C.B. DAVEY

TWENTIETH ANNUAL REPORT

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

School of Forest Resources
North Carolina State University
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FOREWORD

Contrary to the gloomy outlook expressed in last year's Nineteenth Annual Report, the current attitude of the forest industries in the South is generally optimistic. Most grades of paper are selling well, with nearly all mills operating close to capacity, and the demand and price for solid wood products is increasing although the upturn has been slower than hoped.

During the past 25 years, forest management activities, and especially research, were generally the first to be curtailed by the wood-using industries when operating funds became limiting. Such a curtailment did not come about during the recent recession, as most organizations continued forestry activities at a high level, with some even expanding their research programs. The general concern about availability of timber, both for the present and for the future, is evident from the continued requests of the administrators of the Cooperative members for information on the timber inventory and options available to them to assure an adequate long-term supply of the desired quality wood. One major concern deals with the amount of "captive" timber of a suitable size and quality available at a reasonable cost which an organization should control. All major options are being investigated, namely (1) better utilization of the timber resource presently available; (2) expanding the timberland base; (3) supplementing the raw material available by overseas operations, especially in South America; and (4) increasing the productivity of forest land.

The concern about timber inventories is not equally divided between hardwoods and pine. Although quality hardwoods are becoming very scarce, most members of the Cooperative are not dependent upon them for the products they manufacture. In most of the South there still remains such a large inventory of low-quality hardwoods that in some areas they are a "drug on the market." Because of this, it is difficult to maintain the interest and vitality in the Hardwood Cooperative at the enthusiastic level of the Pine Cooperative. Yet, five members of the Hardwood Cooperative foresee a period in the future when the hardwood inventory will become limiting; they have launched into intensive operational hardwood plantation programs, which has added vitality to the hardwood research effort.

The supply of pine is generally satisfactory but recent happenings are causing concern. If the demand for chips or pulp by the Scandinavian countries ever reaches the level now being discussed, the pine timber supply situation in the South will be tight indeed. Pressures for use of wood for energy seem to continually increase, and the possible use of wood as a chemical base (about which we have had several inquiries lately) is causing considerable concern amongst mill executives. The high price of land and certain types of difficulties with overseas operations have thrown emphasis on the option of <u>making our forest land more productive</u>.

This is where the Cooperatives can make most significant contributions.

FUTURE DIRECTION OF THE COOPERATIVES

Any ongoing program will satisfy the original objectives after a period of time, requiring that new goals be considered. In the Pine Cooperative, for example, the tree selection and seed orchard establishment phases have nearly been completed while the second phase of testing, upgrading and establishing new improved orchards is well along. This raises the question, "Where should emphasis be placed in the future?" Similar deliberations need to be made for the Hardwood Cooperative, especially because of the increased emphasis on hardwood management by some industries.

In light of the announced retirement of Bruce Zobel as head of the Cooperatives before mid-1979, the time for reassessment and setting the future direction and emphases of the Cooperatives is upon us. For the past year, staff members of the Cooperative have been developing a prospectus on (1) Where have we been? (2) Where are we now? (3) Where do we go in the future? This working paper was presented to a "Blue Ribbon" committee within the Cooperative, for ideas and suggestions. The amended prospectus will be presented at the June meeting to the Advisory Committees of the Cooperatives for their input. After further consultation and discussions, a final document will be developed to set the course of the Cooperatives for the future.

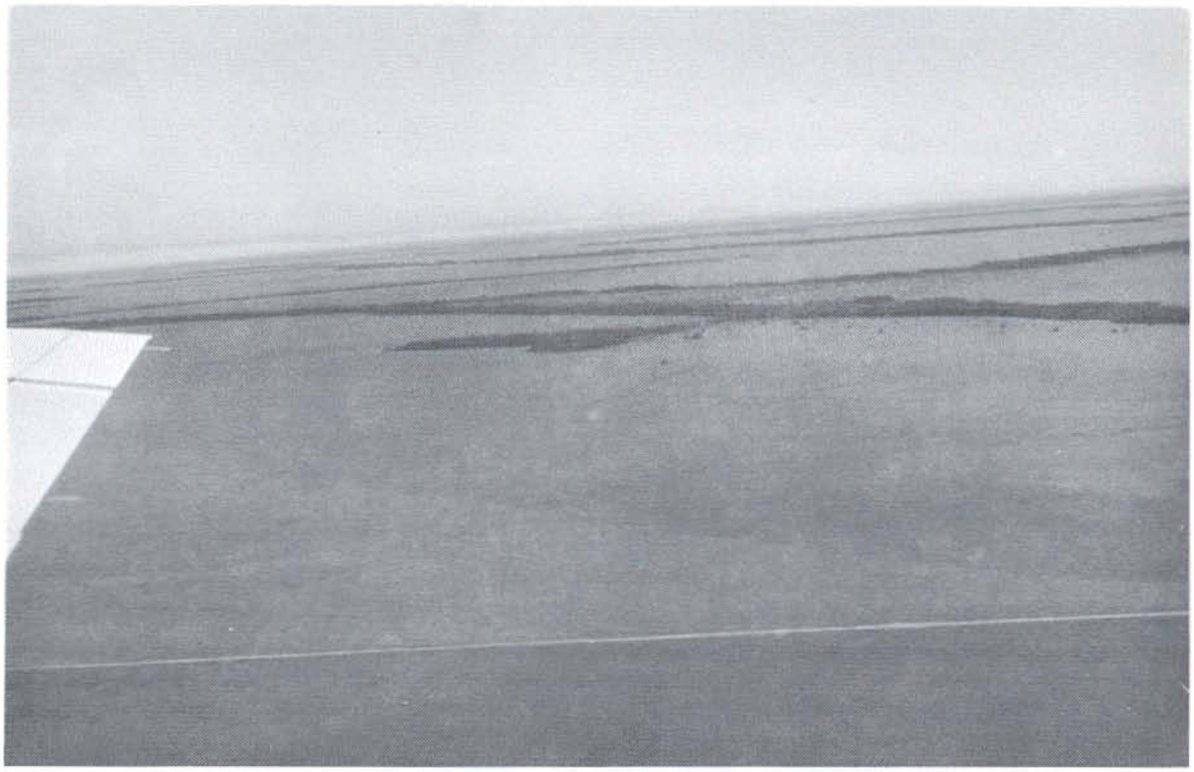
STATISTICS OF COOPERATIVE MEMBERS

Some years ago an estimate was made of the size of planting programs, land ownership, and forest landholdings of members of the Cooperatives. This information, updated to March 1, 1976, is shown in Table 1 as a combined summary for all members of both Cooperatives.

Table 1. Summary data relative to membership of the Pine and Hardwood Cooperatives

General for the industries	
Acres of forest land operated	19,000,000
Percentage of holdings classified as pine land	73
Pine	
Acres of plantations established	6,200,000
Acres planted annually	440,000
Number of seedlings planted annually	334,000,000
Number of acres direct-seeded annually	18,000
Hardwood	
Acres of plantations established	22,000
Acres planted annually	6,700
Number of seedlings planted annually	3,400,000
Three state forestry organizations	
Number of conifers produced annually in nurseries	142,000,000
Number of hardwoods produced annually in nurseries	3,840,000

A major economic benefit will occur when only genetically improved trees are used in the annual regeneration program of 440,000 acres. An additional benefit will be obtained from planting programs when the 142,000,000 seedlings grown in state nurseries are of genetically improved stock. Compared to the commercial check, a 10% improvement in yield will be initially obtained from the genetically improved material, and after the orchards are rogued of the poor genotypes this figure will be about 20%. At the present rate of



Interest in forestry in South America is at an all-time high. Bob Kellison visited the llanos of Venezuela (above, planting P. caribaea) and Bruce Zobel the llanos of Colombia (below, aerial view). Millions of acres of such land are available for forestry or other uses on the lower Orinoco in Venezuela and on the upper Orinoco in Colombia. Soil management and species determinations are essential.

development it appears that by 1980 essentially all plantations established by members of the Cooperative and many acres regenerated by the small landowners will be from genetically improved stock.

THE COOPERATIVE TREE IMPROVEMENT PROGRAM--PINE

Last year a detailed discussion was featured on "Where do we go from here?" It is a pleasure to report that the approach suggested of getting the most from what we now have and proceeding into advanced generations with a minimum of relatedness, has developed well. The part of the program to widen the working genetic base through new plantation selections is on schedule with 366 trees graded, most of which are now established in clone banks. Crossing has been started amongst the good general combiners, and pollen collections are being made in anticipation of crossing among the second-generation selections. Generally, the Cooperative is off to an excellent start on the revised and improved program.

There has been no slack in activities related to the pine program. The rush has been especially fast-paced because of the heavy load of progeny measurements, second-generation and plantation selections, and the production of heavy cone crops in the seed orchards. Problems have developed in a couple of seed orchards that cause concern, and the attempt to find ways to control cone and seed insects has taken much time and effort. Conversion to the use of the data recording MSI System has been smooth but time-consuming. Conversely, activities associated with the seed harvester have been minimal following acceptance of the machine in mid-1975.

Tree improvement has received increased emphasis the past few years in the South, in the western United States, and overseas. As a result of specific requests during the past year, J. B. Jett and Bruce Zobel visited Colombia to help with tree improvement programs. Bob Kellison spent a short time in the Guyano Llanos of Venezuela, and Bruce Zobel has been to the Pacific Northwest twice and to British Columbia once to advise on research activities. Several cooperatives have been started in Brazil, in which companies are working together to develop improved planting stock. Other countries with active tree improvement programs continue their good studies on ways to make land more productive, as exemplified by the following excerpt from the Annual Report of the Foundation for Forest Tree Breeding in Finland:

> "Finland's forests have become more important than ever. Increasing the growth of the country's forests, which during the past few years have not received sufficient attention in Finnish economic policy, appears once again to be one of the few ways remaining of sustaining the utilization of our natural resources. The role of tree breeding in increasing timber yields and in enabling our industrial sector to become more self-sufficient than ever before has gained a new importance. Forest tree breeding represents a way of increasing the efficiency of solar energy utilization, the natural resources being increased without any subsequent pollution--the competitive position of forestry has changed."

To meet the challenge, Finland has selected 7,000 pines and established 3,000 hectares of seed orchard through 1974. For all species there are 316 seed orchards, covering 3,385 hectares on which 1,336,000 grafts have been established.

It is clear that the most efficient way of increasing conifer yields is to make the land more productive, using all methods at our disposal; an integral part of such an attempt is to improve the genetic quality of the trees used in plantations.

Tree Selection

Although tree selection is continuing in natural stands, emphasis has been on plantation selections, as indicated in Table 23.

Table 23. Coniferous trees selected for use in first-generation seed orchards or clone banks by members of the Cooperative as of April, 1976 1/

Species		Number of Trees
Loblolly		
Coastal--Plantation	223	
--Natural	950	
Piedmont & Mountain--Plantation	88	
--Natural	780	
Total Loblolly		2041
Slash		
Plantation	55	
Natural	155	
Total Slash		210
Virginia		256
Longleaf		178
Shortleaf		118
Pitch		21
Pond		87
Spruce		19
White		75
Total Trees Selected		3005

1/ Second-generation selections are 937 loblolly, 118 slash, and 44 Virginia pine, as reported in Table 33.

A strong emphasis of the Cooperative is to broaden the genetic base by making more selections from plantations. This beautiful slash pine from an International Paper planting is similar to the 366 trees already graded for members of the Cooperative.

Seed Orchard Establishment, Cone and Seed Production

In the past we have urged that the establishment of second-generation orchards proceed at a relatively slow pace because of the shortage of scions from the limited number of suitable selections needed for balanced orchards. Following development of clone banks, and with the increasing number of selections within the older age classes, second-generation orchard establishment is now progressing on a significant scale. In addition, the acreage of specialty orchards has been increased, and the newer companies have continued to establish first- and 1.5-generation orchards. Sizes of the orchards by species, source, and type are indicated in Table 24.

Table 24. Coniferous seed orchard acreage in the N. C. State Cooperatives as of June 1, 1976

Species and Source	First-Gen.	1.5-Gen.	Second-Gen.	Disease-Resistant	Other Specialty	Total
Vegetative Orchards						
Coastal loblolly	1171	229	110	88	24	1622
Piedmont and Mountain loblolly	677	176	60	30	7	950
Slash	564	50	9	29	-	652
Longleaf	80	-	-	-	-	80
Virginia	97	-	-	-	-	97
White Pine	62	-	-	-	-	62
Sand Pine	37	-	-	-	-	37
Pond Pine	32	-	-	-	-	32
Shortleaf Pine	23	-	-	-	-	23
Pitch Pine	4	-	-	-	-	4
Spruce Pine	3	-	-	-	-	3
Seedling Orchards						
Fraser Fir	4	-	-	-	-	4
Virginia Pine	12	-	-	-	-	12
Total	2766	455	179	147	31	3578

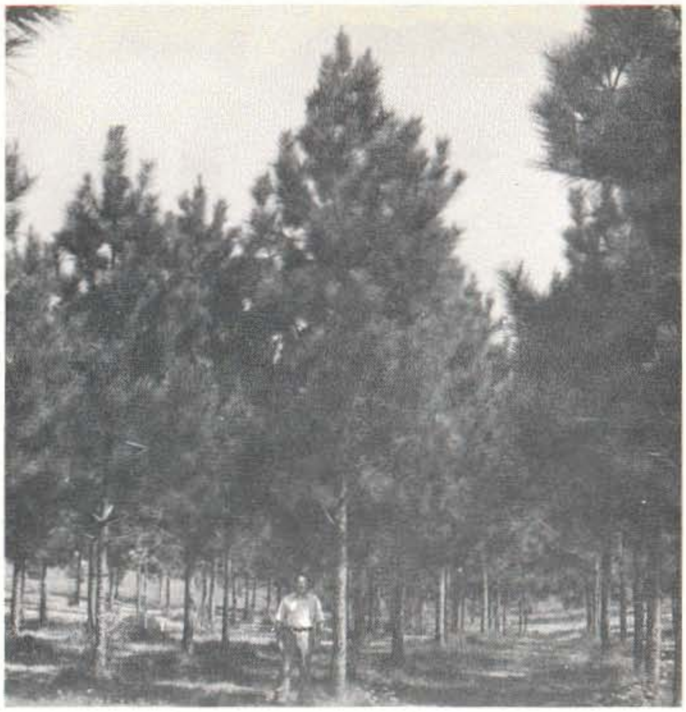
Seed and Cone Yields

Cone and seed yields hit an all-time high in 1975. Crops were generally poor on the upper Atlantic Coast region because of late freezes in 1974, although a couple of orchards partially escaped. Seed yields per bushel of cones considerably exceeded previous years (Table 25) because of better insect control, better extraction methodology, and because seed yields/bushel are always better in years with the heavy cone crops.

Table 25. Cone and seed yields in fall, 1975, from pine seed orchards of the Cooperative

	Bushels of Cones	Pounds of Seed	Pounds of Seed/ Bushel of Cones
Loblolly Pine-- Coastal Source	9284	12,384	1.33
Loblolly Pine-- Piedmont & Mountain Source	7064	9,032	1.28
Slash Pine	5516	5,146	0.93
Virginia Pine	324	314	0.97
Shortleaf Pine	86	58	0.67
White Pine	72	26	0.36
Pond Pine	23	21	0.92
Total	22,369	26,981	

The excellent yields obtained in 1975 should put to rest the fears that grafted seed orchards would produce good seed crops initially but decline with age. For example, all sources of loblolly pine within the Cooperative yielded 16,348 bushels of cones from which were obtained 21,416 pounds of seed for a lbs./bu. yield of 1.31. Slash pine was dramatically improved over previous years, as was Virginia pine. White pine yields are still low, but pollen availability remains a major problem. Yields in 1976 appear to be about the same as for



Above--One reason for the great increase in seed yields for 1975 was that a number of the younger orchards came into production. Shown is Dale Bowling of Masonite in Mississippi proudly standing near his prize clone which is superior in growth, form, and seed production.

Below--The "name of the game" in 1975 was heavy cone yields, resulting in 26,900 pounds of seed obtained from orchards within the Cooperative. Richard Smith of Georgia Kraft shows off a heavy loblolly cone producer in their young orchard in central Georgia.

1975; the flower crop in 1976 (cones to be collected fall, 1977) is the best in recent history. All orchards of all species, with two exceptions, have had record flower production, and at time of writing most have escaped serious damage from freezing. If insects can be controlled, the 1977 seed crop will exceed the total seed needs within the Cooperative.

Much of the improved yields can be credited to improved seed extraction methods. When it appears that cone opening is not good, we have suggested a second seed extraction to obtain maximum yields from seed orchard cones. One company obtained only 5% more seed from the second extraction, making the operation uneconomic. However, Masonite obtained 114 pounds of seed from 107 bushels of cones on the first extraction (1.06 lbs./bu.) and 19 more pounds from a second extraction for a total of 133 pounds or 1.24 lbs./bu. This 17% increase in seed yield certainly made a second extraction worthwhile and profitable. Each member of the Cooperative should take a close look at their yields, and, if poor extraction is suspected, a second extraction should be made. There is no cheaper way of obtaining additional seed. Trends of cone and seed yields since Cooperative orchards have been in commercial production are shown in Tabel 26.

Table 26. Cone and seed yields within the Cooperative over the past seven years 1/

	Loblolly		Slash		Virginia	
Year	Bushels of Cones	Lbs. Seed/ Bushel	Bushels of Cones	Lbs. Seed/ Bushel	Bushels of Cones	Lbs. Seed/ Bushel 2/
1969	1769	1.10	317	0.42	212	0.63
1970	5146	1.36	1744	0.88	186	0.31
1971	6478	1.14	3795	0.80	323	0.58
1972	6807	0.98	1684	0.60	152	0.49
1973	11853	1.09	2779	0.58	214	0.34
1974	8816	0.99	4088	0.74	144	0.25
1975	16348	1.31	5516	0.93	324	0.97

1/ Loblolly flower crops were badly damaged by freezing weather in 1973.

2/ Total cone yields of Virginia pine are not of importance, since more seed is produced than is needed; consequently, only part of the cones have been collected each year. The point of illustration is how greatly the seed yield per bushel fluctuates from year to year.

The variation in number of seeds/bushel of cones between years is illustrated by Catawba's orchards at Rock Hill, S. C. (Table 27). Note the near doubling of seed per bushel caused by a good spray schedule and environmental conditions conducive to cone development.

Table 27. Variation in cone and seed yields by year for loblolly and Virginia pines in the seed orchards of Catawba Timber

	Loblolly		Virginia	
	1974	1975	1974	1975
Bushels of Cones	111	250	11	38
Pounds of Seed	93	407	3.5	30
Pounds of Seed/Bushel	0.84	1.63	0.32	0.79

We have had several reports of low seed germination percentage from the 1975 crop, although most germination has been good. Some unusual germination results were obtained by the S. C. Division of Forestry. They obtained very poor germination from unstratified seed and good germination from stratified seed of both slash and loblolly pines. Usually, stratified seed germinate more rapidly than the unstratified, but final percentage after 28 days is close. Yet South Carolina obtained over a 20% difference in final germinability from some lots (Table 28).

Table 28. Seed germination for stratified and unstratified seed from orchards and commercial lots for the South Carolina Division of Forestry

Species	Source	% Germination Stratified	% Germination Unstratified
Loblolly	Piedmont Commercial	75	55
Loblolly	Piedmont Seed Orchard	88	65
Loblolly	Coastal Commercial	73	66
Loblolly	Coastal Seed Orchard	79	64
Slash	Seed Orchard	85	73

In 1975 a number of cone production records were set, with several orchards averaging over 100 bushels/acre. Perhaps the heaviest producer of all was the 7-year-old Piedmont orchard of Continental Can near Springfield, Georgia which averaged 70 bushels per acre, an amazing production for such a young orchard. American Can also obtained about 1800 bushels of cones from 21 acres of orchard which had an average age of 11 years. As usual, the vagaries of climate adversely affected production in some orchards. A heavy loss of flowers from freezing was experienced by Westvaco at Summerville, South Carolina, but a heavy crop was obtained from their small orchard at Georgetown, South Carolina. One would assume the climate to be similar for these two orchards, which are separated by about 60 air miles, but the difference between success and failure is often dependent on local climates. Many aspects of seed orchard production can be controlled by the orchard manager, but others are certainly a matter of chance and luck.

Cost of Seed

There is always a lively interest in the cost of seed from seed orchards. Reporting such values may seem futile because of differences in efficiencies in collection, cone yields, size of orchards, and methods of accounting. However, general results are reported in the form of the graph shown on the following page. As expected, orchards with heavier yields had the least expensive seed.

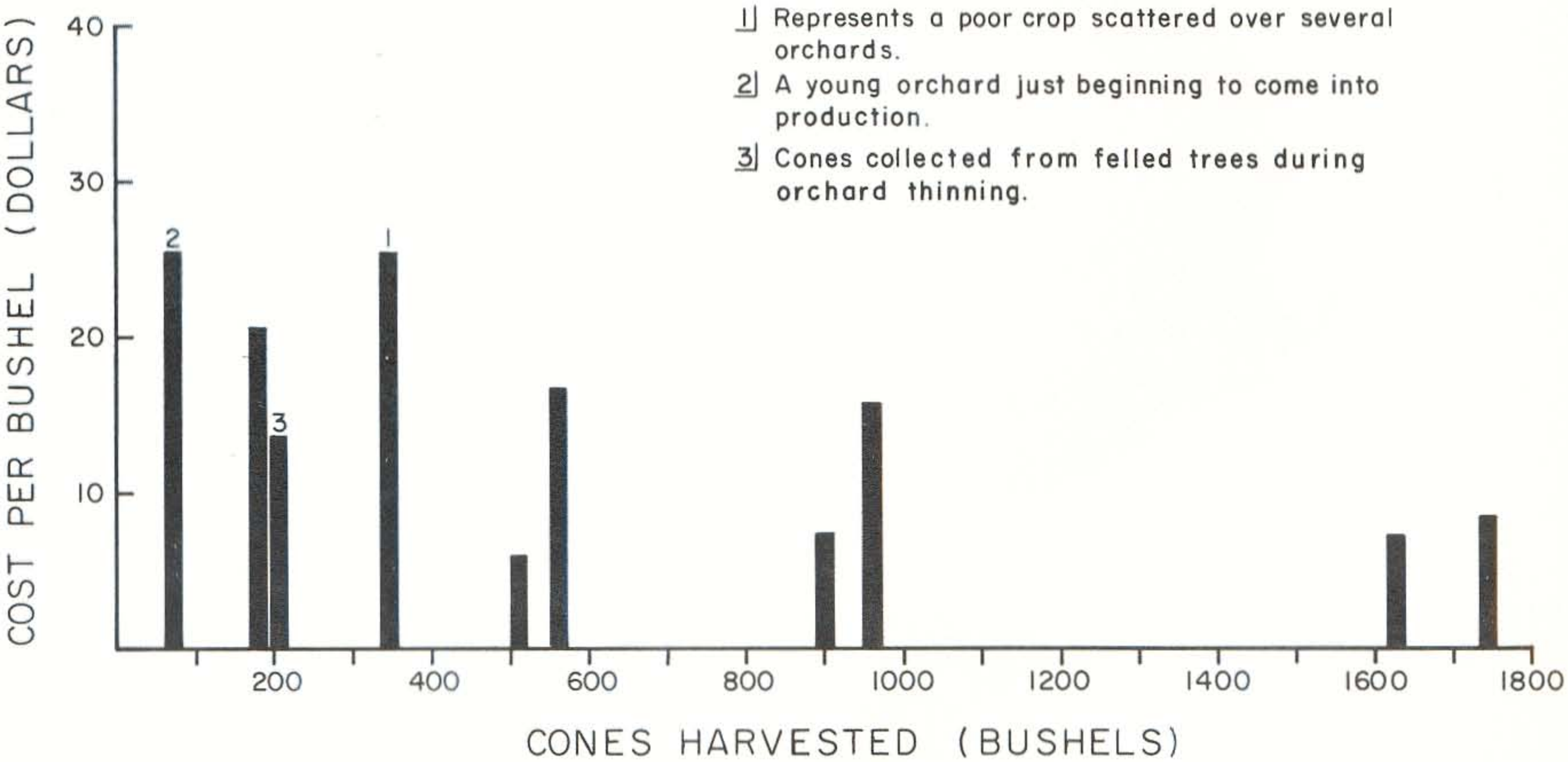


Fig. RELATIONSHIPS BETWEEN SIZE OF CONE CROP AND HARVESTING COSTS FOR THE 1975 COLLECTION PERIOD.

Flowers, flowers everywhere! This is the happy scene in the young loblolly pine seed orchard of Weyerhaeuser in Alabama. Cone and seed yields from this orchard have been excellent from time of establishment.
Inset: Flowers aplenty. A close-up of one of the trees in the Weyerhaeuser orchard.

Differential Seed Production

Differential cone production by clone within seed orchards has resulted in the rough rule of thumb that 20% of the clones produce 80% of the seed. It was suspected that this ratio might change as the orchards matured, that the heaviest producers might show a decline while clones that were initially poor producers might come into heavy productivity. However, cone production inequality has not changed greatly with time. Some clones continue to be of much greater importance than others, and emphasis in testing and treatment should take this into account. In the Cooperative, two of Catawba's orchards at Rock Hill, South Carolina show strong clonal differences in seed production (Table 29).

Table 29. Cone production from the high and low cone producers in two of Catawba's seed orchards

Clone No. Upper 20%	High Specific Gravity Orchard (Contains 25 clones) # Cones/Tree		Clone No. Upper 20%	Low Specific Gravity Orchard (Contains 20 clones) # Cones/Tree	
1-521	177		1-521	513	
1-502	114		1-509	166	
1-501	80		1-513	162	
1-535	61		1-522	160	
3-29	60				
Total Cones, Upper 20%		492	Total Cones, Upper 20%		1001
Average for Remaining 80%	17		Average for Remaining 80%	30	
Total Cones, Lower 80% 1/ 2/		336	Total Cones, Lower 80% 1/		478
Ratio, Upper 20% to Total	59%		Ratio, Upper 20% to Total	68%	

1/ Assuming one ramet of each clone in the orchard

2/ Two clones produced no cones; one averaged one cone/tree.

The ratio is no longer 80:20 in this older orchard, but still 20% of the clones are producing the bulk of the crop (59% and 68%) for the high- and low-gravity orchards, respectively.

Location of Seed Orchards

Frequent flower losses from the northern orchards, and a continued heavy and quite regular production of seeds from orchards in the vicinity of Savannah, Georgia has influenced several organizations to plan establishment of 1.5- and second-generation orchards in this "sexy" region. The area has been relatively ice-free, freezes have done little damage, and there have been few hurricanes and tornadoes.[1/]

We have puzzled for years as to what environmental conditions constitute a good seed orchard site. Our ideas have generally resulted in successfully locating orchards where seed production has been good, particularly for the more recently established orchards. Three years ago Carl Gallegos took on this most complex problem for his Ph. D. research. The job has proven to be tough indeed, requiring a tremendous amount of work, thought, and interpretation of a mass of data. But perseverance has paid off and Carl has summarized his findings as follows:

> "The investigation concerning seed orchard site selection was made by evaluating a number of loblolly pine seed orchards older than nine years, classified as being in production. Cone counts, obtained for the ten best-producing clones in each seed orchard, were used as the measure of productivity. The counts were related to three categories of factors suspected of influencing cone production--tree characteristics, soil chemical and physical characteristics, and climate. Using cone production as the dependent variable, regression analyses were employed to determine which tree or environmental factors were most effective.

[1/] Immediately after the claim about hurricanes and tornadoes was stated publicly, a tornado sideswiped the Georgia-Pacific seed orchards near Clyo, Georgia, damaging only a few trees but destroying their greenhouse and shops.

"To evaluate the mass of weather data available and produce an accurate and concise description of climate, the 'drought index' method developed by Sopher, et al. (1973) was used. This index, based on the Thornthwaite (1948) system of climatic classification, combines data on rainfall with estimates of daily water loss through evapotranspiration to determine the number of days that available moisture in the soil is reduced to zero. A day when available moisture is zero is a 'drought day' (van Bavel, 1953). 1/

"The results indicate that moisture stress and associated factors such as soil moisture-holding capacity, temperature and precipitation, strongly affect cone production. The length of time during which moisture stress occurs is important. Trees should be under moisture stress during the first five to six months when cone primordia are initiated. During the remainder of the first growing season and the entire second and third growing seasons, moisture should be available to the tree for best cone development.

"Physical dimensions of the tree and soil characteristics did not produce results as well defined as did the 'drought index.' Tree height, DBH, age and type of graft (field grafts produce more cones than transplanted grafts) exerted some influence on cone production. A positive correlation with cone production was found for phosphorus in the A horizon, clay content (B horizon), and depth of the A horizon. Soil variables such as exchangeable aluminum (A horizon) and clay content (A horizon) had a negative effect on the production of cones.

"Implications for seed orchard site selection are:

"1. Choose well-drained soils 6 to 10 inches deep with sandy loam or loamy sand A horizons that are underlain by friable clay B horizons.

"2. Do not irrigate the seed orchard during the first five to six months of the year in order to increase cone primordia initiation; irrigate during the remainder of the year to assure survival and good development of cones.

"3. Large trees produce more cones so that everything should be done to a young orchard to get trees to an acceptable cone-bearing size."

Fertilization, Irrigation and Subsoiling

The effects of fertilization and irrigation on cone production in Catawba's South Carolina seed orchard have been reported in past annual reports. Cone yields have varied greatly from year to year, but there is a distinct trend for

1/ Sopher, C. D., R. J. McCracken, and D. D. Mason. 1973. Agron. Jour. 65:351-354.
Thornthwaite, C. W. 1948. Geog. Rev. 38:55-94.
van Bavel, C. H. M. 1953. Agron. Jour. 45:167-172.

greater cone production when fertilizers and irrigation are used (Table 30). Results are most interesting in light of the recent finding by Carl Gallegos that a dry period in spring is conducive to floral initiation. The irrigation treatment by Catawba was geared to keep soil moisture close to optimum during the growing season, which resulted in greater cone production.

Table 30. Effects of fertilization and irrigation on cone production in the loblolly orchard of Catawba in South Carolina

Year	Check	Fertilizer Only	Irrigation Only	Fertilization and Irrigation
1971	45	60	81	102
1972	72	134	99	145
1973	70	88	88	100
1974	55	117	98	144
1975	210	281	240	224
Average	90.4	136.0	121.2	143.0

For many years subsoiling has been a standard treatment in all seed orchards. It can have several beneficial results: (1) Increase seed production; (2) improve moisture relations, root development, and vigor of the grafts by better water penetration through break-up of a hardpan; (3) cut roots that could transport *Fomes* via root grafts; (4) cut large surface roots, reducing the damage caused by equipment on areas on which traffic is considerable.

Although we have observed increased cone production following subsoiling, it was not until Jimmy Gregory completed his graduate studies in the orchards of the Virginia Forest Service and Union Camp that sound data were obtained. In the latter orchard, which was already flowering, he obtained interesting differences (Table 31). Of the three clones listed, the first responded positively, the second was variable, and the third did not show response.

Observations show that subsoiling in late July or August is most effective. Since cutting the roots results in a shock effect with a reduction in the root mass, it may be that results are similar to the effect of drought stress as reported by Gallegos. Thus we are now generally recommending subsoiling at a set time rather than at any convenient period as had been previously suggested.

Table 31. Response to subsoiling of 9-year-old grafts, by clone, in the Union Camp seed orchard in North Carolina 1/

Subsoil Treatment	Number of Flowers/Tree			
	Average All Clones	Clone 2/ 2 - 40	Clone 2/ 2 - 18	Clone 3/ 2 - 39
Check (0")	9.1	16.7	17.4	6.7
Shallow (7")	14.0	45.0	9.7	5.3
Deep (17")	22.7	60.1	44.3	7.8

1/ From a study by Jimmy Gregory

2/ Heavy flower producers

3/ Light flower producer

Gains from Seed Orchards

In a study to determine the gain from seed orchard seed compared to commercial planting stock of loblolly pine, Westvaco used multi-tree square plots in a 10-year-old planting which was growing on a good site in South Carolina. On a volume basis, the select trees are 17% better than the commercial checks, while on a dry weight basis the superiority is 16% (Table 32). These results are very similar to those reported in previous annual reports. Final assessment of the value of seed orchards will be from whole orchard collections compared to commercial seed. To be meaningful, it should be made only after the orchards have been rogued of the poor clones.

Table 32. Volumes and dry weights from seed orchard clones and commercial checks from Westvaco in a 10-year-old planting of loblolly pine on a good site in the Coastal Plain of South Carolina

Clone	Cubic Feet/ Acre	Cords/Acre/ Year	Tons Dry Wood/ Acre	Tons/Acre/ Year
11-21	1890	2.4	23.01	2.3
11-22	2212	2.8	24.85	2.5
11-23	2145	2.7	26.12	2.6
11-25	2032	2.5	22.83	2.3
11-28	1929	2.4	21.07	2.1
11-61	2292	2.9	27.95	2.8
Average	2084	2.6	24.31	2.4
CC1[1/]	1576	2.0	18.59	1.8
CC2	1845	2.3	21.76	2.2
CC3	1860	2.3	21.93	2.2
Average	1760	2.2	20.76	2.1

[1/] Three commercial checks

In a summary of the performance of clones from their Virginia source loblolly pine seed orchard, Union Camp provided results for six tests. At four years, 60 of the 86 families (crosses) were superior to the commercial checks in height growth. Ten families were 10% or more taller, and one family was 19% taller. Reduced to a clonal basis, 28 of the 32 clones tested were superior to the commercial check. A percentage of "loser" clones of this magnitude is rather typical, and in nearly all orchards roguing is necessary to remove clones whose growth performance is inferior to the commercial check. For disease resistance, the loss is sometimes greater, with clone-to-clone differences being large. For example, in one test in an area where infection averaged only 20% the family performance ranged from 2 to 43%. We continue to find occasional very resistant clones from geographic areas where little or no natural fusiform infection occurs.

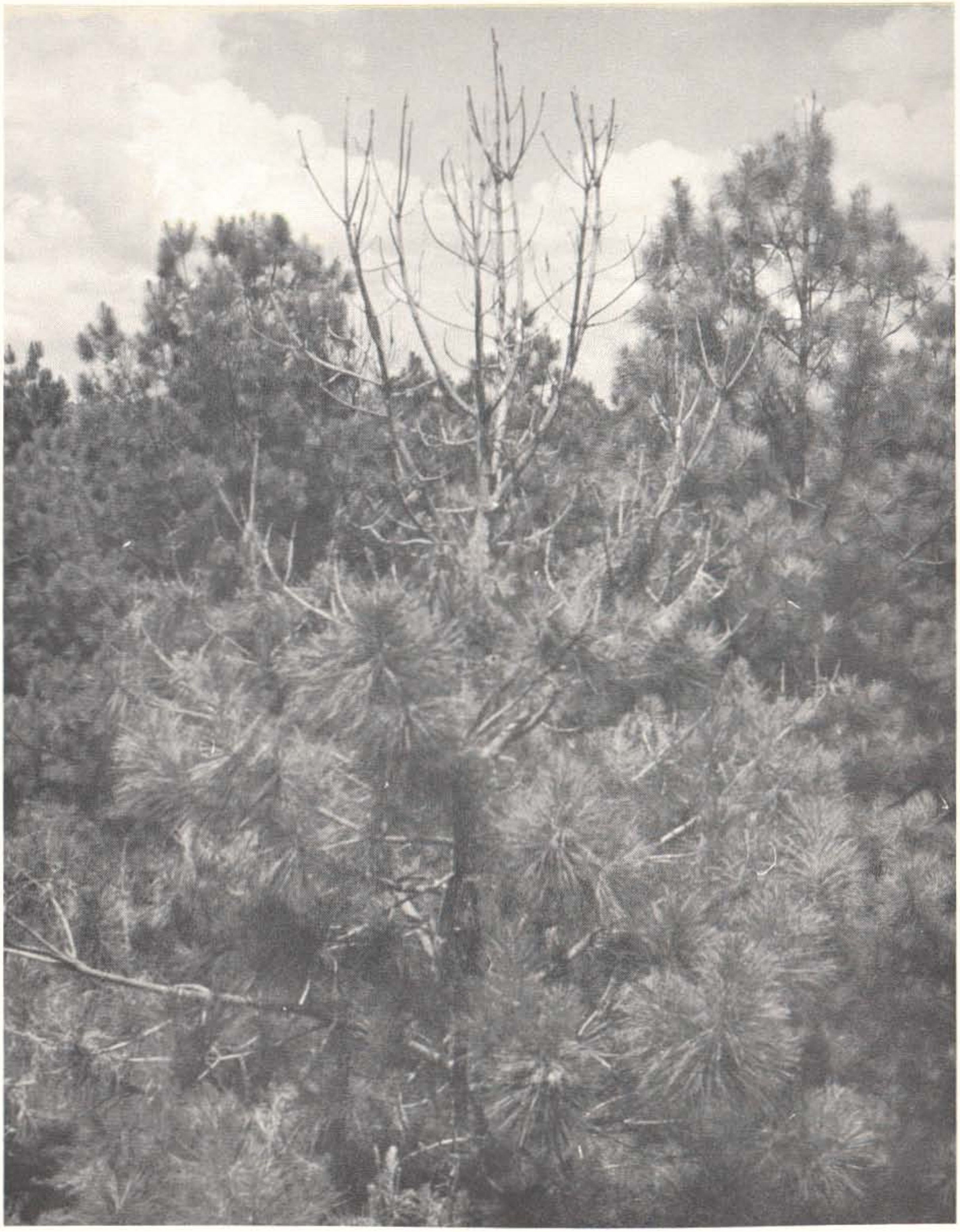
In a recent summary of an 8-year-old progeny test, Westvaco obtained 8.9% greater diameter, 9.7% greater height, and 19.2% greater volume from the orchard stock compared to the commercial check. For all tests completed, the commercial check generally ranks among the lower 20% in growth rate compared to the orchard crosses. Occasionally the commercial check will rank high in growth at the young ages, but this usually changes as the tests become older. Tree quality is always better from seed orchard seed.

Damage Within Seed Orchards

A very perplexing and potentially dangerous situation has developed in a couple of loblolly seed orchards. Rather severe branch dieback and needle drop has occurred in one Atlantic Coastal Plain and in one Gulf Coastal Plain orchard. In the northern area, damage is moderate but is continuing, resulting in flower and conelet loss along with defoliation, and may cause some kill of the grafts.

At first, small dead flags appear scattered in the upper crown, followed by a twig dieback. Often second-order branchlets are killed following movement of the necrosis down the stem. The dead twig is usually completely resin-soaked, as is the bud. Immediately below the dead twig the live cambium has spots of necrotic tissue, and in the center of the dead spot a dark spot occurs. When a number of these necrotic areas occur and join together, the twig above dies. The tree remains alive with normal-appearing bark and cambium except for the dead twig tips; on some clones essentially all the needles are shed, many falling off while they are still green. Because the cambium remains bright and green, the trees appear to be capable of recovery the following spring. Damage is extremely clonal, with some clones being completely unaffected, others with the ends of most branches resin-soaked.

Although the current problem may not be the same, dieback of tops in seed orchards is common and has been watched for the past 15 years. Everyone was very worried when dieback was first found on slash pine. Pathologists,



There are always problems that develop in any intensive management program. Two loblolly seed orchards have developed a heavy dieback of terminals and main branches; the branches become pitch-soaked. Many people from various organizations are investigating the problem, but as of now the cause of the needle kill and branch dieback is unknown.

entomologists, and others evaluated the problem but no causative factor was found. The slash pine bled profusely from the killed area but loblolly did not. Damage ranged from simple needle browning, with the bud and leader still green (bud will flush next spring), to severe dieback and kill of six feet or more of the tree's top. Dieback does not continue beyond the initially affected zone, and new growth the next year offsets and overgrows the kill. Damage was extremely clonal and occurred every year, generally appearing immediately following early fall freezes. Because of the timing, we have associated this common dieback with cold damage. However, some dieback was observed last fall in the two badly affected orchards before the temperature had dropped below 45°F, indicating that something other than cold is involved. Every orchard of all species in our Cooperative has been affected by the common type dieback but we have not been concerned since tree kill or extensive damage never resulted.

No one knows for sure the cause of the present dieback problems in the two orchards. Many possible factors are being investigated, including diseases, insects, and physiological upsets. Several researchers have suggested pitch canker (or another Fusarium), while others report the damage is caused by midges. Spray interaction or fertilization problems such as too much N is being considered along with other management practices such as subsoiling. Within the orchards, young as well as old grafts are attacked, but some geographic sources are much more severely harmed than are others. Since all grafts appear to have a form of latent incompatibility which can be triggered by physiological stresses such as drought, severe cold, or other imbalance, there is some suspicion that this may be the cause. A great effort from several different disciplines, including a special task force from the U. S. Forest Service is being mounted to diagnose and correct the malady.

Growing Seed Overseas

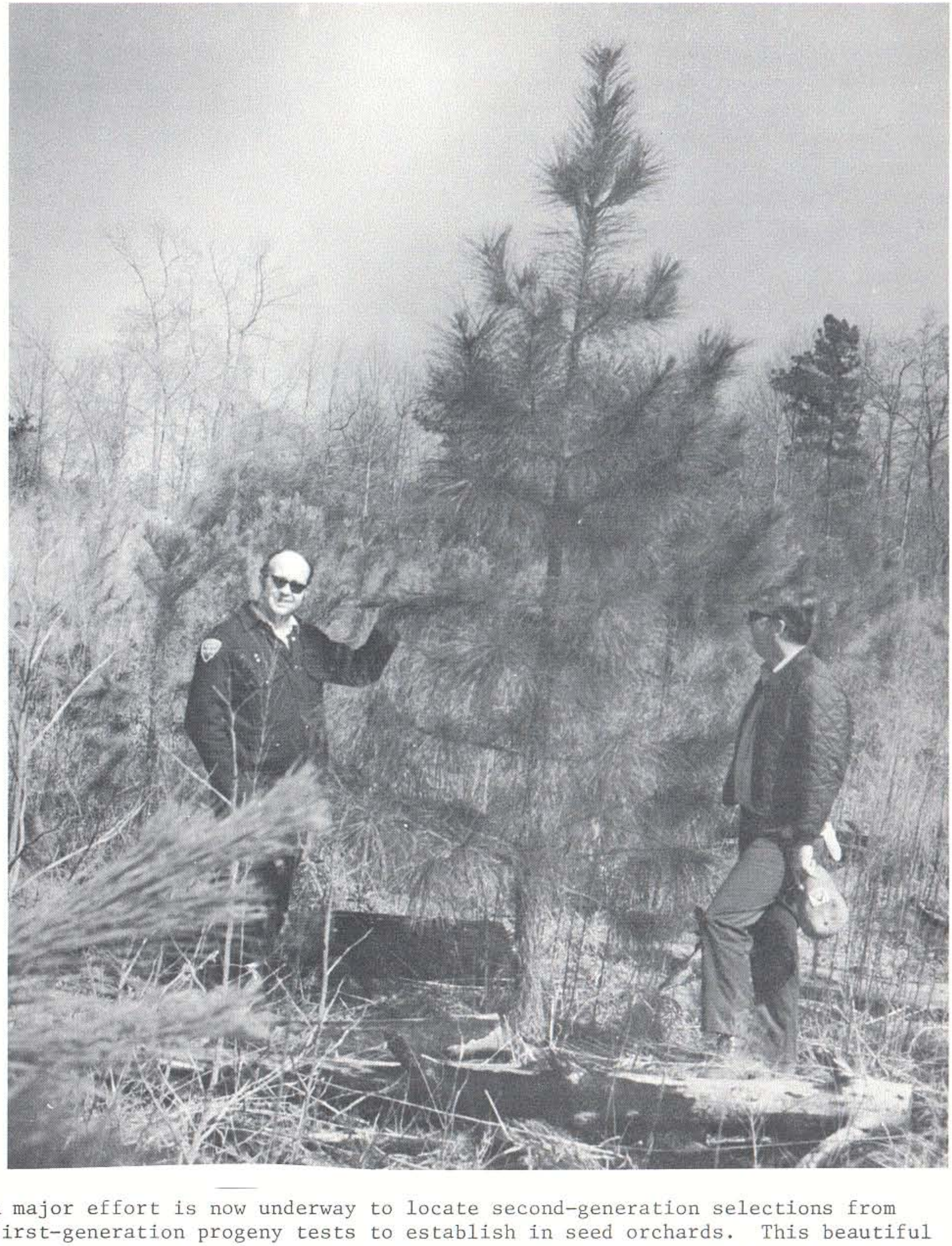
There has been considerable interest in the possibility of having seed grown overseas to quickly increase seed supply. Such seed will serve as a supplement to that produced in the orchards in the United States. Interest has been expressed by South African Forest Investments Limited, a company in South Africa, and by the government of Rhodesia in producing loblolly and slash pine seed.

Seed to be produced is primarily 1.5- and second-generation material. Plans are now past the talking stage, with six companies involved in contract negotiations and some scion material already shipped. The cuttings will be grafted into a clone bank for about six months while the material is screened for insects and diseases. After release they will be grafted into production seed orchards, where good seed production is anticipated starting at about four years.

Second-Generation Seed Orchards

Progress in establishing second-generation orchards is very rapid. Even though we always recommend starting on a small scale, establishing a few acres each year, the total effort has been large, with 179 acres of production orchards already grafted (Table 24). Even greater establishment of second-generation orchards has been restricted by lack of enough suitable selections for some regions, especially those in the more western areas, and by lack of cuttings available from the young selections. The first problem of too few selections will soon be over, with nearly 1100 selections already made and more trees becoming available each year. To date, 538 of the selections have been established in operational seed orchards (Table 33).

The number of rejects between the time of initial selection at year five and the second selection at year nine was initially high, but as we have gained experience and now use a more sophisticated selection system the current rate of about 30% drop-outs is steadily being reduced. Many rejects are caused by



A major effort is now underway to locate second-generation selections from first-generation progeny tests to establish in seed orchards. This beautiful 3-year-old loblolly is in a progeny test of the Virginia Division of Forestry. Such trees are established in production second-generation seed orchards if they maintain their superiority through the ninth year in the progeny tests.

fusiform rust bole galls appearing on trees which were initially categorized as clean of the disease. There is no explanation for this sudden appearance of the disease other than it is caused by a latent infection in the tree bole that suddenly becomes active after five, six, or seven years. The rejection rate is also being reduced by avoiding "pretty little trees." Initially this type tree was sometimes selected with anticipation that relative growth rate would increase with age, but this rarely happens. A pretty little tree stays in that category as the stand develops. The method of initial selection after year five, followed by a "final" selection after year nine works well. As more selections become available the intention is to use only the 9-year-old or older material in developing production seed orchards.

Table 33. Second-generation selections within the Cooperative to June, 1976

Loblolly Pine	Number Selected	Number Established in Second-Generation Orchards
Catawba	13	11
Hiwassee	103	50
Union Camp	66	31
Champion International	45	30
Chesapeake	64	31
Continental Can	95	35
Hoerner-Waldorf	67	35
International Paper	60	31
Weyerhaeuser	125	65
Federal Paper Board	60	40
Westvaco	86	38
Kimberly-Clark	99	47
American Can	9	3
Tennessee River	22	13
Virginia Division of Forestry	15	10
Georgia-Pacific	4	2
South Carolina Commission of Forestry	4	4
Total	937	476
Slash Pine		
Union Camp, St. Regis	118	62
Virginia Pine		
Hiwassee, Kimberly-Clark	44	0
Grand Total	1099	538

Several organizations plan to expand their second-generation orchards rapidly in the next couple of years. Flowering of the young grafts has been spotty but better than hoped. We may be able to dispense with the first-generation pollen parents that have been included in the orchards because some of the young grafts are producing a considerable male crop; however, a decision on this cannot yet be made.

There has been considerable discussion of the best method to use in selecting trees for second-generation orchards. An index system is being evaluated which includes both family and best tree within-family selection, as does the current selection system. The gains from within-family selection are the best with high heritability, while more gain is obtained from family selection for traits having low heritabilities. Don Smith made some calculations as to relative gains when only family or family-plus-individual tree selection systems are used (Table 34). He concluded that with our conditions and heritabilities roughly 60% of the gain in volume for second-generation selection is from family selection and 40% is from best tree within-family selection.

Table 34. Gains (%) in single traits, using different breeding procedures in second-generation selections

	Breeding Method[1/]	
	A	B
Height (ft.)	5.3	8.7
Straightness (score)	8.2	14.7
Volume (cu.ft.)	9.0	25.0
Fusiform rust (score)	21.5	35.0

[1/] A. Selection of top 25% of families

B. Selection of top 25% of families, plus additional selection of top 3% of individuals within families

Seed and Cone Insects

Considerable data are now available on control of cone and seed insects, using sprays or systemics; there are too many to include in this report, but a few will be summarized. Generally, chemicals to control both cone and seed insects are now known but full usage awaits labeling by EPA and practical methods of application.

Virginia Pine

Although most emphasis on insect control has been for slash and loblolly pines, we have been experiencing heavy seed and cone losses in Virginia pine seed orchards. One of the hardest hit has been Catawba's orchard at Rock Hill, South Carolina, where very low yields have been obtained the past several years.

Results from a test spray program using Guthion and several levels of Thimet ground application gave encouraging results (Table 35). In his report of the study, Gary DeBarr, U. S. Forest Service entomologist, stated: "Guthion had a dramatic effect on the average number of filled seed per cone. Sprayed cones averaged almost seven times more filled seed/cone than the unsprayed. More than 25% of the seed from the Guthion-sprayed cones showed damage by seed bugs. Since radiographic analysis detects primarily late season damage, it appears the spray program was ineffective during the weeks prior to harvest." Thimet was not very effective, and a late spray of Guthion is necessary for better results. Still, the 28 seeds/cone following use of Guthion is not a suitable yield, showing the need for Furadan or some other insecticide that will enable us to double this number of seeds/cone.

Table 35. Response of Virginia pine to Guthion sprays and Thimet application in Catawba's orchard in South Carolina

Treatment	Total Seed/ Cone	Number Filled Seed/Cone	Percent Filled Seed/Cone	Percent Seed Damaged By Seed Bugs
Check	22.7	4.1	18.9	29.0
Guthion	45.0	27.9	58.0	26.9
Thimet (2 oz./in. DBH)	16.7	4.8	30.6	24.7
Thimet (4 oz./in. DBH)	24.6	8.1	30.3	20.5
Thimet (6 oz./in. DBH)	16.9	5.3	28.1	31.7

White Pine

Furadan has been very effective on the white pine cone beetle, as found from a study by the N. C. Forest Service. Results (Table 36) were so good as to be almost unbelievable.

Table 36. Control of the white pine cone beetle by Furadan in a seed orchard of the N. C. Forest Service, Morganton, North Carolina

Furadan Treatment	Number of Sound Cones Left on Trees	Percent Sound Cones
4 oz./in. DBH	749	75
8 oz./in. DBH	988	97
12 oz./in. DBH	823	97
Check--No treatment	105	8

Slash Pine

Furadan treatment has been very effective on slash pine. The magnitude of control effects on the cone worm (*Dioryctria*) and seed bugs (*Leptoglossus* or *Tetyra*) are shown by a study conducted by Union Camp in Georgia (Table 37). Approximately three times as many cones were obtained from the treated compared to the untreated grafts. Of special interest is the relatively low effectiveness of the Guthion sprays in total cones per tree. The effect of Furadan can be designated as nothing short of *fantastic*.

Table 37. Cone yields of slash pine in 1975, as affected by insecticides in the Rincon, Georgia slash pine seed orchard of Union Camp

Treatment	Oz./In. DBH	Cone Worm Infested (%)	Cone Yield (No. Cones/Tree)
Check	0	1.9	70
Furadan 1/	4	0.7	213
Furadan 1/	8	0.9	246
Furadan 1/	16	0.5	250
Operational Guthion	spray	2.4	80

1/ One application/year of 10-G concentration in 1974 and 1975

Much of the improved cone yield is the result of the greater retention of yearlings following Furadan treatment (Table 38).

Table 38. Strobili survival[1/] from flowering to cone maturity in the Union Camp slash pine seed orchard, Rincon, Georgia

Treatment	Trees	Conelets	Survival %	
	--------Number---------		Avg.	Range
Check	10	132	15.9	(0 - 38.9)
Furadan (16 oz./in. DBH)	5	125	87.2	(75 - 100)

1/ Tagged 3/14/74; final tally 9/10/75

2/ Applied March 21, 1974

Loblolly Pine

Most discussion of the value of Furadan has related to control of seed bugs. A pleasant surprise has been its relatively good control of cone worms (Dioryctria) determined at time of harvest. This is illustrated by tests made by members of the Cooperative with treatments applied the year before harvest, the year of harvest, and both years (Tables 39, 40, and 41).

Table 39. *Dioryctria* (cone worm) control in 1975 with one broadcast application of Furadan on loblolly trees in the second year of cone development

	Oz. Furadan/Inch DBH		
	0	4	8
	(% Infested with *Dioryctria*)		
Continental Can, Hodge, La.	10.0	4.9	5.7
International Paper, Georgetown, S. C.	7.3	2.2	1.6
Virginia Division of Forestry, Providence Forge, Va.	10.9	1.6	0.7
Weyerhaeuser, Aliceville, Ala.	No *Dioryctria* Problem		

Application of Furadan is quite effective for the maturing cones in the year applied.

Table 40. *Dioryctria* (cone worm) control in the second year following one treatment of loblolly trees with Furadan in the first year of cone development

	Treatment in First Year-- Oz. Furadan/Inch DBH			
	0	4	8	16
	(% Infested with *Dioryctria*)			
Georgia Kraft, Greensboro, Ga.	1.9	3.0	5.4	2.2
Georgia Forestry Commission, Cochran, Georgia	3.0	3.7	3.7	2.1

There is essentially no carry-over for cone worm control evident from the first to the second year. Therefore, application of the chemical must be made early in the year during both years of development for continuous and full protection.

Table 41. Dioryctria control of the 1975 cone crop of loblolly pine treated with Furadan, both in 1974 and 1975

	Oz. Furadan/Inch DBH		
	0	4	8
	(% Infested with Dioryctria)		
Virginia Division of Forestry, Providence Forge, Va.	10.9	--	0.6
Weyerhaeuser, Washington, N. C.	41.7	17.8	12.0
Federal Paper Board, Lumberton, N. C.	14.4	2.7	1.7

Treatment for two years also preserves many yearlings, the results of which are not shown in the above table. Cones are well protected the second year, as shown in Table 41. Jim Capony, entomologist for the Virginia Division of Forestry, summarized the situation well when he stated, "The results speak for themselves but it looks like Furadan gave us as much control of Dioryctria as we could hope for."

The practical importance of sprays in controlling insects was illustrated for two small, similar-aged, equal-sized orchards. Orchard No. 1 was sprayed twice with Guthion; Orchard No. 2 was not sprayed.

	Bushels	Pounds of Seed	Pounds of Seed/ Bushel
Orchard No. 1	73	66	0.90
Orchard No. 2	38	27	0.71

Results indicate that the sprays protected the yearling cones, resulting in nearly twice the cone yield, and that it controlled seed bugs enough to gain a 0.2 lb./bu. differential. These differences are credited to insecticides, but other factors such as freeze damage from a differing irrigation schedule might have biased the outcome.

The high cost of Furadan at 4 to 8 oz./in. of tree diameter has caused some concern. With the kind of control and improved yields obtained in the preliminary tests reported here, the extra money spent for the insecticide produces very inexpensive seed. The costs of orchard establishment and management are paid, regardless of seed yield; so if one can double, triple, or quadruple the seed yields through expenditure of a couple of dollars per tree for Furadan, it will be an excellent economic investment.

A good study spanning an 18-month period in the Virginia Division of Forestry seed orchards has been summarized in an internal report.[1/] Two paragraphs from the conclusions follow:

> "Compared with previous years, overall loss of seed caused by insects was probably moderate in 1975. First-year seed bug damage was heavy, second-year damage was very light, and total cone worm damage was moderate. However, these apparently moderate losses to insects amounted to more than the total seed actually harvested, and these losses should be regarded as essentially preventable. If all insect damage had been prevented, the total sound seed harvested would have been over 2.3 times greater.
>
> "In this study, losses to insects were much greater during the first year of cone and seed development than during the second (28.0% seed loss vs. 9.2%). While this relationship may change from year to year, it appears that the potential for insect-caused losses is greater during the first year. Therefore, control measures should be directed primarily toward protecting cone crops during the first year of development. If substantial insect control is realized, then some protection will probably be gained the second year because of reduced insect populations."

Progeny Tests

The success of any genetics program revolves around the efficiency and results from its testing program. Progeny testing has been a main focus within the Cooperative because it produces (1) information on the value of parents used in seed orchards, enabling an upgrading of genetic quality by roguing, (2) a population from which trees can be obtained for advanced-generation breeding, (3) information

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[1/] Capony, J., R. G. Wasser and T. C. Tigner. 1976. Evaluation of seed losses by mortality factors of the 1974-75 loblolly pine seed crop (mimeo report). Virginia Division of Forestry, Charlottesville.

enabling estimates and uses of genetic variation for further development of a breeding program.

Most of the initial tests of the original selections used to establish production seed orchards have been completed or are well advanced. Testing of progeny from special wide-cross selections, disease-resistant selections, and high yielders are underway; this year the first comprehensive crossing program amongst the good general combiners was started. When all progeny testing is combined it adds up to a very large, complex and costly effort, the magnitude of which can be seen from Table 42.

Table 42. Acreage planted and number of lots of control-pollinated progeny tests by species and type in the N. C. State Cooperative as of May 1, 1976

Species and Geographic Location	Acreage Planted Through 1975	Acreage Planted in 1976	Total Acreage
Loblolly--Coastal	908.6	88.5	997.1
Loblolly--Piedmont	682.2	96.1	778.3
Virginia Pine	97.7	27.2	124.9
Slash Pine	202.3	38.2	240.5
Pond Pine	52.4	4.6	57.0
Shortleaf Pine	16.9	0.0	16.9
Hybrid Pines	14.6	0.0	14.6
Longleaf Pine	3.9	0.0	3.9
Loblolly--Southwide			
Good General Combiners	140.6	54.5	195.1
Disease Diallel	22.6	29.2	51.8
Total	2141.8	338.3	2480.1
Kind of Test			
Main	1340.7	213.6	1554.3
Supplemental	770.8	124.7	895.5
Special	30.3	0.0	30.3
Total	2141.8	338.3	2480.1

Above--Progeny tests as far as the eye can see is the view from the youngest part of Champion International's tests near Newberry, S. C. Young tests in the foreground give way to the older tests in the background. This is an expensive, time-consuming but most essential part of a tree improvement program if maximum gains and a broad genetic base for ongoing generations are to be achieved.

Below--Most springs are frantic, but the spring of 1976 topped others of memory. A long period of cold followed by a long period of warm weather caused everything to happen at once. These happenings result in a choice of priorities, as shown by Georgia Kraft's having to delay moving grafts longer than desired. Despite the delay, they obtained excellent success in moving the 8-month-old grafts, thanks to their mechanical tree mover.

Genotype-x-Environment Interaction (Overseas Tests)

Several tests underway in the United States on African source material and in Africa on United States material have matured to the point that some useful comparisons can be made on relative performance in these two diverse areas. A knowledge of interaction is of vital importance if seed are to be produced overseas, based on performance in the new environment.

A major study involving growth of a number of clones from Weyerhaeuser's seed orchard after 43 months in South Africa, compared with 8-year results in the United States, gave generally very poor correlations (Table 43).

Table 43. Rank comparison of height growth of progeny of loblolly pine from Weyerhaeuser's North Carolina seed orchards at 8 years of age in North Carolina and 3 years, 7 months in Olifantsgeraante, South Africa

Weyerhaeuser--South Coastal			Weyerhaeuser--North Coastal		
Family	North Carolina (Rank)	Africa (Rank)	Family	North Carolina (Rank)	Africa (Rank)
8-66	1	7	8-59	1	10
8-74	2	8	8-61	2	6
8-102	3	4	8-50	3	8
8-68	4	11	8-141	4	7
8-76	5	5	8-1	5	1
8-31	6	1	8-43	6	11
8-29	7	6	8-5	7	4
8-35	8	2	8-26	8	5
8-33	9	3	8-8	9	14
8-78	10	10	8-7	10	2
8-53	11	9	8-46	11	12
8-106	12	12	8-44	12	13
8-63	13	13	8-58	13	3
			8-80	14	9

Another group of loblolly pine families whose seed was supplied by Neville Denison showed a little better correspondence when grown in South Africa and in the United States but still not an overall good correlation. Tests in the United States were made by Union Camp in Georgia and by Georgia-Pacific in Georgia (Table 44).

Table 44. Relative growth rates of the same families of loblolly pine from South Africa, when grown at two locations in Georgia

Family	South Africa 5.5-yr. height (ft.)	Rank	Georgia (Union Camp) 4-yr. height (ft.)	Rank	Georgia (Georgia-Pacific) 4-yr. height (ft.)	Rank
T-37	31.3	1	12.0	5	15.0	7
T-41	31.2	2	12.3	4	17.0	1
T-7	30.4	3	13.5	2	16.2	4
T-8	30.3	4	13.0	3	16.7	2
T-45	29.7	5	13.7	1	16.2	4
T-33	29.3	6	11.2	9	16.7	2
T-27	29.3	6	11.8	6	17.0	1
T-24	29.3	6	11.6	8	16.0	5
T-26	28.9	7	11.7	7	15.6	6
T-21	28.2	8	11.8	6	16.3	3
Average of local checks		(4 cks.)	10.3	(2 cks.)	14.8	

Although families T-41, T-7 and T-8 are consistently good growers, the overall correspondence in growth between all families is not very high. Concern has been expressed as to how susceptible the South African material might be to fusiform rust. Both tests in Georgia are in disease hot spots for rust, especially the Georgia-Pacific planting. Variation among families is shown in Table 45. Differences were very large amongst parents, and correspondence between families in the two Georgia plantings was reasonably good.

Table 45. Percent rust infection of loblolly pine families from South Africa when grown at two locations in Georgia where rust was prevalent.

Source	Union Camp Test % Infection	Rank	Georgia-Pacific Test % Infection	Rank
T-8	11	1	50	2
T-33	16	2	53	3
T-41	19	3	48	1
T-21	28	4	78	6
T-24	29	5	80	7
T-7	36	6	75	5
T-27	45	7	63	4
T-45	83	8	83	8
Checks	40		89	
Average	34		69	

Based on these comparisons and on test results reported in earlier annual reports, it is evident that growth correlations amongst young stands of similar genetic material are not always good between the southeastern United States and southern Africa. However, in the Martin Forest Reserve in Rhodesia, Coastal Plain clones 7-56 and 11-61 ranked the best, as they do in the Southeast, while several clones from the Piedmont have performed poorly in both areas. The Rhodesian study makes it clear that there is a very real difference in performance among geographic sources, with somewhat less correspondence in growth performance among families within a geographic source.

Special Disease Diallel

Several years ago a comprehensive crossing program was started involving a half-diallel among 23 parent trees whose progeny were known or suspected of having superior resistance to fusiform rust. Crossing was done regardless of the geographic source of the parents, creating some rather wide as well as some local crosses within a given physiographic area. The effort required to develop a 23-tree half-diallel is formidable indeed, but by joint action and participation by six members of the Cooperative all crosses were completed within three years. Generally, excellent seed yields were obtained. The field planting was designed to test resistance throughout the worst rust areas of the Cooperative's operating territory, both in the Piedmont and Coastal Plain. Outplanting began in 1974-75 with a total of four plantations, two in the Piedmont and two in the Coastal Plain. Additionally, four primary plantings and two secondary plantings were made during the 1975-76 planting season. Field plantings will continue for two more years until the bulk of the available crosses are well represented in approximately 22 different test areas.

The objective of this broad-based study is to pinpoint those specific crosses and clones that carry general resistance, thus enabling a broadening of the genetic base for disease resistance as well as for growth, form and adaptability. The results will provide the opportunity to get a "handle" on the genetics of fusiform rust, rust resistance, and rust-environmental interaction. Of major importance, the information and plant material necessary for establishing specialty disease resistance orchards with a broad genetic base will be generated.

Wood Properties of Progeny

When progeny test plantations are thinned, wood qualities are usually determined. Such was the case for two 10-year-old progeny tests of loblolly pine grown in the Piedmont of South Carolina by Champion International. The parents were average or below average in specific gravity.

Wood samples were obtained 5 and 15 feet above ground. In the main test, an average of 11 trees/family were sampled while four trees per family were sampled on the supplemental test. Specific gravity of wood with and without bark and of bark was determined. Moisture content of wood with and without bark was also determined. The difference in weight of about two lbs./cu.ft. between the debarked and unbarked samples gives an estimate of the weight per unit volume obtained when bark is included with chips, as would be obtained with a whole-tree chipper. Values have been summarized in Table 46.

The test trees had lower specific gravity wood than did the checks, a reflection of the average and low specific gravity of the parents. Family average values in the main test had considerable variation from .362 to .400.

Table 46. Weight and moisture content of barked and unbarked wood and of bark from two 10-year-old loblolly pine progeny tests in the Piedmont of South Carolina (Parentheses are lbs./cu.ft.)

Type of Test	No. Trees Sampled	With Bark		Debarked		Bark
		Sp. Gr.	Moisture %	Sp. Gr.	Moisture %	
Main	181	.350 (21.9)	150	.378 (23.6)	154	.230 (14.4)
Supplemental	44	.340 (21.2)	157	.376 (23.5)	163	.253 (15.8)

	Wood Specific Gravity	
	With Bark	Debarked
Main test orchard progeny	.351	.373
Main test check trees	.363	.384
Supplemental test orchard progeny	.340	.376
Supplemental test check trees	.357	.406

Testing for Special Problem Areas

Trees for Deep, Droughty Sands

Several members of the Cooperative have studies underway to determine which species, and which sources of the most suitable species, will grow best in the droughty sandhills area. An additional objective is to determine sources of disease resistance in this area of very high incidence of fusiform rust.

In the more southern areas, sand pine (Choctawhatchee Race) has performed well for St. Regis, Brunswick, Union Camp, and others. Its utility farther north is now being tested by Federal and Catawba and is being compared with sources such as the Texas drought-resistant loblolly, Virginia pine from the Eastern Shore of Maryland, and longleaf pine.

Many foresters accept that slash pine performs better than loblolly pine on deep, sandy soils. Contrary to this idea, Catawba has found loblolly to be better than slash, even without using the drought-resistant source, although growth of neither could be considered satisfactory (Table 47).

Table 47. Survival and growth of loblolly and slash pine on deep sands after six years' growth at two locations in the sandhills of North Carolina

	Tract 1		Tract 2	
	Loblolly	Slash	Loblolly	Slash
Height (ft.)	12.0	11.7	9.6	8.4
DBH (in.)	2.7	2.4	2.0	1.6
Survival (%)	97	97	90	92
Fusiform Infection (%)	41	30	44	46

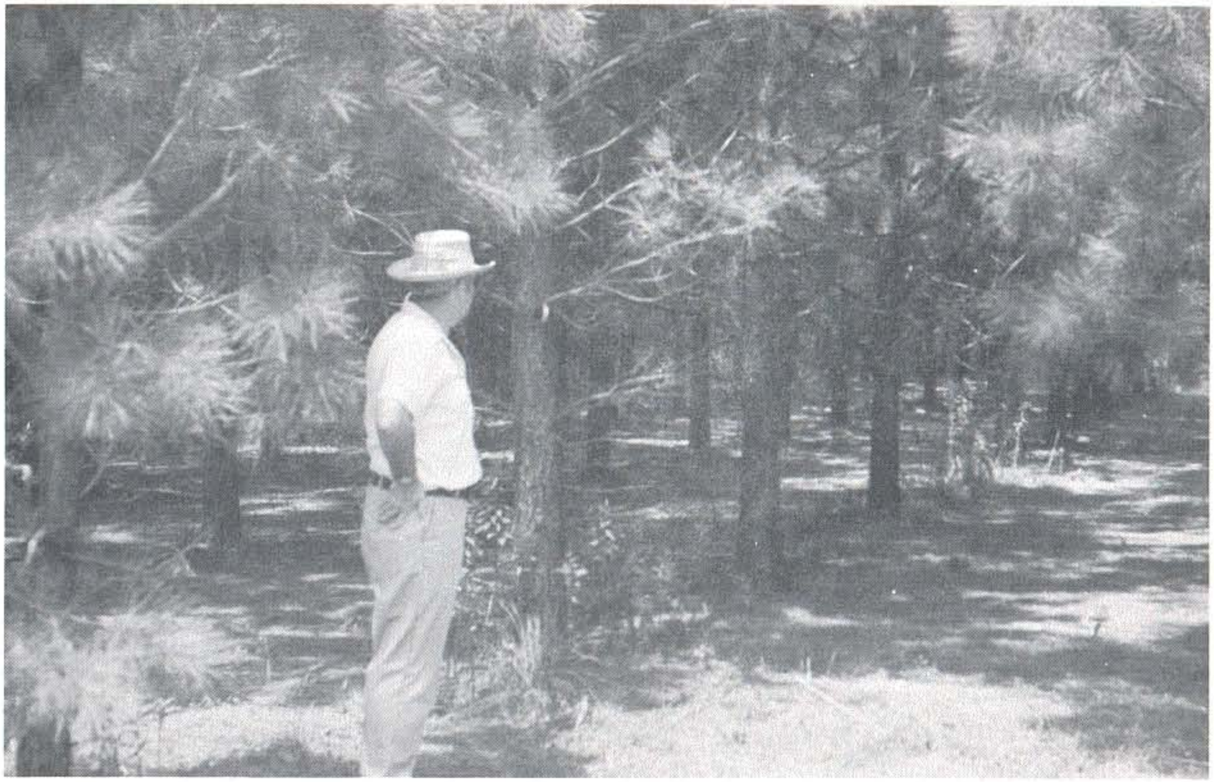
Loblolly grew better at both locations, with both species having similar survival rates. Although fusiform rust infection is about the same for the two species, many more of the slash will break and die in the next few years.

To obtain more information, Catawba established two tests of eight sources on deep sands. Results after three years are shown in Table 48.

Table 48. Three-year height and survival from a test of eight sources and species by Catawba on deep sands in North Carolina

Source	Height (ft.)	Survival (%)
Slash pine	3.9	87
Texas drought-resistant loblolly	3.9	95
Seed orchard loblolly (Piedmont)	3.5	97
Seed production area loblolly	2.9	95
Sand pine--Choctawhatchee Race	2.9	87
Virginia pine-- Eastern Shore of Maryland	2.8	97
Virginia pine-- Seed production area, Virginia	2.5	100
Longleaf pine	0.5	7

Observation after the fourth year shows the Texas drought-resistant loblolly pine source has drawn ahead of the others. Tip moth has caused great deformation in all but slash and longleaf pines. After the trees grow beyond the general range of tip moth damage, we expect the sand pine to challenge the loblolly in growth rate unless it is damaged by cold weather.



Many of the progeny tests of the seed orchard parents are large enough to thin. Shown is an 11-year-old Piedmont test of Champion International (above) before thinning, and (below) after half the stems were removed in the thinning operation. Good data on growth and wood qualities are obtained from the felled trees.

St. Regis has several species-comparison studies underway, primarily in areas of heavy fusiform rust infection. Three of these (Lumpkin, Blakely, and Cordele, Georgia) are summarized for survival and fusiform infection after four years' growth (Table 49). A striking result is the very low fusiform rust infection of the East Texas loblolly source and the low survival of slash pine, mostly for causes unknown but which may be due to early fusiform rust. The high amount of stem infection in the Marion County, Florida source is of special interest.

Table 49. Species comparison study by St. Regis in Georgia--Summary of survival and fusiform rust infection of slash and loblolly pines after four growing seasons at Lumpkin, Blakely, and Cordele, Georgia on lands of St. Regis

	Nursery Slash (%)	Marion County, Fla. Loblolly (%)	Nursery Loblolly (%)	East Texas Loblolly (%)
Survival	60.4	76.0	85.0	81.4
Mortality, Unknown Cause	32.2	18.2	10.3	15.7
Mortality, *Cronartium*	7.4	5.8	4.7	2.9
Total *Cronartium* Infection	47.5	48.0	40.0	6.5
Trees with Stem Gall (Potential *Cronartium* Mortality)	33.9	32.4	21.2	5.2

Trees for Severe and Cold Sites

As pressures for new forest land continue, operations are being pushed into areas for which pine species now used are only marginally suited. In addition to trials of potentially adapted species, for several years Westvaco has been field testing the pitch-x-loblolly hybrids in West Virginia, in cooperation with the U. S. Forest Service. Although the oldest plantings are now only five years of age, performance has been so encouraging that an operational hybridization program has been initiated.

From tests underway and those being planned, a determination is being made of the best parents to use to develop hybrids. Westvaco has found great differences in field performance of the hybrid, depending on specific parents used in the crosses. For example, in a 5-year-old test of 32 crosses at Alderson, West Virginia (elev. 2,350 feet) pitch 66 x loblolly 15A averaged 12.0 feet in height while pitch 63 x loblolly 23 averaged only 9.9 feet tall. Specific cross differences of this magnitude can be used to advantage in producing hybrids. The loblolly parent check (Maryland source) averaged 10.2 feet, the hybrids 11.1 feet, and the pitch parent check 7.9 feet tall. Nearly all the hybrids have better growth and form than the pitch and loblolly parents. Survival was excellent for the pitch pine and hybrids (85 to 100%) but, due to girdling by mice, loblolly survival dropped to 53%. The loblolly survivors have grown well considering annual terminal dieback, probably caused by sudden temperature drops characteristic to this area.

On a much poorer site at Duo, West Virginia, with an elevation of 3,250 feet, growth after four years was:

Hybrid (pitch-x-loblolly)	--4.4' tall
Pitch pine	--3.1' tall
Maryland loblolly	--2.5' tall

On this poor site the hybrid was definitely superior, although the overall growth rate was poor. Survival of the hybrid averaged 86%, the pitch pine 95%, and the loblolly check dropped to 38%.

Because of the need to increase the production on upland hardwood sites, there is a strong movement to manage the better ones for pine, following logging of the residual hardwoods. When such site conversion is done, a decision must be made on the best pine species and the best geographic source of that species to be used. Catawba has two such tests in the upper Piedmont which showed that loblolly pine has outgrown Virginia pine but, even so, Virginia pine has grown reasonably well through age six. The North Carolina seed source of Virginia pine from a seed production area was best in both tests. Survival was over 90% for both species (Table 50).

Table 50. Comparative growth of loblolly pine and two sources of Virginia pine after six growing seasons in the upper Piedmont of Virginia and North Carolina on lands of Catawba

	Patrick County, Virginia		Rutherford County, North Carolina	
Seed Source	Height (ft.)	DBH (in.)	Height (ft.)	DBH (in.)
Loblolly pine	14.4	2.8	15.0	3.1
Virginia pine (N. C. Source)	11.9	2.2	11.4	2.0
Virginia pine (Virginia Source)	10.1	1.6	10.5	1.6

A comparison of the central Alabama, east Tennessee, and western North and South Carolina Virginia pine sources by seed orchard and select tree family performance tests was made on the high Piedmont and Cumberland Plateau by Champion International (Table 51).

Table 51. Growth of four sources of Virginia pine and the loblolly pine check on lands of Champion International on the Cumberland Plateau of Tennessee

Seed Source and Species	Three-year Height Growth (ft.)
Central Alabama Virginia pine (orchard)	5.9
East Tennessee Virginia pine (orchard)	5.9
Western North and South Carolina Virginia pine (orchard)	5.8
Commercial Check Virginia pine	5.2
Loblolly Pine Check	6.7

These plantings have developed very well despite a high tip moth infestation. At least for three years' growth on these rather severe sites there is no difference among three geographic sources of Virginia pine from seed orchards; however, the orchard stock has outgrown the commercial check. We were concerned that the central Alabama source might not tolerate the low temperatures of the Cumberland Plateau, but no problems have yet developed. Family differences within source are quite outstanding; for example, among the 20 central Alabama sources planted in Jackson County, Alabama, height growth by seed orchard mother-tree varied from 7.2' to 6.1', with the commercial check being 5.8' tall.

General Combiners

Plantings of the loblolly pine general combiners throughout the South and overseas have developed exceedingly well. From the approximately 2,500 clones under test in the Cooperative, 160 were classified as good general combiners, *i. e.*, they produce good progeny irrespective of the other parent. As of June, 1976 these clones have been planted at 54 different locations by 33 companies in the United States, by two state forest services, and by nine overseas organizations in seven countries. Seven additional plantings will be established in the field in 1976-77.

Approximately 20 of the very best clones from different sources have been included in all plantings, regardless of location, while the remaining 25 to 30 clones of each planting are those deemed most suitable for the specific geographic location concerned. In addition to the good general combiners, sources representing the local commercial check and commercial collections from Livingston Parish, Louisiana, Marion County, Florida, and the Eastern Shore of Maryland are included in each test.

As this study of general combiners matures, four types of information will be obtained:

1. Locate genotypes that will do well within a region outside its native range. Inclusion of such good performing genotypes in 1.5- and second-generation breeding programs will greatly increase the genetic base of nonrelated genotypes.

2. Indicate how far it is safe to move the best-performing clones before problems related to pests, growth rate, or adaptability occur.
3. Give an unparalleled opportunity to make assessments of the strength and importance of genotype-x-environment interaction. This study has been designed especially to determine genotype-x-fusiform rust interaction as well as genotype-x-growth rate interactions.
4. Determine the performance of disease-resistant clones when grown in different geographic areas. It is now clear that there are different "strains" of fusiform rust and we need to know whether a specific clone resistant to one strain will also be resistant to the strain of rust in a different geographic area.

In Georgia, a rather high level of infection occurred in one nursery in which two general combiner tests were seeded, one scheduled for planting in the northern, the other in the western areas of the Southeast. Seedlings from clones from the northern sections of the Southeast, where rust is rather rare and thus not a major selection criterion, had nursery infection varying from 0 to 25%. Surprisingly, the Marion County and Gulf Hammock, Florida sources were as lightly affected as was the Livingston Parish, Louisiana source which is known for its uniform disease resistance. Three Virginia clones of loblolly pine were hard hit by rust. For the western area, where parents were severely selected for rust resistance, infection varied from 0 to 18%, with only one clone being over 10%. Infection of all clones common to both tests is shown in Table 52.

Table 52. Percent infection of two general combiner plantings infected by Cronartium fusiforme in a nursery in Georgia, compared to infection in field plantings

Clone	Nursery Infection (%)	Field Performance of Progeny 1/	Source and Comments re Areas Where Progeny were Tested 2/
10-5	0.0	E	Bad rust area in Ga.
10-2	0.5	E	Bad rust area in Ga.
8-68	0.5	E 2/	North of bad rust area in N. C.
7-2	1.0	G	Bad rust area in Ga.
17-16	1.5	G	Bad rust area in Ala.
10-25	2.0	E	Bad rust area in Ga.
8-59	2.5	A 2/	North of bad rust area in N. C.
7-56	3.0	E	Bad rust area in S. C.
11-16	3.0	A	Bad rust area in S. C.
11-10	4.5	G	Bad rust area in S. C.
11-61	5.0	Not Tested	Bad rust area in S. C.
11-2	5.0	A-	Bad rust area in S. C.
1-64	5.5	G	Moderate rust area in Ga.
10-10	6.0	E	Bad rust area in Ga.
8-76	7.5	A 2/	North of bad rust area in N. C.
8-1	9.0	E 2/	North of bad rust area in N. C.
5-5	11.0	G	Bad rust area in Ga.
8-61	11.0	A 2/	North of bad rust area in N. C.
4-18	11.0	A 2/	North of bad rust area in Va.
2-40	14.5	A 2/	North of bad rust area in Va.
2-33	25.0	A 2/	North of bad rust area in Va.

1/ Performance of progeny classified as excellent, good, average, or poor, based on several plantings 5 to 10 years old.

2/ Test plantings had low infection percent, so rust resistance data are not too reliable.

Resistant clones from various areas throughout the Southeast were also generally resistant in the nursery in Georgia. Although a tree from north of the rust area occasionally is resistant (8-68 and 8-59), the majority of trees from the lightly tested northern sources, whose classification as to rust resistance is suspect because of the low rates of infection in the progeny tests, are the most susceptible. In another test from the northern sources where there was little selection for disease resistance, rust infection in the Piedmont progeny averaged 19% (2% to 48%), while the Coastal Plain sources, intensively selected to be rust-free from badly diseased stands, were only 5% infected (0% to 15%).

MSI Portable Data Recorder--Troubles and Triumphs

The entire Cooperative has completed the transition to use of the MSI battery-operated portable data collection terminals. All progeny measurements collected in the winter of 1975-76 were entered on the computer directly from the portable units. In general the transition went well, with few major complications and overall faster turnaround of measurement summaries. However, the switch to this new system has not been without some frustration, and, in retrospect, some of the mistakes listed below are even amusing. For example:

1. The machine was stopped in the middle of data transmission to the computer because the operator thought the beeps and buzzes (the actual data signal) were "garbage" noises.
2. The wrong side of the tape was transmitted and the operator couldn't understand why an expected 5-minute transmission was finished in 5 seconds!
3. An entire test was recorded without including the company number in the cross designation. The rationale was that, since all crosses were among clones from the same company, it wasn't needed. The fact that these data are stored on the computer with data from all other cooperators requiring company designation was not understood.
4. A serious mistake made by too many people was forgetting to record or recording one or more replication ID codes incorrectly. This necessitates a correction on all trees in the replication done wrong, a very time-consuming process that greatly slows data turnaround.

5. The expected "row-measured-backward" error and the 95-foot tall (instead of 9.5') tree in a 4-year-old test were encountered. Only in a couple of cases were such errors frequent enough to cause concern.

The Cooperative has taken a bold step forward in modernizing the data collection and analysis system by using the portable data recorder. We are already realizing the benefits as a result of faster and less expensive data processing, resulting in more up-to-date information becoming available sooner for decision-making. Improved technology will enable even more progress in the future, but we are well satisfied that the new system will serve well for many years. The widespread concern that the system would not be adaptable, that errors would be rampant, did not materialize. Several companies sent in errorless transmissions; the prime example is Weyerhaeuser's crew in North Carolina, who measured and transmitted data on 16,000 trees (192,000 individual measurements plus hundreds of header notations) with not one single detectable error. Such an accomplishment is fantastic and shows that errors made by others are mostly of the human type, not a failure of the system.

Miscellaneous--Pine

Site Preparation

The effect of site preparation, especially bedding, on growth, survival and disease resistance of loblolly pine was recently evaluated after five years in the field by Container Corporation near Fort Deposit, Alabama in an area of heavy rust infection (Table 53).

Table 53. Effect of site preparation on growth, survival, and disease incidence on a 5-year-old loblolly pine plantation 1/

Treatment	Tree Height (ft.)	% Survival	Rust Infection Severity Index 2/	Rust Infection %
Subsoil and bed	13.5	87	2.7	55
Bed only	12.2	92	1.9	31
Check (flat planted)	10.6	83	1.5	13

1/ From a study by Container Corporation, Brewton, Alabama, on rolling, upper Coastal Plain terrain near Fort Deposit, Alabama

2/ The higher values indicate more severe stem infections.

Major findings were:

1. Height growth differences, statistically significant at the 5% level, were best on subsoil and bed, poorest on flat planting.
2. There is no statistically significant difference in survival by treatments.
3. Rust infection as measured by the severity index indicated subsoil and bed plantings were most susceptible (55% infection) and flat-planted the least (13% infection); differences were statistically significant at the 5% level.

Champion International in Alabama has established an excellent site preparation study including both hardwoods and pines. Fourth-year measurements have shown that for all species the bedding treatment is the best, with shearing plus windrowing alone the poorest. Loblolly pine is distinctly superior to the other species, with the seed orchard source being a little better than the others. The hardwoods respond much more positively to intensive site preparation than do the pines (Table 54).

Table 54. Response of 4-year-old pine and hardwood to different methods of site preparation. study by Champion International in north Alabama

Species	Clear 1/		Clear & Disk		Clear, Disk & Bed		Clear & Bed		Species Means	
	Surv. %	Ht. (ft.)	Surv. %	Ht. (ft.)	Surv. %	Ht. (ft.)	Surv. %	Ht. (ft.)	Surv. %	Ht. (ft.)
Sweetgum	77	5.5	90	5.5	90	6.8	87	6.1	86	6.0
Sycamore	70	3.9	93	5.3	100	6.2	90	6.2	88	5.4
Black Alder	80	5.2	75	5.1	70	6.1	95	7.1	80	5.9
Yellow-Poplar	85	4.2	100	5.6	100	7.1	93	5.5	95	5.6
Hiwassee S. O. Lob.	82	8.8	93	9.3	88	9.0	84	9.1	87	9.1
K.-C. Supp. Va. Pine	80	6.0	89	6.8	93	6.5	77	6.8	85	6.5
Tenn. Comm. Lob.	93	8.1	98	8.8	95	9.2	89	8.9	94	8.7
Ala. Comm. Lob.	87	7.6	93	9.1	98	8.7	87	8.6	91	8.5
Site Prep. Means	82	6.2	91	6.9	92	7.5	88	7.3	88	7.0

1/ Clear--shear and windrow

Seedling Size

Although it is generally recognized that large seedlings are essential for good growth of hardwoods, the importance of seedling size within pines has been hotly debated. A recent study in South Carolina by Catawba showed the following (Table 55):

Table 55. Nine-year growth and survival of two seedling size classes of loblolly pines in the Piedmont of South Carolina

Seedling Size Class	Height (ft.)	DBH (in.)	Survival (%)	Fusiform Infection (%)
1/8" or more	32.2	5.7	83	20
1/8" or less	30.4	5.6	86	17

Catawba's report stated, "Initially the large size class seedlings outgrew the smaller seedlings. By the end of the third growing season the larger seedlings were . . . visibly larger than the smaller seedlings. During the fourth and fifth growing seasons the smaller seedlings 'caught up' a little . . . After

Top--Advertising pays!

Bottom--As pressures for land increase, foresters are forced to use marginal sites. To do this well it is necessary to find the species best adapted. Compared are slash and sand pine plantations on deep sands of Brunswick in Florida. The Choctawhatchee race of sand pine is well suited for these sandy, droughty sites.

nine growing seasons the larger seedling class is 1.8 feet taller and 0.1 inch larger in DBH." So the "jury is still out," but after nine years' growth the larger seedlings still have a small advantage.

Wood Properties and Rust Infection

In his continuing study on the effects of fusiform rust on wood and product yields, graduate student Mick Veal found that the terpene content of diseased wood was increased much more than were the nonvolatile extractives. In the most severely infected wood, he obtained a severalfold increase in terpenes (Table 56).

Table 56. Differential in yield of terpenes from rust-infected and rust-free wood

Wood Type	Terpene Content (% of O. D. Wood)	Percentage Increase in Terpene Content (Based on Clean Wood)
Clean (rust-free tree)	0.30	0
Clean (rust-infected tree)	0.28	0
Rust Severity Class 1	0.66	236
Rust Severity Class 2	2.04	730
Rust Severity Class 3	2.28	815

Veal points out that only 0.73 gal./cd. of terpenes was obtained from the clean wood compared to an expected yield of about 4 gal./cd. usually obtained from mature wood. He hypothesizes that the difference is due to the juvenile wood effect in the 12-year-old trees with which he was working.

The study to determine the effect of fusiform rust on pulping properties is nearing completion. Some results are summarized in Table 57 by Veal:

> "The data indicate strength of paper from the control is lower than commonly observed for loblolly pine . . . this may be the juvenile wood effect. Burst and breaking length of rust-infected wood are about 20% lower than the control but tear is unaffected. In the composite mix (25% gall wood, from all 3 severity classes, and 75% rust-free wood), breaking length is reduced by 10% - 15%, burst by about 10%, but tear is not affected. Pulp from diseased wood is easier to beat, requiring about 15% - 25% fewer PFI mill revolutions to achieve a C.S.F. of 600 mls. The 25% gall wood mix needed about 10% less beating. These data cannot be explained in terms of tracheid morphology or

chemistry. However, since the diseased wood tracheids are differentiated in the presence of the fungus, it is possible that the chemical organization of the cell walls of diseased wood is abnormal, hence affecting fiber strength per se as well as bonding properties."

Table 57. Strength of pulp from rust-infected wood (preliminary results for loblolly pine--kappa #90 pulps)

	Beating (PFI Mill Revolutions) CSF (mls)		Burst Factor		Breaking Lgth. (Km)		Tear Factor		Burst Factor		Breaking Lgth (Km)	
			Apparent Density						Tear Factor			
	600	400	0.60	0.75	0.60	0.75	0.60	0.75	85	110	85	110
Control	6000	9000	50	63	7.00	8.55	132	98	67	56	9.50	7.95
Severity Class 1	4500	7800	43	52	5.10	7.10	141	105	57	50	8.35	7.20
Severity Class 2	5250	8250	38	51	5.30	7.20	142	102	57	47	8.15	6.60
Severity Class 3	3500	6700	38	52	6.00	7.15	121	97	56	49	8.10	7.20
25% Gall Wood	5500	8250	45	57	5.45	7.35	129	104	68	54	8.60	6.85

Inheritance of Wood Qualities

As a continuing part of the Heritability Study with International Paper at Bainbridge, Georgia, the 11-year-old control-pollinated study was thinned. On the average, 25 trees per family were sampled for growth, specific gravity and moisture content, while about seven trees of each family were sampled for cellulose yield. Wood qualities were determined for some of the families, including holocellulose yield determinations, which are related to yields when pulped. Heritabilities have not yet been determined but variation patterns among families are evident; an idea of differences among families can be obtained from Table 58.

The large family differences of 6.2 feet in height, 1.4 inches in diameter, .07 in specific gravity, and 50% in moisture content were expected. Of special interest was the 3.6% difference among families in cellulose yield; it was smaller than anticipated. Even if high heritabilities are found, gains may not be large. Values were obtained, using the sodium chlorite method[1/] for samples obtained at the 5-foot level.

[1/] Byrd, Van L. 1964. An investigation of the effect of wood chemical constituents on kraft paper properties of four selected loblolly pines. M. S. Thesis, School of Forest Resources, N. C. State University, Raleigh.

Table 58. Growth and wood quality characteristics from 22 control-pollinated families of 11-year-old loblolly pine 1/

Family #	Avg. Ht. (ft.)	Avg. DBH (in.)	Sp. Gr. (Tree Avg.)	% Moist. Cont. (Tree Avg.)	% Cell. Yield (5' Level)
5A	34.5	5.9	.32	202	79.1
5C	34.4	5.2	.32	200	80.9
5E	35.6	5.7	.34	191	80.6
6B	35.4	5.8	.34	198	78.4
6C	33.1	5.4	.31	219	78.6
6D	35.5	5.6	.33	200	80.6
23A	37.1	5.7	.36	177	81.2
23C	36.9	5.6	.35	194	79.8
23E	36.5	5.5	.34	196	78.8
24A	38.8	6.0	.34	191	80.2
24B	35.3	5.7	.34	194	79.7
24F	35.2	5.3	.34	198	79.5
25A	39.3	5.9	.38	169	80.0
25C	38.2	6.2	.37	169	80.3
26A	38.3	6.1	.35	184	80.5
26B	34.7	4.8	.33	209	80.4
26C	36.9	5.2	.32	213	82.0
41B	35.1	5.4	.34	201	80.4
41C	35.1	5.7	.32	207	79.8
41F	33.9	5.3	.33	196	80.8
55B	37.8	6.1	.34	198	80.2
55C	37.2	5.8	.34	192	78.9
Avg.	36.1	5.6	.339	195.4	80.0
Range	33.1 - 39.3	4.8 - 6.2	.31 - .38	169 - 219	78.4 - 82.0

Seed Harvester

Persistence pays dividends. This axiom was demonstrated in 1975 with the seed harvester. Following eight years of trials and tribulations, the Seed Harvest Committee accepted the vacuum model developed by Bowie Machine Works of Bowie, Texas as meeting the specifications set forth for seed pickup and separation. Following that milestone, the Committee was dissolved at the 1975 annual meeting of the Advisory Committee.

Two of the seed harvesters were sold by Bowie last fall for use in production seed orchards, one to the U. S. Forest Service for trial in their southern pine seed orchards in Mississippi and Georgia, and the other to Union Camp for use in

Above--Basic studies must accompany applied research. A special long-range project carried on by Hoerner-Waldorf is the establishment of a holding area of selfs from throughout the Cooperative. Ray Brown is showing some of the trees which are beginning to produce both male and female flowers.

Below--Differences in growth and form of selfs are great. One family of the 3-year-old selfs in Hoerner-Waldorf's arboretum grew rapidly and had wide, heavy crowns, while the other was small-limbed and slow of growth.

their loblolly pine orchards near Savannah. Neither machine performed completely satisfactorily, with the greatest limitation being the under-designed suction head and the narrow straw walker; the result was that the machine had to operate at about one-third of its desired speed to prevent clogging by debris picked up. Seed pickup was excellent. Both buyers were sufficiently encouraged by the performance of the machine to develop certain modifications to make the shaker-sweeper more operational.

Pollen Storage

During the past several years Jerry Sprague and Vernon Johnson have been developing a method to extract and store pollen for use in making future crosses amongst general combiners, second-generation selections, and wide crosses. Methods used have been reported in earlier annual reports.

The pollen storage facility is in full oepration. In January, 1976 there were 133 test lots of 103 clones stored in 749 vials, and many more were added during the spring of 1976. Germination of the stored pollen has been excellent, much better than we had hoped. This backlog of stored pollen enables activation of the plans for crossing needed to speed up activities in the Cooperative Program.

Block Planting of Half-Siblings

We have had several requests for information relative to the block plantings being made by Weyerhaeuser in North Carolina. Upon request Floyd Bridgwater submitted the following:

> "The North Carolina Region of Weyerhaeuser Company is regenerating settings with single half-sibling family blocks for the second season. Eighteen million genetically improved seedlings from the first-generation North Coastal High-Density Orchard were planted in half-sibling blocks during 1974-75. During 1975 and 1976, 21 million seedlings from the same orchard will be planted in half-sibling family blocks.

"The average setting size regenerated with the single half-sibling family is 50 acres. The maximum size is 75 acres, with the exception of one or two larger settings planted on a trial basis.

"Half-sibling families are assigned to sites representing eight soil management classes on the basis of their performance in progeny tests established on three sites from 1964 through 1967. This practice will result in gains greater than those predicted for bulked seed from first-generation orchards, since it takes advantage of the genotype-x-site interaction in addition to the additive genetic variance.

"It should be noted that this practice per se does not decrease the genetic variability of material planted in North Carolina. The same numbers of each half-sibling family represented in an orchard bulk seed lot are simply rearranged into contiguous half-sibling family blocks."

Membership of the Pine Cooperative

Organization	Working Units and States
American Can Company (Southern Woodlands Division)	Ala., Miss.
Brunswick Pulp Land Company	S. C., Ga., Fla.
Catawba Timber Company (Bowaters Carolina)	S. C., N. C., Va., Ga.
Champion International	Alabama Div.--Ala., Tenn. Carolina Div.--S. C., N. C., Ga.
Chesapeake Corporation of Virginia	Va., Md., Del., N. C.
Container Corporation of America	Ala.
Continental Can Company, Inc.	Savannah Div.--S. C., Ga. Hopewell Div.--N. C., Va.
Federal Paper Board Co., Inc.	N. C., S. C.
Georgia Kraft Company	Ga., Ala.
Georgia-Pacific Corporation	Va., N. C., S. C., Ga., Fla.
Great Southern Paper Company	Ga., Ala., Fla.
Hammermill Paper Company	Ala.
Hiwassee Land Company (Bowaters Southern)	Tenn., Ga., Ala., Miss., N. C.
Hoerner-Waldorf Corporation (Halifax Timber Division)	N. C., Va.
International Paper Company	S. C., N. C., Ga.
Kimberly-Clark Corporation (Coosa River Division)	Ala.
MacMillan-Bloedel Corporation	Ala., Miss.
Masonite Corporation	Miss.
North Carolina Forest Service	N. C.
Rayonier Inc.	Fla., Ga., S. C.
South Carolina State Commission of Forestry	S. C.
St. Regis Paper Company	Ala., Miss., W. Fla.
Tennessee River Pulp and Paper Company	Tenn., Ala., Miss.
Union Camp Corporation	Savannah Div.--Ga., S. C., Ala. Franklin Div.--N. C., Va.
Virginia Division of Forestry	Va.
Westvaco Corporation	South--S. C. North--Va., W. Va., Ohio, Tenn., Ky., Miss.
Weyerhaeuser Company	N. C. Div.--N. C., Va. Miss.-Ala. Div.--Miss., Ala.

SHORT COURSES

Due to personnel changes which frequently occur in industry, the Cooperative staff has periodically held short courses to give new personnel practical orientation in the basics of tree improvement or hardwood management. The Tree Improvement Short Course covers such topics as genetics, seed source, inheritance, and genetic gain, plus the practical aspects of selection, establishment and management of seed orchards, progeny testing, and seed orchard soil management. In recent years a short course pertaining specifically to hardwoods has been given several times, covering items such as natural regeneration, artificial regeneration, wood properties, hardwood tree improvement, and economic considerations. The last Hardwood Short Course was given May 18 - 20, 1976. A special Hardwood Seed Orchard Short Course was held in Raleigh on February 27, 1976, following requests by cooperators.

In addition to the more formal courses for pine and hardwood, we have held special short courses on hardwood management for the operational foresters for several Cooperative members. Such is done when at least 20 foresters are involved; those held to date have been very successful.

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