IMPROVED TREES: ECONOMIC PROMISES AND PITFALLS

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ABSTRACT.--Surging demands for wood fiber that must be produced on a decreasing acreage of forest land suggest soaring prices, a shrinking market for wood products, or both. Either of these consequences can be forestalled or prevented by implementing existing technologies, one of which is cultivation of genetically improved trees. Multiple and sizable gains from improved trees are likely. Gains are not without risks, however, as possible losses may occur through failure to accumulate capital necessary to establish plantations of improved trees on good sites.

Reasons for widespread reliance on improved trees are plentiful and pressing. Almost daily, trade announcements and public media forewarn of escalating demands for wood fiber from a diminishing land base. Like a mathematical equation, the oft reported and most assured result is a shortfall in timber supplies, signaled initially by soaring prices, and quickly followed by deteriorating markets as competing materials replace wood. Whether these calamitous outcomes are forthcoming is a matter of speculation, but the ability of improved trees to ameliorate such dire consequences is unquestioned. As a means to increase and improve the nation's wood supply, the genetically improved tree has no peers.

Yet, use of genetically improved trees is not without risk. In this paper, I emphasize probable gains and economic promise, but also describe hazards. I also review a method for analyzing the economics of tree improvement recently advocated by Clark Row and me.

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MORE WOOD FROM FEWER ACRES

A program to provide improved planting stock calls for substantial investments of money, land, and labor. All these productive resources could be profitably used elsewhere; they remain in timber production only as long as rewards are high enough to keep them there. Strong and stable demands for wood for the foreseeable future underlie decisions to commit resources to timber production. Thus, it behooves us to briefly examine the probable strength and durability of the demand for wood.

Most experts anticipate an upward climb in the demand for wood fiber (Armitage 1976, Zobel 1977b). Consumption of wood by the entire world is expected to rise from 95 billion cubic feet in 1975 to 140 billion cubic feet in 1990, an increase of approximately 50 percent in only 15 years (Armitage 1976). Worldwide pulpwood consumption is projected to rise even faster, doubling by 1985. Reports published by the USDA Forest Service project steep increases in consumption for industrialized nations, especially the United States, Japan, and countries in western Europe (Phelps 1975).

A significant hike in the supply of timber could prevent price increases, but even optimists are projecting, at best, a modest increase in available wood on the world market. Thus, the present trend of rising relative prices for wood and wood products will likely extend indefinitely into the future. And, investments in tree-improvement programs will probably not be buffeted by waves of dwindling demand.

Major additions of land devoted to timber production cannot be expected. In fact, historical evidence and a parade of prognosticators assert the opposite; i.e., land devoted to commercial production of wood fiber has declined and will continue to do so. Not only is forest acreage declining, but the more productive lands often are among the earliest casualities. Many productive sites are diverted to agricultural crops as landowners seek higher profits. Rich soils in bottomlands face a similar fate or inundation. And, sites both rich and poor face limitations on commercial timber production as environmental restrictions are imposed.

The Mississippi Delta offers an example (Sternitzke and Nelson 1970). Since the earliest surveys in the 1930's, almost 40 percent of the 12 million acres of commercial forest land has been lost to other uses. Even land held by forest industries has declined because of the lure of higher profits in other land uses. Loss of quality land is underscored by the growing percentage of forest acres of species that inhabit only poorly drained clay flats. Forestry's losses were gains for soybeans, improved pastures, and cotton, in that order.

Without further belaboring the point, it appears certain that demand for wood fiber will remain strong and that timber supplies will come from a smaller land base. Such circumstances suggest that prudent investments to augment timber supplies will be profitable. One such investment of proven value is in tree improvement. Economic analyses paint an encouraging benefit--cost picture for tree-improvement programs as a means of accelerating per acre production of wood.

BENEFITS OF IMPROVED TREES

In considering the host of benefits that reputedly accrue to the new subscriber to improved trees, a critical oversight frequently occurs. Tree improvement is pictured as independent of other recommended management practices. No assumption about improved trees is more likely to reap financial havoc. Yield increases promised for genetically-improved planting stock occur only when properly combined with site selection, site preparation, fertilization, and silvicultural maintenance. Gains from improved trees, as with most intensive forest practices, demand close adherence to a series of recommended treatments. Attempts to reduce costs or cut corners in silvicultural prescriptions will likely erase gains. Benefits are listed here in the context of fully integrated forest management.

Much attention and effort in the South have been directed to pines, but hardwood tree-improvement programs are also well underway, and hardwoods promise to respond well to improvement efforts. Demand for pine stumpage, markets for pine products, relative ease with which pines can be genetically improved, and overall economy, however, have dictated some neglect of hardwoods and concentration on softwoods. Thus, most gains and analyses mentioned in this paper pertain to softwoods.

Overall objectives of tree improvement programs read like familiar sign posts: faster growth rates, increased resistance to forest pests, better tree form and wood quality, and heightened adaptability. If our storeroom of economic data were replete with necessary and accurate information, and if our markets fit the requirements of perfect competition, then our economic analyses could clearly assess costs and benefits of each stated objective. In the absence of both data and free markets, we can only roughly estimate probable gain. Nevertheless, one conclusion surfaces over and over: improved trees promise substantial financial reward at minimal cost, especially for industrial landowners. This beneficial ratio stems largely from gains in specific tree characteristics which individually and collectively enhance the value of the wood for processing. Furthermore, small per-acre gains in desirable characteristics become significantly more important when measured over large tracts of managed forest lands.

Volume gain is a primary goal for most tree-improvement programs. Early advocates of genetic improvement predicted volume gains in excess of 50 percent, but current workers expect volume increments of 10 to 20 percent in the first breeding cycle (Zobel 1977a). Additional gains are expected in future generations, but a gain of 10 to 20 percent appears reliable and defensible.

Tree straightness is desirable, but not easily measured. Straight trees more than pay for themselves when accountants measure harvesting and manufacturing cost advantages and the increased yield as sawtimber is produced. Geneticists report, too, that this goal can be achieved quickly, possibly within one generation of breeding (Zobel 1974).

Another characteristic desired in the South is resistance to fusiform rust. Every analysis stresses importance of progress toward this goal. If trees die, growth and conversion economics become meaningless. But resistant strains are being found and made available for planting in the South (Zobel 1974). Specific gravity of wood can be a significant determinant of pulp yield and processing time in the mill. Moreover, specific gravity increases of 5 to 7 percent have been realized in tree-improvement programs (Ottens and Carlisle 1976).

Revenue gains from tree-improvement programs are measured by comparing additional costs and returns associated with improved planting stock. Only costs or gains over and above those for plantations of unimproved trees are relevant. In practice, additional costs are minimal; in most instances, the only additional or marginal cost goes for improved seeds. Since the economic analysis compares the extra seed costs with discounted values of extra yields at harvest, added expenditures for improved trees are strongly supported. Yield increases of about 5 percent more than justify foreseeable expenditures for seeds (Zobel 1974). Ottens and Carlisle (1976) found that seed costs could be 10 times greater than current rates and still promise profits over a typical rotation. Similarly, it was shown that discounted gains in revenue exceeded current costs of seed production by a multiplicative factor of 4 to 70, depending upon price and yield assumption. In every case, results implied an underinvestment in tree improvement.

Other economic analyses focused on present net worth or internal rate of return as criteria for evaluating tree improvement. Except at abnormally high discount rates, present net worth of investments in tree improvement proved profitable (Dutrow and Row 1976). Internal rates of return were favorable too. Most studies reported rates exceeding 10 percent, ranging up to about 20 percent (Dutrow and Row 1976, Porterfield 1974). Profits from tree improvement can be traced to nominal cost increments even more than to value gains. The cost of improved trees is only a few dollars more than normal stock, and this cost is incurred only once per rotation Other cost advantages should not be overlooked. For example, acres of forest lands required to supply a mill can be reduced, with associated economies in transportation, management, and harvesting operations. From a national or regional perspective, tree-improvement programs release forested acres for other uses by reducing land required to supply a given amount of wood.

Although results and recommendations are similar, a recent study by Clark Row and myself warrants discussion before we consider the possibility that our chosen path may lead to economic pitfalls (Dutrow and Row 1976).

In our approach, we tried to address the question that haunts economists' efforts to predict dollar returns from improved trees: what is the relative growth pattern of superior trees during an entire rotation? Do superior trees exhibit an early burst of growth and then merely parallel growth rates of normal planting stock? Or, is the early growth advantage of improved trees maintained throughout rotations? Admittedly, these questions will be answered only by time. Our technique offers an improved estimate in the interim.

Equations were derived from data on height, diameter, volume, and survival of unimproved loblolly plantations, and were then modified to show gains made by 8-year-old trees in actual tree improvement programs. Indices of gain were then calculated and inserted in the growth equations for unimproved loblolly plantations to simulate behavior of genetically-improved stock in a plantation environment. With growth equations modified to reflect genetic gain, we were able to estimate corresponding economic gains.

Some of the specific measures of gains through use of improved loblolly pine trees are of interest. Height indices or adjustment ratios were calculated and reflected an average gain of 3.5 percent over unimproved stock. In over 50 percent of the genetic trials height gains were at least 2.6 percent, and gains of more than 10 percent were recorded for 17 percent of the trials.

Diameter-adjustment ratios were derived by dividing the average diameter of genetically improved trees by the average diameter of unimproved trees. Tree gains were converted to stand gains by applying the diameter-adjustment ratio to anticipated maximum and mimimum diameters; relative frequencies of basal areas occurring for the enlarged diameters were also calculated. The simulation was run, and notable gains in diameter occurred. Fifty-four percent of the genetic crosses showed diameter growth that surpassed the unimproved trees. Average growth increases were about 2 percent, with almost 20 percent of the genetic crosses exceeding a 10 percent gain over unimproved stock. Survival gains also were estimated and results were similar to gains in height and diameter. Volume estimates, however, required a slight departure from the foregoing procedures.

Volume gains in juvenile trees are not directly proportional to volumes anticipated at harvest for either improved or unimproved trees. Thus, instead of calculating "volume-adjustment factors", we estimated diameters and heights at harvest and inserted these measures into accepted volume equations. Average volume increases were significant, about 12 percent per acre. Over large tracts, 63 percent of the acres of improved trees would exhibit growth rates higher than acres of unimproved trees. Furthermore, 20 percent of these acres of improved trees would display volume gains of more than 30 percent.

As in any economic analysis, we eventually turned to evaluating financial implications of gains expected from improved trees. Present net worth was one of the criteria we used for comparing improved and unimproved trees. About 6 percent of the genetic crosses showed financial gains of up to 150 percent. The average increase in present net worth was almost 30 percent, with a median value of 16 percent. Very few of the genetic crosses indicated returns poorer than unimproved trees.

The estimates can be transformed directly from percentage to dollar gains for private plantation managers. Industrial landowners can expect nearly a 30 percent increase in present net worth. For example, if a forest manager estimates a net worth of his loblolly plantation at $100 per acre, he can increase the estimate by about 30 percent or $30 if he changes to genetically-superior stock. Or, stated differently, he could afford to pay up to $30 more per acre for genetically-improved seedlings.

For large timber-producing regions or ownerships with substantial acreages, gains from tree improvement justify large expenditures in nurseries, orchards, and research to assure even higher productivity. For example, in the three-state area of South Carolina, Georgia, and Florida, loblolly pine plantations occupy about 1,100,000 acres. If through conversion to genetically-improved trees, financial productivity per acre could be increased by 30 percent, extremely large investments in tree improvement efforts, with associated economies of scale, would be justified. Since the forest land base is shrinking, publicly subsidized tree-improvement efforts would enhance wood supplies on those acres retained for commercial production.

POTENTIAL PITFALLS

Before the list of benefits from tree improvement generates absolute confidence in our abilities to meet future wood demands, we need to recognize a few pitfalls. Some financial dangers are commonly recognized, but repetition can do no harm. Other dangers are not so well known, yet cast threatening shadows along future paths of tree-improvement efforts.

A familiar and oft cited note of caution is that improper site selection can erase all promise of gain and cause financial ruin. In most cases, the growth rate forecast for improved trees can be obtained only on good sites. These same sites, incidentally, are capable of supporting high value agricultural crops like cotton and soybeans. So we may find ourselves attempting to market improved seeds that grow well on sites that are no longer available to forestry. It makes little economic sense to invest heavily in producing genetically improved stock for nonexistent acres. We might better prepare for the future by investing more research and development dollars to provide planting stock that grows reasonably well on marginal and even poor sites.

Several years ago, I pointed out that rates of return for cottonwood plantations in the Mississippi Delta offered an excellent investment opportunity relative to other forestry uses. But the investment was poor relative to nonforestry opportunities on those sites; and since then agricultural acreage has expanded and acreage intensively managed for forestry has declined (Sternitzke and Nelson 1970).

Geographic location of the site is another potential problem. The history of tree improvement includes many failures when well-intentioned managers transported seeds or seedlings outside natural geographic ranges. Again, we are confronted with a much-invested, nothing-gained outcome.

Furthermore, we are continually directed to combine our genetically-improved trees with plantation management, including site preparation, planting, and cultural treatment. We are also admonished to select the best available sites if we plan to establish a plantation -- with or without improved trees.

Wood production per acre is highest when we establish plantations of superior trees on good sites and follow proven methods of intensive forest management. The group, consisting of plantations, good sites, and genetically-improved trees, must march together either to financial success or disaster. Designing our tree-improvement programs to be so dependent upon capital intensive management techniques on the most expensive acres may be a mistake.

Costs of establishing and maintaining plantations are escalating so rapidly that companies are beginning to reassess expansion plans. If plantation costs become prohibitive, we may find that our increased production of genetically-improved stock serves a declining market.

Interest rates on funds for long-term investments are rising. Labor costs also have increased dramatically in recent years. In either case, we confront a growing scarcity of productive resources. Existing investment funds, arising from internal or external sources, necessarily dwindle. The net result for forest industry might be continued ideological support for plantations of improved trees but lack of money to establish and maintain them.

Other economic forces add to the restrictions on investment capital. In the South, trends are towards harvesting smaller and younger hardwood and softwood trees, with expanding efforts to utilize the entire tree. Processors cannot sit by and await emergence of plantations of large, clear, and straight trees. Survival in the intervening years necessitates adaptation to existing wood supplies of younger and smaller trees. Utilization of these trees requires substantial capital investments in equipment for harvesting, hauling, and processing. This investment capital may have to be reallocated from planned expenditures on plantations of improved trees. Furthermore, as processors and consumers adapt to the use of entire trees of smaller size, the available supply of wood will dramatically increase and premiums for quality wood from improved trees will fall. Certainly, such bleak prospects do not arise from genetic improvement, but from the widespread reliance on capital intensive forest management, with which tree improvement is closely aligned.

If plantation management is becoming prohibitively expensive, some evidence should be emerging that points to failure to maintain plantations or shortfalls in planned rates of planting. In North Carolina, a number of Forest Survey plots containing pine, including plantations, were harvested between 1964 and 1974. Fifty-eight percent of these plots are now occupied by hardwoods (Boyce and Biesterfeldt 1977). Harvested pine stands in Georgia and Virginia experienced a similar fate; over half have reverted to hardwoods. Most of these stands are not plantations and most are in the hands of small, nonindustrial owners. But, loss of plantations from industrial lands has been reported and is included in the data.

The Southern Forest Institute reports that over 157 million superior seedlings were planted in 1975-1976 (Box 1976). But these seedlings occupy only about 200,000 acres, or 0.1 percent of the commercial forest land in the South. It is estimated that more than 1 million acres east of the Mississippi River would have to be reforested to pine each year just to maintain current percentages of loblolly and slash. We are not meeting this goal; instead, we are planting only about 800,000 acres per year and only about 25 percent of these acres receive improved planting stock.

Thus, data suggests that many of our pine forests are reverting to hardwoods and our rate of planting is insufficient to maintain existing percentages of pines. The culprits, in my opinion, are escalating costs and growing scarcity of capital. Small private landowners do not have the money or inclination to invest in intensive forest management. A growing percentage of industry representatives are making expensive adaptations in harvesting, hauling, and processing to accomodate available wood supplies. With limited capital, industry is finding that circumstances often suggest greater profits through adapting to the forest resource rather than investing so heavily to alter it.

This may seem a depressing note to conclude on, but I feel that these are realistic considerations that offer opportunity as well as consternation. I am merely suggesting that risks are inherent in an alliance of so great a proportion of our tree-improvement efforts with the most expensive forest management regimes. We might realize greater long-run benefits by seeking ways to increase or just maintain acceptable growth rates on poorer sites with less intensive management. Insuring natural regeneration of chosen stock, relying very little on fertilizer application, and developing trees that compete efficiently and produce added wood fiber appear to be research goals that would pay off in terms of enhanced wood supplies. I applaud and am awed by progress in genetic improvement, but feel constrained to point out some economic factors that urge us to align our improved trees with less costly management companions.

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