obtained on racial variation in height growth. A research bulletin is now in press dealing with these studies, and will be in print in a week or two.

The yellow-poplar seed source study initiated by the Forest Service in 1952 includes established field plantings in Ohio, Indiana, and Illinois. The interregional white pine provenance tests will include a series of plots in the Central States region; seedlings will not be ready for field planting until 1960, however. The Ohio Agricultural Experiment Station is planning to cooperate with the Forest Service in provenance testing of white pine, and additional seed collections have been made from several isolated stands of native white pine in Ohio.

Replicated seed source tests of shortleaf pine from six northern sources ranging from New Jersey to Missouri are planned for Ohio; one test will be on strip-mine spoils. These plots will provide eastern supplements for the shortleaf provenance tests in Illinois and Missouri established by the Forest Service.

1/ Assistant Professor, Ohio Agricultural Experiment Station, Wooster, Ohio.

Provenance tests are being conducted at Iowa State College on Scotch pine and European larch; nine sources of larch are included, and McComb plans to augment these with additional sources.

Genetic Selection and Clonal Testing

In Ohio, cooperative State-Federal tests are planned of 10 selections of black locust, using stock grown from cuttings at Beltsville, Md. Plots will be established on four different sites in eastern Ohio, to study variation in borer resistance, form, and vigor.

Four promising clones of the hybrid *Populus grandidentata* x *P. alba* have been discovered in Iowa. Two have been distributed to other states for testing. One of these clones has a figured grain.

At Wooster we now have about 25 clones of sugar maple selected in Ohio and the northeastern states on the basis of high sugar content of the sap, and propagated vegetatively by grafting and budding. Several hundred ramets have been produced, and seed orchards will be established in the spring of 1958.

A program of individual tree selection for vigor has been started in eastern white pine; selections are being propagated by greenhouse and field grafting.

Hybridization

Some intraspecific crosses have been made on sugar maple to study inheritance of sugar content among progenies from selected trees. Crosses have been made among trees rating high, low, and intermediate in sugar content, as determined by repeated refractometer tests over a period of several years. We hope to obtain information by progeny testing about inheritance of capacity for high syrup yield. This winter, small-tree tests of sugar content are planned for both clonal stock and seedling progenies, using special techniques for measurement.

In 1956 we began controlled pollination at Wooster of white pines, both within the eastern white pine species and between this species and other related five-needle pines. Flowering specimens of several species of the subgenus Haploxylon in our arboretum make this possible. In addition to eastern white pine, these include Himalayan, Japanese white, and Korean pines. Phenological records are being accumulated of flowering and fruiting in the pines and several other genera in the arboretum, where a diversity of breeding material is available for use here or in exchange with other institutions. We are increasing our arboretum stock of potential breeding trees of documented seed source in a number of species.

Techniques for Vegetative Propagation

In the spring of 1956 we conducted studies of factors affecting survival and growth of greenhouse-grafted sugar maples. Approximately 700 trees were involved and various factors investigated, including type of potting soil, time of bringing stock into greenhouse, time of grafting, vigor of scion, type of graft, and type of humidity enclosure.

The data have been transferred to IBM punch cards for multiple-factor analysis. Studies were also made of budding techniques for sugar maple.

Certain physiological studies either initiated or planned include experiments in flower induction and dwarfing, variation in tolerance to low pH as indication of suitability to strip-mine planting, and continuance of research on juvenile selection criteria with respect to form, vigor, length of growing season, and other phenotypic responses.

Discussion on Recent Advances in Forest Tree Improvement in Other Regions

Most of the discussion concerned seed orchards and related topics. It was pointed out that progeny tests are under way for all material included in the seed orchards in the University of Florida program. Based on these tests poor trees will be rogued out of the seed orchards. Concerning the number of clones represented in seed orchards, it was stated that in the North Carolina State College program each seed orchard has a minimum of 15 clones all obtained from one company's selected trees, and there are many companies in the program. Also, wild stands are being used as seed production areas during the interval in which the seed orchards have not yet reached adequate seed production. Presently, for example, the West Virginia Pulp and Paper Company is collecting all its seed from seed production areas, and they plant some 10 million trees per year.

It was pointed out that we may be overlooking the contribution that U. S. Forest Survey crews could be making to the tree improvement program. With just a little more training they could obtain valuable tree improvement field data from the plots they sample as a regular part of their work.

ACTIVITIES OF THE LAKE STATES FOREST TREE IMPROVEMENT COMMITTEE[1/]

Chairman Earl Adams conducted a brief business meeting of the Lake States Forest Tree Improvement Committee on the evening of September 17. Reports of subcommittees, announcements of new appointments, and election of officers were the principal items of business.

Reports of Subcommittees

Chairman Adams reported that the subcommittees on Bibliography, Superior Tree and Stand Selection, and Seed Collection Zones have completed their assignments, published reports (see back cover), and been discharged. The subcommittee on Projects for Study has been discharged and its functions absorbed by a new subcommittee on Research Evaluation, Coordination, and Planning.

Paul Rudolf reported that the latter subcommittee has canvassed the entire Committee for suggestions on the desirability of and best means for preparing project summary statements covering all forest tree improvement research in the region. The survey will be done in cooperation with the Forest Genetics Research Foundation.

Two recently formed subcommittees on Forest Tree Seed Certification and on Register and Marking of Selections do not yet have any activities to report.

Report on Northeastern Forest Tree Improvement Conference

Paul Rudolf represented the Lake States Committee at the Fifth Northeastern Forest Tree Improvement Conference held at Orono Me., on August 22 and 23. He reported a well-planned, well-attended, and well-conducted conference with a registered attendance of 91. A number of very interesting papers were presented and an instructive field trip conducted. Because the Proceedings of the Northeastern Conference will be published, no further details will be included here.

New Committee Appointments

Members of the Lake States Forest Tree Improvement Committee are appointed for 4-year terms by the agencies they represent. At each biennial conference appointments are made of 7 members, half of the Committee. At this Conference members appointed to serve until 1961 were as follows:

1/ This material was summarized by Paul O. Rudolf, Executive Secretary, Lake States Forest Tree Improvement Committee.

Member	Representing
Earl Adams	Minnesota Conservation Department
W. H. Brener	Wisconsin Conservation Department
R. A. Brink	University of Wisconsin
John Macon	Lake States Council of Industrial Foresters
Paul O. Rudolf	Lake States Forest Experiment Station
S. H. Spurr	University of Michigan
J. W. Wright	Michigan State University

All these represent reappointments except Macon and Wright who replace respectively Bruno Berklund and P. W. Robbins. The latter two men have been members of the Committee since its inception in 1953. Their active participation in Committee projects is much appreciated.

The other members of the Committee, whose terms extend to 1959, are as follows:

Member	Representing
F. J. Hodge	Michigan Conservation Department
A. C. Hodson	Central International Forest Insect and Disease Conference
P. N. Joranson	Institute of Paper Chemistry
H. L. Mitchell	Forest Products Laboratory
H. E. Ochsner	North Central Region, U. S. Forest Service
S. S. Pauley	University of Minnesota
A. J. Riker	Central International Forest Insect and Disease Conference

Nomination and Election of Officers

The nominating committee (B. L. Berklund and P. N. Joranson) offered the following nominees: W. H. Brener (Wisconsin Conservation Department) for Chairman, and S. H. Spurr (University of Michigan) for Vice-Chairman. They were elected unanimously. The office of Executive Secretary is continuing, so the present incumbent remains on the job.

The 1959 Lake States Forest Tree Improvement Conference is planned for Michigan. The Vice-Chairman will be in charge of planning and arranging the Conference and will be assisted by the other Committee members from Michigan.

Other Business

Discussion of publishing the proceedings of this Conference were resolved by arranging to have the officers work out details with agencies that have indicated a willingness to do the job.

The report of the Resolutions Committee (appended) was read and adopted unanimously.

Report of the Resolutions Committee
(Adopted unanimously 9/17/57)

1. We wish to thank Supt. Matalamaki and his staff of the North Central School and Experiment Station for providing the facilities and services that have done so much to make our meeting a success.

2. We wish to thank Mr. Z. A. Zasada of the Lake States Station, Dr. Scott Pauley of the University of Minnesota, and Mr. M. J. Latimer of the Blandin Paper Co. for making arrangements for the fine field trip scheduled for this Conference.

3. We recommend to the Society of American Foresters that another special issue of the Journal of Forestry be devoted to forest tree improvement, probably some time during 1958.

4. We wish to express our appreciation to Paul Rudolf, our Executive Secretary and first Chairman, for faithful and efficient service to the Committee, for systematically reminding the rest of us of our assignments and responsibilities, and for otherwise keeping our Committee alive and functioning.

H. L. Mitchell, Chairman
H. E. Ochsner
J. W. Wright

Slide Show

On the evening of September 17 approximately 100 kodachrome and black-and-white slides were shown. They illustrated such tree improvement items as unusual trees, selections, progeny tests, vegetative propagation techniques and results, bark inversion, and hybrids. The following showed and described slides: C. E. Ahlgren of the Quetico-Superior Wilderness Research Center, S. S. Pauley of the University of Minnesota, H. B. Kriebel of the Ohio Agricultural Experiment Station, Hans Nienstaedt of the Lake States Forest Experiment Station, A. L. McComb of Iowa State College, A. G. Johnson of the University of Minnesota, R. G. Hitt of the University of Wisconsin, W. J. Gabriel of the Northeastern Forest Experiment Station, and T. O. Perry of the University of Florida.

This slide show was one of the most interesting and popular parts of the Conference.

POINTS OF INTEREST ON FIELD TRIP, SEPT. 18

Headwaters Forest Research Center, Lake States Forest Experiment Station

The Pike Bay Experimental Forest and Vicinity

The Pike Bay Experimental Forest, 5 miles southeast of Cass Lake, is an area of 3,940 acres timbered chiefly with aspen and mixed hardwoods. A belt of aspen reaches through it from north to south, merging on the west with pine and on the east with hardwoods and balsam fir. The entire area was cut over for pine between 1903 and 1915; no pine was left except scattered seed trees and immature stands. A great part of it was logged also for aspen and hardwoods between 1925 and 1929. Consequently, the stands now present are immature second-growth and decadent hardwoods. In all their major aspects, this forest fairly represents the aspen and mixed hardwood forests of northern Minnesota. Projects at Pike Bay include:

a. Aspen Management - Thinnings
b. Aspen Management - Harvest Cuttings
c. Mixed Hardwood Management
d. Stand Improvement in Mixed Hardwoods
e. Stand Improvement in White Pine
f. General Planting Studies
g. Conversion Experiments
h. Testing Different Species and Strains
i. Aspen Hybrid Tests

Pike Bay source-of-seed plantings.--These plantings represent part of an international source-of-seed study. The seed was sowed in 1938, and the out-plantings were made in the early 1940's. Represented here are Scotch pine seed from 15 localities and Norway spruce from 20 localities in the Baltic Region of Europe. Also included in this study are several exotics--lodgepole pine, Englemann spruce, western yellow pine.

Aspen hybrid tests were carried out with stock furnished by the Northeastern Forest Experiment Station. The testing was of first-generation hybrids and was started in 1935. The hybrids were not hardy enough for this locality and only one clone still survives.

In the spring of 1954 a planting of white pine hybrids was installed here. These plantings, now 4 years old, begin to show their adaptability in the area.

Red pine source-of-seed plantation.--This plantation was made in 1937 from 2-1 stock on a carefully prepared planting site. Some 51 seed sources from the Lake States, northeast United States, and Canada are represented here. The plantation has been thinned twice, but care has been exercised to preserve trees from all seed sources. Considerable demonstration use is made of this plantation to show how well carefully tended stands can grow.

An article in the Journal of Forestry, Vol. 52, No. 9, Sept. 1954, "Wood Density and Seed Source in Young Plantation Red Pine" by L. W. Rees and R. M. Brown is based on this study.

A much larger study of red pine seed sources was established on the Superior National Forest in 1932.

Aspen stands.--This is a 50-year-old stand of excellent Minnesota aspen. Nearby is a 35-year-age class of same high quality aspen. A major thinning study is located in each of these age classes.

These trees have been selected as an elite clone by several geneticists. The trees are 83 feet tall at 50 years of age. It should be noted that this stand is growing on a fertile heavy loam soil.

Lake 13 red pine stand.--These are 140-year-old red pines known locally as the Lake 13 stand. The trees range from 95 to about 105 feet in height, and the stand has from 25 to 35 MBM per acre. Growth on the 11 permanent sample plots varies from 200 to 300 board-feet per acre per year. Mr. R. G. Hitt has several selections marked out in this stand.

Cutfoot Experimental Forest

This 3,000-acre experimental forest has extensive 45- and 90-year age classes of red pine. A number of silvicultural studies are carried on in both age classes. Besides the silvicultural experiments, 1,000 acres of this forest are in a management unit, and another 640 acres are in a natural area.

Growing-stock-levels studies.--This is one of a number of growing-stock-level studies in red pine in Minnesota. In this experiment levels of 60, 80, 100, 120, and 140 square feet of basal area per acre are maintained. Cubic volume growth for the past 5 years has been highest on the 120-square-foot level but only slightly lower on the other levels.

Cutting-methods studies.--In this experiment trees are cut by 3 methods: from above, from below, and by a combination of from above and below. The cubic volume growth results from the first 2 of the 3 replications show little variation between the 3 cutting methods.

School of Forestry,
University of Minnesota

North Central School and Experiment Station, University of Minnesota (about 1 mile east of Grand Rapids)

Chapman Plantations.--Of considerable historical interest to foresters are the several red pine plantations established at the North Central Station in 1900 by the then director of the Station, Professor H. H. Chapman. Planting stock consisted of 2- to 4-year-old wildlings collected near Carlton (vicinity of Cloquet), Minn. in spring 1898, and grown in transplant beds until time of outplanting.

Tree improvement nursery.--The major portion of the conifer propagation work carried on in conjunction with the School of Forestry's tree improvement project is centered at the North Central Station. Several thousand seedlings and transplants of white spruce, black spruce, red pine, jack pine and white pine are currently lined-out in the nursery for use as rootstocks in the grafting program. The hardwood nursery and seedbeds for the project are located on the St. Paul Campus.

Demonstration area.--This triangular area, lying south of the North Central Station tree improvement nursery, was planted in part in spring 1956 with various parental clones of balsam poplar and aspen and their F_1 offspring. The balance of the area will be planted with certain related F_2 populations now being grown in the St. Paul nursery.

D. M. Gunn Memorial Park (about 5 miles north of Grand Rapids on Highway 38, west shore of Prairie Lake)

Tree improvement arboretum.--This arboretum occupies a portion of the D. M. Gunn Memorial Park established by the Charles K. Blandin Foundation. In cooperation with the Blandin Foundation, the School of Forestry has undertaken establishment of the arboretum to ensure perpetuation of a reservoir of potentially useful tree genes for future breeding work. Initial plantings were made in spring 1956. Each clone or seedling family is represented by a single plot of at least 4 trees. Spacing is 10x10 feet. Two genera are now represented: Populus (80 clonal lines of 20 different species or hybrid combinations); and Betula (128 paper and yellow birch seedling families of different seed source).

Blandin Tree Nursery.--This modern nursery, adjacent to the D. M. Gunn Memorial Park, is under development by the Blandin Paper Company. Initial work on the nursery site was started only last year.

LIST OF THOSE REGISTERED AT THE CONFERENCE

Name	Address

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Earl J. Adams, Div. of Forestry, Minn. Conserv. Dept., St. Paul, Minn.
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John C. Berbee, Univ. of Wis., Madison, Wis.
B. L. Berklund, Nekoosa-Edwards Paper Co., Port Edwards, Wis.
W. H. Brener, Wis. Conserv. Dept., Wisconsin Rapids, Wis.

Knud Clausen, Univ. of Minn., St. Paul, Minn.
Paul E. Collins, S. Dak. State Col., College Station, So. Dak.
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Bill Cromell, Univ. of Minn., Grand Rapids, Minn.

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B. J. Zobel, School of Forestry, N. C. State Col., Raleigh, N. C.

COMMON AND SCIENTIFIC NAMES OF TREE SPECIES MENTIONED IN THE TEXT

Common Name	Scientific Name
Ash, green	*Fraxinus pennsylvanica*
Ash, white	*F. americana*
Aspen, bigtooth	*Populus grandidentata*
Aspen, European	*P. tremula*
Aspen, quaking	*P. tremuloides*
Birch, bog	*Betula pumila* var. *glandulifera*
Birch, gray	*B. populifolia*
Birch, paper	*B. papyrifera*
Birch, river	*B. nigra*
Birch, yellow	*B. alleghaniensis*
Basswood, American	*Tilia americana*
Butternut	*Juglans cinerea*
Caragana (see Siberian pea shrub)	
Cherry, black	*Prunus serotina*
Chestnut, American	*Castanea dentata*
Chestnut, Chinese	*C. mollissima*
Cottonwood, eastern	*Populus deltoides*
Douglas-fir	*Pseudotsuga menziesii*
Elm, American	*Ulmus americana*
Elm, rock	*U. thomasii*
Elm, Siberian	*U. pumila*
Elm, slippery	*U. rubra*
Fir, balsam	*Abies balsamea*
Hemlock, western	*Tsuga heterophylla*
Honeylocust	*Gleditsia triacanthos*
Larch, Dunkeld	*xLarix eurolepis*
Larch, European	*L. decidua*
Larch, Japanese	*L. leptolepis*
Larch, Siberian	*L. sibirica*
Locust, black	*Robinia pseudoacacia*
Maple, red	*Acer rubrum*
Maple, silver	*A. saccharinum*
Maple, sugar	*A. saccharum*

Oak, northern red	Quercus rubra
Oak, white	Q. alba
Peashrub, Siberian	Caragana arborescens
Pine, Austrian	Pinus nigra
Pine, Balkan	P. peuce
Pine, eastern white	P. strobus
Pine, Himalayan	P. griffithi
Pine, jack	P. banksiana
Pine, Japanese white	P. parviflora
Pine, Korean	P. koraiensis
Pine, limber	P. flexilis
Pine, loblolly	P. taeda
Pine, lodgepole	P. contorta
Pine, longleaf	P. palustris
Pine, Mexican white	P. ayacahuite
Pine, Norway (see red pine)	
Pine, pitch	P. rigida
Pine, ponderosa	P. ponderosa
Pine, red	P. resinosa
Pine Scotch (Scots)	P. sylvestris
Pine, shortleaf	P. echinata
Pine, slash	P. elliotii
Pine, sonderegger	P. x sondereggeri
Pine, spruce	P. glabra
Pine, Swiss stone	P. cembra
Pine, Virginia	P. virginiana
Pine, western white	P. monticola
Poplar, balsam	Populus balsamifera
Poplar, silver	P. alba, clone silver
Poplar, white	P. alba
Redcedar, eastern	Juniperus virginiana
Redcedar, western	Thuja plicata
Spruce, black	Picea mariana
Spruce, blue	P. pungens
Spruce, Colorado (see blue spruce)	
Spruce, Norway	P. abies
Spruce, Sitka	P. sitchensis
Spruce, white	P. glauca
Walnut, black	Juglans nigra
Willow, black	Salix nigra
Yellow-poplar	Liriodendron tulipifera