Impact of stand diameter and product markets on revenue gains from multiproduct harvesting

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Abstract

Data from 113 sample thinning plots and a microcomputer program called APTHIN were used to demonstrate the impact of mean stand diameter and product markets on revenue gains from multiproduct versus single-product pulpwood harvests in poletimber and small sawtimber stands of Appalachian hardwoods. The analysis of revenue gains included product mix as a function of the quadratic mean diameter at breast height (DBH), product market prices, and haul cost as a function of market location. Yields of sawlogs, sawbolts, pulpwood-fuelwood, and chips were estimated with APTHIN to determine shifts in the available product mix. Results show that as the mean DBH of harvested trees increases from 6 to 12 inches, the proportion of total roundwood classified as pulpwood or fuelwood declines from 77 to 24 percent, with large sawlogs increasing from 0 to 49 percent. Results suggest that when market conditions favor multiproduct harvesting, revenue gains can range from $12/acre for 6-inch-DBH stands to $809/acre for 12-inch-DBH stands. The impact of market price and haul cost differentials for 10-inch-DBH stands shows revenue gains ranging from $178/acre to $439/acre. Application of revenue gain estimates is demonstrated by a generalized model for evaluating revenue gains and shifts in system production rate, costs, and stumpage prices relative to the profitability of the harvesting firm.

Multiproduct harvesting affords loggers and landowners the opportunity to increase economic returns by allocating each component of the available wood resource to its highest value market. Sorting sawlogs prior to whole-tree chipping has increased the profitability of hardwood stand conversion (14). In mixed hardwood stands with a significant aspen component, integrated harvesting with several product sorts increased financial returns on investment for four of five harvesting systems studied (5). Blinn et al. (5) also found that capital and labor efficiency vary significantly between timber stands and harvesting systems. Product sorting and separation also helps loggers contend with market fluctuations and production quotas for specific products (1). These reports indicate that multiproduct harvesting in eastern hardwoods can be profitable. However, the demonstrated variability of economic returns imposed by timber-stand attributes and harvesting systems makes identifying feasible opportunities for multiproduct harvesting essential to the success of the harvesting firm. Although much of this research has analyzed harvesting technology and costs, market factors are of equal importance. An analysis of multiproduct harvesting alternatives in loblolly pine stands showed that product prices, mill requirements, and tract location are important variables (8).

Harvesting revenue gain is one of the more important variables affecting the profitability of multiproduct harvesting. The potential for increased revenues, the objective of multiproduct harvesting, is a function of timber-stand attributes and primary product markets. Stand attributes and product requirements determine the product mix available from the trees to be harvested. Product markets are defined by product specifications, prices, marketable volume, and market location. The stand attributes that influence product mix include species composition, tree quality, and diameter. Diameter is a primary determinant of product yields and harvesting revenues. Market location relative to stand location also dictates haul routes and road classifications chosen, thereby influencing haul costs and net gains from multiproduct harvesting.

The objective of this article is to 1) describe a methodology for estimating revenue gains from multiproduct harvesting; and 2) use the results based on sample plot data and surveyed market prices to demonstrate the im-

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class. The two most significant trends are the decline in the percentage of pulpwood-fuelwood, from 77 percent at 6 inches to 24 percent at 12 inches, and the increase in the percentage of large sawlogs, from 0 percent at 6 inches to 49 percent at 12 inches (Fig. 1).

Product markets

Primary product markets and the resulting difference in prices between product classes create opportunities to increase revenue through multiproduct harvesting. Price differentials between the product classes in Table 2 were obtained from forest products price bulletins (7,11,15,16). Sawbolts, as defined in this paper, were not identified specifically in the price bulletins. Consequently, the sawbolt prices shown in Table 3 are those reported for low-grade, small-diameter roundwood used for pallets or blocking-processes that can utilize roundwood down to the 6-inch-d.o.b. limit specified for sawbolts. The range of prices for large sawlogs reflects potential shifts in log grade and species distribution; the upper limit is set by the diameter of logs available from the thinnings represented in Table 2. The range of prices for other products represents regional differences in reported prices, indicating that product marketing opportunities vary by region.

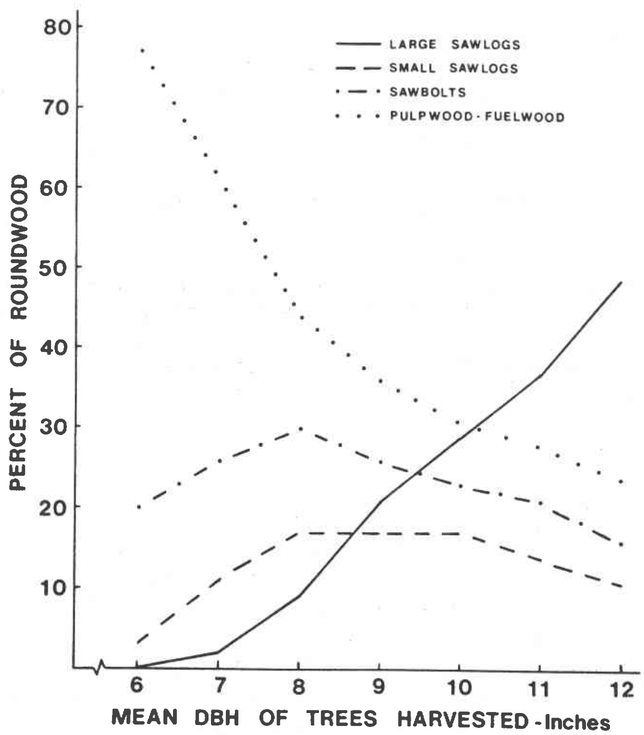

Figure 1. — Available product mix as a function of the mean DBH of trees harvested.

For comparative purposes, reported prices are converted to dollars/ton values based on the APTHIN estimates of weight and volume specific to the diameter of the roundwood allocated to each product (Table 3). These values show considerable overlap of equivalent unit values between product classes, which is an indication that revenue gains from separating and sorting small sawlogs or sawbolts will require significant savings in haul cost, or relatively strong markets for these products combined with moderate to weak markets for pulpwood, fuelwood, or chips. Reported fuelwood prices also overlap prices of large sawlogs, a condition that likely would be confined to locations with a high demand for residential fuelwood.

Location relative to harvesting sites is an important attribute of product markets, because it determines truck haul distance and cost. The resulting haul cost differentials for alternative markets can increase or decrease the revenue gains created by product price differentials. Because haul costs are affected by truck type and road class, these two variables also affect revenue gains. This is particularly important in the Appalachian hardwood region where truck size and speed often are constrained by road grade and alignment. On the basis of haul cost equations by LeDoux (9), a tractor-trailer combination operating on good roads would require a price differential of \$2.06/ton to cover the cost of hauling an additional 30 miles (Fig. 2). This break-even price differential increases to \$3.76/ton for a tandem-axle straight truck on good roads, or \$11.40/ton on poor roads.

Estimated revenue gains

The net effect of product markets and mean diameter on harvesting revenue was estimated for five hypothetical market cases (Tables 4 and 5). These cases include

TABLE 3. — *Reported product prices converted to equivalent dollar/ton values.*

Product	Price range
	(\$/ton)
Large sawlogs[a]	20 to 30
Small sawlogs[b]	12 to 18
Sawbolts[c]	11 to 16
Pulpwood	12 to 19
Fuelwood	12 to 25
Whole-tree chips	14 to 22

[a] \$120 to \$175/MBF, 5.8 tons/MBF.
[b] \$90 to \$120/MBF, 6.8 tons/MBF.
[c] \$90 to \$120/MBF, 7.8 tons/MBF.

TABLE 4. — *Market price and haul distance for multiproduct harvest, by product, for five hypothetical market cases.*

Case	Large sawlogs		Small sawlogs		Sawbolts		Pulpwood		Fuelwood	
	(\$/MBF)	(mi.)	(\$/MBF)	(mi.)	(\$/MBF)	(mi.)	(\$/ton)	(mi.)	(\$/ton)	(mi.)
1	175	20	120	20	120	20	14	40	--	--
2	175	40	120	40	120	40	14	40	--	--
3	175	60	120[b]	60	120[b]	60	14	40	--	--
4	145	40	95[b]	40	95[b]	40	14	40	--	--
5	145	40	95[b]	40	95[b]	40	14[b]	40	20	40

[a] Base market price and haul distance for single-product pulpwood harvest is \$14/ton and 40 miles.
[b] Product not harvested, or harvested only in larger diameter stands. Wood allocated to pulpwood or fuelwood.

both cases assume relatively high prices for small sawlogs and sawbolts, the resulting price differential between these products and pulpwood is insufficient to cover the increased haul cost. Because revenue gains in small-diameter stands rely heavily on small sawlog or sawbolt revenues, multiproduct harvesting in these stands will require favorable market locations relative to the alternative pulpwood market.

Case 5 demonstrates the impact of a strong fuelwood market. Due to the high price received for fuelwood, all wood except large sawlogs is channeled into the fuelwood market. For stands less than 10 inches mean DBH, revenue gains exceed those in all other scenarios. At 10 inches and above, only the high prices for large sawlogs in cases 1 and 2 yield greater gains. These results emphasize the potential role of strong fuelwood markets in harvesting or thinning small-diameter stands.

Applying revenue-gain estimates

Revenue gains resulting from multiproduct harvesting can be applied by linking these gains to the profitability of the harvesting firm or logger. Profitability is determined by four principal factors: 1) harvest system production rate (units/hour); 2) cost to own and operate the system (dollars/hour); 3) revenue (dollars/unit); and 4) stumpage cost (dollars/unit). All four factors can be affected by the shift from single to multiproduct harvesting. Harvest-system costs depend on the need for additional men and machines, or perhaps additional landing space to implement product separation and sorting. System productivity may decrease if the product-separation process constrains system output. Since other system components such as felling, skidding, or trucking also can constrain production, a complete system analysis is required to evaluate the effects of product mix on production rates. For three hardwood harvesting systems analyzed through computer simulation, reductions in productivity attributed to multiproduct harvesting ranged from 5.7 to 11.3 percent (5). The variability of these four profit factors limits the application of case-study results, requiring site- and system-specific analyses of multiproduct harvesting opportunities.

Profits from multiproduct harvesting that equal or exceed those available from the single-product alternative provide the required economic incentive. This constraint can be expressed as:

$$(P + P_d) \times [(R + R_d) - (S + S_d)] - (C + C_d) \geq P \times (R - S) - C \qquad [1]$$

where:

P = single-product production rate (in units/time)
P_d = change in single-product production rate (in units/time)
R = average unit revenue for single-product harvest (in dollars/unit)
R_d = change in average unit revenue (in dollars/unit)
S = average unit stumpage price for single-product harvest (in dollars/unit)
S_d = change in average unit stumpage price (in dollars/unit)
C = total cost of owning and operating the single-product harvest system (in dollars/time)
C_d = change in system cost (in dollars/time)

A margin for risk also can be included as a percentage of C or C_d. This constraint can also be reduced and rearranged to show that marginal revenue must equal or exceed marginal cost, or:

$$P \times R_d + P_d \times (R + R_d) \geq P \times S_d + P_d \times (S + S_d) + C_d \qquad [2]$$

A third constraint that requires multiproduct harvesting to show a profit is:

$$(P + P_d) \times [(R + R_d) - (S + S_d)] - (C + C_d) \geq 0 \qquad [3]$$

Although this constraint is essential to the survival of the firm, it alone is not sufficient to provide economic incentive for multiproduct harvesting. The fact that multiproduct harvesting may be at least a break-even proposition provides no incentive for the firm that has more profitable alternatives.

The revenue gains in Table 5 represent values of R_d and indicate the extent to which R_d can be influenced by stand diameter, location, and product price differentials. Hence, these same variables implicitly constrain changes in harvest system productivity, cost, or stumpage prices insofar as they provide economic incentives for multiproduct harvesting. For example, given the \$3.95/ton revenue gain for Case 1 at 8 inches mean DBH (Table 5), assume that:

P = 100 tons/day
P_d = unknown
C = \$500/day
C_d = \$100/day
R = \$8.00/ton
R_d = \$3.95/ton
S = \$1.00/ton
S_d = 0

Solution of the first or second constraint shows that production cannot decline by more than 26.9 tons/day ($P_d > -26.9$). A larger reduction would reduce profits below the \$200/day available from single-product harvesting. Repeating the same scenario for Case 3 market conditions, where R_d is only \$1.26/ton, $P_d \geq -3.1$ tons/day, which is a much more stringent constraint imposed by market location. A similar limit on C_d or S_d could be derived for sets of assumptions specifying values of P_d and S_d, or C_d.

To be consistent with Table 5, this and subsequent analyses include deductions for haul cost in the estimates of R and R_d. Therefore, cost and production rates used in the constraint equation do not include trucking. When the logger does not contract hauling, R and R_d would not include haul cost deductions. Furthermore, C, C_d, P, and P_d would include trucking and its impact on system costs and production rates.

Profitable sets of market and stand conditions also can be identified through required revenue gains, given P, S, and C, and the expected shifts in these rates due to multiproduct harvesting. If in the previous example $P_d = -10$ tons/day, then R_d must equal or exceed \$1.89/ton. Were the estimates of P and P_d based on harvesting firm to quantify the constraints on incremental costs that must be satisfied through the selection and application of efficient harvesting technology. Conversely, given system-specific cost and production estimates, revenue gains linked to stand and market attributes define feasible harvesting alternatives. With this knowledge, the landowner is in a position to bargain for a larger share of harvest revenues. The APTHIN program and profit constraints collectively define a methodology for estimating product yields and revenue gains, and for integrating these results with harvest-system cost and production estimates.

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