FIFTY-FIRST

PROGRESS REPORT

OF THE

COOPERATIVE

FOREST TREE IMPROVEMENT

PROGRAM

By

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INTRODUCTION

The Western Gulf Forest Tree Improvement Program (WGFTIP) faces both opportunities and challenges as it begins its second half-century. Chief among these are the potential to steadily increase the genetic quality of planting stock used for reforestation and the need to accelerate the rate at which these improvements are captured. As in all such endeavors, future successes are built on past efforts. Much of the future's potential will be realized by doing well the things we already know how to do. Efficient orchard establishment is now routine. Orchard site selection, site preparation, and management are all well understood factors in obtaining early and abundant seed production. Economic orchard rotations have been widely adopted, rapidly incorporating genetic gains from the breeding population into the production population. Furthermore, much of the advanced-generation breeding strategy is set. The breeding population has been structured into breeding groups and breeding zones. Both procurement and deployment zones have been defined. Complementary mating and testing has been adopted and implemented on a collaborative basis across the cooperative's operational area. Accelerated breeding techniques, such as topgrafting for the promotion of early flowering is now a standard procedure. Effective progeny test designs for delineating differences among families are in use. A good deal of the next breeding cycle has been selected and rapid progress is being made on evaluating this population. Much of the 51st Progress Report of the Cooperative Forest Tree Improvement Program is dedicated to chronicling the members' successes in implementing the existing program.

With opportunities come challenges that directly impact the ability of the program to deliver on its promises. These challenges fall into three categories: continuing improvement of current methods, adopting new technology, and maintaining the synergy from collaborative effort.

The first challenge is to continually evaluate and improve current methods. During the past year, height growth was developed as an additional parameter for summarizing family performance. Many members manipulate site index within their growth and yield models to predict economic returns from tree improvement. For this reason, the membership requested that gain be reported both as improvement in mean annual increment and change in height growth. While this was done to meet the specific need of supporting growth and yield models, another advantage was soon discovered. By comparing these two estimates of genetic gain, it quickly became apparent that different families were using different growth strategies to obtain the same volume per acre. Some families achieve excellent volume growth by moderate improvements in height, diameter, and survival while other families have relatively fewer, but larger trees per acre. Knowing more about family growth strategies has already paid dividends by identifying the most appropriate selections to meet deployment and management objectives when designing new seed orchards. A second example of continuous improvement is the development of an elite wood quality population. This population consists of individuals that combine improved wood density with moderate improvements in growth rate. Enough control-pollinated seed lots are now in hand to begin the establishment of the selection population for the next cycle of improvement in this elite population.

The second challenge facing the WGFTIP is the rapid adoption of emerging technology. Better understanding of population structure and gene organization forthcoming from the study of genomics may make it possible to restructure the breeding population in ways that make the program both more effective and efficient. WGFTIP continues to support these efforts by providing access to our large base population to organizations doing this type of research. One example is the Founders Project being conducted by the USDA Forest Service – Southern Institute of Forest Genetics. This large regional research program involves both the other southern tree improvement cooperatives: The Cooperative Forest Genetics Research Program hosted by the University of Florida and the North Carolina State University – Industry Cooperative Tree Improvement Program.

The third and potentially most difficult challenge is maintaining the collaborative approach to tree improvement that has been so successful over the previous fifty years. This challenge has at least two facets. The first is to maintain a sufficient number of organizations supporting the improvement of the base population so that the effort is mutually beneficial. In other words, are enough organizations working in a given deployment zone so that the gain from their joint effort exceeds the gain that they each could achieve independently? The second facet of maintaining a collaborative atmosphere is the need to maintain a balanced perspective on intellectual property. To reap the maximum benefits from new technology a distinction must be made between intellectual property that bestows a true competitive advantage and that which can give greater overall returns when shared.

Continued restructuring within the forest industry has made maintaining a critical number of cooperators within a breeding region increasingly difficult. Mergers and the subsequent shakeout among the remaining players have resulted in a reduction in the number of traditional forest industries that have historically supported research in long-term forest productivity. In 2003, the WGFTIP lost a long-time member and one of its strongest supporters with the withdrawal of Bosch Nursery. This family-owned company had been in the business of supplying genetically improved seedlings to North Louisiana for seventeen years. Bosch Nursery formed when Continental Forest Industries sold their North Louisiana land holdings to Willamette Industries. At that time, Leonard Bosch obtained ownership of the seed orchard and nursery complex he had previously managed as a company employee (Figure 1). This program's heritage, which traces back through the ownership of Continental Can Corporation, was one of the oldest programs in the region. The WGFTIP members have made efforts to insure that this legacy will not be lost. The Louisiana Department of Agriculture and Forestry and Boise have taken steps to insure that the best of the breeding population is preserved. A coalition of five members has made sure that all the active Bosch progeny tests are maintained and that final measurements are taken. Further consolidation occurred when Weyerhaeuser Company completed its acquisition of Willamette Industries, Inc. This program will continue in the WGFTIP as a working unit with the breeding and progeny testing programs carried forward by Weyerhaeuser Company. At the end of 2003 thirteen organizations, five state forestry agencies and eight industry members, supported the Western Gulf Forest Tree Improvement Program in our five-state operational area.

Figure 1. Leonard Bosch of Bosch Nursery.

A new factor in the forestry business sector is the recent proliferation of institutional investors and individual speculators. During the last few years, traditional forest industries have sold large acreages to these landowners. In Texas, for example, approximately half of the property previously owned by the forest industry has been sold to a combination of institutional investors and speculators. Some of this land has been kept in large ownerships, and one such land trade made during the last year will impact the WGFTIP membership list. Louisiana-Pacific Corporation sold the majority of their East Texas holdings to ETT, L.P. along with their seed orchard and all of their active progeny tests. ETT, L.P., managed by Molpus Timberlands Management, LLC, in recognition that tree improvement contributes to overall asset value, has committed to maintaining the existing program.

Many tracts, however, have been divided into holdings that are too small to justify direct investment in forestry research. The immediate complication for the WGFTIP is to maintain access to progeny tests located on recently traded property. The state agencies have not been immune to this problem. One of the Texas Forest Service's primary testing areas, previously under long-term lease from a forest industry, was sold to an individual. To date, no active progeny tests have been lost prior to their five-year measurements. The long-term consequences of these changes in ownership pattern are not yet fully understood. It seems certain that the methods of funding and conducting forest health and productivity research of the past will have to evolve in response to continued fragmentation of land ownership patterns.

The second part of the challenge of preserving the collaborative spirit of tree improvement is the need to maintain the proper perspective on intellectual property. The WGFTIP always recognized that an essential element for success is that all of the members contribute equally and that each member derives a fair share of the benefits from the program. Increasing emphasis on the value of intellectual property, germplasm ownership, and the development of proprietary technology threatens this perception. For the first fifty years of the WGFTIP, all members had access to virtually the same technology and applied similar methods. With the advance of genomics, clonal propagation, and the potential to artificially modify the genome, this is no longer necessarily the case. The WGFTIP has attempted to meet this challenge by more precisely articulating its guiding principles. This discussion has taken place over several years during which policy statements on germplasm ownership and data exchange have undergone extensive review by the membership. Through these discussions, the Western Gulf Forest Tree Improvement Program has reaffirmed its role as a population improvement program, feeding germplasm to both public and private reforestation programs. All members have equal responsibilities and abilities for breeding and testing the base population. This leaves member organizations free to innovate with elite populations and unique products for commercial development. The reverse side of this same issue is the necessity to recognize instances when withholding intellectual property is counterproductive, stifling progress in the communal base population from which all hope to be the ultimate beneficiaries. Decisions on how and when emerging technology should be shared will likely be ever more important in the years to come.

Despite these challenges, tree improvement efforts continue to be critically important, as there is no environmentally acceptable alternative to wood in a world that is placing increasing demands on its natural resources. Tree improvement will continue to be a vital silvicultural tool for maximizing forest productivity. For example, average growth from seed produced from new orchards established in 2003 is predicted to exceed that of unimproved woods run seed by 47.9 percent for slash pine and 36.5 percent for loblolly pine. Average gain captured in the production population has increased by an annual value of 1.5 percent over the last decade. The rate at which gain can be captured should accelerate if advanced-generation breeding is done efficiently. The WGFTIP breeding program will make even larger contributions to overall value as multiple traits such as improved disease resistance, stem form, and wood quality are more fully incorporated into the breeding program. The second half-century for the Western Gulf Forest Tree Improvement will be bright indeed if these promises can be met.

Highlights

- The WGFTIP members manage 2,343 acres of seed orchard. Of the total, 1,146 acres are advancing-front orchards comprised of a combination of the best tested material and forward selections.
- Loblolly pine orchards grafted in 2003 contained only tested material and had a predicted improvement in volume growth of 36.5 percent.
- In 2002 the WGFTIP harvested 27,423 pounds of loblolly pine seed and 4,560 pounds of slash pine seed. The 2003 cone harvest totaled 39,858 bushels of loblolly pine cones and 6,781 bushels of slash pine cones.
- Seed harvests have met or exceeded annual demands over the last three years indicating that the WGFTIP members have successfully made the transition from dependence on large, older first-generation orchards to managing advancing-front orchard complexes with younger, multiple age class blocks.
- Breeding value for height growth was developed for summarizing loblolly pine family growth performance. This will supplement the currently reported breeding value for mean annual increment.
- Five of the six members working with slash pine have completed establishment of all of their required first-generation progeny tests for this species leaving only 23 parents untested. In the loblolly pine program, ten of thirteen members have completed establishment for all their first-generation progeny tests. Only 44 loblolly pine first-generation parents remain untested.
- A reception was held at the Southern Forest Tree Improvement Conference in Stillwater, OK to commemorate the 50th Progress Report of the Cooperative Forest Tree Improvement Program. The CD containing a compilation of historical pictures distributed as a souvenir is available on request.

Seed Orchards

The advancing-front orchard strategy, employed by the Western Gulf Forest Tree Improvement Program for upgrading and replacing orchards, requires that older, more genetically obsolete blocks be removed and replaced with new orchards at five-year intervals. This is done in order to rapidly capture the most recent gain from the breeding population by establishing the highest gain families in genetically improved orchard blocks. By recycling areas on existing orchard complexes, maximum use is also made of previous investments in buildings, tractors, and other infrastructure such as irrigation systems and wells. The disadvantage of the advancing-front orchard is that the older, more productive orchards are removed in order to favor younger, higher gain, but less dependable and less productive orchards. The more successful the progeny testing and breeding program is in identifying better clones for seed orchard establishment, the quicker the older seed orchard blocks become genetically obsolete and in need of replacement. To deal with this paradox, most members of the WGFTIP have committed to a 20-year orchard cycle for loblolly pine and a 25-year cycle for slash pine as a workable trade-off between the need to have a dependable supply of seed and the desire to capture the most genetic gain (Figure 2).

Figure 2. Terry Rucker of Boise standing in front of a newly grafted slash pine seed orchard.

With a five-year interval between establishment efforts, there may be four to five age classes of orchards in any advanced-generation orchard complex. In most years, only half of the available orchard acres will actually be old enough to be in production. Therefore, as seed orchards approach removal age, it is necessary to bank seed surpluses to offset the lean years that can be anticipated before younger orchards reach their full potential. This situation has resulted in some tense moments as the cooperative has converted from larger, older first-generation orchards with excess seed production capacity to advanced-generation orchards that have been fine-tuned to better fit existing regeneration programs. Harvest levels have met or exceeded demand over the last three years (2001-2003) indicating that most members have successfully made the transition to managing orchard complexes with multiple age classes.

Orchard Establishment and Roguing

The members of the Western Gulf Forest Tree Improvement Program now manage 2,343 acres of orchard (Figure 3). Of this total, 1,197 acres consist of rogued

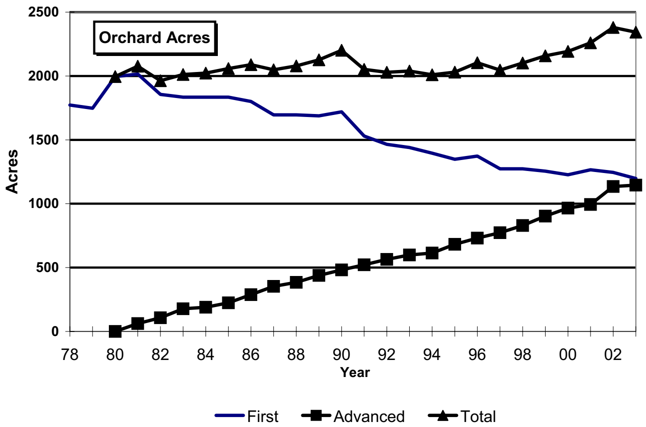

Figure 3. Seed orchard acres managed by the cooperative.

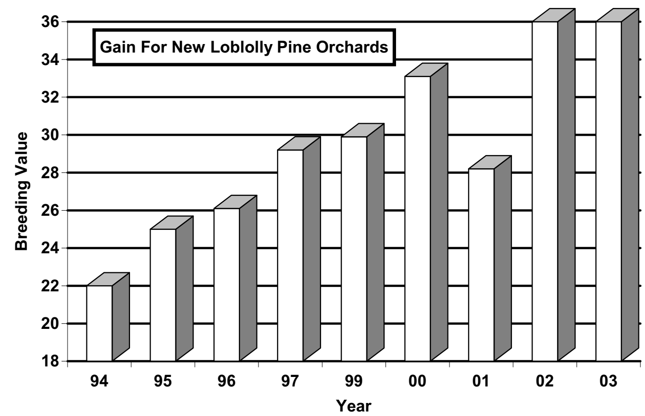

Figure 4. Gain in breeding value for volume growth averaged over new loblolly pine seed orchards by year of establishment.

first-generation orchards and 1,146 acres are advanced-generation orchards consisting of a combination of proven first-generation selections and both tested and untested second-generation selections. In all recently established orchards, strong preference has been given to only progeny tested selections chosen on the basis of their genetic merit regardless of the generation in which they originated. The orchard acreage managed by the WGFTIP declined in 2003 as the orchards previously managed by Bosch Nursery were taken out of production. This decline was somewhat offset by newly grafted orchards. In 2003, 41 acres of new orchards were grafted by Boise and Plum Creek Timber Company.

The selections assigned to the newly grafted loblolly pine seed orchards had an average predicted gain in volume growth of 36.5 percent, expressed as a change in mean annual increment estimated for age 20, above the performance expected from unimproved woods-run material (Figure 4). The gain captured from the breeding population in newly established orchards has increased annually at an average of 1.56 percent over the last decade. The slash pine seed orchard grafted in 2003 had an expected performance of 47.9 percent improvement in volume growth at age 15. Slash pine gain is compared to the fusiform rust susceptible checklot which suffers moderate to severe mortality be age 15 in the WGFTIP region. The ability to sustain this level of improvement in growth rate has been possible because of the continued inflow of new progeny test data on previously untested first- and second-generation selections. Other characteristics such as stem straightness and wood specific gravity are becoming increasingly more important. This change in emphasis is in recognition that the ultimate goal of the tree improvement program is to increase profitability, not just growth rate. Of course, the paradox of all breeding programs is that the more traits included for improvement, the less gain that can be made in any single trait. The key to making acceptable gains in multiple traits is to have a sufficiently large base population from which to make selections for the deployment population. The influx of new progeny test data has allowed the WGFTIP to be more selective in choosing individuals for inclusion in orchards. This trend to emphasize wood quality in the design of new orchards is expected to continue over the next few years as members justify seed orchard programs in a market where many believe there is a surplus of commodity grade raw wood. Under this assumption, tree improvement programs remain economically viable by either lowering the cost of production through improvements in growth rate or by adding value through improvements in quality.

Orchards designed for the Lower Gulf region of Mississippi and Louisiana increasingly consist of the very best clones from the WGFTIP program, from the North Carolina State University-Industry Cooperative and from the Cooperative Forest Genetics Research Program hosted by the University of Florida. This is possible in part because of an effort the three southern pine tree improvement cooperatives are making to test their very best material for this area in a common set of progeny tests. Five-year results from this effort are described for three locations maintained by WGFTIP cooperators later in this report.

Only two organizations did extensive roguing of orchards in 2003. This was an off year for this effort as many orchards were rogued during the summer of 2002. The same parameters that apply to orchard design also apply to orchard roguing. Increasingly, the trend is to favor improvement for stem form and wood quality by roguing on these traits as well as on growth rate.

Orchard Yields

Annual demand for loblolly pine seed in the WGFTIP is approximately 30,000 pounds. The demand for slash pine varies from year to year but is generally less than 2,000 pounds. There is only a small demand for longleaf, shortleaf, and Virginia pine as these species are produced for specialty markets. The 2002 seed harvest totaled 27,423 pounds for loblolly pine and 4,560 pounds of slash pine (Figure 5). Seed yields, while better than those achieved over the last few years at 1.11 pound of loblolly pine seed per bushel of cones, were below levels obtained regularly just a few years ago. This decline in seed yields per bushel of cones coincides with the reduced

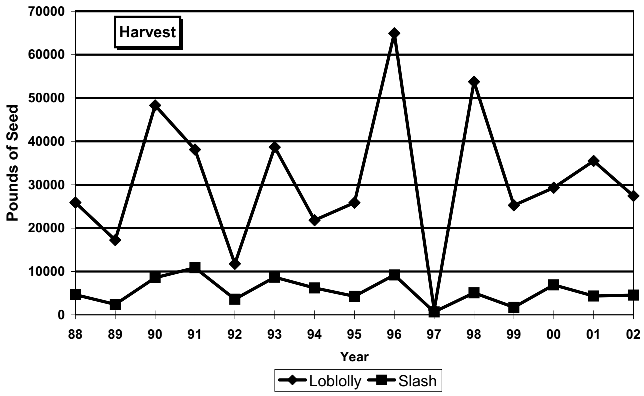

Figure 5. Pounds of seed harvested by the cooperative from 1988 to 2002.

use of organophosphate pesticides for cone and seed insect control. This has occurred in response to increased regulatory restrictions and reflects the tree improvement community's inability to find an adequate substitute.

The 2003 collection will likely prove to be the best seed harvest the WGFTIP has experienced since 1998. This outstanding harvest did not include Bosch Nurseries' older orchards that have historically been very productive. There were 39,858 bushels of loblolly pine cones collected, which included the first harvest from Louisiana Pacific's oldest block of orchard (Figure 6). This orchard produced 99 bushels of cones from 24 acres of five-year-old grafts. In addition to the loblolly harvest, the cooperative collected 6,781 bushels of slash pine cones and 30 bushels from the minor species in the program. Seed yields are expected to be good as this outstanding cone crop apparently coincided with a naturally occurring downturn in the cone and seed insect populations.

Wood Quality Elite Breeding Population

Wood quality is an increasingly important breeding objective for the cooperative. Projections are that low quality wood will be abundant and therefore relatively inexpensive. Therefore, increased growth rates alone without a simultaneous increase in wood quality will add little overall value to reforestation programs. High quality wood for lumber and other solid wood products is expected to be relatively less available, and therefore more valuable. Improving wood quality is the first step in changing what is now a commodity into a value-added product.

Figure 6. Arthur Nichols and Greg Garcia in the oldest Louisiana-Pacific orchard block that produced 99 bushels of cones from 24 acres at age five.

The Wood Quality Elite Breeding Population will eventually consist of 30 progeny-tested parents selected from each of four breeding zones selected for simultaneous improvements in volume and specific gravity. These parents are being grouped into small diallels nested within breeding zones and crossed to create a selection population. Outstanding individuals from these crosses will be identified to form the base for the next cycle of breeding. Because parental values are already known and the mid-parent values of planned crosses already calculated, the crossing scheme need not be genetically balanced nor do the selection plots need to be replicated. Once the selections have been identified, replicated field tests of families created with polymix pollen will be needed to estimate the breeding values of the next cycle of selections.

Selections for this population are being made as data becomes available and only as outstanding parents can be identified. At present, 38 parents from the intended goal of 120 have been selected. Eight cooperators are actively supporting the breeding effort in this population either by making crosses or by collecting pollen for others to use. Seed was collected in 2002 and in 2003 and the cooperative plans to establish the first fourteen crosses in 2004.

The selection index for this population places more economic weight on improvement in specific gravity relative to improvements in volume growth. As a result, many of the parents in this program have not been previously used in seed orchards selected for improved growth rate and are present only in scion banks. As a result, several organizations are topgrafting these selections into production orchards before they attempt to perform the required crosses. As top-grafts in active orchards, they are both more accessible and can be more easily protected from cone and seed insects. While this has delayed the initiation of some crosses, it is expected to ultimately save time by make the crossing program more effective.

Breeding and Progeny Testing

Cooperation has remained the 'name of the game' in 2002/2003 when it came to progeny testing (Table 1). The Mississippi Forestry Commission, Plum Creek Timber Company and Weyerhaeuser Company combined seed and effort to establish one location each of a South Mississippi/ South Louisiana regional second-generation polymix trial with 65 selections. The Mississippi Forestry Commission, Weyerhaeuser Company and Temple-Inland Forest combined efforts to establish one location each of a first-generation slash pine diallel test with 75 families. This test series completed testing of a single diallel for both the Mississippi Forestry Commission and Temple and completed three diallels for Weyerhaeuser.

Table 1. Progeny tests established during the 2002/03 planting season.

Cooperator	Number of Tests	Diallel by Location Combinations
First-Generation Loblolly Pine Tests		
Temple-Inland Forest	3	12
Weyerhaeuser Company	2	6
First-Generation Loblolly Pine Total:	**5**	**18**
First-Generation Slash Pine Tests		
Mississippi Forestry Commission	1	5
Temple-Inland Forest	1	5
Weyerhaeuser Company		
First-Generation Slash Pine Total:	**3**	**15**
Advanced-Generation Loblolly Pine Polymix Tests	Number of Tests	Number of Families
Mississippi Forestry Commission	1	65
Plum Creek Timber Company	1	65
Weyerhaeuser Company	1	65

Temple-Inland Forest established three locations of East Texas loblolly diallel tests including 70 families, completing four diallels. The Weyerhaeuser Company established two locations of a North Louisiana diallel test with 66 families. The establishment of the third location will complete three diallels, including two former Bosch Nurseries diallels.

First-Generation Breeding and Progeny Test Establishment

First-generation breeding and progeny test establishment is nearing completion. Few first-generation parents have been left untested at this point. In the first-generation, only 44 loblolly pine parents and 23 slash pine parents have never been established in progeny tests. Parents that are as yet untested have proven difficult to cross for both biological and logistical reasons or they belong to populations that have received lower priority because of other operational constraints. The cooperative is systematically assessing the value of completing these crosses and is making the decision to abandon some parents in areas where the breeding population is sufficiently large. In other populations, where the selections may have a higher value, efforts to complete the establishment of first-generation progeny tests will continue. As of the 2002/03 planting season, five of the six members working with slash pine and ten of the cooperative's 13 members had completed establishment of all of their first-generation progeny tests.

Slash Pine

Slash pine first-generation progeny testing program has lagged behind loblolly pine. This has occurred for a number of reasons. Because resistance to fusiform rust infection is the most important breeding objective for members deploying slash pine within the Western Gulf operating region, first-generation breeding was delayed until all of the first-generation selections could be screened at the USDA Forest Service Resistance Screening Center. Only the best half of the population, or approximately 500 of the original 1,000 parents, were moved into the pedigree crossing program with the intent of establishing field tests. Slash pine is a secondary species for the six members working in this portion of the program, and therefore has received less emphasis. At the end of the 2002/03 planting season, 426 first-generation slash pine parents had been established in field tests. Seed is either in hand or should be collected in 2004 to complete establishment for all of the remaining first-generation progeny tests for this species.

Loblolly Pine

The cooperative has now established 2,530 loblolly pine parents in balanced control-pollinated progeny tests (Figure 7). Breeding values were estimated for an additional 693 parents in open-pollinated progeny tests. During the 2002/03 planting season, five first-generation loblolly pine progeny tests were established. These plantings will evaluate the performance of 36 parents at multiple locations. All of these parents are new to the program (Figure 8). There remain fewer than 44 first-generation loblolly pine parents that need to be established in field plantings.

Height as a Predictor of Site Index Gain.

Site index, the average height of dominant trees at a given reference age, is widely used in forest operations to assess site productivity. It is one of the key parameters modified in growth and yield models to reflect changes in site quality. It can also be used to predict the impact that genetic improvement in height growth has on stand yields. The WGFTIP has traditionally reported results from

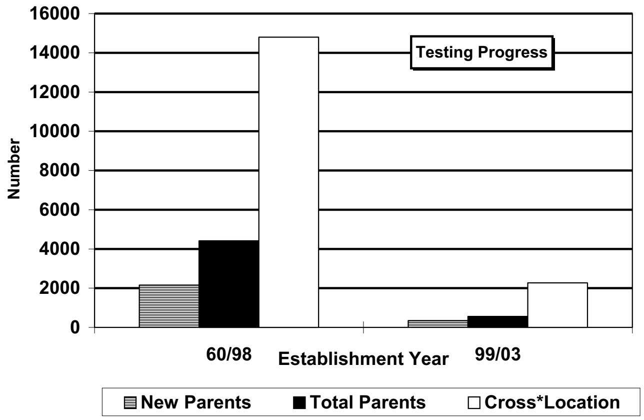

Figure 7. The number of loblolly pine crosses (total number of cross by location combinations), the total number of parents, and the number of parents established in tests for the first time from 1960/98 and from 1999/2003.

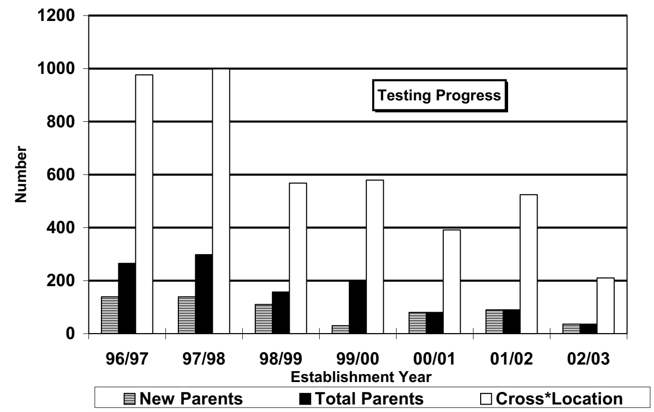

Figure 8. The number of loblolly pine crosses (total number of cross by location combinations), the total number of parents, and the number of parents established in tests for the first time in each of the last six years. The 1997/98 establishment year represents the progeny tests that were evaluated in 2002/03.

progeny tests in terms of mean annual increment (MAI) projected to a base age of 20 years. This trait integrates information on height, diameter, and survival. Many members, however, have found this to be an unwieldy parameter for their financial models and requested that gain in height growth be reported separately.

To meet this request, age-dependent site index equations were developed using data from the cooperative's loblolly pine progeny tests. These equations were then incorporated into the procedures for generating family performance summaries in order to report changes in breeding values for both volume and height growth.

Development of predictive equations was based on three 20-year-old tests and nine 15-year-old tests measured at five-year intervals. Site index (base age 25) was estimated using equations specific to the western Gulf Coastal Plain according to Popham *et al* 1979[1]. Estimates of the coefficient of genetic prediction (CGP) for height at ages 5 and 10 with height at age 15 were on average 0.55 and 0.61, respectively. This compared to a family heritability for height at age 20 of 0.82. The mean CGP values were similar in magnitude to those reported for volume by Lowe and van Buijtenen[2].

As expected, heights at age 5 poorly predicted site index. Ten-year heights predicted site index fairly well relative to site index predicted from 15-year measurements. Therefore, the 15-year measurements were used to derive predictive equations (Table 2). The correlation (R^2=1.00) at age 15 reflects the fact that this was the reference age for which the models were developed. The age-dependent site index equations and CGP estimates for height were then used to predict breeding values for change in site index with the same methodology currently used to report changes in volume growth (Lowe and van Buijtenen[2]).

These formulas were incorporated into all loblolly pine progeny tests analyses programs and site index breeding values developed for all parents and families in tests measured in 2002-2003. In addition the oldest data set from nearly every WGFTIP loblolly pine progeny test was reanalyzed for significant differences in height growth and site index breeding values calculated where appropriate. This required reanalyzing approximately 500 data sets.

For illustration, volumes were predicted for the unimproved checklots using their predicted site index performances as input into a Texas Forest Service timberland stand management model (http://tfsfrd.tamu.edu/tdss/models/tis.asp). Harvest volumes were estimated for a cutover site-prepared loblolly pine site established with 600 trees per acre and grown unthinned for 20 years. These volumes were then compared to the expected base volume of 79.9 tons (base site index 60 feet at age 25) and the change in volume growth calculated for each lot. Predicted breeding values from the site index data were then compared to most recent breeding values for volume predicted from WGFTIP progeny tests for each lot (Table 3).

Volume breeding values predicted directly from progeny test data matched very closely with that calculated from the growth and yield model where breeding values for height were used as input. On average the volumes predicted from changes in height tended to be slightly higher than

Table 2. Site index predictive equations developed from age 15 data.

Age	Regression	R^2
5	SI25 = 10.50 + 2.15 * HT05	0.58
10	SI25 = 5.62 + 1.33 * HT10	0.83
15	SI25 = -0.15 + 1.31 * HT15	1.00

[1] Popham, T. W., D. P. Feduccia, T. R. Deli, W.F. Mann. Jr., and T. E. Campbell. 1979. Site index for loblolly pine plantations on cutover sites in the West Gulf Coastal Plain. USDA Forest Service Research Note SO-250. Southern Forest Experiment Station, New Orleans, LA. 7p.
[2] Lowe, W.J. and J.P. van Buijtenen. 1991. Progeny test data summarization procedures in the Western Gulf Forest Tree Improvement Program. PP. 303-312 *In* Proc. of the 21st Southern Forest Tree Improvement Conference. Knoxville, TN

Table 3. Breeding values (BV) for volume (Vol) and site index (SI) for unimproved checks and predicted BV Vol derived from TFS growth and yield model using BV SI to adjust initial model site index.

Region	BV SI	BV Vol	Predicted BV Vol using BV SI as Input for Growth & Yield
NE TX	96.76	91.46	92.99
E TX	97.62	93.37	94.87
SE TX	99.03	97.43	97.87
N LA	95.21	90.08	89.74
LIV PAR	99.02	98.11	97.87
AR/OK	97.17	93.85	93.87
S MS	97.31	92.00	94.12
N MS	96.86	95.25	93.24

the observed values. This may be due to the fact that predictions based on height alone fail to factor in differences in survival.

Correlation between parental breeding values for volume production and predicted gains in site index breeding values among all WGFTIP parents were high (r = 0.80). There were, however, examples of families that obtained high breeding values for volume production through different growth strategies. Some families produced excellent gain in volume production through simultaneous improvements in height, diameter, and survival while other families produced relatively fewer, but much larger stems. Volume improvement per unit area (MAI) will remain the cooperative's primary breeding objective. As reported in last year's annual report, breeding value for volume as currently implemented by the cooperative is equal to or better than height to accomplish this goal. The additional information provided by site index breeding values, however, will give members of the WGFTIP additional information for decision-making when designing deployment populations.

Lower Gulf Elite Breeding Population.

The Lower Gulf Elite Breeding Population (LGEBPop) is a joint effort between the North Carolina State University-Industry Cooperative, the Cooperative Forest Genetics Research Program hosted by the University of Florida, and the WGFTIP. The objective of the project is to use the best selections from all three programs to establish an elite breeding population for the Lower Gulf region of the United States. This area could potentially extend from Georgia through the coastal areas of Alabama, Mississippi, and Louisiana into Texas and is a region where the selection and testing programs of the three cooperatives have extensive overlap. The first objectives were to verify the extent of the appropriate deployment area and to determine how selections from the different programs compared in common progeny tests. In order to meet these objectives, polymix seedlings generated with Atlantic Coastal Plain polymix pollen were established in progeny tests across the region. Progeny tests established by WGFTIP were comprised of 15 replications of single-tree plots and included approximately 37 Atlantic Coastal Plain selections from the NC State Cooperative, 20 selections from the Florida Cooperative and 15 selections from WGFTIP. The location and average five-year performance are summarized in Table 4.

At the Copiah County, MS location there were no differences among provenances for height or volume, while at both the Washington Parish, LA location and the Jasper County, TX sites there were significant differences among provenances for both traits (Table 5). At the Washington Parish, LA location, the Florida source produced more volume than did the Atlantic Coastal Plain material, which in turn outperformed the WGFTIP material. Further west, at the Jasper County, TX site, the Florida material was faster growing than either the Atlantic Coastal Plain or Western Gulf material which were not significantly different from each other. Future developments at these sites will be closely followed as previous studies have indicated that both the Florida and Atlantic Coastal Plain material may encounter survival problems if moved too far west. Specific gravity measurements were made at the Copiah County, MS and the Jasper County, TX sites. Both the Atlantic Coastal Plain and WGFTIP selections outperformed the Florida material but were not significantly different than each other (Table 6).

Table 4. Five year averages by progeny tests for the Lower Gulf Elite Breeding Population.

Cooperator	Location (County/Parish State)	Survival (%)	Height (m)	Rust (%)	Volume (dm^3/planted tree)
Mississippi (MFC)	Copiah, MS	94	7.2	33.8	24.2
Temple-Inland	Jasper, TX	98	6.8	12.2	18.5
Weyerhaeuser	Washington, LA	94	5.2	26.4	9.9

Table 5. Provenance performance for the Lower Gulf Elite Breeding Population progeny tests at age five.

Provenance	MFC			Weyerhaeuser			Temple-Inland		
	Ht(m)	Vol(dm^3)	Rust(%)	Ht(m)	Vol(dm3)	Rust(%)	Ht(m)	Vol(dm^3)	Rust(%)
ACP [1/]	7.2	24.4	30.4a [2/]	5.3a	10.2b	23.3a	6.7ab	17.9 b	10.8a
Florida	7.2	24.1	36.2ab	5.4a	10.9a	24.6a	6.8a	20.0a	10.9a
West Gulf	7.1	23.9	39.2 b	5.0b	7.9c	36.1b	6.7b	17.9 b	16.5b

[1/] Atlantic Coastal Plain

[2/] Means followed by the same letter are identical at the 10% level on a Duncan's Multiple Range Test

Table 6. Specific gravity for the Lower Gulf Elite Breeding Population progeny tests at age five by provenance.

Provenance	MFC	Temple
ACP [1/]	0.388a[2/]	0.394a
Florida	0.383 b	0.386 b
West Gulf	0.391a	0.393a

[1/] Atlantic Coastal Plain

[2/] Means followed by the same letter are identical at the 10% level on a Duncan's Multiple Range Test

In all three locations, the WGFTIP material exhibited more fusiform rust than did either of the two other sources (Table 5). This was contrary to expectations as this source is widely planted in high rust hazard areas within the Lower Gulf region. A number of tentative explanations for this performance can be conjectured. It may be that this particular sample of WGFTIP families did not capture the rust resistance expected from this provenance. Conversely, the Atlantic Coastal Plain and Florida families may have more rust resistance as a result of selection than expected from their respective provenances. Perhaps the more logical explanation involves the variation in the rust pathogen rather than the host. It is possible that the local source of fusiform rust is more virulent on the local material because of an inopportune gene-for-gene type of interaction.

Virginia Pine

Two cooperators, the Texas Forest Service and the Oklahoma Department of Agriculture, Food and Forestry, have active improvement programs for Virginia pine. These programs are concentrating on creating a land race of this exotic species for use by the Christmas tree growers in the area. Second-generation selections from progeny tests established within the region for a variety of purposes are being crossed with polymix pollen by the states of Oklahoma and Texas. The seedlings are being tested in collaboration with the Christmas tree growers in the states of Oklahoma, Texas, Louisiana, and Mississippi. The first series of these polymix tests were planted in 2001/02. At the end of the second growing season, there were no differences among families for survival, but there were significant differences among families for height growth. Christmas tree quality and intensity of management required to grow a marketable tree will be evaluated before the tests are released for harvest by the cooperating landowners. The intent is to test 138 second-generation selections that have been grafted into scion banks by the states of Oklahoma and Texas for preservation. A second series of tests were planted in the 2003/04 season (Figure 9). Currently 53 selections have been established in field trials. Polymix crossing continues on the remaining 85 parents.

Seedling seed orchards are currently managed to supply the nursery needs for this species. Virginia pine, while an excellent species for the short rotations used for Christmas trees, is poorly adapted to the Western Gulf region. As a result, these seedling orchards are over mature, have suffered a great deal of mortality, and are in need of replacement. The Texas Forest Service will begin establishment of the first grafted advanced-generation orchards for this species in 2005. This effort will be initiated with only a fraction of the data that will eventually be available for this species and it is anticipated that a much smaller version of the advancing-front orchard will be used as better material is identified. This should be possible because this species flowers heavily at an early age and small trees can effectively be managed for seed production.

Test Measurement and Second-Generation Selection Activity

During the 2002/2003 measurement season, the cooperative measured 110 progeny tests. Of these 75 were

Figure 9. Virginia pine progeny test seedlings intended for outplanting with a collaborating grower from the Texas Christmas Tree Growers Association.

Figure 10. Joe Weber and Jeff Donahue from Boise in a progeny test they are preparing to take over from Bosch Nursery.

loblolly, 17 were slash pine and ten were Virginia pine. Forty percent of the tests were age ten while 23 tests were age five (Figure 10). The five-year-old tests provided an evaluation of 577 families, 161 for the first time. Survival was assessed in twenty tests, with half of those being Virginia pine polymix trials established in Texas, Oklahoma, Louisiana, and Mississippi.

Cooperators made a total of 103 new second-generation selections in 2003. Of these 95 were loblolly and eight were slash pine. The greatest number of new loblolly selections was made with Temple-Inland Forest, who added 21 selections to the cooperative's advanced-generation population. Plum Creek Timber Company had the second highest number with 14, with the majority of those coming from south Arkansas. International Paper Company, Potlatch Corporation and Weyerhaeuser Company each added twelve new second-generation selections this past season. The Mississippi Forestry Commission added four new slash pine second-generation selections, the most for any one cooperator this season. The cooperative has now identified a total of 1,554 loblolly pine and 180 slash pine second-generation selections (Figure 11).

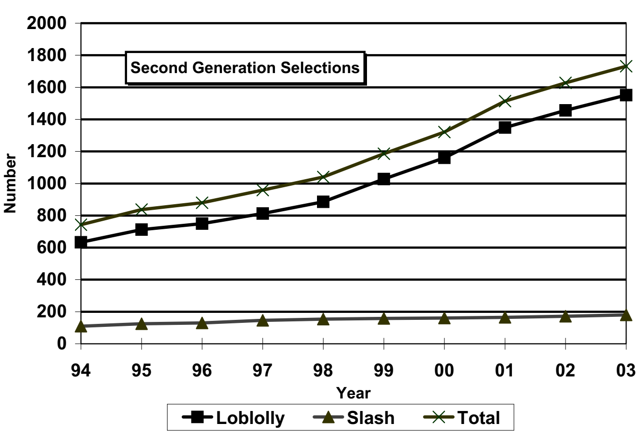

Figure 11. Cumulative number of second-generation selections

Second-Generation Breeding and Testing

Second-generation breeding and testing continues to be conducted on a regional basis. Each member is grafting and breeding second-generation selections belonging to breeding groups for which they have responsibility. Once polymix seed is in hand, production and planting of progeny tests series is being done collaboratively. This has a number of advantages. Chief among these is the ability to deploy progeny tests more rapidly. All of the members of the cooperative, with the exception of Louisiana-Pacific Corporation, have identified second-generation selections and are actively involved in the advanced-generation breeding program. Louisiana Pacific, now ETT, L.P., will begin contributing to the advanced-generation population in 2004/05 when they measure their oldest first-generation progeny tests.

During the 2003/04 season only one series of polymix tests was planted. This series of tests, established collaboratively by the Mississippi Forestry Commission, Plum Creek Timber Company and Weyerhaeuser Company, contained 65 selections from the South Louisiana/South Mississippi population. To date, 676 selections have been established in polymix tests (Figure 12).

The second part of the advanced-generation breeding program is the establishment of pedigree crosses to form the selection population for the next cycle of breeding. These crosses are being planted in unreplicated block plots containing either 100 trees at one location or 49 trees at two locations. Seven cooperators have established selection plots for 325 control-pollinated families for both the loblolly and slash pine programs.

Additional Activities

Contact Representatives' Meeting

The annual Contact Representatives' Meeting was held May 6-7, 2003 in Gulfport, MS. The meeting was co-hosted by the USDA Forest Service Southern Institute of Forest Genetics (SIFG), which provided the speakers for the first day. Presentations were made by Dr. Dana Nelson on an overview of current research, Dr. Floyd Bridgwater on the Founder Project, James Roberds on southern pine

Figure 12. Don Travis, Jr. laying out an East Texas advanced-generation polymix test ahead of the planters established during 2003/04 planting season.

beetle, and Dr. Jennifer Myszewski on breeding for wood quality. In addition to reports on current research provided by SIFG scientists, the members also toured the Harrison Experimental Forest (HEF) and the associated research laboratories (Figure 13). This installation has played an extremely significant role in the history of forest research and the cooperative members continue to benefit from the work done there. One of the highlights of the meeting was having Dr. Ron Schmidtling come out of retirement to give a history of the HEF (Figure 14).

Drs. Alex Mangini and Jim Hanula discussed developments in cone and seed insect control. Their talks centered on the possibility of using pheromone traps to time pesticide applications for the control of coneworms. Attendees received 6.5 CEUs from the SAF.

Other Activities

Western Gulf staff and many of the cooperative's members participated in the 27th Biennial Southern Forest Tree Improvement Conference hosted by Oklahoma State University at Stillwater, Oklahoma. A reception held to celebrate 50 years of tree improvement in Texas and the Western Gulf Region of the United States was attended by several Texas Forest Service alumni, such as Craig McKinley (now Forestry Department head at OSU) and Hans van Buijtenen (Head, Reforestation Department, now retired), by employees of current members, and 'friends of the family' from across the southeast. Guests reminisced over photographs of people and machinery associated with the tree improvement program over the years. Copies of the slide show and the 50th WGFTIP Progress Report were made available to attendees on CD. Additional copies of the CD can be obtained by contacting the WGFTIP staff.

Formal Reviews

Three of the four formal reviews scheduled for 2003 were completed. Formal reviews were conducted for

Figure 13. Dr. Tom Kubisiak of the USDA Forest Service Southern Institute Forest Genetics explains fusiform rust research at the Institute to attendees of the 2003 Contact Representatives' Meeting.

Figure 14. Jim Roberds and Dr. Ron Schmidtling hosting the 2003 Contact Representatives' Meeting field trip in a longleaf pine diallel test on the Harrison Experimental Forest.

Louisiana-Pacific Corporation, Plum Creek Timber Company, and Weyerhaeuser Company. These comprehensive program assessments are conducted every three years and are intended to provide the participants an overview of the accomplishments of their respective programs. They also provide an opportunity to reassess the strategic goals of the individual members and to insure that the WGFTIP is positioned to support these goals. The rapidly changing organizational environments in which our members currently operate almost always insure that the formal reviews are timely for a variety of reasons. This year, the formal review conducted for the Louisiana-Pacific Corporation was conducted after the landbase and seed orchards were sold to ETT, LP. The formal review provided the opportunity to familiarize their management partner, Molpus Timberlands Management, LLC, with the program and to ease the transition between ownerships. To a lesser extent the Weyerhaeuser Company's formal review served much the same purpose, as this was the first comprehensive program assessment since their acquisition of the Willamette program was completed (Figure 15). Five formal reviews are scheduled for 2004. This includes one review delayed from 2003.

Figure 15. Patrick Cumbie, John Anthony, Clem Lambeth, and Tom Vermillion participate in the Weyerhaeuser formal review.

Highlights

- Joe Hernandez received the 2003 Texas Forest Service Director's Award for Support Staff - Field. This was given in recognition of the outstanding contribution that he has made to the WGFTIP - Hardwood and Texas Forest Service Hardwood programs during the first 28 years of his career with the agency.
- Five-year data from a subset of the cooperative's Nuttall oak progeny tests suggests that provenances from the central part of the range should be favored when buying wild seed. There are, however, good families from all regions that can be incorporated into seed orchards.
- Louisiana Forest Seed Company, the Mississippi Forestry Commission, and the Louisiana Department of Agriculture and Forestry are establishing new hardwood seed orchards.
- The Texas Forest Service collected 220 pounds of Shumard oak acorns from orchards established for the Urban Tree Improvement Program.

Introduction

The highlight of 2003 occurred when Joe Hernandez receiving the 2003 Texas Forest Service Director's Award for Support Staff - Field (Figure 16). This award is given annually to recognize the TFS Specialist that has 1) had a positive impact on the overall efficiency and effectiveness of his unit and other units with the TFS, 2) has been creative and innovative in developing and improving method to accomplish his assigned tasks, and 3) displays an outstanding subject matter knowledge and competency. Joe Hernandez was justly recognized for taking a leadership role in planning and implementing the objectives of the WGFTIP – Hardwood program and the Texas Forest Service Urban Tree Improvement program during his 28 years with the program.

Figure 16. Joe Hernandez receives the 2003 Texas Forest Service Director's Award for Support Staff – Field from State Forester James Hull.

Tree Improvement

Progeny Testing

The number of active progeny tests maintained by the Western Gulf Forest Tree Improvement – Hardwood cooperative fell to 28 (Table 7). The cooperative made final twenty-year evaluations on four tests during the 2003 measurement season and these tests were subsequently abandoned. Progeny tests dropped from the program included one cherrybark oak planting, one green ash planting, and two sycamore plantings. Most of the cooperative's progeny testing efforts now center on evaluating Nuttall oak both from the prospectives of making recommendations on wild seed collection and selecting parents for inclusion in seed orchards.

Table 7. Active progeny tests in the Hardwood Tree Improvement Program.

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

Nuttall Oak

Nuttall oak (*Quercus texana* Buckl. formally *Q. nuttallii* Palmer) is a valuable species because it produces high quality sawtimber on poorly drained sites and because it is beneficial to wildlife, producing large acorn crops at young ages. Nuttall oak is currently favored for bottomland planting and restoration because it exhibits good survival on a range of sites and is fast growing.

The cooperators of the Western Gulf Forest Tree Improvement Program – Hardwood established 22 Nuttall oak progeny tests divided into five planting series between 1994 and 1999. These open-pollinated progeny tests evaluate the performance of 216 parents. All progeny tests will have been evaluated for five-year growth after the 2003/04 growing season and the oldest test series will have also been evaluated for 10-year growth. If there are few rank changes between age five and age ten in the first series, orchard establishment can begin in 2004/05. If there are a considerable number of rank changes, orchard establishment will be delayed until ten-year data is available on all series.

Four Nuttall oak progeny tests were measured in 2002/03 (Table 8). Survival in these plantings ranged from an average of 91.8 percent at the Lonoke County, AR site to 49.5 percent at the Richland Parish, LA site. Growth was acceptable at three of the four locations despite various

Table 8. Fifth-year results from the Nuttall oak progeny tests measured in 2002/03 measurement season. Family differences were significant at the 10 percent level or less for all traits except as noted (n.s.).

Location (Co./Par., State)	Plantation Average			
	Survival (%)	**Height (m)**	**Diameter (cm)**	**Volume (dm³)**
Lonoke, AR	91.8	2.16	1.71	0.233
Tyler, TX	66.8	1.83	1.12	0.061
Sharkey, MS	87.6	1.39	0.92 (n.s.)	0.032 (n.s)
Richland, LA	49.5	0.48	-	-

problems suffered during the first five years. Red oak borers attacked several trees in the Lonoke County, AR test. Multiple attacks from this pest result in tree death. When it attacks the bole it frequently kills the main stem resulting in the formation of forks. The Tyler County, TX test was planted on a previously timbered bottomland site where hardwood sprouts dominated the competition. When this test was mowed prior to measurement, it was necessary to walk the test, flagging trees ahead of the tractor and shredder. Reasonable survival and growth rate under these conditions is a tribute to this species resiliency. The Sharkey County, MS location suffered hog damage during its first growing season making it necessary to drop two replications and causing scattered mortality throughout the planting.

Nuttall Oak Provenances

Provenance variation has been examined in the first three series of Nuttall oak progeny tests. Each series was established at each of three locations: Desha and Lonoke Counties in Arkansas and Sharkey County in Mississippi. Series 1 was established in 1994, series 2 in 1995 and series 3 in 1997. The three series included 28-42 different half-sib families collected from throughout the natural range of Nuttall oak. Families were arbitrarily divided into provenances based on the river basin in which they originated. The provenances were Black-White, Ouachita, Mississippi, Red, Tallahatchie-Yalobusha Rivers and the sixth provenance (Western Region) originated in the western fringe of the main natural range of the species. The test design at each location was a randomized complete block design replicated ten times with four-tree row plots for families. Spacing was 2.4 x 2.4 m in all tests. All tests were assessed at five years for survival, height and diameter, with the exception of the Desha County test in series 2, which was measured at age 7. Height and diameter were used to calculate volume of each tree. Analyses were carried out for survival, height, diameter and volume for each series separately. In each series data at each age were pooled across the tests.

Although there were significant differences among provenances for survival at age five in all three series, the provenance differences were probably not operationally meaningful as survival per provenance was generally good, being greater than 80% (Table 9). The Western sources tended to have slightly poorer survival in all series. In series 1, provenances had similar volume growth performance after five years (range: 0.195- 0.247 dm³). In series 2, the Ouachita River provenance had the best volume growth (0.184 dm³) and the Black-White River provenance the poorest after five years (0.097 dm³). In series 3, the Red River provenance had the best volume growth performance (0.314 dm³), and the Black-White River and the Mississippi River provenances (0.184 and 0.185 dm³, respectively) performed the poorest in volume growth after five years. Individual-site analyses indicated that local seed sources either performed equal to or poorer than some distant seed sources. For example in series 3, the distant provenances, Western Region and Red River, outperformed the more local seed sources at the Sharkey, MS and Desha, AR sites. Provenance performance was not consistent across series

Table 9. Nuttall oak provenance means across three sites for survival, height, diameter and volume by river basin.

Provenance (River basin)	Survival (%)	Height (m)	Dbh (cm)	Volume (dm³ tree⁻¹)
Series 1 (age 5 years)				
Western	80.1c	2.10ab	1.31a	0.247a
Ouachita	88.4a	2.14a	1.42a	0.195a
Mississippi	86.4ab	2.06b	1.34a	0.219a
Tallahatchie-Yalobusha Rivers	85.5b	2.04b	1.30a	0.231a
Series 2 (age 5 years)				
Western	83.6b	1.83b	0.99bc	0.138b
Black-White	94.6a	1.80b	0.88c	0.097c
Ouachita	96.9a	1.99a	1.21a	0.184a
Mississippi	94.2a	1.86b	1.03b	0.131bc
Series 2 (age 7 years)				
Western	90.0a	4.60c	4.87c	4.36c
Black-White	96.0a	5.24b	6.09b	6.12b
Ouachita	96.3a	5.66a	6.59a	7.34a
Mississippi	96.4a	5.10b	6.00b	5.52b
Series 3 (age 5 years)				
Western	91.1bc	2.25a	2.00b	0.279b
Black-White	91.7c	1.92d	1.71c	0.184c
Ouachita	94.4b	2.13b	1.94b	0.254b
Mississippi	96.8a	2.01c	1.65c	0.185c
Red	93.1bc	2.24a	2.11a	0.314a

and this may be attributed to the fact that the provenances were arbitrarily divided and may not reflect true biological differences.

By comparing data from age seven measurements of series 2 with age five measurements from series 1 and 3 (tests located on adjacent sites in Desha County, AR), it would appear that Nuttall oak is capable of rapid growth between five and seven years. At five years provenances were on average 0.280 dm^3 in volume compared to 6.014 dm^3 volume at seven7 years, an increment of more than 20 fold. The results at age seven years suggest that Nuttall oak is fast growing once established. The interactions between site and provenance were significant for all growth traits in all series. Family-mean heritability estimates were high for height (0.72-0.96) and for diameter (0.22-0.95). There were good families from all sources indicating that family selection will be effective in this species.

In summary, Nuttall oak provenances had excellent survival and growth confirming it is a good choice for planting and restoring bottomlands. The provenance and family-within provenance variation and estimates of heritability indicate that genetic improvement of Nuttall oak would be successful. Provenance effects were inconsistent, but it would appear that seed collected toward the center of the range (northern Louisiana or southern Arkansas) should be favored when purchasing wild seed. Nuttall oak tree improvement and orchard establishment programs should concentrate on identifying the best individuals regardless of provenance because provenance effects were inconsistent and heritability estimates were high. This analysis, which only included plantings from the first three progeny test series, will be repeated once data from all five series are available.

Seed Orchards

Several members of the WGFTIP – Hardwood program are actively establishing or expanding orchards for a number of reasons. First and foremost is the fact that seed orchard seed is genetically improved, from known sources, and is repeatable from year to year, all attributes that are not available in wild seed collections. Members are also motivated by the expectation that hardwood seed will be more difficult to obtain in the future as hardwood bottoms become unavailable for seed collection. In many wildlife management areas seed collection is increasingly restricted to maximize the mast production. A secondary consideration is that wild seed has generally been procured by paying individuals by the pound or bushel, and there are fewer seasonal workers willing to undertake this arduous task.

The Louisiana Department of Agriculture and Forestry continues to develop numerous hardwood orchards at their Monroe Nursery. The largest of these is a bald cypress orchard. Most of the selections contained in this orchard were originally identified and tested for survival and growth rate in the Urban Tree Improvement Program. Eventually this site will also contain orchards for cherry-bark and Nuttall oak.

Louisiana Forest Seed Company, the cooperative's newest member is preparing to graft orchards for several species (Figure 17). This organization will emphasize species that are marketed for both forest and urban landscapes including green ash, willow oak, Chinkapin oak and cherrybark oak. They began site preparation activities in 2003 and will begin grafting in 2004.

The Mississippi Forestry Commission is continuing to establish Nuttall oak scion banks at their Winona Nursery. They also began site preparation for separate water and willow oak orchards in 2003. Both the Mississippi Forestry Commission and Louisiana Forest Seed Company are benefiting from the maturity of the progeny testing program to establishing pure willow oak orchards. The program initially depended on progeny tests of acorns collected from ortets in the wild. Because of the nature of these older stands, the fact that these two species frequently hybridize, and the similarity of the seed, it was not always possible to reliably distinguish between these two species. Therefore, progeny testing and original orchard establishment was done for the water/willow oak complex. Now that the cooperative has had an opportunity to observe these trees both as grafts and as seedlings in replicated progeny tests, a number of selections have been identified as pure willow oak which will be established as separate orchards from the water oak which will contain both water and putative willow/water oak hybrids.

The Texas Forest Service collected 220 pounds of Shumard oak acorns in 2003 from their orchards originally established to supply seedlings for the urban program (Figure 18). This seed will be grown as bare-root seedlings in 2004 and used for reforestation and habitat restoration. Shumard oak was the only seed harvested from the Texas Forest Service hardwood orchards in 2003 because of disappointing seed and acorn crops across many species. The decision was made to thin and prune all of the older orchards to attempt to enhance future seed production (Figure 19).

Figure 17. Derwood, John and Gary Delaney on the site of Louisiana Forest Seed Company's future Cherrybark orchard.

Figure 18. Part of the 220 pounds of Shumard oak harvested from the Texas Forest Service's Urban Tree Improvement Seed Orchard.

Table 10. 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.

Selections and Scion Banks

Five additional second-generation willow oak selections were made in 2003 to support the effort to establish separate seed orchards for this species. Currently, second-generation selection efforts have been completed for six species (Table 10). The cooperative has collected seed and attempted to establish progeny tests for green ash in each of the last two years. Both attempts have failed because of poor seed germination at the family level. Germination has always been problematic for this species. When the program started with wild seed collections from ortets, approximately half of the families were abandoned at the nursery stage because of poor germination. This attrition level among families is not acceptable for testing second-generation orchards. The timing of collection and proper seed handling has been given particular attention in an attempt to rectify this situation, but the problem of poorly germinating families has not yet been overcome.

The WGFTIP-Hardwood cooperative has routinely grafted to establish hardwood orchards and scion banks. Included in the list are many species, especially the oaks that are recognized as difficult to graft. This year, Joe Hernandez's skill in grafting was put to the test when he was asked to preserve material from two historically important live oaks in the state of Texas. He grafted scion from the Goose Island Live Oak and the Treaty Oak from Austin (Figure 20).

Robert Stewart with the Mississippi Forestry Commission attempted chip bud grafting on Nuttall oak (Figure 21). This technique, which has been successful with species recalcitrant to other traditional methods, allows multiple grafts to be made on the same stem and seems to be easier to learn than conventional grafting.

Figure 19. The Texas Forest Service's Live Oak orchard at Indian Mound Nursery after thinning and pruning.

Figure 20. Live Oak graft from the Goose Island Oak, one of the largest coastal live oaks in Texas. (Photograph of the Goose Island Oak from Texas Parks and Wildlife).

Figure 21. Chip bud grafts with Nuttall oak performed by Robert Stewart of the Mississippi Forestry Commission.

PERSONNEL

This year saw several changes in personnel. Jim McLemore who was employed as Joe Hernandez's assistant in the Hardwood program retired. This vacant position was moved from College Station to the Arthur Temple Research Area in East Texas to provide more strength to the hardwood orchard production program. This position was filled by Adam Crain who is rapidly becoming indispensable. Dr. David Gwaze accepted a permanent position with the Missouri Department of Conservation as a Resource Scientist charged with developing and directing the ecological research component of a multi-disciplinary Missouri Ozark Forest Ecosystem Project. Jennifer Myszewski completed the requirements for her doctorial degree and has relocated to the USDA Southern Institute of Forest Genetics in Gulfport, MS. Dr. Myszewski has taken over stewardship of the Southwide Seed Source Study data and will fill the role of quantitative geneticist for the project. These three individuals have made significant contributions to the Western Gulf Forest Tree Improvement Program and the Texas Forest Service Tree Improvement Program and will be sorely missed.

The staff now includes the following:

T. D. Byram .... WGFTIP Geneticist
L. G. Miller .... WGFTIP Assistant Geneticist
E. M. (Fred) Raley .... WGFTIP Assistant Geneticist
P. V. Sieling .... Staff Assistant
J. G. Hernandez .... Research Specialist
G. R. Lively .... Research Specialist
I. N. Brown .... Research Specialist
D. M. Travis, Jr. .... Research Specialist
G. F. Fountain .... Aide to Specialist
A. R. Crain .... 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 in 2003 include the Arkansas Forestry Commission, Boise, Deltic Timber Corporation, International Paper Company, Louisiana Department of Agriculture and Forestry, Louisiana-Pacific Corporation, Mississippi Forestry Commission, Oklahoma Department of Agriculture, Food and Forestry, Plum Creek Timber Company, Potlatch Corporation, Temple-Inland Forest, Texas Forest Service, Weyerhaeuser Company.

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

Hardwood Program

The WGFTIP Hardwood Program includes the Arkansas Forestry Commission, Louisiana Department of Agriculture and Forestry, Louisiana Forest Seed Company, 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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Texas Forest Service's hardwood orchards at Hudson, TX.