CONSTRAINTS AND OPPORTUNITIES FOR TREE IMPROVEMENT IN THE APPALACHIAN HARDWOOD REGION[1]

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Abstract :--The Appalachian Hardwood Region resembles the Georgia + Alabama portion of the Southern Pine Region in timber volume, amount of commercial forest land, and percentage of land forested. However, the regions differ in important respects that affect opportunities for tree improvement. Several real and perceived constraints on tree improvement in the Appalachian Hardwood Region are identified and discussed: diversity of species, paucity of industry-controlled land, administrative heterogeneity, underutilization of resource, and biological difficulties. These constraints demand innovative approaches to tree improvement and a closer integration with research on hardwood silviculture, utilization, and forest economics. Several opportunities are briefly discussed.

INTRODUCTION

This presentation originally was to focus on "the future" of tree improvement in the Appalachian Hardwood Region, a topic devised rather hastily over the telephone. Calmer reflection suggests the less audacious topic and title shown above. My young children sometimes believe I know everything that has happened, especially if they have

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been up to mischief; but not even they believe that I know what <u>will</u> happen. Furthermore, some of the papers I have read in preparation for this talk--those old enough to be viewed with hindsight--convince me that we forest geneticists have often shown more optimism than realism in forecasting the future.

Progressive and intensive forest management practices have created a climate of demand for tree breeding and selection in many parts of the country. In this region we have had a tougher row to hoe, although we have benefited from the aura of promise that has surrounded forest genetics everywhere. However, changes are occurring in the climate for tree improvement and genetics research, and a good dose of realism will be important in planning for the future.

University research programs are experiencing the effects of fewer students entering graduate school, and fewer graduate forest geneticists are finding jobs. Federal funding for formula and competitively funded research is undergoing scrutiny and change. Forest Service research moneys are being cut, and federal assistance to state tree improvement programs is in danger of disappearing completely. Furthermore, even as it is eliminating some conventional tree improvement projects, which have yet barely exploited the possibilities, the Forest Service is substantially increasing its funding of more novel aspects of genetics research, which have high appeal but less immediate promise. Now seems an appropriate time to reassess the role of tree improvement within the region.

The Appalachian Hardwood Region as defined here lies largely within eight states straddling the Appalachian highlands from Ohio and Pennsylvania to Tennessee and North Carolina (Figure 1). Its axis is the Ridge and Valley Province extending from Pennsylvania to Tennessee. To the west the region includes the Allegheny and Cumberland Plateaus, and to the east the Blue Ridge and Smoky Mountains. It comprises two principal forest types: the "mixed mesophytic" and "Appalachian oak" (or oak-chestnut) forests of Bailey (1978), Braun (1950), and Kuchler (1964). However, I am excluding the glaciated and piedmont sections of the latter, extending from southeastern Pennsylvania to Massachusetts, because of the different land use patterns that prevail in that more populated portion of the East.

As discussed later, the Appalachian Hardwood Region is seldom viewed as a unit in forest research, extension, and national planning activities. Yet it is remarkably homogeneous in its forest cover and land use patterns

FIGURE 1.--The Appalachian Hardwood Region.

(Tables 1 and 2) [1]. Oaks comprise the dominant species group, and conifers are a relatively minor component except in the southern portion of the region (Table 1). Pure stands of any species are rare. Outside the region, especially to the north, south, and southeast, species composition of the natural forest is very different. The region is predominately forested and largely devoid of metropolitan areas, contrasting markedly with the important agricultural lands to the immediate east and west of the region.

[1] Some caution must be exercised in interpreting those tables because the data come from state inventories completed in various years spanning as much as a decade.

TABLE 1. -- Growing stock composition by volume of major species within Appalachian Hardwood Region.[a]

Species	Percentage composition within states and region:							
	PA	WV + MD	VA	NC	TN	KY	OH	REGION
Chestnut oak[b]	12.8	10.3	16.3	11.2	10.9	10.5	7.2	11.5
Northern red oak	15.2	9.9	8.8	8.1	4.7	5.0	6.0	9.3
Other red oaks[c]	7.4	10.5	15.1	11.8	12.0	16.8	9.2	11.3
Select white oaks[d]	8.8	9.7	9.8	6.1	9.1	12.1	13.3	9.6
All oaks	44.2	40.4	50.0	37.2	36.7	44.4	35.7	41.7
Virginia pine	0.5	3.1	3.3	5.4	12.4	*	2.0	3.5+
Eastern white pine	3.4	1.0	4.2	7.1	2.6	*	1.2	2.7+
Pitch & shortleaf pine[b]	1.1	0.8	4.1	6.1	8.3	*	*	2.6+
Eastern hemlock	3.8	1.3	1.6	2.6	1.3	*	*	1.8+
Other softwoods	0.1	1.2	1.8	0.8	2.7	11.0	2.3	2.3-
All softwoods	8.9	7.4	15.0	22.0	27.3	11.0	5.5	12.9
Yellow-poplar	2.7	10.2	10.6	13.4	10.7	12.2	10.7	9.2
Hickories	2.7	8.5	6.9	5.5	9.3	12.3	8.7	7.3
Red maple[b]	12.6	6.3	4.0	5.8	3.9	4.0	5.1	6.7
Sugar maple[b]	5.4	5.7	2.0	1.4	2.1	1.9	6.4	3.9
Beech	2.2	4.4	1.6	1.8	1.2	4.8	3.0	2.9
Black cherry	6.4	3.3	0.3	0.5	0.4	*	3.3	2.6+
White ash[b]	3.4	2.1	1.0	1.1	1.5	1.2	4.1	2.1
Yellow & sweet birch	3.7	2.8	0.1	0.7	0.6	*	*	1.7+
Basswoods	1.5	1.5	1.5	1.2	0.7	1.6	*	1.2+
Black locust	1.4	*	1.7	2.7	0.7	*	1.9	1.0+
Blackgum	0.8	1.0	0.9	1.0	1.4	1.7	*	1.0+
Black walnut	0.3	0.8	0.6	0.2	0.4	0.7	1.6	0.6
Other hardwoods	3.8	5.6	3.8	5.5	3.1	4.2	14.0	5.2-
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Volume (million cu. ft.):	12,026	13,980	6,612	5,762	6,928	5,934	4,201	55,443
Year of inventory:	1978	1975/76	1977	1974	1980	1975	1979	

[a]Values pertain only to those portions of each state that are within the region.
[b]Values may include small volumes of related species.
[c]Scarlet, black, pin, shingle, and willow oaks
[d]White, swamp white, bur, chinkapin, and swamp chestnut oaks
*Volume is included in figure for "other softwoods" or "other hardwoods."

TABLE 2.--Selective contrasts between the Appalachian Hardwood Region and a comparable portion of the Southern Pine Region.

	Appalachian Hardwood Region	Georgia + Alabama
Area of commercial forest land (million acres)	48.7	46.1
Proportion of commercial forest to total land area	65.8%	66.3%
Proportion of commercial forest in public domain	15.1%	5.5%
Proportion of commercial forest owned by forest industry	5.1%	18.5%
Total growing stock volume (million cubic feet)	55,443	49,784
Major species group as percentage of total growing stock	41.7% (oaks)	52.5% (pines)
Most abundant species as percentage of total growing stock	11.5% (chestnut oak)	25.9% (loblolly pine)
Proportion of growing stock removals to net annual growth	38%	61%

Some insight into the tree improvement situation within the region can be obtained through comparisons with the Southern Pine Region, where activity in tree improvement is much higher. These comparisons are provided in Table 2 for a portion of the Southern Pine Region (Georgia and Alabama) that is very similar in amount of forest land, percentage of forest cover, and total timber volume. Of course, the regions differ in species composition, land ownership patterns, and intensity of management practices. These differences serve to introduce some of the constraints faced by tree improvement within the Appalachian Hardwood Region. Some of the constraints are real, some are merely the result of faulty perceptions.

CONSTRAINTS ON TREE IMPROVEMENT

Diversity of Species

The Appalachian Hardwood Region contains over 65 commercial tree species, more than any other physiographic region of comparable size within the country. Although a much smaller number of common species accounts for most of the timber volume (Table 1), no single species predominates as loblolly pine does in the Southern Pine Region (Table 2). In terms of both value and volume, northern red oak is our most important species. It is followed in decreasing volume by yellow-poplar, probably white oak (available statistics lump this with several other species), red maple, sugar maple, Virginia pine, beech, white pine, and black cherry.

The main point is that no species is of dominant importance, and indeed no three species taken together equal the importance of loblolly pine in the South. This of course contributes to a diffusion of research effort and limits the resources that can be brought to bear upon the improvement of any one species.

Paucity of Industry-Controlled Land

In every region where tree improvement is most active, the inducements have come largely from private corporations that have perceived the economic benefits. The proportion of commercial forest land owned by forest industry within the region is less than one-third of that in Georgia and Alabama, while the proportion of land in the public domain is three times as great (Table 2).

Furthermore, on the processing end, industrial interest in the resource is spread over many, mostly small firms. In Pennsylvania, for example, roughly 60 percent of the timber harvest is in sawlogs, which are processed by about 740 sawmills in the state (Bones and Sherwood 1979). Georgia's substantially larger harvest is 60 percent pulpwood, which in that state goes to only 15 pulpmills (Welch and Bellamy 1976). Even if prospective economic benefits were the same, there is no way that 740 independent sawmill operators could be convinced to fund research at the level of 15 pulpmill owners. The federal government must play a role in funding research for which the benefits are diffuse. Often it does not, because the same fragmentation of private interests that affects research funding creates a weak political voice as well.

Administrative Heterogeneity

No other natural forest region of comparable size is so badly fragmented by administrative divisions. The Appalachian Hardwood Region includes two National Forest regions and three regional Forest Experiment Stations. It is served by three different USDA Regional Research Projects on tree improvement, which are responsible for much of the cooperative research on forest genetics in the East. Research communications are further fragmented among three "tree improvement conferences" including NEFTIC, each of which addresses different portions of the region. It crosses more than eight states, seven of which have more important forests outside the region. Because of these divisions, the Appalachian Hardwood Region is often ignored as an entity, and its importance gets overlooked in research planning, coordination, and funding.

Underutilization of Resource

Growing stock removals amount to less than 40 percent of net annual growth, a figure which is fairly consistent throughout the Appalachian Hardwood Region. The analogous statistic for Georgia and Alabama, is 61 percent (Table 2). The fact that we are already growing much more wood than we are cutting is often used as an argument against additional research on the culture and genetics of Appalachian hardwoods.

However, this statistic is deceptive because utilization ratios differ widely among species. For example, the most recent Pennsylvania estimate of the removals/growth ratio for red maple is 21 percent, while that for select white oaks is 123 percent (Considine and Powell 1980). In fact, we appear to be overcutting high quality hardwood sawlogs, the principal product of the region, and shifting standing volume to less valuable species such as red maple.

Furthermore, timber harvests are expected to roughly double over the next 20 years in much of the region. Species which are now disproportionately represented in sawtimber size classes will be harvested at levels well above 40 percent of net annual growth. Northern red oak is the principal such species--its volume is disproportionately in sawtimber in all portions of the region. If we continue to have difficulty regenerating northern red oak, as we do now, then this valuable species will decline in abundance.

Biological Difficulties

Among the Appalachian hardwoods, northern red oak is the most likely candidate for genetic improvement from the standpoint of abundance and value. Yellow-poplar, white oak, red maple, sugar maple, black cherry, and white ash are other plausible choices at least in portions of the region. Other species are planted for special purposes such as Christmas trees, landscaping, and surface mine reclamation, and several pines are of minor importance; but the species I have listed are the principal ones that provide value to the timber resource of the region.

Significantly, these species all share one or more of the following biological constraints on tree improvement:

1) planting difficult and expensive

2) controlled pollination difficult (few seeds per infloresence, insect pollination, or infrequent seed years)

3) reproductive maturity at advanced ages and long economic rotations

4) vegetative propagation impracticable.

Together, these obstacles slow the potential rate of genetic gains, they detract from the economic feasibility of tree improvement, and they make difficult the silvicultural use of genetically improved stock. All four constraints apply particularly to the oaks, our major species group. In fact, item number 2 is so severe a constraint that controlled pollination of oaks would be virtually out of the question in a purely applied tree improvement program.

Of the four, the most serious obstacle to progress is the difficulty of planting these species. It is not that they cannot be planted successfully, but that they cannot be planted successfully with the minimal site preparation and weed control normally afforded to conifer plantations. For that matter, conifer plantations in the region are often not established with the same care they are given in other parts of the country. A recent survey of state and private plantations established with stock produced by the Pennsylvania Bureau of Forestry showed an average survival within ten years of planting of only 29 percent for conifers and 3 percent for hardwoods (Frank et al. 1983). In comparison, survival in industrial southern pine plantations for the period 1960-78 was estimated as 78 percent in a survey by Weaver et al. (1981).

Partly because of persistent failures with hardwood plantations, planting activity in the Appalachian Hardwood Region is at a very low level compared to some other regions of the country. It can be calculated from available statistics (Anonymous 1978, 1982a) that planting in this region is substantially less than 10 percent of the rate in the South and Pacific Northwest, and about 30 percent of the rate in the Lake States, compared on the basis of equivalent forest areas.

OPPORTUNITIES FOR TREE IMPROVEMENT

Despite the pessimistic tone of the foregoing, I still believe that there is a role for tree improvement in the Appalachian Hardwood Region. This belief stems partly from a conviction that the Appalachian hardwoods have been undervalued from the research standpoint, and partly from a good deal of faith that certain tree improvement activities could be shown to be economically justified.

Most of the restraints I have tested cannot be overcome by any means within the power of the tree breeder. However, the constraints do not preclude advances in tree improvement, they merely place limits on the opportunities. To go forward, tree breeders in this region must recognize and accept those limits, and in some cases we may have to depart from some of the conventional tree improvement procedures and objectives appropriate to other regions and species. Failure to be realistic in our activities can jeopardize our credibility, which perhaps has already suffered from an absence of any major tree improvement successes with the Appalachian hardwoods.

Tree improvement goes hand-in-hand with intensive silviculture, and impediments to one tend to he obstacles to the other as well. For this reason, it is imperative that tree breeders work closely with silviculturists in solving problems of mutual importance. One of the most difficult silvicultural problems in the Appalachian Hardwood Region is regeneration of high-value species, especially northern red oak. Complete regeneration failures are disturbingly common, and many "successes" would be failures were it not for an abundance of red maple or other low-value species.

Although we must contend with a tradition of reliance on natural regeneration, there is obviously a need for demonstrably successful techniques for planting valuable hardwoods.

The objective in planting need not, and perhaps should not, be plantations in the conventional sense. Smith's (1971) concept of supplementary plantings of small numbers of seedlings per acre still seems appropriate. In the case of northern red oak, the seedlings should perhaps be planted before harvest in order to aid their chances of competing with the more vigorous vegetation (Sander 1979) that appears when the canopy is opened. Since most forest geneticists are knowledgeable about plantation culture, there is a need for them to become involved in developing planting techniques and educating forest managers.

At the present level of sophistication in managing the Appalachian hardwoods, it is pointless to focus on sawlog production in formulating improvement objectives. For one thing, rotations are so long that we would be working under strained predictions of juvenile-mature correlations. But most importantly, the species are simply not being planted enough to make genetic improvements in sawlog yield worthwhile.

Rather, it seems much more appropriate that we strive for genetic improvements in hardwoods that will contribute to planting success. With northern red oak, and indeed probably most of the valuable hardwoods, the major factor limiting field survival is slow juvenile growth rates (McGee 1979, Johnson 1981). Unable to outgrow the natural vegetation under affordable levels of weed control, the planted trees eventually succumb. Thus, growth rate in the very short term, in the nursery and perhaps as little as five years beyond, may be the most worthwhile improvement objective--not superior volume production at rotation age. Without a doubt some very large genetic gains could be achieved quickly. If they enhanced planting success, the potential economic benefits would be enormous just because of the species conversions that could otherwise not be accomplished. Any growth rate improvements that carried through to rotation age would be icing on the cake.

Thus, faster juvenile growth is an improvement objective that could actually facilitate its own implementation in silvicultural practice. We can further enchance the opportunities for hardwood tree improvement if we dispense with the idea that breeding must be a part of any "real" improvement program. There are two reasons for this. One is that controlled pollination is a difficult and expensive proposition with almost all of the valuable hardwoods in the region. The other, related reason is that seed production per acre per year tends to be low in these species, with oaks at the extreme of the spectrum.

Since it is difficult to justify heavy investment in hardwood tree improvement, costs must be kept low. Without the realistic potential of spreading program costs among millions of genetically improved seedlings, programs will have to be streamlined by heavy reliance on inexpensive selection, probably among naturally occurring populations or families. Plus-tree selection is expensive and probably not effective with these species, because of their sensitivity to site conditions and tendency to occur in more-or-less uneven-aged stands of complex and variable structure. Because of the biological constraints mentioned earlier, seed orchards for most of the important Appalachian hardwoods may be too expensive to justifiably implement.

In this context, the first step should be short-term progeny tests in closely spaced plots (recognizing the principal goal of rapid juvenile growth), with the objective of identifying superior wild individuals or stands for designation as "seed production trees" or seed production areas. It is possible of course to look beyond this step. However, I think the potential gains with this simple procedure are large enough to discover whether genetic selection for rapid juvenile growth can contribute to hardwood planting success. Costs would be so low that the risk of failure is inconsequential.

I have focused on hardwoods because they are the principal resource of the region, but softwoods do play a role in our timber economy. That role could increase in the future, although we cannot expect to compete with the South, New England, and the Lake States in softwood production. White pine is reproducing quite readily in Pennsylvania, and often it composes the majority of advance reproduction under hardwood stands. There is a moderate level of commercial interest in larch and pine plantations in this state, and I believe that interest is higher in states to the south. In fact, many of our poor quality hardwood sites would be more productive if they were in conifers. As Smith (1971) put it, there are "more millions of acres of hardwoods than of good hardwood sites." Some tree improvement with the softwoods certainly is warranted.

But we should bear in mind that there is not going to be a rush to plant Japanese larch or the pitch/loblolly pine hybrid simply because they can be shown to be more productive per acre than chestnut oak. There must be a good market for the softwoods that are planted, which there is definitely not in some parts of the region. There must also be a market for the low quality hardwood that is to be removed in the conversion process. Although there is great demand for high quality hardwood timber, the low demand for poorer quality material is one of the principal hinderances to more intensive forest management in the region. Until products and product markets are developed for this material, it will stay there and provide little value other than shade for deer and turkeys.

Given the right market conditions, softwood tree improvement would be a very attractive proposition in this hardwood region. However, to pursue softwood tree improvement, geneticists will have to support and even participate in the silvicultural, economic, management, and wood utilization research that can encourage conversion to more productive land uses.

In conclusion, there is a role for tree improvement in the Appalachian Hardwood Region if geneticists take a realistic view of the constraints and tailor their goals and strategies accordingly. By way of examples, I have suggested two modifications to conventional tree improvement, selection for juvenile growth and reliance on progeny-tested seed production areas, that seem appropriate to the species in this region. Most importantly, tree breeders cannot afford to continue "business as usual", pursuing our personal research interests as though the rest of the world will suddenly wake up to their worth. We must broaden our perspectives by participating in or supporting all research that contributes to better management and utilization of this important timber resource. We must recognize and acknowledge the obstacles to tree improvement that face us, and then do the work necessary to remove them.

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