# THIRTEENTH ANNUAL REPORT

N. C. State University
Cooperative Tree Improvement
and Hardwood Research Programs

School of Forest Resources
North Carolina State University
Raleigh

May, 1969

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## FOREWORD

What a privilege it is to be associated with forestry in the southeastern United States! With the intensive forestry activities and expansions among the industries and the forward-looking activities of the state organizations with which we work, there is never a dull moment. This is as it should be, for there is no place anywhere that progressive forestry is more needed! That it is being practiced is evident from an acceleration of the "revolution" in forestry activities referred to in the Twelfth Annual Report.

More timber is being grown in the Southeast than ever before, but demands are developing to an extent even greater than increased growth. Although we have been called pessimists by some, it is clear that there is danger of a shortage (not a famine) of desired products in certain portions of the 13 states in which supporting organizations of the Cooperatives operate. Optimistic and highly favorable reports notwithstanding, there are certain critical areas in which a massive effort will be necessary to supply the needs of all timber users with reasonably accessible, suitable and economically available raw material. Many organizations are doing their best to keep supply and demand in balance by means of intensive forest management practices, including fertilization and use of improved strains and by improved harvesting and fuller use of the total timber resource. Our Cooperative is involved in many of these activities, keeping the five faculty, seven staff, and the several cooperating specialists at N. C. State University on the jump.

Questions are often raised about the current and future supply of pines and hardwoods in the Southeast. In some areas where wood fiber is the raw material in demand, a critical shortage is developing in both pine and hardwoods, whereas in other areas hardwoods are in considerable surplus because of a lack of good markets. Quality pine and hardwood are both disappearing at a rapid rate, partially as the result of the demand for plywood and lumber, partially as the result of logging operations where efficiency is dependent upon heavy equipment operating in large stands of large timber, and partially as the result of planned liquidation of the timber resource from company lands. Except in certain local areas there is no immediate shortage of either pine or hardwood in the Southeast because of the relatively large inventory of timber to be drawn upon. But if current trends, expansions and liquidations continue, we foresee some most interesting times in southern forestry, starting perhaps in 1980 and continuing several years thereafter. To meet the demand during this period, large amounts of timber must be produced in a hurry. Many of the activities of the Cooperative are geared to do just that.

Luckily, the pine program was started early enough that it will have a major effect in the difficult years ahead. It has been vigorously pushed, and the effects of the findings on wood quality, tree form, adaptability, and disease resistance on the plantations resulting from selected trees will be seen in forestry in the Southeast. For example, in the N. C. State Cooperative alone, nearly 100,000,000 trees of improved seed orchard stock are expected in 1970, and many more will be available from other programs in the South. Unfortunately the belated interest in hardwoods will restrict their potential for bridging this gap. Although some excellent experiments and studies are under way, application of results has been slow despite a lot of talk and propaganda. The productive potential of hardwood lands makes them

Figure 1. Intensive site preparation is becoming an integral part of forest management. Shown at top is a scene that typifies the intensity of site preparation done by Hammermill on soils of light texture in Alabama. The apparent field of weeds and flowers in the lower picture is a good, one-year-old pine plantation on intensively site-prepared lands of Weyerhaeuser in Alabama. Here the heavy clay soils increase site preparation costs. Growth on both sites will be good.

very attractive for growing timber, but costs of intensive management and uncertainty of returns from hardwood stands result in reluctance to make management investments on such lands. Hopefully, growth and yield studies and species-site studies now under way by members of the Cooperative will provide sufficient answers to help make necessary management decisions.

After a period of adjustment the combined Pine Tree Improvement and Hardwood Research Programs are working together smoothly. The expected efficiency of operation has become evident. It is much better to deal with the total raw material resource of an organization rather than artificially divide it into two components. Thanks to the good start achieved by the Hardwood Program prior to the merger of the two cooperatives, solid results for hardwoods as well as for pine can be reported.

## THE COOPERATIVE TREE IMPROVEMENT PROGRAM -- PINE

### General

With the accumulation of data now available, the annual report could well become a research paper filled with numerous figures and graphs. This we will avoid but will summarize and report results of certain studies in brief form, to give a cross-section of the extensive work under way.

In July, 1968, Container Corporation (Brewton, Alabama) joined the Cooperative. They have a vigorous program that includes a loblolly pine seed orchard well under way. Also new to the pine cooperative is the Alabama working unit of U. S. Plywood-Champion Papers, Inc. Operations are just beginning in this area, but thanks to the fine cooperation of their neighbors they already have a seed orchard partially established.

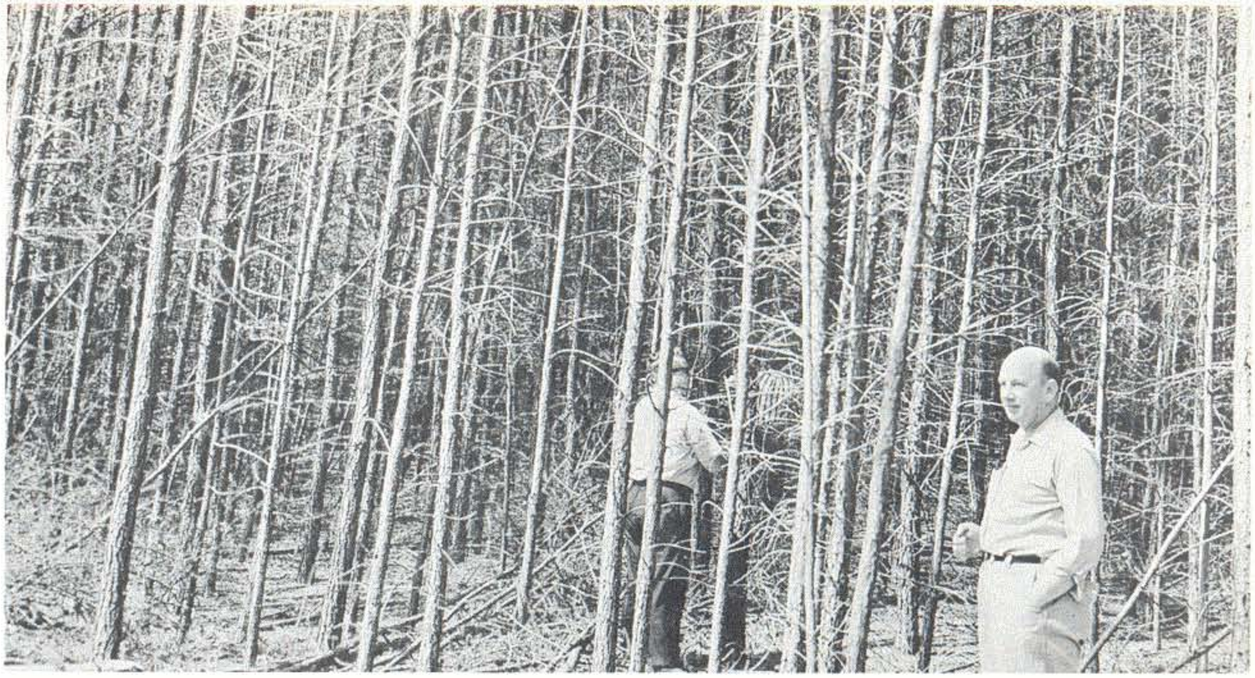

Figure 2a. Difficulties come in all forms. Shown is the result of conditions too favorable for loblolly pine establishment, resulting in an overdense, stagnated stand fifteen years old but with no merchantable volume. The example of this very common problem is from lands of Chesapeake Corporation in Virginia but occurs throughout the southeastern pine region and delays the expected time for harvesting.

Figure 2b. Another cause of trouble from "too good" conditions is shown on the maximum growth progeny test of U. S. Plywood-Champion in South Carolina. Fusiform rust infected 69% of all the four-year-old trees, and some families had nearly 85% infection. The disease was so heavy on the intensively site prepared, heavily fertilized area that it will be impossible to get a good estimate of the growth potential. Luckily, disease resistance of pines appears to be strongly genetically controlled.

When asked about membership of the Cooperative Tree Improvement Program we find ourselves giving varied answers, due to mergers, purchases and new memberships. By discrete organizations we now have 19 companies and 3 state forest services represented. But by the more meaningful working units (a number of which were formerly independent companies) we have 25 operating units and 3 state forestry divisions operating in 13 southeastern states, all east of the Mississippi River and south of the Mason-Dixon Line. (The member organizations are listed at the end of this section.)

Cooperation becomes greater every year, making the program of increasing value to the membership. The helpful attitude displayed toward each other by highly competitive industries as well as cooperation between industry and governmental organizations cannot be easily understood by the host of foreign and out-of-region visitors we have each year. They go away shaking their heads in wonder.

## The Applied Seed Orchard Programs

### Progeny Tests

One of the most difficult tasks we have is to deliberately destroy something that has taken considerable time and energy to develop. The roguing of seed orchards is no exception. In many orchards we have progressed to the point that progeny testing, clonal evaluation and orchard management have identified those clones having undesirable qualities. Ten orchards have been rogued during the past year, based on progeny test results, graft compatibilities, and seed producing characteristics of the parental clones. The magnitude of the progeny test effort is summarized in Table 1.

Table 1. Control-pollinated progeny crosses field planted in the Cooperative Pine Program

| | Number of Crosses 1/ | Acres Planted |
|---|---|---|
| Main tests 2/ | 2242 | 307.8 |
| Supplementary tests 3/ | 2152 | 167.9 |
| Total | 4394 | 475.7 |

1/ Includes commercial and seed production area checks

2/ Each cross is planted in six, 10-tree row plots for each of three years, on an area considered representative of the companies' lands.

3/ Each cross is planted in three, 10-tree row plots for each of three years, on areas considerably different from those of the main test or that are managed differently.

A number of orchards are producing commercial quantities of seed. As predicted last year, the 1968 seed crop was poor because of extensive freeze and hail damage and probably will not produce many more than 30,000,000 seedlings (in contrast to 24,000,000 seedlings produced in 1968). Prospects look good for producing 100,000,000 trees in 1970 from the bumper 1969 cone crop. Continental Can Company (Georgia) has obtained enough seed to plant their complete production nursery in 1969 with seed orchard seed. Unfortunately an ice storm in February 1969 seriously damaged one highly productive orchard and one that was just coming into production. Such disasters are always dreaded but expected occasionally, since we have nearly 80 orchards scattered over several states in our operating territory. Considering all of the orchards in the Cooperative, we have been exceptionally free of catastrophic damage; however, this does not soothe the feelings of those organizations that have had damage.

Figure 3a. Ice storms have created havoc with seed orchards. Wind and rain storms can also cause extensive damage as shown by the young, recently thinned slash pine seed production area on lands of Masonite in Mississippi. With nearly 80 seed orchards scattered over the southeastern states, some catastrophes are expected.

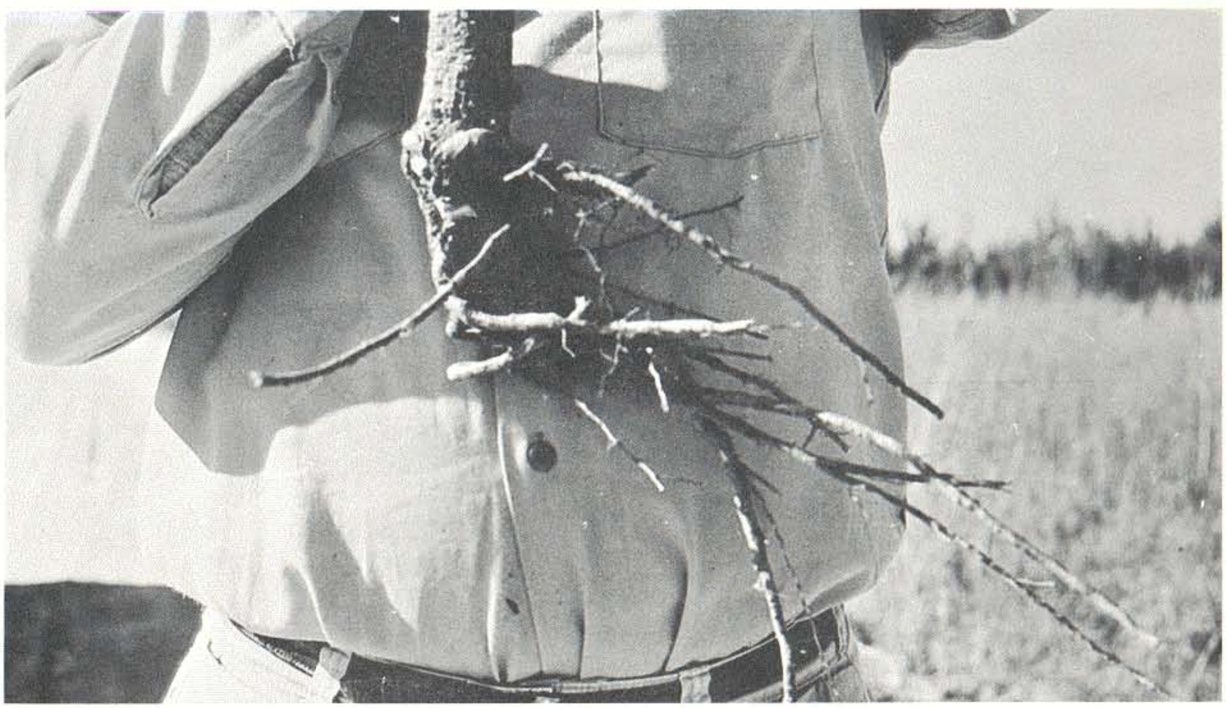

Figure 3b. Troubles from mechanization required on large programs are sometimes encountered. Shown are the roots of a four-year-old loblolly pine that had fallen over. It was planted by machine on a wet heavy soil; conformation of the roots indicates the difficulties developed.

Many of the progeny tests are old enough to obtain the first meaningful information on the value of seed orchard parents. Particularly outstanding have been the results on fusiform rust (Cronartium fusiforme). These results are summarized in Table 2 for several four-year plantations, both for regions with high infection and those with low infection. Where tests have been made on sites conducive to infection the differences in disease susceptibility among crosses is large. Information on disease resistance is especially valuable information because it is very difficult to control infection by forest management practices and it is difficult to select resistant parents from older stands of trees. Major gains and genetic information will be obtained by using progeny test information.

The rate of infection for the commercial checks is almost exactly the same as it is for the average of all progeny tests, but the seed production area lots used often show heavy infection. The spread between the most heavily infected family to the least infected is large for any given test, especially where infection is heavy overall. In progeny test areas such as for Chesapeake Corporation in Virginia, differentials are of little importance; but in plantations like those of U. S. Plywood-Champion, differences in resistance are of great economic importance.

It has been hypothesized that application of fertilizers will increase rust infection. Results from Weyerhaeuser's studies (Table 2) show a weak trend in this direction, while those of International Paper Company's special study (Table 5) show a slight reversal. Overall, it appears from our progeny tests to this date that fertilization has not greatly affected susceptibility to fusiform rust.

Results from the supplemental loblolly pine progeny test at Union Camp Corporation near Savannah, Georgia were chosen to illustrate inheritance of rust resistance. Trees in the test are particularly vigorous, averaging 6.3 feet in height at the end of the second growing season in the field. The best cross averaged 7.2 feet in height; the seed production area check (the poorest growing seed lot) averaged 5.3 feet. The five most resistant and the six most susceptible seedlots are listed in Table 3. Infection rate was measured as percentage infected, regardless of the position of occurrence of the galls, and by severity index, which places more weight on bole than on less harmful branch galls.

Table 2. Fusiform rust infection rates are shown for specific progeny crosses of loblolly pine from several commercially productive seed orchards. Results are based on fourth-year measurements.[1/]

| Seed Orchard Ownership and Location | Seed Source[2/] | Progeny Test Location 3/ | Per cent Infection of Progeny Test Crosses | | | | |
|---|---|---|---|---|---|---|---|
| | | | Av. | High-est | Low-est | Comm. Check[4/] | S.P.A.[5/] |
| Champion So.Carolina | Piedmont S. Car. | Pied. - S.C. Main Test | 69 | 83 | 50 | 68 | 78 |
| Champion So. Carolina | Piedmont S. Car. | Pied. - S.C. Supp. Test | 24 | 47 | 5 | 22 | 29 |
| Riegel No.Carolina | Piedmont N.C.&S.C. | Pied. - N.C. Main Test | 9 | 33 | 2 | 10 | 12 |
| Riegel No.Carolina | Piedmont N.C.&S.C. | Pied. - N.C. Supp. Test | 14 | 36 | 0 | 8 | 8 |
| Kimberly-Clark Alabama | Piedmont Alabama | Pied. - Ala. Main Test | 11 | 21 | 2 | 16 | 2 |
| Kimberly-Clark Alabama | Piedmont Alabama | Pied. - Ala. Supp. Test | 12 | 33 | 4 | 10 | 24 |
| International So.Carolina | Coastal N.C.&S.C. | Coast. - S.C. Main Test | 21 | 35 | 10 | 21 | 57 |
| International So.Carolina | Coastal N.C.&S.C. | Coast. - S.C. Supp. Test | 8 | 16 | 0 | 15 | 4 |
| Union Camp So.Carolina | Coastal Ga.&S.C. | Coast. - Ga. Main Test | 19 | 45 | 7 | 20 | 26 |
| Chesapeake Virginia | Coastal Virginia | Coast. - Va. Supp. Test | 4 | 14 | 0 | 4 | 7 |

(Table 2 continued next page)

Table 2. (cont.) Fusiform rust infection rates are shown for specific progeny crosses of loblolly pine from several commercially productive seed orchards. Results are based on fourth-year measurements.1/

| Seed Orchard Ownership and Location | Seed Source 2/ | Progeny Test Location 3/ | Per cent Infection of Progeny Test Crosses | | | | |
|---|---|---|---|---|---|---|---|
| | | | Av. | High-est | Low-est | Comm. Check 4/ | S.P.A. 5/ |
| Weyerhaeuser 6/ No.Carolina | N.Coast. Lob.-N.C. | N.Coast.N.C. 6/ Main-Unfer. | 13 | 37 | 3 | 7 | 21 |
| " " | " " | N.Coast. N.C. Main-Fertil. | 13 | 28 | 0 | 10 | 32 |
| " " | " " | N.Coast.N.C. 7/ Main-Unfer. | 11 | 26 | 3 | 17 | 14 |
| " " | " " | N.Coast.N.C. 7/ Main-Fertil. | 12 | 35 | 3 | 10 | 24 |
| " " | " " | N.Coast.N.C. Supp. Test | 7 | 16 | 0 | 4 | 3 |
| Weyerhaeuser 6/ No.Carolina | S. Coast. Lob.-N.C. | S.Coast.-N.C. 7/ Main-Unfer. | 11 | 41 | 0 | 19 | 14 |
| " " | " " | S.Coast.N.C. 7/ Main-Fertil. | 18 | 58 | 3 | 11 | 30 |
| " " | " " | S.Coast.N.C. Main-Unfer. | 6 | 28 | 0 | 4 | 0 |
| " " | " " | S.Coast.N.C. Main-Fertil. | 8 | 28 | 0 | 12 | 3 |
| " " | " " | S.Coast Supp. Test | 7 | 30 | 0 | 8 | 8 |
| | | | 14.9 | 34.5 | 8.4 | 14.8 | 20.8 |

1/ All planted in 1965 unless otherwise indicated.
2/ Geographic source of parental trees.
3/ Geographic area where progeny tests are located. The main test has 6 replications of 10 trees each; the supplementary tests 3 replications of 10 trees each.
4/ Commercial check. 5/ Seed production area check.
6/ Progeny are reported for main tests as 3 replications fertilized, 3 unfertilized.
7/ Planted in 1964.

Infection rates in this test ranged from 3.5 to 72.4 per cent. The ranking of families by per cent infection and severity index were nearly the same, but some families in the intermediate infection range had different ranking for

Figure 4. Growth of progenies from seed orchards has been very good. Shown above is a five-year-old plantation in the Coastal Plain of South Carolina on International Paper Company lands. Growth in the Piedmont has also been good as indicated by the four-year-old plantation on Kimberly-Clark's lands in Alabama. Loblolly pine starts growth slowly but usually growth rate increases rapidly after three years.

these two measures of infection. For example, 10-8 x 10-33 had 36.7 per cent infection, with the severity index being 1.97, whereas 10-14 x 10-37 also had 36.7 per cent infection but a severity index of 2.47. This larger index of the second cross indicates a much greater amount of stem infection. Crosses with parental clone 10-25 are always in the low infection group, while those with 10-8 as a parent are always in the high infection group. The knowledge that certain clones produce progeny consistently resistant or susceptible will be used to choose seedlots for planting in areas of high or low fusiform rust potential.

Table 3. Variability in fusiform infection of two-year-old loblolly[1/] pine (showing most severely and least severely infected families)

| Cross | % Infection | Rank by % Infection | Severity Index Value | Rank by Severity Index |
|---|---|---|---|---|
| 10-5 x 10-25 | 3.5 | 1 | 1.14 | 1 |
| 10-14 x 10-25 | 14.3 | 2 & 3 | 1.46 | 2 & 3 |
| 10-33 x 10-25 | 14.3 | 2 & 3 | 1.46 | 2 & 3 |
| 10-6 x 10-37 | 17.2 | 4 & 5 | 1.48 | 4 |
| 10-18 x 10-14 | 17.2 | 4 & 5 | 1.69 | 5 |
| 10-14 x 10-8 | 44.8 | 20 & 21 | 2.38 | 20 |
| 10-18 x 10-8 | 44.8 | 20 & 21 | 2.69 | 22 |
| 10-16 x 10-37 | 56.7 | 22 | 2.77 | 23 |
| 10-12 x 10-8 | 59.3 | 23 | 2.59 | 21 |
| Seed Prod. Area | 63.0 | 24 | 2.96 | 24 |
| 10-16 x 10-8 | 72.4 | 25 | 3.28 | 25 |
| Progeny Test Average of 25 Families | 33.0 | - | 2.08 | - |

1/ From the supplemental progeny test, Union Camp Corporation, Savannah, Georgia

For many years the question about resistance of loblolly pine to Fomes root rot has been raised. We in the Cooperative had neither the knowledge nor the ability to test Fomes but we are delighted to report such tests are now under way. Dr. E. G. Kuhlman, plant pathologist with the Southeastern Forest Experiment Station of the U. S. Forest Service, developed a relatively quick and simple method of artificially inoculating seedlings with Fomes annosus. We supplied him with all the excess control-pollinated progeny seedlings he could test. In a relatively short time the variability in resistance to this disease in loblolly pine will be known. Future tests for Fomes resistance will be dependent on Dr. Kuhlman's results but he already reports differential death due to Fomes from different geographic areas and by individual crosses of loblolly pine seedlings.

The progeny tests are also yielding some interesting results for stem and crown form, as well as height growth. To illustrate these results we have listed in Table 4 data from the two-year-old supplementary progeny test of Union Camp Corporation which was planted on a good site in the lower Coastal Plain of Georgia, the four-year-old main progeny test of Union Camp which is growing on an excessively wet site in the lower Coastal Plain of Georgia, and the supplementary test of Kimberly-Clark Corporation which is growing on a fair Piedmont site in Alabama. Only the best and poorest progeny are listed, rated in order of relative straightness but with crown and height rankings also shown.

It is dangerous to generalize but there appears to be a positive correlation between bole straightness and crown traits, especially for the extremely good and poor seedlots. There appears to be little relationship between straightness or crown traits and height growth. For example, the cross 10-12 x 10-8 is an extremely rough progeny but has fast height growth. In contrast,

Table 4. Bole straightness, crown characteristics, and height for three progeny tests. Families are listed in order of straightness rank, with only the best and poorest families being shown.

| | Cross | Straightness Rank | Crown Rank | Height Rank |
|---|---|---|---|---|
| Good Site[1/] -- Supplementary Test 25 families tested | 10-13 x 10-14 | 1 | 1 | 3 |
| | 10-14 x 10-8 | 2 | 7 | 1 |
| | 10-18 x 10-39 | 3 | 8 | 17 |
| | 10-18 x 10-14 | 4 | 2 | 23 |
| | 10-6 x 10-37 | 22 | 19 | 7 |
| | 10-18 x 10-8 | 23 | 24 | 18 |
| | 10-12 x 10-25 | 24 | 12 | 17 |
| | 10-12 x 10-8 | 25 | 25 | 8 |
| Poor Site[2/] -- Main Test -- 23 families tested | 10-18 x 10-39 | 1 | 2 | 11 |
| | 10-18 x 10-25 | 2 | 7 | 21 |
| | 10-13 x 10-39 | 3 | 12 | 7 |
| | 10-16 x 10-8 | 4 | 4 | 20 |
| | 10-6 x 10-8 | 20 | 23 | 17 |
| | 10-16 x 10-37 | 21 | 18 | 6 |
| | Comm. Check | 22 | 17 | 21 |
| | 10-12 x 10-8 | 23 | 15 | 3 |
| Fair Site[3/] -- Supplementary Test -- 18 families tested | 1-60 x 12-12 | 1 | 2 | 1 |
| | 1-60 x 12-7 | 2 | 5 | 2 |
| | 1-60 x 12-9 | 3 | 6 | 12 |
| | 12-17 x 12-7 | 16 | 15 | 3 |
| | 12-13 x 12-9 | 17 | 16 | 14 |
| | Comm. Check | 18 | 17 | 12 |

1/ Two-year-old loblolly, Union Camp Corporation, Coastal Plain, near Savannah, Georgia, average height 6.3 feet.

2/ Four year-old loblolly, Union Camp Corporation, wet Coastal Plain southwest of Savannah, Georgia, average height 7.1 feet.

3/ Four-year-old loblolly, Kimberly-Clark Corporation, fair Piedmont site southwest of Birmingham, Alabama, average height 11.4 feet.

Figure 5a. Forest fertilization in all aspects is receiving more attention. Shown is Catawba Timber Company's (Bowaters Southern) seed orchard which has been irrigated and fertilized since its establishment. Differences due to treatment can be seen from the grass cover and have been evident on the flowering of the grafts. (Photo, courtesy of Dr. Charles B. Davey).

Figure 5b. Progeny testing includes fertilization to determine response of seedlings from different clones to fertilizer. Shown is excellent growth of three-year-old progeny from International Paper Company's clone 7-56, growing in the South Carolina Coastal Plain.

10-13 x 10-14 had excellent bole form, crown characteristics and rate of height growth. Most of the good crosses on the good site had one parent (10-14) in common, and all the good ones on the fair site had a common parent, 1-60. Note also that the ranking of the commercial checks is poor for bole form, crown form and height growth. Crosses such as 10-8 x 10-14 are discouraging since they have excellent form but are slow growing, as are crosses like 10-12 x 10-8 which have excellent height growth but very poor straightness and crown characteristics.

The special study, reported in Table 5, is for a three-year-old supplementary progeny test at International Paper Company's Eight Oaks Seed Orchard near Georgetown, South Carolina. The plantation was on an old field and treated at the beginning of the second year's growth as follows: no fertilization, optimal fertilization (4 oz. of 5-10-10 per tree and 0.5 tons of lime per acre), and heavy fertilization (12 oz. of 5-10-10 per tree and 2 tons of lime per acre). Growth has been excellent and differences among progeny are large. The optimally fertilized was superior in all growth characteristics over the "too heavy" fertilized and unfertilized treatments. Family differences were very large, with clone 7-56 being uniformly a good parent. Among the crosses, volume of the best was nearly 80 per cent greater than the poorest, nearly 50 per cent greater than the average, and over 70 per cent greater than the commercial and seed production area checks.

Table 5. Growth on the supplementary progeny test of International Paper Company, showing the effects of fertilizers on three-year-old loblolly pine, ranked by volume growth

| Seed Lot | Volume (cu.ft./ tree) | Height (feet) | Diameter (inches) | Fusiform Infection (Per cent) |
|---|---|---|---|---|
| 7-56 x 7-33 | .2199 | 13.0 | 1.61 | 6.9 |
| 7-4 x TC | .1937 | 12.2 | 1.58 | 23.3 |
| 7-56 x TC | .1782 | 12.7 | 1.46 | 14.3 |
| 7-56 x 7-51 | .1707 | 11.8 | 1.49 | 16.7 |
| 7-56 x 7-2 | .1704 | 12.7 | 1.45 | 3.3 |
| 7-56 x 7-29 | .1637 | 12.3 | 1.42 | 20.0 |
| Comm. Check | .1462 | 10.9 | 1.45 | 13.8 |
| Seed Prod. Area (Coastal Source) | .1318 | 9.8 | 1.44 | 13.3 |
| 7-51 x 7-22 | .1275 | 10.1 | 1.39 | 28.6 |
| 7-29 x 7-51 | .1231 | 10.0 | 1.37 | 20.0 |
| 7-51 x 7-51 | .1040 | 9.4 | 1.24 | 29.6 |
| Seed Prod. Area (Piedmont Source) | .0948 | 8.5 | 1.13 | 14.3 |
| | | | | |
| Unfertilized 1/ | .1275 | 10.4 | 1.32 | 19 |
| Optimal Fertilization 1/ | .1746 | 12.0 | 1.49 | 17 |
| Heavy Fertilization 1/ | .1525 | 10.9 | 1.43 | 15 |

1/ Average of treatment effects

Figure 6. Some seed orchards have come into heavy production and it is essential to find a quick and efficient method of harvesting cones and seed. A "Seed Harvest Committee" from the Cooperative has been hard at work on this for two years. A prototype "vacuum principle" machine has been developed to pick up seeds from the ground and an operational model is now under construction. (Photo, courtesy of Barry Malac, Union Camp Corporation)

Improving Seed Yields and Seed Harvesting

There has been a concentrated effort by members of the Cooperative to increase and improve seed yields from the seed orchards. Several methods have been tried, including a series of studies involving the use of fertilizers and irrigation. These have been carried on for several years in a number of orchards with the help of Dr. "Chuck" Davey and his students. He has written the following summary of some results to date:

1. With an assumed value of $15 per pound for seed from the seed orchard it was determined for one orchard that for every 36 cents worth of fertilizer used an additional $1.20 worth of seed was obtained.

2. The 1968 cone crop was small because of a late freeze and drought, and production in the Albemarle orchard was as follows: 3.8 cones per ramet in the control treatments; 4.9 with irrigation alone; and 15.3 with combined fertilization and irrigation. There is promise of a bumper crop of cones in 1969; a count in 1968 showed 10.7, 15.7, 32.7 and 54.1 flowers per ramet, grading from the check through irrigated, fertilized and irrigated-plus-fertilized treatments. The flower crop in 1969 was even better, following roguing of the orchard.

3. Plots that have been established for five years (orchard is ten years old) appear to have a stabilized flower and cone crop in the control and irrigation plots, but there is a continued increase in the fertilizer and the fertilizer-plus-irrigation plots. The length and magnitude of this continued increase is of great importance.

4. The most important factor in flowering and seed production is the inherent fruitfulness of the clones, although fertilization significantly affects the expression of this inherent potential. Although cone production

varied almost threefold with different treatments in one orchard, it varied almost eightfold across clones.

5. Detailed experiments have now been established which will help determine the influence of N, P, and K on seed production and the optimum levels of N and P for maximum production.

6. With the information now available we can make fertilizer recommendations for most orchards which result in improved seed production. However, as newer tests yield information, we will refine estimates of needs and can then maximize production at the lowest possible cost. This is the ultimate aim as the orchards come into full production. In young orchards we are trying for maximum yields even if the unit cost is initially higher than the possible minimum.

Last year initial studies from ten clonal seed orchards to see how early cones could be harvested were reported; these have now been completed. Of the eight treatments tested, early cone collection followed by moist, cool storage was best. Most loblolly pines harvested three weeks early yielded good seed; Virginia pine responded particularly well and, commercially, has been collected early. There was considerable variation in cone opening among clones of a species. Some clones in loblolly pine seed orchards can have cones collected from two to three weeks earlier than is currently practiced without loss of seed or hurting seed germination. Results of the two years' early collection study have been written up by John Kundt and Clark Lantz (two graduate students) and have been submitted to the Journal of Forestry.

Two years ago the advisory committee of the Pine Cooperative established the seed harvest committee to investigate cone and seed harvesting methods. Efforts were concentrated on loblolly and Virginia pines because of their

Figure 7a. This has jokingly been referred to as "the most expensive pile of firewood in history." It represents one of the major activities last year -- roguing seed orchards. The Albemarle Paper Company seed orchard in the background had the inferior clones removed to improve its genetic potential and seed production capacity.

Figure 7b. Some people are lucky! The two-year-old Hammermill orchard (Alabama) is already flowering very heavily. The administrators of the company claim a secret ingredient (TLC[1/]) does it, but others use TLC without similar results. Many of the more recently established orchards have flowered heavily at young ages.

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1/ Tender Loving Care

tenacious cones which cannot be harvested efficiently by equipment such as the tree shaker. This committee has been very active in pursuing its objective, and last year the Cooperative's advisory committee voted special funds to develop a prototype seed harvester, using a vacuum principle to pick up seed from the ground. This prototype has been completed and quite thoroughly tested. The verdict: "It has excellent potentials." It picks up and cleans seed well, both with and without the seedwings attached, and tests to date have shown no injury to the seed or seed coat, as determined by germination tests and X-ray inspection of the seed. To get the seed to the ground, several organizations tried bumping or shaking the trees when the cones were open, and a high proportion of seed were recovered. These are easily picked up by the vacuum harvester from a surface that has been previously vacuumed to remove the grass clippings, branches, pine needles and other litter from the ground. A contract has been let for an operational vacuum prototype which will undergo tests and modifications during 1969. Plans for the machine belong to the Cooperative and, as such, will be available, upon request, to members only.

Seed Orchards and Selected Trees

Although we had expected tree selection activities and seed orchard establishment to level off somewhat, we were wrong. In fact, the pace has increased. During the past year, nearly every organization located additional select trees for use in seed orchard expansions or to be held in clone banks until needed. Many trees from new sources such as the north-central Florida loblolly pine or the Eastern Shore loblolly pine have been added. Additional selections in "minor" species have contributed a number of trees. The central Florida loblolly growing in the hammock country near Gulf Hammock, on lands of Georgia-Pacific, are very fast growing and have high wood density. The

Eastern Shore loblolly grows in the low-lying, oceanic climate of the Eastern Shore of Virginia, Delaware and Maryland, and will be in Chesapeake Corporation's seed orchard.

The Twelfth Annual Report showed that 1300 acres of seed orchard had been established and tentative plans called for 800 additional acres. This has been increased to 2400 acres (Table 6) in orchards established or nearly completed.

The largest single installation in the Cooperative is that of the Virginia Division of Forestry. They have already established 290 acres of seed orchard, made up of 27,563 established grafts of loblolly, white, Virginia and shortleaf pines. Each of several members of the Cooperative now have 150 or more acres of seed orchard. The "prize" for numbers of species goes to Weyerhaeuser Company near Washington, North Carolina, which has several geographic sources of loblolly as well as slash, longleaf and pond pines and several species of hardwoods in the approximately 250 acres of established orchard.

Table 6. Trees selected and acres of pine seed orchard under establishment as of April 1969

| Species | Number Trees Selected | Acres of Seed Orchard |
|---|---|---|
| Loblolly pine (P. taeda) | 1373 | 1635 |
| Slash pine (P. elliottii) | 127 | 355 |
| Virginia pine (P. virginiana) | 204 | 150 |
| Longleaf pine (P. palustris) | 207 | 90 |
| White pine (P. strobus) | 60 | 90 |
| Shortleaf pine (P. echinata) | 76 | 55 |
| Pond pine (P. serotina) | 81 | 40 |
| Pitch pine (P. rigida) | 15 | 3 |
| Sand pine (P. clausa) | 4 | 3 |
| Spruce pine (P. glabra) | 7 | 10 |
| Total | 2154 | 2431 |

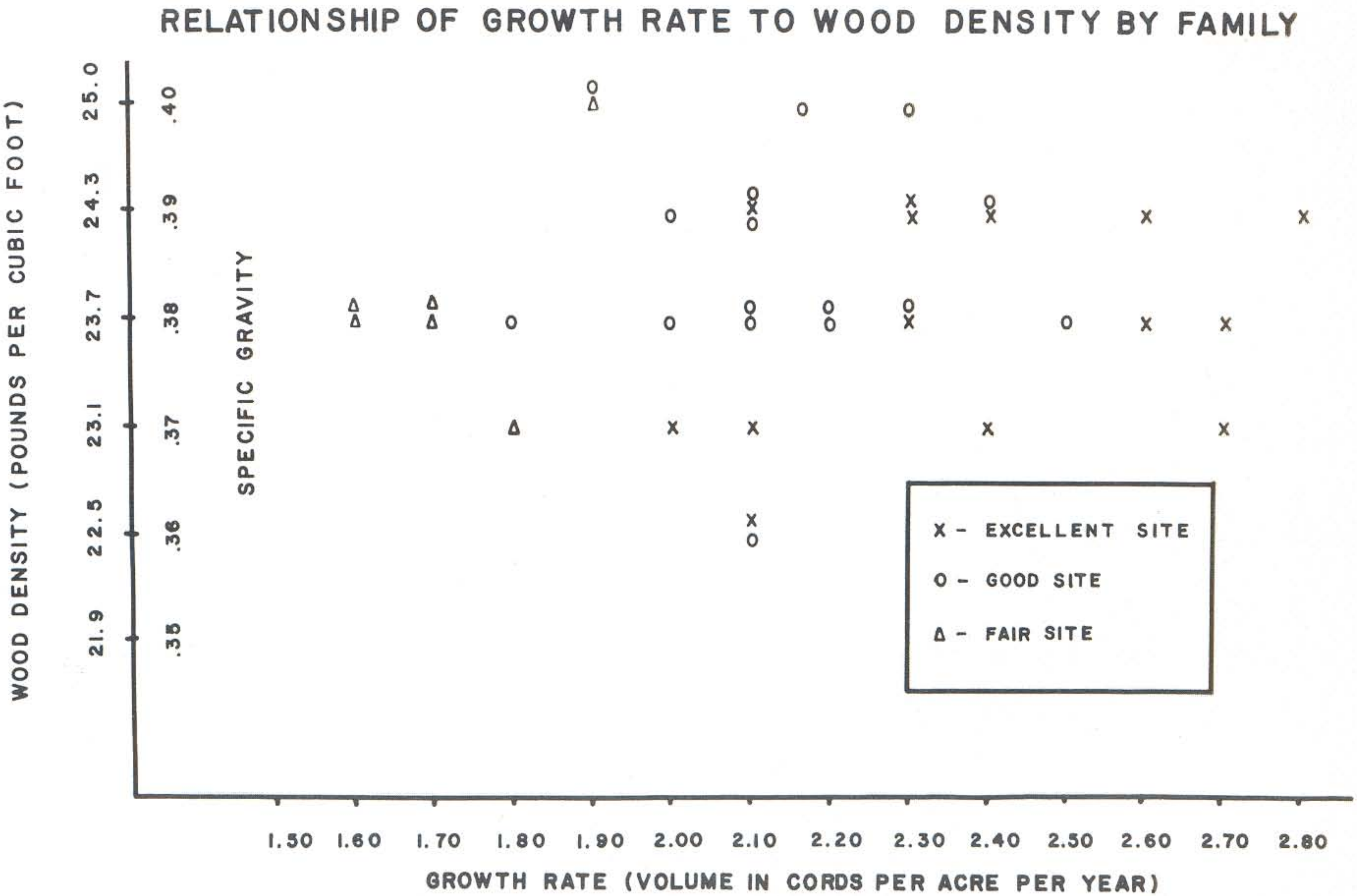


Figure 8. Many foresters feel that fast growth produces wood of light weight. Many recent studies have shown this to be a fallacy or, at best, the relationship is very weak. Above is a graph showing the lack of relationship of wood specific gravity and growth rate for 36 families of 7.5-year-old loblolly pine. Each family is represented by 40 trees.

Many members of the Cooperative have established seed production areas as a temporary source of seed until the seed orchards come into full production. In the past, costs of collecting and seed yields for several organizations have been reported. To supplement this information, the Virginia Division of Forestry has supplied the following summary from a seed production area on the Pocahontas State Forest in Virginia. Data reported are for loblolly pine cones collected "by hand" from standing trees.

| | |
|---|---|
| Number of trees collected | 74 |
| Total bushels | 128 |
| Total seed | 172 lbs. |
| Av. no. bu. per tree | 1.7 |
| Cost of harvest per bushel | $4.50 1/ |
| Seed yield per bushel | 1.34 lbs. |
| Seed cost per pound | $3.35 |

1/ Climbing cost was $3 per bushel. Climbers averaged 5.7 trees per day. Cone counts ranged from 302 to 610 cones per bushel. Climbing costs include climbers, collection of cones from the ground, and supervision.

Wood Studies

Determination of variation in wood, dry weight yields, moisture content, effect of wood qualities on the final product, and wood property inheritance have been a major activity and contribution of the Tree Improvement Program. Several studies, especially those dealing with effects of wood qualities on product have been made in cooperation with Dr. Eric Ellwood, head of the Department of Wood Sciences at N. C. State, and with the research laboratories of several of the cooperating industries. There is room in this report to discuss only a few of the several studies under way or recently completed. When published, results of these studies have been well received. For example,

Table 7. Comparison of growth and wood qualities for paired loblolly and Virginia pine plantations in the Piedmont of Alabama -- Age 15 (Kimberly-Clark Corporation)

| Plot[1/] # | Species | Site Index (Base 25) | Age | No.[2/] Trees/ Acre | Wood[3/] Density (lb./ cu. ft.) | Moisture[4/] Content (%) | Growth: Cords[5/] Acre Year | Growth: Solid[6/] Wood (cu.ft./ ac./yr.) | Growth: Tons[7/] Wood/ Acre/ Year | Bark[8/] Thick-ness (in.) | Av.[9/] DBH o.b. | Av. Ht. (ft.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Virginia pine | 71 | 15 | 545 | 28.3 (63.8) | 115 | 1.8 | 130.8 | 1.30 (4.17) | 0.5 | 5.8 (5.3) | 50 |
| 2 | Loblolly pine | 71 | 15 | 705 | 27.2 (62.6) | 124 | 2.7 | 144.9 | 1.42 (4.52) | 1.1 | 6.4 (5.3) | 51 |
| 3 | Virginia pine | 62 | 15 | 560 | 28.1 (62.7) | 120 | 2.3 | 171.8 | 2.41 (5.38) | 0.3 | 5.5 (5.2) | 43 |
| 4 | Loblolly pine | 62 | 15 | 535 | 28.2 (61.0) | 118 | 2.3 | 120.6 | 1.70 (3.68) | 1.0 | 6.6 (5.6) | 49 |
| 5 | Virginia pine | 59 | 14 | 655 | 27.5 (64.7) | 117 | 1.6 | 103.5 | 1.42 (3.35) | 0.4 | 5.6 (5.2) | 40 |
| 6 | Loblolly pine | 59 | 15 | 625 | 24.0 (58.1 | 136 | 2.4 | 126.0 | 1.51 (3.66) | 1.0 | 6.7 (5.7) | 52 |

Height of Virginia pine was used as basis for site index calculations.

1/ Plots 1/5 acre in size, 10 trees per plot, felled and sampled from base to top by 5-foot bolts.
2/ Merchantable stems, 4.6" DBH or greater. 3/Green weight given in parentheses.
4/ Based on dry wood. 5/ Includes bark. 6/ Excludes bark, "clean" wood only.
7/Green weight in parentheses. 8/ Double bark thickness at top of 5-foot bolt.
9/ O.B. is outside bark diameter; inside bark is shown in parentheses.

Figure 9. The Heritability Study (Quantitative Genetics Studies) done cooperatively with the Southlands Experiment Forest (International Paper Company), N. C. State University, the National Institute of Health and the National Science Foundation has yielded much useful data. Surprises occur -- such as the curly progeny (compared to the normal) of one of the crosses made in the extensive test program. Basic research data from jointly sponsored studies on lands of members of the Cooperative are essential to proper development of the applied programs. (Photo, courtesy of Roy Stonecypher, International Paper Company)

demand has been so heavy for Technical Report No. 37, "Moisture Content of Southern Pine Trees," that it was necessary to have a second printing to satisfy requests for it.

A major objective of several studies was to compare species to determine which should be favored in forest management operations on different sites. Several such species comparisons were completed -- one by Kimberly-Clark has been chosen to illustrate generalized results. Of particular interest was the relative dry wood production of loblolly and Virginia pines when grown under similar conditions. To test this, paired plantations at each of three sites were sampled to determine growth and wood characteristics (Table 7). The results are for 15-year-old stands because older paired plantations are not available. Points of interest from the paired species study are:

1. Cordage volume growth per acre per year is good in all three pairs of plantations, averaging over 2.1 cords per acre per year at 15 years of age for sites that are not outstandingly good. This supports our general observation that plantation yields are often greater than yield tables indicate for natural stands.

2. Because of the differential in bark thickness and tree taper, cordage and solid wood values are quite different for the two species. For example, the 0.9 cords per acre per year superiority of loblolly pine (Plot 2) over Virginia pine (Plot 1) is in actuality only a difference of 14 cubic feet per acre per year of solid wood. These results also support the general observations that bark differences between species, percentage bark differences between different age trees of the same species, and differences in bark thickness for separate geographic areas cause a large "error" in estimation of usable wood.

3. Wood density has considerable effect. For example, loblolly weighs 3.5 pounds per cubic foot <u>less</u> than does the paired Virginia pine (Plots 5 and 6), helping Virginia pine to compare reasonably favorably in dry weight production even though trees of this species were somewhat smaller. Studies by other members of the Cooperative show wood density of young Virginia pine to be equal or slightly higher than loblolly pine of the same age grown under similar conditions. At older ages the wood density of Virginia pine tends to be slightly less than that of loblolly pine.

4. Earlier studies indicated that older stands of Virginia pine usually had lower wood moisture content than loblolly. This is not strongly evident for the three young plantations reported in Table 7.

5. Because of bark thickness, the relative outside bark diameter and the inside bark diameter at breast height for the two species change drastically. Virginia pine tends to have less height growth than loblolly but form class is somewhat better. Limb characteristics of the geographic source of Virginia pine that Kimberly-Clark used were little different from those of loblolly pine when grown under similar conditions, averaging about 0.7 inch in diameter.

The results of another study involving Virginia and loblolly pines of the same age growing in mixed stands on lands of Georgia Kraft Company are shown in Table 8. The Virginia pine had somewhat higher specific gravity and lower moisture content than the loblolly pine with which it was growing.

Table 8. Comparative wood properties from mixed stands of Virginia and loblolly pines, Georgia Kraft Company 1/

| Stand # | Species | Number of 5-ft. bolts | Tree Age | Specific Gravity | Lbs./ cu.ft. | Moisture Content |
|---|---|---|---|---|---|---|
| I | Loblolly | 8.6 | 30 | .442 | 27.6 | 113 |
| | Virginia | 8.7 | 31 | .445 | 27.8 | 103 |
| II | Loblolly | 5.9 | 18 | .432 | 27.0 | 131 |
| | Virginia | 4.8 | 18 | .441 | 27.5 | 123 |

1/ Preliminary results were reported in Georgia Kraft Research Note #10, "The effects of species and age upon green and dry weights of wood -- an interim report," by John E. Newland.

To determine the effects of stand age on the wood of loblolly pine in the Piedmont of North Carolina and South Carolina, Catawba Timber Company cut and sampled trees from 21 plots. As expected, tree-to-tree variability was large. Trends of gravity and moisture content with age were evident, as shown in Table 9 below.

Table 9. Wood properties of loblolly pine of different age stands -- Piedmont of North and South Carolina (From studies by Catawba Timber Company)

| Age Class (Yrs.) | No. 1/ of Trees | Whole Tree Values 2/ Sp. Gr. | Whole Tree Values 2/ Dry Wood Density (lb./ cu.ft.) | Whole Tree Values 2/ Moist. 3/ Cont. (%) | Basal Bolts 4/ Sp. Gr. | Basal Bolts 4/ Dry Wood Density (lb./ cu.ft.) | Basal Bolts 4/ Moist. Cont. (%) | Seventh Bolt 4/ Sp. Gr. | Seventh Bolt 4/ Dry Wood Density (lb./ cu.ft.) | Seventh Bolt 4/ Moist. Cont. (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 (under 19) | 24 | .445 | 27.78 | 105 | .475 | 29.65 | 96 | .395 | 24.66 | 142 |
| 25 (20 - 29) | 24 | .464 | 28.97 | 98 | .490 | 30.59 | 83 | .437 | 27.28 | 109 |
| 35 (30+) | 15 | .485 | 30.28 | 91 | .518 | 32.34 | 81 | .454 | 28.34 | 106 |

1/ Each tree was cut and sampled by 5'3" bolts.
2/ Whole tree values are weighted values of each bolt by the proportion of total tree volume it represents.
3/ Per cent based on dry wood.
4/ The 15-year age class trees averaged 7 bolts, the 25-year trees 10 bolts, the 35-year trees 12 bolts. The basal and seventh bolts were selected for illustrative purposes.

Figure 10. Exchange of information and experiences with others is essential for efficient operation. Members of the Cooperative have wide contacts both within and outside the United States. Shown is Peter Banks, Rhodesia, looking at 18-month-old progeny of improved loblolly pine. Directly behind him is a row of commercial source material. Observations of activities of this kind are made possible by Bruce Zobel's recent trip to South Africa and Rhodesia.

Measurements have been taken on a number of families in 8- to 9-year-old progeny trials to study bole characteristics which affect estimates of wood volume growth. When estimated independently of the effects of diameter and height, no consistent differences in form class or trunk taper could be detected among the families sampled; however, significant differences in bark thickness were obtained. In one trial in coastal South Carolina involving control-pollinated families derived from one common mother tree but with different fathers,[1/] wood volume of the family with thickest bark (0.62") obtained from a volume table was overestimated 3.0% compared to volume corrected for bark thickness. Similarly, the wood volume of a family with thin bark (0.44") was underestimated by 2.9%. The proportion of total tree volume comprised of bark in 8- to 9-year-old stands was 25.0% and 21.2%, respectively, in the Coastal Plain and was 34.0% for a Piedmont plantation.

An interesting set of studies is under way dealing with the variation and inheritance of five different sugars and lignin content of wood. This is a joint project between the Department of Wood Science at N. C. State and the Cooperative Tree Improvement Program. It consists of an analysis of chemical characteristics in the second 5-foot bolt from three trees from each of six replications of each of six control-pollinated families in the progeny test of Westvaco Corporation. The preliminary analyses will be completed soon; depending upon results, a much more comprehensive study of the inheritance and variation in chemical constituents in wood may be initiated.

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[1/] Control-pollinated plantings on lands of Westvaco Corporation

Quantitative Genetic Studies

The several studies comprising this very large research project were reported in last year's annual report and will not be repeated here. A number of separate papers have been published -- these will be pulled together and analyzed as a unit in a "monograph" by Stonecypher and Zobel in 1969. Inheritance of disease resistance and wood properties continues high, and genetic gains in a number of characters are satisfactory to good. For the main study area near Bainbridge, Georgia (Southlands Experiment Forest of the International Paper Company), genotype-x-environment interactions were small for most characteristics studied. The oldest progeny are large enough that they will be first thinned within the next couple of years.

A paper dealing with methodology and efficiency of progeny testing will be completed in 1969. This work constitutes the Ph. D. dissertation of Jim Roberds and combines theoretical mathematical developments with data and experience from the Cooperative Program.

Membership of the Pine Cooperative

| Organization | Working Units and States |
|---|---|
| Albemarle Paper Company (Roanoke Rapids Division) | N. C., Va. |
| American Can Company (Southern Woodlands Division) | Ala., Miss. |
| Catawba Timber Company (Bowaters Carolina) | S. C., N. C., Va., Ga. |
| Chesapeake Corporation of Virginia | Va., Md., Del. |
| Container Corporation of America | Ala. |
| Continental Can Company, Inc. | Savannah Div. - S.C., Ga.<br>Hopewell Div. - N.C.., Va. |
| Georgia Kraft Company | Ga., Ala. |
| Georgia-Pacific Corporation | Va., N. C., S. C., Ga., Fla. |
| Hammermill Paper Company | Ala. |
| Hiwassee Land Company (Bowaters Southern) | Tenn., Ga., Ala., Miss., N. C. |
| International Paper Company | Coastal Plain - S. C., N. C.<br>Piedmont - S. C., N. C. |
| Kimberly-Clark Corporation (Coosa River Division) | Ala. |
| Masonite Corporation | Miss. |
| North Carolina Division of Forestry | N. C. |
| Riegel Paper Corporation | N. C., S. C. |
| South Carolina State Commission of Forestry | S. C. |
| Tennessee River Pulp and Paper Company | Tenn., Ala., Miss. |
| U. S. Plywood-Champion Papers, Inc. | S. C., N. C., Ala., Ga., Tenn. |
| Union Camp Corporation | Savannah Div. - Ga., S. C., Ala.<br>Franklin Div. - N. C., Va. |
| Virginia Division of Forestry | Va. |
| Westvaco Corporation | South - N. C., S. C.<br>North - Va., West Va., Ohio |
| Weyerhaeuser Company | N. C. Div. - N. C., Va.<br>Miss.-Ala. Operations - Miss., Ala. |

# EDUCATION

## General

One of the least known but most important activities of the Cooperative is its educational function. This includes graduate students, postdoctoral students, short courses, symposia and special schools for members of the Cooperative.

An example of the latter activity is the Tree Improvement Short Course, held January 14 - 17, 1969. The course was designed to give the 18 attendees basic information on activities of the Cooperative Programs so that they could gain the necessary background to understand the reasons why various approaches and procedures are used in the Tree Improvement and Hardwood Research Programs. Such short courses are held every two or three years for new personnel of the cooperating organizations. At the express request of the Food and Agriculture Organization of the United Nations, another short course will be given in June and July in Raleigh, just prior to the Second World Consultation on Forest Tree Breeding. The course is for chosen representatives from developing countries, where basic information is needed to begin and operate tree improvement programs. Members of the Cooperative have been most helpful in offering assistance and facilities for the several field trips planned for the attendees.

Several times during the year, grafting and grading schools are held for members of the Cooperative. Additional sessions are conducted to teach field personnel how to take and interpret progeny measurements. Discussions and lectures on wood and wood quality variation are frequently held, both with forest management and mill personnel. The latter sessions are regularly requested and often include seminars for supervisory personnel within the mills. In several instances "seminars" dealing with facets of forest management, wood qualities, procurement policies and economic considerations have been held. Such seminars are usually led discussions and always are lively and informative because of the participation of the attendees. Sometimes the staff of the Program are invited to participate in special seminars such as the one held recently in conjunction with N. C. State University Forestry Extension specialists, for members of the North Carolina Division of Forestry on hardwood regeneration, management and utilization.

Perhaps the most effective educational meetings held every year are the Contact Men's Meetings for both the pine and hardwood cooperatives. These are "led" discussions in which a free exchange of experiences is held amongst those involved in activities of the Cooperatives. Ideas and results are made known, many of which will never be formally published. These meetings are most stimulating and encourage exchange of ideas not possible under any other circumstances.

Graduate Students

Names of students currently working for advanced degrees, who are associated with the Cooperative Programs, are listed below. Note the diversity of background, geographic location and research under way. We often receive comments about the difficulty of efficiently handling such a large group of students. This would be particularly difficult if it were not for a high proportion of older students who have spent 10 to 15 or more years in the field before returning to school. Such students are mature, they have their objectives firmly in mind and therefore need a minimum of guidance. Our policy is that a graduate student is a mature scientist and we expect him to proceed accordingly.

Education consists of many things, but one of the most effective processes is exchange of ideas among students. Such exchange is always enhanced when there are mature, experienced men among the graduate students. In addition, three of the faculty of the Cooperatives who are nearing completion of their Ph. D. Degrees give most valuable help and guidance to the graduate students. Bob Kellison, Bob McElwee and Jim Roberds each have special responsibility for several graduate students with whom they work closely, as well as help and counsel all students associated with the Program.

There is a unique policy of interdepartmental functions at N. C. State University which is of special value to students and to general operation of the Cooperative's functions. Many professors are on more than one faculty, and the students work freely between departments and schools on campus. This allows specialization and training in many fields, all related to the betterment of forestry. Such a broad background, combined with the close ties to the N. C. Agricultural Experiment Station, produces a great breadth of opportunity for student and faculty alike.

Table 17. Current graduate students working directly with or associated with the Cooperative Programs.

| | Name | Previous Employer or School | Degree Sought | Research Project and Major Interest |
|---|---|---|---|---|
| 1. | Adams, Tom | Humbolt State, California | M. S. | Genetic analysis of competition in pines |
| 2. | Barker, James | University of Florida | Ph. D. | Genotype-x-environmental interaction, pine |
| 3. | Blair, Roger | Yale University | Ph. D. | Genetic analysis of resistance to fusiform rust |
| 4. | Cole, Donald | Continental Can Company | Ph. D. | Variation and comparison of different sources of slash and loblolly pine |
| 5. | Kitzmiller, Jay | West Virginia University | Ph. D. | Fertilization of sycamore |
| 6. | Kundt, John | Union Camp Corporation | Ph. D. | Diallel analysis of Virginia pine |
| 7. | Land, Sam | N. C. State University | Ph. D. | Salt tolerance of loblolly pine |
| 8. | Lantz, Clark | Virginia Division of Forestry | Ph. D. | Incompatibility of pine grafts |
| 9. | Mallonee, Ed | West Virginia University | M. S. | Species-site studies of hardwoods |
| 10. | Porterfield, Dick | Ohio State University | M. S. | Economic aspects of hardwood growth and yields |
| 11. | Quijada Rosas, Marcelino | Venezuela | Ph. D. | Genetics of drought resistance |
| 12. | Rockwood, Don | University of Illinois | Ph. D. | Population analysis by isozyme frequencies and oleoresin characteristics of loblolly pine |
| 13. | Smouse, Peter | University of California | Ph. D. | Taxonomic relationship and introgression in _P. taeda_, _P. serotina_, _P. rigida_ and _P. echinata_ |
| 14. | Sluder, Earl | U. S. Forest Service | Ph. D. | Causes of variation in wood of yellow poplar |
| 15. | Weir, Bob | University of Maine | M. S. | Development of a "strain" of upland site sycamore |

Degree Students Who Have Graduated

A large number of students have completed their degrees since the Cooperative Programs were initiated late in 1956. Summarized, these are:

| Degree Granted | Number of Students |
|---|---|
| M. S. and M. F. Degrees | 13 |
| Ph. D. Degrees | 20 |

Most of the students graduated are employed in universities, federal or state organizations, or industries. Of the total of 33 ex-students, 24 are employed in the United States and 9 have obtained foreign employment. Many of these serve in key jobs and their influence is being widely felt. We are understandably proud of these men and the role of the Cooperatives in helping develop persons with the abilities and potentials shown by our graduates.

Nondegree Students

Every year there are one or more persons who spend six months to a year working with the Cooperative, usually taking specially desired courses to augment their educational background and to complete a special research project. Some of these are postdoctorals, others are special students without advanced degrees. All are experienced and provide a wonderful opportunity for the faculty and students to broaden their outlook as well as help the regular graduate students. During the life of the Cooperative we have had 14 nondegree and postdoctoral students from the United States and from nine countries outside the United States.

Dr. Åke Gustafsson from Sweden came to N. C. State to teach in 1968 and contributed greatly to our overall program during his semester on the faculty. In addition to nondegree students who stay for some time, there are literally hundreds of short-term visitors staying for periods of a day to a month. These visitors provide a means for exchange of information and provide opportunities for discussion of activities under way. Many of the short-term visitors are from foreign countries, and persons from nearly every nation with forestry activities have visited the Cooperative.

The value of the educational functions of the Cooperative cannot be overlooked. No organization or person can work in a vacuum, and the questions, comments and experiences of the visitors and students add a real dimension to the Cooperative. As a result we are continually reassessing our approach, our methods, our results. This stimulation, combined with the policy of inter-departmental relationships at N. C. State University and the constant contact with industrial and research foresters in the field, give the faculty of the Cooperative an unusual opportunity to be conversant in the many facets of research and application necessary for efficient operation of the large and complex program under way.

## MISCELLANY

### Service Functions

As all members of the Cooperative Programs are aware, we fulfill many functions outside those narrowly defined as tree improvement or hardwood research. As much help as possible is given for general forest management activities, and much time of staff members of the Cooperatives is being used for these generalized functions. We feel one of our greatest services is to disseminate information, trends and activities throughout the area in which we operate. Members of the Cooperative staff have a unique opportunity to observe, discuss and learn through constant travel in the 13-state area in which members of the Cooperatives are located.

This generalized service function takes many forms. For example, questions about rotation ages, site preparation methods, harvesting techniques, fertilization, planting and direct seeding operations throughout the Southeast are continually asked. Frequently our opinion about timber supply trends is requested. Recommendations for fertilization are given with the aid of Dr. C. B. Davey and Dr. T. E. Maki on questions in relation to progeny tests, hardwood regeneration and preharvest manuring of nearly mature stands. Additionally, advice is rendered on the conduct and design of maximum yield tests, in which the objective is to apply intensive site preparation, fertilization, and protection, and to use good genetic stock and even to cultivate to determine the maximum wood per unit area that can be grown in a specified time period. This is done for both pines and hardwoods.

Newsletter

The NEWSLETTER, edited by Bob Kellison, continues to be our "hottest" item. It contains all kinds of interesting tidbits of unpublished information and rumor which are not available anywhere else. We have increasing requests for the NEWSLETTER, but in keeping with the directive of the Advisory Committee, distribution is strictly limited to members of the Cooperative and a few persons who contribute directly to it.

Personnel

Changes and additions to the staff reflect the increasing activity of the Cooperative Programs; the past eighteen months have brought several new faces to the laboratory and offices, and unfortunately we have lost three people formerly working with us.

Bill Johnson is now devoting full time to teaching and his graduate studies. During the past year he has been teaching the silviculture courses of Jack Duffield, who is on a one year's leave of absence to teach in Yugoslavia.

Mrs. Judy Faircloth resigned after ably serving a number of years as lab technician and secretary. She is devoting full time to her family.

After working with us for many years as secretary, lab technician, and statistical analyst, Miss Cicely Browne retired at the end of 1968 to devote full time to her hobbies of dog training, photography and floriculture. We wish her much happiness in her new-found "leisure."

J. B. Jett joined us in November as liaison geneticist to fill the gap left by Bill Johnson. J. B. recently completed his Master's Degree at the University of Tennessee. He has quickly adjusted to the travels and strenuous activities and has been kept busy with other field activities. He will be undertaking research on flowering of grafted hardwoods as his special research project.

In June, Mrs. Carolyn Ariail joined us to help Mrs. Holland as secretary. Mrs. Ariail came to Raleigh from Athens, Georgia, where she worked in a similar capacity with the University of Georgia Forestry Extension. If you ever feel low, her cheery smile and willingness to help always are a fine antidote.

Mrs. Alice Hatcher also came with us last summer to work as a statistical analyst with Jim Roberds. They have been extremely busy with the computations and computer programs for progeny testing and the many field studies under way.

Two new people have joined the laboratory force, Mrs. Carol Jarman and Danny Isom. Mrs. Jarman joined us as Miss Ellis but her recent marriage has forced us to become accustomed to her new name. Danny has worked for us part-time as an undergraduate student but recently joined the lab on a full-time basis.

In summary, the Cooperative staff now consists of the following:

| Professional | Secretaries | Laboratory |
| --- | --- | --- |
| J. B. Jett, Jr. | Mrs. Martha Holland | Mrs. Lanora Goss |
| R. C. Kellison | Mrs. Carolyn Ariail | Mrs. Martha Matthias |
| R. L. McElwee | | Mrs. Carol Jarman |
| James H. Roberds | | Mr. Danny Isom |
| Bruce J. Zobel | | |

| Statistical | Field Technician |
| --- | --- |
| Mrs. Alice Hatcher | Vernon Johnson |

## PUBLICATIONS

We try very hard to summarize all pertinent data obtained by the Cooperative Programs and to make them available to members at the very earliest opportunity. This is being done by sending out mimeographed summaries of studies, of completed theses, and by publishing the more pertinent studies in our Technical Report series. The more scientific research is published in regular national and international journals, although these outlets sometimes delay publication of results by as much as two years.

Following is a list of publications put out directly by the Cooperative and other closely related papers authored by other members of the faculty or members of the Cooperative. Copies or reprints of most publications listed have been sent to the membership or will be sent when published.

Information sheets continue to be sent to members of the Hardwood Cooperative. These summaries by Dr. Miller of recent articles update those listed in the Southern Hardwood Bibliography published in March, 1967. To date, 162 information sheets have been sent. They continue to be enthusiastically received.

PUBLICATIONS

Gladstone, W. T. 1968. Responses of earlywood and latewood from loblolly pine to kraft pulping. Ph. D. Thesis, N. C. State Univ., Raleigh. 123 pp.

Jett, J. B. 1968. The vegetative propagation of yellow-poplar. M. S. Thesis, University of Tennessee, Knoxville. 51 pp.

Kellison, R. C. 1968. Natural variation of yellow-poplar in North Carolina. Proc., 15th Northeastern For. Tree Impr. Conf., Morgantown, West Virginia, July 25-26, 1967. pp. 7-14.

Kellison, R. C. 1969. Establishment and management of clonal seed orchards of pine. (To be given at Second World Consultation on Forest Tree Breeding in Washington, D. C., August)

Kinloch, B. B. and Stonecypher, R. 1969. Genetic variation in susceptibility to fusiform rust in seedlings from a wild population of loblolly pine. Phytopathology (In press)

Kundt, J. F. and Lantz, C. W. 1969. Cone ripening study of loblolly, Virginia, and shortleaf pines. (Submitted to Journal of Forestry)

Lantz, C. W. and Hofmann, J. G. 1969. Geographic variation in growth and wood quality of loblolly pine in North Carolina. (To be given at the Tenth Southern For. Tree Impr. Conf., Houston, Texas, in June)

McElwee, R. L. 1968. Artificial regeneration of hardwoods. Society of American Foresters, Annual Meeting, Philadelphia, Pennsylvania, October. 13 pp.

Saylor, L. C. 1967. Variability of chromosome structure and behavior in southern pine hybrids. Proc. Ninth South. Conf. For. Tree Impr., Knoxville, Tenn. pp. 95-100. Sponsored Publication No. 28 of the Committee on Southern Forest Tree Improvement.

Saylor, L. C. 1969. Provenance testing Mexican pines in the United States and Brazil. (To be given at the Tenth Southern For. Tree Impr. Conf., Houston, Texas, in June)

Saylor, L. C. 1969. Chromosomal differentiation as a barrier to interspecific hybridization among pines. (To be given at Second World Consultation on Forest Tree Breeding, Washington, D. C. in August. In press)

Saylor, L. C. 1969. Summary of the National Symposium on Forest Resources Undergraduate Education and the Forestry Profession. Newsletter, Appalachian Section, Society of American Foresters.

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