ECONOMIC OPPORTUNITIES IN HARDWOOD SILVICULTURE:

PLANTATION VERSUS NATURAL STAND MANAGEMENT

By

R. C. Kellison and Richard Resovsky

The timber use of hardwoods is projected to increase by 300% from 1976 to 2030, from 2.9 to 9.0 billion cubic feet (OTA, 1983). The increase will occur in all conventional hardwood product lines such as lumber and veneer, but the big increase will occur in the manufacture of fiber products. Advancements in technology allow the use of hardwoods for products that were manufactured only from coniferous fibers five years ago. Among the advancements are multiple-wire forming of paper and paperboard which replaces the single-thickness forming on fourdrinier paper machines (Smith, 1984) and the application of elevated levels of vacuum and heat during sheet formation to permit the total use of oak fibers in the manufacture of linerboard (Horn and Setterholm, 1983). The use of hardwoods in linerboard production has averaged about 8% historically but this use is projected to increase to 20% by the year 2000 (Haynes, 1981).

The economics of using greater amounts of hardwoods in pulp, the roundwood of which can be delivered to the mill at about 25% less cost than pine roundwood and which gives about 5% greater pulp yield than pine from the kraft process, have caused corporate management to dictate higher uses of hardwoods. Some pulp mills have increased the mill furnish from 10% to 30% hardwoods for linerboard production within the last 18 months. Other mills are retrofitting operations to allow greater use of hardwoods.

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Hardwood growth in the Eastern Deciduous Forest is exceeding drain by 2 to 1 (OTA, 1983). That favorable ratio implies an abundant supply throughout the region but shortages in the fiber supply are projected for southwestern Alabama and North Florida-South Georgia by 1985. There is also a pervasive shortage of quality sawtimber throughout the region. Hardwood management is needed in plantations and natural stands to avert timber imbalances and to improve stand quality. The economics for attaining these objectives are the subject of this paper.

**Plantation Management**

Plantations of eastern cottonwood (*Populus deltoids*) have been established on a commercial scale in the Mississippi River Delta since the mid-1950's. Vain attempts were also made, until about 1970, to plant other commercially important hardwood species on sites and under conditions suited for growing southern pines. Success in plantation establishment was achieved for other indigenous species only after foresters realized the benefits of matching species to site, proper site preparation, use of robust planting stock of good genetic quality, competition control, and nutrient supplementation. About 125,000 acres of hardwood plantations exist in the South and the total is increasing at about 6,000 acres annually. The annual effort has decreased from about 10,000 acres in 1980 to about 6,000 acres today (Kellison, 1981).

The hardwood species being planted commercially and the relative proportion of the 125,000 acres by species are:

- **Eastern cottonwood** 30%
- **Sweetgum** (*Liquidambar styraciflua*) 25%
- **Sycamore** (*Platanus occidentalis*) 20%
- **Water oak** (*Quercus nigra*), **willow oak** (*Q. phellos*), **green ash** (*Fraxinus pennsylvanica*) 10%
- **Eucalyptus** spp. 10%
- **Other** 5%
Establishment and maintenance costs for hardwood plantations, exclusive of land costs in 1981 and 1984, are presented in Table 1.

Table 1. Costs of hardwood plantation establishment in the southern United States

<table>
<thead>
<tr>
<th>Item</th>
<th>1980 Cost/Acre</th>
<th>1984&lt;sup&gt;1/&lt;/sup&gt; Cost/Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Preparation</td>
<td>$222.00</td>
<td>$243.00</td>
</tr>
<tr>
<td>Planting</td>
<td>66.00</td>
<td>72.00</td>
</tr>
<tr>
<td>Fertilizer Applications</td>
<td>49.00</td>
<td>53.00</td>
</tr>
<tr>
<td>First-Year Cultivation&lt;sup&gt;2/&lt;/sup&gt;</td>
<td>32.00</td>
<td>36.00</td>
</tr>
<tr>
<td>Second-Year Cultivation&lt;sup&gt;2/&lt;/sup&gt;</td>
<td>16.00</td>
<td>18.00</td>
</tr>
</tbody>
</table>

<sup>1/</sup> Estimate

<sup>2/</sup> Costs are given on a year rather than acre basis.

Expected growth from successful plantations are provided in Table 2 by Smith (1973).

Table 2. Growth of plantation hardwoods in the southern United States

<table>
<thead>
<tr>
<th>Species</th>
<th>Rotation Age (yrs.)</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Cottonwood</td>
<td>10</td>
<td>4 Cords/acre/year</td>
</tr>
<tr>
<td>Sycamore</td>
<td>12 - 15</td>
<td>3</td>
</tr>
<tr>
<td>Sweetgum</td>
<td>22</td>
<td>2.2</td>
</tr>
<tr>
<td>Oak and Ash</td>
<td>25</td>
<td>2.0</td>
</tr>
</tbody>
</table>

These yields are representative only of fully stocked stands and do not represent the range of stand conditions in which tree growth has sometimes not reached stand potential. The concept of full stocking, its relation to existing hardwood plantations, and its inherent uncertainties are being addressed by a growth and yield project initiated by the Hardwood Research Cooperative at N. C. State University.

The justification for hardwood plantations was the assurance of supply during peak demands and during inclement weather, consistency in species mix,
reduced harvesting and transport costs relative to natural hardwood stands, optimum use of genetically improved planting stock, and the management of two to three coppice crops from the root system of the planted crop. Many of these potential attributes are valid under specified conditions but some have lost their validity. For example, coppice rotations are not practiced with eastern cottonwood because of sporadic sprouting caused by genetic and environmental factors. Conversely, sweetgum is a prolific stump and root sprouter. Genotypes from progressive tree improvement programs for some species are also sufficiently superior to the previous generation to warrant replacement of the original rootstock. Each of the species being commercially planted reproduce from stump sprouts, but there is insufficient evidence to determine whether the coppice yields would equal or exceed the seedling crop yield at financial maturity. We speculate that intensive cultural measures such as weed competition control and fertilization will be needed if coppice yields are to equate with the seedling yield. By comparison, Eucalyptus plantations in various areas of the world already provide coppice yields of 1.2, 1.1 and 0.8 times the seedling yield.

The decrease in acreage established annually from 1980 to 1983 is an indication that hardwood plantations for fiber and lumber cannot be economically justified except by those firms which need the species mixture for the product being manufactured. The species mix is especially desired by organizations manufacturing high-grade printing papers and by that segment of the furniture and wood ornament industry requiring figurative wood. Those organizations are often immune to the establishment costs and even to stumpage costs and mill-delivered prices. The unit cost of raw material is small in relation to the revenue obtained from the manufactured product. Because of existing market conditions and relatively inelastic demand for the particular products,
most of the higher cost is accounted for in higher product price. With the exception of those organizations, we do not recommend that hardwood plantations be established. The return from the plantation wood does not justify the expense at today's prices, which are largely dictated by the huge reserve of wood from natural stands.

**Natural Stands**

The emphasis in the southern United States within the past decade has been to shift to regeneration and management of natural hardwood stands, as opposed to establishment of hardwood plantations. The incentive for the change is the anticipated demand for pine wood, which by the year 2030 will increase about 50%, from 9.5 billion cubic feet to 14.0 billion cubic feet (OTA, 1983). The pine resource, already in limited supply in some areas because of imbalances in desired diameter and age classes, will be extended by the substitution of hardwoods. A number of organizations belonging to the N. C. State Hardwood Research Cooperative are anticipating the heavier use of hardwoods and are starting to manage their hardwood stands accordingly.

The history of hardwood stand development in the Eastern Deciduous Forest has been to "take the best and leave the rest." This concept is economically attractive to the owner and the timber buyer, but, if practiced more than two or three times without control of residuals, the stand deteriorates badly. Most of the southern hardwood forests are in this deteriorated condition. Commitment is needed to restore those highly productive lands to their potential. Evidence from railroad logging at the turn of the Twentieth Century has clearly demonstrated that biological clearcuts are the desired practice in restoring the forest potential. The reasons why railroad logging, which employed a high-lead-cable system, were so successful were that there was little soil disturbance and the residual trees were so mutilated in the extraction process that they
offered little competition to seedling and sprout reproduction, resulting in a biological clearcut.

Other harvesting methods such as single-tree and group selection are theoretically and even practically acceptable but they often fall short because of improper application. A diameter-limit cut is often equated to single-tree selection. The comparison is valid when the cull trees are also removed or controlled but, since that rarely happens, the theoretically valid system culminates in a high-graded stand.

Biological clearcuts are differentiated from economic clearcuts in that the former method ensures removal of the merchantable timber as well as control of the residuals. The latter method is concerned only with removal of the commercial timber. An accepted working definition of a biological clearcut is the removal or control of all trees larger than 1.6" diameter at breast height. For practical purposes, that definition is too restrictive. We hypothesize that 15 to 20 ft²/acre of residual basal area can be tolerated in trees that are about equally distributed and average less than 6" dbh.

The most economical site preparation for natural reproduction of hardwoods is a good harvesting job. Without the need for residual control, there are no site preparation costs. In the absence of intermediate stand management, e.g., thinning and fertilizing, from which a biologic response can be obtained but from which an economic response is difficult to elicit, the only cost to be carried to rotation age is for management at approximately $3/acre/year (taxes, administration, protection).

**Economic Opportunity**

Since it is often difficult to attain a complete harvest, either because of poor timber quality, poor utilization, or of landowner and logger resistance, some residual control is needed. Three natural stand management scenarios
are compared to plantation management as investment alternatives. The first is a stand in which a biological clearcut is applied. The second is a stand in which 30 ft²/acre of basal area in large-sized trees remain after harvest. The residual stand can best be controlled by herbicide injection at about $29/acre, using 1984 as the base year.\(^1\) The third scenario assumes 50 ft²/acre of basal area in residual trees of all sizes, including a high proportion of unmerchantable subcanopy tolerants. Control of the unwanted trees is best achieved by use of a shear blade at a cost of about $58/acre at 1984 prices.\(^2\)

Total-stem yields (outside bark) of 7221 ft³/acre can be expected from the three natural-stand alternatives at the rotation age of 40 years for a red river bottom (Gardner, et al., 1982). As for the biological clearcut, no intermediate stand management will be practiced, resulting in expenses of $0, $29 and $58/acre for site preparation and an assumed $3/acre/year administrative cost. The 40-year rotation is based on the financial maturity of southern hardwood for a pulpwood and sawtimber product mix (Porterfield, 1972).

The sweetgum plantation, harvested at 20 years of age (Smith, 1973) will be coppice-managed for one additional rotation of 20 years. Total-stem yields are assumed to be 4845 ft³/ac\(^3\) for each rotation. The only additional cost for the coppice crop will be one disk and one fertilizer application, which at 1984 prices are approximately $1.00 per and $53 per acre, respectively.

At 6% interest and $0.07/ft³ stumpage, the after-tax return on investment is determined for a plantation in which two pulpwood harvests are obtained in 40 years and for three natural-regeneration alternatives from which one pulpwood harvest each is obtained in 40 years (Table 3).

\(^1\) Estimated

\(^2\) Estimated

\(^3\) Unpublished data, Hardwood Research Cooperative, N. C. State University, Raleigh
Table 4. Summary of present value analysis for three natural hardwood stand management alternatives (after taxes of 28%, using a sawtimber and pulpwood product mix)

<table>
<thead>
<tr>
<th>Management Alternative</th>
<th>6%</th>
<th>8%</th>
<th>IRR%</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0/acre regeneration costs</td>
<td>$19.65</td>
<td>$5.10</td>
<td>8.42</td>
</tr>
<tr>
<td>$29/acre regeneration costs</td>
<td>-8.57</td>
<td>-33.72</td>
<td>5.59</td>
</tr>
<tr>
<td>$48/acre regeneration costs</td>
<td>-36.77</td>
<td>-62.35</td>
<td>4.62</td>
</tr>
</tbody>
</table>

The $0/acre regeneration cost alternative becomes the most economically attractive option of all those examined. It is unfair, however, to judge the merit of the two costly regeneration alternatives to a fully stocked stand with no initial regeneration cost. Given the same rotation lengths, merchantable yields and costs, one intuitively deduces this result without the help of a present value or IRR. A more correct analysis would be the comparison of fully stocked stands in which residual control was done against stands which should have had some residual control but did not and are therefore less than fully stocked at the end of the rotation. This comparison is made in Table 5 and assumes the same yields and stumpage prices for full stocking as Table 4 but a reduced pulpwood-sawtimber yield and sawtimber stumpage price of 1559 ft³/acre, 3.34 MBF/acre and $55/MBF for the zero cost option.

Table 5. Comparison of fully stocked stands receiving residual control against a stand in which residual control should have been, but was not, accomplished (after taxes, using a sawtimber-pulpwood product mix)

<table>
<thead>
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<th>Management Alternative</th>
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<tr>
<td>$29/acre regeneration cost (fully stocked stand results)</td>
<td>-$8.57</td>
<td>-$33.72</td>
<td>5.59</td>
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<tr>
<td>$48/acre regeneration cost (fully stocked stand results)</td>
<td>-$36.77</td>
<td>-$62.35</td>
<td>4.62</td>
</tr>
<tr>
<td>$0/acre regeneration cost (less than fully stocked stand with less resulting quality)</td>
<td>-$24.66</td>
<td>-$36.08</td>
<td>2.69</td>
</tr>
</tbody>
</table>
Even though the PV of the two costly regeneration systems are still negative, the least costly of these is better than the PV of the last alternative in Table 5. It is less costly to control residuals, at $29/acre, than it is to follow the "cut the best and leave the rest" philosophy.

Summary and Conclusions

The southern forest industry has committed time, labor and capital to managing the hardwood resource. Some organizations rely heavily on hardwood plantations but the majority are planting pines on land that can be site-prepared and planted. Hardwood natural stand management is taking place along watercourses and on mountainous terrain.

The present value and internal rate of return was calculated from a plantation system of sweetgum over a 40-year period from which two crops are obtained. This alternative, at two cost structures, was compared to a natural system in which the residual control after harvest was $0, $29 and $58 per acre. The after-tax values, based on 6% and 8% discount rates, and $70/MBF, $55/MBF and $.07 per cubic foot for sawtimber and pulpwood show the $0/acre residual control cost to attain full stocking to be superior to all alternatives. This suggests that the most economical site preparation for natural reproduction is a good harvesting job.

When a deteriorated stand with no cost of residual control is compared to a fully stocked stand having some cost of residual control, the fully stocked stand having some initial cost input has the higher PV and IRR. Although the PV of both alternatives is negative, the residual control has minimized the cost of managing natural hardwood stands.

Before discounting plantation hardwoods totally, one must be reminded that certain values accrue to plantation wood and fiber which are not appropriately covered in this analysis. Plantations are usually established on
sites sufficiently well drained that they are accessible during all seasons of the year. Natural stands are often seasonally inaccessible. The species mix from plantations is much more uniform, consisting of only one or a few species as opposed to natural stands from which a multitude of species is derived.

Hardwood plantations could be located on the best sites, adjacent to the mill, thereby reducing transportation costs. The plantations may result in the reduction of land base and its corresponding attendant costs because double-cropping yields two harvests totaling more than twice the volume of a single natural stand harvest in the same amount of time. Despite the apparent greater cost per unit of wood, the plantation alternative may in some instances be superior to any of the natural stand options.

It is apparent from these calculations and conclusions that a single hardwood management system will be inappropriate for most southern forest industries. Each organization will have to determine the best combination of alternatives to meet specific needs.
Literature Cited


