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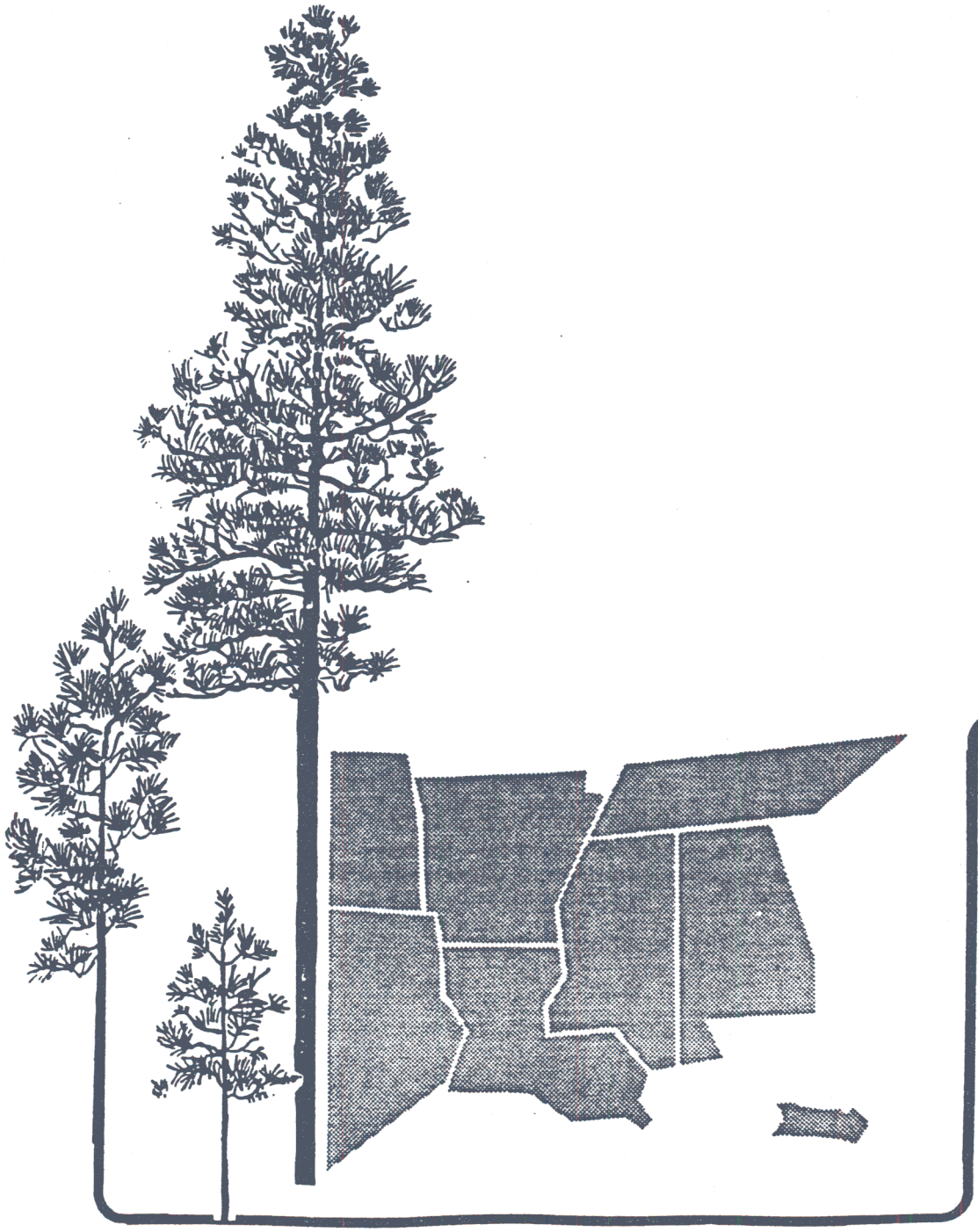

Southern Forest Experiment Station

ENERGY BUDGET FOR AN ENERGYWOOD HARVESTING SYSTEM[1/]

W. F. WATSON, D. E. MILLER, B. J. STOKES, and

M. L. BROUSSARD[2/]

Abstract.--The fuel and energy requirements for alternative energywood harvesting operations were determined from field operations. Comparisons were made among the total energy requirements including transportation for conventional operation and one- and two-pass energywood operations. The two-pass energywood operation required more energy per green ton than the other operations. Transportation required twice as much energy as did the woods operations.

INTRODUCTION

Wood as an energy source is becoming considerably more important in the United States. In OTA (1980), wood was estimated to be supplying 2% of the nation's energy requirements. Moshofsky (1980) indicated that wood consumption for energy was increasing at a rate of 10 to 15% annually.

Much of the wood for fuel is derived from manufacturing residues; however, energywood harvesting operations are becoming more prevalent. The successful energywood harvesting operations have been those which use conventional logging equipment in combination with in-woods chippers (Kluender et al., 1983).

Energywood harvesting operations like other energy production operations must be fuel efficient to be viable. Hayes (1976) reported that coal production yielded 48 Btu for each Btu expended in the production while gas and oil yielded 25 Btu for each Btu expended in production. Smith and Cochran (1976) estimated that in traditional logging 40 Btu are produced for each Btu expended in production while chipping operations produce 45 Btu for each Btu expended in production.

Scott Paper Company has instituted several energywood production operations to support a new boiler complex at its Mobile, Alabama, papermill. These operations have been monitored and compared with conventional operations on comparable test blocks to compare productivity and costs of the operations under a variety of conditions (Stokes, Watson, and Savelle 1985; Watson, Stokes, and Savelle 1986; Miller et al., 1985). These operations utilized conventional logging equipment (feller-bunchers and grapple skidders) with in-woods chippers to harvest the wood for energy. A unique aspect of Scott Paper's operations was the level of utilization. All trees 1 inch DBH and larger were harvested. This afforded a savings in site preparation costs but increased the cost of harvesting (Watson, Stokes, and Savelle 1984; Stokes and Watson 1986).

During production studies, two modes of operation were tested for harvesting energy. The first mode was to remove all stems having no higher value (such as pulpwood or sawlogs) as energywood in a first-pass through the stand. In a second-pass all fiber material and logs were removed several months later. The second mode of operation was to remove all energywood simultaneously with the fiber and logs. This second mode was called a one-pass operation.

During the energywood harvesting tests, comparable test blocks were harvested using conventional utilization standards and removing the material as roundwood. During the field studies the fuel consumed by each machine used in the tests was recorded. An additional fuel consumption data set for conventional logging by a contact logger was added to the information from the trials.

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ANALYSIS

The fuel consumed for each green ton produced was determined for each type of machine and for each method of harvest. The averages for this data are shown in Table 1. The felling of the energywood in the two-pass used significantly more fuel than did the felling in any other harvesting method. This was due to the feller-bunchers taking only the small stems and having to move around the larger stems to form bundles. Note that the differences over the harvesting methods were not significant in the fuel required to skid a ton of wood. Since the skidders were taking a full turn in all methods, it made no difference in terms of fuel consumption whether the load was energywood or logs.

The total fuel consumed per green ton of wood harvested by the energywood phase of the two-pass method was also significantly greater than the fuel consumed by the other methods of harvest. Differences in the total fuel consumed among the other methods were not significantly different. This is interesting in that a portion of the wood in the one-pass method was also chipped. However, in the one-pass method the skidding course was clearer than with any of the other methods and this afforded a fuel savings in skidding which offset the additional fuel consumed in chipping.

To test the fuel efficiency of the various methods of harvest, fuel samples were taken and evaluated by the Mississippi Petroleum Testing Laboratory. The fuel used in these tests averaged 135,350 Btu per gallon. The total fuel required to harvest a ton of wood in Btu is given in Table 2.

Smith and Corcoran (1976) give estimates of the energy invested in the manufacture of the equipment used in the harvest expressed on a per ton processed over the life of the machine. These energy estimates are added to the diesel fuel requirements to give the total energy required to harvest one green ton of wood and load it onto a truck (Table 2). Smith and Corcoran also reported the total energy requirements of log trucks and Table 3 reports the energy required to produce one green ton of wood when hauling is included.

The wood processed in these tests averaged a moisture content of 64 percent (oven-dry basis). Tillman (1978) reports the following equation for net fuel value for wood (E_m) in Btu per pound as a function of percent moisture content (M):

$$E_m = 8800 - 100.28\ M.$$

Thus, the net fuel value for the material sampled was 4,764,160 Btu per green ton. Then the fuel value generated per unit of fuel expended was found by dividing 4,764,160 by the total fuel expended reported in Table 3. This efficiency measure is given in Table 4.

DISCUSSION

Clearly wood fuels would be comparatively as efficient as coal or natural gas if moisture content could be lowered. This might be accomplished by transpirational drying by leaving the tops in place and allowing the trees to lay in the woods for several weeks. Scott Paper Company attains a 40 percent moisture content by the use of transpirational drying during the months in which foliage is present.

The harvesting of the wood is not the most costly aspect in terms of fuel consumed (Table 3). Transportation of the wood 50 miles requires 3 times as much fuel as does the conventional logging operations. This statistic best exemplifies the necessity for locating energywood harvesting operations near the point at which the wood will be used.

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Table 1.--Average fuel consumed by harvesting function for each method of harvest.

Method of Harvest	Felling	Skidding	Loading	Chipping	Total
	gallons of fuel/green ton				
Conventional	0.193	0.243	0.045	--	.443
Two-pass (Energywood)	0.459	0.248	--	0.424	1.129
Two-pass (Roundwood)	0.193	0.207	0.027	--	0.420
One-pass	0.234	0.186	0.046	0.347	0.679
Significant Differences	**	NS	NS	NS	**

** Differences significant at the .01 level
NS Differences not significant

Table 2. Fuel required by method of harvest.

Method of Harvest	Diesel Fuel Required To Harvest A Green Ton of Wood	Energy Invested in the Manufacture of the Equipment				Total Energy Required (Stump to Truck per Green Ton)
		Feller-Buncher	Skidder	Loader	Chipper	
	Btu/Green Ton					
Conventional	59,960	6,311	6,341	2,378	--	74,990
Two-pass (Energywood)	152,810	18,933	6,341	--	5,793	183,877
Two-pass (Roundwood)	56,847	6,311	6,341	2,378	--	71,877
One-pass	91,903					

Table 3.--Energy required for harvesting and transporting one green ton of wood.

Method of Harvest	Stump to Truck	Hauling (50 mile Roundtrip)	Total to Mill
Conventional	74,990	231,524	306,514
Two-pass (Energywood)	183,877	231,524	415,401
Two-pass (Roundwood)	71,877	231,524	303,401

Table 4.--Efficiency of the various methods for producing fuels.

Method of Production	Btu Produced Per Btu Utilized
Wood	
Conventional	15.5
One-pass	11.5
Two-pass	15.7
Coal (Hayes 1976)	48
Gas (Hayes 1976)	25