TREE IMPROVEMENT ACTIVITIES IN THE SOUTH

by

Herschel G. Abbott[1]

I was recently privileged to travel for three months in the southern United States, where I visited 12 forestry schools, most research facilities of the Southeastern and Southern Forest Experiment Stations of the U.S. Forest Service, and with foresters of several major industries whose southern forest ownerships total more than 20 million acres. This was an exceptionally informative experience for one whose professional career has been restricted largely to New England and I recommend it as an effective remedy for the provincialism which afflicts so many Northeastern foresters.

I am pleased to share some of these experiences with you and appreciate your permitting this type of paper to be included among those 1 of a more technical nature.

My real purpose here is not to entertain you with a sylvan travelog but to discuss some of the forestry operations in the South, as elements of a new and complex "systems approach" to meeting society's growing demands for wood. I chose tree improvement activities as my topic not solely in deference to your special interests but because it is not

[1]Professor of Forestry, University of Massachusetts, Amherst.

being effectively demonstrated that the future success of southern forestry is dependent upon the application of genetic principles through carefully planned tree improvement programs. Conversely, the success of such programs is dependent upon their skillful incorporation into the total forest management system. I have selected this truism as the theme of my remarks because it will ultimately apply to the fruits of most tree genetics research in all forest regions, including the Northeast.

The breeding of southern pines has made remarkable progress since its inception in the early 1950's. Many factors have influenced this progress but five of them seem to me to be unique. First, most of the work has been concentrated on two species, loblolly and slash. Secondly, the practice of establishing southern pine plantations with nursery-grown seedlings was well-established prior to the beginning of the tree-breeding effort, with slash and loblolly pine seedling production exceeding that of all other North American species combined. Thirdly, there has been a steady decline in the production of southern pine lumber and a quadrupling in pulpwood production (1946 to 1967) with an accompanying emphasis on more intensive, short-rotation forest management. Fourth, forest land ownership in the South has undergone a marked change in 20 years, characterized chiefly by a reduction in farm woodlots (91 to 70 million acres) and a substantial increase of industry holdings (24 to 37 million acres) with ownership or control by pulp and paper companies increasing more than 500 percent (5 to 25 million acres). Finally, and of paramount importance has been the unprecedented degree of collaboration between state agencies (including academic institutions), the U.S. Forest Service and forest industry as exemplified by: the Cooperative Forest Genetics Research Program at the University of Florida; the Texas Forest Service Pine Tree Improvement Program; the Western Gulf Forest Tree Improvement Program; and the North Carolina State University Cooperative Tree Improvement and Hardwood Research Program.

In the brief time available, I'll attempt to review highlights of this work and point to some of the future problems associated with the interdependency of forest genetics and management of southern pine, especially loblolly and slash.

It is generally known that the emphasis on breeding the southern pines has been on tree selection, clonal seed orchard establishment and the genetic gains to be expected therefrom. One measure of progress is the extent and productivity of first generation orchards. These now exceed 6000 acres (approximately 90 percent of all seed orchards in N.A.) and the oldest ones are producing seeds for reforestation. Those in one Cooperative are yielding 40 percent of the annual seed requirement of its 26-member organization. By another 5 years most of the seedlings raised in southern nurseries should be of orchard origin.

These orchards not only supply seeds for planting but after roguing to the better families have furnished scions to create additional orchards. The new orchards of any individual ownership may be from clones of its own original one or from others throughout the South and especially from those within the respective Cooperative.

A major phase of the tree improvement program is the progeny testing of the better families in the F_1 orchards. The method of testing--open pollinated, pollen-mix, tester system or diallel--has varied, especially between Cooperatives. Hundreds of acres of these tests are in progress, and early results, though somewhat premature, are being used in selecting the best trees of the best families to create breeding clone banks from which scion material will be drawn to establish second generation orchards. Deposits in the breeding clone bank may also be made from other sources such as the products of open-pollinated progeny tests of late selections from wild stands or plantations. Crosses among clones within the breeding bank will provide material for selecting the best families for third generation and/or speciality orchards.

Projected capital value at age 15 of approximately 6000 acres of established seed orchards is estimated at over 30 million dollars or in excess of $5000 per acre. A major task of orchardists managing this valuable forest real estate is to avoid the poor cone crops and low yields of vaible seeds which are of too common occurrence. This involves the control of numerous casual factors by such practices as irrigation, fertilization, subsoiling, proper cone collection and seed extraction measures, pollen management and insect control. Although all of these may be important, the insect problem is generally most severe. Excellent research is being done on the subject at U.S. Forest Service laboratories at Athens, Georgia and at Olustee, Florida which has come to be regarded as a national leader in seed and cone research.

There are more than 20 species of insects affecting the seed production of southern pines, but the following ones are the most troublesome: 5 species of coneworm larvae (*Dioryctria* spp.); larvae of 3 seedworm species (*Laspeyresia* spp.); adults of two species of true bugs (Hemiptera), *Leptoglossus* corculus and *Tetra bipunctata;* tip moths (*Rhyacionia* spp.) and flower thrips (*Gnophothrips* spp.). Seed production potential in some orchards has been reduced one-third by one or more of these species and it has been estimated that without adequate control, size and cost of second generation orchards will need to be increased by 50 percent.

I am not familiar with the program for controlling all these insects, but it seems to be presently dominated by spraying with Guthion for coneworms and seedworms, Malathion for thrips and Phorate for tip moths. A promising new method of control involves the use of systemic insecticides such as Bidrin.

It has been said that interest in tree improvement of southern pines was generated on promises, especially in terms of genetic gains in volume. Early estimates of 5 percent from genetically improved stock over commercial stock have proved very conservative for gains of 8 to 12 percent have been common.

These achievements verge on the spectacular when we appreciate that volume production was not stressed in making the original selections. Hence, it seems quite possible that equal or greater gains will be obtained from second generation orchards where more emphasis will be placed on this characteristic.

One of the most interesting stops on my tour was at the Naval Stores and Timber Production Laboratory of the U.S. Forest Service at Olustee, Florida, where genetic improvement of southern timber species had its beginning in the early 1940's. Early research with slash pine showed that its ability to produce gum is a highly heritable trait and that high gum-yielding trees are not particularly rare (top 5 percent of trees in a plantation may produce 100 percent more than average trees). A genetically superior strain of gum-yielding slash pine has been developed and is available for commercial planting. When worked for gum, these trees will yield 1.5 to 2.0 times as much as woods-run trees and when grown for pulpwood, 12 percent more cubic volume. Also, when pulped, tall oil yields are about 12 percent greater than from average slash pine pulpwood.

Tree form has had a high priority in all southern pine tree improvement work and was strongly emphasized in the original selection phase. Although slash and loblolly are inheriently crooked, this trait is under only moderate genetic control. The high intensity selection has resulted in progeny from first generation seed orchards with very straight boles. It is believed that additional genetic gain will be too low to justify much attention to this characteristic in second generation orchards. Since the expense of plus-tree selection is estimated to represent less than 1 percent of the total tree improvement cost, these early gains in straightness have been at barcain prices.

I hesitate to discuss the controversial subject of breeding for wood qualities although such properties as specific gravity and tracheid length are highly heritable and have been among the most consistent characteristics to respond to tree improvement efforts. The expertise is available to manipulate wood quality through breeding and there is certainly sufficient economic incentive to encourage programs for altering tracheid dimensions and increasing fiber yields per unit area. The problems associated with incorporating such objectives into a short rotation management system are complex and have been discussed in a recent issue of the Journal of Forestry by two eminent scientists in forest genetics and wood science.

No single environmental factor affecting the silviculture of slash and loblolly pines impressed me more than did fusiform rust (Cronartium fusiforme). Any superlatives applied to it seem inadequate to describe its adverse influence on the successful monoculture of these two pines. I saw young plantations that had been badly decimated by this disease, and I visited logging operations in stands with more than 75 percent infection. This is not an unusual occurrence as 90-95 percent infections have been reported. Present day practices in the short-rotation management of these species, such as intensive site preparation, wide spacing of trees, off-site planting and fertilization tend to increase the incidence of fusiform rust. Thus, planting of rust resistant strains is of utmost importance if large genetic gains in volume production and other characteristics are to be realized.

Losses to rust in loblolly can be reduced by using seed from appropriate provenances as an interim measure but the same does not hold true for slash pine. Improved resistance in these species through selection of plus-trees free from rust has not been promising as only moderate genetic gains appear likely. The more logical places to seek new sources of resistance within the species are in heavily infected young plantations and in existing provenance and progeny test plantings located in high-risk areas.

Rust resistance of southern pine hybrids has received much attention and three potentially resistant ones are relatively easy to produce: longleaf X slash; shortleaf X slash; and shortleaf X loblolly. However, the tenure of resistance through interspecific hybridization has been questioned.

Progeny testing seems essential to determine resistance to rust and thus any appreciable gains in this important characteristic will probably come only after speciality orchards have been established on the basis of such tests. Some progeny tests have already shown that several parental clones are sources of progenies with consistently lower than average rust infection percentages.

Special tests for rust resistance have been made by two methods. First, by establishing a "rust nursery" where pine seedlings are planted between hedgerows of oaks which are annually inoculated with aecia to furnish a source of inoculum for the pines. Secondly, artificial inoculation is conducted by placing potted pine seedlings in special sheds where temperature and humidity are controlled. Oak leaves, bearing telia, are positioned over the seedlings. Following an appropriate inoculation period, the seedlings are planted in nursery beds to allow development of the disease and are inoculated a second time a year later.

I have not mentioned tree improvement work with longleaf pine even though a few acres of seed orchards have been established much in the same manner as have those of loblolly and slash. Industry presently has little interest in this species and is generally planting slash pine on former longleaf sites.

The well-known "grass stage," prolonged by seedling susceptibility to brown-spot (Scirrhia acicola) cause longleaf pine to be incompatible with the current southern pine management system. However, resistance to brown-spot has been shown to be heritable and one highly resistant genotype has been located along with several other phenotypically resistant individuals. Intraspecific hybrids and open-pollinated progenies of these selections have demonstrated exceptional resistance and a high rate of juvenile height growth. If longleaf pine is ever to regain its position of importance in southern pine forests, it will do so as a result of future successes of forest genetics research.

I have ignored hardwood improvement but assure you that the southern geneticists and foresters have not. Genetic efforts have been very limited due largely to three facts: (1) a lack of experience in regenerating hardwoods; (2) little knowledge of the yields that can be expected from fully-stocked stands; and (3) practically no one is growing hardwoods deliberately nor has industry shown the same enthusiasm to support this work as they did with the pines. There are indications that this situation will change for foresters of the wood industry, if not its policy-makers, are interested in growing hardwoods. Many paper companies are increasing the proportion of hardwoods used and are showing concern over the dwindling of this resource. Several foresters indicated to me that their companies have an adequate land base of pine forests to meet future consumption of softwood but the hardwoods, which now constitute from 10 to 70 percent of their raw material, will soon be in short supply. The largest landowner in the South, which uses 40 percent hardwoods in its paper mills, planted 1000 acres of sycamore and sweetgum this year and plans to plant 2000 acres in 1973 and 5000 in 1974.

I hesitate to present a priority list of angiosperms in order of their importance as such a list would vary throughout the South. However, the ones receiving the most attention by research silviculturists are eastern cottonwood, sycamore, sweetgum, green ash and tulip-poplar. Other species considered important at the U.S. Forest Service's Southern Hardwoods Laboratory at Stoneville, Mississippi, include: Nuttall, Shumard, water, willow, and cherrybark oaks; black willow, sweet pecan, water tupelo and sugarberry.

A major activity of the Hardwood Cooperative in North Carolina has been to determine the species most adaptable to various sites and the best methods of establishing and managing these species. Without this information to serve as a guide to management, tree improvement programs in hardwoods will make little progress.

It is my impression that most of the research activity with hardwoods has dealt with cellulose or pulp production but there are indications that growing quality hardwoods for solid wood products may soon become a major goal in some parts of the South. Quality hardwoods are already in very short supply, based upon current utilization practices. If these practices are modified, such as a shift from standard long-lengths to short bolts, the supply of high quality material would be greatly increased, probably by 50 percent. Eventually, such a change may become an important element in the hardwood management system. A major deterrent to growing quality hardwoods in the South is the time required for the crop to mature. Rotations beyond 40 years now appear economically prohibitive. Thus the challenge here will probably be met only through intensive management of genetically improved growing stock to produce younger timber in the form of random-length bolts rather than the present standard long-lengths.

Of the hardwood research related to tree improvement which I saw during my travels, the work with cottonwood in the Mississippi Delta was the most fascinating. Ramets of 14 selected clones of native cottonwood are being used to establish test plantations which are showing phenomenal growth rates (2.5-3.0 cds per acre per year) on intensively prepared planting areas. Site requirements are stringent, however, and it is estimated that there are only about three million acres in the South where cottonwood can be grown economically by this system of management.

One industrial concern has about 15,000 acres of cottonwood plantations near Fitler, Mississippi, and there are about 30,000 acres in the Delta between Baton Rouge, Louisiana, and Memphis, Tennessee. Time does not permit further discussion of this subject, but a few of my slides illustrate the potential of cottonwood culture.

I'd like to close by making a few special points to emphasize an earlier premise regarding the interdependency of tree improvement and forest management. It should not be taken for granted that extensive seed orchards of genetically improved trees will in themselves meet the reforestation needs of an area, either in the South or elsewhere, even if problems of orchard management are solved promptly. Coniferous plantations will generally be established from seedlings not seeds, regardless of the potentials of direct seeding and container planting. Hence, forest nurseries must appreciably improve upon their present capacity and efficiency. Although there is a trend to the contrary, the bulk of southern pine seedlings are being propagated in state nurseries whose policies are determined in part by politics and whose practices are sometimes pragmatic and not determined by genetic priorities.

It is common practice for a large industrial landowner to ship cones from its various orchards to a state nursery for extraction, storage, testing, and planting, thus placing a tremendous logistic and cultural responsibility on the over-burdened nurseryman who has long been at the low end of the forestry spectrum. Consequently, statistics on nursery tree percents can be unreliable and records of seedlings from specific seed orchards may be in error. Orchard owners who process and store their own seed can greatly reduce such risks and those that also operate their own nurseries are in the best position to capitalize upon the full potential of their tree improvement program.

Finally, geneticists should appreciate the problems of forest managers to understand why the fruits of tree improvement programs may fail to produce harvestable forest crops. The annual task of planting thousands of acres is a difficult one. Year-round site preparations with large, expensive machinery usually precede a too-brief planting season often plagued with uncertainties of weather which can prevent timely planting in many areas. When several million seedlings still remain in cold storage at the end of the normal planting season (witnessed in one instance), it is easy to understand why the problems of promoting the Third Forest do not end at the seed orchard.

Thus the field forester is not only dependent upon the geneticist to provide seeds of better genotypes, but also upon the indispensable skills of the nurseryman and on new machinery developed by forest engineers. In the last analysis, he is left to his own ingenuity (enhanced by pertinent knowledge from contemporary silvicultural research) to prepare the land, plant the improved seedlings and then nurture them through a predetermined mature forest.

DISCUSSION

Gerhold - I have a question for Dick Miller. I think that you're quite familiar with the program that R. T. Bingham and his colleagues have been carrying on for some time with western white pine. For many years planning was based on the assumption that additive gene effects were largely responsible for resistance to blister rust. More recently, though, several major gene effects have been identified. Are you aware of any indication of major gene effects in resistance of eastern white pine to blister rust, and would this have an impact on your program?

Miller - I'm familiar with Bingham's program and with the sugar pine program, too, in Region Five (Forest Service). We have never observed major gene effects in relation to blister rust resistance in eastern white pine, and I've never heard of anyone else seeing it, although Zufa might have more information. It would change our program a little bit; however, I'm hesitant to working with a single dominant gene. I'd like several dominant genes to control resistance.

Gerhold - I think it may have been somewhat upsetting to that group to find out that perhaps just one or a few genes of these major genes could account for the kind of resistance that was being utilized in their program. Do you have any plans to look for these kinds of effects?

Miller - If we see it, we'll sure report it and use it.

Gerhold - The evidence for major genes inwesternwhite pine was not seen until Ray Hoff and Geral McDonald spent a whole summer on their hands and knees looking at individual needles and classifying symptoms. The evidence was not obvious until they had defined the system.

Miller - It's interesting to note that Bingham reported yellow needle spots and red needle spots. Believe it or not, we found red needle spots resulting from our inoculation work, too; however, people who have worked with eastern white pine in the past have observed only yellow needle spots. I don't know, maybe we have the same type of genes that Bingham reported.

Gerhold - I'd be surprised if some of the same genes weren't operating in both white pine species.

Miller - I'd be surprised, too, frankly. I'm sure the genes are present. I think our inoculation technique is such that we're going to be able to detect major gene effects if they are present and possibly find results similar to Bingham's.

Gabriel - My question is directed towards Dick also, and I was wondering if he plans on using any of Bingham's blister rust resistant genotypes in his program of interspecific hybridization?

Miller - We made some crosses this spring using pollen from four tested western white pine genotypes included in the Region Six (Forest Service) program. We hope to include pollen from other exotic species as well. Some crosses made by Patton between P. griffithii and P. strobus for instance, have shown up to 86 percent resistant offspring. Our efforts in interspecific hybridization will probably increase as the grafts get older and produce more flowers.

Gabriel - Are you planning on doing any backcrossing? I didn't see any plans for that.

Miller - This wasn't in my time schedule; however, backcrossing will have to be considered in the future.

Zufa - Your information on the general combining ability of the parent trees would naturally depend very much on how many times do you inoculate your progeny, for how many years you keep the trees under observation, and if your progeny tests are replicated? According to our experience the number of blister rust diseased trees increases with every inoculation and with every additional year of observation.

Miller - The tests were replicated in the flats. There were 15 columns in each flat, with each column representing one source. Each source was planted in ten flats.

Zufa - Did you get much variation between replications?

Miller - As I've said, we inoculated them last summer, and I don't have the data yet. I know that the inoculation worked because ther were plenty of needle spots on the seedlings.

Zufa - This worked in our case, but we had a very large variation between the replications of the same family.

Miller - The seedlings that survive the inoculations will be outplanted at the Oconto River Seed Orchard, and observations will be made for new blister rust infection.

Zufa - You are inoculating once?

Miller - Yes, at this stage of the program. As long as we get a lot of needle infection throughout the flats, we'll inoculate them one time. When the seedlings are three or four years old, we will transplant them into the field and let nature inoculate them.

Zufa - Were the trees which you grafted and put in your orchard selected for any other characteristics but blister rust resistance.

Miller - No, the trees were selected only for their apparent resistance to blister rust.

Zufa - You don't do anything about their growth?

Miller - We will evaluate growth on the seedlings that survive our inoculation test.

Fowler - There appears to be several different types of resistance in western white pine: resistance to needle infection, hypersensitivity, etc. Do you intend to keep your selections separate on this basis? Are you looking at this in eastern white pine?

Miller - Yes, we are looking for the various types of resistance. We haven't evaluated our first inoculation yet, so I have no data to support the presence or absence of the various types of resistance you mentioned.

Fowler - Would it be advisable to maintain separate programs? Breeding for one type of resistance rather than trying to throw them all together?

Miller - If we can locate different types of resistance, I think it would be most effective to breed like types together.

Fowler - I think that one of the things we missed in some of our earlier work at Maple was not attempting to separate the different types of resistance. It is conceivable that you could have a resonable level of resistance through hypersensitivity in one clone and resistance to needle infection in another. Their hybrids may show reduced resistance as the genetic basis for the resistance may differ in the two clones. I think it is important that you identify the type or types of resistance you are working with and maintain separate breeding lines if necessary.

Miller - This is a good suggestion, and I'm sure we will be giving this much more consideration as our inoculation and breeding programs develop.

DISCUSSION

Jones - In regard to the salt business, about ten of fifteen years ago some representative of the New Jersey Highway Department came up to central Pennsylvania and wanted to buy eight to ten foot Austrian pines "because of their known salt resistance," that's quoting them. A friend of mine had a field of about 40,000 Austrian pines which had gone past the shearing stage, and he was delighted to sell them 8,000 trees at a dollar a foot; and they dug them themselves, bagged them, balled them, and took them to New Jersey. He really hit the jackpot in something that he thought was going back to old forest. At that time I happened to mention the subject of road salt to my brother, who is a chemist, and incidentally discovered 2,4-D, and he said that at that time chemicals were known and available which would replace salt as a deicing agent and it was far cheaper than salt. I then pursued the subject further with the Highway Department in Pennsylvania; and with the usual monolithic slowness of the typical State Highway Department, they said that they were contracted to salt purchases for the next ten years. Maybe if we do some chemical research of this instead of tree research, we'd be getting at the base of the problem.

Demeritt - This could be the case, Mr. Jones, although most of the recent information put out by the highway departments indicates that they still feel sodium chloride is cheaper, about three times cheaper than calcium chloride. They just keep using sodium chloride because of cost.

Hicks - In your testing of intraspecies tolerance to salt, have you considered actually going to highway roadsides and taking soil samples to determine the approximate sodium concentrations you would encounter? In the spraying experiments, have you considered the possibility that winter spraying may be different than summer spraying?

Demeritt - There may be considerable seasonal variation between winter and summer spraying. I think one would have to look at season of spraying, salt concentration, temperature, and other environmental factors. Soil samples would be useful in determining residual salts in the soil. Some studies have shown that abundant rainfall in the spring will leach most residual salt from the top soil layers. The real accumulation of salt in the soil comes from dry springs when residual salts aren't leached from the root zones.

Hicks - The salt that's applied in winter is what I'm getting at. Highway salt spray is applied to the tree in the winter, so maybe you'll have to get out in the winter to do your testing.

Demeritt - We don't have anything else to do in the winter in the way of field experiments. A study of this type might be a good allocation of time.

Larsson - I'd like to find out if you have any information on the tolerance of basswood and black locust to salt. The reason I asked this question is that the Ontario Bee Keepers Association is planning to plant up the highways and byways of Ontario with species of plants that will produce nectar. Since these two tree species are potential nectar producers, it is most important to know ahead of time their chances of withstanding salt.

Demeritt - There has been work done on some 60 to 80 species of trees and ornamental shrubs. Black locust tends to be quite tolerant. I'd have to look up to see if basswood has been listed or not. Littleleaf Linden (Filia cordata) which is in the same genus has been reported as being poorly tolerant to salt in the soil.

Gabriel - Do all the ramets in that clone have the rough bark we saw in the slides?

Abbott - I believe they would. Yes, definitely.

Farmer - This is very strongly controlled genetically.

Gerhold - Herschel Abbott referred to resistance of southern pine to fusiform rust. It has been very interesting to see increases of disease resistance over a period of years. In the early stages of several programs, care was taken to select only disease-free trees; but selecting specifically for disease resistance did not have the highest priority. Now this has changed. The disease has been recognized as being much more important, and also there is a great deal of concerted effort to select individuals and families that have higher resistance. Disease resistance has been recognized as a very valuable part of the improvements that can be achieved.

Abbott - In the type of selection program that they had, I don't think it would have done too much good anyway. I think the answer to the disease problem will be along two lines. One will be a different kind of selection program than they have had in the past. Selecting, lets say, from high risk areas in some of the progeny tests and some of the plantations in these high risk areas. Of course, in the meantime with loblolly pine they can help the rust situation by paying special attention to the geographic sources that they come from, but not so with slash pine. The other approach that's being made, of course, is through hybridization to incorporate the rust resistance of long-leaf pine and short-leaf pine into the loblolly and slash. Now there are three crosses they can make rather readily here: longleaf x slash, shortleaf x slash, and shortleaf x loblolly.

Schreiner - I have a comment that I'd like to get on the record. At the Poplar Council meetings in Vicksburg, Mississippi, in June, I stated that in my opinion they should have a larger number of select cottonwood clones. As I recall, they have only 14 different genotypes (clones) of a single species. Even for a native poplar species such limited genetic diversity from a local provenance involves a serious risk of high disease and insect susceptibility. Greater genotypic diversity is essential. The program should be greatly expanded; it should aim for a much larger number of selections from a diversity of sites and provenances;

and it most certainly should include racial and species hybridization. The presently selected clones are apparently suited only for the best sites. What they need, and this comes back to something we discussed yesterday, are poplars that will grow on the poorer soils. Bob Farmer may have a differentcpinion.

Schmitt - I'd like to correct a possible misconception about the poplar program at Stoneville. At the time that I left, we already had in test 700 new clones and were planning on testing at the rate of a thousand new clones a year. So, although only 14 clones which have been rather thoroughly tested have been released, the base of the program is far from narrow.

Abbott - I didn't have time to go into the details, but I didn't want to tell Ernie that these native clones outdid his hybrid poplars. There's been a lot of preliminary work on these.

Schmitt - I am not certain that Ernie really said it, but I didn't want to leave the impression that the program at Stoneville was very narrowly based.

Schreiner - I was aware of that, but I suggest that there is need for intra- and inter-specific hybridization to get a wider genetic base. In my opinion, the present genetic base is too narrow for the sites they want to plant. They are already worrying about where they are going to plant their poplars if agriculture takes their best sites.

Schmitt - It seems to me that you are suggesting the native cottonwood population in the lower Mississippi Valley lacks a sufficient genetic base for a breeding program. This is a valid opinion.

Schreiner - I suggest that they must broaden their genetic base beyond the local, batture cottonwoods; they haven't found any yet that will do well on the poorer sites, particularly outside the batture lands, have they?

Schmitt - Well, that's quite true. We realize that cottonwood required a good site. Dr. Abbott correctly gave the impression that the amount of good cottonwood land is not extensive, that's true.

Farmer - I think that there are two points here that we haven't brought up. One is genotype-site interactions which are being thoroughly tested at Stoneville. Some genotypes may be suitable for poorer sites and thorough investigation of genotype-site interactions will be required before picking cottonwood for them. Second, when you begin moving out of the Delta to the poorer upland sites, then perhaps the answer is other species rather than trying to plant poplars. You'll be planting sweetgum or sycamore if you are interested in hardwoods, and then pines. With respect to drought resistance, there may be some hybridization work that would be applicable; this would involve perhaps some western races of P. deltoides. We might make some wide crosses within the species and be able to get some drought resistance. The main site problem is drought. I think that troadening the genetic base and still staying within the species or within Populus in the southern part of the country would be of some utility, and I believe there are long-range plans to broaden the base as it is needed. But at the present time, I think there is sufficiently broad genetic base within the southern cottonwood population and that the genotype-site interaction tests will tend to distinguish the clones that will be useful on the poorer sites.

Schreiner - I agree with you that there are sites that are not suited to poplar. But have you seen the cottonwoods on the strip-mine banks around Carbondale, Illinois?

Farmer - Yes, and that's fine.

Schreiner - Why shouldn't you try to breed a poplar that would out-grow sycamore? I believe a poplar can be bred to surpass the sycamore on the poorer sites and higher ground in the Delta. Woessner points out that our Northeastern hybrids are not growing as rapidly as the cottonwoods in Texas, but they tend to be more insect resistant. That is another factor you should take into consideration. I still think you need a broader genetic base, and I think cottonwood can replace some of these other hardwoods on many sites--not everywhere. There is reason to expect that the Northeastern hybrids might not do well in the south; they were originally selected for their performance in Maine. But frankly, I do not consider that the Northeastern hybrids have been adequately tested on a sufficiently wide range of sites in the Delta region.