HARDWOOD TREE IMPROVEMENT TO DATE AND TOMORROW

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Abstract.--Sycamore, sweetgum, black walnut, cottonwood, yellow-poplar and eucalyptus have been planted in commercial size plantations in the Southern U.S. These species and 35 more are under some degree of tree improvement research with very small seed orchards established for 15 species. Limited research funds dictate a challenge to systematically analyze for prediction of future tree improvement needs with selected hardwood species. Twenty-nine institutions are doing some study of tree improvement research with hardwoods.

Additional keywords: Genetics, planting, superior tree selection.

Tree improvement in hardwoods has been a haphazard thing, a searching for meaning and direction. Reason is gradually bringing some semblance of order as sufficient experience is generated among researchers and as economic and aesthetic demands unravel themselves. About 40 hardwoods have been touched by the magic wand of experimental endeavor in the U.S. but only a few species are on the way to practical improvement (Table 1). Thus, with limited funds and personnel, research organizations have been working on a broad front. Now it appears time for an assessment of where that exploring has brought us and to once again reason together for a more meaningful effort into hardwood tree improvement.

Table 1.-- Listing of hardwood species on which there has been some tree improvement research

Eastern cottonwood	Cherrybark oak	Black alder
Black cottonwood	Black oak	Hackberry (sugarberry)
Plains cottonwood	Scarlet oak	Balsam poplar
Yellow-poplar	Swamp chestnut oak	Aspen
Black walnut	American chestnut	Basswood
Black cherry	Chinese chestnut	American elm
Sycamore	White ash	Water tupelo
Sweet gum	Sugar maple	Black tupelo
Green ash	Silver maple	Swamp blackgum
Northern red oak	Red maple	Royal paulowonia
Southern red oak	Pecan	Ailanthus altissima
Chestnut oak	Black birch	Eucalyptus spp.
White oak	Yellow birch	Eurasian elms
Water oak	Paper birch	Persian walnut
Willow oak	River birch	English oaks

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COMMERCIALLY PLANTED SPECIES

Cottonwood

The hybrid poplar program started by Ernest Schreiner in 1925 in the northeast is still alive and well. A survey by the Northeastern Forest Experiment Station of public and private nurseries during the spring of 1974 showed between 4 and 6 million trees were out-planted either as rooted or unrooted stock. The plantings are scattered on small areas and spoil banks associated with mining.

In the South, genetically improved Stoneville select cottonwood clones are being planted on a large scale (Mohn, 1970). Some wood industries have selected and planted clones of eastern cottonwood which exhibit at least juvenile superiority. Between 40 and 50,000 acres of cottonwood are now in commercial plantations and the majority of new plantings are of superior clones. Of equal or even greater importance to the success of this first major commercial planting of hardwoods in the U.S. were the intensive methods of site preparation, planting and tending of the trees found essential to the over-all tree improvement program (McKnight, 1970). Lessons learned by researchers and practitioners with this species have guided tree planters in developing methods for successfully planting other species of hardwoods on a commercial scale.

Black Walnut

Some basic genetic trends for this species have been established and forest geneticists are talking about improved seed to produce better timber trees in the future. A total of 181 acres of walnut seed orchards were reported in October of 1974 for the eastern United States, the greatest number of acres for any hardwood (Table 2). The multiple objective seed orchard is being used for black walnut because of the value of nuts and lumber. Hundreds of clones are being tested at a number of locations in the East and Midwest. Plantation care has been found basic to establishment of successful walnuts as it has with other species. Both chemicals and mechanical cultivation have proven successful, each for the particular circumstances under which walnut has been planted.

Sycamore

The planting of sycamore has run the experimental gamut from the silage concept (McAlpine 1966) to conventional planting supplemented by intensive care in planting and cultivating during establishment years. Thousands of acres are now planted to this species and research and application trials have guided successes (Briscoe 1969). Recent research with this species at Stoneville, Mississippi, has shown that southern sources grow faster and are more disease resistant (Ferguson, etal and Cooper etal, in press). When this information is put to use, much better and faster growing sycamore should be the result in commercial plantations.

Sweetgum

This tree may be the most important species of hardwood in the South due to its relative freedom from insects and diseases, the desirability of the wood for many uses, and its apparent ease of propagation with prolific seeding annually, beginning within the first five years after planting. Early emphasis on tree improvement was of variability in natural stands and on progeny testing to obtain measures of phenotypic, genetic and environmental variances, genotype environmental interactions, heritabilities, correlations, and effectiveness of selection in natural stands. Large differences in foliation dates have applicability. Progeny that foliate early have been found to be the best growers on sites and soils where moisture supply is depleted early in the summer. However, tests so far show selection in natural stands has been ineffective in improving growth of progeny. Although thousands of acres of this species are planted, every plantation where there is a high degree of success has shown poor height growth in the first several years but has grown rapidly thereafter. One plantation averages 7"d.b.h. at age ten, where it was cultivated to keep down weeds during establishment.

Progeny or provenance experiments are being conducted by the Western Gulf Regional Tree Improvement Cooperative, North Carolina State University Industry Cooperative Tree Improvement and Hardwood Research Program, International Paper Company, and the Southern Forest Experiment Station.

Table 2.--Summary of acres of hardwood seed orchards, by species and region 1/

Species	South 2/	West and North	Total
	(Acres)	(Acres)	
Northern red oak	51	26	77
Sycamore	5		5
Black cherry	2	48	50
White oak	2		2
Hybrid poplars	6		6
Cottonwood 3/	1	3	4
Chinese chestnut	4	2	6
Black walnut	49	132	181
Sweetgum	15		15
Yellow-poplar	40	10	50
Maple	4		4
Cherrybark oak	2		2
American chestnut	1	2	3
Persian walnut		5	5
Paper birch		5	5
	182	233	415

1/ Summarized from U.S. Department of Agriculture, Forest Service. Forest Tree Seed Orchards, A Directory of Industry, State and Federal Forest Tree Seed Orchards in the U.S. 33 pp. October, 1974.

2/ Includes Mo. and Ktky.

3/ This figure does not show the several hundred acres used for vegetative propagation of superior cottonwood clones for planting in the Mississippi Valley.

Yellow-poplar

This species is one of the most widely planted hardwoods in the Southeast even though plantations in any one place are limited in size. There are over 50 acres currently in seed orchards and research in superior tree selection and progeny testing is underway in a number of locations. Although a fast-growing tree its wood characteristics do not make it very desirable for pulpwood, it is a favorite species for furniture plywood core stock.

Eucalyptus

Eucalyptus was first planted in Southern Florida before 1900 where it was used for a shadetree. Eucalyptus robusta, after intensive research for genetic improvement begun in 1966 (Franklin etal 1973), is now being used to establish commercial plantations for pulpwood production in the warm climes. Additional research is underway at Bainbridge, Georgia where frost-hardy species of eucalyptus are being sought for planting on sites typically dry in summer months.

GUIDES TO FUTURE TREE IMPROVEMENT

There you have it, a too-brief summary of where we are in the application of hardwood tree improvement, but essential to a review of where we are going. Research on over 40 species is underway; yet, only sweetgum is a species that can be widely planted on a range of sites. Sycamore, cottonwood and black walnut, though aimed at entirely different final products, are all prima donnas that need careful site selection and intensive care for establishment. Eucalyptus is limited by climate to areas of frost-freedom. Yellow-poplar is primarily a factory lumber or commercial veneer species.

Many other species have peculiar properties that make them desirable trees in specific situations and/or specific for specific products. For example, green ash is an easy one to grow in the nursery, plants well, and is successful on many wet, clay sites. Its wood is desirable for fiber and for many solid products of high value. The oaks are tremendously variable in growth rates between species but all have high specific gravity and produce good yields on a wide variety of sites. However, some of the easiest to propagate, such as pin oak and water oak, rarely develop clean stems suitable to high quality lumber production. No one has come out with a sure-fire way to kick off early growth of oak, though several researchers are delving deeply into studies on the subject. Water tupelo grows well in nurseries and can be planted successfully in swamps.

Lest we forget, not all tree improvement aimed at increased timber production yields superior planting stock for that purpose alone or even for that purpose at all. For example, cottonwood selection yielded some progeny that were persistently limby to the ground -- good characteristic for windbreaks but not so good for timber. Sweetgum progeny tests discovered vivid colorations in spring and fall foliage in some trees -- desirable for roadside and urban plantings.

Although we see the beauty of cherry probably more than any other wooden furniture part, the research in black cherry improvement is limited. Various reasons are given including the ease of propagating this species naturally. Still, in relation to black walnut the effort in tree improvemnt for this fine furniture wood is mighty slim when you consider that the species is adaptable to a broader range of sites than black walnut.

In my estimation some approach similar to that discussed by Farmer (1973), for administrative decision-making will need to be used at all levels to stretch the research dollar and to eventually yield the most useful results. Specific industry programs might take a different evaluation than one made for the non-industry private sector. However, in both cases planting to translate genetic improvement to application will need to be feasible and thoroughly tested to assure biological and financial success. "Tree improvement" becomes the whole program, including genetically developed superiority and the range of other inputs such as planting methods to insure cost efficiency. With thirty research institutions doing some form of tree improvement on a wide range of species, such a system is mandatory (Table 3).

The method of ranking used by Farmer integrates available quantitative information and judgment of experienced specialists around key elements of species selection. Weighting and scoring provide a ranking of species. The inputs include (1) value improvement rate; (2) predominance in existing forest; (3) values for uses other than timber production; (4) plantability; (5) acreage available for artificial regeneration; (6) likelihood and cost of breeding success; (7) and cost of improved stock.

Marquis (1973) points out the variation in potential returns from hardwood tree improvement. He states that black cherry and paper birch could sustain much higher expenditures for some genetic gain than could red oak. Species that produce large quantities of seed and species with high sawtimber values and rapid growth rates are likely to be good tree-improvement investments. I would add that where there are ready or developing markets for hardwood fiber, the investment-time factor before financial return must strongly enter the picture. Of major importance is his conclusion that the amount of genetic gain required to justify tree improvement for the fine hardwoods is small. He calculates that increases in quality, or growth increases in excess of 10 percent, would make for profitable investments with this species.

Dutrow, etal (1970) provide an investment guide to cottonwood planters and indicate a 20 percent increase in yield from superior cuttings. Of particular importance to the cottonwood investor and tree improver are the figures allowing determination of returns to be expected for pulpwood rotations alone and a combination of pulpwood-sawtimber-veneer timber rotations at various initial establishment costs. Such investment guides should be an aid to the researcher who must analyze opportunities before investing years and dollars into genetic improvement research.

OTHER CONSIDERATIONS

There is often a tendency to plod the same paths though change may indicate a better direction. Selection of species to apply the approach of total tree improvement might be guided by the so-called multiple use concept. Trees in forests, whether naturally occurring or planted, can provide timber, wildlife food, aesthetic buffers, windbreaks, water filters, soil binders, and so on. Perhaps we should all be considering some new approaches, or maybe not-so-new but, at least, little talked about. For example, in cottonwood plantations for sawtimber, interplanting with superior pecans may provide particular mast for wildlife, excellent timber, and a variety in the forest.

As we look to genetic improvement of sweetgum and maples, there will be foliage of some progeny extremely pleasing for fall colors. Perhaps some attention to

Table 3.--Some institutions doing tree improvement relative to concerns of the Southern Forest Tree Improvement Conference.

Institution	Oak	YP	Cw	Syc	Sg	Chs	Map	Elm	Pec	EO	Wal	Tup	BC	Bir	Ash	Bass	Ail	BLoc
Forest Ser.																		
SO	*	*	*		*				*		*	*			*			
SE	*	*		*	*					*		*	*					
NE	*		*				*	*					*	*	*			
NC	*		*				*				*							
NCSU Coop.	*	*		*	*		*				*	*	*		*	*		
TVA	*	*									*							
VPI	*																*	
U.of Ga.	*	*		*	*													
Auburn				*	*													
Miss.St.U.					*										*			
LSU			*	*					*									
Tex.A&M Coop.	*		*	*	*										*			
Okla.St.U.			*															
U. of Tenn.	*	*				*					*							
U. of Ktky.	*	*		*							*							
Clemson U.	*	*			*													
Sou.Ill.U.											*				*			
U. of Ill.			*					*										
Purdue								*			*							
Ia.St.U.								*			*							
Kan.St.U.	*		*				*		*		*							
Mich.St.U.	*																	
U.of Minn.				*				*										
U. of Neb.				*														
Ohio Res.Ctr.	*	*	*															
St.F.Austin				*										*				
West Va. U.	*	*						*			*		*					*
U. of Wisc.								*			*							

planting these varieties along roadsides and interspersed on appropriate sites with pine could reduce the accusing "monoculture" designation being assigned commercial plantations of a single species.

In mountain hardwoods regeneration with improved stock may well take the form of a few dozen crop trees per acre, cared for individually, rather than the present row-planting. Underplanting or interplanting has been found feasible with birch, maple and some oaks. Though this method may not be suitable for lowland sites and for large industry-oriented holdings it may be the most feasible approach on upland sites of relatively small acreage held by non-industrial owners. Minkler (1975) suggests a form of silviculture for multiple benefits to such owners where the crop tree approach to incorporating genetically improved stock may be entirely acceptable.

Some bottom-land sites in the South are typically a series of ridges, flats sloughs, and swamps. Some very wet areas during normal planting season have excellent soils that don't come out from under water until the seed have all gone. Here underplanting of green ash that has been selected for good initial growth in partial shade may put low-productive forest conditions into high production with relatively little cost for site preparation and cultivation. Once the trees are well established the unwanted overstory can be removed, if merchantable, or deadened if cull. Similarly, work with tupelos already started by the Forest Service at Charleston and Stoneville should concentrate on tree improvement, in its broadest sense, to provide planting stock and methods suited to planting in the fall when water levels are low in swamps.

There are hundreds of thousands of acres of sites where clays predominate in soils that drain slowly on the outside and little at all internally. In some cases the very best trees on such sites would be those that quickly produce wood of high yield but perhaps of less than desired clearness for factory lumber or veneer. The full range of planting recommendations will compose "tree improvement" for such sites and the part of genetic improvement may be to provide an oak or an ash or whatever that is plantable at other times than winter or early spring, has good initial growth, and sustains acceptable growth until minimum size for harvest. At the same time the species chosen might well be a mast producer to enhance the value of the forest for wildlife.

A NEW CHALLENGE

From this analysis can be drawn six recommendations:

1. Systematically analyze for prediction of future needs. Eliminate research on species or site-species combinations that do not stand up to par on objective analysis.

2. Do not overlook the trend toward forest practices that demand a forest with variety to meet many human needs.

3. Do recognize the potential productivity of some difficult to plant sites, both natural, such as swamps, and artifically created, such as strip mined areas.

4. Do consider total "tree improvement" and plan genetic improvement around the many facets of planting or seeding a particular species or variety for a specific site and forest condition.

5. For the big planting opportunities look to the "tough" species or strains that seem to grow under a variety of conditions and are used for a number of purposes. Assess potential for developing planting stock relatively free of disease and insect pests.

6. Continue and expand basic research that answers questions about "how trees make wood?" Information gained by such research will further refine the decision-making process recommended in the first challenge.

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