POTENTIAL FOR SMALL-DIAMETER SAWTIMBER UTILIZATION BY THE CURRENT SAWMILL INDUSTRY IN WESTERN NORTH AMERICA

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ABSTRACT

New silvicultural prescriptions for ecosystem management on both public and private timberlands in western North America will likely result in an influx of relatively small-diameter sawtimber for processing. Since sawmills currently process a majority of sawtimber harvested in western North America (more than 80% in some regions), this study concentrated on determining the value of small-diameter sawtimber delivered to sawmills. Data were collected during the summer of 1997 to describe a representative random-length sawmill and a representative stud mill for the inland region of the United States. Data included inputs for machinery, mill layout, machine speeds, volume and grade recovery, product prices, and fixed and variable manufacturing costs. A simulator (MSUSP) was employed to describe the sawmills and to determine delivered-sawtimber values by stem diameter for each mill. The value of sawtimber delivered to a sawmill was based upon a 25 percent and a 10 percent return on investment (ROI) capital and upon covering only variable costs of production. Results showed that sawtimber under 9 inches (23-cm) diameter at breast height (DBH) could not cover harvest and delivery costs and earn even a modest ROI capital at sawmills in the region. The 6- and 7-inch (15.2- and 17.8-cm) DBH sawtimber harvested from gentle slopes could not cover the variable costs of manufacture and the costs of harvest and delivery to the sawmill. Sawtimber under 10 inches (25.4 cm) DBH harvested from steeper slopes would require substantially higher lumber prices to cover variable costs. Results indicate that small-diameter sawtimber may have to be subsidized to allow for profitable manufacture of products by the current sawmill industry in western North America.

Past selective logging of seral species and effective fire suppression have dramatically altered the composition and health of forest ecosystems in many parts of western North America (12). Many forest stands are now overstocked with small-diameter, late-succession species such as Douglas-fir, grand fir, and western hemlock. Public concern over management practices that emphasized a narrow range of resource outputs has also caused forest managers to reexamine the ecological basis and visual impacts of traditional approaches (5,7). Collectively, these conditions have pushed managers to consider more ecologically based, socially acceptable management approaches (6). These management approaches will likely result in an influx of small-diameter sawtimber at existing processing plants throughout the region. Since sawmills process a majority of sawtimber harvested in this region (more than 80% in the inland region of the western United States), this study concentrated on determining the value of small-diameter sawtimber delivered to sawmills. A simulator (MSUSP) (21) was employed to describe a representative random-length sawmill and a representative stud mill for the region and to determine delivered-sawtimber values by diameter breast height (DBH) class for each sawmill.

BACKGROUND

The sawmill industry has used numerous sawmill simulators to investigate the log-sawing process (1,2,4,8,13,14,17-20,22). These simulators were designed to improve either the lumber-volume yield or the lumber-grade yield from sawlogs. A few large companies have used simulators to evaluate overall sawmill performance (3,10,11,21), and recently, sawmill simulators have been designed that incorporate graphics ani-

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mation and object-oriented libraries (9,15).

The sawmill-flow simulator (MSUSP) employed in the current study, has been used by Temple-Inland Forest Products to model the operation of sawmills in eastern Texas and southwestern Louisiana (21). Specifically, they employed the MSUSP simulator to value and to allocate sawtimber to each of their four sawmills. Temple-Inland Forest Products has used this approach since 1991. During 1994, they produced approximately 500 million board feet (BF) of lumber from sawtimber worth $154 million and estimated that they saved approximately $5 million through improved bid prices and improved allocation of sawtimber.

METHODS

As mentioned, the MSUSP simulator (21) was employed to value sawtimber by DBH class in this study. Data for the simulator were collected during the summer of 1997. The goal was to use the simulator to design representative random-length and stud sawmills for the inland region of the western United States. Random-length sawmills and stud mills in northwestern Montana were visited, and managers were interviewed to obtain the following data: 1) a full description of each sawmill (machines, conveyors, and surge decks); 2) lumber-volume and lumber-grade yields from logs of different diameters, lengths, and grades; and 3) machine processing rates by log diameter, length, and species.

Lumber prices were from the *Random Lengths Yardstick* (16) for hem-fir (late-succession species group) lumber during August 1997. Other product prices and costs were from sawmill surveys conducted by the Bureau of Business and Economic Research at The University of Montana-Missoula. Fixed costs were based upon capital investments of $22 million for the random-length sawmill and $17 million for the stud mill. These capital investments represent existing sawmills that have been partially depreciated but maintained through the addition of new and used equipment. Annual labor, utilities, property taxes, and other non-timber, non-capital costs were $6.9 million annually for the stud mill and $8.1 million annually for the random-length sawmill based on 500 8-hour shifts per year.

The sawmill design selected to represent random-length sawmills in the region had the following characteristics and machines: 1) two lines; 2) produces lumber 8 to 20 feet (2.4 to 6.1 m) in length, 4 to 12 inches (8.9 to 28.6 cm) wide, and 1 and 2 inches (1.9 and 3.8 cm) thick (majority was 2-inch- (3.8 cm) thick structural lumber); 3) processes multiple mill-length sawtimber; 4) circular log-cutoff saw; 5) ring debarker; 6) band headrig with conventional carriage on the large-log side; 7) twin-band, sharp-chain headrig on the small-log side; 8) double-arbor gang resaw on the large-log side; 9) quad-band resaw on the small-log side; 10) two lumber edgers; 11) lumber trimsaw; 12) automatic J-bar lumber sorter; 13) chipper for undersized and poor-quality sawlogs; and 14) chipper for log cutoffs "lily pads." The sawmill also had slabbing chippers at the headrigs, appropriately sized surge decks at each machine, and conveyors.

The sawmill design selected to represent stud mills in the region had the following characteristics and machines: 1) one line; 2) produces lumber 6 to 10 feet (1.8 to 3.0 m) in length, 4 and 6 inches (8.9 to 14.0 cm) wide, and 1 and 2 inches (1.9 and 3.8 cm) thick (majority 2 inches (3.8 cm) thick, 4 inches (8.9 cm) wide, and 8 feet (2.4 meters) long); 3) processes multiple mill-length sawtimber; 4) circular log-cutoff saw; 5) chipping-canter twin-band headrig; 6) single-arbor gang resaw; 7) lumber edger; 8) lumber trimsaw; 9) automatic J-bar lumber sorter; 10) chipper for undersized and poor quality logs; and 11) chipper for log cutoffs "lily pads." The sawmill also had appropriately sized surge decks and conveyors for each machine.

The USDA Forest Service Best Opening Face (BOF) program has been incorporated into the MSUSP simulator (8). The BOF program was modified to create lumber look-up tables for headrigs and resaws based upon sawmill parameters and sawmill efficiency. Before the simulator is run, the BOF program creates a look-up table that represents the lumber that would be produced from a range of logs processed at a sawmill. For this study, separate BOF look-up tables were created for the random-length sawmill and the stud mill. For creation of the look-up tables, it was assumed that lumber recovery factor (LRF) (BF of lumber tally per cubic foot of log input) was 7 for the random-length sawmill with an average log diameter of 10 inches and was 7 for the stud mill with an average log diameter of 8 inches. The BOF program automatically adjusts LRF for logs of different diameters. Each time a log or a cant is processed by a headrig or a resaw in the simulator, the log or cant disappears and lumber enters the simulator based upon a BOF look-up table and the diameter, length, and grade of the log or cant processed.

Multiple runs of the MSUSP simulator were made to determine the value of sawtimber at each sawmill. Sawtimber delivered to the sawmills had an average length of 41 feet (12.5 m) and an average taper of 2.5 inches (6.3 cm) per 16 feet (4.9 m) and was bucked to log-processing lengths at each sawmill. Processing lengths were 8 feet (2.4 m) plus trim at the stud mill and were from 8 to 20 feet (2.4 to 6.1 m) plus trim at the random-length sawmill. Percentages in each length class at the random-length sawmill were 1 percent for 8 feet (2.4 m), 9 percent for 10 feet (3.0 m), 15 percent for 12 feet (3.7 m), 5 percent for 14 feet (4.3 m), 30 percent for 16 feet (4.9 m), 10 percent for 18 feet (5.5 m), and 30 percent for 20 feet (6.1 m). In each run, a specific sawtimber DBH class was evaluated (6 to 18 inches (15.2 to 45.7 cm) DBH at the random-length sawmill and 6 to 14 inches (15.2 to 35.6 cm) DBH at the stud mill). Diameters within each sawtimber DBH class followed a lognormal distribution with a standard deviation of 0.25 inches (0.6 cm). Most sawmills in western North America do not sort by sawtimber DBH class for processing. However, this step was necessary to determine the relative value of each sawtimber DBH class in this analysis.

After each run, the profit/loss (less sawtimber costs) and volume of sawtimber processed (thousand BF (MBF) Scribner scale) were recorded. The break-even value of each sawtimber DBH class was then calculated by dividing profit/loss by MBF Scribner scale for each run. Value of sawtimber was based upon 25 percent and 10 percent return on investment (ROI) and upon covering variable costs of manufacture. Twenty-five percent ROI is considered by many forest products companies and by many lending institutions to be a reasonable long-term ROI for high-risk ventures. Ten-percent ROI is viewed as a minimum ROI to attract capital into the sawmill industry. Under certain *extreme* situations, sawmill managers may choose to operate if they can cover the variable costs of production.

RESULTS

In multiple runs of the simulator, lumber production for an 8-hour shift of the random-length sawmill ranged from 60.08 MBF (97.5 m^3) for 6-inch (15.2-cm) DBH sawtimber to 358.91 MBF (582.6 m^3) for 17-inch (42.5-cm) DBH sawtimber, and lumber production for an 8-hour shift of the stud mill ranged from 56.12 MBF (91.1 m^3) for 6-inch (15.2-cm) DBH sawtimber to 204.23 MBF (331.5 m^3) for 14- inch (35.0 cm) DBH sawtimber (**Table 1**). The LRF (BF lumber tally/ft.^{3} of log input) for the random-length sawmill ranged from 4.52 (25.9 percent of log volume) for 6-inch (15.2-cm) DBH sawtimber to 8.92 (51.1 percent of log volume) for 18-inch (45.7-cm) DBH sawtimber, and LRF for the stud mill ranged from 4.53 (25.9 percent of log volume) for 6-inch (15.2-cm) DBH sawtimber to 8.57 (49.1 percent of log volume) for 14-inch (35.6-cm) DBH sawtimber (**Table 2**). The ranges in LRF values were automatically determined by the modified BOF program through each run of the simulator.

The break-even values of sawtimber at the simulated random-length sawmill and the simulated stud mill are shown in **Tables 3** and **4**, respectively. Relative break-even values of sawtimber at the two sawmills are dependent upon many factors, and direct comparisons of values should be approached with caution. With a 25 percent ROI, 6-, 7-, and 8-inch (15.2, 17.8, and 20.3-cm) DBH sawtimber had negative values at both mills. Even when only variable costs were covered, the break-even values for 6- and 7-inch (15.2 and 17.8-cm) DBH sawtimber at both mills would not cover harvest and delivery costs. Harvest and transportation costs for 6- and 7-inch (15.2 and 17.8-cm) DBH sawtimber on gentle slopes (tractor ground) is nearly $500/MBF and $360/MBF Scribner scale ($36/m^3 and $33/m^3), respectively (Bureau of Business and Economic Research, Forest Industry Data System, The University of Montana-Missoula 1998). Note that as DBH decreases, the Scribner scale underestimates, by an increasing amount, the volume of wood fiber in the sawtimber. For example, to produce an MBF Scribner scale from 6-inch (15.2- cm) DBH sawtimber would require 14 m^3, while a MBF Scribner scale from 10-inch (25.4-cm) DBH sawtimber would require just 7 m^3, which is half the volume. With a 25 percent ROI, the break-even values of sawtimber did not exceed the cost of harvest and delivery on tractor ground until DBH was 11 inches (27.9 cm) or larger at both sawmills. With a 10 percent ROI, the break-even values of

TABLE 1. — Lumber production for an 8-hour shift of the simulated random-length sawmill and stud mill by diameter class of sawtimber.

Sawtimber DBH	Random-length sawmill	Stud mill
(in.)	------ (MBF tally) ------	
6	60.08	56.12
7	61.35	62.88
8	67.72	77.30
9	86.60	100.70
10	111.60	130.45
11	137.90	172.79
12	171.30	196.08
13	214.08	202.34
14	245.55	204.23
15	280.34	
16	328.78	
17	358.91	
18	337.35	

TABLE 2. — Lumber recovery factor (LRF) for the simulated random-length sawmill and the stud mill by diameter class of sawtimber.

Sawtimber DBH	Random-length sawmill LRF	Stud mill LRF
(in.)	------ (MBF tally) ------	
6	4.52	4.53
7	5.71	5.98
8	5.84	6.74
9	6.39	7.38
10	6.83	7.81
11	7.02	8.04
12	7.32	8.23
13	7.77	8.40
14	8.04	8.57
15	8.23	
16	8.47	
17	8.74	
18	8.92	

TABLE 3. — Break-even sawtimber value (delivered) for the simulated random-length sawmill with 25 percent and 10 percent return on investment (ROI) and with variable costs covered, by diameter class.

Sawtimber DBH	25 percent ROI	10 percent ROI	Variable costs
(in.)	-----------------	($/MBF Scribner)	-----------------
6	-341.21	-92.57	311.47
7	-315.99	-75.84	314.42
8	-172.09	26.54	349.33
9	31.84	181.69	425.19
10	202.29	314.49	496.82
11	300.16	385.86	525.13
12	383.30	449.72	557.64
13	461.19	513.63	598.84
14	502.01	546.54	618.90
15	538.89	577.05	639.06
16	567.62	599.28	650.72
17	622.03	652.54	702.13
18	573.39	603.50	652.43

TABLE 4. Break-even sawtimber value (delivered) for the simulated stud mill with 25 percent and 10 percent return on investment (ROI) and with variable costs covered, by diameter class.

Sawtimber DBH	25 percent ROI	10 percent ROI	Variable costs
(in.)	-----------------	($/MBF Scribner)	-----------------
6	-499.94	-249.76	142.18
7	-316.82	-108.99	216.60
8	-87.88	69.30	315.55
9	104.92	216.99	392.58
10	227.18	307.49	433.30
11	317.81	375.00	464.60
12	339.92	387.65	462.21
13	334.60	379.17	449.00
14	326.54	369.37	436.48

TABLE 5. — Average sawlog small-end diameter processed by the simulated random-length sawmill and stud mill, by diameter class of sawtimber.

Sawtimber DBH	Random-length sawmill sawlog diameter	Stud mill sawlog diameter
	(in.)	
6	5.00	5.03
7	5.09	5.26
8	5.39	5.70
9	5.84	6.33
10	6.44	7.06
11	7.27	7.96
12	8.21	8.96
13	9.19	9.92
14	10.21	10.94
15	11.18	
16	12.14	
17	13.18	
18	14.18	

sawtimber did not exceed the cost of harvest and delivery until DBH was 9 inches (22.9 cm) or larger at both sawmills.

Much of the forest land in need of management is on steep slopes (35%) requiring cable-harvest systems. These systems often result in harvest and delivery costs in excess of $400/MBF Scribner scale ($60/m^3) for sawtimber of 9 inches (25.4-cm) DBH and less; for larger sawtimber, harvest and delivery costs may be as high as $300/MBF Scribner scale ($45/m^3) (Bureau of Business and Economic Research, Forest Industry Data Systems, The University of Montana-Missoula 1998). These costs exceed the delivered value of sawtimber under 10 inches (25.4-cm) DBH when covering just variable costs (**Tables 3** and **4**). Only 10-inch (25.4-cm) DBH and larger sawtimber would cover harvest and delivery costs and would return a 10 percent ROI on investments at both sawmills.

Conclusions

Results of this study address several important forest land management questions. One question deals with whether the value of small-diameter sawtimber exceeds the cost of harvest and delivery to sawmills in western North America. Although many variables (i.e., milling efficiency, lumber prices, and chip prices) impact the answer to this question, results suggest that at the present time, the break-even values of small-diameter sawtimber (< 9 in. (22.9 cm) DBH for tractor ground and < 11 in. (27.9 cm) for cable ground) did not cover the cost of harvest and delivery. However, considerable variation exists among sawmills, and some sawmills in the region could process logs more or less efficiently than the sawmills profiled in this study.

In times of peak markets for lumber and chips, sawmills could pay substantially more for sawtimber than indicated in **Tables 3** and **4**. However, lumber prices used in this analysis (16) are on a par with prices over the past few years and are relatively high by historic standards. Most experts do not expect dramatic sustained increases in lumber prices.

In the short run, some sawmills may be willing to pay considerably more than long-term break-even value for sawtimber. This happened in 1994 when sawtimber prices rose to unprecedented levels in western North America due to sawtimber shortages resulting from reductions in harvest from USDA Forest Service lands. Today, many sawmills in western North America are operating at substantially below-optimum levels of production due to sawtimber shortages. Some sawmills are operating in a survival mode hoping that sawtimber harvests will increase. In the short run, these sawmills may secure sawtimber at prices that will allow them to only cover variable costs of production as shown in **Tables 3** and **4**. However, forest restoration prescriptions are long-term propositions, and the sawmill industry will have to make ongoing investments in equipment and facilities to efficiently process sawtimber from these lands. The two columns in **Tables 3** and **4** illustrating break-even sawtimber value for 10 and 25 percent ROI provide a better basis for long-term planning than do prices when only variable costs are covered.

Although many factors affected the break-even value of small-diameter sawtimber at the two mills, the factors that had perhaps the greatest impact were lumber production and lumber recovery. As can be seen in **Table 1**, lumber production for 6-inch (15.2-cm) DBH sawtimber was only about one-fourth that of lumber production for 14-inch DBH (35.6-cm) sawtimber processed at both mills. Although some sawmill machines process smaller pieces somewhat faster than larger pieces, the increases in processing speeds were not enough to offset the low volume per piece for small-diameter sawtimber. The LRF (**Table 2**) for 6-inch (15.2-cm) DBH sawtimber was only about one-half that for 18- and 14-inch (45.7 and 35.6-cm) DBH sawtimber processed at the random-length sawmill and the stud mill, respectively. As a result, twice as much cubic log volume had to be processed to produce the same volume of lumber from the 6-inch (15.2-cm) DBH sawtimber as from the larger-diameter sawtimber.

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