FORTY-NINTH

PROGRESS REPORT

OF THE

COOPERATIVE

FOREST TREE IMPROVEMENT

PROGRAM

By

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INTRODUCTION

The year 2001 was one of change for the cooperative in many important ways. Industry consolidation and the shifts in land ownership patterns continued to accelerate. International Paper Company's acquisition of Champion International, which was actually completed in 2000, resulted in a loss of a cooperative member in 2001. Fortunately, this occurred without a corresponding loss of breeding material as International Paper Company assumed responsibility for testing Champion's selections. In fact, International Paper Company completed their first-generation progeny test establishment for a second time by planting the last series of Champion International selections. Land ownership patterns continued to change as industry attempted to divest itself of land that no longer supported its long-range goals. This resulted in several progeny tests changing hands including some of the most critical advanced-generation plantings. Again the cooperative was fortunate in that other members acquired the plantings and access for maintenance and measurement was assured. A second corporate merger with significance for the Western Gulf Forest Tree Improvement Program was the acquisition of The Timber Company by Plum Creek Corporation. This merger returned orchards to the cooperative that were dropped when Manville Corporation withdrew from membership in 1983.

At least as traumatic as the industry consolidation was the change that the weather forced on the progeny testing program in Oklahoma and Arkansas. The region experienced back to back record-breaking ice storms in December 2000. This left many progeny test trees either leaning or with broken tops. The damage was so extensive that all plantings age 5 and older in Oklahoma were dropped from the program. While the damage in south Arkansas and northeast Texas was less severe, it covered a much larger area and resulted in abandoning several older tests (Figure 1). But once again the cooperative was extremely fortunate. In every single case, the tests that were abandoned had been measured at least once. In addition, most of the plantings had already been screened for second-generation selections.

Figure 1. Gerald Lively of the Texas Forest Service surveys ice damage in a second-generation polymix test in Bowie Co., TX.

Losses to the advanced-generation progeny testing program were exacerbated by the damage to top grafts. Several crosses that should have been completed with the 2001 cone harvest will now have to be done over after the grafts are reestablished. In order to expedite test establishment, the cooperative took advantage of the fact that polymix crosses can be evaluated on a regional basis. Seed from five cooperators in the Oklahoma/Arkansas breeding region were combined into a joint series of test plantings. The Arkansas Forestry Commission produced the seedlings and three organizations each planted one location.

A subtle but long reaching change experienced by the cooperative is the transition from first-generation breeding and progeny testing to advanced-generation breeding. While this transition has been underway for several years, it is gaining momentum as more members become involved. The ramifications felt in the mainline breeding program are manifest in several ways. The most obvious impact is in the adoption of a new strategy with the application of the complementary mating system. This has resulted in planting both replicated single-tree-plot tests with polymix seedlings to estimate family breeding values and block plots of pedigreed crosses for advanced-generation selection. A second consequence of completing evaluations for many of the first-generation selections is the possibility to use this information to establish specialty populations. The cooperative is making crosses among the best first-generation selections for volume growth in a scheme pairing breeding groups into super breeding groups. The intention of these crosses is to support the orchard program with an additional high-value selection population. A second type of elite breeding population is being designed to simultaneously improve wood quality and volume growth. Creating all these crosses with their different objectives is an increase in complexity that has resulted in the need to more closely track and coordinate breeding programs.

The regulatory environment surrounding the use of pesticides for control of cone and seed insects also continues to shift. The tree improvement community, including the Western Gulf Forest Tree Improvement Program, has attempted to be proactive in this area by participating in pesticide use surveys and southwide efficacy studies. These are regional and national efforts to maintain access to seed orchard management tools. These efforts are organized under the auspices of the Seed Orchard Pest Management Subcommittee of the Southern Forest Tree Improvement Committee. However, the work is actually being done by individual member organizations. In this endeavor, our industry's experiences working together to put in joint research projects and the willingness to quickly share information have proven invaluable. The three southern tree improvement cooperatives working together with the support of the USDA Forest Service-Forest Health Protection group have become the industry's default representative with the government regulators. Rapidly changing regulations will require that the cooperative members continue to put in region wide orchard studies and remain innovative in applying insect control measures.

The hardwood programs have undergone their share of changes over the last few years as well. In the Western Gulf Forest Tree Improvement Program – Hardwood Cooperative, the first-generation progeny test establishment has been completed. One hundred and thirty-two plantings have been established to evaluate seven species. The youngest of the first-generation hardwood plantings is a series of Nuttall oak tests that will be measured after their fifth year of growth in 2003/04. The next phase of this program is to evaluate the performance of the second-generation selections established in seed orchards. Two series of tests have been planted in cooperation with the North Carolina Hardwood Research Cooperative to do just this for sycamore and sweetgum advanced-generation selections. Seed orchards in both the Western Gulf Forest Tree Improvement – Hardwood, and the Urban Tree Improvement Program are beginning to produce commercial quantities of seed on a regular basis. The cooperative is faced with making the necessary connections with nurseries, municipalities, and commercial growers to insure that these resources are fully utilized (Figure 2).

Changes in the cooperative staff have also had a significant impact on the Western Gulf Forest Tree Improvement Program during the last year. The cooperative supports four employees to coordinate the organization's activities. This includes the WGFTIP Geneticist, two Assistant Geneticists, and a Staff Assistant. During the past year, three of these four employees have left the cooperative. Dr. W. J. Lowe, who has served as the WGFTIP Geneticist since 1978, retired and was replaced by Dr. T.D. Byram. G. D. Gooding, who had been with the cooperative as an Assistant Geneticist for four years, left to pursue other opportunities. Mr. L. G. Miller and Dr. E. M. Raley were employed to fill the two Assistant Geneticist positions. The Staff Assistant position vacated by Ms. P. Castro was held by a series of temporary employees before being filled by Ms. P. Sieling.

Figure 2. Texas Forest Service hardwood seed orchards at Hudson are inspected during the Formal Review of the tree improvement program.

WESTERN GULF FOREST TREE IMPROVEMENT PROGRAM

Highlights

- Despite the extensive ice storm damage suffered by orchards in Oklahoma, Arkansas, and North Louisiana the members harvested over 40,000 bushels of cones in 2001.
- The Mississippi Forestry Commission collected 950 bushels of cones from their 13-year-old longleaf pine seedling seed orchard in 2001. This is the oldest seed orchard for this species in the cooperative.
- To date, 21 super breeding groups have been designed for eight members. Block plots of seedlings with known midparent values have been established for 118 crosses.
- Members began crossing to support elite breeding population for the simultaneous improvement of volume growth and wood specific gravity in three of the cooperative's breeding regions. Selections from this population should be valuable for both pulp production and solid wood product manufacture.
- Growth curve parameters for loblolly pine height are heritable indicating that it may be possible to alter the shape of growth curves through selection. This would make it possible to improve cropping characteristics for intensively managed plantations even though final height at maturity might not be changed.
- Analysis of the Western Gulf Forest Tree Improvement Program Geographic Seed Source Study indicated that genotype by environment (G X E) interaction observed for height and volume at age 5 and for volume at age 10 had disappeared by age 15. Sources moved 125 miles or more north or south of their origin suffered decreases in yield.
- The worst ice storm in the cooperative's history resulted in dropping 20 progeny tests from the program. All of these plantings had been measured at least once and most had been screened for second-generation selections.
- If 2001/02 progeny test establishment efforts are successful, the cooperative will have less than 100 first-generation loblolly pine selections left to evaluate in field trials

Seed Orchards

Seed orchards are the cooperative's bread and butter because they produce the seed for the members' operational planting programs. The cooperative's overall goal is to make it possible for the members to produce a reliable supply of seed with a high level of genetic improvement and to do this at a reasonable cost. As with all such complex endeavors, there are several interacting factors that impact the ability to meet these objectives, some of which can be managed while others can not.

Management decisions that impact seed yields include such things as orchard rotations and insect control measures. Replacement schedules determine size and average age of orchards under management. The number of orchard acres managed by the cooperative continued to increase slowly as the members graft advanced-generation blocks to capture genetic gain from the breeding and progeny testing program. At the same time, the average age of orchards is decreasing as older blocks are taken out of production. Another important element in reliable and inexpensive production of seed is effective cone and seed insect control. This has always been problematic, as the insects that prey on pine seed are extremely difficult to manage. However, this task is becoming even more challenging as the regulatory environment surrounding agricultural pesticides becomes increasingly restrictive. Both younger orchards and more uncertain cone and seed insect control measures contribute to more unpredictability in seed yields.

As with any agricultural crop, the weather has always had a significant impact on seed supply. The size of the flower crops varies from year to year in ways that are not fully understood. However, even when flower crops are adequate, disastrous weather can still alter the outcome. This was true in 2000 when temperatures exceeded 110° F on several days in August and September while cones were ripening and the seed was completing its development. The hot dry weather hastened cone ripening and made it more difficult to complete the harvest before the cones began to open. As a result, yields were below normal and seed quality may have been impacted. For the 2001 crop, the problem was cold rather than heat. Two of the worst ice storms in history occurred in December 2000, extensively damaging orchards in Oklahoma, Arkansas, and North Louisiana (Figure 3). As a result, one organization harvested no cones in 2001 and collections in several other orchards were well below early projections.

Figure 3. Extensive ice storm damage occurred to several orchards in Oklahoma and Arkansas as exemplified by this damage to Oklahoma Forestry Services' shortleaf pine seed orchard at Idabel, OK.

Despite both unknowns in the regulatory environment and the unpredictability of the weather, members of the cooperative continued to manage their orchards to maximize genetic gain in the production population. Members continued to establish advancing-front orchards, five organizations grafted expansion orchard blocks in 2000, three in 2001, and seven organizations planted rootstock for grafting in 2002. Orchards were still being rogued and seed orchard managers continue to collect only the best families. Seed orchard managers were attempting to proactively meet the pesticide regulation challenge with a series of southwide efficacy studies sponsored under the auspices of the Seed Orchard Pest Management Committee. As always, this was being done against a backdrop of uncertain long-term seed demands. The one thing that does seem certain is that as long as the south continues to be a significant source of wood fiber for the nation and the world, the seed orchards of the Western Gulf Forest Tree Improvement Program will have an important role to play.

Orchard Establishment and Roguing

The 2001 grafting season represented a lull in orchard establishment between the hectic seasons experienced in 2000 and the one anticipated in 2002. In 2000, six members grafted 63 acres of advancing-front orchard. In 2001, three members grafted a total of 38 acres of advanced-generation orchard blocks and seven members established rootstock for grafting in 2002 (Figure 4). Members grafting new orchard blocks in 2001 included the Louisiana Department of Agriculture and Forestry, the Mississippi Forestry Commission, and the Texas Forest Service. Rootstock was established in 2001 for grafting in 2002 by Bosch Nursery, Louisiana Department of Agriculture and Forestry, Louisiana-Pacific Corporation, Temple-Inland Forest, The Timber Company, Weyerhaeuser Company, and Willamette Industries. The only orchards removed from production were a one acre block of loblolly pine and a 2 acre block of Virginia pine orchards that were cut by the Oklahoma Forestry Services to make room for their next loblolly pine expansion. The removal of these orchard blocks was done in conjunc-

Figure 4. Potlatch Corporation continues to expand their new orchard at Prescott, AR and to fill in one-year-old blocks.

tion with the general clean up required after the ice storm damage suffered at their Idabel, OK orchard complex.

The restoration of a previously abandoned first-generation orchard to management has been a relatively rare event in the history of the cooperative. It has happened in the past when changing seed demands have necessitated reactivation of mothballed orchards or when a member has acquired an abandoned orchard from an inactive former member. In 2001, a new player brought an old orchard back into the program. This happened when Plum Creek Timber Company acquired The Timber Company and brought the orchards established by previous cooperative member Manville Corporation back into the program. With these additions and deletions, the cooperative now manages 2,260 acres of loblolly and slash pine orchards (Figure 5). Of this total, 994 acres (44 percent) are advanced-generation orchards.

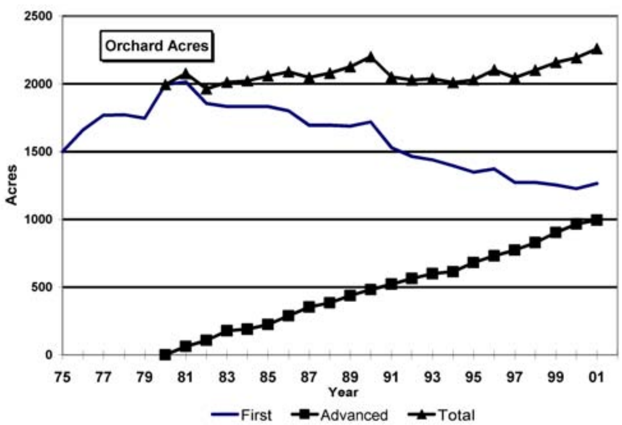

Figure 5. Seed orchard acres managed by the cooperative.

Genetic gain for the most recently established orchard blocks averaged 28.2 percent above the unimproved checklots (Figure 6). This gain was substantially lower than the gain achieved over the last three years for two reasons. The orchards grafted in 2001 were designed for a limited deployment area with a small base population and limited numbers of tested second-generation selections. In addition, these orchards were designed for areas in which the unimproved checklot is a strong performer.

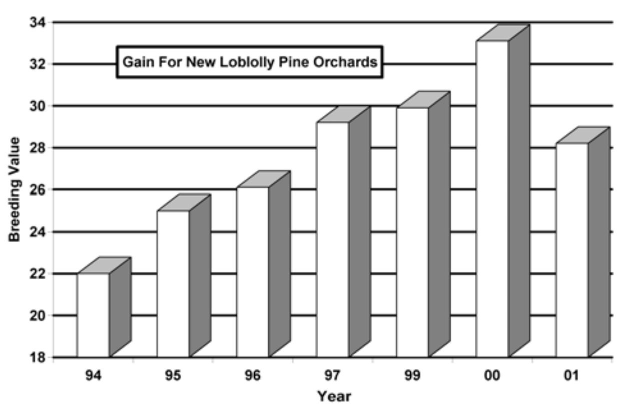

Figure 6. Gain in breeding value for volume growth averaged over new loblolly pine seed orchards by year of establishment.

Very little genetic roguing occurred in 2001 when most of the tree removal was associated with the cleanup required after the 2000 ice storms. Extensive sanitation efforts were necessary in several orchards. Previous experience with ice storm damage has shown that the long-term impact on orchard productivity is minimal with most of the recovery occurring within a two or three year period.

Orchard Yields

The cooperators collected over 36,000 pounds of seed in the year 2000. This included 29,319 pounds of loblolly pine seed, 6,894 pounds of slash pine seed, and 52 pounds of longleaf pine seed (Figure 7). This was sufficient to meet the cooperative's annual sowing demand but did not allow any surplus to be placed in storage. Yields were below historical norms, averaging only 1.05 pounds of seed per bushel for loblolly pine and 1.00 pounds of seed per bushel for slash pine. However, these yields were better than expected given that daily high temperatures exceeded 110° F on several occasions during August and September when the cones were ripening. As a result of the unusual weather, the cones opened early and over a short period of time. Most seed seemed to develop normally; however, a number of families were reported by nursery managers to have lower than expected germination rates. Outstanding yields were reported in orchards managed by the Timber Company at Point Pleasant in northern Louisiana (1.44 pounds/bushel), the Arkansas Forestry Commission at Bluff City in southern Arkansas (1.38 pounds/bushel), and the Timber Company at Moselle, MS (1.34 pounds/bushel).

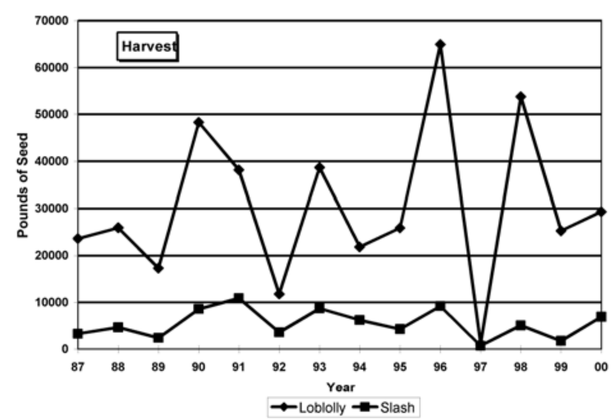

Figure 7. Pounds of seed harvested by the cooperative from 1987 to 2000.

The 2000 ice storm caused extensive damage to several orchards in Oklahoma, Arkansas, and northern Louisiana. As a result, 2001 harvests were lower than projected across the entire region. Damage was so extensive that one organization did not harvest any cones and another member harvested only a few bushels. Despite these problems, the 2001 cone harvest exceeded the previous year's crop with 35,816 bushels of loblolly pine and 4,114 bushels of slash pine cones collected.

Interest in longleaf pine has been growing with the increased appreciation of the species' historical role in the southern forest ecosystem. In an effort to provide a source of improved longleaf pine seed, the cooperative established a series of short-term tests to evaluate families for survival and early growth initiation. Successful families in these tests were established simultaneously in long-term progeny tests and seedling seed orchards. The Mississippi Forestry Commission harvested the first cone crop from the oldest block of seedling seed orchard in 2000, extracting 52 pounds of seed from 83 bushels of cones. In 2001, this 13-year-old orchard yielded nearly 70 bushels per acre for a total harvest of 950 bushels of cones (Figure 8). Families were included in this orchard based on their performance in the short-term tests and have been rogued further on data from 10-year-old growth and form progeny tests. This orchard should produce seedlings improved for survival, brownspot resistance, early growth initiation, and growth rate.

Figure 8. Mississippi Forestry Commission's longleaf pine seed orchard at age 13. This orchard had an average yield of nearly 70 bushels of cones/acre in 2001.

Super Breeding Groups

Super breeding groups are intended to supplement the mainline breeding program by providing selections from crosses among the best of the proven parents from the previous generation. Super breeding groups maintain sublines within the breeding population by restricting super breeding group crosses to individuals from pairs of breeding groups. These selections are expected to have an incremental gain above that achieved in the mainline breeding program because they use proven parents. They also consist of crosses that would not have been made in the cooperative's mainline breeding population because of the restriction against making crosses that commingle individuals from different breeding groups. These individuals will be available for use in orchards or for further breeding.

Potlatch Corporation identified the first super breeding group selections this year in the block plots they established in 1997. These selections will be top-grafted and evaluated in polymix tests along with the forward selected second-generation population prior to their use in orchards. To date, 21 super breeding groups have been designed for eight members. Block plots of 118 pedigreed crosses with known midparent values have been established by three members.

Wood Quality Elite Breeding Population

The cooperative initiated a breeding program in 2001 to provide loblolly pine selections improved for both volume growth and wood specific gravity. The intent of this project is to provide selections for use in deployment populations either as entries in advanced-generation seed orchards or as breeding stock for vegetative propagation programs. Initially, these elite-breeding populations are being established by region and include only the best of the progeny-tested parents. The wood quality elite breeding population differs from the super breeding groups in that breeding group affiliations are ignored entirely when the crossing scheme is derived. The intent is to use approximately thirty parents from each zone. Pollen was collected in 2000 from the best parents identified to date from Arkansas, North Louisiana, and Texas (Table 1). The first crosses were made in 2001.

Table 1. Average performance of the loblolly pine parents in the elite breeding populations for improvement in volume growth and wood specific gravity.

Zone	Parent (number)	Volume[1] (%)	Specific Gravity[2]
Arkansas	7	21.0	0.022
Louisiana	5	25.8	0.018
Texas	13	21.7	0.029

[1] Breeding value expressed as change in mean annual increment at age 20 compared to an unimproved checklot performance.

[2] Absolute change in specific gravity compared to an unimproved checklot.

The wood quality elite breeding populations will be open with infusions from the mainline population, super breeding groups, and selections from within the wood quality elite-breeding program itself. The index for weighting simultaneous improvement in volume growth and wood specific gravity described in the 46th Progress Report of the Cooperative Forest Tree Improvement Program (pp. 11-12) and in Forest Science[1] was used to rank all parents in the program with known performance for both traits. This index allows tradeoffs to be made between these two characteristics in order to maximize the economic value of selections for pulp production. Each 0.01 increase in specific gravity results in an increase of approximately 50 pounds of fiber per cord of wood. This must be balanced against changes in fiber production caused by changes in growth. Improvements in wood specific gravity will also have an impact on structural properties of solid wood products.

At this time, no zone has enough parents with suitable levels of improvement in both traits to completely fill out the scheme. However, this was not necessary to begin crossing, as the individuals in the program are backward selections with known breeding values. Pedigreed crosses can be made and planted in block plots as a selection population. Once selections have been made from these block plots, they

[1] Lowe, W.J., T.D. Byram and F.E. Bridgwater. 1999. Selecting loblolly pine parents for seed orchards to minimize the cost of producing pulp. Forest Science 45(2): 213-216.

can be evaluated with polymix crosses as if it were part of the mainline complementary mating scheme. Because a rigorous pedigreed crossing scheme is not needed to estimate breeding values, new material can be included as it is identified. Examining the cooperative's population for new breeding material will be done annually. In addition to identifying more selections for the three populations for which breeding is currently underway, the cooperative will initiate a similar population for southeast Louisiana/South Mississippi as soon as suitable parents can be identified.

Breeding and Progeny Testing

The breeding and progeny testing program continued to support multiple objectives. In the mainline breeding program, first-generation progeny tests were established for loblolly, slash, and shortleaf pine. These included the tests necessary to evaluate the last of the first-generation selections originally identified by St. Regis Corporation before they were purchased by Champion International Corporation. The seedlings were grown by Champion and then established in the field by International Paper Company following their acquisition of Champion. Five organizations established advanced-generation selections in polymix tests for breeding value estimation. Three of these plantings will be the first to evaluate second-generation selections in South Mississippi and southeast Louisiana. Several members also planted block plots for third-generation selections.

The 2000 ice storm caused extensive damage to progeny tests throughout Oklahoma and Arkansas. The damage in Oklahoma was so severe that 12 tests, all loblolly tests 5 years of age and older managed by the Oklahoma Forestry Services, were dropped from the program (Figure 9). Field review of tests in Arkansas resulted in dropping an additional eight progeny tests, all belonging to International Paper Company. While these losses were detrimental to the progeny testing program, they were not incapacitating. All of the tests had been measured at least once and in some cases, up to three times. In addition, almost all of the plantings had been screened for second-generation selections.

The mainline progeny testing program is in a transitional phase as first-generation breeding is completed and second-generation breeding receives more emphasis. This involves more than just the change from one generation to another. The breeding scheme is more complicated because of the necessity of dealing with inbreeding depression in a closed and evermore related population. But along with this complexity comes opportunity. As the knowledge base about the selections in the population increases, the opportunities to capture value by creating specialty populations also increases.

Figure 9. Ice storm damage in an older Oklahoma Forestry Services progeny test in McCurtain Co., OK.

In addition to the applied goals of ranking parents and providing a population for advanced-generation selection, the progeny testing population continued to furnish answers to a number of basic questions. Results from three such analyses follow. The first of these attempts to define the types of crosses best suited to ranking parents. Theory supports the idea that self-pollinated seedlings would more readily display deleterious genes and are therefore best for estimating general combining ability. Experimental evidence in the first study does not support this hypothesis. The second study examines family variation in the expression of growth curves. This study implies that cropping characteristics of intensively managed plantations may be improved even if final height is unchanged. The third study is based on results for the Western Gulf Geographic Seed Source Study and has implications for seed movement and deployment strategies.

Comparison of Selfs and Polymix Crosses for Ranking Parents

Two tests were planted in 1988/89 to test the hypothesis that self-pollinated progenies would give better estimates of breeding values than other kinds of pollen parents. The trial included four groups of crosses created with the same group of female parents: 1) polymix crosses created with a mix of 10 "Good" pollen parents (average breeding value for volume = 105.3), 2) polymix crosses created with 10 "Poor" pollen parents (average breeding value for volume = 91.2), 3) wind pollinated seed, and 4) self-pollinated seed.

After 11 and 12 years in the field, respectively, the four groups of crosses were compared for their ability to rank the parents relative to breeding values estimated from two to five standard progeny tests. There were no significant differences among the means of the progenies produced by the three non-self polymixes, so these three groups were pooled and compared to the self-pollinated progenies. This comparison was done for each of the two tests separately. The comparison was based on 8 and 7 parents respectively.

Rank correlation between the breeding values estimated from standard progeny tests and plot volumes from these two studies indicated that neither pollen source ranked parents entirely as expected (Table 2). However, self-pollinated seedlings were clearly inferior for this purpose and the hypothesis that self-pollinated progenies would give better estimates of breeding values than other kinds of pollen parents was not supported. This, coupled with the difficulty of producing sufficient numbers of self-pollinated progenies

Table 2. Spearman rank correlation between breeding values estimated from traditional progeny tests and parents ranked by crossing with an unrelated polymix and seedlings produced by selfing. Families were planted in two duplicate field tests. The number in parenthesis is the probability of a larger correlation.

	Outcrossed Seedlings	Polymix Selfed Seedlings
Test 255	0.66	-0.14
(8 parents)	(0.08)	(0.74)
Test 265	0.83	0.61
(7 parents)	(0.02)	(0.15)

for testing, indicated that this strategy would have no advantage for estimating breeding values.

Genetic Analysis of Growth Curves of Loblolly Pine[2]

The Richards function has been found ideal for quantifying growth traits that follow a sigmoid curve as is typical for height in forest trees. The Richards function for height growth is:

$$Y = A(1 - \exp(-b*age))^c + e$$

where Y is the height at a given age, A is the asymptote or maximum height, b is the rate parameter, c is the shape parameter and e represents the random error. The rate parameter is the rate at which height approaches the asymptote. The shape parameter is the rate at which height approaches the asymptote at the inflection point of the growth curve and generally indicates the pattern of development of the tree.

Growth curves have received attention in animal breeding where rate of growth may be more important than final size. In tree species, there are large tree-to-tree differences in growth curves. This implies that breeders could select trees with the optimal growth curve characteristics changing the shape of the growth curve by selecting for its parameters. Furthermore, estimation of growth curves can correct for irregularities in the data caused by human error or random environmental effects. Despite these advantages, genetic analyses of growth traits in forestry have primarily focused on age-specific measurements and studies of growth curve parameters are limited.

This study estimated genetic parameters of height growth curve parameters for loblolly pine. Based on these estimates, potential for early selection based on growth curve parameters was compared to selection on age-specific heights.

The data were from tests established by International Paper Company (IP) and Weyerhaeuser Company (WEY). The IP dataset was from 222 families mated in a nested mating design and planted in two first-generation genetic tests in Georgia. Seedlings were planted in 12-tree row plots and replicated 3 times. Systematic thinning was carried out in the tests at age 10 years. The tests were assessed at ages 1-10, 13-17, and 25 years of age. Statistical analyses were carried out only on trees that had measurements at 25 years and only for heights measured at ages greater than 3 years. The WEY dataset was from two six-parent diallels planted in six second-generation genetic tests; four established in North Carolina and two in Oklahoma. A total of 30 full-sib families from the Atlantic coastal plain were planted in single-tree plots in 36 replicates at each location. The WEY tests were assessed for height at ages 2-7, and 10 years. Growth curves were fitted using 1) a linear regression model (Wey tests and IP tests, 4-10 years) and 2) a non-linear model based on the Richards function (IP tests, 4-25 years).

In general, heritability estimates for the growth curve parameters derived from the non-linear model (h^2 =0.06-0.18, Table 3) were lower than those for age-specific heights (h^2 = 0.25 for height 10 and h^2 = 0.20 for height 25). Estimates derived from linear models were comparable to those of age-specific heights. Additive variance exceeded dominance variance for the rate and shape parameters, but not for the asymptote (Table 3). For the asymptote, the dominance variance was more than twice the additive variance.

Genetic correlations between rate parameter and age-specific heights increased with age and were largest with 10 year height in the WEY tests (Table 4). Genetic correlations varied from 0.44 with height at 2 years to 0.97 with height at 10 years, indicating that the rate parameter and height at 10 may be the same trait. These correlations were slightly lower than those observed between height at 10 years and height at younger ages (0.61-0.98).

Table 3. Dominance as a proportion of the additive variance, dominance as a proportion of the phenotypic variance and heritability for the growth curve parameters.

Trait[1]	Model	D_A	D_P	h^2
A (IP)	Non-Linear	2.25	0.13	0.06
$ß_1$ (WEY)	Linear	0.21	0.03	0.15
$ß_1$ (IP)	Linear	0.24	0.06	0.26
b (IP)	Non-Linear	0.77	0.07	0.09
c (IP)	Non-Linear	0.00	0.00	0.18

[1]A = asymptote, $ß_1$ = rate parameter from linear model,
b = rate parameter from non-linear model, c = shape parameter.

[2] Gwaze, D.P., F.E. Bridgwater, C.G. Williams. Genetic analysis of growth curves for woody perennials: A case study for *Pinus taeda* L.. Theoretical and Applied Genetics (In press)

Table 4. Genetic correlations (below diagonal), and phenotypic correlations (above diagonal) of age-specific heights and rate parameter for the WEY tests.

	HT2[1]	HT 3	HT 4	HT 5	HT 6	HT 7	HT 10	$ß_1$
HT2		0.95	0.84	0.69	0.59	0.48	0.38	0.06
HT3	0.94		0.97	0.90	0.83	0.76	0.66	0.35
HT4	0.85	0.98		0.98	0.95	0.90	0.82	0.57
HT5	0.73	0.94	0.99		0.99	0.97	0.91	0.70
HT6	0.67	0.88	0.97	1.00		1.00	0.96	0.81
HT7	0.72	0.90	0.97	0.99	1.00		0.98	0.86
HT10	0.61	0.84	0.93	0.96	0.98	1.00		0.93
$ß_1$	0.44	0.69	0.81	0.87	0.91	0.95	0.97	

[1]HT = height number is age, $ß_1$ = rate parameter from linear model

For the IP tests, height at 10 years and the rate parameter derived from 4-10 year data were well correlated (r_g = 0.92, Table 5). Both traits were well correlated with height at 25 years (r_g = 0.72 and 0.78, Table 5). The asymptote was negatively correlated to the other two curve parameters from non-linear model (r_g = -0.87 and -0.70, Table 5). The genetic correlation between the rate and shape parameters was positive and high (r_g = 0.90). The high negative correlations between the asymptote and both the rate parameter and the shape parameter show that trees with smaller asymptotes (shorter height at maturity) reach that maximum height at a younger age compared to trees with higher asymptotes. The rate and shape parameters derived from the non-linear model were poorly correlated with age-specific heights (Table 5). The asymptote was well correlated with height at 25 years, as expected (r_g =0.74).

The study provided insight into the genetic variation in growth curve parameters. The observed genetic variation in the height-age growth curve parameters suggests that the possibility of altering the shape of growth curves through genetic selection exists in loblolly pine. Genetic correlations for height at 10 years and the rate parameter from the linear model with height at 25 years were not statistically different. Therefore, the rate parameter is likely to be as efficient as the age-specific height at predicting height at maturity. However, altering the shape and rate parameters may be desirable if changing the growth pattern can improve the cropping characteristics of intensively managed stands.

Stability and Seed Movement for Loblolly Pine in the Western Gulf Region[3]

The Western Gulf Tree Improvement Program geographic seed source study was established to examine genotype by environment (G X E) interactions and the stability of selected families in the WGFTIP loblolly pine breeding program. Results from this study were intended to establish seed transfer recommendations and to assist in the selection of genotypes for different planting sites. The first phase saw five open-pollinated families and an unimproved checklot from each of four seed zones (southern Arkansas, northern Louisiana, southern Louisiana, and southeastern Texas) planted in fifteen tests. Total height, diameter at breast height, and survival were measured at 5, 10, and 15 years.

At age 5, variation in the responsiveness of different families to changes in site quality could be detected for both height and volume. These differences among families remained significant at age 15 but the changes among family ranks across sites were not important. The G X E interaction was significant for height and volume at age 5 but only for volume at age 10. By age 15, the G X E interaction was no longer significant, indicating that measures designed to capitalize on the G X E interaction (e.g. thinnings) must be taken prior to age 15. The results further indicated that stratifying environments based on family performance could decrease the impact of the G X E interaction detected at early

Table 5. Genetic correlations (below diagonal), and phenotypic correlations (above diagonal) of age-specific heights and growth curve parameters for the IP tests.

	HT10[1]	HT25	$ß_1$	A	b	c
HT10		0.49	0.80	-0.06	0.15	-0.31
HT25	0.78		0.40	0.78	-0.60	-0.49
$ß_1$	0.92	0.72		0.00	0.15	-0.02
A	-0.06	0.74	0.20		-0.86	-0.67
b	0.30	-0.37	0.11	-0.87		0.89
c	-0.33	-0.38	-0.10	-0.70	0.90	

[1]HT = height number is age, A = asymptote, $ß_1$ = rate parameter from linear model, b = rate parameter from non-linear model, c = shape parameter.

[3] J.L. Yeiser, W. Lowe, and J.P. van Buijtenen. 2001. Stability and seed movement for loblolly pine in the Western Gulf Region. Silvae Genetica 50(2): 81-88

measurement ages and increase the predictability of family performance.

In general, families from northern Louisiana and southeast Texas expressed intermediate stability at all ages. Families from South Arkansas showed little responsiveness (stable) to changes in site quality through age 10 but were intermediate in responsiveness by age 15. The converse was true for families from South Louisiana which were very responsive to changes in site quality through age 10 but less responsive at age 15 (intermediate stability). Several factors could contribute to the change in stability. Growth patterns could vary by geographic zone of origin with the South Arkansas families becoming more responsive to site conditions at age 15. Alternatively, families from South Arkansas could have been better at competing for water and other resources and thus were able to grow at higher densities. Families from South Louisiana which were originally faster growing may have been closer to their maximum size at these high densities and so their growth was slowing.

At all sites, local genotypes tended to perform well under their local growing conditions. Genotypes that were moved east or west to sites with poor growing conditions also tended to perform well. However, genotypes moved north or south more than 125 miles from their source of origin suffered decreases in yield.

First-Generation Slash Pine Breeding and Progeny Test Establishment

Slash pine is favored on poorly drained, phosphorous deficient sites commonly found in the flatwoods region that stretches along the Gulf coast and includes areas in East Texas, Louisiana, and Mississippi. It is also slightly more resistant to fire and tip moth damage than loblolly pine. While on most sites, it is generally thought to produce less volume per acre than loblolly pine, it has superior stem straightness and better form class. As a result, it may have a higher value for solid wood products. It has an added advantage in that it roots relatively easily. This allows vegetative propagation to be considered as an option for rapidly capturing more of the genetic gain in the production plantations.

Slash pine is an exotic species in Texas and western Louisiana and as a result of its limited geographic range, it has always been of secondary importance within the cooperative. However, because of its merits, six of the cooperative's 15 members maintain breeding programs for slash pine. These include the three state organizations that serve landowners in the lower coastal plain plus three industrial members with landholdings in the same region. Slash pine currently represents only about 17% of the total seed demand for members with active orchards for this species.

In recognition of its minor importance, the breeding program for slash has not been as extensive as that for loblolly pine. First, half of the breeding population was eliminated based on poor performance for fusiform rust susceptibility at the Resistance Screening Center. This left approximately 500 clones to be field tested in growth and form trials. Five of the six members have finished crossing all of their first-generation selections. It is anticipated that the remaining member will complete breeding in 2002.

Three members established control-pollinated first-generation progeny tests for slash pine in 2001 (Table 6). These five tests represented 21 diallel-location combinations and were sufficient to evaluate 69 new parents (Figure 10). The tests planted by the Louisiana Department of Agriculture and Forestry were the last field trials necessary to completely test all of their first-generation selections. Boise Cascade Company, Mississippi Forestry Commission, and Weyerhaeuser Company will plant their last field tests of first-generation selections for this species in 2002. It is anticipated that the remaining first-generation selections will be put into trials in 2003.

These tests will be used to make both forward (second-generation) and backward (proven first-generation) selections for orchard establishment and to feed into special breeding programs to support vegetative propagation programs. Further development of the program will depend on the anticipated future demand for slash pine planting stock.

First-Generation Loblolly Pine Breeding and Progeny Test Establishment

Four of the cooperative's members established a total of seven first-generation loblolly pine tests during the 2000/01 planting season. These included the last tests needed to evaluate the selections originally identified by St. Regis Corporation before their acquisition by Champion International. These selections were preserved and bred as Champion selections, but were finally planted by International Paper Company who took over the breeding and testing responsibility after the merger of their two organizations. As a result, International Paper Company has now completed establishment of all of its required first-generation progeny tests - twice. International Paper Company's effort is the latest example of a cooperative member working to maintain the integrity of the breeding program despite the upheaval at the institutional level. The recognition that tree breeding is a

Figure 10. One of Boise Cascade's first-generation slash pine tests after one year in the field on a bedded site.

Table 6. Progeny tests established during the 2000/01 planting season.

Cooperator	Number of Tests	Number of Diallels
First-Generation Loblolly Pine Tests		
International Paper Company	3	8
Louisiana-Pacific Corporation	2	10
Temple-Inland Forest	1	5
Willamette Industries, Inc.	1	2
First-Generation Loblolly Pine Total:	**7**	**25**
First-Generation Slash Pine Tests		
Boise Cascade Company	2	6
Louisiana Department of Ag and Forestry	2	10
Temple-Inland Forest	1	5
First-Generation Slash Pine Total:	**5**	**21**
Advanced-Generation Loblolly Pine Polymix Tests	Number of Tests	Number of Families
Deltic Timber Corporation	2	74
Mississippi Forestry Commission	1	107
Potlatch Corporation	1	75
The Timber Company	1	107
Weyerhaeuser Company	1	106

regional effort has contributed significantly to the longevity of the cooperative breeding programs in the south.

The seven first-generation progeny tests established in 2000/01 represented 25 diallel-location combinations evaluating 151 parents. The majority of these parents (135) had never before been planted and therefore represent novel material within the breeding program. Progeny tests have now been established to evaluate a total of 3,147 first-generation selections, 2,454 parents in balanced control-pollinated progeny tests and an additional 693 in open-pollinated plantings. Tests planted in the fall of 2001 are not shown in this total. If this fall's efforts are successful, two more organizations will have planted all of their first-generation progeny tests. This includes The Timber Company and the Louisiana-Pacific Corporation. The Timber Company completed establishment of selections originally identified by Nekoosa. Louisiana-Pacific Corporation accepted responsibility for four groups for which breeding was nearing completion when they joined the cooperative in 1997. They have established field tests to evaluate all 94 parents over a three-year period. As a result of this year's progeny testing effort, there are less than 100 first-generation loblolly pine selections left in the cooperative that have not yet been planted in field tests.

Test Measurement and Second-Generation Selection Activity

The cooperative measured record numbers of progeny tests in both 1999 and 2000. The decline in number of plantings measured in 2001 was real both in terms of the number of total tests measured and in terms of the number of parents evaluated (Figure 11). The peak in activity represented by these numbers signified a major milestone in the history of the cooperative. The record numbers of progeny tests measured in 1999 and 2000 (tests planted in 1994/95 and 1995/96) represented the payoff for the intensive effort to complete first-generation breeding made by the cooperative in the early 1990's. While the number of tests measured

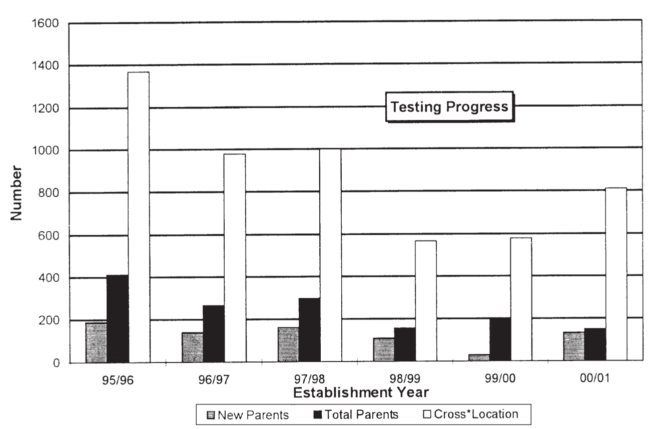

Figure 11. The number of loblolly pine crosses (total number of cross by location combinations), the total number of parents, and the number of parents established in tests for the first time in each of the last six years. The 95/96 establishment year represents the progeny tests that were evaluated in 2000/01.

will peak again in 2004 and 2005 when these tests reach age 10, the total number of active tests is never again expected to be as large as it is now. A majority of first-generation tests will be phased out after 10-year measurements. Furthermore, advanced-generation populations will require fewer progeny tests than the first generation because there will be smaller numbers of selections and each parent will require fewer seedling for estimation of parental breeding values. As a result, more parents will be evaluated in each test planting.

During the 2000/01measurement season, the cooperative was scheduled to evaluate 107 progeny tests. Of this total, measurement was delayed on 14 tests because of the ice storm damage incurred in December of 2000. All but one of these tests will be measured off cycle at age 6 or 11 in 2001/02. In one case, the measurement will be delayed until the next measurement cycle in five years. The cooperative attempts to complete measurement of five-year-old tests prior to January in order to complete selection activities before the end of grafting season. This past year the emphasis on timely measurement was particularly important as it meant almost all of the five-year-old tests were measured prior to the storm damage. In Oklahoma, the early measurement effort averted a tragedy. Damage was so extensive that it was necessary that all tests 5 years old and older had to be dropped from the program (Figure 12). Fortunately, measurements had been completed on the 5-year-old tests and it was possible to make both forward and backward selections to reconstitute the breeding population.

The cooperative measured 78 loblolly pine tests, 8 slash pine tests, 5 longleaf pine tests and 2 shortleaf pine tests. Thirty-seven of the loblolly tests were five-years-old. These progeny tests provided information on 413 parents, of which 190 were evaluated for the first time. The total number of loblolly parents evaluated was down from the 468 parents evaluated a year ago and the 515 parents evaluated in 1999. A total of 574 new parents have been established in tests that have not yet reached measurement age (Figure 13). Breeding needs to be completed on less that 100 loblolly parents to finish testing for the first generation.

Eighteen of the 107 tests were evaluated for first year survival and two of the loblolly pine tests were second-generation polymix tests. Of the remaining tests, 73 were

Figure 12. Eight-year-old Oklahoma Forestry Services loblolly pine progeny test after the 2000 ice storm.

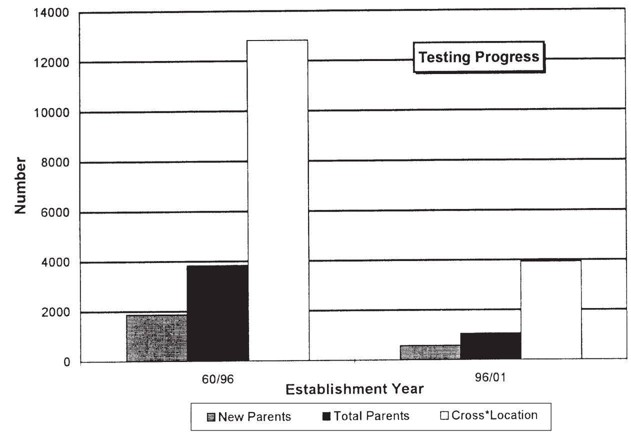

Figure 13. The number of loblolly pine crosses (total number of cross by location combinations), the total number of parents, and the number of parents established in tests for the first time from 1960/1996 and from 1997/2001.

eligible to be screened for second-generation selections. From these tests, nine cooperators identified 192 loblolly pine and four slash pine second-generation selections. The loblolly pine selections originated in 38 breeding groups and contributed to the breeding population in all of the cooperative's breeding zones. Currently, selections have been identified in 87 of the cooperative's 116 loblolly pine breeding groups. Sufficient numbers of selections have been made in 40 of these groups to reconstitute the population for the next cycle of breeding. Twenty-nine of the breeding groups have yet to provide any selections for the next cycle of breeding. In most cases, this is because the tests containing these breeding groups are too young to have been screened. However, in a few cases, the first-generation parents assigned to particular breeding groups have proven to be poor performers and no selections will be carried into the next generation.

The International Paper Company contributed the majority of the selections in 2000/01 with 72 individuals identified from the combined International Paper/Champion International breeding populations. The Arkansas Forestry Commission and the Oklahoma Forestry Services each contributed 20 or more selections. The cooperative now has identified a total of 1,345 loblolly pine second-generation selections and164 slash pine selections (Figure 14).

Second-Generation Breeding and Testing

All of the cooperative members, with one exception, have identified second-generation selections and are currently involved in the advanced-generation breeding and testing program. The one exception is the Louisiana-Pacific Corporation whose oldest first-generation test was only in its second growing season in 2001. Louisiana-Pacific Corporation planted its last first-generation progeny test in the fall of 2001 so they can anticipate making most of their second-generation selections within a very short time.

During the 2000/01 planting season, six polymix progeny tests were established to evaluate advanced-generation selections. This included the first such tests to evaluate

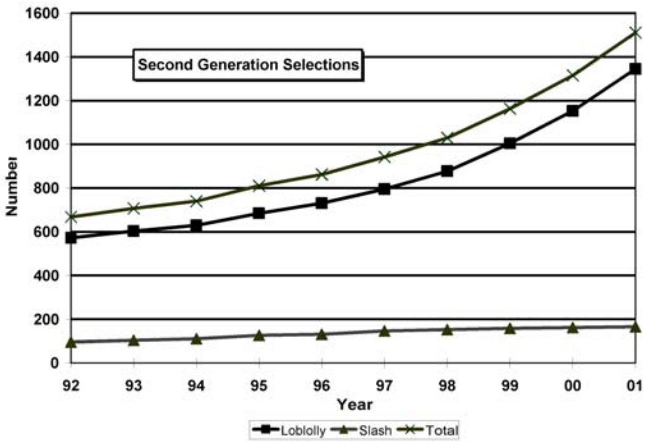

Figure 14. The cumulative numbers of second-generation selection in the cooperative.

advanced-generation selections from the southeast Louisiana/South Mississippi breeding zone. These tests included sources from The Timber Company, Weyerhaeuser Company, and the Mississippi Forestry Commission. Each test contained over 100 sources planted as single-tree plots. Plantings in South Arkansas included both first and second-generation selections crossed with the South Arkansas polymix pollen. These tests will provide information for Deltic Timber Corporation's first-generation breeding program and information for the advanced-generation population in South Arkansas.

The advantages of the regional breeding and progeny testing program were reconfirmed by the ice storm damage that occurred during the winter of 2000/01. Almost all of the cooperators in Oklahoma and Arkansas suffered losses to their advanced-generation breeding programs because of lost cones and flowers due to broken limbs and top grafts. However, because of the ability to combine selections from multiple organizations, the cooperative was still able to establish an additional series of advanced-generation progeny tests for that region during the fall of 2001. Five organizations, none of which had sufficient seed on hand to establish their own series of test, were able to work together to plant field trials of 56 parents. Oklahoma Forestry Services, International Paper Company, Potlatch Corporation, the Arkansas Forestry Commission, and Deltic Timber Corporation each contributed seed and the Arkansas Forestry Commission grew the seedlings. Potlatch Corporation, the Arkansas Forestry Commission, and International Paper Company each planted one of the three required field tests (Figure 15).

Additional Activities

The members of the cooperative participated in a number of additional activities in 2001. This was done directly or by making important resources available to others outside the cooperative. Additional activities in 2001 included the Contact Representatives' Meeting, Formal Reviews, and support of both the Seed Orchard Pest Management Subcommittee and forest genetics research at Texas A&M University. These last two items are important activities that contribute significantly to the tree improvement effort, but

Figure 15. Potlatch's installation of the Oklahoma/ Arkansas regional polymix test planted in 2000/01.

generally go beyond the scope of most organizations immediate objectives and resources.

Contact Representatives' Meeting

Temple-Inland Forest hosted the 2001 Contact Representatives' Meeting in Jasper, TX. The theme for this year's gathering was breeding for disease resistance with special emphasis on the relationship between southern pines and the fusiform rust fungus. An attempt was made to broadly cover a number of topics related to host plant-pathogen interactions and their management within tree breeding programs and production forestry. Dr. Ed Barnard, from the Florida Division of Forestry, laid the groundwork for the remaining speakers with an overview of plant diseases and resistance mechanisms. The life cycle and epidemiology of fusiform rust was briefly summarized by Dr. Tom Byram, and the evidence of gene for gene resistance within the pine-rust system was characterized by Dr. Henry Amerson (North Carolina State University). Dr. Tom Kubisiak, from the USDA Forest Service Southern Institute of Forest Genetics, completed the discussion of fusiform rust by describing the geographic variation in the rust pathogen revealed by genetic marker technology.

Three additional talks brought information to bear on the problem from related fields. Dr. Dave Marshall, a small grain breeder with the Texas A&M University System, broadened the discussion by describing the management of disease resistance in annual crops. Dr. Jeff Wright then described disease management in clonally deployed forest tree species and Joe Pase, with the Texas Forest Service - Pest Control Section, characterized the threat from exotic pests and pathogens. Dr. Floyd Bridgwater, from the USDA Forest Service Southern Institute of Forest Genetics, summarized all these diverse presentations by describing how the current knowledge informs the management of the cooperative's breeding program for disease resistance.

As with all Contact Meetings, an attempt was made to cover a variety of topics unrelated to the central theme.

Dr. Dudley Huber and Geoff Gooding described the Slash Pine Hybrid Study, installed in cooperation with the University of Florida Cooperative Forest Genetics Research Program. Jennifer Myszewski summarized results from the Slash Pine Demonstration Plantings. Installations of the Hybrid Study and the Slash Pine Demonstration Plantings were visited on the field trip. Dr. Jimmie Yeiser provided practical prescriptions for herbicide applications to progeny tests. These recommendations were based on many years of experience with field trials in our area. Dr. Alex Mangini summarized the previous year's activities of the Seed Orchard Pest Management Subcommittee and the progress on the southwide Asana Rate Study.

The field trip and the dinner provided an opportunity to wish Bill Lowe and Geoff Gooding farewell (Figure 16). Both left the program at the end of May, Bill to start his "retirement" in Washington State and Geoff to raise his family in the cooler climes of Canada.

Figure 16. Bill Lowe receives well wishes from the cooperators at the 2001 Contact Representatives meeting.

Seed Orchard Pest Management Subcommittee

The Seed Orchard Pest Management Subcommittee (SOPM), as a working group of the Southern Forest Tree Improvement Committee, is a very loosely organized group of people interested in management of seed orchard pests. The group includes representatives from the Pacific Northwest, the three southern tree improvement cooperatives, state agencies, the USDA Forest Service, and the forest products industry. In addition to the official members of the committee, every forest tree seed orchard manager is also a de facto member. This was especially true this year as the Subcommittee attempted to respond to a number of regulatory issues by coordinating replies to the Environmental Protection Agency (EPA) from our commodity group. These issues included a rewording of the standard clause on pesticide labels prohibiting drift and a complete rewriting of the Guthion®[4] registration.

Orchard managers played an important role in providing thoughtful and factual information to the EPA on needs and actual pesticide use patterns. They have done this by submitting comments to their respective tree improvement programs. These comments have been forwarded to Dr. John Taylor (USDA Forest Service-Forest Health Protection) who has done an excellent job of summarizing them and then relaying them to the appropriate people in the EPA and the USDA Office of Pest Management Policy.

The input from the SOPM and individual orchard managers was instrumental in the labeling of Imidan® for cone and seed insect control in conifer seed orchards. This is an organophosphate in the same family of chemicals as Guthion®. It has the advantage of being less toxic to mammals and safer to use than Guthion®. This chemical has proven effective in studies where it was applied with a hydraulic sprayer to single trees. The SOPM hopes to test its efficacy with operational aerial applications in a southwide study in 2002.

The committee also serves as a focal point for communication among researchers and practitioners. At its twice-yearly meetings, members of the committee updated each other on research results, needs, and future plans. This information ranged from basic research on insect life cycles to needed research to support continued pesticide registrations. One such area identified for further study was the Asana® study described below.

Asana Rate Study

Asana XL® is one of three synthetic pyrethroids labeled for use in conifer seed orchards. It is closely related to Pydrin®, the first such chemical ever registered for use in seed orchards and was widely adopted for use because of this association. While experience has proven it to be an effective control for coneworms and seed bugs at the registered rate, its use has frequently caused damage due to the buildup of secondary insects. For these reasons, it was selected for a southwide rate study conducted in 2001. The objective was to determine if there were lower rates that would give effective control of cone and seed insects with the hope that these lower rates might cause less problems with secondary insects.

Three levels of chemical control were compared to an untreated control. Treatments consisted of applications at the registered rate of 0.19 pounds of active ingredient per acre (lb/ai/ac), 0.10 lb/ai/ac, and 0.03 lb/ai/ac. Applications were made by air five times during the growing season. Flower survival, conelet survival, coneworm damage, and seed data will eventually be taken on sample ramets in each treatment. The six orchards included in the study were managed by the Florida Division of Forestry, International Paper Company (Jay, FL and Springhill, LA), Mississippi Forestry Commission, Temple-Inland Forest, and Weyerhaeuser Company.

This represented a substantial commitment of time and resources by all of the participants in the study. There were direct costs incurred in the study installation. Samples had to be counted and tagged and treatments made according to the study plan. At some orchards this meant renting

[4] Mention of trade names is solely to identify material and does not imply endorsement by the Texas Forest Service or the Western Gulf Forest Tree Improvement Program, nor does it imply that the discussed uses have been registered.

extra lift equipment and employing additional help. At all orchards, this complicated the insect control program and added cost to the application schedule. There were also substantial indirect costs incurred due to seed losses in the untreated controls and the buffer zones between treatments.

Dr. Alex Mangini (USDA Forest Service-Forest Health Protection) was essential in seeing that the study was properly installed. He worked directly with the orchard managers to insure that the applicators used properly calibrated and characterized equipment and that counts were done correctly. Ultimately, almost every forest entomologist in the south with interest in cone and seed insects was involved in one aspect of the study or another. The tree improvement community owes a debt of gratitude to Drs. Stephen Clarke, Jim Meeker, Dan Miller, Don Duerr, and Don Grosman.

Preliminary data analysis indicates that only the labeled rate (0.19 lb/ai/ac) had any impact on coneworm damage when the cones were inspected. All treatments increased flower to conelet survival above that in the untreated control. Damage of this type is generally attributable to seed bug damage. A more thorough analysis will be reported once seed extraction has been completed.

Formal Reviews

Formal Reviews offer an opportunity to strategically reexamine each member's tree improvement program every three years. The reviews consist of both field and office surveys and include documentation of the current status and progress of the program. Of equal importance is the reconciliation between short-term objectives and long-term goals. Experience has shown that the Formal Reviews function best when they involve personnel from all levels of the organization. A particularly important function of the Formal Review is the information exchange between the people charged with developing the strategic goals and those responsible for their implementation. The cooperative staff brings an added element to the discussion with an overall view of the regional status of the tree improvement program. The process also includes a critique of how the cooperative's program can best serve member goals. The synergy that develops during this process makes the Formal Reviews one of the most important functions performed by the cooperative staff (Figure 17).

Seven Formal Reviews were planned for 2001. Five reviews were actually conducted, one was delayed because of weather, and one was postponed to accommodate staff changes within the member organization. These reviews were particularly timely for two novel reasons this year. The number of staff changes experienced by the cooperative in 2001 was extensive and the Formal Reviews proved to be a particularly effective method to acquaint new and reassigned staff members with individual programs. A second and more unanticipated reason that the 2001 Formal Reviews were so valuable was the extensive ice storm damage that occurred across the region during the winter of 2000/2001. Four of the five reviews were for programs with concentrations of progeny tests in the regions of Oklahoma and Arkansas that were most heavily damaged. During these reviews, a majority of the active progeny tests in these states were examined.

Figure 17. Ted and Tim Bosch review a progeny test during the Formal Review of the Bosch Nursery tree improvement program.

Forest Genetics Research at Texas A&M University[5]

Over 250 microsatellite markers have been developed for loblolly pine using techniques pioneered by the Forestry Biotechnology Program at Texas A&M University. These methods concentrate on finding triplet repeat microsatellites in low copy and undermethylated sequences of DNA. Markers located in these portions of the genome are more likely to be near functional genes and should be extremely valuable for studying how the genes are organized in the genome. These studies will eventually lead to the development of tools for selection and to guide the development of breeding schemes.

For markers to be useful, they need to be inexpensive and easy to generate. High throughput marker data collection with radioactive tags (M13-tailed primers) has not worked well for the triplet repeat loblolly pine microsatellite markers developed at Texas A&M University. This is likely because of the huge size of the pine genome and the preponderance of highly repetitive DNA. A fluorescent-labeled forward primer system read with a Li-Cor 4200 DNA Analyzer has given very repeatable results.

As part of the laboratory's technology transfer effort, a Conifer Microsatellite Workshop was held June 4-7, 2001. Even though the workshop was limited to 25 partici-

[5] Submitted by Dr. C. G. Williams

pants, seven countries were represented among the attendees. In conjunction with the workshop, a laboratory protocol handbook was compiled and is now available. Updates on marker development are available at **http://forestry.tamu.edu/genetics**.

Markers are being used to address several important genetic questions such as the evolution of species, population dynamics, patterns of inheritance, and developmental biology. A number of projects have been initiated to use markers for these purposes. Species similarities have been studied by comparing the ability of the loblolly pine microsatellite markers to amplify and to detect polymorphisms in other pine species (Table 7). In nearly all cases, DNA sequencing reveals that both the flanking region and the repeat motif composition are conserved. This information will greatly aid in developing consensus maps across species and contribute to the understanding the evolution of the pine genus.

Microsatellite markers used to determine the numbers of alleles per locus and their distribution can be used to study population dynamics. For example, loblolly pine populations east of the Mississippi River have slightly more alleles per locus than populations west of the Mississippi River even after adjustment for differences in land area and sample size. This type of information can be used to look for bottlenecks in population numbers, migration patterns, and gene exchange among populations on a geological time frame. This information can then be used to help explain observed differences among populations. Markers have also been used to characterize two regions in the loblolly pine genome that appear to promote outcrossing. The system of embryo lethal in pines is unique to conifers and a better understanding of the underlying mechanism will have important implications for the long-term management of breeding populations.

Dr. Humberto Reyes-Valdes, working with the program as a visiting professor has advanced the theory for using marker frequencies to calculate line-origin probabilities in offspring. This information can then be used to detect loci that control quantitative traits (QTLs) in outbred pedigrees with extended kinship groups. The software program, SATORI, that he developed for this purpose has been used to determine degrees of relatedness by descent among progeny in an extended three-generation pedigree. Using these techniques, Dr. David Gwaze was able to identify a QTL with a large effect on volume growth operating within a southern pine family that has contributed a significant number of elite individuals.

Markers and the related field of genomics are contributing greatly to the understanding of how genes are organized and inherited. A deeper understanding of these areas will eventually lead to more efficient selection and breeding programs.

Table 7. Marker variation by species for four microsatellite markers developed in loblolly pine (*Pinus taeda* L.). P (polymorphic) – more than one DNA sequence detected. M (monomorphic) – DNA sequence is present but has only one form. A (absent) – DNA sequence was not detected.

Marker	*P. taeda*	*P. elliottii*	*P. virginiana*	*P. sylvestris*	*P. halepensis*
PtTX2123	P	P	P	P	P
PtTX3020	P	P	P	M	P
PtTX4001	P	A	P	P	M
PtTX4062	P	P	P	M	P

HARDWOOD TREE IMPROVEMENT PROGRAM

Highlights

- Longtime member, Champion International Corporation, withdrew from the cooperative after its merger with International Paper Company. Six organizations consisting of four states and two industrial members now support the hardwood program.

- The progeny testing program has three areas of emphasis: testing and second-generation selection for the original five species evaluated by the program, testing and ranking ortets for inclusion in Nuttall oak orchards, and evaluation of second-generation orchards.

- First-year survival was evaluated on two second-generation sweetgum tests established in collaboration with the North Carolina Hardwood Research Cooperative.

- Two studies to evaluate short-rotation forestry showed that sycamore had extremely fast growth for the first three growing seasons. This was despite the fact that sycamore decline was already appearing in some plots.

- Efforts to collect open-pollinated seed by family from second-generation selections continued with the anticipation that the next round of tests to evaluate these orchards will be established in 2002.

Introduction

The Western Gulf Forest Tree Improvement Program – Hardwood lost a long-standing member in 2001. Champion International Corporation, which had been an active participant in the cooperative since its founding, withdrew from the program after being purchased by International Paper Company. Six organizations currently support the hardwood tree improvement cooperative.

The reasons behind the interest in hardwood tree improvement have varied over the years. When the cooperative was founded, research focused on species-site trials with the hope that productive varieties could be identified for traditional plantation management. Seven species were included in a selection and testing program, with second-generation selections made and established in orchards. Because economic conditions have never favored this type of hardwood forestry, the cooperative initiated a series of natural-stand management studies. These trials, which emphasized site preparation techniques and mid-rotation thinning in bottomland forests, have been important in providing guidelines for managing existing stands. Interest in hardwood plantations was temporarily rekindled with the realization that harvests on most of the quality hardwood sites would eventually be severely limited. This is occurring because of increased regulation of logging in these areas and conversion to other uses. With these limitations in mind, several organizations evaluated short-rotation hardwood forestry. These pilot scale studies differed from traditional plantation management by combining close spacing with fertigation. Interest in short-rotation forestry seems to be waning as the predicted shortages in the hardwood supply have not materialized.

Currently, the hardwood tree improvement programs in the Western Gulf region emphasize planting trees for restoration of marginal cropland and for enhancement of wildlife management. Programs such as these, which stress nontimber priorities, are traditionally promoted by government agencies, a fact that is reflected in the makeup of the hardwood cooperative's current membership. Four state agencies and two industrial members now support the program. The two industrial members have extensive holdings in major river bottoms, which they manage for a variety of values including wildlife and water quality.

The hardwood species selected for study by the membership have proven to be extremely adaptable in meeting a number of these changing objectives. The program has evaluated sycamore, sweetgum, green ash, cherrybark oak, water/willow oak and most recently Nuttall oak. Progeny testing has nearly been completed for the original five species. All of the ortet selections have been established into open-pollinated progeny tests and evaluation has been finished for most of these. Only ten older tests now remain active. Second-generation selections were identified from these plantings and established into seed orchards. The tree improvement program for these species will soon enter a new phase with the establishment of progeny tests designed to evaluate the orchards. Currently, Nuttall oak progeny tests make up the majority of the cooperative's active progeny tests (Figure 18). As soon as these plantings have been evaluated,

Figure 18. A Mississippi Forestry Commission three-year-old Nuttall oak progeny test located in Grenada Co., MS.

several members of the cooperative will establish grafted orchards to supply this highly sought after species to the nurseries.

The Western Gulf Forest Tree Improvement Program – Hardwood has always been a cooperative in fact as well as in name. Because of the limited demand for hardwood seed, the decision was made that the state agencies would cooperate in the development of seed orchards. Each state is establishing orchards for a limited number of species and exchanging seed. This enables each state to have access to a supply of improved seed without having the expense of establishing a seed orchard for each species. This year, the Texas Forest Service's orchards provided green ash and sweetgum seed to other members (Figure 19).

Figure 19. The Texas Forest Service's sweetgum seed orchard in Angelina Co., TX.

Tree Improvement

Progeny Testing

The number of hardwood tests maintained by the members of the Western Gulf Forest Tree Improvement Program – Hardwood decreased by one in 2001 to a total of 32 (Table 8). The Mississippi Forestry Commission's oldest sycamore test was dropped after the fifteen-year measurements were collected.

Table 8. Active progeny tests in the Hardwood Tree Improvement Program.

Species	Number of Tests
Cherrybark oak	3
Green ash	1
Nuttall oak	22
Sweetgum	2
Sycamore	3
Water/willow oak	1

The cooperative's progeny testing program currently has three areas of emphasis. The first of these areas is the first-generation testing program for the species that the cooperative initially selected. These species were chosen because of their potential use for fiber production (sycamore, sweetgum, and green ash) or because of their potential to produce quality hardwoods (oaks). Tests for these species will continue to be abandoned as they reach age 20. In a few cases, the better tests will be converted into seedling seed orchards to produce an interim supply of improved seed. However, most of these tests have met their objectives and the stands are being released to the landowners. Over their useful lifetime, these tests have provided information on geographic variation within species and selections for second-generation orchards.

The second area of emphasis for the cooperative is on the Nuttall oak first-generation progeny tests. This species was selected for progeny testing as a result of the emphasis placed on wetland restoration during the last decade. The species was selected for its adaptation to slightly wetter sites than suitable for either cherrybark oak or water/willow oaks. This species has proven to be an excellent choice for the program as it is suitable for planting on a wide range of sites, has good survival, and excellent growth rates. This species is currently much sought after as an excellent choice for operational planting. Nuttall oak now comprises the majority of the active progeny tests with 22 plantings established to evaluate 216 selections from Arkansas, Louisiana, Mississippi, and Texas. These tests now range in age from three years in the field to eight years in the field (Figure 20). Fifteen of these selections were lost before they could be grafted. Of the remaining 201 ortets, 188 have been preserved by grafting into scion banks by the Texas Forest Service and the Mississippi Forestry Commission. When all of the tests have reached age five, grafted seed orchards will be established with both backward (the best parents) and forward selections (progeny from the best families).

Figure 20. Mike Lee of the Mississippi Forestry Commission at the edge of the three-year-old Nuttall oak progeny test located in Grenada Co., MS. This test had an average survival of 97 percent after its first growing season.

The final area of emphasis in the progeny testing program is the evaluation of second-generation selections. The strategy used with green ash, sweetgum, sycamore, cherrybark oak, and water/willow oak was to test open-pollinated families from the ortets, to identify second-generation selections, and to establish these into grafted seed orchards. Many of these orchards are now producing seed and the second-generation selections need to be evaluated. Open-pollinated seed are being collected from these orchards and will be established in tests with the objective of ranking families and roguing seed orchards. The initial effort to do this began with a sycamore test established in 1998 by Temple-Inland Forest in collaboration with the North Carolina Hardwood Research Cooperative. This test, which was evaluated last year after three growing seasons, contained selections from both programs. The effort to evaluate second-generation selections continued in 2001 with a multiple location sweetgum study also established in collaboration with the North Carolina Hardwood Research Cooperative. These tests were planted in our area by the Arkansas Forestry Commission and Temple-Inland Forest and contained approximately 130 families. Thirty-seven of the families were from the Western Gulf Forest Tree Improvement Program.

The Texas Forest Service's effort to collect and maintain seed by open-pollinated families, which began in 2000, was continued in 2001. The status of this effort is shown in Table 9. Because hardwood seed generally stores poorly, it is imperative that these selections be established in field tests as soon as possible. It is anticipated that the first of these plantings will be grown during the summer of 2002 for fall planting.

During the 2000/2001measurement season, first-year survival on two second-generation sweetgum tests was evaluated by the Arkansas Forestry Commission and Temple-Inland Forest. Both of these tests had poor initial survival because of a number of environmental factors. The summer of 2000 was one of the hottest on record with temperatures exceeding 105° F on several days in late August and early September. Site preparation in one test was less than desirable because the intended progeny testing area was lost at the last minute to the rerouting of a major highway. Average survival of 41 percent in Arkansas and 53 percent in Texas (Temple-Inland Forest) was attributed to drought and less than desirable competition control. Many of these trees have shown signs of sprouting from the root collar and it is anticipated that actual survival will be slightly better than indicated by the initial tally.

Table 9. Status of seed collection and testing of hardwood second-generation selections.

Species	Number of Selections		
	Total Selections	Established In Tests	With Seed Collected
Green Ash	61[1]	0	32
Sweetgum	84	37	69
Sycamore	70	12	24
Cherrybark oak	62	0	0
Water/willow oak	44	0	0
Yellow-poplar	12	0	0

[1] 35 of these selections are female and 36 are male.

Despite these environmental problems, genetic differences in survival were also apparent. There was a range of survivals attributable to family differences at both locations. At the Temple-Inland Forest location, the average family survival ranged from a low of 25 percent to a high of 82 percent. In Arkansas, family averages ranged from 20 to 68 percent. Joint location analysis indicated significant differences among families as well as a significant family by location interaction. Only 37 of the 130 families tested were from the Western Gulf region; however, six of the top ten families were from Texas sources (Table 10). Performance levels for the remaining 30 local families were evenly dispersed. These results once more underscore the need for progeny testing as stand-to-stand and family-to-family differences result in superior families originating across wide geographic ranges.

Table 10. Survival for the top ten sweetgum families in the combined location analysis of the Arkansas Forestry Commission and Temple-Inland Forests open-pollinated second-generation selection tests. Origin is county from which the first generation ortet originated.

Female	Origin (County, State)	Survival (%)
10-183	Cherokee, TX	64.9
10-076	Eastern US	64.0
10-166	Liberty, TX	63.5
10-164	Henderson, TX	62.2
10-175	Walker, TX	61.3
10-138	Cherokee, TX	61.3
10-074	Eastern US	60.3
7-98-1	Eastern US	60.0
10-150	Anderson, TX	60.0
10-197	Eastern US	59.4
Test Average		47.8

Four Nuttall oak tests were scheduled for measurement after their fifth growing season. Analysis for two of these locations has been completed and is summarized in Table 11. Nuttall oak is an extremely hardy species that survives well when planted as bareroot seedlings. This was again proven true in the plantings evaluated last year, with average location survivals of 88.2 and 96.7 percent after five years in the field. Growth for this species has also proven to be outstanding making this species an excellent choice for planting on a wide range of sites. However, not all tests have grown well, reinforcing the notion that even broadly adapted hardwood species must be deployed judiciously by site. Anecdotal evidence suggests that while soil texture does not ap-

Table 11. Fifth year results from the Nuttall oak progeny tests measured in 2000/01 measurement season.

Location (Co./State)	Plantation Average Survival (%)	Height (m)	Diameter (cm)	Volume (dm^3)	Range Volume (dm^3)
Lonoke, AR	88.2	2.2	1.6	0.21	0.40-0.02
Sharkey, MS	96.7	1.5	0.3	0.01	0.03-0.00[1]

[1] Family had no trees taller than 4.5 feet, therefore it had no dbh measurements and no volumes were calculated. Survival in this family was 52 percent.

pear to harm survival in this species, it may be a limiting factor in determining growth rates.

Temple-Inland Forest also measured a sycamore study after three growing seasons in the field. This planting, established in 1998, represented several firsts for the cooperative. It was the first study established as a collaborative effort between the Western Gulf Forest Tree Improvement Program – Hardwood and the North Carolina – Industry Cooperative Hardwood Research Program to evaluate second-generation selections. It was the cooperative's first hardwood planting established with single-tree plots and it was the first to be grown under an intensive silvicultural regime including chemical weed control and fertigation.

There were significant differences among families for height, diameter, and volume, but not for survival. After only three growing seasons in the field, these trees averaged 5.0 m in height, and 4.5 cm in diameter and had an overall survival of 98 percent.

Short-Rotation Hardwood Study

Temple-Inland Forest measured two projects intended to evaluate the potential of several species grown under a short-rotation, intensive management regime for fiber production. These studies were located on adjacent sites in Jasper County, TX on a well-drained sandy soil and included chemical weed control and fertigation. The first of these studies compared sycamore, cottonwood, and sweetgum grown in pure species blocks. The second study compared

Figure 21. Andrew Crocker standing in a block of three-year-old sycamore in Temple-Inland Forest's short-rotation forestry trial comparing sycamore, cottonwood and sweetgum.

seven different species in mixed plots. Both studies were designed in a collaborative effort between Temple-Inland Forest and the Western Gulf Forest Tree Improvement Program (Figure 21).

The first study, which compared sycamore, cottonwood, and sweetgum, was installed as a split plot design with species established in blocks as the main plots. Ten families within each species, planted in rows, were the subplots. After three years, there were significant differences among species for all of the traits measured (Table 12). Sycamore outperformed the cottonwood, which in turn outperformed the

Table 12. Comparisons among species established in pure plots by Temple-Inland Forest after three growing seasons in the field. Ranges among families within species for traits in which the families were significantly different are shown in parentheses.

Species	Survival[1] (%)	Height (m)	Diameter (cm)	Volume (dm^3)
Sycamore	95.6 a	4.9 a	4.8 a	3.1 a
	ns[2]	ns	ns	ns
Cottonwood	88.2 b	4.5 b	3.8 b	2.0 b
	ns	(3.9-5.1)	(2.9-4.3)	(1.1-2.8)
Sweetgum	98.2 a	3.4 c	3.5 c	1.2 c
	ns	(3.1-3.6)	(2.8-4.0)	(0.8-1.7)

[1] Means followed by the same letter are not different at the 10 percent level of confidence on a Duncan's Multiple Range Test.
[2] Families within species were not significantly different.

sweetgum. There were also significant differences among cottonwood and sweetgum families when they were compared to other families within the same species (Table 12).

The second study compared sycamore, loblolly pine, sweetgum, green ash, black willow, cherrybark oak and Nuttall oak in mixed species plots. At age three, the best performer was the sycamore closely followed by loblolly pine (Table 13). Black willow was statistically equal in performance to loblolly pine. These three species produced more volume than any of the other four species. The sycamore produced over a thousand times more volume than did the cherrybark oak, the slowest growing source in the test. As in any species-site trial, one must keep in mind the objectives of the test when evaluating the data. Had these trees been evaluated at older ages or had the intended product been different, the results could also have been different.

The results from these two studies combined with that from the second-generation sycamore test described in the earlier section indicate that sycamore would be a likely candidate for use in a short-rotation high intensity management regime. If sycamore is successfully used for plantation fiber production in East Texas, it will likely have to be under this type of management scheme. In older plantings it frequently succumbs to a decline caused by an anthracnose fungus. In fact, sycamore decline was already evident in the block plot study even though it had not yet had an impact on growth rates.

Seed Orchards

While short rotation hardwood forestry has not developed in the Western Gulf region beyond pilot scale testing, programs that emphasize bottomland restoration continue to grow in importance. These programs generally require planting a mixture of hardwood species for biological diversity and to provide a variety of habitats for wildlife. As a result of this emphasis on diversity, seed from all the orchards that the cooperative has developed are in demand. The grafted seed orchards for green ash, sweetgum, and sycamore are all producing meaningful quantities of seed (Figure 22). This year, the Texas Forest Service provided sweetgum and green ash seed to other members from its oldest orchards.

Figure 22. The 2001 green ash crop in the Texas Forest Service's Hudson seed orchard.

None of the grafted second-generation oak seed orchards are producing operationally meaningful quantities of seed. Seed for these species is also somewhat difficult to obtain reliably from the wild, as many of the best natural stands are in wildlife areas where seed collection is regulated. Therefore, to obtain an interim supply of genetically improved seed, a portion of the cherrybark oak and water oak progeny tests were converted to seedling seed orchards. This effort began last year with the Louisiana Department of Agriculture and Forestry converting two cherrybark oak progeny tests, the Mississippi Forestry Commission converting two cherrybark oak progeny tests and one water oak progeny test, and Temple-Inland Forest converting one cherrybark and two water oak progeny tests to seedling seed orchards (Figure 23). Selection pressure to improve stem form and volume was applied by leaving only the best tree/plot in the top 50 percent of the families. Details are discussed in the 48th Progress Report of the Cooperative Forest Tree Improvement Program. This represents the first attempt by the cooperative to turn progeny tests into seed orchards.

Table 13. Comparisons among species established in mixed plots by Temple-Inland Forest after three growing seasons in the field.

Species	Survival[1] (%)	Height (m)	Diameter (cm)	Volume (dm^3)
Sycamore	95.2a	4.7a	4.6ab	2.75a
Loblolly	93.0a	3.4b	5.1a	2.34ab
Willow	84.0b	3.6b	3.0d	1.79b
Sweetgum	97.0a	3.3b	3.3cd	1.04c
Green Ash	98.0a	1.8c	1.6e	0.18d
Nuttall Oak	98.0a	1.8c	1.2e	0.08d
Cherrybark Oak	66.0b	1.0d	0.5f	0.002d

[1] Means followed by the same letter are not different at the 10 percent level of confidence on a Duncan's Multiple Range Test.

Figure 23. The 21- year-old Mississippi Forestry Commission cherrybark oak test near Vicksburg, MS after thinning to create a seedling seed orchard. a) The stocking was reduced by leaving only the best tree/plot in the top 50 percent of the families. b) The crowns are beginning to develop one year after thinning.

Because of the changing seed demands for selected species, the state forestry agencies of Mississippi and Louisiana have been adjusting the number and size of grafted seed orchards. The Mississippi Forestry Commission is expanding their cherrybark oak orchard while abandoning efforts with yellow poplar (Figure 24). Their sycamore orchard is producing a surplus of seed and has been put on a reduced management regime. The Louisiana Department of Agriculture and Forestry is expanding several hardwood orchards including some for which selections were originally made for the Urban Tree Improvement Program. They will begin grafting bald cypress and expanding orchards for Nuttall oak this winter at their new hardwood orchard and nursery site near Monroe, LA. They will continue efforts to establish green ash at their DeRidder Orchard and sweetgum at their Annex Orchard.

Figure 24. The Mississippi Forestry Commission's cherrybark oak seed orchard at Winona, MS. These trees will provide additional genetic gain above that obtained from the seedling seed orchards when they begin meaningful acorn production.

Selections and Scion Banks

The current number of second-generation selections grafted into the cooperative's seed orchards and scion banks is shown in Table 9. No new second-generation selections were made during the last two years. Efforts in the cooperative are directed toward attempting to insure that the selections already identified are preserved and tested.

URBAN TREE IMPROVEMENT PROGRAM

The status of the Urban Tree Improvement Program was last reported in the 45th Progress Report of the Cooperative Forest Tree Improvement Program. The Urban Tree Improvement Program is a Texas Forest Service effort carried out in collaboration with commercial growers and municipalities located entirely in the state of Texas. It has as its objective the production of seed suited to the urban environment in Texas by identifying and testing local selections of native species (Figure 25). The program is unique in that it is based on population improvement strategy rather than cultivar development typical of most horticultural programs. This approach has the advantage of allowing improvements in desired traits while maintaining a wide genetic base across the urban forest.

Figure 25. Joe Hernandez of the Texas Forest Service in the City of Fort Worth's chinkapin oak test after its fifth growing season. These trees will be used by the city for planting on public property.

Table 14. Species established in orchards for the Urban Tree Improvement Program by location.

	Year Established	
Species	**Hudson**	**Indian Mound Nursery**
Shumard Oak	1989	1988
Live Oak	1988	1981
Bald Cypress	1991	1981
Magnolia	1998	1992
Bur Oak	1991	1999
Chinkapin Oak	1996	
Cedar Elm	1994	1994

By 1997, the program had achieved many of its major objectives. The members of the Urban Tree Improvement Program had established, maintained, and measured 189 progeny tests. These plantings evaluated 1,300 selections from 12 different species. Second-generation selections were made in eight species and grafted into seed orchards (Table 14). Many of these orchards are now producing genetically improved seed, which can be purchased from the Texas Forest Service either as seed or as seedlings. Plans are to continue orchard development and to evaluate all of the second-generation selections now established in orchards. Various Urban Tree Improvement orchards are represented in Figures 26-28.

Figure 26. The magnolia seed orchard maintained by the Urban Tree Improvement Program at Hudson, TX: a) the trees in the orchard average three-years-old, and b) are producing seed on a regular basis.

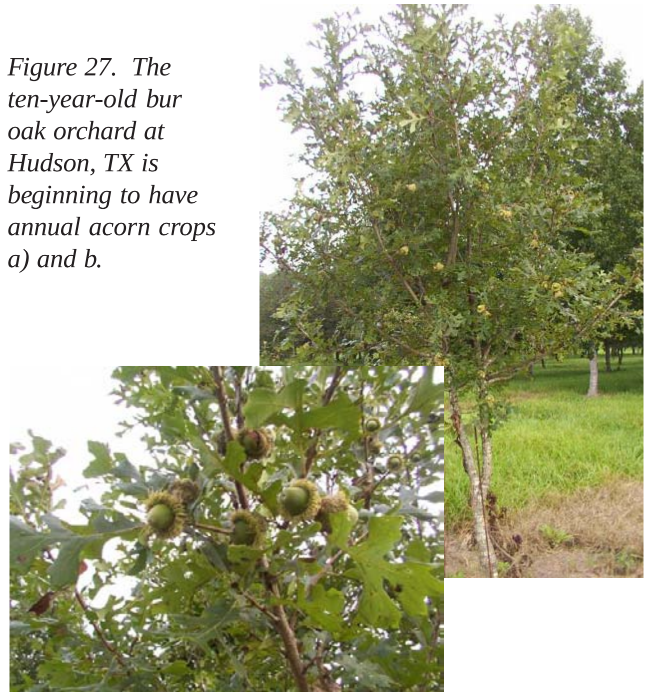

Figure 27. The ten-year-old bur oak orchard at Hudson, TX is beginning to have annual acorn crops a) and b.

Figure 28. Ten-year-old bald cypress grafts at Hudson. This Urban Orchard is providing selections for the Louisiana Department of Agriculture and Forestry's bald cypress orchard near Monroe, LA that will supply seedlings for reforestation.

PERSONNEL

The staff underwent major changes in 2001 with the retirement of W. J. Lowe. Dr. Lowe spent 26 years with the Texas Forest Service during which time he served as Director of the WGFTIP- Hardwood Cooperative and the Urban Tree Improvement Program. For 23 years he also directed the WGFTIP – Pine cooperative. Dr. Lowe relocated to Washington State where he will continue to be active in the tree improvement community, serving on graduate student committees and making his skills available on an as needed basis. G. D. Gooding resigned his position as Assistant WGFTIP Geneticist to pursue other opportunities with his family in Edmonton, Alberta. Dr. T. D. Byram was promoted to the position of WGFTIP Geneticist. He has been with the WGFTIP – Pine program since 1978. L. G. Miller and Dr. E. M. (Fred) Raley were employed as Assistant WGFTIP Geneticists. Larry Miller and Fred Raley both have extensive experience with operational tree improvement programs, greenhouse operations, and nurseries. Their addition to the staff provides an unprecedented amount of depth in operational tree improvement.

Ms. Penny Sieling filled the position of Staff Assistant vacated by Phoebe Castro. Ms. Sieling has many years experience with office operations in a large private industry and is learning the state system rapidly.

The staff now includes the following:

T. D. Byram .... WGFTIP Geneticist
L. G. Miller .... AssistantWGFTIP Geneticist
E. M. (Fred) Raley .... AssistantWGFTIP Geneticist
P. V. Sieling .... Staff Assistant
J. G. Hernandez .... Research Specialist
J. H. McLemore .... Aide to Specialist
D. P. Gwaze .... Postdoctoral Research Associate
J. H. Myszewski .... Graduate Student
G. R. Lively .... Research Specialist
I. N. Brown .... Research Specialist
D. M. Travis, Jr. .... Aide to Specialist
G. F. Fountain .... Aide to Specialist

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COOPERATIVE TREE IMPROVEMENT PROGRAM MEMBERS

Western Gulf Forest Tree Improvement Program Membership

Pine Program

Full members of the Western Gulf Forest Tree Improvement Pine Program include the Arkansas Forestry Commission, Boise Cascade Company, The Bosch Nursery, Inc., Deltic Timber Corporation, International Paper Company, Louisiana Department of Agriculture and Forestry, Louisiana-Pacific Corporation, Mississippi Forestry Commission, Oklahoma Forestry Services, Potlatch Corporation, Temple-Inland Forest, Texas Forest Service, The Timber Company, Inc., Weyerhaeuser Company, and Willamette Industries, Inc.

Associate members include International Forest Seed Company, Louisiana Forest Seed Company, PacificMillennium Corporation, and Robbins Association.

Hardwood Program

The WGFTIP Hardwood Program includes the Arkansas Forestry Commission, Louisiana Department of Agriculture and Forestry, Mississippi Forestry Commission, Potlatch Corporation, Temple-Inland Forest, and the Texas Forest Service.

Urban Tree Improvement Program

Membership in the Urban Tree Improvement Program includes the following municipalities and nurseries: Aldridge Nurseries (Von Ormy), Altex Nurseries (Alvin), Baytown, Burleson, Carrollton, Dallas, Dallas Nurseries (Lewisville), Fort Worth, Garland, Houston, LMS Landscape (Dallas), Plano, Rennerwood (Tennessee Colony), Richardson, Robertson's Tree Farm (Whitehouse), and Superior Tree Foliage (Tomball).

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