POTENTIALS AND PROBLEMS OF HARDWOOD TREE IMPROVEMENT

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In preparing a paper on hardwood tree improvement for this Sixth Southern Forest Tree Improvement Conference, we wanted to contribute something other than the obvious truths. Everyone knows that there are great potentials for improving growth rate, quality, figure, resistance to insects and idseases and to inundation, and other desirable characteristics. The geneticists here understand many of the problems in applying their science to an oak tree or a poplar tree, just as they understand the problems of breeding pine trees. What more, then, can be said about the potentials and problems of hardwood tree improvement--particularly by a pair of unimproved tree-improvers?

In searching the literature and in conversing with others, we ran into such questions as, Where would a researcher start when he considers tree improvement with southern hardwoods? Where could he find records on flowering and seeding characteristics, or cytogenetic data? Where could he get information on methods of propagating the species, or on past breeding work? And perhaps most important of all, what facts could he use to assign work priority to selected species?

In an attempt to answer this multitude of questions, we have systematized as much data as we could find for the 20 southern hardwood species listed in table 1 .

These 20 are perhaps the most valuable southern hardwoods at present, as judged by such factors as quality and growth, adaptability to particular sites, and utility. As in most literature reviews, some work may have been inadvertently omitted. If you know of published or unpublished data that we have missed, we sincerely hope you will tell us of it.

The information in table 1 is mainly from dendrology texts and various botanical publications (3, 7, 8, 9, 18, 23, 24, 25, 45, 61, 63, *66, 69, 71,* 77), and from

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[1] The authors are members of the Stoneville (Mississippi) Research Center, maintained by the Southern Forest Experiment Station in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

Table 1.--Flowering and seeding characteristics of 20 important southern hardwoods

Species	Type of flowers	Time of flowering	Time of seed maturity	Av. germinative capacity of stratified seed	Occurrence of good seed years 1/
				Percent	
Black cherry, *Prunus serotina* Ehrh.	Perfect	Mar.-June	June-Oct.	63	Annually
Black walnut, *Juglans nigra* L.	Monoecious	Apr.-June	Sept.-Oct.	75	Irregular
Black willow, *Salix nigra* Marsh.	Dioecious	Feb.-May	May-June	85	Annually
Cherrybark oak, *Quercus falcata* var. *pagodaefolia* Ell.	Monoecious	Feb.-Apr.	Sept.-Oct. 2/	38	Frequently
Eastern cottonwood, *Populus deltoides* Bartr.	Dioecious	Feb.-May	Apr.-June	88	Annually
Green ash, *Fraxinus pennsylvanica* Marsh.	"	Mar.-May	Sept.-Oct.	45	Frequently
Nuttall oak, *Quercus nuttallii* Palmer	Monoecious	Feb.-Apr.	Sept.-Oct. 2/	82	"
Overcup oak, *Quercus lyrata* Walt.	"	Mar.-Apr.	Sept.-Oct.	84	"
Shumard oak, *Quercus shumardii* Buckl.	"	Feb.-Apr.	Sept.-Oct. 2/	80	"
Silver maple, *Acer saccharinum* L.	Polygamo-dioecious	" "	Mar.-Apr.	76	"
Swamp chestnut oak, *Quercus michauxii* Nutt.	Monoecious	Mar.-May	Sept.-Oct.	87	Irregular
Sweet pecan, *Carya illinoensis* (Wangenh.) K. Koch	"	" "	" "	50	Frequently
Sweetgum, *Liquidambar styraciflua* L.	"	Feb.-May	Sept.-Nov.	80	Annually
Sycamore, *Platanus occidentalis* L.	"	Mar.-May	Sept.-Oct.	50	Frequently
Water oak, *Quercus nigra* L.	"	Feb.-Apr.	Sept.-Oct. 2/	61	"
Water tupelo, *Nyssa aquatica* L.	Polygamo-dioecious	Mar.-Apr.	Sept.-Oct.	50	Annually
White ash, *Fraxinus americana* L.	Dioecious	Apr.-May	Aug.-Oct.	38	Irregular
White oak, *Quercus alba* L.	Monoecious	Mar.-May	Sept.-Oct.	78	"
Willow oak, *Quercus phellos* L.	"	Feb.-May	Aug.-Oct. 2/	46	Frequently
Yellow-poplar, *Liriodendron tulipifera* L.	Perfect	Mar.-June	Sept.-Nov.	5	Irregular

1/ Frequently--every 1 to 2 years; irregular--every 3 to 5 years with no set cycle.
2/ Maturing the year following pollination.

pamphlets on silvical characteristics (32, 33, 37, 40, 42, 51, 84, 85). Some material from files of the Stoneville Research Center is also included. It should be realized that the times given for flowering and seed maturity reflect latitudinal extremes. The occurrence of good seed years should also be taken with a grain of salt, as meteorological variations play a great part.

Notably absent from this table is a listing of minimum flowering ages, certainly a helpful tool to the plant breeded. The literature is largely silent on this subject, though it does report flowering of an 8-year-old black walnut (6), and a 7-year-old green ash (85). At Stoneville, W. M. Broadfoot has observed flowers on a 4-year-old cottonwood.

Several of the species are rather easy to propagate by vegetative means (tables 2, 3, and 4); some, notably sweetgum and the oaks, are difficult; and some, such as black cherry and water tupelo, just haven't been tried much. Horticulturists have worked a great deal with sweet pecan and black walnut, but almost always in the field of budding and grafting. At Stoneville we have recently initiated a long-range study in which we hope eventually to establish suitable methods for vegetative propagation of all southern hardwoods.

In table 5, on natural variation and tree improvement work, details of variation and hybridization are necessarily omitted, but literature references are noted. Many references on cottonwood and willow breeding are omitted, as this is a field in itself, and the material is easier to find than for other species. Considerable breeding work has been done with black walnut and sweet peon by horticulturists, whose results will yield a wealth of information to the interested researcher on these two species. The same thing is true for black cherry, for while we have very little information on this species (10, 26) there is much horticultural literature on the genus Prunus (83).

It is in flower morphology, pollination, and cytogenetic characteristics that the gap in our knowledge is largest. Such basic information must be on hand before results of any tree improvement work can be completely interpreted. There are too many blank spaces and too many probably's in table 6. Take, for instance, the natural variation of chromosome number. Jonathan Wright has found the northern geographic race of white ash to have a diploid chromosome number of 46, while the southern race may have a diploid number of 46, 92, or 138 (73). The entire genus of Salix is very variable in this respect (52). What other species or genera have similar variations? At the present time we do not know. But in view of the results that followed discovery of the famous triploid aspens (Populus tremula L.) in Sweden in the 1930s (52, 83), the possibility of similar conditions in any of our southern hardwoods is a tantalizing one for any tree improvement worker.

Table 2.--Ease of propagating hardwoods by cuttings[1]

Easy	Difficult	Unsuccessful	Unknown
Eastern cottonwood	Yellow-poplar	Water tupelo	Black cherry
Black willow	Nuttail oak	Water oak	Black walnut
Silver maple	Sweet pecan		Other oaks
Sycamore	Sweetgum		
Green ash[2]			
White ash[2]			

1. For further information, see: 16, 17, 35, 40, 43, 44, 62.
2. With cuttings from young tree seedlings. Difficult with cuttings from mature trees.

Table 3.--Ease of propagating hardwoods by air-layering[1]

Easy	Difficult	Unsuccessful	Unknown
Eastern cottonwood	Sweetgum	Yellow-poplar	Black walnut
Black willow	Sycamore	Cherrybark oak	Sweet pecan
Silver maple			Black cherry
Green ash			Water tupelo
White ash			Other oaks

1. For further information, see: 11, 21, 43, 62.

Table 4.--Ease of propagating hardwoods by budding and grafting[1]

Possible	Probably possible[2]	Unknown
Black walnut	Black willow	Sweetgum
Sweet pecan	All oaks	Sycamore
Eastern cottonwood		Black cherry
Green ash		Water tupelo
White ash		
Yellow-poplar		
Silver maple		

1. For further information, see: 19, 50, 62, 64, 68, 85.
2. Success with closely related species indicates the possibility.

Table 5. --Natural variation and tree improvement work in some important southern hardwoods

Species	Known species variation	Natural interspecific hybrids	Artificial hybridization	Other improvement work
Black cherry				Selection 1/, other (4, 36)
Black walnut	2-3 geog. races (28, 78, 80)		Some 2/ (34, 52, 54, 58, 88)	Seed source, selection 1/ (1, 12)
Black willow	Entire genus very variable (52)	1 known (30)	Some 3/ in the genus (52)	
Cherrybark oak		1 suspected		
Eastern cottonwood	2 geog. races, other variation (46, 76)		Very extensive (83)	Selection 1/
Green ash	3 geog. races, other variation (41, 72, 78, 83, 84, 86)	Suspected with white ash (83)	Some inter- and intraspecific (27, 59a, 76)	Seed source studies (41)
Nuttall oak				
Overcup oak		3 known, 1 suspected (30, 39)	NESS hybrids (19)	
Shumard oak	Some geog. variation (22, 82)	6 known (30)		
Silver maple	Extensive, even locally (74)		Some interspecific (2, 20, 59a, 75, 79)	
Swamp chestnut oak		1 known, 1 suspected (30, 39)		
Sweet pecan		4 known (7, 30)	Some 2/ intraspecific	
Sweetgum				Selection 1/
Sycamore		1 known (15, 23, 53, 67)		
Water oak	Some geog. variation (82)	5 known (30)		
Water tupelo				
White ash	3 geog. races, other variation (72, 73, 76, 78)	Suspected with green ash (83)	Some inter- and intra-specific (59a)	Selection 1/ (4)
White oak	Extensive, even locally (55, 83)	6 known (30, 59)	Some inter-specific (57)	Selection 1/, other (13, 28)
Willow oak		8 known (7, 30)		
Yellow-poplar	Local variation, geog. races probable (28, 29, 31, 47, 60, 79)		Some intra-specific (79)	Seed source, selection 1/ (4, 5, 28, 31, 60)

1/ Implies selection of "plus trees" for any of several purposes.
2/ Nearly all for nut production.
3/ Mainly European work.

Table 6. --Some pollination and cytogenetic characteristics of southern hardwoods

Species	Normal diploid chromosome number	Natural variation of chromosomes	Natural pollinating agent	Irregularities encountered in breeding
Black cherry	32			
Black walnut	32 (52, 62)	In certain hybrids (52)		Parthenogenesis (87), dichogamy (52), metaxenia (54)
Black willow		Common in the genus (52)	Insects (23, 18)	
Cherrybark oak	Probably 24 (14)		Wind (7, 48)	
Eastern cottonwood	34 (62)		Wind (49)	Androgynous flowers reported (38)
Green ash	45 (62, 81)		Wind (85)	
Nuttall oak	Probably 24 (14)		Wind (7, 48)	
Overcup oak	Probably 24 (14)		Wind (7, 48)	
Shumard oak	Probably 24 (14)		Wind (7, 48)	
Silver maple	52 (62, 81)		Insects (75)	Sometimes self-pollinated (48), unusual flower structure (79)
Swamp chestnut oak	24 (52, 62)		Wind (7, 48)	
Sweet pecan	Probably 32 (62)		Wind (70)	Parthenogenesis indicated, some trees self-sterile (70)
Sweetgum	30 (62)			
Sycamore	42 (53, 62)			
Water oak	24 (52, 62)		Wind (7, 48)	
Water tupelo				
White ash	46--northern race (73)	46, 92, and 138 in southern race (73)	Wind (84)	
White oak	24 (52, 62)		Wind (7, 48)	Flowers only partly developed when pollinated (65), metaxenia (57)
Willow oak	Probably 24 (14)		Wind (7, 48)	
Yellow-poplar	38 (62)		Insects (79), mostly honey-bees (51)	Low self-compatibility (56), parthenocarpy exists (79)

In closing, we would like to point out a condition that we think needs alteration. A glance through the literature cited in this paper will show that more than 90 percent of the references are to work done in the northern United States or in Europe. Yet more than half of the Nation's hardwood timber is grown and cut in the South. There is no doubt about the potentials of growth and value in our southern hardwoods, but the problems for research and application are also present.

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