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 (≤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 alone 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...
Table 1. Harvest equipment assessed for machine cost.

<table>
<thead>
<tr>
<th>Site</th>
<th>Chainsaw</th>
<th>Skidder</th>
<th>Loader</th>
<th>Tractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>2008 Husqvarna 372</td>
<td>1992 Timberjack 380B grapple</td>
<td>Service contracted</td>
<td>Service contracted</td>
</tr>
<tr>
<td>IV</td>
<td>2006 Stihl 460</td>
<td>1979 JD 440C cable</td>
<td>1991 Serco 6000</td>
<td>1979 Kenworth W900</td>
</tr>
<tr>
<td></td>
<td>2008 Stihl 460</td>
<td>1998 Serco 7000</td>
<td></td>
<td>1993 Peterbilt</td>
</tr>
</tbody>
</table>

* Only italicized equipment had financing charges.
† Trailers were locally built and unbranded.
‡ 1992 Bell tree cutter was included in the analysis.

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 post-harvest 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 clear cut 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.

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+ yr 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 yr 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 only experienced 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 ≥1.5 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 stop watches 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, deliming, 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 ¼-in. rule for 8- or 9-ft logs) by one of the authors (Site 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 ¼-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 t/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 costs, but did not incorporate inflation or taxes. Fuel costs were the average for the four most likely sources of error in our estimation of machine costs.

Equipment 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 for the Missouri Ozarks. Production-based fees for other crew members (skidder operators) in lieu of hourly wages were
Table 4. Productivity and machine costs of harvest equipment.

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</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5.0</td>
<td>7.2</td>
<td>22.6</td>
<td>1.68</td>
<td>21.75</td>
<td>34.72</td>
<td>54.22</td>
</tr>
<tr>
<td>II</td>
<td>7.0(^c)</td>
<td>9.6</td>
<td>NA</td>
<td>2.03(^d)</td>
<td>22.53</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>III</td>
<td>9.5</td>
<td>11.6</td>
<td>33.2</td>
<td>2.29</td>
<td>20.07(^e)</td>
<td>34.72(^f)</td>
<td>54.22(^f)</td>
</tr>
<tr>
<td>IV</td>
<td>7.0</td>
<td>10.1</td>
<td>13.1</td>
<td>1.73</td>
<td>19.60</td>
<td>40.73(^e)</td>
<td>43.75(^e)</td>
</tr>
</tbody>
</table>

\(^a\) 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.

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 t/acre 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 t/acre 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 utilized due to 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.

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 t/PMH, cable skidder: 7.5 t/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 USDA 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 them 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 in²) 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 co-harvest 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.

Table 5. Standardized harvest and delivery economics for loggers.

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

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 the logger-owner of the operation (1-3 people), and “day” refers to the number of productive days 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.
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 harvesters 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).

Literature Cited


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