FIELD NOTE

Economics of Coharvesting Smallwood by Chainsaw and Skidder for Crop Tree Management in Missouri

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ABSTRACT

Forest improvement harvests using individual-tree and group selection were conducted in four oak or oak-hickory stands in the Missouri Ozarks with conventional equipment (chainsaw and skidder). Volumes (and revenues) for different timber classes (sawlogs and smallwood from topwood and small trees) and hours of machine use were recorded to calculate production rates. Multiplying these by estimated hourly machine costs and adding loading and transportation costs plus stumpage yielded harvest plus delivery costs. Loggers kept machine costs low by operating old equipment with low capital costs and by owner servicing. Coharvesting of sawlogs and smallwood provided \$240–\$340/person-day in net operating revenues to loggers. Smallwood harvest yielded positive net revenues because loggers paid little or nothing for this material. Nevertheless, loggers could continue to generate positive net operating revenues if they paid a modest fee of \$4–\$5/ton for smallwood (as occurred in a subsequent salvage harvest). The cost of implementing best management practices (water bars and other erosion-control structures) with a skidder was affordable ($\leq$2% of logger's net operating revenue). Overall, the results supported crop tree management as a financially rational alternative across a variety of sites and showed that smallwood harvest does not always require subsidy.

Keywords: best management practices (BMPs), forest improvement harvest, machine costs, Ozarks, sawlogs

Loggers in the Missouri Ozarks have typically cut the largest, most valuable trees and left the rest, a practice known as high grading (Walter and Johnson 2004). A proven alternative is crop tree management, which improves forest health and increases the amount and quality of timber production (Perkey et al. 1994). Inferior, competing trees and those unlikely to survive to the next harvest are removed to concentrate water, nutrients, and sunlight on the crop trees, which are left to grow and increase in market value. Sawtimber and/or smaller trees might be harvested, depending on the intensity and timing of crop tree management.

Forest stand improvement (FSI), or removal of selected small trees (4–10 in. dbh), may not by itself generate enough immediate revenue to pay for its cost, but the expected return comes later in improved residual timber growth. It is offered as a state and federal cost-share practice to promote its adoption by private forest owners.

Although FSI is typically viewed as a precommercial thinning (e.g., Palmer 2004), a combined harvest of small trees and sawtimber within the same block provides an indirect subsidy for FSI and reduces environmental impact by eliminating a second entry. Such coharvesting also broadens the size range of trees removed under crop tree management, facilitating stand regeneration (Larsen et al. 1999).

Disregarding environmental costs, crop tree management generally cannot match the immediate financial returns of high grading or clear cutting to either the landowner or logger. Yet there is growing evidence that forest improvement harvests to implement crop tree management offer greater long-term profit to the landowner and significant environmental benefits (Hamatani and Goslee 2008).

Best management practices (BMPs), such as restricted harvesting near streams, careful layout of logging roads and skid trails, and postharvest treatments, can prevent soil erosion and protect water quality. Unfortunately, effective erosion controls (water bars, tree tops) on primary skid trails were lacking in the majority of the inspected private timber sales in Missouri that (typically) did not involve a professional forester (John Tuttle, pers. comm., Missouri Dept of Conservation, Dec. 20, 2010).

Crop tree management, like following BMPs, requires more time to harvest a given timber volume, and is therefore more expensive than the predominant high grade or clearcut harvest. Smallwood (pulpwood, blocking, and pallet wood) can represent a substantial portion of the timber removed in a forest improvement harvest, but it is much less valuable than sawtimber per unit volume. Loggers and landowners may therefore view crop tree management and BMPs as cost-prohibitive and avoid them.

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Table 1. Harvest equipment assessed for machine cost.[a]

Site	Chainsaw	Skidder	Loader	Tractor[b]
I	2007 Stihl 441	1973 JD 440B cable	1996 Serko 8000	1983 Ford 9000
II[c]	2008 Husqvarna 372	1992 Timberjack 380B grapple	Service contracted	Service contracted
III	2008 Stihl 441	1983 JD 540 cable	1996 Serko 8000	1983 Ford 9000
		1990 JD 640 cable		
IV	2006 Stihl 460	*1979 JD 440 C cable*	1991 Serco 6000	1979 Kenworth W900
	2008 Stihl 460		*1998 Serco 7000*	*1993 Peterbilt*

[a] Only italicized equipment had financing charges.
[b] Trailers were locally built and unbranded.
[c] *1992 Bell tree cutter* was included in the analysis.

The objective of the case studies reported here was to quantify actual timber revenues, the production rates and hourly machine costs of conventional harvest equipment (chainsaw and skidder), and the cost of loading and transporting timber from the woods to the mill. This permitted an assessment of the net operating revenues to loggers generated by forest improvement harvests using BMPs and crop tree management in the Missouri Ozarks. Our aim was to assess whether these harvest practices were an affordable option for loggers and landowners.

Neither silvicultural prescriptions nor harvest practices were modified for this study, which measured outcomes based on actual costs and revenues. The loggers were exceptional in that all but one team were state or regional loggers of the year, and all incorporated smallwood harvesting in their normal operations. The low capital cost of their equipment was, however, typical of family logging operations, which predominate in the Missouri Ozarks.

Materials and Methods

Site Descriptions and Silvicultural Prescriptions

Four upland oak or oak-hickory stands in the Missouri Ozarks were selected on the basis of the willingness of landowners and their loggers to participate in the study. All stands had some sawtimber 70+ years old. Slope varied from 0% to 50%, and soils were mainly silt loams varying in depth from 1 to 8 ft. Our harvests occurred in 2008 and 2009, at least 30 years after the previous harvest.

We studied a variety of approaches to crop tree management to better assess the economic feasibility of forest improvement harvests. At all sites, professional foresters selected individual crop trees (e.g., Iffrig et al. 2008) and marked trees for felling. Additionally, some group openings due to mortality or current prescription occurred at Sites II and IV. Two sites (II and III) had been harvested under crop tree management for at least three decades and were already producing sawtimber of greater size and quality than the other two sites, which had experienced only diameter-limit cuts. These groups were further dichotomized by the extent of FSI performed (greatest at Sites I and II).

Smallwood consequently made up very different proportions of harvested timber volume and revenue among the sites. We have reported the results for individual sites so that readers can better judge their generality.

Stand Inventories

Preharvest inventories of trees >l.5 in. dbh with a basal area factor prism of 10 followed standard procedures (Missouri Department of Conservation 2007).

Postharvest damage was assessed for all live trees ≥5 in. dbh in 7 or 12 plots of 0.1 ac each, established in a systematic grid at about 3% sampling intensity. The boundary of the harvest area was mapped with a GPS device, as were the location of log decks within the harvest area and skid trails with three or more hauls to measure their areas.

Work and Production Records

Loggers were financially compensated for their time to record production data and furnish inputs for estimation of machine costs. Operators used electronic stopwatches and recorded the daily operational hours (to nearest 0.25 hour) for each piece of equipment. Becker et al. (2006) found that this procedure was sufficiently accurate at the whole system operational level.

At Site I, the landowner performed FSI around crop trees only, felling, delimbing, and topping small trees down to a 4-in. dbh. The time to process used trees only was charged to the operation at the logger's machine cost for a chainsaw.

Prior to delivery to the mill, sawlogs were scaled (International 1/4-in. rule for 8- or 9-ft logs) by one of the authors (Sites I and III) or the loggers (II and IV). All consumer scale weight tickets for sawlogs and smallwood were collected.

Because the harvest times of sawlogs and smallwood were not separated and these products were sometimes sold by different units, volumes were converted to a common unit (green tons) for productivity analyses. Tons per thousand board feet (mbf) (International 1/4-in. rule) was calculated for each sawlog according to Doruska et al. (2006, Equation 10 for all logs of all study species, namely, oak, hickory, and sweetgum). This ratio (site averages: 5.9–6.3 tons/mbf) was multiplied by the scaled mbf per log to estimate the weight in tons, which was then summed over all sawlogs. This estimated value was just 3% greater and 2% less than the mill-measured weights of sawlogs from Sites III and IV, respectively.

Machine Costs

Machine costs of the harvest equipment (Table 1) were calculated according to Miyata (1980), as modified by Brinker et al. (2002, Table 2), using a spreadsheet developed by deLasaux et al. (2009). This approach provides a standard and transparent basis for time-averaging productivity and unusual expenses, as applied to a particular operation. It does, however, partially disregard the time value of money (Bilek 2008, Rummer 2008).

Loggers estimated their annual repair and maintenance costs (including tire replacement) and annual productive hours (accounting for down time due to repair, service, and bad weather) of the harvest equipment without the benefit of records. For example, ranges for skidders were $3,000–$8,700 for repair and maintenance costs and 430–1,280 for productive machine hours (PMH). These inputs were the most likely sources of error in our estimation of machine costs.

Equipment capital costs were allocated over time using straight-line depreciation. The analysis included any equipment insurance

Table 2. Preharvest stand characteristics.

Site	Acres	No. of plots	Basal area (ft^2/ac)	QMD[a] (in.)	Trees (no./ac)	Stocking[b] (%)	Sawlogs[c] (mbf/ac)
I	28	20	139	7.9	409	132	10.2
II	17	10	85	8.6	212	79	7.4
III	27	14	106	9.1	236	96	8.1
IV[d]	19	5	72	9.9	134	63	4.5

[a] QMD (quadratic mean diameter) = $[(\Sigma dbh^2)/N]^{0.5}$.
[b] Calculated according to stocking chart for even-aged, upland central hardwoods (Gingrich 1971).
[c] Sawlog = 8.67-ft log >9.l in. dbh in preharvest inventory. mbf, thousand board feet.
[d] Inventoried 7 years prior to harvest.

Table 3. Total site volumes sold, gross revenues, stumpage, and net revenue from timber.

Site	Sawlogs[a]	Blocking	Pulpwood	Sawlogs	Blocking	Pulpwood	Stumpage	Net[b]
	(tons)			($)				
I	203[c]	229	234	9,374	6,862	4,988	6,320	14,905
II	266[c]	0	332	16,471	0	7,959	9,713[d]	14,717
III	436	162	149	20,056[e]	4,860	3,363	14,215	14,064
IV	302	118	200	15,060	3,068	3,609	8,070	13,666

mbf, thousand board feet.
[a] A portion (0–35%) of sawlogs (small end diameter ≥8 in.) was pallet wood, which, together with blocking (≥5 in. small end, 15–19 ft long) and pulpwood (≥3 in. small end, 15–19 ft long), composed smallwood.
[b] Gross revenues less stumpage ($150 to $190/mbf paid on cruised volume) or shares.
[c] Volume converted to weight according to Doruska et al. (2006).
[d] Based on shares, not stumpage, with the landowner's portion being $1/ton for pulpwood, $30/mbf for pallet wood, $120/mbf for ties and #3 logs, $170/mbf for flooring (none in this study), 60% of grade logs earning $171 to $999/mbf, and 75% of grade/veneer logs earning at least $1,000/mbf.
[e] Includes adjusted stumpage actually paid by mill to landowner to facilitate comparison with other harvests.

costs but did not incorporate inflation or taxes. Fuel costs were the average for the four harvests: $2.55/gallon for diesel and $2.25/gallon for gasoline.

Fuel consumption rates were according to Brinker et al. (2002) for the skidders and loaders and as recorded for the chainsaws in the individual operations. Fuel consumption for the tractor-trailers was the highest value of three local fleets (5 miles per gallon) and assumed an average travel speed of 50 miles per hour. Subsidies for hauling smallwood long distances in two operations were excluded from the analyses.

Owner-operator wages and benefits were not charged to machine costs to reflect the actual practice of these family logging businesses, which is typical for the Missouri Ozarks. Production-based fees for other crew members (skidder operators) in lieu of hourly wages were included in harvest and delivery expenses, again reflecting actual business practice.

Net Operating Revenues

Net operating revenues for the four contractors and sites were calculated and compared. These revenues were based on the actual prices received from the sale of the logs, less actual costs for stumpage and estimated costs for logging, loading, and hauling timber. The average prices paid by the mills to the loggers were $270–$370/mbf for sawlogs, $26–$30/ton for blocking, and $18–$23/ton for pulpwood. Sawlog prices mainly reflected timber quality, whereas the lowest price for pulpwood reflected a general economic decline.

To facilitate comparisons among the four operations, hauling costs were standardized based on average fuel prices and a fixed haul distance (100-mile round trip). The intent was to test financial viability at the most expensive, yet plausible, unsubsidized hauling distance. Actual haul distances were generally lower than this because Missouri Ozark loggers usually quit harvesting at midday to haul a load before returning home.

No allowances were included for moving equipment (using different equipment than that for harvest operations) or overhead because arbitrary allocation of these costs would have further complicated comparisons among the operations. Overhead costs average <3% of total expenditures by small to large logging operations, which often conduct business and keep books from their home (Stuart et al. 2010).

Results

Stand and Harvest Characteristics

The harvested stands were relatively small (17–28 ac) and moderately to highly overstocked with sawtimber (Table 2). Loggers sold 23–35 tons/ac of timber (all classes) from these forest improvement harvests (Tables 2 and 3). This was partly due to high utilization of the harvested trees, with smallwood constituting 51–80% of the green weight and 17–23 tons/ac of the sold timber.

Log size and quality varied considerably among sites. Sites II and III had the largest sawlogs (data not shown) and earned their landowners the highest price per ton (Table 3). Only Site II produced veneer logs, and there the timber was sold on variable shares (Table 3, footnote *d*).

Utilization of FSI trees cut by the landowner immediately before the commercial harvest at Site I was assessed by a complete survey with strip transects. Of the cut trees, 60% were not used because of swamping by tops of felled sawtimber, excessive distance from the deck, failure of the skidder to enter the area, or small size (some trees as small as 4 in. dbh were cut). In retrospect, it would have been better to mark FSI trees and allow the logger to choose whether to fell and extract them. Unfelled trees could then be cut after the commercial harvest.

The FSI trees extracted at Site I accounted for 20% of the pulpwood on a load basis and about 10% of the smallwood on an estimated weight basis (data not shown). Thus, the additional smallwood extracted under FSI complemented topwood (upper stems and large limbs) removed during ordinary operations. Allocation of FSI- and topwood-derived smallwood at the other sites was not possible.

Table 4. Productivity and machine costs of harvest equipment.

Site	Chainsaw	Skidder	Loader	Chainsaw	Skidder	Loader	Tractor/trailer
	(tons/PMH)[a]			($/PMH)			
I	5.0	7.2	22.6	1.68	21.75	34.72	54.22
II[b]	7.0[c]	9.6	NA	2.03[d]	22.53	NA	NA
III	9.5	11.6	33.2	2.29	20.07[e]	34.72[f]	54.22[f]
IV	7.0	10.1	13.1	1.73	19.60	40.73[e]	43.75[e]

[a] Tons/PMH, tons of sawlogs and smallwood per productive machine hour (excluding site preparation and best management practices times).
[b] Missing initial machine time records were corrected by a factor of 1.18, estimated from timber sales.
[c] Includes inseparable Bell tree cutter time, which was 9% of total.
[d] Machine cost of Bell tree cutter was $21.02 per productive machine hour.
[e] Mean of two machines, weighted by their production times in study harvest.
[f] Identical machine used in Site I harvest, which was taken to represent the cost of two similar machines also used in Site III harvest.

Table 5. Standardized harvest and delivery economics for loggers.[a]

Site	Timber revenues	Stumpage or shares cost	Cutting + extraction cost	Loading + hauling cost	Net operating revenue[b]	Net operating revenue	Net operating revenue with smallwood fee[c]
	($/ton)					($/person-day)[d]	
I	31.85	9.48	7.06[e]	4.95	10.35	345	241
II	40.91	16.26	2.92	8.77	12.96	267	232
III	37.81[f]	19.01[f]	4.78[e]	4.38	9.64	267	215
IV	35.02	13.00	4.94[e]	6.50	10.58	235	185

[a] To facilitate comparison among harvest operations, expenditures were based on average fuel costs, a round-trip haul distance of 100 miles (50 loaded miles) for sawlogs and smallwood, and an average hauling speed of 50 miles per hour. Stumpage or share costs were those of the actual harvests, involving generally shorter hauling distances. Machine costs were specific to the equipment actually used and were based on their total times, including site preparation, logging, and best management practices. Tonnage was that of sawlogs and smallwood combined.
[b] Does not account for hauling machines to and from harvest site, business costs other than those of machines and operator fees (where applicable), taxes, and inflation.
[c] If logger paid landowner $5/ton and $4/ton for blocking and pulpwood, respectively, sold in addition to stumpage or shares for sawtimber in actual harvests.
[d] "Person" refers to a logger-owner of the operation (1–3 people), and "day" refers to a productive day on the harvest site (20, 29, 9, and 14 days for Sites I, II, III, and IV, respectively).
[e] Includes production-based fee paid to skidder operator(s).
[f] Includes stumpage actually paid by sawlog mill to facilitate comparison with other harvests.

Harvest Economics

Chainsaw and skidder productivities were correlated (Table 4) and, as expected, were lowest at Site I, which had the smallest skidder and smallest sawlog portion (Tables 1 and 3). Productivities exceeded those previously reported (chainsaw: 4.6 tons/PMH, cable skidder: 7.5 tons/PMH) for the Missouri Ozarks and eastern hardwoods (Becker et al. [2006] and references therein; conversion based on 63 lb/ft^3 for green red oak according to US Forest Service [1975, Table 2.16]).

Machine costs were quite consistent (Table 4), suggesting that any errors or variation in key, undocumented inputs canceled out. For example, these inputs varied three-fold among skidders in our study (see Machine Costs). Our loggers' costs were low because their equipment, except chainsaws, was old and mostly unfinanced (Table 1), with a current machine value generally not exceeding $25,000. According to an unpublished survey of loggers, this is typical for Missouri (Steve Jarvis, pers. comm., Missouri Forest Products Association, Dec. 20, 2010). Although old equipment usually has higher repair and maintenance costs than new, all four contractors in our study kept such costs low by performing service work themselves.

Stumpage or shares for sawtimber represented the greatest expense to loggers on a unit production basis (Table 5). Loading + hauling costs per ton were greatest at Site II where they were contracted, and almost equaled or exceeded cutting + extraction costs, except at Site I. Loading + hauling costs per load ranged from $140 to $260 (data not shown) and had the same rank order by site as the per-ton values.

Loggers' net operating revenues ranged from $10 to $13 per ton or $240 to $340 per day (Table 5). Note that these values were for a conservative hypothetical scenario in which all timber products were hauled 50 loaded miles from woods to mill.

Even under these circumstances, revenue for pulpwood, the least valuable smallwood fraction, exceeded harvest and delivery costs by $6.60 to $13.30 per ton (Tables 3 and 5). At Sites I and III, smallwood made up >90% of loggers' net operating revenues, compared with half at the other sites (data not shown).

Thus, smallwood harvest was profitable without subsidy at these sites and contributed substantially to loggers' net operating revenue. This was because only $0–$1/ton was paid for smallwood, and markets were available within economic hauling distances. Were loggers to pay a modest fee of $4–$5/ton to landowners for blocking and pulpwood sold, their net operating revenues would be reduced but could remain sufficient for loggers to continue harvesting smallwood (Table 5).

BMP Costs

At $0–$5.50/ac, the cost of implementing BMPs was ≤2% of the logger's net operating revenue (data not shown), compared with 7–10% in five Midwestern states (Ellefson and Miles 1985). In our study, BMP costs were calculated from the machine costs and time spent by skidders during installation of erosion-control features. Thus, our BMP costs did not involve expensive road construction, material costs (e.g., culverts), or special harvest practices in streamside management zones. The cost of not skidding during wet weather to avoid rutting was reflected by reduced annual productive machine hours, which raised hourly machine cost (see Machine Costs).

Residual Stand Damage

Under crop tree management, damage to the residual stand has serious economic consequences because the best trees are retained to grow in size and value. In our study, skid trails and decks made up

≤5% of the harvest areas, which retained 6.0–6.6 mbf/ac of sawtimber.

At two sites (III and IV), the percentage of trees with bole wounds (16 and 24%, respectively) substantially exceeded that observed (8.5%) in a study of logging damage in well-supervised group selection harvests in Missouri (Dwyer et al. 2004). The discrepancy may be partly explained by the nature of the harvests. Group selection harvests leave fewer residual trees to be damaged, and the smallwood harvest in our study provided more opportunity for damage. Mean bole wound area (50–85 in.^{2}) was smaller than that observed (141 in.^{2}) in the previous study. Of residual trees in this study, ≤2% suffered sufficient crown damage (10%) to affect their future timber production (Becker et al. 2006).

Discussion

Harvesting smallwood is often perceived by Missouri loggers and foresters as not being financially worthwhile in the short term. However, the results of these four case studies indicated that coharvest of smallwood and sawlogs while applying BMPs can generate positive net operating revenues for loggers. This sort of harvest would enable landowners to practice crop tree management and create healthier forests with improved timber quality to generate higher future revenues.

None of the four logging firms provided complete job charges. They did not note charges for owner-operator wages and benefits, any overhead (e.g., accounting), or future equipment purchases. This reflected their standard practice, but it created difficulties in our study by inflating apparent profits. It also added an extra layer of uncertainty to calculations of margins that could be paid to landowners for smallwood. There was about $10/ton in net operating revenue to absorb additional expenses (Table 5).

These case studies provide a starting point for demonstrating the economic potential of smallwood to loggers and managers. Payment of smallwood fees by loggers would provide additional revenue to landowners and thereby motivate broader adoption of improved forest management, even when cost-share subsidies are unavailable. Our proposed fees of $4–$5/ton for blocking and pulpwood are realistic and feasible because they were based on actual payments during a large-scale salvage harvest conducted after our study (Terry Cunningham, pers. comm., Pioneer Forest, LLC, May 13, 2010).

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