

Five New Machines and Six Products Can Triple Commodity Recovery from Southern Forests

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ABSTRACT — Mixed southern pine-hardwood stands now yield 20 to 22 percent of their biomass in wood products. A new energy self-sufficient system using tree pullers, wet-fuel burners, mobile chippers, shaping-lathe headrigs, and continuous kilns can convert 67 percent of the biomass (above- and below-ground parts of trees of all species) into products worth about \$150 per dry ton. Products of the system are pallets; dowel-laminated crossiles (no adhesive); structural exterior flakeboard; structural lumber glue-laminated from veneer; studs; and hogged fuel for plant energy. Composite structural panels or fiberboards could be made also. Application of the system could provide high returns to private landholders while halting incursion of low-grade hardwoods into the southern pinery.

In the opinion of many managers of southern pinelands, invasion by unwanted low-grade hardwoods—to the detriment of pine growth—is their major silvicultural problem. This statement applies over most of the 73 million acres in the southern pinery. On average, about 0.8 ton of hardwood biomass grows for every ton of pine biomass (biomass is used here to mean all above- and below-ground parts of trees). About half of this hardwood volume is in 11 oak (*Quercus*) species, with sweetgum (*Liquidambar styraciflua* L.) and hickory (*Carya* spp.) also comprising important fractions. About half the volume is in trees 5.0 to 10.9 inches in d.b.h., with the remainder about evenly divided between trees 11.0 to 14.9 and trees 15+ inches in d.b.h. (Christopher et al. 1976, Murphy and Knight 1974).

The difficulties in utilizing this hardwood resource are many. Trees are often scarred and defective from fires and from previous

pine harvesting. They are slow growers because the sites are not right for them—trees 6 inches in d.b.h. are typically 40 years of age (Manwiller 1974). They are short and crooked in bole. The low cubic content per stem, the highly variable species mix from stand to stand and even from site to site within stands, and the low cubic volume per acre all combine to raise harvesting costs. Moreover, their value after harvest is low. Knots and other defects, short boles, and small diameters preclude any hope of sawing quality lumber in conventional lengths. Not least among the problems is that of maintaining a species mix suitable for a manufacturing operation (Barber 1975).

Because of the vast area involved, the huge volume of unused hardwood biomass, and the diversity of species, solutions should be appropriate for extensive acreages and designed to use very large numbers of trees of all species and sizes. Intensive harvests and clear felling will likely be the pathway to any such solution. Because of land holding patterns, equipment and procedures must also permit economic harvests of tracts as small as 40 acres.

To increase pine growing stock, the clearcut land should be promptly planted or seeded. To accomplish this, I propose the concept of leasing land for immediate clear felling and harvest of biomass, followed by replanting to southern pine, periodic thinning, final harvest of pine, and a second planting of pine—all at the expense of the company to whom the lease is given.

Solutions that require 25- to 35-year commitment of land, commencing with more or less com-

plete biomass harvest followed by immediate replanting, will not be attractive to all landholders. If remuneration to the landholder is sufficient, however, significant acreages should be available. An indication of the return required to induce such commitments is suggested by the market for industrial and utility bonds. Well-rated bonds redeemable in 30 years sell briskly if they yield 10 percent annual interest. Should not a commitment of land for 30 years also be popular if annual rent is 10 percent of market value today? At bond maturity the investor receives only his purchase price in dollars unadjusted for inflation; the landowner who makes a 30-year rental agreement continues to hold his land—thus protecting himself against inflation.

To contribute significantly to solution of the hardwood problem, large acreages must be treated. In the concept I propose, the manufacturing plant will annually use about 1,800,000 hardwood and pine trees with total oven-dry biomass of about 585,000 tons (650 pounds per tree) cut from 18,000 acres (100 trees per acre). Over a rotation of 25 years, total cut would be 45,000,000 trees harvested from 450,000 acres. If centrally located in a procurement area 106 miles in radius, the plant could be supplied from 2 percent of the gross area.

As explained in another article (Koch 1976a, part III), a rental of \$23 per acre per year, i.e., 10 percent of an estimated average value of \$230 per acre, would not result in excessive stumpage costs; annual stumpage, including regeneration costs, would total only \$5,184,000 while annual sales of wood products would total about \$58,793,000. This very low ratio of stumpage

and regeneration costs to gross annual sales is achievable because harvest is intensive and manufacturing procedures waste little biomass.

The Concept

More complete harvesting and utilization of all species from the southern pinery will permit mills to keep up with the increasing demand for wood products. The five new machines and six products that I will describe are the elements of a concept that make such intensive utilization feasible. Implementation of the concept, called Biomass Retrieval and Utilization with Shaping-lathe Headrigs (BRUSH), can triple the commodity recovery on southern forestland. And the manufacturing plant should be self-sufficient in energy.

The machines and products are as follows:

Machines

1. Tree puller (harvests central root mass along with stem)
2. Mobile chipper (recovers tops, branches, and standing cull trees)
3. Green-fuel burner (burns wet wood and bark that has been hammermilled into small particles)
4. Shaping-lathe headrig (makes cants, cylindrical peeler blocks for veneer, and flakes for structural flakeboard)
5. Continuous dry kiln (dries straight 2 by 4 or 2 by 6 studs made from juvenile southern pine wood).

Products

1. Pallets
2. Dowel-laminated crossties (no adhesive needed)
3. Structural exterior flakeboard from mixed species
4. Lumber laminated from veneer
5. Studs
6. Hogged fuel for plant energy.

In the BRUSH system, as schematized in figure 1, hardwood and softwood biomass from acres harvested enters the mill as tree-length stems (with central root mass attached) or as chipped wood from tops and standing culls.

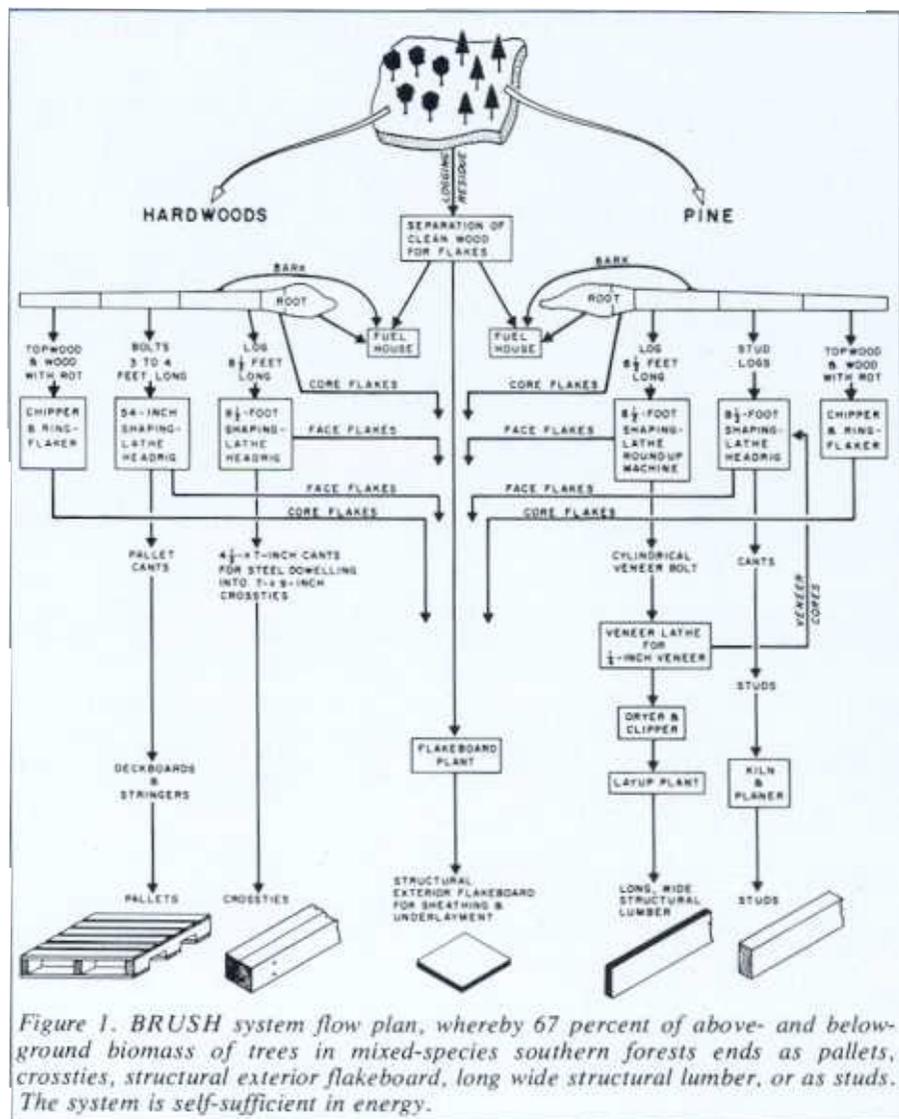


Figure 1. BRUSH system flow plan, whereby 67 percent of above- and below-ground biomass of trees in mixed-species southern forests ends as pallets, crossties, structural exterior flakeboard, long wide structural lumber, or as studs. The system is self-sufficient in energy.

Present and Proposed Use as Biomass

Components of southern pine biomass are as follows (Howard 1973):

Percent

of paper for each pound of stem-wood pulped, and for every pound of pine perhaps ¼-pound of hardwood is pulped. Output of paper expressed as a percentage of total biomass of cordwood stands is about 20 percent.

As the BRUSH system can recover about 67 percent of tree biomass of all species as solid wood products (table 1), worth in early 1978 at least \$150 per dry ton, the yield would be three times that currently available in sawmills (67 ÷ 22 percent) and 3.3 times that obtained in kraft pulp mills (67 ÷ 20 percent).

Table 1. Percentage of total biomass recovered as solid-wood products in proposed facility for processing mixed species.

Product	Percent
Total biomass (above and below ground)	100
Less:	
Foliage	4.0
Stembark	12.5
50 percent of barky tops and branches, i.e., (0.5) (8.5) ¹	4.2
75 percent of root and stump, i.e., (0.75) (16.5) ²	12.3
Sawdust and trim ³	.0
	33 ⁴
Percentage of total biomass ending as product	67

¹50 percent recovered as flakeboard furnish.

²25 percent recovered as flakeboard furnish.

³These residues recycled by fiberizing and using as flakeboard furnish.

⁴Most of this, except foliage, ends as fuel.

How BRUSH Works

Trees 5 to 12 inches in d.b.h. and of all species are harvested, with the central root mass intact, by a tree puller developed cooperatively by the Southern Forest Experiment Station and Rome Industries (fig. 2). Trees larger than 12 inches are cut 6 inches above ground level. Tops and limbs are severed on the site, and full-length stems (including central root mass) are skidded to roadside and transported to the mill.

Tops, branches, brush, and all residual standing trees are chipped in place with a mobile chipper (fig. 3), and the chips are hauled to the mill. Thus, site preparation for regeneration is simultaneous with harvest, and planting or seeding

can be accomplished promptly. The mobile chipper is being developed by the Southern Forest Experiment Station in cooperation with Nicholson Manufacturing Company, a consortium of five forest products companies, and the Department of Energy.

At the mill the chips are screened and the fraction that is bark-free and clean—about half of the total—is processed through a ring flaker (a machine that converts chips to flakes) for inclusion in the interior layer or core of structural flakeboard. The other chips are burned for fuel.

Full-length stems, on arrival at the mill, are conveyed through the merchandising deck, where roots and bark are removed. The bark and most of each root are used for fuel in a burner under development by the Southern Forest Experiment



Figure 2. Complete loblolly pine tree, with taproot attached, pulled from the soil like a carrot after lateral roots have been severed (Koch 1976 b; 1977). Small hardwoods can also be pulled with this equipment.



Figure 3. Mobile chipper and forwarders for retrieval of cull trees and logging residues. The machines are capable of traversing an acre an hour and delivering chips to roadside inventory (Koch and Nicholson 1978).

Station and Moore-Oregon (fig. 4); about one-quarter of each root becomes core flakes.

The few high-grade sawlogs and veneer logs in the hardwood stems are removed and resold. Remaining hardwood logs down to 8.5 inches in diameter are cut in 8.5-foot lengths and a shaping-lathe headrig (fig. 5, bottom left) converts them

Figure 4. Suspension burner for hogged green wood or bark. Exiting hot exhaust gas can directly heat kiln, or can heat a boiler to produce steam for process use and power generation. Left: Diagram of flow of fuel, combustion air, and exhaust gas. Right: Complete burner operating in North Portland, Oregon, test facility (Koch, Day, and Jasper 1978).

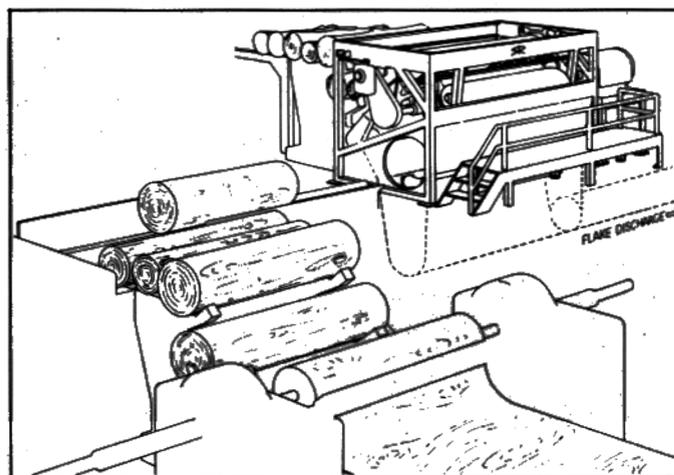
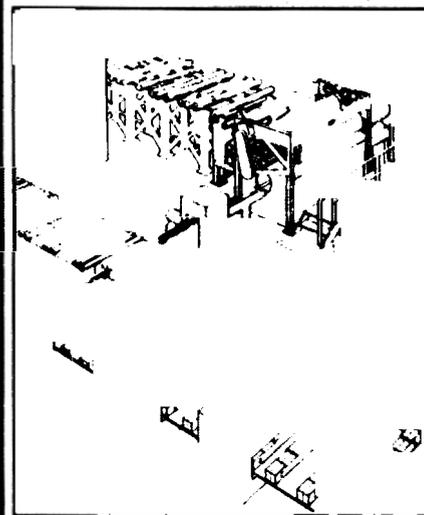
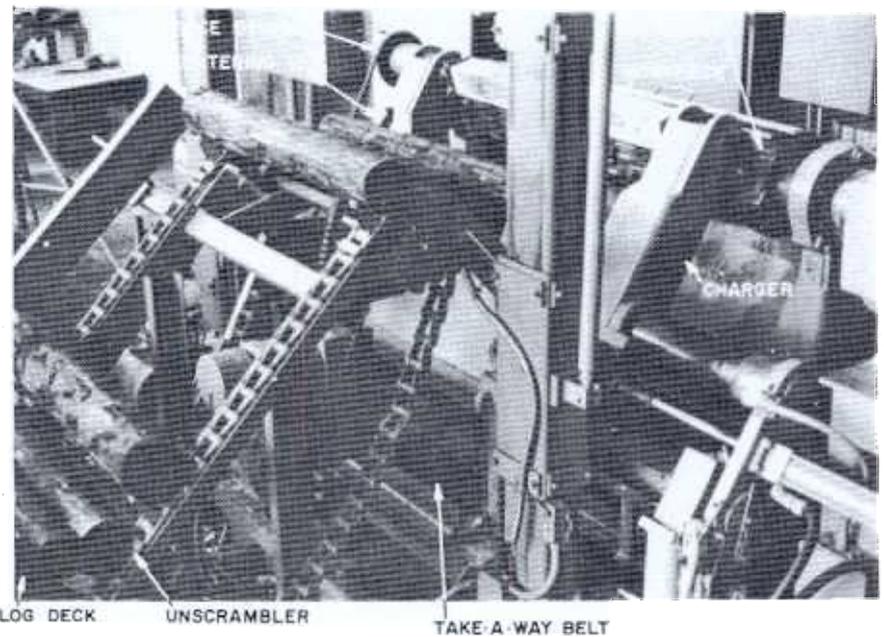
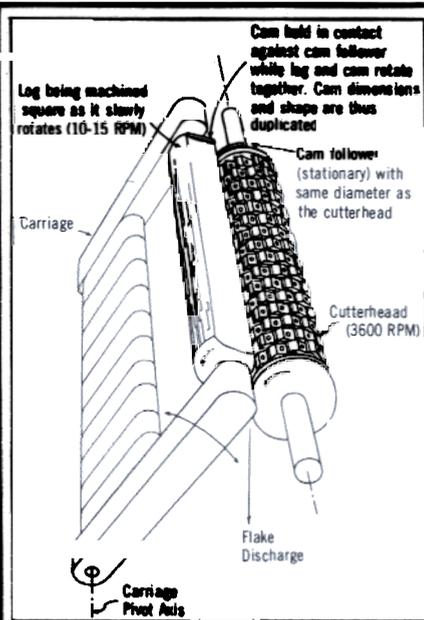
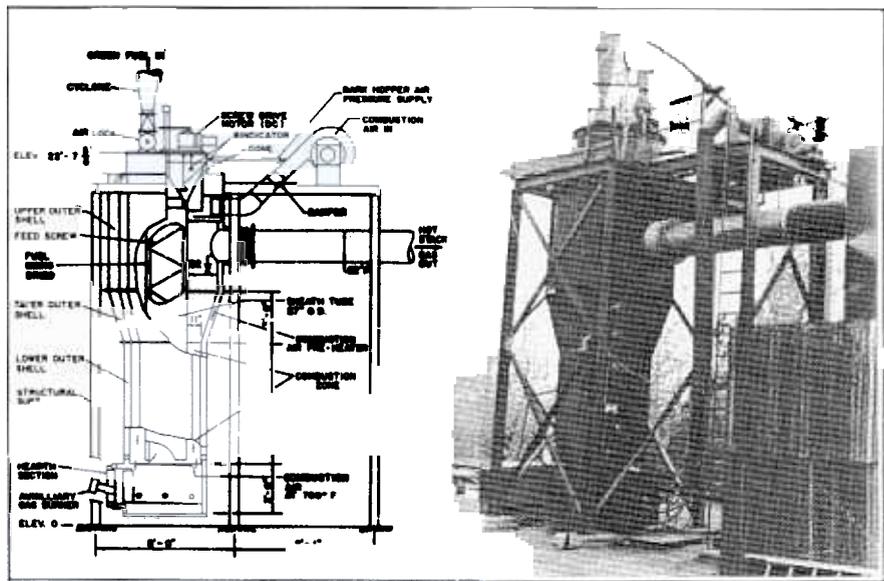


Figure 5. Schematic of shaping-lathe headrig and three configurations for making cants or cylinders plus flakes. Top left: A cam arrangement governs shape and dimensions of product. Top right: Machine for logs 40 to 53 inches long and 4 to 12 inches in diameter; it is primarily a pallet-cant producer. Bottom left: Nine-foot model for production of railroad crossties, posts, and cants to be resawn from logs 6 to 9 feet long and up to 15 inches in diameter. Bottom right: Roundup machine to produce flakes plus perfect cylinders, i.e., peeler bolts, from logs 8½ feet long and up to 30 inches in diameter. For description of these machines see Koch (1975), Koch and Caughey (1978), Springate (1978), Springate et al. (1978).

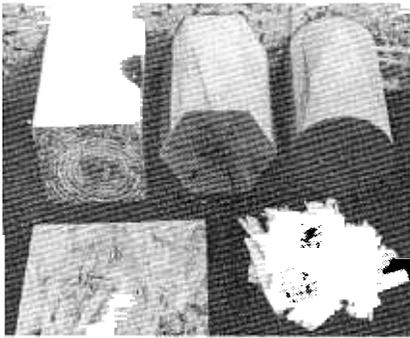


Figure 6. Cants produced on the shaping-lathe headrig may be rectangular or octagonal as well as square, hexagonal, or round. Flakes residual from the machining operation are typically 3 inches long and 0.015 or 0.025 inch thick. With addition of phenol-formaldehyde resin, these flakes can be hot-pressed to yield exterior structural panels of exceptional strength and stiffness (Hse et al. 1975, Price 1978).

into high-quality flakes for outermost face layers of structural flakeboard and cants (fig. 6) that are later dowel-laminated into 7- by 9-inch mainline crossies (Howe and Koch 1976).

Hardwood bolts 5 to 8.5 inches in diameter are converted on a 54-inch shaping-lathe headrig (fig. 5, top right) to face flakes and pallet cants for deck boards and stringers (fig. 7). Hardwood less than 5 inches in diameter and any bolts containing rot are chipped and ring-flaked into core stock.

With pine, 8-foot logs with diameters as small as 8 inches are rounded on a shaping lathe (fig. 5, bottom right), producing face flakes and perfect cylinders to be peeled into 1/4-inch veneer. The veneer is then parallel-laminated into structural lumber of any desired length or width (Koch 1973). Veneer cores and small pine logs are converted on another shaping-lathe headrig into face flakes and cants for resawing into 8-foot 2 by 4s to be kiln-dried under restraint to yield straight studs (Koch, Wellford, and Price 1978). Very small bolts are chipped and ring-flaked into core flakes. The shaping-lathe headrigs in three configurations (crosstie or stud, pallet cant, and veneer bolt roundup machines) are being cooperatively developed by the Southern Forest Experiment Station and Stetson-Ross Machine Company.

Shaping-lathe headrig capacity.

—Six trees per minute crossing the merchandising deck could yield

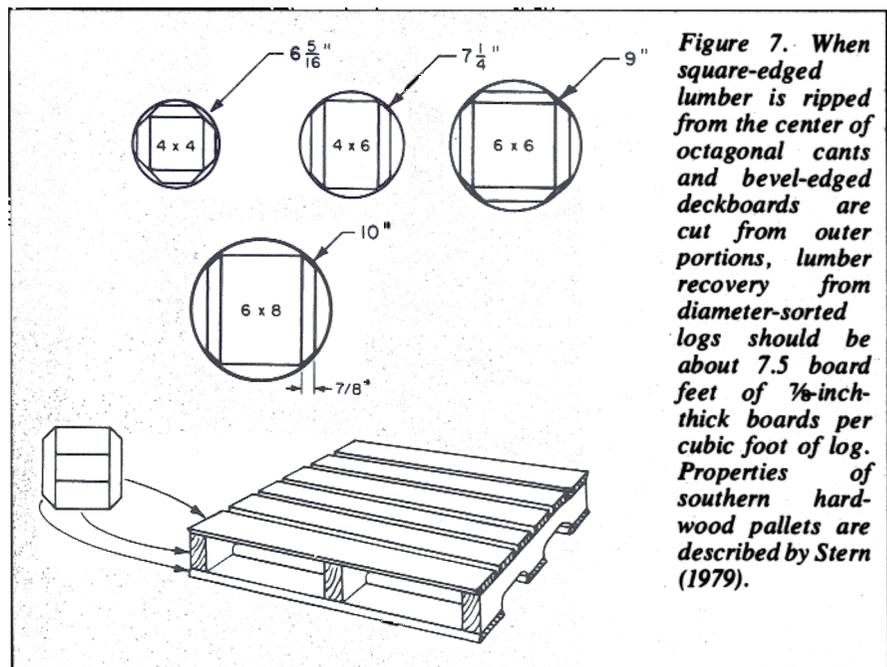


Figure 7. When square-edged lumber is ripped from the center of octagonal cants and bevel-edged deckboards are cut from outer portions, lumber recovery from diameter-sorted logs should be about 7.5 board feet of 1/4-inch-thick boards per cubic foot of log. Properties of southern hardwood pallets are described by Stern (1979).

four or five 8.5-foot hardwood logs per minute large enough (8.5 inches minimum diameter) to contain a half-tie and four or five 8-foot pine bolts large enough to be peeled (8-inch diameter or larger). Thus, one 8.5-foot crosstie headrig would be required for hardwoods and one 8-foot roundup headrig and a rotary veneer lathe for pine.

Since the rotary veneer lathe would turn out four or five pine veneer cores per minute and the merchandising deck would deliver five or six pine stud logs per minute, two more 8-foot headrigs would be needed to make cants from which studs could be resawn.

Finally, one might expect that the tree merchandising deck would yield 15 to 18 bolts per minute measuring 40 to 53 inches long and 5 to 8.5 inches in diameter; conversion of this boltwood (mostly hardwood) would call for three 54-inch shaping lathes.

Total headrig complement would therefore be seven shaping lathes: an 8.5-foot crosstie machine, an 8-foot roundup machine, two 8-foot canters for studs, and three 54-inch machines for pallet cants. Additionally, an 8-foot veneer lathe would be required, as well as cant resaws. These machines would produce about 585,000 tons of product annually (table 2) and be energy self-sufficient.

Alternative Products

Composite panels.—It is possible that, rather than flakeboard, a structural composite panel of ven-

eer faces over a flake core will be marketed to compete with plywood. Only slight revision of the layout shown in figure 1 would be required to manufacture such panels. To this end, logs would be rounded on a shaping-lathe to perfect cylinders (resulting flakes going into panel cores) and these cylinders rotary-peeled to yield panel faces. Springate (1978) and Springate et al. (1978) have explained the profit potential of such a manufacturing system.

Fiberboard.—Also, with addition of disk defibrators, fiberboards of low, medium, or high density could be manufactured from flakes and residual chips instead of the structural flakeboard called for in figure 1 (Woodson 1976a, 1976b, 1977; Suchsland and Woodson 1976).

Conclusion

The flexible system that I have proposed can yield a range of commodities that would satisfy major product demands on southern forests and triple commodity recovery from them. Other reasons for seriously considering the proposed manufacturing system are:

- The raw material is now under-used and is available in many southern (or eastern) locations.

- Recovered but unused tree portions amounting to nearly 200,000 dry tons annually (table 2) should be adequate fuel for energy self-sufficiency in the manufacturing plant.

- Markets for the products

Table 2. Annual output by product.¹

Commodity	Ovendry tons	Other measure
Crossties (7- by 9-inch)	46,440	675,000 pieces or 30,121,875 board feet
Long, wide lumber	64,462	4,297,467 cubic feet
Studs	26,250	31,980,000 board feet
Pallets	48,555	31,500,000 board feet
1/2-inch flakeboard sheathing	206,243	215,172,700 square feet
Fuel (approx.)	193,050	
Total	585,000	

¹100 effective operating hours per week, 50 weeks per year.

should be strong.

- The manufacturing processes are simple.
- The processes have minimal water demand.
- Degree of utilization of the wood resource is high.

- The processes are nonpolluting.
- Ecologically and silviculturally, the processing cycle is sound. As duff and foliage on the forest floor would not be harvested, nutrient cycles should not be upset

beyond ready remedy.

- Raw material feeding the system will be regenerated at an expanding rate.

- The system appears capable of alleviating impending national shortages of sheathing, long and wide structural lumber, crossties, and pallets.

- The intensive utilization proposed should yield generous net return to the landholder, thereby encouraging increased production from now poorly managed private nonindustrial woodlands in the South.

- Yet, cost of raw material to the mill is low.

- Application of the BRUSH system would halt incursion of low-grade hardwoods into the southern pinery. ■

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