NINETEENTH ANNUAL REPORT

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

School of Forest Resources
North Carolina State University
Raleigh

June, 1975

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FOREWORD

A person can't help thinking "What next?" When last year's annual report was prepared, mills were having difficulty obtaining enough wood, solid wood products brought a good price and were selling briskly, the paper market was good, and optimism was generally widespread. At the time of writing the current annual report, timber is abundant, the solid wood product market is very depressed, paper markets are soft, and segments of the industry have a very pessimistic outlook. The current trend varies from cautious optimism to cautious pessimism; everyone seems to be waiting for an upturn--but the question is "when."

Despite the general slowdown and some budget problems, both the Pine and Hardwood Cooperatives have continued operations at a rapid pace. We become more enthusiastic each year as the increasing number of positive results from studies within the Cooperative make it easier to give positive recommendations and it is possible to suggest with more certainty methods to improve yields and quality of products from southern timberlands. We are using to full advantage the results from many years of research efforts to advise members of the Cooperative on the most efficient approaches to increasing timber production as early as possible. Now as never before, time is of key importance. Members of the Cooperative are not satisfied with improvements in general, and we are under increasing pressures to speed up utilization of information now available to obtain accelerated gains.

Although functions and services of the Cooperatives have remained generally the same, one important new dimension has been added. At the request of the highest level administrative officials within the industry, we have had a series of conferences and given numerous talks to those formulating policy and distributing funds for forestry activities. This most interesting job, which really is a "missionary" effort to place forest management within its proper perspective in the total wood-using industry, has required considerable time and effort but has been successful. Discussions center around available inventory over the long term and what can be done to insure a continued, reasonably priced supply of the best quality timber. One way to have an assured inventory is to make forest land more productive of desired amounts and qualities of products; this is a major objective of cooperative activities.

THE COOPERATIVE TREE IMPROVEMENT PROGRAM--PINE

Progress within the Pine Cooperative has been excellent; in this annual report we will feature two activities: (1) Long-range plans which can be summarized as "Where do we go from here?"; (2) progress and problems related to cone and seed production.

"Where do we go from here?"

For the past three years we on the staff of the Cooperative have had numerous planning sessions with detailed discussions and arguments concerning needed activities to make the Pine Cooperative of maximum value to its members, both in the short and the long term. Although much of the long-term planning fell on the capable shoulders of Bob Weir, he received a great deal of help and many suggestions from others, both within and outside the Cooperative. In retrospect, we have essentially completed the first phase of activities related to location of select trees and establishment of first-generation seed orchards, started 19 years ago. The second phase, which includes testing the selected trees to find the best genetic stock, is well advanced. The question then arises, "What next?"

Maximum Gains from Currently Available Material

We now have in our possession a tremendous amount of plant material for which considerable genetic information is available. This has been derived from over 4000 select trees that have been established in more than 170 seed orchards that occupy over 3000 acres. Many of these trees have been completely progeny tested in over 2100 acres of control-pollinated tests, while additional data have been obtained from several hundred acres of open-pollinated and special tests. This plant material is available now; some ideas to exploit it are shown on the flow chart (Fig. 1 on the next page). Immediate, large-scale payoffs from the Cooperative can only come if full use is made of what is already in hand.

1. One way of maximizing gains from currently available, genetically improved trees is to bring the outstanding general combiners[1/] from a number of organizations together into what is often referred to as "1.5-generation" orchards. Such improved first-generation orchards have been widely established and most new production orchards are of this type. Gains in volume production from these will be in the order of 15 to 25% over unimproved trees now being planted. Another way to capture gains from good general combiners is by distributing their pollen throughout the orchard; various schemes have been suggested. The objective is to increase the number of seed from the orchard whose parent (or parents) are the best general combiners.

[1/] A general combiner refers to a thoroughly tested clone that is uniformly good, regardless of other parents involved.

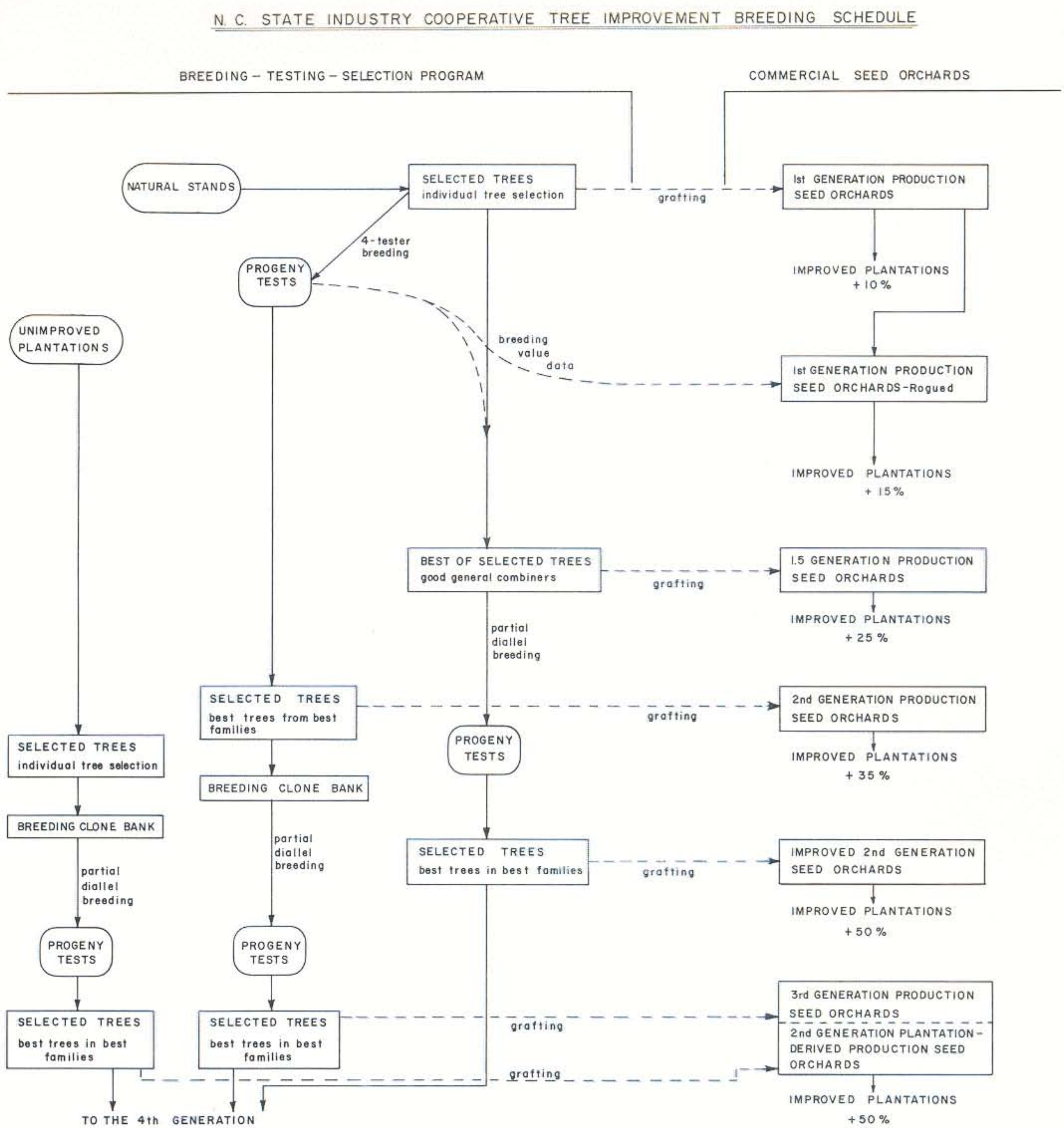


Fig. 1. Flow chart showing some short-term and long-term activities for the Cooperative; these consist of two basic activities:

1. Maximum, immediate utilization of the best plant material already developed
2. Development of a sound, broad genetic base through a long-term selection and breeding program

2. Another method of producing larger gains from currently available improved plant material is through development of super second-generation seed orchards; this has been started. It consists of:
   a. Crossing amongst the best general combiners, both within and between geographic regions.
   b. Selecting the best trees from the best families in progeny tests of these crosses.
   c. Moving the selected trees into production, super second-generation seed orchards. Because of the quality of parents used, we expect 50% gain rather than the 35% gain usual from second-generation orchards. Gains are always relative to the commercial planting stock now being used.
3. Sometimes there are specific combinations of clones that are greatly superior to other crosses; it is not unusual to find a specific cross 40% better than average. Large quantities of seed from specific crosses can be obtained from two-clone orchards or from mass production of a specific cross. Two-clone orchards have been established, although they must be planned carefully with special attention to selfing, phenology, and crossing ability. Seed from these good crosses will be incorporated into the general orchard seed supply, to increase the number of individuals from the good parents.
4. Specialty orchards are being widely used for problem areas. Special disease, drought and cold resistance, wet site, or specialty wood seed orchards have been established and are now producing seed in commercial quantities. As forestry gets pushed from the better sites to more marginal timber-growing areas, the need for specialty orchards with outstanding adaptability increases.

Selection and testing of trees in the first generation are nearly completed and we are now moving into advanced-generation breeding. The top picture is of an 11-year-old open-pollinated plantation of Weyerhaeuser in coastal North Carolina, grown with minimal cultural treatments. The seed orchard stock had 30% more volume than did the commercial stock. Below are second-generation grafts of International Paper Company now coming into seed production.

Long-Term Plans to Maintain a Broad Genetic Base

Because of the generally deleterious results from related matings, and because of the need to keep the genetic base broad, it is mandatory to continually infuse new material into a tree improvement program. We cannot operate in the future with a closed breeding program. The best method to maintain a broad base is to capture as much of the natural variation as possible. In the future, variation may need to be induced by radiation and hybridization, but for now we need to find and use the best that nature has developed. Therefore, we are expanding our selection program to double the number of parents currently being tested by requesting each member of the Cooperative to obtain an additional 100 selections for each of his major seed orchards. The current selections will differ from the initial selections as follows:

1. Insofar as feasible, selections will be from plantations.
2. Emphasis will be on volume growth, disease resistance, and adaptability, while still maintaining high quality standards. Because of greater efficiency of selection, gains in volume should be considerably greater than the 10 to 20% from the current first-generation orchards, in which tree quality was emphasized.
3. The selections will be established in holding clone banks, not placed in production first-generation orchards.
4. Trees will be crossed and progeny tested. From these, the best trees of the best families will be selected (second-generation selections) and combined with the third-generation selections of the original program to produce a new generation of orchards with a much wider genetic base than available in the second or super second-generation orchards.

It is essential to remember that the objective of this phase is to bring together and produce new gene combinations while still increasing gains. This is now being done by making wide crosses among our current best selections. By so doing we create new gene combinations not previously available; each of these must be tested for utility in a given area before it can be used to produce seeds for production plantations.

A wide cross study recently analyzed by graduate student Fred Owino was established eight years ago by Dr. Ronald Woessner; results have enriched our second-generation orchards with a considerably broader base. Fred summarizes as follows:

> "Studies on wide crosses are of practical importance in large tree improvement programs for several reasons. For companies with large landholdings, it is important to determine how far breeding stock can be moved from one geographic area to another both by themselves and/or when crossed with selection from other areas. Such studies also provide insight as to the desirability of exchange of trees among companies. Even of more long-term importance is the use of wide crosses to keep a broad genetic base for future selections. For these reasons, the big study involving the performance of wide crosses of loblolly pine planted in eight locations in the Southeast was established. The five-year field growth of these crosses is partially summarized in Table 1."

There are only small differences in height growth, fusiform rust resistance and straightness between the wide crosses and the within-company crosses. Crosses of Piedmont North Carolina and Texas loblolly appear slightly superior to the rest in both height growth and rust resistance. However, the general picture presented by these data is that companies can engage in exchange of selections after they have been tested for adaptability and growth rate. Such an exchange will broaden the range of adaptability within an organization's orchards. A number of selections from the wide-cross tests have already been established in second-generation seed orchards.

To further enrich the genotypes available for use within a region, the best of the 100+ good general combiners are under test. In 1975, 37 plantings were established throughout the South, and five are growing overseas. In 1976, 20 additional plantings, each consisting of open-pollinated seed from 30 to 60 of the best general combiners will be established in the South. Results from these tests will help determine where the best general combiners can be used. We find, for example, that Hoerner-Waldorf's clones 6-9 and 6-20 seem to be very adaptive and grow well in many differing environments.

Table 1. Performance of wide crosses amongst loblolly pine when tested in eight locations in the Southeast 1/

Cross	Mean Height (ft.)	Mean Rust Score 2/	Mean Straightness 2/
Weyerhaeuser x Weyerhaeuser 3/	9.03	1.13	3.31
Weyerhaeuser x Texas	9.37	1.06	2.67
Weyerhaeuser x Continental Can (Ga.)	10.06	1.12	2.55
Weyerhaeuser x Champion International (S. C.)	10.02	1.15	2.67
Weyerhaeuser x Continental Can (La.)	10.34	1.11	2.45
Weyerhaeuser x Hiwassee Land Co. (Tenn.)	9.97	1.06	2.23
Weyerhaeuser x Hoerner-Waldorf (N. C.)	10.19	1.20	2.52
Average with Weyerhaeuser	9.85	1.12	2.63
Hoerner-Waldorf x Hoerner-Waldorf 3/	10.58	1.33	2.73
Hoerner-Waldorf x Texas	10.97	1.02	2.54
Hoerner-Waldorf x Continental Can (Ga.)	9.81	1.32	2.31
Hoerner-Waldorf x Westvaco (N. C., wet site)	9.67	1.20	2.63
Hoerner-Waldorf x Kimberly-Clark (Ala.)	10.19	1.24	2.36
Hoerner-Waldorf x Union Camp (Ga.)	10.53	1.28	2.49
Average with Hoerner-Waldorf	10.29	1.23	2.52

1/ Weyerhaeuser is a North Carolina coastal plain source, while Hoerner-Waldorf is a North Carolina Piedmont source.

2/ The lower the score, the better the rust resistance or straightness.

3/ Shortened company names will be used throughout the report; complete names are shown in the membership lists.

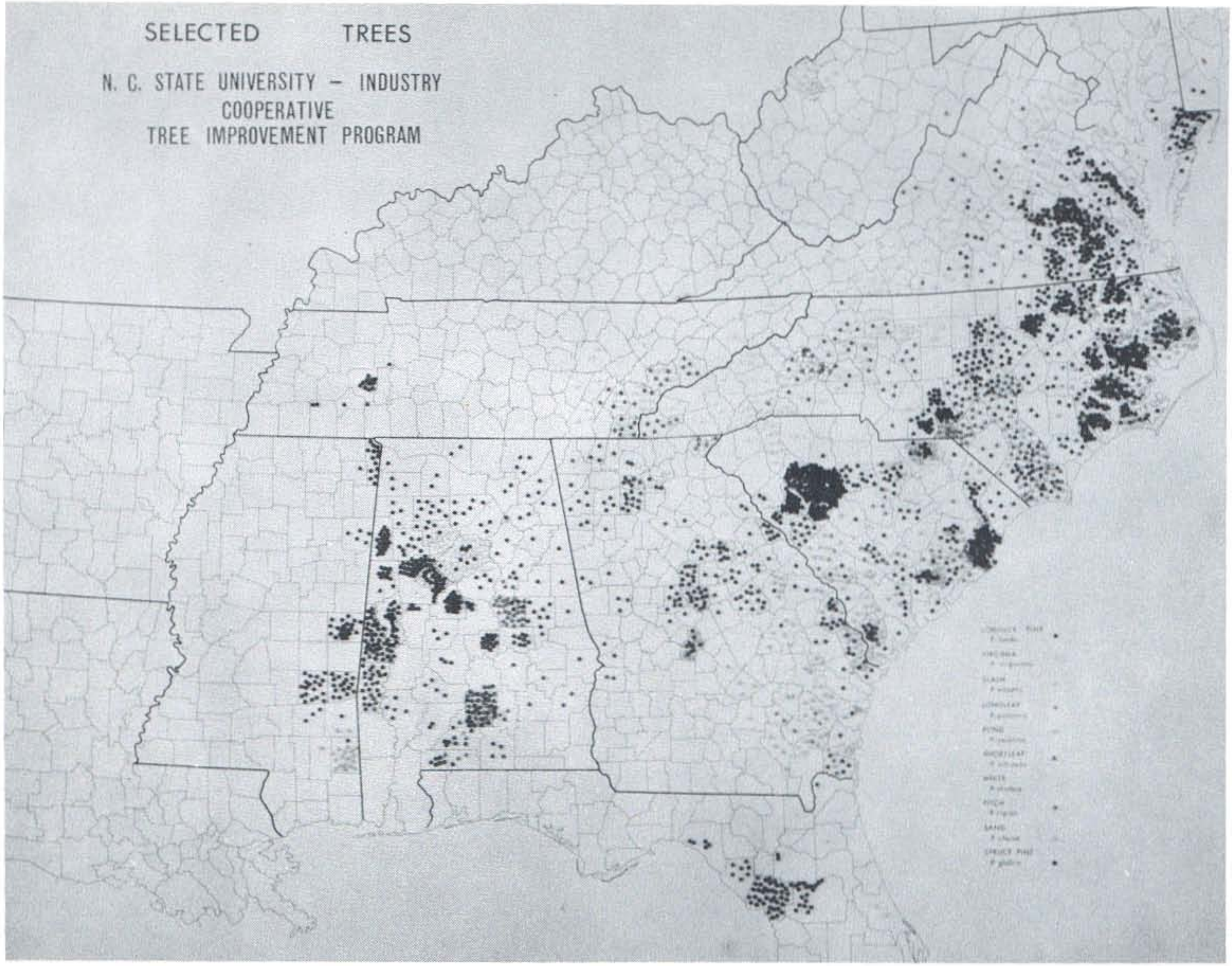
As pressures mount for the use of forest land for purposes other than growing trees, it is necessary to develop strains adaptable to adverse environments and marginal sites. Progress is being made, as evidenced by the loblolly pine (top picture) which is performing well in Ohio, well outside the species range. The bottom picture is a 10-year-old plantation of loblolly in East Tennessee growing well from seed orchard stock selected for more severe climates by Hiwassee Land Company.

Seed Orchards

Establishment of seed orchards continues at an ever-increasing rate and the Cooperative is getting heavily into advanced-generation and specialty orchards (Table 2).

Table 2. Acreages of the 171 seed orchards established (or to be established) by members of the N. C. State University Pine Cooperative, as of January 1, 1976

	Orchard Acreage by Generation and Type					
Species and Source	First-Gen.	1.5-Gen.	Second-Gen.	Disease-Resistance	Other Specialty	Total
Vegetative Orchards						
Coastal loblolly	1163	134	72	58	18	1445
Piedmont and Mountain loblolly	677	136	31	30	5	879
Slash	564	50	5	29	-	648
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
Sycamore	15	-	-	-	-	15
Sweetgum	21	-	-	-	-	21
Yellow-Poplar	7	-	-	-	-	7
Seedling Orchards						
Fraser Fir	4	-	-	-	-	4
Virginia Pine	12	-	-	-	-	12
Total	2801	320	108	117	23	3369



Select trees, as shown on the map, pretty well blanket the Southeast. The thrust of the third phase of the program is to double the number of selected trees, to broaden the breeding base and avoid relatedness in advanced-generation breeding. Greater emphasis will be on volume production in the selection of these trees than was placed on the original selections.

Three major problems have developed in the seed orchard program: (1) How persistent cones, such as loblolly pine, can best be harvested, (2) how to protect seed and cones from pests, and (3) how to manage the orchards to obtain maximum flowering, cone production, and maximum seed yields.

Seed and Cone Yields

With the known value of genetically improved seed, the economic worth of a tree improvement program can be related directly to the amount of seed produced within the seed orchards. It is essential to do everything possible to produce the maximum amount of seed, including management practices such as fertilizing and irrigating as well as preventing losses from pests and catastrophes caused by man or nature.

There has been considerable discussion about a fall-off of seed production as the orchards get older. This trend appears in the southern slash pine orchards but is not so evident in the northern slash or loblolly orchards if known losses from untimely freezing weather are taken into account.

Overall, loblolly pine seed production in 1974 was relatively poor, partially due to the small crops caused by a late freeze in the spring of 1973 (Table 3). Supplies of loblolly pine of any kind are in great demand for the 1975 planting season and will be critical for the 1976 season, because of a similar heavy freeze kill in spring 1974. The seed shortage has been magnified because of the greater seedling needs generated by the programs to assist landowners and because a high proportion of loblolly pine is now being planted in what was formerly considered as slash pine range. This switch from slash to loblolly gained momentum as results from paired species plantings show that on many sites, loblolly significantly outproduces slash pine.

Hiwassee Land Company's gamble in moving a nearly mature orchard, to prevent loss from flooding, has paid off. This "instant" loblolly seed orchard in Tennessee is flowering heavily four years after being moved.

We concentrate on loblolly pine but considerable work is done with other species. This healthy sand pine graft in the orchard of Union Camp Corporation in Georgia is producing good quantities of seed.

Table 3. Cone and seed yields in fall, 1974, from pine seed orchards of the Cooperative, compared to 1973 1/

	Bushels of Cones	Pounds of Seed	Pounds of Seed/ Bushel of Cones
Coastal Source Loblolly Pine	5122	5528	1.08
Piedmont and Mountain Source Loblolly Pine	3694	3245	0.88
Slash Pine	4088	3027	0.74 2/
Virginia Pine	144	36	0.25
Shortleaf Pine	36	8	0.22
White Pine	3	3	1.00
Longleaf Pine	24	4	0.17
Pond Pine	16	5	0.31
Fraser Fir	6	22	3.67
Total	13,133	11,878	----

1/ In 1973 we obtained 11,853 bushels of cones from loblolly and 2,779 bushels of cones from slash pine. These averaged 1.08 pounds/bushel for coastal loblolly, 1.06 pounds/bushel for Piedmont loblolly, and 0.58 pounds/bushel for slash pine.

2/ This value is low because one orchard produced 2,224 bushels of cones which yielded only 845 pounds of seed (0.38 lbs./bu.).

One of the more productive young orchards in the Cooperative is the Burnt Gin Seed Orchard of the South Carolina Commission of Forestry. It shows the normal trend of increasing seed yields with age, but with occasional serious drop-offs such as 1974, caused by the late freeze in spring 1973 that killed the flowers. There is an exceedingly heavy conelet crop for the 1975 harvest. Most striking is the difference in age when Coastal Plain and Piedmont loblolly source orchards come into production. Although acreages are not exactly the same, the orchards (Table 4) are the same age, grown on the same site, managed in the same manner. Piedmont sources always produce earlier and heavier seed crops than do the Coastal Plain sources, no matter where the orchards are located.

Table 4. Seed yields in pounds of seed from a Piedmont and a Coastal Plain loblolly pine seed orchard of the South Carolina State Commission of Forestry to show yearly fluctuations

Year	Piedmont Loblolly (40 acres)	Coastal Plain Loblolly (31 acres)
1969	28	--
1970	277	30
1971	225	5
1972	486	35
1973	1295	148
1974	335	64

International Paper has provided the following seed yields from their relatively heavy cone-producing Coastal Plain source loblolly orchard at Georgetown, South Carolina. As for many orchards, losses from freezes and insects caused low yields in 1974.

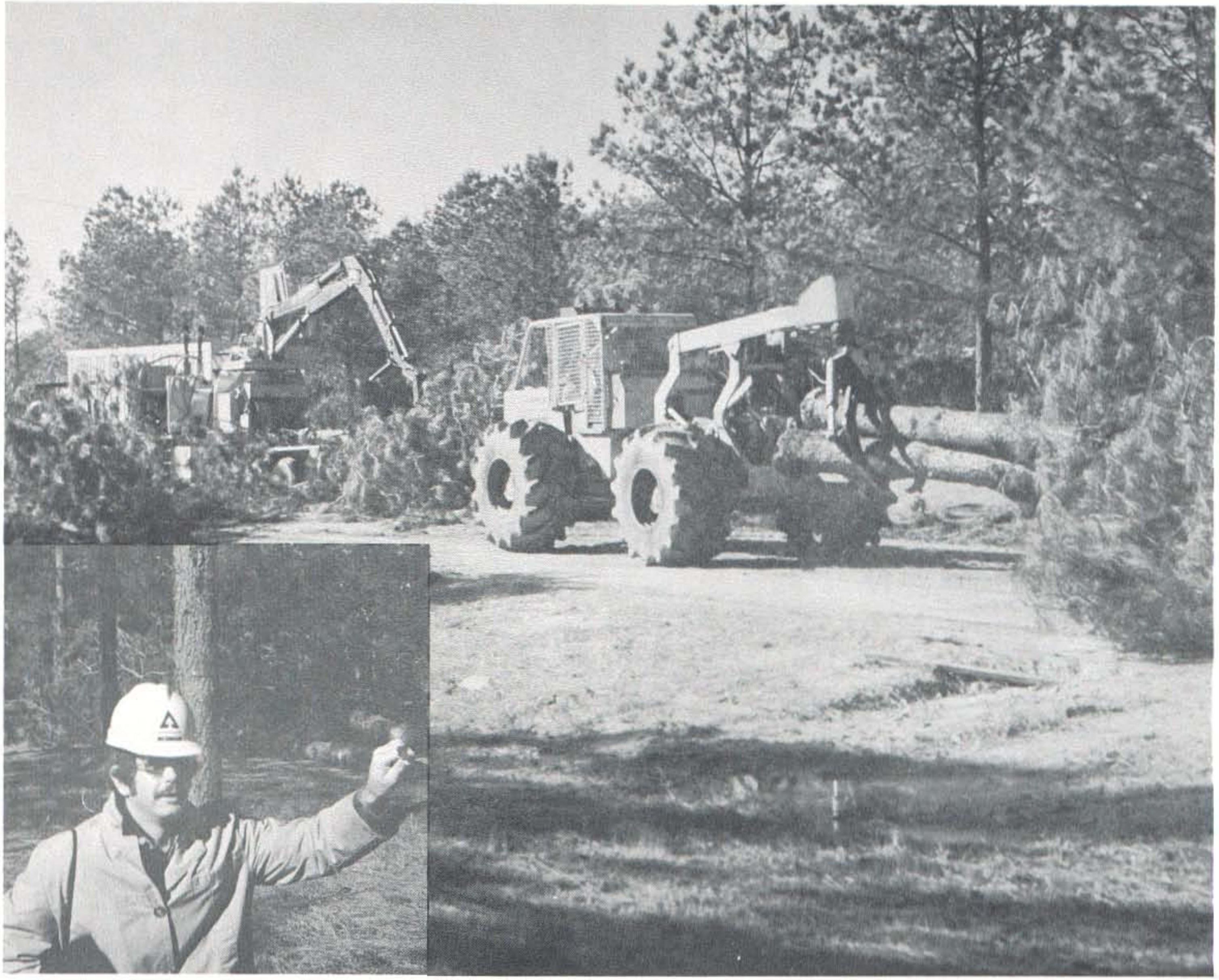
Pounds of Seed by Year

1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
12	17	23	305	449	476	655	1321	1763	1570	1135	488

The yields from Westvaco's young 28-acre loblolly orchard in coastal South Carolina also illustrate the effect of age and year on cone and seed production:

Year	Bushels of Cones	Lbs. of Seed/ Bushel
1970	371	1.2
1971	974	1.3
1972	169	0.6
1973	410	0.8
1974	258	0.6

In spring 1971, 1972, some in 1973 and 1974, late frosts hit the orchard, causing reduced yields, and it appears also in 1975. The pounds seed/bushel would indicate that insects may be causing an increasing amount of damage.



Thinning a seed orchard is always traumatic; when the trees are large it's also a major job. The problem was settled by Weyerhaeuser in North Carolina by using a whole-tree chipper (inset). During the thinning operation, Steve Dianis found a four-leaf clover which he hopes will mean no further visits from the orchard-markers from N. C. State.

Although our experience with cone and seed yields has been primarily with loblolly pine, St. Regis supplied us with a table of their slash pine seed orchard production on the Gulf Coast (Table 5). Notice the annual fluctuations in both cone and seed yields; years of heavy cone yields usually result in heavy seed yields although there are occasional exceptions. It is suspected that insects are becoming increasingly serious as indicated by seeds/bushel.

Table 5. Slash pine cone, seed, and seedling production from St. Regis orchards on the Gulf Coast

Year	Bushels of Cones	Pounds of Clean Seed	Pounds of Seed/ Bushel of Cones	Seedlings/ Pounds of Seed
1968	304	215	.71	8,372
1969	359	278	.77	8,633
1970	462	345	.75	8,406
1971	1,068	1,130	1.05	8,496
1972	305	167	.55	6,100
1973	650	494	.76	8,502
1974	930	461	.49	7,215

Their average yields of 8,000 estimated nursery seedlings per pound of seed are excellent for slash pine. (Estimates are from germination tests made at the Eastern Tree Seed Laboratory rather than from actual nursery inventory.)

Records on the effect of temperature kill of loblolly pine flowers were kept by the North Carolina Forest Service. There was no severe cold, but four days in the latter part of March had freezing temperatures. When an inventory was taken on April 12, the following was found (Table 6):

Table 6. Dead and live flowers of loblolly pine by clone, following three freezing temperatures in late March 1/

Clone	Total Flowers	Alive	Dead	% Survival
6-6	43	3	40	7
14-54	44	14	30	32
16-20	154	98	56	64
16-21	44	0	44	0
16-22	39	18	21	46
16-55	107	71	36	66
16-58	446	107	339	24
16-111	162	51	111	31
16-164	462	40	422	9
16-165	166	98	68	59
16-166	80	0	80	0
16-231	101	64	37	63

Overall Survival %: 31

1/ Two or three ramets were measured for each clone by the North Carolina Forest Service.

A great clonal response to kill by frost is very evident--two clones had all flowers killed, while two clones had over 60% of the flowers alive. Heavy losses from cold, such as the 69% shown by this sample of clones from the N. C. Forest Service's seed orchard, have contributed to the severe seed shortage. During the same cold period, Catawba Timber Company estimated they lost about 50% of their flower crop in the South Carolina Piedmont, and the heavy flower crop of Chesapeake Corporation in coastal Virginia was completely destroyed.

It is known that large yearly fluctuations take place in cone and seed yield, raising the question of the value of a single year's determination as compared to several continuous years. Table 7 shows results for consecutive yearly measurements for a few clones from Union Camp Corporation's orchard in Virginia. It appears that trends of cone size and seed/cone are evident enough in a single year, so the extremes can be broadly ranked. For example, clone 2-22 and 2-63 have large cones while clone 2-8 had small cones over all three years. Seed yields/

cone are consistently poor for 2-18 while 2-33 and 2-63 have good yields. Germination of sound seed is generally good for all clones over all years. Our assessment is that a single year's determination will indicate the extremes, but a really definitive determination of cone and seed production and characteristics will take several years.

Table 7. Cone size, seed yield/cone, and germination percent for three consecutive years for Union Camp's loblolly seed orchard in Virginia

	Cones/Bushel			Total Seed/Cone			Sound Seed Germination %		
Clone	1971	1972	1973	1971	1972	1973	1971	1972	1973
2-12	182	---	174	92	79	69	94	88	96
2-33	210	232	230	105	124	123	99	90	97
2-8	268	294	244	91	113	122	98	98	98
2-22	144	155	89	96	121	109	79	88	90
2-63	159	146	175	116	119	106	97	84	93
2-18	232	---	220	21	37	48	95	84	97
2-40	182	123	208	119	133	116	94	83	78
2-5	276	199	178	76	76	100	97	94	94
Average	207	192	190	90	100	99	94	89	93

A very valuable contribution from the U. S. Forest Service has been the assessment of cone and seed yields and losses through SOS (Seed Orchard Survey) and SOSET (Seed Orchard Seed Evaluation Tests). Such information is needed for proper assessment and subsequent removal of inferior clones from the seed orchards. Seed and cone characteristics for several members of the Cooperative are summarized in Table 8.

Table 8. Seed and cone characteristics of loblolly pine from different seed orchard tests in 1973 1/

Organization	Geographic Source	Average Cones/ Bushel	Total Seed/ Cone		Germination % of Sound Seed	
			Average	Range	Average	Range
S. C. Commission of Forestry	Piedmont, S. C.	356	88	49-158	97	89-99
Union Camp	Lower Coastal, Ga.	295	85	54-122	94	91-97
" "	Upper " "	255	94	36-129	95	86-99
" "	Coastal, Va.	204	100	48-123	93	76-97
Hammermill	Ala.--Upper Coastal Plain	--	89	29-166	97	91-100
Catawba	Piedmont, S. C. (High Sp. Gr.)	263	69	26-96	99	98-100
Catawba	Piedmont, S. C. (Low Sp. Gr.)	236	62	36-85	99	98-100
Continental Can	Coastal Va.	--	84	43-140	98	94-100
Hiwassee	High Piedmont, Ga.	--	69	22-127	97	78-100
"	Mountain, Tenn.	--	50	16-95	99	97-100
Champion International	Piedmont, S. C.	--	90	41-124	97	91-99
Average		268.2	80		96.8	

1/ Data where average cones/bushel are reported come from SOS tests; others are from SOSET tests. As expected, seed yields per cone vary considerably among orchards and tremendously among clones within an orchard.

A determination of the consistency of clonal seed production from year to year was one of the objectives of the SOS program. Shown are three-year results as supplied to us by Federal Paper Board (Table 9). There are large differences in seeds per cone among clones (Coastal 54 to 130; Piedmont 47 to 128). Generally, clones are consistent over years, although occasionally large yearly fluctuations are evident. Note the average year differences and the similarity between seed/cone yield in Piedmont and Coastal sources.

Table 9. Consistency of seed per cone by clone over years for the Coastal Plain and Piedmont sources in the orchard of Federal Paper Board Company

	Coastal Plain Seed/Cone					Piedmont Seed/Cone			
Clone	1971	1972	1973	3-Yr. Avg.	Clone	1971	1972	1973	3-Yr. Avg.
9-3	55	56	50	54	9-9	66	92	59	72
9-4	117	106	167	130	9-10	50	49	43	47
9-6	88	106	51	82	9-14	86	104	87	92
9-7	113	111	108	111	9-15	89	87	41	72
9-19	105	102	100	102	9-16	95	108	70	91
7-32	54	99	88	80	9-17	105	145	134	128
8-74	111	72	52	78	9-18	107	122	129	119
8-46	97	94	93	95	9-22	44	54	42	47
8-50	57	100	94	84	9-26	112	108	98	106
					6-20	106	127	74	102
Average	89	94	89	91		86	100	78	88

Value of Seed

Last year we presented data showing the present value of the extra wood produced by a pound of seed orchard seed, with given gains, interest rates, and stumpage values. One company made calculations using their own costs, interest, and yield figures, and found that the discounted value of a pound of seed determined by the extra wood produced 25 years hence was $577.44. Another company, operating in an area of high stumpage prices, obtained a seed worth of $1,010/lb. Because of the much greater genetic gains, the worth of second-generation seed will be greater than $1,000/lb. Seed worth also fluctuates with plantation spacing which varies from about 500 trees to as many as 1,000 trees/acre. Similar calculations were made by Bob Weir, based on the losses from insect depredations. The annual losses an organization experiences when 20, 30, or 40% of their orchard seed is lost to insects (or other pests and mishandling) are dramatic (Table 10). The value of methods to obtain greater seed production is also evident; great effort is warranted to prevent losses and to maximize production from seed orchards.

Table 10. Present value per pound of seed and present value of different percentage of seed loss to pests on a 40-acre loblolly pine orchard 1/

Value/cord ($/cord, 25 yrs. hence)	Present Value Seed/lb.	Present Value of Seed Loss from 40-Acre Seed Orchard					
		20% Loss Seed Yield/Ac./Yr.		30% Loss Seed Yield/Ac./Yr.		40% Loss Seed Yield/Ac./Yr.	
		20 lbs.	40 lbs.	20 lbs.	40 lbs.	20 lbs.	40 lbs.
20	$238	$38,000	$76,200	$57,100	$114,200	$76,200	$152,300
25	297	47,500	95,000	71,300	142,600	95,000	190,100
30	357	57,100	114,200	85,700	171,400	114,200	228,500
40	476	76,200	152,300	114,200	228,500	152,300	304,600
50	595	95,200	190,400	142,800	285,600	190,400	380,800

1/ Based upon:

a. One pound of seed produces 8,000 plantable seedlings.
b. Trees will be planted at an 8' x 10' spacing = 540/acre (or one pound of seed will plant 14.5 acres).
c. Rotation age is 25 years.
d. Genetic gain is 15%.
e. Interest rate is 8%.
f. Basic growth rate of unimproved stands is 1.5 cords/acre/year.

To indicate the loss from insects for the overall planting program in the southern United States for 1974, Weir developed Table 11. Note the many millions of dollars of potential loss each year from insects, or, conversely, the effort that should be made to determine controls or that could be spent to increase seed yields.

Table 11. Present value of seed losses from insect attack in established slash and loblolly pine seed orchards combined for the South 1/

Stumpage Value ($/cord, 25 yrs. hence)	Present Value of Annual Seed Losses		
	20% Seed Loss to Insects	30% Seed Loss to Insects	40% Seed Loss to Insects
20	$8,084,000	$12,126,000	$16,168,000
25	10,088,000	15,132,000	20,176,000
30	12,126,000	18,189,000	24,252,000
40	16,168,000	24,252,000	32,336,000
50	20,210,000	30,315,000	40,420,000

1/ Slash orchard acreage is 2,668, loblolly is 3,360, for a total of 6,028 acres of orchard. Calculations are for orchards having a potential production of 30 lbs. of seed/acre/year. The base growth rate of seedlings from orchard seed is 1.5 cords/acre/year.

Basic research is essential to a successful, ongoing, applied program. The most extensive and fruitful basic studies are those associated with the Heritability Study, a joint effort of International Paper Company and the Cooperative (with past funding by the National Science Foundation and the National Institute of Health). Each year, from 20 to 30 faculty and students travel from Raleigh to Bainbridge, Georgia to help make the great mass of measurements. Part of the group is shown at lunch break. Note the new addition--females.

Losses from seed and cone insects increase as more orchards come into production and closer attention is paid to orchard management. The estimated insect loss of 20 to 30% of the seed translates to a loss of wood production of approximately $25,000,000/year for all seed orchards in the South. It is axiomatic that the value of seed will increase greatly as advanced-generation orchards, with their greater genetic gains, come into production. To illustrate this, Don Smith developed Table 12, which shows the value of seed from a first- and second-generation orchard of the same size but with differing genetic gains.

Table 12. Seed value contrasts for first- and second-generation seed orchards[1/]

Quantity of Seed	First-Generation Orchard Seed Value	Second-Generation Orchard Seed Value
One pound	$591	$1,057
One year's production from 50-acre orchard	$1,182,000	$2,114,000

[1/] Based upon:
Present value of extra wood produced at 25 years of 1 lb. of seed, which will regenerate 16 acres from an orchard producing 40 lbs. seed/acre/year with stumpage values of $40/cord (25 years hence); calculations refer to:

Item	First-Generation	Second-Generation
Interest Rate	8%	10%
Genetic Gain	15%	35%
Productivity of Land Base	1.5 cords/acre/year	2 cords/acre/year

Increasing Seed Yields by Insect Control

If maximum seed production is to be obtained, seed and cones must be protected from insects. This need is well recognized by members of the Cooperative as shown by formation of the Seed Protection Committee which is investigating ways and means of control. Members of the Cooperative were asked to support requests for funds for U. S. Forest Service research on seed and cone insects, which they did in good fashion. Response to their collective action has been promising.

Storms don't always kill outright. The bark of this graft in Kimberly-Clark's loblolly seed orchard was twisted off by a tornado (left picture).
Tip moth attacks make it very difficult to assess tree quality at an early age. This is shown on an otherwise good, 6-year-old loblolly pine progeny of Continental Can Company in Virginia (right).

A number of studies have shown the amount of seed being lost to insects is large, and some results by Brunswick in a study with Gary DeBarr of the U. S. Forest Service illustrate this well. Part of the company's control-pollinated crosses were caged to protect them from insects, part left uncaged. Results for one very insect-susceptible clone and the average for the orchard (Table 13) indicate the heavy losses sustained.

Table 13. Seed yield/cone from caged and uncaged pollinations of slash pine; average for the orchard and for one very susceptible clone of Brunswick Pulp Land Company

	Plantation Average		Clone #271	
Pollination	Uncaged	Caged	Uncaged	Caged
Self	33	63	3	54
Polymix	45	55	2	17
Wind	56	76	15	139

As part of the tests of chemical control, the Seed Protection Committee, in cooperation with Gary DeBarr, caged cones in a number of orchards. Several orchards had no seed bug damage at all while others were hard hit (Table 14). This spreading menace must be controlled; damage was not restricted to mature cones and seeds but was also heavy to immature cones. Some estimates of 50% loss of conelets have been made, and in one orchard in Virginia it is fairly certain that 85% of the yearling cones were destroyed by insects.

Table 14. Estimates of cone and seed losses of loblolly pine from caging tests made by members of the Cooperative 1/

Orchard	Total Seed/Cone		Full Seed/ Cone		Full Seed Loss/Cone 2/		Seed Bug Damaged Seed/Cone	
	Caged	Uncaged	Caged	Uncaged	No. Seed	%	Uncaged	Caged
American Can	128	117	106	89	17	16	10	1
Virginia Div. For.	121	104	102	70	32	32	13	1
International Paper, 8 Oaks	112	106	94	53	4o	43	28	0
Hammermill	111	117	91	101	0	0	1	0
International Paper, Delwood	106	100	90	93	24	30	18	1
Weyerhaeuser (N. C.)	104	108	78	55	0	0	4	1
Tennessee River	87	63	66	37	27	42	12	2
Georgia Kraft	85	83	65	63	2	3	6	0
Federal Paper	83	76	64	37	29	43	16	1
Catawba Timber	83	81	44	46	0	0	7	1
Continental Can (Ga.)	57	60	39	41	0	0	9	0
Union Camp (Ga.)	42	29	36	12	24	66	9	0
Average	93	87	73	58	16	23	11	0.7

1/ Courtesy Gary DeBarr, U. S. Forest Service, Athens, Ga.

2/ Estimates

In the N. C. Forest Service Piedmont loblolly seed orchard at Goldsboro, N. C., nine ramets of four clones were included in a preliminary study on the timing, sequence, and possible involvement of insects in conelet abortion. A minimum of ten conelets per ramet were caged (total of 82 conelets), to protect them from insect attack. An additional 81 conelets on each ramet were left uncaged, as controls. The results are summarized in Table 15.

Table 15. Summary of conelet abortion from caged and uncaged conelets from four clones of loblolly pine in the N. C. Forest Service loblolly pine seed orchard at Goldsboro, North Carolina

	Number and Percent of Conelet Abortion											
	June 3 to August 21				August 21 to October 7				June 3 to October 7			
	Caged		Uncaged		Caged		Uncaged		Caged		Uncaged	
Clone	#	%	#	%	#	%	#	%	#	%	#	%
16-165	0	0	0	0	0	0	6	24	0	0	6	24
16-20	3	10	0	0	2	7	16	59	5	17	16	59
16-168	1	8	1	8	1	8	1	8	2	15	2	17
16-164	1	5	0	0	4	22	1	6	5	28	1	6
Total	5	6%	1	1%	7	9%	24	30%	12	15%	25	31%

1/ The % column indicates the conelets aborted, by clone, for that time period, based on the initial number of conelets in the caged or uncaged category.

For the entire period from June 3 to October 7 there was approximately 15% conelet abortion from the caged and 31% abortion from the uncaged conelets. Ninety-six percent of the conelet abortion from the uncaged material took place in the last period from August 21 to October 7. The abortion from the caged material, however, was spread out almost evenly over all time periods. Some of the abortion from the caged conelets was directly attributable to damage by contact of the cages with the conelets. The larger amount of conelet abortion from the unprotected conelets and its occurrence in the period just prior to cone maturity indicate that considerable cone and seed loss from this seed orchard must be due to insects.

The Seed Protection Committee has been very active the past two years and has sponsored a number of studies with considerable success. General conclusions from studies to date are that Gardona has been ineffective, Thimet has given spotty results, Guthion has been quite effective but expensive, and Furadan has considerable promise (Table 16). The only chemical now labeled for use on seed and cone insects of slash and loblolly is Guthion. Furadan, especially the heavy treatments, reduced infestation to such an extent as to justify further testing of this relatively safe systemic.

Table 16. Furadan tests in four loblolly pine seed orchards[1/]

	Amount/Tree (oz./in. of DBH)	Average Infestation of Dioryctria	Range of Infestation
Furadan (single application)	8	7.2	0.8 - 22.9
	16	4.4	0.0 - 13.9
Furadan (three applications)	8	10.3	2.8 - 25.4
	16	5.9	0.0 - 20.2
Control (no treatment)	0	14.9	5.5 - 29.1

[1/] Based on tests which included a total of 350 grafts from one orchard in Arkansas, two in Georgia, and one in Virginia; data from a summary by Gary DeBarr, U. S. Forest Service, Athens, Georgia

Evidence is rapidly building about the effectiveness of Furadan. For example, preliminary results from the Virginia Division of Forestry showed the following:

	Avg. # Conelets/ Tree
Check trees	24
Furadan-treated (8 oz./in. of DBH)	63
Furadan-treated (16 oz./in. of DBH)	73

Based upon some very recent results of the Furadan tests, Gary DeBarr found that seed yield/cone was only half as large from the checks as from Furadan-treated trees.

A study in the Burnt Gin Piedmont loblolly seed orchard of the South Carolina Commission of Forestry revealed the following data on cone and conelet losses:

First-Year Cones (1973)

Type of Loss	%
Dioryctria spp.	.4
Unknown	1.2
Natural abortion	6.1
Miscellaneous insects	.1
Scale insects	.4
Mechanical injury	.5
Total % of crop loss	8.7

Second-Year Cones (1973)

Type of Loss	%
Dioryctria spp.	8.4
Unknown	3.1
Natural abortion	1.0
Miscellaneous insects	.3
Scale insects	.2
Mechanical injury	.7
Dwarfed or distorted	.1
	13.8

The problem of insect control has become so important and general in the South that it is now being attacked jointly by a number of organizations. As one example, a special committee of the Southern Forest Tree Improvement Committee, headed by Dr. Hans van Buijtenen of Texas, is coordinating activities amongst a number of organizations in the South. Such regional unity should bring the needed resources to solve the insect problem.

Increasing Cone and Seed Yields--General

A. Cone and Seed Processing

As large collections of cones are becoming available from seed orchards, problems are developing in the processing of cones. There is no problem when cones are collected and seeds extracted within three weeks to a month after harvest, but if held for a longer time a semi-case hardening can set in and the cone scales never fully open, trapping much of the seed. Consequently, care must be taken not to fill sacks or boxes too full of green cones which might restrict cone opening as they dry in bulk and long-term storage. One example, showing results of careful extraction, is the new seed extraction plant of Weyerhaeuser in North Carolina. From 2,707 bushels of cones they obtained 3,787 lbs. of seed, a seed/bushel ratio of nearly 1.8. This is approximately 62 lbs. of seed/acre from a mature loblolly pine orchard. Steve Dianis reports, "As a result of this seed plant, plus some other variables such as seed set due to the weather, insect control, and other, we produced 1,210 more pounds of seed this year than last with only an additional 75 bushels of cones. As a result, we have 100% of our company nursery needs (in N. C.--Ed.) satisfied with orchard seed for the 1975 crop."

Mice depredation of seed shed in sacks of cones waiting for extraction can cause the loss of large volumes of seed within a short period of time. Unless one is alert and watching for it, such destruction will take place with no outward visible signs of seed destruction.

A major concern is the loss of seed because of poor or perfunctory seed extraction. We are convinced that some of the erratic and low yields can be traced to this cause. Several organizations have run tests by sending their cones, extracted by a standard commercial process, through for a second time. Results have shown that 5 to 15% (in one case, 20%) additional seed were obtained. These seed tend to be somewhat smaller than average but the extra effort will pay dividends unless the initial extraction is done under very carefully controlled conditions.

B. Irrigation and Fertilization

Another method of increasing seed yields is to use the best combination of fertilization and irrigation. Among the many studies by Cooperative members, the one by Catawba Timber in South Carolina was established in 1964 and has produced some of the best results. The most remarkable aspect of the results is that the orchard is on a river

Irrigation of seed orchards is proving beneficial for tree development and seed production. This 1.5-generation loblolly seed orchard of Weyerhaeuser in Alabama is equipped with a permanent irrigation system (top picture). Tree improvement is hardly an indoor activity, as shown by this "neatly kept" Scout of Westvaco Corporation in Kentucky (bottom picture). But so far we have always made it home.

terrace that appears to have ample moisture. Results obtained from the 1974 cone collections show that the average trend is toward a good increase in cone yields with fertilizers and irrigation but that specific clones sometimes vary considerably in their response (Table 17).

Table 17. Effect of fertilization and irrigation on number of cones produced per tree for 5 clones in a 10-year-old loblolly pine seed orchard of Catawba Timber Company 1/

Clone	Check	Fertilizer Only 2/	Irrigation Only	Fertilizer Irrigation 3/	Standard Orchard Treatment
1-521	98	189	136	229	160
1-509	47	52	96	94	115
1-515	15	40	50	68	11
1-513	101	235	173	191	146
3-43	6	37	17	85	8
Totals (5 clones)	267	553	472	667	440

1/ The study has been underway since establishment in 1964. Cone counts were based on two or more ramets per clone per treatment.

2/ 700 lbs. NH_4NO_3 + 500 lbs. 10-10-10/acre/year

3/ Same fertilizer as footnote 2/

Data on the economics of irrigation and fertilization are sparse but, based on the long-term study of Catawba Timber Company (Table 17a), Don Smith made some estimates. He concluded that irrigation benefits are large enough to consider along with fertilization. An increase of seed/acre due to fertilization alone was 20 lbs.; with a value of seed of \$200 to \$300/lb. of seed, there is a benefit-to-cost ratio of 25 to 1 or more, even with the current high cost of fertilizers. The improvement in seed yields when irrigation is added come to about 26% but vary widely by year.

Table 17a. Increase in cone production by loblolly pine with fertilization and irrigation 1/

Year	Check	Irrigation Only	Increase from Irrigation Only	Fertilizer Only	Fertilizer and Irrigation	Increase from Irrigation When Fertilized
	Cones	Cones	%	Cones	Cones	%
1971	226	405	79	301	580	93
1972	358	496	38	672	724	8
1973	351	400	25	441	501	14
1974	273	492	80	587	722	23

1/ Cone numbers shown are totals of the average number of cones/tree for each of 8 clones.

An alternative is to establish more orchard acres rather than put in irrigation. Smith concludes that if acreage suitable for orchard establishment is limiting, irrigation would be favored. When benefits from irrigation additional to seed production are considered, it appears irrigation is a good economic investment, especially for improved seed orchards with their greater genetic gain and higher seed values.

C. Subsoiling

Subsoiling in seed orchards has become routine. It was started as a cultural practice, to correct soil compaction which was occurring in most orchards as a result of the necessary traffic. Until now the practice has been done without research information to indicate what is producing the favorable effect of subsoiling on tree growth and flowering. Jim Gregory, a graduate student, has undertaken a study of both deep and shallow subsoiling in two seed orchards in Virginia (Virginia Division of Forestry at Buckingham, and Union Camp at Murfreesboro). The shallow subsoiling (6" to 8") is designed primarily to cut roots, whereas the deep subsoiling cuts roots and opens up the soil to a depth of 16" to 20".

Early results suggest that for maximum response to subsoiling, timing may be more important than we had originally thought. The subsoiling was done in the Buckingham orchard on June 6 and 7, 1973, and the 1974 flower count showed no obvious effect either positive or negative. At Murfreesboro, however, the subsoiling was done on July 25, 1973, which is a critical time insofar as the initiation of flower bud primordia is concerned. The results were highly favorable, as indicated by the 1974 flower crop.

Treatment	Females/Tree
Control	13.7
Shallow (7")	23.8
Deep (16")	30.5

This is just the first bit of evidence and we anxiously await development of the 1975 flower crop. Additional treatments will be imposed in 1975. In addition to the flowering data, root regrowth patterns and intensity, water use by the trees, and alterations in soil properties are under study.

D. Predicting Seed Production

The question often arises as to how to predict the number of seed to be harvested prior to cone collection. The Virginia Forest Service made an excellent study on prediction of the number of sound seed/cone from a cone-cutting study in two 12-year-old loblolly pine seed orchards. The study was done on the Coastal and Piedmont source orchards, 10 clones/orchard, 6 ramets/clone, 5 cones/ramet, for a total of 600 sampled cones.

The number of sound seed/cone was 58 in the Coastal orchard, 59 in the Piedmont orchard, but with the usual large cone-to-cone differences, which varied from 29 to 95 for the Coastal, 37 to 83 for the Piedmont orchard. Although the regression equations from the two orchards were somewhat different, they gave reasonable results when combined, as shown in Table 18; results were compared with a rule-of-thumb method sometimes used ($y = 6x + 20$).

Table 18. Estimated number of sound seed/cone for different numbers of cut sound seed 1/

Average Number of Cut Sound Seed	Number of Sound Seed per Cone	Rule of Thumb ($y = 6x + 20$)
2	31	32
4	43	44
6	54	56
8	66	68
10	77	80
12	89	92
14	100	104

1/ 15 cones sampled for each clone

The Seed Harvester

Our hopes for a successful seed harvester have been dashed so many times during the past six years that we almost feared the results from the model tested last fall in the orchard of Hoerner-Waldorf at Tillery, North Carolina. After extensive modification by Bunn Hofmann and Ray Brown of Hoerner-Waldorf, Barry Malac of Union Camp, and Bob Favor, consultant for Bowie Machine Works (the company responsible for machine development), the harvester was demonstrated for members of the Cooperative. The demonstration was less than successful, largely due to the faulty engine which caused the machine to operate at a fraction of its potential.

Failure of the machine to perform to expectations could have had a negative impact on the Seed Harvest Committee but it didn't. Optimism was evident because the harvester finally embodied the basic requirements which required only a little more engineering. Bowie Machine Works agreed to build an operable model,

Top: Work on the vacuum seed harvester continues. Shown is a pilot model in the orchard of Hoerner-Waldorf. A final, operational, more compact machine is now under trial.

Below: An ever-present problem is to protect cones from depredation by squirrels. Piles of scales and cone remnants under a tree like those found in one seed orchard necessitate quick corrective action.

using the expertise of Bob Favor as design consultant. The machine was scheduled for testing in the Virginia Division of Forestry's seed orchard at Providence Forge in April. If specifications as set forth by the Seed Harvest Committee are met, Bowie Machine Works will sell the harvester on a first-come basis. Thereafter the machines will be built as the demand warrants; they are estimated to sell for $15,000 to $20,000 each.

Progeny Testing and Genetic Improvement

The load of progeny test data to be analyzed has become very large and, as shown by acreage increase (Table 19), is rapidly expanding.

Table 19. Acreage planted and number of lots of control-pollinated progeny tests in the N. C. State Cooperative

Species and Geographic Location	Acreage Planted Through 1974	Acreage Planted in 1975	Total Acreage
Loblolly--Coastal	798.3	110.3	908.6
Loblolly--Piedmont	574.2	108.0	682.2
Virginia Pine	65.5	32.2	97.7
Slash Pine	156.9	45.4	202.3
Pond Pine	46.0	6.4	52.4
Shortleaf Pine	16.9	0.0	16.9
Hybrid Pines	14.6	0.0	14.6
Longleaf Pine	0.0	3.9	3.9
Loblolly--Southwide			
Good General Combiners	0.0	140.6	140.6
Disease Diallel	0.0	22.6	22.6
Total	1672.4	469.4	2142.2
Kind of Test			
Main	1014.1	326.6	1340.7
Supplemental	628.0	142.8	770.8
Special	30.3	0.0	30.3
Total	1672.4	469.4	2141.8

A total of 19,252 seed lots and their checks have been planted.

To stay abreast of the analytical load, a new system of data collection will be instituted by the Cooperatives, starting with the 1975-76 measurement season. It involves the use of a battery-powered portable recorder which stores research data on cassette tapes that are transmitted via telephone to the computer at Raleigh. An improvement in data processing services will be realized from this system because data are collected in the field in computer-usable form which bypasses the transcription (keypunching) step and makes possible faster turnaround with fewer errors. The Cooperatives will also realize a cost-saving with this system.

Extensive tests were run on the system in 1974-75 by several Cooperative members, which included measurement of 33 progeny tests. Data for over 60,000 trees have been transmitted, processed, analyzed and returned to the respective cooperators; Union Camp Corporation alone has logged over 200 hours of field operating time on the recorder. The bulk of tests involved pine progeny measurement; however, we have worked closely with Bob Heeren to develop procedures for measurement of hardwood studies. Following positive results from these extensive tests, the Advisory Committee Members of the Cooperative voted (26 "yes" votes, 1 "no" vote) to adopt the system as a means to make our data processing more effective.

Progeny Tests of Loblolly Pine

Each year we report results from a few progeny tests to show family differences and gains by crosses or clones. In one small supplemental test, Westvaco obtained results as shown in Table 20; note the relative position of the commercial check. Generally the commercial check is in the bottom third or fourth of the lots tested.

Table 20. Eight-year growth of coastal loblolly pine crosses, Westvaco Corporation

Cross	Height (ft.)	Number of Cronartium Infections on Stem
7-56 x 11-20	28.9	0
11-23 x 11-20	28.6	0
11-16 x 11-2	28.0	2
7-56 x 11-23	27.8	2
7-2 x 11-23	25.0	2
Seed Production Area	24.6	2.2
Commercial Check	24.4	1.6

In a study of an 11-year-old open-pollinated loblolly pine test, Weyerhaeuser in coastal North Carolina found a 30% volume improvement of selected trees over the average comparison trees.

In a comprehensive study involving development of a selection index, graduate student Matziris was able to rank clones based on several characteristics, weighted by their relative economic values (Table 21). Such indices are essential for proper assessment of clonal values, and, as more data become available, all clones within the Cooperative will be ranked. A key factor in proper use of the index is the determination of suitable economic values. Such information is just now becoming available, based upon both yield and quality criteria.

Table 21. Rank of clones, for aggregate economic value, based on the selection index developed for 8-year-old control-pollinated progeny tests of Weyerhaeuser's North Coastal Plain loblolly pine seed orchards (Progeny tests were planted 1964 and 1965 in North Carolina.)

Rank	Clone Number	Index	DBH (in.)	Height (ft.)	Volume (cu.ft.)	Rust (score)	Crown (score)	Straightness (score)
1	8-61	32.91	3.7	18.6	.6165	1.5	4.0	4.4
2	8-21	28.49	3.4	17.5	.5035	1.6	3.7	4.1
3	8-33	27.92	3.5	18.4	.5062	1.4	3.5	3.5
4	8-01	25.95	3.3	17.5	.4860	1.4	3.6	3.7
5	8-59	24.29	3.7	18.8	.5767	1.5	3.5	3.3
6	8-07	23.98	3.4	17.5	.4757	1.7	3.6	3.7
7	8-44	23.96	3.3	17.3	.4914	1.7	3.5	3.7
8	8-05	23.90	3.6	18.3	.5393	1.7	3.6	3.6
9	8-86	23.87	3.7	18.5	.5766	1.7	3.6	3.6
10	8-43	23.78	3.6	17.9	.5296	2.0	3.6	3.8
11	8-53	23.70	3.0	17.0	.3903	1.3	3.4	3.5
12	8-80	23.11	3.4	16.9	.4640	1.7	3.8	4.1
13	8-31	22.67	3.3	17.1	.4405	1.5	3.3	3.3
14	8-46	22.09	3.4	17.2	.4691	1.8	3.8	3.9
15	8-141	21.90	3.4	17.3	.4724	1.8	3.5	3.6
16	8-24	21.55	3.2	17.0	.4301	1.5	3.5	3.5
17	8-08	21.13	3.2	16.7	.4150	1.6	3.6	3.7
18	8-50	16.86	3.3	17.4	.4463	2.0	3.3	3.2
Overall Mean			3.37	17.58	.4905	1.63	3.56	3.73
Mean of top 50%			3.50	18.02	.5302	1.56	3.60	3.49
Realized Gain [1/] (% of Mean)			3.9	2.5	8.1	4.4	-1.1	6.4

A similar study of 22 clones in the South Coastal Plain of North Carolina showed the following summary results:

	DBH	Height	Volume	Rust	Crown	Straightness
Overall Mean	2.56	13.96	.2881	1.29	3.33	3.26
Mean of Top 50%	2.62	14.09	.3002	1.20	3.37	3.20
Realized Gain [1/] (% of Mean)	2.2	0.9	4.2	6.4	-1.1	2.1

[1/] Realized gain actually has been achieved. For the greatest overall gain it was found that a relaxation in crown characteristics was necessary in order to take full advantage of fast growth.

After the fifth year, progeny from one of International's Mississippi seed orchards had considerable difference between the best and poorest clones (Table 22). Note the consistently poor growth of the commercial check and the large percentage gains in volume over the commercial check for the best progenies and the gains even for the poorest clones.

Table 22. Progeny performance of the best and poorest loblolly pine clones from a Mississippi seed orchard of International Paper Company

	Volume		Height			Diameter		
Family	Rank	% Superiority Over Check	Feet	Rank	% Superiority Over Check	Inches	Rank	% Superiority Over Check
WO-3	1	98	16.5	1	20	2.97	1	29
CR-33	2	75	15.9	3	15	2.85	2	24
HO-9	3	73	16.1	2	22	2.81	3	22
CC-22	4	66	15.8	4	14	2.77	5	20
OH-10	5	66	15.6	5	13	2.79	4	19
SPA	16	28	14.2	19	3	2.6	16	11
HO-3	17	27	14.6	15	6	2.5	17	8
HO-8	18	23	14.5	16	5	2.4	19	5
HO-12	19	20	14.5	16	7	2.5	18	7
Comm. Ck.	20	0	13.8	20	0	2.3	20	0

Tests Outside the Natural Range

A test of loblolly pine from their South Carolina seed orchard was made in southern Brazil by Westvaco Corporation, using open-pollinated seed. Tree growth at the Brazil location is superb; additionally, considerable family differences are evident (Table 23). Note the relative growth rankings for the same clones when grown in two different locations. Data on only the fast- and slow-growing clones are shown; there was no commercial check.

Table 23. Growth rate of fast- and slow-growing open-pollinated loblolly pine progenies in Brazil 1/

	Clone	Fazenda Experimental Height (ft.)	Fazenda Experimental Diameter (in.)	Fazenda Gregorio Height (ft.)	Fazenda Gregorio Diameter (in.)
Fast Growth	11-2	33.1	7.0	31.9	6.9
	7-56	32.7	7.2	29.8	7.0
	7-2	32.8	7.1	31.8	7.3
	11-19	32.6	6.9	31.7	7.1
	11-9	32.5	7.2	31.4	7.1
Slow Growth	11-14	31.1	7.2	30.0	7.2
	11-10	30.9	6.8	29.7	6.7
	7-34	30.6	6.8	29.8	6.9
	11-21	30.8	6.8	30.2	6.5
	11-25	30.7	6.7	30.2	6.7

1/ Test by Westvaco Corporation

In a test of 35 clones from several members of the Cooperative by Westvaco in western Tennessee, the following was obtained for the best and poorest lots:

	Clone	Source	Height Rank
Best Growth	3-41	Piedmont, S. C.	1
	3-40	" "	2
	3-38	" "	3
	6-9	" N. C.	4
	18-97	" S. C.	5
	18-1	" "	6
	3-7	" "	7
	6-42	" N. C.	8
Poorest Growth	14-15	Piedmont, Va.	31
	Arkansas	-------	32
	Arkansas	-------	33
	18-41	Piedmont, S. C.	34
	Kentucky (Comm.)	-------	35

It is amazing how consistently the North and South Carolina Piedmont trees have been the best performers so far from their native range. Similar results were also obtained in Kentucky--the Champion (#3) clones have consistently done well north and west of their native range.

To determine the worth of the Livingston Parish, Louisiana source of loblolly pine outside its native range, MacMillan-Bloedel made 100,000 seedlings of this source available to members of the Cooperative; many took advantage of the offer resulting in a number of plantings being established throughout the Southeast. We will soon be able to define limits where the Livingston Parish loblolly seed source is of value.

Progeny Test of a Minor Species

Gains from seed orchards of minor species such as Virginia pine have been good and are obviously well worth while. Results for two Virginia pine tests by Hiwassee Land Company are shown in Table 24. Note the magnitude of the volume gains over the commercial checks.

Table 24. Growth of select and check 8-year-old Virginia pine trees in progeny tests of Hiwassee Land Company in Tennessee and Georgia

Source	Diameter (in.)	Height (ft.)	Volume (cu.ft.)	Straightness (Score)
Hiwassee--Main Test:				
Improved Clones	4.1	20.0	.74	3.59
Commercial Check	3.6	18.8	.55	3.34
Percent Improved	15%	6%	35%	7%
Hiwassee--Supplemental Test:				
Improved Clones	3.3	16.8	.44	3.34
Commercial Check	2.9	15.6	.33	3.19
Percent Improved	14%	7%	34%	5%

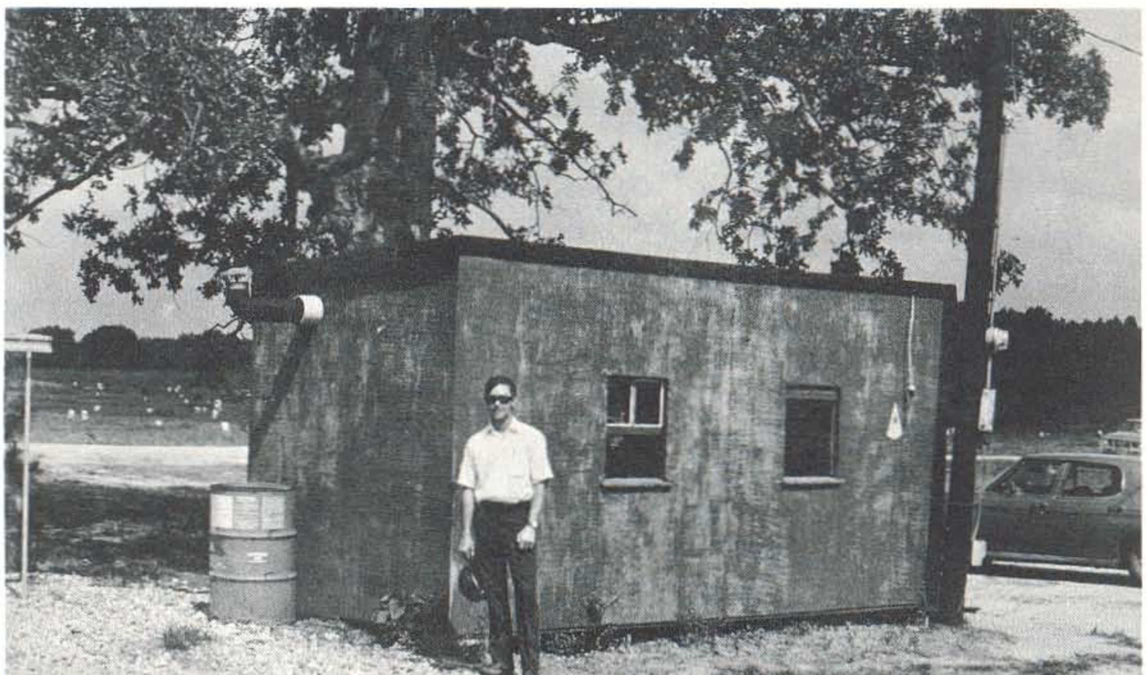
Effect of Fusiform Rust on Wood Qualities

A study on the effects of fusiform rust infection on wood and paper qualities and yields has been recently completed. It was supported by a special $1,000 contribution by each of 10 members of the Cooperative. Complete results will soon be supplied to cooperators and eventually will be summarized and published in Tappi. A summary of results to date has been prepared by Mick Veal[1], who has done much of the work as part of his Ph. D. thesis.

> "The effects of fusiform rust on the yield and quality of pulp and chemical byproducts obtained from loblolly pine and slash pine plantations were investigated. Rust galls were collected from 10-year-old trees in 15 families of loblolly pine grown in the International Paper Company-N. C. State University Heritability Study in south Georgia. The galls were classified into light (<20%), medium (30 - 50%), and heavy (>60%) severity classes according to the percentage of stem circumference involved. Bolts of stemwood containing galls in each severity class were pulped by the kraft process to a nominal 90 kappa number (lignin content 13.5%). Compared with nonaffected stemwood, bolts from light, medium and heavy gall (canker) classes yielded 4, 10, and 22% less pulp which had lower strength properties and required 4, 6, and 20% more alkali to achieve comparable delignification. However, these gall classes yielded 100, 300, and 500% more ethanol-benzene soluble extractives and 6, 9, and 24% more outside diameter wood per unit green weight of wood, respectively, than did "clean" wood. Only medium class galls were sampled from 10-year-old slash pine from central Georgia. Pulping data on this material indicate that the effects of rust on slash pine wood are equivalent to, or slightly more severe than for loblolly pine.
>
> "Composite mixes of 20% affected-80% nonaffected, and 30% affected-70% nonaffected stemwood were pulped. Although no significant pulp yield loss could be detected, these mixtures required 2 to 4% more alkali for comparable delignification and yielded 20 to 30% more extractives than the nonaffected stemwood.
>
> "Assessment of the Heritability Study showed 30% of the trees had stem infections and 7% of the total dry weight of stemwood was affected by rust, as defined by the severity classes. Wood from this stand required 1% more alkali in pulping, yielded 1% less pulp, 25% more crude tall oil, and 1% more outside diameter wood per unit green weight than wood from a rust-free stand. The lower pulp yields and greater tall oil yields make rust-affected wood in a young stand with no more than 30% infection and without fire-charring economically equivalent to nonaffected wood for production on linerboard grade pulps. There will be limited financial loss involved when pulping rust-affected wood because of reduced pulp strength, lower quality tall oil, and increased capital costs of processing. Rust-affected wood will be of less value than nonaffected wood when the incidence of stem infections increases over 30% in a stand, fire-charring occurs, or bleachable pulp grades are the desired product."

[1] Also reported as: Veal, M. A., Blair, R. L., Jett, J. B. and McKean, W. T. 1974. The impact of fusiform rust on pulping properties of young loblolly and slash pines. (Presented at the TAPPI Forest Biology Committee Meeting in Seattle, October)

Progeny tests are vulnerable to many agents (see list in the text). Shown above is the partial destruction of an 8-year-old test (and one of our very best second-generation selections) by the tornado that hit Kimberly-Clark Corporation in Alabama.



I did it!! After several years of threatening, the ultimate in seed orchard facilities is exposed. Company? The closest clue is that it's somewhere in the Southeast.

A secondary but important effect of rust infection on wood quality is the larger quantity of juvenile wood harvested when a salvage operation must be made in young stands to minimize mortality losses from the disease.

Disease Resistance

There has been considerable interest and a number of tests on the gain to be achieved by selecting resistant individuals from badly infected plantations. We reported results earlier from Union Camp's selections in which four out of seven trees gave very resistant progeny; more recent results showed two out of six had excellent resistance, two quite good resistance, while two others were average.

In 1963 Brunswick removed all diseased individuals from a badly infected 8-year-old slash pine plantation and for several years has been using the remaining trees as a seed production area. Seed were collected from individual trees and progeny were tested in high-hazard areas in the field. They plan additional tests of 80 parents in three high-hazard areas in 1975.

Results from one of the earlier tests made by the Florida Cooperative on a high-hazard site were as follows:

Regular test material from seed orchards of all Florida cooperators--47.0% infected (Range 8 to 83%)

Clean trees (117 trees) from Brunswick's rust-resistant seed production area--26.9% infected (Range 0 to 55%)

Best 12% of trees (15 trees) from Brunswick's rust-resistant seed production area--9.9% infected (Range 0 to 15%)

It is clear from these results on slash pine and our results on loblolly that plantation selection of resistant trees is very worthwhile. We are concentrating on finding the occasional clean tree which also has good growth and form growing in stands with an infection percentage above 90 to 95%. Several hundred trees of this type have been graded and will be tested as soon as seed can be obtained.

Hammermill Paper Company, as well as Weyerhaeuser Company, has established a large number of such selections in small clone bank-seed orchards for further testing, roguing, and ultimate seed production.

For several years now, a number of the Cooperative members have been making half-diallel crosses among the most disease-resistant clones available from the seed orchards. All crossing has been completed; four field plantings were made in spring, 1975, six more will be made in 1976, and the remaining four will be established in 1977. Results from this coordinated attempt to further test and develop disease-resistant lines will be of great value to all members of the Cooperative.

Of great benefit in the battle against fusiform rust was the establishment of the Fusiform Test Center at Asheville, North Carolina by the U. S. Forest Service. The center is now in full operation, with most of the "bugs" in testing methodology worked out. The exact relationship between greenhouse tests and field tests has not yet been determined, but such studies are currently underway. Generally it appears that clones showing resistance in the greenhouse are generally resistant in the field, but some appearing only moderately resistant in the greenhouse have proven to be quite resistant in the field. Additionally, several studies have been initiated by Harry Powers of the U. S. Forest Service (Athens, Georgia) to help determine why some clones produce resistant seedlings consistently while others produce susceptible or resistant seedlings erratically.

Reciprocals and Seed Size

While studying the performance of reciprocals and the effect of seed size on growth, Neville Denison (former graduate student at N. C. State) evaluated a 5-year old reciprocal test of loblolly pine in South Africa. He summarizes, "I could find no evidence of reciprocal effects at the 0.5 level of significance."

In a well-designed study to assess seed size and speed of germination, Tom Dierauf of the Virginia Division of Forestry provided us with some most interesting early results. At time of lifting he found:

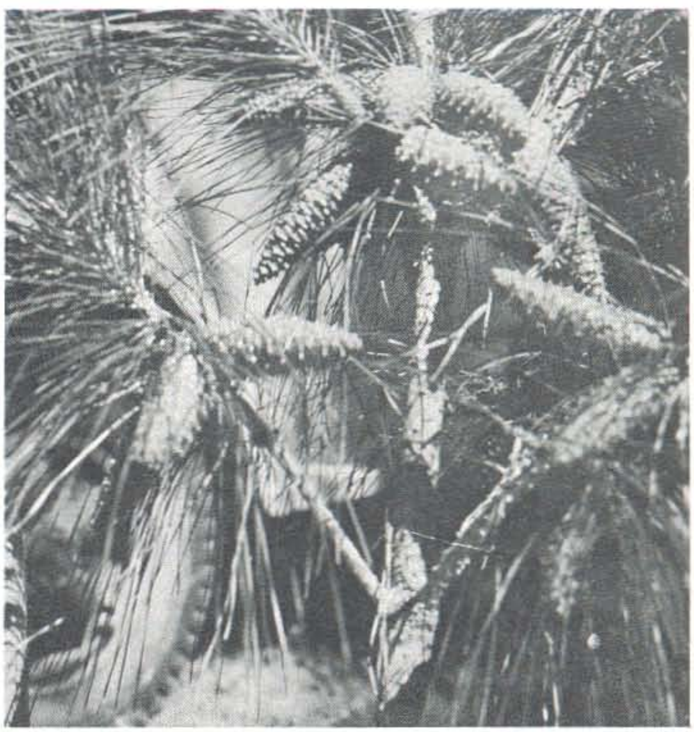
1. Clone 6-10 (small seed) was the slowest germinator and grew better in pure sown rather than mixed sown plots. In the mixed lots, many seedlings of 6-10 were suppressed. (In progeny tests, where seed are sown pure, 6-10 is one of the fastest growers after several years in the field.)
2. Clones 20-508 and 20-512 (large seed) were fast germinators and did best in the random sowing.
3. Clone 14-15 was average in germination and did equally well in mixed or pure plots.

Studies such as this, to be followed for several years, give badly needed answers and may indicate the need to produce seedlings by clone, at least in some instances. For example, 6-10, an outstanding grower in progeny tests, had 37% culls in mixed sowings and less than 10% culls in pure stands; thus planting by clone in the nursery would reduce the cull percentage.

Interaction With Fertilizer

A paper has been prepared by Ray Goddard of the Florida Cooperative with Bruce Zobel on the interaction of growth of progenies by fertilizer. Although an occasional specific cross shows a strong genotype-x-fertilizer interaction, it is rare in loblolly pine to find a strong differential clonal response to fertilization. In an analysis of five 8-year-old and five 4-year-old loblolly pine tests, no genotype-x-fertilizer interaction was found; there are indications that greater interaction may exist in slash pine.

Problems come in all forms, sometimes unexpectedly. Beavers are recognized for their destruction of hardwoods but they seem to be getting an increasing taste for pine. Destruction of this young pine stand (above), high up on a Piedmont slope, is on lands of Chesapeake Corporation in Virginia.



When all goes well, crops of cones as obtained by Union Camp Corporation in Georgia are obtained. Generally, flower production is satisfactory but adverse weather and insects have a profound effect on cone and seed production.

What Can Happen Next?

Throughout the years we have had our share of problems with progeny tests; it seemed of interest to outline all the things that have already happened. With over 2,000 acres of progeny established in hundreds of tests, anything seems to be possible. The catastrophies are not necessarily listed in order of seriousness although fire has done the greatest damage and is our greatest potential enemy. But any loss is serious and results in a loss of money, effort, and especially time. We have had to thin a couple of seed orchards because of lack of data, resulting from damage to the progeny tests.

1. Fire. Several tests have been eliminated by fire, caused by such things as:
   a. Locals were angry at a hunting club for killing their dogs, so set fire to the company plantings.
   b. Control burns "got away" due to carelessness of forestry personnel.
   c. Lack of fire lanes. Several tests have been saved by fire lanes, but one was burned when fires were set inside the lane.
2. Trees cut for Christmas trees; one test of white pine was dug for Christmas trees.
3. A small landowner felt he was cheated by the land survey on some property he bought, so he "took" several acres of 6-year-old tests, burned them, and built dog pens.
4. Crews put logging roads and skid trails through the nice, open area "with only a few little trees and stakes to interfere."
5. Poor survival for any one of many reasons, usually poor lifting, storage, or planting control. This has been our second most serious cause of loss of progeny tests.
6. Beavers wiped out almost all trees on one excellent 5-year-old test plantation.
7. A tornado knocked many trees down, uprooted many, and broke many off.
8. An ice storm bent over and uprooted several 6-year-old plantations.
9. One 4-year-old plantation was frozen by an early cold spell, killing some trees while not harming others. Most damage was by family.

10. An old mother goat ate a number of newly planted progeny trees. (The company bought the goat, which promptly had kids which ate trees at the nursery where they are kept--then the nursery employees promptly ate all the goats.)

11. A utility company decided to widen its right-of-way, including part of a progeny test, with no notice given to the company involved.

12. Drainage was blocked by poor operation when bedding was done--result: drowned seedlings.

13. Tags were removed or shot from the tests. On one test the tags were purposely switched to different rows. Stakes (with tags) were pulled and used for a bonfire for (wet?) hunters. Metal stakes were pulled, bent, and thrown in the brush.

14. Because of poor site preparation and no aftercare, the test trees were so suppressed that the plantings were useless.

15. Pales weevils killed most planted trees.

16. Soil variability was so great that at four years part of the test was about 16' tall, the rest 4' tall. Soil differences angled across all replications so none could be salvaged.

17. Fusiform rust was so bad that few measurable trees were left.

18. Hurricanes blew over trees and submerged roots in salty water, with a resultant heavy kill.

19. Records were lost and identity of crosses was suspect.

20. One test was partially wrecked by someone cruising through it, apparently aiming to knock down trees. One case with a bombardier and another in a jeep.

21. There was a train wreck adjacent to the test and in the process of cleaning up the wreckage one part of the test was destroyed.

22. A drainage ditch and culvert were established to drain a wet spot; instead, water from the road drainage came through the culvert, drained <u>into</u> the test, converting it into a lake and dead trees.

UPON WRITING THIS, IT'S HARD TO KNOW WHETHER TO LAUGH OR CRY--THE LATTER REALLY GETS THE NOD.

Advanced Orchard Establishment

Because of abundant data and plant material established and tested over the past 18 years, all future production orchards will be advanced or specialty orchards. The greatest acreage now being established is in the so-called "1.5-generation orchards" which are made up of clones that have been thoroughly tested and classified as good general combiners.

Selection of second-generation trees has proceeded at a rapid rate, and 108 acres of second-generation seed orchards have already been established. With experience, we have been able to do a better job of selecting second-generation trees; the total selected and used to date is shown in Table 25.

Table 25. Second-generation selections made and in use

Loblolly Pine	Number Selected	Number Established in Second-Generation Orchards
Catawba	4	0
Hiwassee	69	34
Union Camp	47	18
Champion International	39	24
Chesapeake	64	31
Continental Can	79	30
Hoerner-Waldorf	56	31
International Paper	40	22
Weyerhaeuser	106	54
Federal Paperboard	53	34
Westvaco	78	30
Kimberly-Clark	88	29
American Can	1	0
Tennessee River	15	5
Virginia Division of Forestry	6	2
Georgia-Pacific	4	2
Slash Pine		
Union Camp, St. Regis	111	43
Virginia Pine		
Hiwassee, Kimberly-Clark	44	0
Total	904	389

Although we have now established 389 trees in second-generation orchards, one problem has plagued us from the beginning, namely, the constant recurrence of certain clones as parents of the selected trees, making it very difficult to establish orchards without danger of related matings (See clone 8-33 in Table 25). As expected, this problem has been partially caused by use of the tester system but with so many member organizations with so many orchards (over 170) it has not been too serious.

All future advanced breeding will employ some type of modified diallel crossing scheme. A main cause of difficulty is the presence of clones with good general combining ability. These outstanding parents are great from the plant breeder's standpoint, enabling large and rapid gains through roguing and establishment of 1.5-generation orchards, but they make advanced-generation breeding more difficult. The problem caused by the very good general combiners has been encountered by others; for example, Neville Denison of South Africa reports that three of his clones appear again and again in the best selections of his best families, making difficult the establishment of second-generation orchards with minimal relatedness.

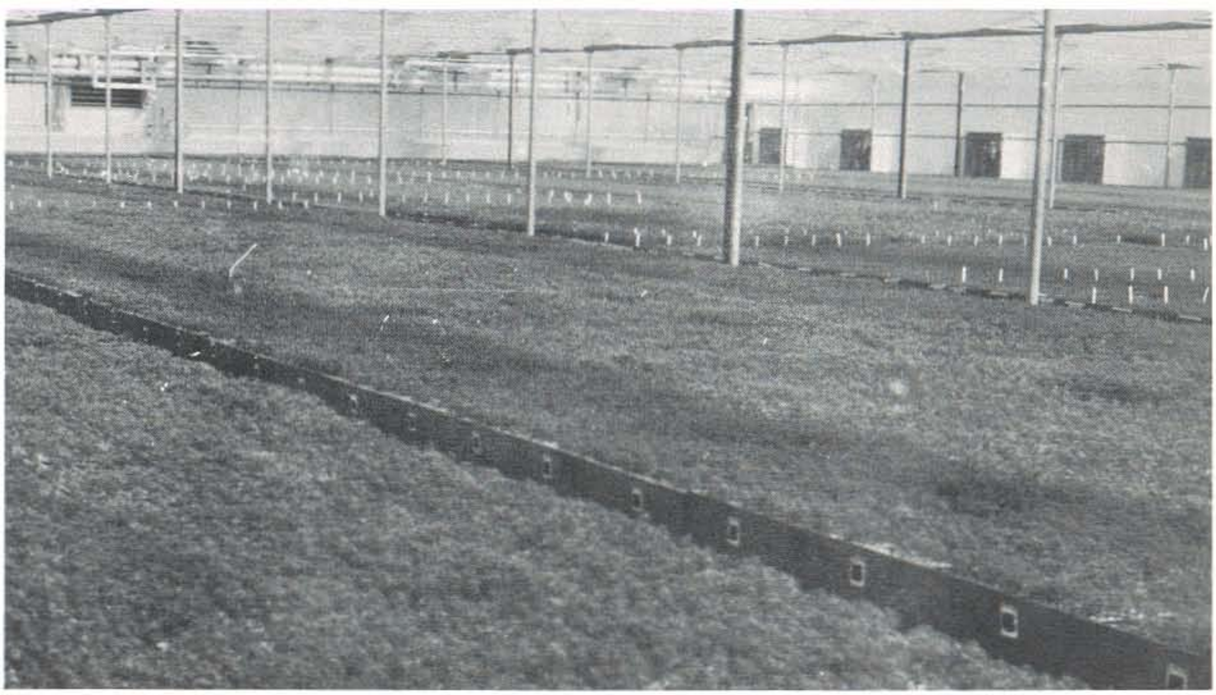
Establishment of advanced-generation orchards makes the value of the Cooperative effort really clear. Note in Table 26 how many of Weyerhaeuser's selections from the South Coastal Plain are being used by other members of the Cooperative. Conversely, Weyerhaeuser is using selections from a number of Cooperative members.

Table 26. South Coastal loblolly second-generation selections from Weyerhaeuser's 8-year-old progeny tests

Cross	Number of Selections Made	Number of Selections Used	Number of Companies Using This Cross
8-33 x 8-31	4	0	0
8-103 x 8-33	4	3	6
8-33 x 8-53	3	1	4
8-33 x 8-142	1	0	0
8-78 x 8-68	5	1	1
8-29 x 8-68	1	1	1
8-76 x 8-53	1	1	2
8-74 x 8-68	4	3	4
8-68 x 8-33	1	0	0
8-33 x 8-103	2	0	0
8-68 x 8-31	1	0	0
8-27 x 8-33	1	0	0
8-102 x 8-33	1	1	3
8-68 x 8-53	2	0	0
8-29 x 8-33	4	0	0
8-76 x 8-31	2	2	4
8-102 x 8-68	2	2	6
8-29 x 8-31	1	0	0
8-33 x 8-142	1	0	0
8-31 x 8-53	2	2	4
8-67 x 8-33	1	0	0
8-27 x 8-68	1	1	2
8-76 x 8-68	1	1	3
8-68 x 8-73	3	2	4
8-65 x 8-33	1	0	0
8-33 x 8-131	1	1	1
SPA	2	1	1
Total	53	23	

Don Smith developed some information on the gains to be achieved (35%) from second-generation seed orchards, as shown in Table 27. Note that system D consists of pollen supplementation from good clones. It appears that the gains attainable by different breeding systems is greater than most of us had expected.

The land base decreases as the demand for timber increases and the need for developing trees for severe sites becomes urgent. Excellent growth has been obtained in the 5-year hybrid pine of Westvaco Corporation in Kentucky.



One method being tried to successfully regenerate problem sites is the use of containerized seedlings. This method is being widely used in the Northwest, as shown in one of Weyerhaeuser's greenhouses in Washington.

Table 27. Predicted gains (%) of single traits from second-generation orchards using different breeding procedures

	A	B	C	D
Height (ft.)	5.3	8.7	8.9	5.7
Straightness (score)	8.2	14.7	14.9	8.8
Volume (cu.ft.)	24.8	40.8	41.5	26.8
Fusiform (score)	21.5	35.0	35.6	23.2

A = Select only the top 25% of the families.

B = Select the top 25% of the families plus making an additional selection of the top 3% of the best individuals within families.

C = Same as (B) plus supplemental pollination with pollen from individuals in the top 0.1% of the population.

D = Same as (A) plus supplemental pollination from individuals in the top 0.1% of the population.

Miscellaneous--Pine

Effect of Tree Form on Pulp and Paper Yield and Quality and on Solid Wood Products

Last year we reported on a study underway to determine yield and quality improvements from growing straight and small-limbed trees as compared to crooked, large-limbed trees. Partial results of that study have now been published[1/], the main results of which are:

1. Selection for straight, small-limbed trees increased pulp yields and improved pulp qualities.

2. Pulp yield per unit oven-dry wood for crooked trees was 44.8%, for straight trees, 45.7%; trees with small limbs gave 0.4% greater yields than large-limbed trees.

3. No important differences in yields of turpentine, extractives, and tall oil were found between straight and crooked trees, but small-limbed trees yielded 12% less turpentine, extractives, and tall oil than did large-limbed trees.

4. Both straightness and limb size affected tear factor, straight trees being 8 points better, small-limbed trees being 10 points better.

5. Straightness was most important for yield while limb size had a greater influence on tear.

[1/] Blair, R. L., Zobel, B. J., Franklin, E. C., Djerf, A. C., and Mendel, J. M. 1974. The effect of tree form and rust infection on wood and pulp properties of loblolly pine. Tappi 57(7):46-50.

We are now analyzing a study in cooperation with Georgia-Pacific relating the effect of bole straightness and crown characteristics to yield and value of plywood. Total yield differences between straight and crooked trees are small, but the yield by quality grade, and thus value of the final product, is considerably different by tree quality. Pending is a study with Weyerhaeuser on the effect of tree form on boards and on chips from the residue from a chip-n-saw operation. Nearly completed is a study with International Paper on the effect of trees produced in the genetics program on strength of solid wood products and on penetration by wood preservatives. It will soon be possible, therefore, to assess the results of breeding for wood quality improvement not only in relation to its effect on yield but also the effect on quality and resultant dollar values.

Developing Desired Wood

A number of years ago Federal Paper Board started a project to see if tracheid length of loblolly pine could be significantly increased or decreased by breeding. They crosses a number of long-fibered and short-fibered trees from their own and other companies' seed orchards and made crosses among them. Although meaningful results for tracheid length won't be evident until the trees are about 10 years old, one of these special tests for long fibers was thinned at five years, to determine uniformity of fiber length (Table 28). The uniformity and actual length fiber for trees of this age are of special interest. Note that clonal specific gravities varied considerably.

Table 28. Specific gravity and tracheid length by clone from a 5-year-old progeny test of loblolly pine parents with especially long tracheids (study by Federal Paper Board Company)

Clone	Company Orchard	Tracheid Length (mm)	Specific Gravity
9-9	Federal	2.31	.360
7-39	International	2.27	.354
9-26	Federal	2.25	.363
9-18	Federal	2.23	.351
2-33	Union Camp	2.21	.359
6-33	Hoerner-Waldorf	2.21	.355
9-14	Federal	2.14	.355
9-17	Federal	2.14	.360
9-41	Federal	2.13	.345

Geographic Differences in Wood Properties of Pitch Pine

There is special interest, such as by Westvaco, in using pitch pine (*P. rigida*) as one parent in the loblolly-x-pitch pine hybrid. Others (N. C. Forest Service and Georgia Kraft) have small orchards established to test this species' growth and adaptability on sites submarginal for loblolly or Virginia pine at high latitudes or in the dry, rocky soils in the high Piedmont and mountains.

To learn more about the wood of this species, we cooperated with Tom Ledig of Yale University, who is conducting an intensive variation study. Results from assessment of 11mm increment cores obtained at breast height showed the specific gravity trend to be very similar to the other southern pines. The highest values (.50 to .55 specific gravity) were in the South (Tennessee, Georgia, and North Carolina), the lowest values (.42 to .45) in the North (Maine, Vermont, and Canada). Specific gravities in the so-called "border states" of Virginia and West Virginia were relatively high, varying from .49 to .55.

Tracheid length also showed a geographic trend with the more northern samples being 2.6 to 2.9mm while the southern sources varied from 3.3 to 3.7mm. Based upon this study and our earlier data, it is obvious that pitch pine has a useful wood that will give reasonably satisfactory yields and pulp quality, especially in the southern portion of the species range.

Pollen Storage and Testing

To develop an efficient crossing program within the Cooperative, we have established a pollen bank at Raleigh from which the desired pollen is supplied to the organization making specific crosses. Jerry Sprague and Vernon Johnson have been developing, and are now operationally using, a method of vacuum storage. A few comparisons over one year's storage are shown below:

	Germination Percent	
Clone	At Time of Collection (1973)	After 1 Year's Storage (1974)
1-11	50	0
1-14	52	58
1-64	48	43
7-2	65	18
7-34	52	38
7-56	56	46
3-2	44	70
3-8	28	42
3-36	29	55
1-11A	76	0

Generally the stored pollen has germinated satisfactorily, except for clones such as 1-11 in which pollen of all stored lots was dead after one year. This loss in viability was apparently caused by improper collection and handling of the catkins, which resulted in mold before extraction. In spring 1974, 1662 lots of stored pollen were tested for viability for members of the Cooperative. This rather large job has paid dividends, and most of the pollens sent to us for testing have germinated well enough to be used in the crossing program. We still urge that fresh pollen be used in preference to stored pollen when it can be obtained.

The Heritability Study

Data are continually being obtained from the Heritability Study done in cooperation with International Paper Company (partially financed by the National Science Foundation and the National Institute of Health) and numerous publications have resulted. In 1973, one major publication[1/] summarized the work to date. Since then Roger Blair has pulled together a list of all the publications that have resulted from data generated by this very large study.[2/] Fifty-two publications are listed, many of which were developed as graduate student theses. The Heritability Study has given us a great deal of data which has helped in the development of our applied programs. It is literally "worth its weight in gold" and several current studies are underway which deal mostly with the impact of disease and wood and tree quality variation on the final product.

Comparison With Finland

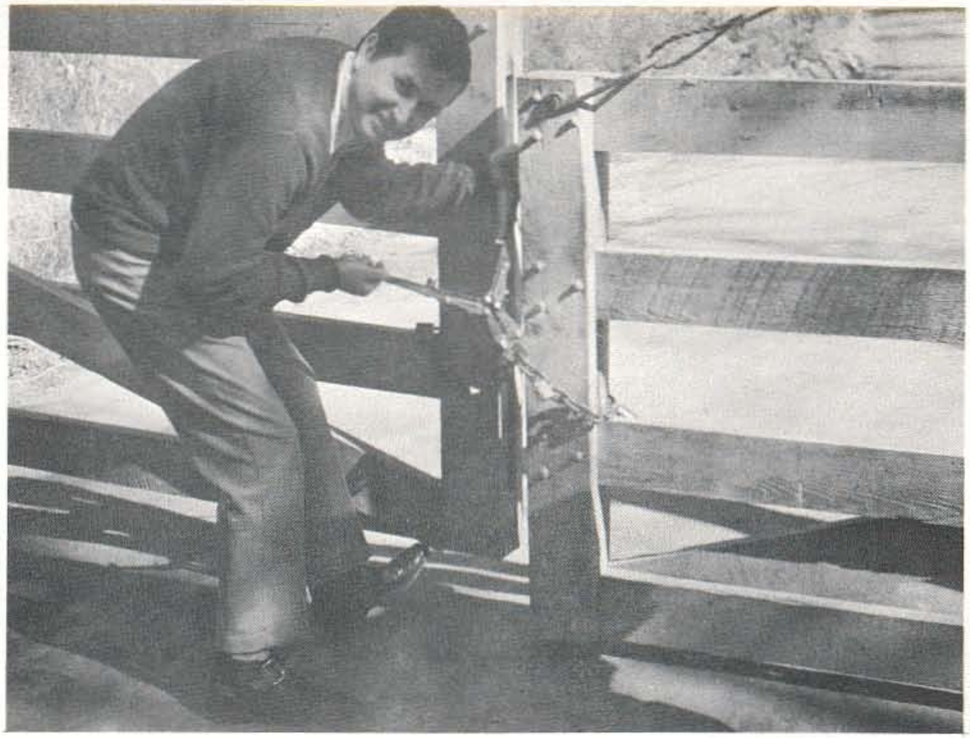
It is always of interest to compare results within our Cooperative with those of other organizations. The following was abstracted from the report from "The Foundation for Forest Tree Breeding in Finland," 1973:

> "About one-half of the quantity of pine seed used in Finnish forest tree nurseries comes from phenotypic plus-stands. It has been established that this will lead to an increase of growth by 5 to 10%. It has been estimated that the seed which can be produced on a practical scale in seed orchards, which cover 2,666 hectares, will increase the growth of pine forests by 10 to 15%. Mature seed orchards, about 20 years of age, should be thinned by removing the poorer half of the clones. New, elite seed orchards will be established in the 1980's, using the best tenth of the approximate original number of 6,000-plus pines. The gain from elite seed orchards has been estimated at 20 to 30%."

Obviously, gains from the Finnish program are in the same ball park as we are achieving in the South.

[1/] Stonecypher, R. W., Zobel, B. J. and Blair, R. 1973. Inheritance patterns of loblolly pines from a nonselected natural population. N. C. Agri. Expt. Sta. Tech. Bull. No. 220. 60 pp.

[2/] A copy of the list of publications may be obtained from Dr. Roger Blair, International Paper Co., Southlands Expt. Forest, Bainbridge, Ga. 31717.



One learns a lot working with members of the Cooperative. For example, what do you do when the lock has been changed and you have no key (top picture)? Ben Knight, Kimberly-Clark Corporation in South Carolina, carries this handy-dandy little chain separator. Below, members of the N. C. Forest Service and the Virginia Division of Forestry gradually "ease" a post out of the ground. The member of the Virginia Division of Forestry who suggested this maneuver has assured anonymity by keeping his nose, mouth, and chin warm with his toboggan.

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.

PERSONNEL

Ed Sossaman has been hired to fill the vacancy created by the resignation of Don Smith, who accepted employment with Potlatch Corporation in Lewiston, Idaho. Sossaman was formerly staff forester with American Can Company, Butler, Alabama. In his new position he will assume partial responsibility for design and analysis of the many studies conducted by the Cooperative, freeing Bob Weir to take on greater policy responsibilities. Additionally, he will enroll in a Ph. D. program, working toward a degree in forestry with a minor in economics.

Bob Kellison has returned to full-time duties following a year's leave of absence spent at the Forest Research Institute, Rotorua, New Zealand. While there he worked on seed orchard problems associated with Monterey pine, giving him additional experience and a greater appreciation for managing our southern pine seed orchards.

Vernon Johnson is now administratively in charge of our laboratory, assuming that responsibility in addition to that as supervisor of all field projects for the Cooperatives at N. C. State. The former move was made to free Martha Matthias from some rather confining duties so that she could devote more time to special wood studies.

Carol Holland is the new stenographer in our office, replacing Susan Bigbee who resigned to accompany her forester husband on a new assignment.

The staff of the Cooperatives reads thus:

Bruce Zobel, Director
Bob Kellison, Associate Director
J. B. Jett, Liaison Geneticist
Bob Weir, Liaison Geneticist
Ed Sossaman, Liaison Geneticist
Jerry Sprague, Research Assistant
Martha Holland, Administrative Secretary
Norma Bergeron, Stenographer
Carol Holland, Stenographer

Alice Hatcher, Computer Programmer
Becky Wagner, Computer Typist
Vernon Johnson, Ag. Res. Technician
Martha Matthias, Res. Tech. II
Addie Byrd, Res. Tech. I
Edith Jones, Res. Tech. I

Graduate Students

Currently the graduate student population is at an all-time low. A number of students have graduated within the past twelve months and are just now being replaced. We have had a good ratio of foreign to domestic students (approximately 30%) but this has dropped considerably so the current group of foreign students is rather small. We like to maintain a ratio of about one-third of our students from foreign countries.

Research by the graduate students has been invaluable and summaries of several studies have been included in the body of this report. They continue to do the bulk of our basic research; the seven just starting their studies will be of great help in furthering the Cooperative Programs.

Short Courses

Whenever the need arises, the Cooperative staff in Raleigh holds a three-day tree improvement short course for the purpose of familiarizing personnel who are newcomers to the tree improvement business. The course is aimed at the people who are actively involved in managing tree improvement programs, and covers topics such as basic genetics (as it applies to tree improvement), selection, establishment and management of seed orchards, progeny testing, wood properties, soil management, and economic considerations. This course has been held about every two years but demand is so great that we're holding one on May 27-29, 1975 even though the last one was only a year ago. Approximate attendance at the 1974 short course was 33.

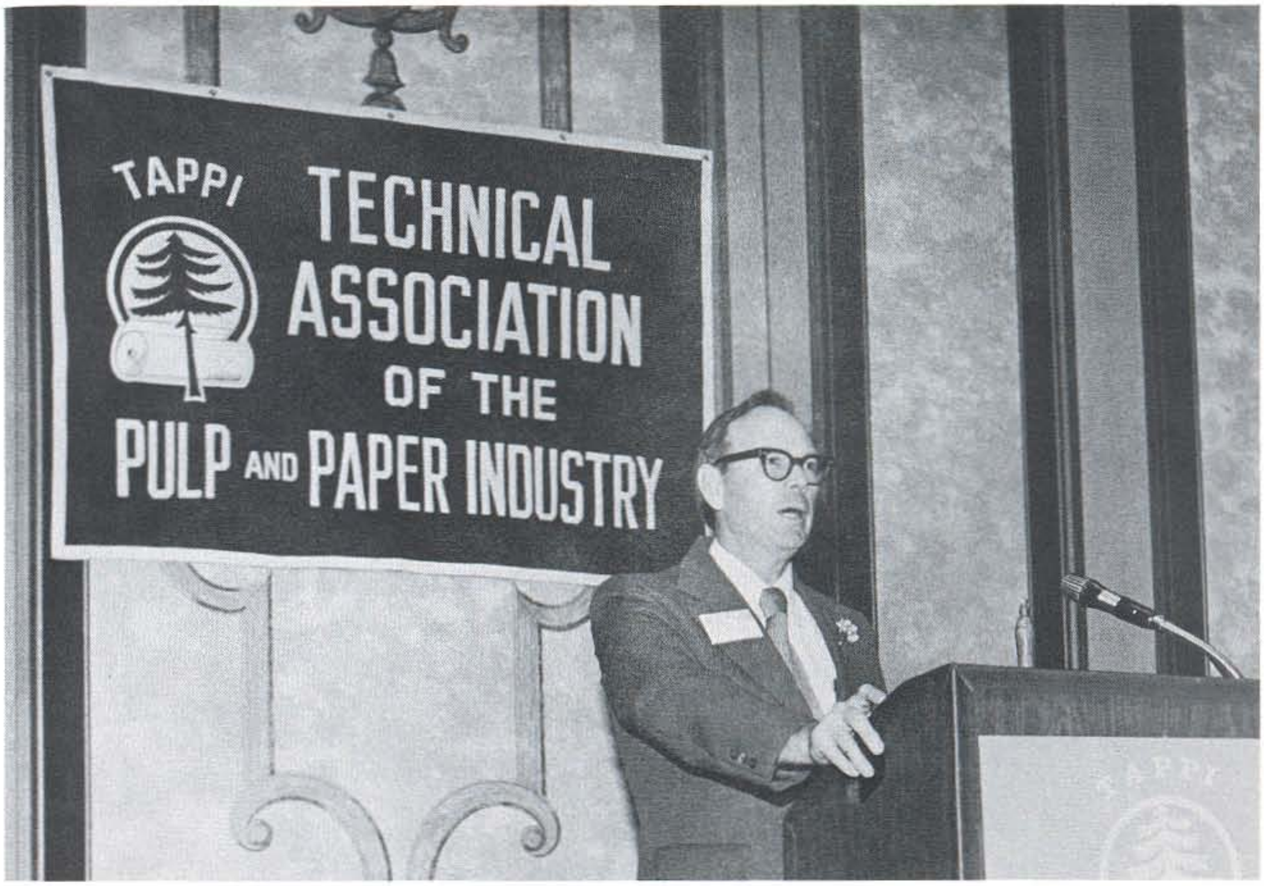
On May 15-17, 1973 the first Hardwood Short Course was held by request of the Cooperative members. Again, this course is aimed at the field forester actively involved in hardwood management. Some of the topics dealt with in the course include hardwood problems, natural and artificial regeneration, seed collection and storage, wood properties, hardwood tree improvement, and economics. Demand for this course was such that a second course was held in December, 1973. The average attendance was about 25. Possibly another hardwood short course will be offered in the fall of 1975.

Special

Worthy recognition continues to be given the career of Bruce Zobel. He is seen on the following page accepting TAPPI's Gold Medal, which was bestowed at the 1975 Annual Meeting in New York. The Gold Medal is the highest honor the Technical Association of Pulp and Paper Industries can give an individual "whose achievements have definitely contributed to the technical progress of the pulp, paper, and paperboard industry."

In making the award, Gunnar Nicholson, a staunch supporter of Bruce's work and a pioneer in the pulp and paper industry, declared that the impact of Bruce's contributions to forestry would surpass those of any other individual in this century.

Bruce was justly proud of the Medal. Of the 42 recipients of the award in the 60-year history of TAPPI, he is the first whose main field of interest and research is forestry.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ASSOCIATION
OF THE
PULP AND PAPER INDUSTRY

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