Whole-Tree Utilization of Southern Pine Advanced By Developments in Mechanical Conversion

Peter Koch

Abstract

In 1963 approximately 30 percent of the dry weight of above- and below-ground parts of southern pine trees ended as dry-surfaced lumber or paper; the remaining 70 percent was largely unused. By 1980, computer-controlled chipping headrigs, thin-kerf saws, lamination of lumber from rotary-cut veneer, high-yield pulping processes, and more intensive use of roots, bark, and tops will likely double the yield of lumber, paper, bark products, and reconstituted board to 60 percent of the dry weight of above- and below-ground tree parts.

THE SOUTHERN PINES are the primary softwood timber species in the United States. Moreover, their commercial importance is increasing. By the end of the

The author is Chief Wood Scientist, Southern Forest Expt. Sta., USDA Forest Service, Pineville, La. This paper was received for publication in December 1972.

century, over half of the softwood manufactured in this country will probably come from the South. It therefore seems useful to examine the implications of recent wood-machining and conversion research on the degree of utilization of these species. With some limitations, conclusions applicable to the southern pines can be extended to other species.

This paper is not a bibliographic review of the literature, since lists of abstracts are readily available.[1]

Better Main-Stem Utilization

A convenient point for beginning the appraisal is 1963. In that year the chipping headrig was still below the horizon, the southern pine plywood industry had not been established, and widespread use of southern pine planer shavings for particleboards was yet to come. Merchantable stems were utilized primarily for lumber and pulp chips. The degree of utilization in 1963 can be simplified by analyzing yield from trees cut into sawlogs for conversion with circular saws:

End use	Percentage of merchantable bark-free stem (basis of ovendry weight)
	Percent
Rough lumber	48
Pulp chips	28
Sawdust	24

[1]Since 1959, members of the FPRS Wood Machining Committee (or its predecessor, the Mechanical Conversion Division) have periodically abstracted world literature on wood machining. The most recent compilation, "Wood Machining Abstracts, 1970 and 1971," has been published as Research Paper SO-83 of the Southern Forest Experiment Station, USDA Forest Service. Copies are available from the Southern Forest Experiment Station, T-10210 Federal Building, 701 Loyola Avenue, New Orleans, Louisiana 70113.

The chief previous compilations were:

Committee on Recent Wood Machining Literature. 1959. Wood machining abstracts, 1957-1958. Forest Prod. Res. Soc., Madison, Wis. 20 pp.

Committee on Recent Wood Machining Literature. 1960. Wood machining abstracts, 1958-1959. Forest Prod. Res. Soc., Madison, Wis. 19 pp.

Committee on Recent Wood Machining Literature. 1961. Wood machining abstracts, 1959-1961. Forest Prod. Res. Soc., Madison, Wis. 18 pp.

Koch, P., and C. W. McMillin. 1966. Wood machining review, 1963 through 1965. Forest Prod. J., I. 16(9):76-82, 107-115; II. 16(10):43-48.

Koch, P. 1968. Wood machining abstracts, 1966 and 1967. USDA Forest Serv. Res. Pap. SO-34, 38 pp. South. Forest Expt. Sta., New Orleans, La.

McMillin, C. W. 1970. Wood machining abstracts, 1968 and 1969. USDA Forest Serv. Res. Pap. SO-58, 35 pp. South. Forest Expt. Sta., New Orleans, La.

About 25 percent of the ovendry weight of 2-inch-thick rough dry lumber was converted to shavings during planing; at that time the shavings had only a nominal value—primarily as fuel. Of the fraction of the stem (28 percent) that went into papermills, only about half emerged as paper; the remainder was spent black liquor. Therefore, in 1963 about 36 percent of the bark-free merchantable stem ended as lumber and 14 percent as paper, for a total utilization of 50 percent. The remaining 50 percent ended as residuals with minimal value. Moreover, all other above- and below-ground tree parts were left in the woods, and bark was burned as a residue.

Analysis of 22-year-old slash pine trees (Table 1) has shown that the merchantable bark-free stem to a 4-inch top comprises 58.5 percent of the entire tree; the remaining 41.5 percent consists of roots, stump, bark, top, branches, and needles. Comparable data (including roots) for sawlog-size timber are not available, but in this discussion the percentages are assumed to be the same.[2] In 1963, therefore, no more than 30 percent (58.5×50 percent) of total tree weight was recovered in primary manufacture. I predict that this percentage will be doubled by 1980.

By then, processing research will have resulted in significant utilization advances, some of which are already in being. Widespread applications of chipping headrigs and edgers, and increased use of thin-kerf saws, have diminished sawdust from about 24 to 5 percent of the bark-free merchantable stem. Further development of technology for sawing with lasers or liquid jets may further reduce sawdust percentage.

Development of log scanning devices coupled to computer-controlled headrigs and resaws will likely boost the percentage of rough lumber recovery from 48 to perhaps 60 percent of the merchantable bark-free stem. Moreover, thickness allowances for planing will be reduced for most structural lumber; this will be made possible through more accurate techniques for smooth resawing. It is possible, and even probable, that certain products, such as 2- by 4-inch studs, will be sold rough. Planer shavings will accordingly be reduced from 25 percent of rough dry lumber weight to perhaps 10 percent.

Since 1963 some 51 plywood plants have been built to utilize southern pine. These mills recover approximately 60 percent of log volume as sheathing plywood and studs from veneer cores (Koch 1972, p. 1537). Should a proposed method (Bohlen 1972, Echols and Currier 1973, Jokerst 1972, Koch 1973, Moody and

[2]In a personal communication, M. A. Taras of the Southeastern Forest Experiment Station, USDA Forest Service, states that loblolly pine trees from 6 to 20 inches DBH show only slight differences in percentages of crown but that proportions of bark are greater in small loblolly pines than in large. Readers whose interest lies in trees older than 22 years should therefore decrease bark percentages and increase stemwood percentages somewhat over the values shown in Table 1.

Table . — WEIGHT DISTRIBUTION (OVENDRY BASIS) OF ABOVE- AND BELOW-GROUND PARTS OF THREE 22-YEAR-OLD, 7.7-INCH, UNTHINNED, PLANTATION-GROWN SLASH PINE TREES CUT IN CENTRAL LOUISIANA.[1]

Portion of tree	Weight fraction of Total tree	Weight fraction of Bark-free stem to 4-inch top (DOB)
		- - -
Bark-free stem	58.5	100.0
Roots and stump[2]	16.5	28.2
Stem bark to 4-inch top	12.5	21.4
Top (with bark)	5.0	8.5
Needles	4.0	6.7
Branches (with bark)	3.5	5.9
Total	100.0	

[1]Adapted from Howard 1973; see also Koch 1972, p. 1541

[2]Roots to a 3-foot radius; see Figure 1, left.

Peters 1972, Schaffer et al. 1972) of making structural lumber from rotary-peeled or sliced veneer take hold in the South, it would provide another method of recovering 60 percent of log volume in the form of sized dry lumber.

It is also likely that higher yielding pulping processes will be in widespread use by 1980. Variations of the kraft process—or entirely new chemical processes—may boost yields from 50 to 60 percent. And it is hoped that a new method of mechanically pulping southern pine chips can be developed to improve the properties and market acceptability of very-high-yield pulp (McMillin 1969). Should both developments be successful, then yield of southern pulpmills, in toto, may average close to 70 rather than 50 percent.

One might predict, therefore, that in 1980 merchantable stems cut for lumber will be converted as follows:

End use	Percentage of merchantable bark-free stem (basis of ovendry weight)
	Percent
Rough lumber	60
Pulp chips	
Sawdust	

As noted above, lumber volume will be reduced perhaps 10 percent when planed, and pulping losses will

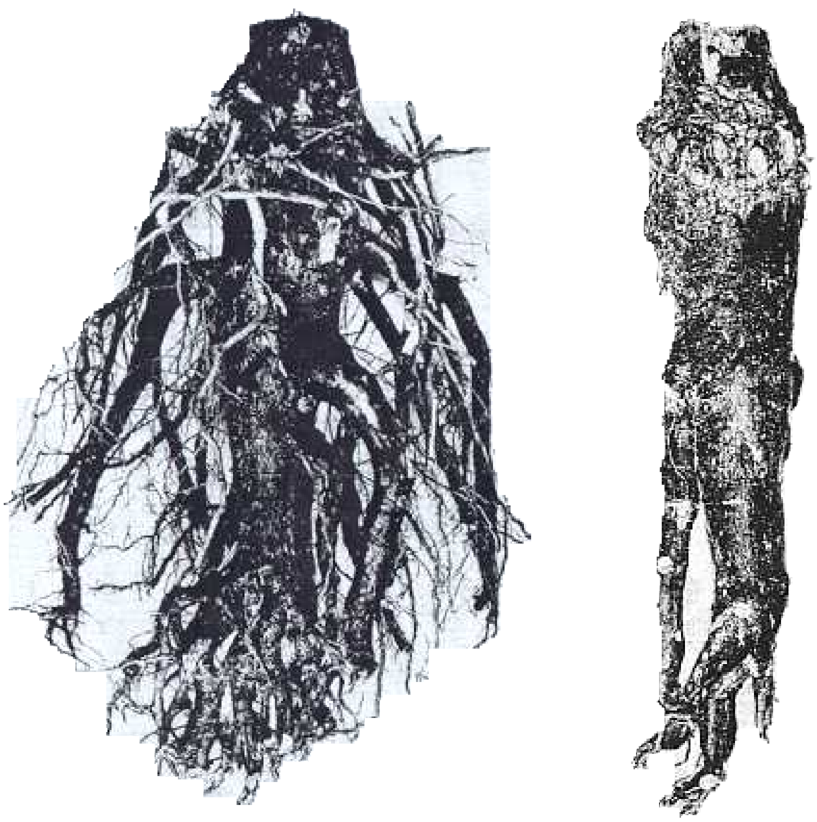

Figure 1. — Root from 22-year-old slash pine tree of 7.6 inches DBH, harvested in central Louisiana. Ovendry weight of the root system to a 3-foot radius (left) was 65 pounds and comprised 19.1 percent of entire dry weight of above- and below-ground tree parts. When trimmed (right), the root measured about 5 feet in length, and 12.9 inches in diameter 3 inches below ground level. In green condition, the trimmed root had 72 percent of the weight of the untrimmed; green weights were 102 and 141 pounds. (Photo from Howard 1973.)

average about 30 percent. Therefore, about 79 percent ($0.9\times60+0.7\times35$) of the bark-free merchantable stem (ovendry weight basis) will end as dry merchantable lumber or as paper. Since the bark-free merchantable stem to a 4-inch top comprises 58.5 percent of the entire tree weight (including roots, stump, bark, branches, tops, and needles), it is therefore likely that by 1980 about 46 percent (79×0.585) of the whole-tree volume of trees cut for lumber will end as merchantable lumber or paper.

If this percentage is to be raised to 60, it is evident that another 14 percent must also end as products. I believe that such further gain is likely.

Utilization of Other Tree Parts

First, it is seen from Table 1 that 16.5 percent of total tree weight is in the stump and roots (Fig. 1, left). Since harvesting technology is not yet well developed, it seems best to assume that only 70 percent of total root volume will prove readily recoverable, i.e., about 11.6 percent of total tree weight (Fig. 1, right). Further, only a fraction—perhaps 50 percent—of all trees cut will be harvested with roots. Because stumpwood (with bark attached) has lower cellulose content than barkfree stemwood(Koch 1972, p. 569), the yield from chemical pulping will be about 50 percent. All things considered, paper yield from roots may not exceed 3 percent of the total weight of all trees harvested ($16.5\times0.7\times0.5\times0.5$).

Stem bark is also an important component of tree weight, averaging 12.5 percent in 22-year-old slash pines (Table 1). By 1980, perhaps three-fourths of the tonnage will be profitably sold by processors of southern pine. Much will be burned as a source of energy for kilns and power plants. Increasing amounts will be marketed as mulches, soil amendments, and growing mediums. Some will be used in Herreshoff furnaces to manufacture charcoal and combustible gases. Additional volumes may be incorporated in particleboards of various kinds. And chemical processes—as yet undeveloped—will likely account for significant sales.

Tops and branches (with bark) comprise about 8.5 percent of total tree weight. It is assumed that 25 percent of this available tonnage will be converted to medium-density fiberboard or other reconstituted products, thus increasing whole-tree utilization by 2 percent. If kraft mills begin to accept chips with some bark attached, a greater percentage of tops and branches may be utilized. Some will also be harvested for fuel.

Approximately 4 percent of whole-tree weight is comprised of needles (Table 1). Moreover, each year a slash pine tree casts off needles (ovendry basis) equal in weight to the wood laid down during the year (Koch 1972, p. 586). New uses are likely to be found for some of this material, but for present purposes the total is assumed to be small.

From the foregoing discussion we can compare the degree of utilization in 1963 with that probably achievable by 1980. In the following tabulation, product yields in primary manufacture are stated in percentages of total tree weight (ovendry basis):

Portion of tree	Fraction of total tree	Product recovery in — 1963	Product recovery in — 1980
	- - Percent		
Bark-free stem to 4-inch top	58.5	30	46
Roots and stumps	16.5	0	3
Stembark to 4-inch top	12.5	0	9
Top and branches (with bark)	8.5	0	2
Needles	4.0	0	0
Total	100.0	30	60

I conclude that it is not only possible, but probable, that by the end of the present decade percentage of tree weight recovered as primary products will be double that of 1963.

Literature Cited

Bohlen, J. C. 1972. LVL Laminated-veneer-lumber — development and economics. Forest Prod. J. 22(1):18-26.

Echols, R. M., and R. A. Currier. 1973. Comparative properties of Douglas-fir boards made from parallel-laminated veneers vs. solid wood. Forest Prod. J. 23(2): 45-47.

Howard, E. T. 1973. Physical and chemical properties of slash pine tree parts. Wood Sci. 5(4):312-317.

Jokerst, R. W. 1972. Feasibility of producing a high-yield laminated structural product: Residual heat of drying accelerates adhesives cure. USDA Forest Serv. Res. Pap. FPL 179, Forest Prod. Lab., Madison, Wis. 10 pp.

Koch, P. 1972. Utilization of the Southern Pines. USDA Agric. Handb. 420. 1663 pp.

————. 1973. Structural lumber laminated from 1/4-inch rotary-peeled southern pine veneer. Forest Prod. J. 23(7):17-25.

McMillin, C. W. 1969. Aspects of fiber morphology affecting properties of handsheets made from loblolly pine refiner groundwood. Wood Sci. and Technol. 3:139-149.

Moody, R. C., and C. C. Peters. 1972. Feasibility of producing a high-yield laminated structural product: Strength properties of rotary knife-cut laminated southern pine. USDA For. Serv. Res. Pap. FPL 178. Forest Prod. Lab., Madison, Wis. 12 pp.

Schaffer, E. L., R. W. Jokerst, R. C. Moody, C. C. Peters, J. L. Tschernitz, and J. J. Zahn. 1972. Feasibility of producing a high-yield laminated structural product: General summary. USDA For. Serv. Res. Pap. FPL 175. Forest Prod. Lab., Madison, Wis. 19 pp.