Appendix

Land Managers, & Forest Products Operators

West Virginia University, *Economic Evaluation of Small-Scale Timber Harvesting*

An Economic Evaluation of a Small-Scale Timber Harvesting Operation in Western Maryland

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I. – Introduction

Owners of small forestland parcels face daunting challenges when attempting to engage in harvesting and timber stand improvement operations on their forests. Modern timber harvesting contractors are highly capitalized operations with a significant investment in expensive, large-scale equipment designed to leverage labor productivity to a very high level. Successful harvesting contractors are able to achieve levels of productivity that would have been virtually unthinkable just a generation ago. However, this productivity comes at a cost.

As a result of their investment in large-scale equipment, and their corresponding fixed costs, conventional harvesting contractors face considerable transportation and set-up expense when moving from site to site. These costs are manageable so long as they can be spread over a significant acreage and harvest volume. As tract size decreases, however, these costs must be spread over a smaller harvest volume, driving unit costs up. At some point, small tract size makes timber harvesting with conventional equipment uneconomical.

In addition to transportation and set-up costs, highly-capitalized operations face significant monthly fixed costs and often incur large hourly operating costs. Generally, the high productivity achieved by these operations more than offsets these higher costs, resulting in improved profitability compared to under-capitalized operations. However, when productivity is limited by site conditions or other factors, the profitability of highly-capitalized operations quickly erodes. On sites with small average tree size or low harvest volume per acre, it is difficult to achieve the productivity levels required to sustain profitability with highly-capitalized operations. If tract size is also small or if the timber is of low value, the obstacles to profitability are often insurmountable.

With a continued reduction in parcel size in many areas, an increasing number of forestland owners are in possession of forest parcels that are too small for economic timber harvests and timber stand improvement operations using conventional harvesting contractors. These landowners find themselves with limited options to practice forest management, short of performing the work themselves. This phenomenon is most pronounced in areas that are experiencing high levels of development. Not only is forestland being converted to non-forest uses, but much of the remaining forestland is being rendered uneconomical for forest management.

In response to these concerns, the Maryland Department of Natural Resources initiated the Working Woodlot Initiative (WWI) project to examine the feasibility of developing small-scale timber harvesting contractors to perform timber harvesting and associated timber stand improvement on small forestland parcels. Small-scale harvesting operators are characterized by a limited amount of capital investment in equipment, all of which is smaller than conventional harvesting equipment. These operations utilize a limited number of employees, often just the owner-operator, possibly assisted by one or two employees.

The WWI project examined several facets of small-scale harvesting operations, including social aspects and the potential market for such operations. This paper examines the economic feasibility of a small-scale timber harvesting operator and identifies the important factors that determine profitability for these operations.

II. – Methodology

Five privately-owned, non-industrial forestland parcels in Allegany County, Maryland were selected for this project. Sites were selected to provide a range of site and stand conditions. Private forestry consulting firms performed pre-harvest evaluations, prepared silvicultural prescriptions for the sites in accordance with landowner objectives, and marked the stands for harvest. The sites ranged in size from 3.4 acres to 8.7 acres.

Four of the five sites were located within six miles of the operator's residence and place of business. One site (Site 3) was 25.5 miles from the operator's place of business. In order to make the cost analysis of this site compatible with the other sites, vehicle mileage was adjusted for Site 3, assuming the site was 2.5 miles from the operator's place of business. The impact of distance to the site on profitability was handled as a separate analysis.

The owner-operator who performed the harvesting for the project was a sole proprietor who was assisted by one part-time employee, who is related to the operator. Equipment for the operation consisted of a commercial-grade chainsaw, a four-wheel-drive all-terrain vehicle (ATV) used for skidding, and a skidding arch. The skidding arch was purchased after the first three sites were completed and was used only on the final two sites, which had larger average tree sizes compared to the earlier sites. The contractor also used a personal vehicle (four-wheel-drive pick-up truck) to travel to the sites, transport equipment, haul firewood from the sites to a stockpile at the operator's place of business, and deliver firewood to customers.

The operator maintained several data logs while conducting harvesting operations:

Daily Log – Scheduled hours to be worked; weather and site conditions; general comments.
Employee Log – Hours worked by each employee; description of work done.
Equipment Log – Number of hours each piece of equipment was used each day; miles driven; general description of work being done with the equipment.
Expense Log – Amount and description of all business-related expenses.
Production Log – Volume of timber harvested or sold, by species and product type; sale income.

Employee hours were classified into the following categories: 1) Woods (felling, topping, skidding), 2) Landing (bucking, loading), 3) Maintenance / Repair, 4) Preparation (meeting landowner, clearing landing and skid trails), 5) Reclamation (seeding, mulching), 6) Transportation (hauling firewood to stockpile, delivering firewood), and 7) Other (splitting firewood, administrative). Woods and Landing hours were summed into a Field category.

Financial and operations data obtained from the various data logs were used to perform a variety of analyses to examine the profitability of a small-scale harvesting operation, as described in the following sections.

Income Statements

Income statements were generated for each site and the project as a whole using information from the Expense and Production Logs in a format that essentially conforms to Generally Accepted Accounting Principles. Capital assets (all-terrain vehicle, skidding arch, and chainsaw) were depreciated over an expected 5-year useful life, using straight-line depreciation. [1]

Given the nature of a small-scale harvesting operation, purchase of a vehicle specifically for business use is questionable. In lieu of a depreciation charge and actual operation and maintenance expenses, use of a personal vehicle for business purposes was expensed at the Internal Revenue Service reimbursement rate of $0.445 per mile.

Wages were not included as an expense on the income statements. One of the objectives of this study is to determine the equivalent wage rate that can be expected from a small-scale harvesting operation. Operating income, or earnings before interest and taxes (EBIT), was divided by the total number of hours worked to calculate the equivalent wage rate for each site. Most work was carried out by the owner-operator. On occasion, the operator was assisted by another individual. Wages for this individual were not included as an expense item. Therefore, the calculated equivalent wage rate represents the wage rate earned by both individuals, where appropriate.

Expenses were classified as either variable or fixed costs, as appropriate. Variable costs include those items used directly in production, such as gasoline and oil for the ATV and chainsaw; chains and bars for the chainsaw; and seed and straw for reclamation. Incidental expenses (office supplies, postage) were included with variable costs for simplicity. Fixed costs included the depreciation charge for capital assets and business insurance. Vehicle costs were tracked separately from other variable costs to facilitate an analysis of distance to site on profitability.

Time Utilization

Information from the Employee Log was used to measure labor utilization for the project. The relative percentage of time spent on various activities (field work, maintenance, etc.) was calculated for each site. The total number of hours worked and the number of field hours worked each month was tabulated for each site.

Productivity Analysis

Analysis of labor productivity was done using data from the time utilization analysis and Production Log. Because of some potential discrepancy with the production data, data from Sites 1 and 2 was combined for this analysis.
Field productivity (tons produced per field hour worked) and total productivity (tons produced per total hour worked) were calculated for each site. Least squares linear

[1] For research purposes, it is most useful to depreciation capital assets over the useful life, using straight-line depreciation. In actual practice, depreciation would most likely be made using the Modified Accelerated Cost Recovery system (MACRS) and would follow an IRS-mandated depreciation schedule using the mid-year convention rule (6 year depreciation schedule for a 5-year asset). Both methods yield the same depreciation expense during the first year.

regression was performed to analyze field productivity as a function of average tree size (tons per tree), harvested trees per acre, and harvested volume per acre. Data on harvested trees per acre was provided by the consulting forester who marked the sites prior to harvest, as this information was not collected by the operator. To facilitate analysis, volume information from the Production Log was converted to a common unit (tons) by assuming 2.9 tons per cord for cordwood and 9.0 tons per thousand board feet for sawlogs.

Cost Analysis

Data from the income statements and Employee and Production Logs was used to analyze variable and fixed costs per ton produced, per field hour worked, and per total hour worked. Field variable cost (variable cost per field hour, excluding vehicle expense) was calculated for each site and for the project as a whole.

Break-even Quantity

Break-even quantity (tons per month) was calculated for the business using data from the entire project. Since price and variable cost vary among sites depending on several site and operating factors, BEQ was stated as a function of those factors. Several sensitivity analyses were performed to measure the influence of these factors on BEQ.

Expected Monthly Income Analysis

An equation to estimate monthly pre-tax net income was developed using information obtained from the time utilization, productivity, and cost analyses. The equation uses site and operating factors (e.g. productivity, net stumpage price, distance to site) to calculate the expected monthly income for a particular site. This equation was used to measure the impact of changes in the site and operating factors on net income through sensitivity analysis.

Equivalent Wage Rate Analysis

The equivalent wage rate earned by the owner-operator is calculated by dividing monthly pre-tax net income by the total number of hours worked during the month. By utilizing the equation to predict monthly income, an equation was developed to estimate the equivalent wage rate as a function of the important site and operating factors. This equation was used to measure the impact of changes in the site and operating factors on wage rate through sensitivity analysis.

Predicted Gross Stumpage Price

Using data from the Production Log and information provided by the cooperating forestry consultants, least squares linear regression was used to predict gross timber stumpage price (per ton) as a function of the sawlog portion of total harvest volume and the “valuable species” portion of total sawlog volume. For the purposes of this project, “valuable species” are defined as black cherry, oaks, ash and hard maple.

III. – Results

Income Statements

The income statement for the Working Woodlot Initiative project is shown in Table 1. The 21-month term of the project includes considerable idle time between sites as the operator waited for timber marking to be completed, contract preparation, etc. Although there is likely to be similar types of idle time between sites in a commercial harvesting operation, the idle time during this project was probably more than would be experienced operationally. For this reason, the income statement also contains financial information for only the 13 months during which the operator was active. These 13 months include idle time due to weather, poor working conditions, equipment failure, holidays, landowner requests, etc. Such idle time is a normal part of any commercial harvesting operation. This presentation of financial results is also useful for modeling break-even quantity, profit potential, and other important business measures. The only difference between the two financial presentations is the difference in fixed costs (insurance and depreciation) incurred during the idle time between sites. In a true commercial operation, expenses and income would likely lie somewhere between these two extremes.

Table 1 - Income statement for the entire Working Woodlot Initiative project.

Working Woodlot Initiative
Income Statement
All Sites

	Actual (21 months)	**Pro-rated** (13 months)
Gross Revenues	$ 20,445	$ 20,445
Less: Transporation Expense	$ 735	$ 735
Less: Stumpage Fees	$ 4,903	$ 4,903
Net Revenues	$ 14,807	$ 14,807
Operating Expenses		
Fuel, oil, etc. (non-vehicle)	$ 720	$ 720
Vehicle Use	$ 1,127	$ 1,127
Misc. Supplies	$ 176	$ 176
Maintenance	$ 437	$ 437
General & Administrative	$ 117	$ 117
Wages	$ -	$ -
Insurance	$ 1,183	$ 733
Depreciation	$ 3,486	$ 2,148
Total Operating Expenses	$ 7,247	$ 5,458
Total Variable Costs	$ 2,578	$ 2,578
Total Fixed Costs	$ 4,669	$ 2,880
Operating Income (EBIT)	$ 7,560	$ 9,349
Total Hours Worked	1,385.75	1,385.75
Equivalent Wage Rate (per hour)	$ 5.46	$ 6.75

Sites 1 and 2 contained a much larger proportion of cordwood than Sites 3, 4 and 5. In addition, the operator spent considerable time splitting and delivering firewood during operations on Sites 1 and 2. These two activities were kept to a minimum on the remaining sites, which also had a much higher proportion of sawlog material marked for harvest. As a result of these differences, which will be discussed in more detail later in the report, a separate income statement was prepared for Sites 3 -5 alone (Table 2). As with the income statement for the entire project, finances were stated for the entire period between the start of Site 3 and the completion of the project (12 months) and for only the period during which the operator was active (7.5 months). The pro-rated figures include idle time while on a site (weather, etc.), but exclude idle time between sites. Again, the only difference between the two presentations is the fixed cost incurred during idle time between sites.

Table 2 - Income statement for Working Woodlot Initiative project Sites 3, 4 and 5.

Working Woodlot Initiative
Income Statement
Sites 3 - 5

	Actual (12 months)		**Pro-rated** (7.5 months)	
Gross Revenues	$	17,390	$	17,390
Less: Transporation Expense	$	735	$	735
Less: Stumpage Fees	$	4,531	$	4,531
Net Revenues	$	12,124	$	12,124
Operating Expenses				
Fuel, oil, etc. (non-vehicle)	$	465	$	465
Vehicle Use	$	821	$	821
Misc. Supplies	$	29	$	29
Maintenance	$	304	$	304
General & Administrative	$	28	$	28
Wages	$	-	$	-
Insurance	$	676	$	423
Depreciation	$	2,084	$	1,291
Total Operating Expenses	$	4,408	$	3,362
Total Variable Costs	$	1,648	$	1,648
Total Fixed Costs	$	2,760	$	1,713
Operating Income (EBIT)	$	7,716	$	8,762
Total Hours Worked		818.25		818.25
Equivalent Wage Rate (per hour)	$	9.43	$	10.71

As an owner-operator company, wages were not considered as part of the expenses. This approach is useful for our purposes, as this allows the use of business income to calculate an equivalent wage rate for the owner-operator.

For the entire 21-month project, the operator and his assistant worked 1,386 hours and earned an equivalent wage rate of $5.46 per hour (Table 1). Ignoring idle time between sites, and the associated fixed costs, the equivalent wage rate increases to $6.75 per hour.

As a result of a higher proportion of sawlog material and a change in operations (less time spent splitting and delivering firewood), Sites 3 – 5 were significantly more profitable than Sites 1 and 2. The equivalent wage rate on Sites 3 – 5 was $9.43 per hour, or $10.71 per hour if idle time between sites is excluded (Table 2).

For comparative purposes, financial results were also stated on a 'per-ton' and 'per-hour worked' basis for each site. These comparative income statements are found in Tables 3 and 4.

Table 3 - Comparative income statement on a per-ton basis for the Working Woodlot Initiative project.

Working Woodlot Initiative
Comparative Income Statement
Per-Ton Basis, by Site

	Per-Ton					
	Sites 1&2	Site 3 *	Site 4	Site 5	All Sites	Sites 3-5
Gross Revenues	$ 16.32	$ 32.74	$ 54.83	$ 25.21	$ 32.29	$ 39.00
Less: Transportation Expense	$ -	$ 1.49	$ 1.46	$ 1.99	$ 1.16	$ 1.65
Less: Stumpage Fees	$ 1.99	$ 11.34	$ 14.74	$ 3.85	$ 7.74	$ 10.16
Net Revenues	$ 14.34	$ 19.92	$ 38.63	$ 19.37	$ 23.39	$ 27.19
Operating Expenses						
Fuel, oil, etc. (non-vehicle)	$ 1.36	$ 2.04	$ 0.82	$ 0.53	$ 1.14	$ 1.04
Vehicle Use	$ 1.63	$ 2.58	$ 0.80	$ 2.49	$ 1.78	$ 1.84
Misc. Supplies	$ 0.79	$ -	$ 0.17	$ -	$ 0.28	$ 0.07
Maintenance	$ 0.71	$ 0.28	$ 1.23	$ 0.35	$ 0.69	$ 0.68
General & Administrative	$ 0.48	$ 0.07	$ 0.11	$ -	$ 0.19	$ 0.06
Wages	$ -	$ -	$ -	$ -	$ -	$ -
Insurance	$ 1.66	$ 1.68	$ 0.63	$ 0.75	$ 1.16	$ 0.95
Depreciation	$ 4.58	$ 4.64	$ 2.10	$ 2.47	$ 3.39	$ 2.89
Total Operating Expenses	$ 11.20	$ 11.27	$ 5.87	$ 6.59	$ 8.62	$ 7.54
Total Variable Costs	$ 4.97	$ 4.96	$ 3.13	$ 3.37	$ 4.07	$ 3.70
Total Fixed Costs	$ 6.24	$ 6.31	$ 2.73	$ 3.22	$ 4.55	$ 3.84
Operating Income (EBIT)	$ 3.13	$ 8.65	$ 32.76	$ 12.78	$ 14.77	$ 19.65
Add Back: Stumpage Fees	$ 1.99	$ 11.34	$ 14.74	$ 3.85	$ 7.74	$ 10.16
Potential Operating Income (PEBIT)	$ 5.12	$ 19.99	$ 47.50	$ 16.63	$ 22.51	$ 29.81

** - Distance to site adjusted to maintain compatibility with other sites.*

Table 4 - Comparative income statement on a per-hour basis for the Working Woodlot Initiative project.

Working Woodlot Initiative
Comparative Income Statement
Per-Total Hour Basis, by Site

	Per Total Hour					
	Sites 1&2	Site 3 *	Site 4	Site 5	All Sites	Sites 3-5
Gross Revenues	$ 5.38	$ 13.17	$ 34.57	$ 15.57	$ 14.75	$ 21.25
Less: Transporation Expense	$ -	$ 0.60	$ 0.92	$ 1.23	$ 0.53	$ 0.90
Less: Stumpage Fees	$ 0.66	$ 4.56	$ 9.29	$ 2.38	$ 3.54	$ 5.54
Net Revenues	$ 4.73	$ 8.01	$ 24.35	$ 11.96	$ 10.69	$ 14.82
Operating Expenses						
Fuel, oil, etc. (non-vehicle)	$ 0.45	$ 0.82	$ 0.52	$ 0.33	$ 0.52	$ 0.57
Vehicle Use	$ 0.54	$ 1.04	$ 0.51	$ 1.54	$ 0.81	$ 1.00
Misc. Supplies	$ 0.26	$ -	$ 0.10	$ -	$ 0.13	$ 0.04
Maintenance	$ 0.23	$ 0.11	$ 0.78	$ 0.22	$ 0.32	$ 0.37
General & Administrative	$ 0.16	$ 0.03	$ 0.07	$ -	$ 0.08	$ 0.03
Wages	$ -	$ -	$ -	$ -	$ -	$ -
Insurance	$ 0.55	$ 0.67	$ 0.40	$ 0.46	$ 0.53	$ 0.52
Depreciation	$ 1.51	$ 1.86	$ 1.32	$ 1.53	$ 1.55	$ 1.58
Total Operating Expenses	$ 3.69	$ 4.53	$ 3.70	$ 4.07	$ 3.94	$ 4.11
Total Variable Costs	$ 1.64	$ 1.99	$ 1.98	$ 2.08	$ 1.86	$ 2.01
Total Fixed Costs	$ 2.06	$ 2.54	$ 1.72	$ 1.99	$ 2.08	$ 2.09
Operating Income (EBIT)	$ 1.03	$ 3.48	$ 20.66	$ 7.89	$ 6.75	$ 10.71
Add Back: Stumpage Fees	$ 0.66	$ 4.56	$ 9.29	$ 2.38	$ 3.54	$ 5.54
Potential Operating Income (PEBIT)	$ 1.69	$ 8.04	$ 29.95	$ 10.27	$ 10.28	$ 16.25

** - Distance to site adjusted to maintain compatibility with other sites.*

Time Utilization

Data from the time utilization analysis is presented in Table 5. For the entire project, 70% of the hours worked were productive field hours (in the woods or on the landing). However, this figure ranged from a low of 49% on Site 1 to a high of 83% on Sites 4 and 5. This variation is due to significant time spent splitting and delivering firewood ("Other" category) while working on Sites 1 and 2. Once the operator began concentrating on harvesting, more than 80% of the total hours worked were spent in the field. As expected, maintenance time increased significantly after Site 2, as a consequence of normal usage of the equipment. For the entire project, maintenance consumed 6% of total hours worked. Over the long-term, this figure is likely to be somewhat higher as equipment wears out. Six percent of the hours worked were spent on pre-harvest preparation of the site and post-harvest reclamation. This figure was fairly consistent throughout the project.

Table 5 - Time utilization analysis for the Working Woodlot Initiative project.

Working Woodlot Initiative
Time Utilization Analysis

		Months	Total	Field		Prep. & Reclamation		Maintenance		Other		Hours per Month	
Location	Acres	on Site	Hours	Hours	%	Hours	%	Hours	%	Hours	%	Total	Field
Site 1	3.4	3.5	311.75	152.00	49%	23.50	8%	16.75	5%	119.50	38%	89.07	43.43
Site 2	7.4	2.0	255.75	143.00	56%	12.50	5%	3.75	1%	96.50	38%	127.88	71.50
Site 3	8.7	3.5	292.50	235.25	80%	17.25	6%	28.00	10%	12.00	4%	83.57	67.21
Site 4	3.6	2.0	281.75	234.75	83%	9.00	3%	23.00	8%	15.00	5%	140.88	117.38
Site 5	7.2	2.0	244.00	203.50	83%	17.00	7%	14.00	6%	9.50	4%	122.00	101.75
Project Total	30.3	13.0	1385.75	968.50	70%	79.25	6%	85.50	6%	252.50	18%	106.60	74.50
Sites 3 - 5	19.5	7.5	818.25	673.50	82%	43.25	5%	65.00	8%	36.50	4%	109.10	89.80

Total hours worked per month ranged from 83.6 on Site 3 to 140.9 on Site 5. Assuming 176 potential working hours per month (22 days X 8 hours/day), total hours worked ranged from 48% to 80% of potential working hours (average = 61%). This does not include idle time between sites, but does include idle time during harvesting of a site resulting from inclement weather, inoperable site conditions, illness/vacation time, equipment failure, and landowner requests for work stoppage due to holidays, hunting season, etc.

Productive field hours ranged from 43.4 hours per month on Site 1 to 117.4 hours per month on Site 4. Once the operator began concentrating on harvesting activities, field time averaged nearly 90 hours per month, or just over 50% of potential working hours per month.

Productivity Analysis

Production data from the first two sites may be somewhat misleading. First, there was an expected "learning curve" during the first few weeks of the project, as the operator became familiar with the equipment and the project requirements. Second, the operator was stockpiling firewood from Site 1 for later sale, which may have resulted in some overlap in production reporting from the first two sites. To make this data easier to interpret, data from Sites 1 and 2 was combined for productivity and cost analysis (this combination was not necessary for the time utilization analysis).

Results from the productivity analysis are shown in Table 6. "Valuable Tons" includes tonnage of sawlog-quality trees of cherry, oak, ash, and hard maple. Harvested trees/acre, tons/acre, sawlog tons/acre, and valuable sawlog tons/acre were considerably higher on Site 4 than on the other sites. Average tree size (tons/tree) was considerably higher on Sites 4 and 5 than on Sites 1-3.

Labor productivity (tons/hour) ranged from 0.50 tons/hour on Site 3 to 0.76 tons/hour on Site 4. Productivity was much higher on Sites 4 and 5 compared to the other sites. Not surprisingly, these sites had the highest average tree size and the highest harvest volume per acre. Figures 1 and 2 illustrate the relationships between these two factors and productivity.

Table 6 - Productivity analysis for the Working Woodlot Initiative project.

Working Woodlot Initiative
Productivity Analysis

Location	Acres	Total Trees	Total Tons	Sawlog Tons	Valuable Tons	Trees / Acre	Tons / Acre	Sawlog / Acre	Valuable / Acre	Tons / Tree	Field Hours	Tons / Hour
Sites 1 & 2	10.8	417	187.15	9.16	3.11	38.61	17.33	0.85	0.29	0.45	295.00	0.63
Site 3	8.7	337	117.62	61.21	21.88	38.74	13.52	7.04	2.51	0.35	235.25	0.50
Site 4	3.6	166	177.65	81.95	60.12	46.11	49.35	22.76	16.70	1.07	234.75	0.76
Site 5	7.2	174	150.68	63.68	15.57	24.17	20.93	8.84	2.16	0.87	203.50	0.74
Project Total	30.3	1,094	633.09	215.99	100.67	36.11	20.89	7.13	3.32	0.58	968.50	0.65
Sites 3 - 5	19.5	677	445.94	206.83	97.57	34.72	22.87	10.61	5.00	0.66	673.50	0.66

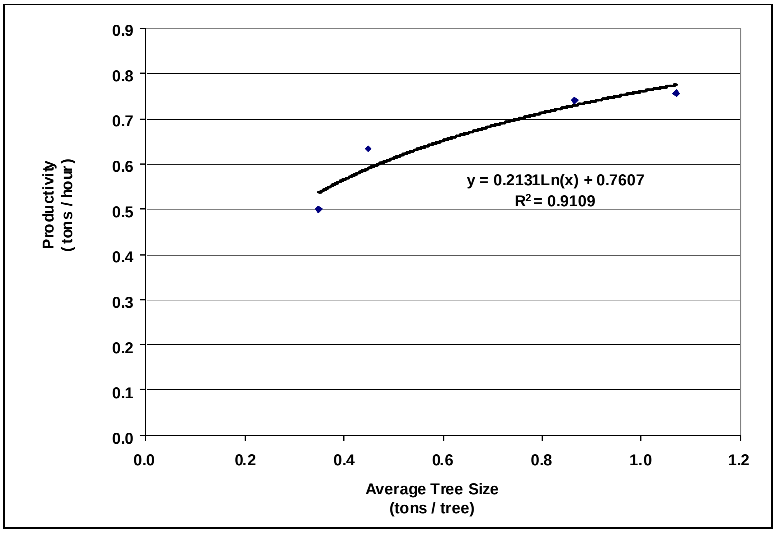

Figure 1 – Relationship between average tree size (tons/tree) and labor productivity (tons/hour).

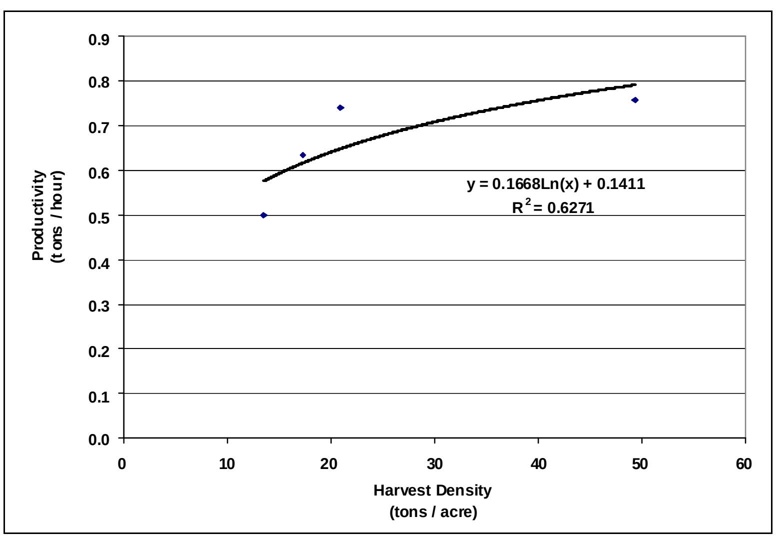

Figure 2 – Relationship between harvest density (tons/acre) and labor productivity (tons/hour).

Due to the limited amount of data, it was impossible to measure the effect of the skidding arch on productivity. The arch was used only on Sites 4 and 5, which also had significantly larger average tree sizes than the other three sites. As a result, any effect of the arch on productivity was masked by the differences in tree size. However, it is reasonable to assume that productivity on Sites 4 and 5 would not have been as great without the use of the skidding arch. The utility of the arch would be expected to be most pronounced on sites with larger trees, where flat skidding would be more difficult.

Cost Analysis

Operating cost data is presented in Table 7. Total and fixed operating costs per ton were nearly twice as high on Sites 1-3 than on Sites 4 and 5. Variable costs per ton were about 50% higher on Sites 1-3 than on Sites 4 and 5. These differences are mostly the result of higher productivity (tons/hour) on Sites 4 and 5 compared to the other sites.

Variable cost per field hour is a valuable measure of operating cost. Since vehicle use is primarily a function of distance, this cost was separated from other variable costs. The impact of distance to the site on profitability will be handled separately in break-even calculations and predictions of monthly income and hourly wage rate.

Non-vehicle variable cost per hour (field variable cost) declined substantially after the first two sites, primarily due to improved efficiency by the operator. For the entire project, field variable cost averaged $1.50 per hour.

Table 7 - Operating cost data for the Working Woodlot Initiative project.

Working Woodlot Initiative
Cost Analysis

	Total	Total	Field	% Time	Tons per Hour		Operating Costs per Ton			Variable Costs per Field Hour		
Location	Tons	Hours	Hours	in Field	Total	Field	Variable	Fixed	Total	Non-vehicle	Vehicle	Total
Sites 1 & 2	187.15	567.50	295.00	52%	0.33	0.63	$ 4.97	$ 6.24	$ 11.20	$ 2.12	$ 1.04	$ 3.15
Site 3	117.62	292.50	235.25	80%	0.40	0.50	$ 4.96	$ 6.31	$ 11.27	$ 1.19	$ 1.29	$ 2.48
Site 4	177.65	281.75	234.75	83%	0.63	0.76	$ 3.13	$ 2.73	$ 5.87	$ 1.76	$ 0.61	$ 2.37
Site 5	150.68	244.00	203.50	83%	0.62	0.74	$ 3.37	$ 3.22	$ 6.59	$ 0.65	$ 1.84	$ 2.50
Project Total	633.09	1385.75	968.50	70%	0.46	0.65	$ 4.07	$ 4.55	$ 8.62	$ 1.50	$ 1.16	$ 2.66
Sites 3 - 5	445.94	818.25	673.50	82%	0.54	0.66	$ 3.70	$ 3.84	$ 7.54	$ 1.23	$ 1.22	$ 2.45

Tons per total hour worked encompasses both a measure of productivity (tons per field hour) and time utilization (ratio of productive field hours worked to total hours worked). Figures 3 – 5 demonstrate the significant impact that the combination of these two factors has on reducing operating costs on a per-ton basis.

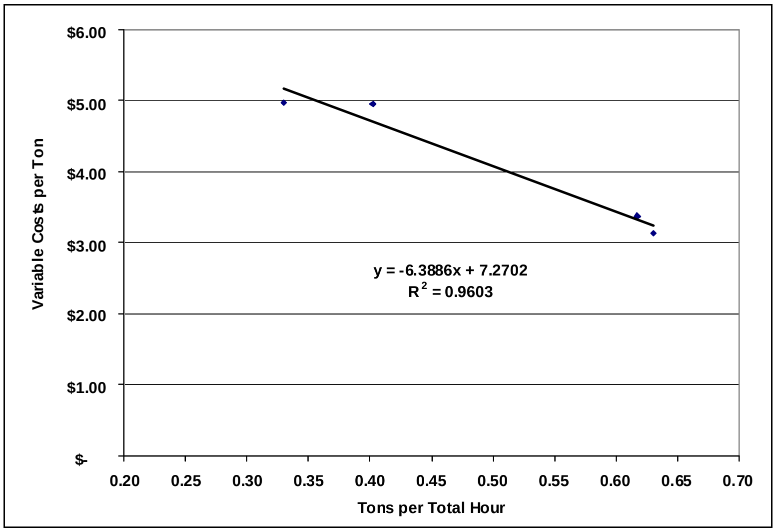

Figure 3 – Relationship between tons per total hour and variable costs per ton.

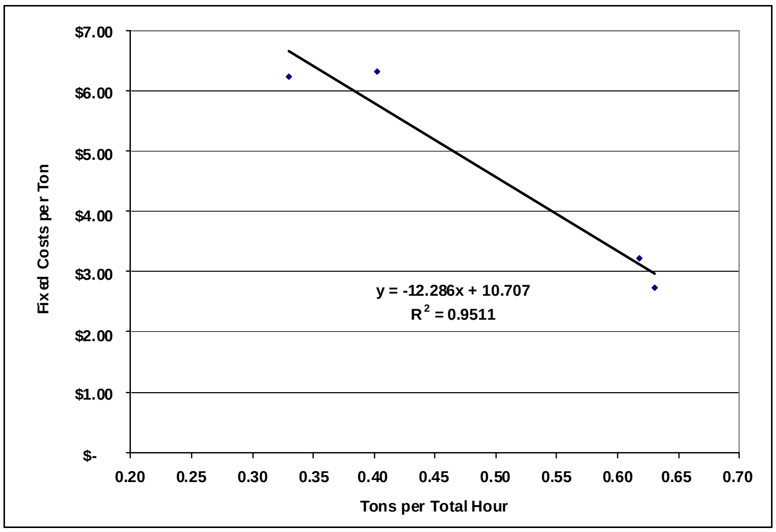

Figure 4 – Relationship between tons per total hour and fixed costs per ton.

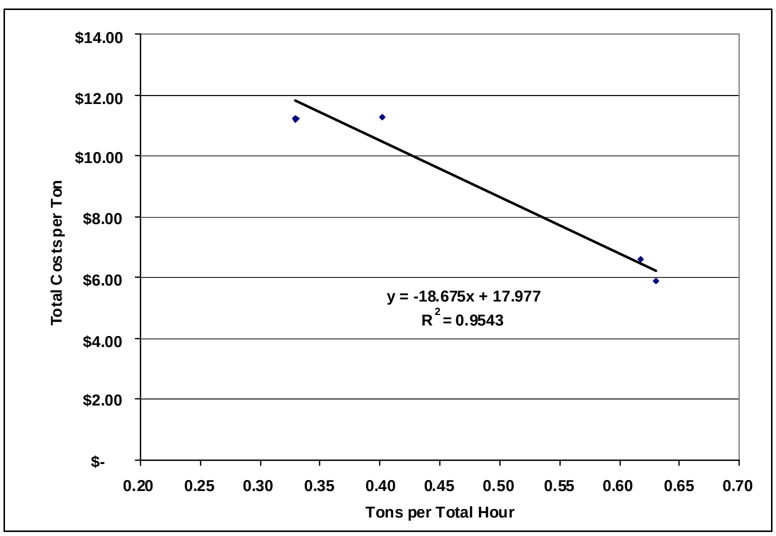

Figure 5 – Relationship between tons per total hour and total costs per ton.

Break-Even Analysis

Break-even quantity (BEQ) is a fundamental calculation for any business with fixed costs. BEQ is the level of production that must be achieved each month to cover the monthly fixed costs. Given the low capital investment by the operator for this project, fixed costs are only $243 per month, consisting of business insurance and depreciation expense for the all-terrain vehicle, skidding arch and chainsaw (Table 8). All three capital assets were depreciated over a 5-year useful life using straight-line depreciation.

Table 8 - Monthly fixed costs for the Working Woodlot Initiative project[2].

Capital Assets					
Asset		Purchase Cost	Useful Life (years)		Monthly Expense
Polaris ATV	$	8,600.00	5	$	143.33
Stihl Chainsaw	$	750.00	5	$	12.50
ATV Skidding Arch	$	1,831.00	5	$	30.52
Total Depreciation Expense				$	186.35
Recurring Expenses					
Logging Insurance				$	56.35
Total Fixed Costs				**$**	**242.70**

Variable costs include consumables used in harvesting (e.g. gasoline and oil), repair and maintenance items (e.g. chainsaw chains and bars), and miscellaneous supplies (e.g. postage, straw for reclamation). Use of a personal vehicle to haul equipment and firewood, as well as to travel to and from the site, is also a variable cost, but is a function of distance to the site rather than a cost attributed to equipment use, etc. For this reason, vehicle use will be considered separately from non-vehicle variable cost ("field variable cost").

Personal vehicle use was charged at the current Internal Revenue Service rate of $0.445 per mile. Given the small-scale nature of the harvesting operation, purchase of a vehicle specifically for the business would not likely be feasible. Analysis of the actual costs of vehicle ownership, operation, and maintenance during this project suggests that the use of the IRS rate is a reasonable approximation of actual expenses, at least for this specific case.

The formula for monthly break-even quantity (BEQ) is:

$$\textbf{BEQ} = \textbf{Fixed Cost} \div (\textbf{Price} - \textbf{Variable Cost}), \qquad (1)$$

where fixed cost is expressed in dollars per month and price and variable cost are expressed in dollars per unit of production (tons, in our case). Since variable cost per ton depends on productivity, BEQ also depends on productivity.

For the WWI project, price is net stumpage revenue per ton, or "net stumpage price" (gross stumpage revenue minus timber transportation cost and stumpage fees paid to the

[2] The skidding arch was purchased after the first three sites were completed. BEQ was calculated assuming ownership of the arch. Actual depreciation expense was adjusted during the project to reflect the change in asset ownership. Accordingly, the depreciation expense for Sites 1 - 3 was $155.83 per month.

landowner). Variable cost consists of two components: 1) field variable cost and 2) vehicle cost. Field variable cost per ton is calculated by dividing field variable cost per hour by productivity (tons per hour). Vehicle cost per hour is calculated by multiplying the round-trip distance by the IRS reimbursement rate and dividing by an assumed 3 field hours per round-trip[3]. Vehicle cost per ton is calculated by dividing vehicle cost per hour by productivity (tons per hour).

For the WWI project, break-even quantity (tons per month) can be stated as:

$$\mathbf{BEQ = F / \{S - [(V_f / P) + (0.445D / 3P)]\},} \qquad \mathbf{(2)}$$

where: F = fixed cost per month
S = net stumpage price per ton
V_f = field (non-vehicle) variable cost per hour
P = productivity (tons per field hour)
D = round-trip distance to site (miles)

Variable costs per field hour (field variable cost) averaged $1.50 per hour (Table 7). As noted earlier, productivity for the entire project averaged 0.65 tons per hour and was slightly higher (0.66 tons per hour) on the final three sites (Table 6). Net stumpage revenue ranged from $14.34 per ton on Sites 1 and 2 to $38.63 per ton on Site 4 (Table 3). The average for all sites was $23.39 per ton, while the average for Sites 3 – 5 (with higher proportions of sawlogs) was $27.19 per ton.

Using average net stumpage price, average productivity for the entire project, and a round-trip distance of 10 miles (typical for the project), monthly break-even quantity is calculated as follows:

BEQ = $243 / {($23.39 – [($1.50 / 0.65) + (4.445 / 1.95)]} = 12.9 tons per month.

As expected, given the low capital investment by the operator, break-even quantity is very low. Assuming average productivity, the number of productive field hours required to break even is: 12.9 tons/month ÷ 0.65 tons/hour = 19.8 hours per month. Thus, the operator could expect to begin making a profit after only 3 full work days each month.

As net stumpage price and productivity change, break-even quantity also changes. Tables 9 and 10 present matrices of break-even quantity assuming varying levels of productivity and net stumpage price with round-trip distances of 10 and 50 miles. For example, for a site 5 miles from the operator's place of business (10 mile round-trip), at a productivity level of 0.60 tons per hour and a net stumpage price of $20.00 per ton, the break-even production quantity would be 16.2 tons per month. At a productivity level of 0.60 tons per hour, this corresponds to a break-even labor quantity of 27 field hours per month. If the round-trip distance increases to 50 miles, break-even quantities increase to 47.2 tons and 79

[3] This number was calculated by dividing total field hours worked on a site by the estimated number of round-trips made (total miles driven divided by round-trip distance) for each site. This value ranged from 1.6 field hours per round-trip on Site 1 to 5.3 field hours per round-trip on Site 3. This value factors in vehicle use for transporting firewood from the site to the operator's place of business and other miscellaneous use, in addition to daily travel to and from the site.

hours per month (Table 10). Table 11 illustrates the impact of distance to the site on break-even quantity, assuming a productivity level of 0.65 tons per hour.

Table 9 - Monthly break-even quantity (tons per month) for the Working Woodlot Initiative project, assuming a round-trip distance of 10 miles and varying levels of productivity and net stumpage price.

Break-Even Quantity (tons per month)
(Round-trip Distance = 10 miles)

Productivity (tons per hour)	Net Stumpage Price ($ per Ton) $10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00
0.50	60.2	26.9	17.3	12.8	10.1	8.4	7.1
0.55	53.0	25.3	16.7	12.4	9.9	8.2	7.0
0.60	48.3	24.2	16.2	12.1	9.7	8.1	6.9
0.65	44.9	23.3	15.7	11.9	9.6	8.0	6.9
0.70	42.3	22.6	15.4	11.7	9.4	7.9	6.8
0.75	40.3	22.0	15.1	11.5	9.3	7.8	6.7
0.80	38.7	21.5	14.9	11.4	9.2	7.8	6.7

Table 10 - Monthly break-even quantity (tons per month) for the Working Woodlot Initiative project, assuming a round-trip distance of 50 miles and varying levels of productivity and net stumpage price.

Break-Even Quantity (tons per month)
(Round-trip Distance = 50 miles)

Productivity (tons per hour)	Net Stumpage Price ($ per Ton) $10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00
0.50			112.0	33.9	19.9	14.1	10.9
0.55			64.1	27.6	17.6	12.9	10.2
0.60		1747.4	47.2	23.9	16.0	12.1	9.7
0.65		189.3	38.6	21.5	14.9	11.4	9.2
0.70		107.3	33.4	19.8	14.1	10.9	8.9
0.75		78.0	29.9	18.5	13.4	10.5	8.6
0.80		63.0	27.4	17.5	12.9	10.2	8.4

Table 11 - Monthly break-even quantity (tons per month) for the Working Woodlot Initiative project, assuming productivity of 0.65 tons per hour and varying levels of round-trip distance and net stumpage price.

Break-Even Quantity (tons per month)
(Productivity = 0.65 tons per hour)

Round-trip Distance (miles)	Net Stumpage Price ($ per Ton) $10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00
10	44.9	23.3	15.7	11.9	9.6	8.0	6.9
20	77.6	29.9	18.5	13.4	10.5	8.6	7.3
30	286.8	41.5	22.4	15.3	11.6	9.4	7.9
40		68.1	28.3	17.9	13.1	10.3	8.5
50		189.3	38.6	21.5	14.9	11.4	9.2
60			60.7	27.0	17.3	12.8	10.1
70			141.3	36.1	20.7	14.5	11.2

The impact of distance to the site on break-even quantity is most pronounced on sites with low net stumpage price. With stumpage prices of $25 per ton or more, the impact is rather modest. However, with stumpage prices of less than $25 per ton, distance to the site has a tremendous impact. For example, with a stumpage price of $10 per ton, it is impossible to break-even on a site with a round-trip distance of 50 miles, regardless of productivity (Table 10). Even with a stumpage price of $15 per ton, it would be extremely difficult to break-even unless productivity is very high.

Throughout the project, the operator was able to produce in excess of 30 tons each month. As long as net stumpage price is $25 per ton or greater and round-trip distance is less than 50 miles, the operator should be assured of earning at least some profit, regardless of productivity. With low stumpage prices or long round-trip distances, productivity becomes an important factor in determining profitability. With low stumpage prices, distance to the site must be kept low to provide any chance of profitability.

Keep in mind that wages are excluded from our costs. Therefore, profitability only ensures that the operator will make some labor income, although the wage rate could be very low.

<u>Expected Monthly Income Analysis</u>

The basic business income formula is:

$$\mathbf{I = R - (V + F),} \qquad \mathbf{(3)}$$

where: I = pre-tax net income
R = revenue
V = variable cost
F = fixed cost

For our project, revenue can be restated as:

$$\mathbf{R = SPH_f,} \qquad \mathbf{(4)}$$

where: S = net stumpage price per ton
P = productivity, in tons per field hour
H_f = productive (field) hours worked

For the WWI project, variable cost is a combination of field variable cost and vehicle use cost. Total variable cost can be stated as:

$$\mathbf{V = H_f\,[V_f + (0.445D / 3)],} \qquad \mathbf{(5)}$$

Inserting Equations (4) and (5) into Equation (3) yields the income formula for the WWI project:

$I = SPH_f - H_f[V_f + (0.445D / 3)] - F$, which can be rearranged as:

$$\mathbf{I = H_f(SP - V_f - 0.14833D) - F} \qquad \mathbf{(6)}$$

Field variable cost averaged $1.50 per field hour. Likewise, we might make an assumption that labor productivity is not likely to exceed 0.75 tons per hour over the long-term. With these two assumptions, income becomes a function of field hours worked, net stumpage price, and distance to the site. Tables 12 and 13 show predicted monthly pre-tax income as a function of number of field hours worked and net stumpage price, assuming productivity of 0.75 tons per hour and either a 10 or 50 mile round-trip distance.

Table 12 - Prediction of monthly pre-tax income for the Working Woodlot Initiative project, assuming productivity of 0.75 tons per hour, a round-trip distance of 10 miles, and varying levels of field hours worked and net stumpage price.

Monthly Income
(productivity = 0.75 tons per hour)
(round-trip distance = 10 miles)

Net Stumpage Price ($ per Ton)

Field Hours per Month	$10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00
60	$28	$253	$478	$703	$928	$1,153	$1,378
70	$73	$336	$598	$861	$1,123	$1,386	$1,648
80	$119	$419	$719	$1,019	$1,319	$1,619	$1,919
90	$164	$501	$839	**$1,176**	$1,514	$1,851	$2,189
100	$209	$584	$959	$1,334	$1,709	$2,084	$2,459
110	$254	$667	$1,079	$1,492	$1,904	$2,317	$2,729
120	$299	$749	$1,199	$1,649	$2,099	$2,549	$2,999

Table 13 - Prediction of monthly pre-tax income for the Working Woodlot Initiative project, assuming productivity of 0.75 tons per hour, a round-trip distance of 50 miles, and varying levels of field hours worked and net stumpage price.

Monthly Income
(productivity = 0.75 tons per hour)
(round-trip distance = 50 miles)

Net Stumpage Price ($ per Ton)

Field Hours per Month	$10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00
60	-$328	-$103	$122	$347	$572	$797	$1,022
70	-$342	-$79	$183	$446	$708	$971	$1,233
80	-$356	-$56	$244	$544	$844	$1,144	$1,444
90	-$370	-$33	$305	**$642**	$980	$1,317	$1,655
100	-$384	-$9	$366	$741	$1,116	$1,491	$1,866
110	-$399	$14	$426	$839	$1,251	$1,664	$2,076
120	-$413	$37	$487	$937	$1,387	$1,837	$2,287

For example, assuming a net stumpage price of $25 per ton (close to the average for the project) and 90 field hours worked per month (the average for Sites 3 – 5), the operator should expect a monthly income of $1,176 if the distance to the site is 5 miles (10 mile round-trip). If the distance to the site increases to 25 miles (50 mile round-trip), expected income falls to $642 per month, or just over half the income if the site was only 5 miles distant. With long distances and low stumpage prices (below $20 per ton), it is virtually impossible to generate any net income, even with high productivity and a large number of field hours worked (Table 13).

As Tables 12 and 13 clearly illustrate, net stumpage price is an important determinant of income. Assuming 80-100 field hours per month, an increase in stumpage price of $5.00 per ton results in an additional $300 - $400 in monthly income. With a stumpage price of $20 per ton, the contractor must work at least 110 field hours per month (if the distance is 10 miles) to generate a monthly income of at least $1,000. With a stumpage price of $30 per ton, the contractor only needs to work 70 field hours per month to earn at least $1,000 per month. With a round-trip distance of 50 miles, stumpage price must be at least $30 per ton for the operator to earn $1,000 per month, regardless of number of field hours worked.

Productivity on Sites 1 - 3 was considerably lower than on the other sites, due primarily to the smaller average tree size. Tables 14 and 15 show predicted monthly income as a function of number of field hours worked and net stumpage price, assuming productivity of only 0.50 tons per hour and either a 10 or 50 mile round-trip distance.

Table 14 - Prediction of monthly pre-tax income for the Working Woodlot Initiative project, assuming productivity of 0.50 tons per hour, a round-trip distance of 10 miles, and varying levels of field hours worked and net stumpage price.

Monthly Income
(productivity = 0.50 tons per hour)
(round-trip distance = 10 miles)

Net Stumpage Price ($ per Ton)

Field Hours per Month	$10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00
60	-$122	$28	$178	$328	$478	$628	$778
70	-$102	$73	$248	$423	$598	$773	$948
80	-$81	$119	$319	$519	$719	$919	$1,119
90	-$61	$164	$389	**$614**	$839	$1,064	$1,289
100	-$41	$209	$459	$709	$959	$1,209	$1,459
110	-$21	$254	$529	$804	$1,079	$1,354	$1,629
120	-$1	$299	$599	$899	$1,199	$1,499	$1,799

Table 15 - Prediction of monthly pre-tax income for the Working Woodlot Initiative project, assuming productivity of 0.50 tons per hour, a round-trip distance of 50 miles, and varying levels of field hours worked and net stumpage price.

Monthly Income
(productivity = 0.50 tons per hour)
(round-trip distance = 50 miles)

Net Stumpage Price ($ per Ton)

Field Hours per Month	$10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00
60	-$478	-$328	-$178	-$28	$122	$272	$422
70	-$517	-$342	-$167	$8	$183	$358	$533
80	-$556	-$356	-$156	$44	$244	$444	$644
90	-$595	-$370	-$145	**$80**	$305	$530	$755
100	-$634	-$384	-$134	$116	$366	$616	$866
110	-$674	-$399	-$124	$151	$426	$701	$976
120	-$713	-$413	-$113	$187	$487	$787	$1,087

As expected, estimated monthly pre-tax income falls off dramatically with lower productivity. Assuming a stumpage price of $25 per ton and 90 field hours worked, monthly income is only $614 if the round-trip distance is 10 miles. This is only slightly more than half the expected income if productivity is 0.75 tons per hour. With lower productivity, stumpage price must remain above $30 per ton and the contractor must work more than 110 field hours per month in order to earn at least $1,000 per month. With a 50 mile round-trip to the site, it is very unlikely the contractor will earn $1,000 per month if productivity is 0.50 tons per hour and it is very likely the contractor will lose money if stumpage price falls below $25 per ton, regardless of number of field hours worked.

Equivalent Wage Rate Analysis

Since wages are excluded from our financial reporting, the equivalent wage rate for the owner-operator is found by dividing monthly income by the total number of hours worked during the month:

$$\mathbf{W = I / H_t} \qquad \textbf{(7)}$$

where: W = hourly wage rate
H_t = total number of hours worked during the month

Time utilization (U) is the ratio of productive field hours to total hours worked:

$$\mathbf{U = H_f / H_t} \qquad \textbf{(8)}$$

Thus, wage rate can be re-stated as:

$$\mathbf{W = UI / H_f} \qquad \textbf{(9)}$$

Inserting Equation (6) into equation (9) yields the wage rate formula for the WWI project:

$$\mathbf{W = U(SP - V_f - 0.14833D) - (UF / H_f)} \qquad \textbf{(10)}$$

The effect of the number of field hours worked on the hourly wage rate is simply to reduce the impact of the fixed costs, by spreading those costs out over a greater number of hours. Although the number of field hours worked each month has a significant impact on monthly income, the effect on the hourly wage rate is rather minimal. For example, increasing the number of field hours worked from 70 to 90 hours each month increases the wage rate by only $0.62 per hour, all other factors held constant.

By contrast, the total number of hours worked has a significant impact on the hourly wage rate. As non-productive hours increase, there is no change in income and, as a consequence, income is spread out over a greater number of hours worked, resulting in a lower wage rate. This relationship between total hours and field hours worked is expressed by the time utilization ratio.

If we assume a field variable cost of $1.50 per hour (average for the project), productivity of 0.75 tons per hour (average for Sites 4 and 5) and 90 field hours worked per month (average for Sites 3 – 5), wage rate becomes a function of net stumpage price, distance to the site, and time utilization (% field hours worked). Tables 16 and 17 show impact of stumpage price and time utilization on wage rate, assuming 90 field hours worked per month, productivity of 0.75 tons per hour, and a round-trip distance of either 10 or 50 miles.

Table 16 - Prediction of equivalent wage rate assuming 90 field hours worked per month, productivity of 0.75 tons per hour, a round-trip distance of 10 miles, and varying levels of time utilization (% field hours) and net stumpage price.

Equivalent Wage Rate ($ per hour)
(productivity = 0.75 tons per hour)
(round-trip distance = 10 miles)

% Field Time	Net Stumpage Price ($ per Ton): $10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00
50%	$0.91	$2.79	$4.66	$6.54	$8.41	$10.29	$12.16
55%	$1.00	$3.06	$5.13	$7.19	$9.25	$11.31	$13.38
60%	$1.09	$3.34	$5.59	$7.84	$10.09	$12.34	$14.59
65%	$1.18	$3.62	$6.06	$8.50	$10.93	$13.37	$15.81
70%	$1.27	$3.90	$6.52	$9.15	$11.77	$14.40	$17.02
75%	$1.37	$4.18	$6.99	$9.80	$12.62	$15.43	$18.24
80%	$1.46	$4.46	$7.46	$10.46	$13.46	$16.46	$19.46

Table 17 - Prediction of equivalent wage rate assuming 90 field hours worked per month, productivity of 0.75 tons per hour, a round-trip distance of 50 miles, and varying levels of time utilization (% field hours) and net stumpage price.

Equivalent Wage Rate ($ per hour)
(productivity = 0.75 tons per hour)
(round-trip distance = 50 miles)

% Field Time	Net Stumpage Price ($ per Ton): $10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00
50%	-$2.06	-$0.18	$1.69	$3.57	$5.44	$7.32	$9.19
55%	-$2.26	-$0.20	$1.86	$3.93	$5.99	$8.05	$10.11
60%	-$2.47	-$0.22	$2.03	$4.28	$6.53	$8.78	$11.03
65%	-$2.67	-$0.24	$2.20	$4.64	$7.08	$9.51	$11.95
70%	-$2.88	-$0.25	$2.37	$5.00	$7.62	$10.25	$12.87
75%	-$3.08	-$0.27	$2.54	$5.35	$8.17	$10.98	$13.79
80%	-$3.29	-$0.29	$2.71	$5.71	$8.71	$11.71	$14.71

Assuming productivity of 0.75 tons per hour (a high level of productivity), a round-trip distance of 10 miles, and a net stumpage price of $25 per ton (both typical for the project), the operator would need to spend at least 80% of his working hours in the field in order to earn a wage rate of at least $10.00 per hour (Table 16). With net stumpage prices below $25 per ton, it is virtually impossible for the operator to earn $10.00 per hour, even with high productivity, good time utilization, and a short travel distance to the site. As distance to the site increases to 25 miles (50 mile round-trip), a net stumpage price of $35 per ton is necessary to earn a wage rate of $10.00 per hour, even with high productivity and good time utilization (Table 17).

As productivity drops to a low level (e.g. on sites with small average tree size and lower harvest volume per acre), wage rate drops significantly. Tables 18 and 19 show the impact of stumpage price and time utilization on wage rate when productivity is 0.50 tons per hour (again assuming 90 field hours worked per month).

Table 18 - Prediction of equivalent wage rate assuming 90 field hours worked per month, productivity of 0.50 tons per hour, a round-trip distance of 10 miles, and varying levels of time utilization (% field hours) and net stumpage price.

Equivalent Wage Rate ($ per hour)
(productivity = 0.50 tons per hour)
(round-trip distance = 10 miles)

% Field Time	Net Stumpage Price ($ per Ton) $10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00
50%	-$0.34	$0.91	$2.16	$3.41	$4.66	$5.91	$7.16
55%	-$0.37	$1.00	$2.38	$3.75	$5.13	$6.50	$7.88
60%	-$0.41	$1.09	$2.59	$4.09	$5.59	$7.09	$8.59
65%	-$0.44	$1.18	$2.81	$4.43	$6.06	$7.68	$9.31
70%	-$0.48	$1.27	$3.02	$4.77	$6.52	$8.27	$10.02
75%	-$0.51	$1.37	$3.24	$5.12	$6.99	$8.87	$10.74
80%	-$0.54	$1.46	$3.46	$5.46	$7.46	$9.46	$11.46

Table 19 - Prediction of equivalent wage rate assuming 90 field hours worked per month, productivity of 0.50 tons per hour, a round-trip distance of 50 miles, and varying levels of time utilization (% field hours) and net stumpage price.

Equivalent Wage Rate ($ per hour)
(productivity = 0.50 tons per hour)
(round-trip distance = 50 miles)

% Field Time	Net Stumpage Price ($ per Ton) $10.00	$15.00	$20.00	$25.00	$30.00	$35.00	$40.00
50%	-$3.31	-$2.06	-$0.81	$0.44	$1.69	$2.94	$4.19
55%	-$3.64	-$2.26	-$0.89	$0.49	$1.86	$3.24	$4.61
60%	-$3.97	-$2.47	-$0.97	$0.53	$2.03	$3.53	$5.03
65%	-$4.30	-$2.67	-$1.05	$0.58	$2.20	$3.83	$5.45
70%	-$4.63	-$2.88	-$1.13	$0.62	$2.37	$4.12	$5.87
75%	-$4.96	-$3.08	-$1.21	$0.67	$2.54	$4.42	$6.29
80%	-$5.29	-$3.29	-$1.29	$0.71	$2.71	$4.71	$6.71

As Tables 18 and 19 clearly demonstrate, with a low level of productivity, it is exceedingly difficult to earn a wage rate greater than $10.00 per hour, and is essentially impossible if the round-trip distance is 50 miles. With low stumpage prices (less than $25 per ton) and long travel distance (50 mile round-trip), the operator is almost assured of incurring a loss (Table 19).

Prediction of Gross Stumpage Price

Since net stumpage price has a strong influence on both monthly net income and the equivalent hourly wage rate, a careful analysis of the expected stumpage price must be made to determine if a particular site is likely to be profitable. Net stumpage price is calculated by deducting timber transportation expense and stumpage fees paid to the landowner from the gross price received from the mill(s). Transportation expense is simply a function of distance from the site to the purchasing mill. Stumpage fees paid to the landowner are subject to negotiation between the operator and the landowner. The strategies and considerations of such negotiations are beyond the scope of this project. However, gross stumpage price (the price received from the mill) is generally the most important factor affecting net stumpage price.

Sawlog volume per acre and the proportion of valuable species on the site are critical determinants of gross stumpage price. A pre-harvest inventory of the site will yield the information necessary to ascertain the expected stumpage price. Using information from the inventory and knowledge of current timber prices, a fairly precise estimate can usually be calculated. For our purposes, however, a more generalized assessment of expected gross stumpage price is sufficient.

Using information from this project, a general equation was developed to predict gross stumpage price based on: 1) sawlog volume as a percentage of total harvest volume and 2) valuable species (cherry, ash, oak and hard maple) volume as a percentage of total sawlog volume. Based on data from the five sites on this project, the stumpage price prediction equation is:

$$\mathbf{S_g = 46.99Q_s + 29.48Q_v + 2.08 \qquad R^2 = 0.90 \qquad (11)}$$

where: S_g = gross stumpage price per ton
Q_s = sawlog portion of total harvest volume (percent)
Q_v = valuable species portion of total sawlog volume (percent)

Table 20 shows predicted gross stumpage price for various proportions of sawlog harvest volume and valuable species portion of total sawlog volume.

The average gross stumpage price on Sites 3 – 5 (the sites with the higher proportions of sawlogs harvested) was $39.00 per ton (Table 3), although this is somewhat skewed by the very high stumpage price on Site 4. These sites were also the most profitable for the operator. Therefore, $35 per ton is a reasonable target gross stumpage price to ensure satisfactory profit for the operator.

Table 20 - Prediction of gross stumpage price per ton assuming varying proportions of sawlog volume to total harvest volume and valuable species as a proportion of total sawlog volume.

Predicted Gross Stumpage Value

Sawlog Volume as Percentage of Total Harvest

Valuable Species as % of Total Sawlogs	10%	20%	30%	40%	50%	60%	70%	80%	90%
10%	$9.72	$14.42	$19.12	$23.82	$28.52	$33.22	$37.91	$42.61	$47.31
20%	$12.67	$17.37	$22.07	$26.77	$31.47	$36.16	$40.86	$45.56	$50.26
30%	$15.62	$20.32	$25.02	$29.72	$34.41	$39.11	$43.81	$48.51	$53.21
40%	$18.57	$23.27	$27.97	$32.66	$37.36	$42.06	$46.76	$51.46	$56.16
50%	$21.52	$26.21	$30.91	$35.61	$40.31	$45.01	$49.71	$54.41	$59.10
60%	$24.46	$29.16	$33.86	$38.56	$43.26	$47.96	$52.66	$57.35	$62.05
70%	$27.41	$32.11	$36.81	$41.51	$46.21	$50.91	$55.60	$60.30	$65.00
80%	$30.36	$35.06	$39.76	$44.46	$49.16	$53.85	$58.55	$63.25	$67.95
90%	$33.31	$38.01	$42.71	$47.40	$52.10	$56.80	$61.50	$66.20	$70.90

As Table 19 illustrates, as the sawlog portion of the harvest falls below 50%, it becomes increasingly doubtful that the gross stumpage price will exceed $35 per ton, unless there is a very high proportion of valuable species. For example, if 50% of the harvest volume is sawlog material, only one-third of the sawlogs must be of valuable species to generate a stumpage price of $35 per ton. If only 40% of the harvest volume is sawlog material, roughly half of the sawlogs must be of valuable species to generate the same stumpage price. If the sawlog portion of the harvest falls to 30%, nearly two-thirds of the sawlogs must be of valuable species to generate a stumpage price of $35 per ton.

<u>Distance to Site vs. Net Stumpage Price</u>

Distance to the site and net stumpage price are both important determinants of profitability for the operation. Since the impacts of these two factors are counter to one another, there is potential for trade-off between the two factors. As distance to the site increases (decreasing profits), a corresponding increase in stumpage price could offset the effect of distance and maintain a similar level of profitability.

Assuming productivity of 0.75 tons per hour, 90 field hours worked per month, a net stumpage price of $20 per ton, and a round-trip distance of 10 miles, monthly income is projected to be $839 (Table 21). As round-trip distance to the site increases to 20 miles, monthly income falls to $705. However, if there is a corresponding increase in net stumpage price to $22 per ton, projected monthly income remains virtually unchanged ($840). As Table 21 illustrates, a $2.00 per ton increase in net stumpage price roughly offsets a 10 mile increase in round-trip distance.

At lower levels of productivity, a larger increase in net stumpage price is required to offset the increase in distance. For example, if productivity drops to 0.65 tons per hour, an increase in net stumpage price of about $2.40 per ton is necessary to offset a 10 mile increase in round-trip distance. A reasonable rule of thumb is to require an increase in net stumpage price of $2.00 - $3.00 per ton for each 10 mile increase in round-trip distance.

Table 21 – Impact of net stumpage price and round-trip distance to the site on expected monthly pre-tax income for the Working Woodlot Initiative, assuming productivity of 0.75 tons per hour and 90 field hours worked per month.

Monthly Income
(productivity = 0.75 tons per hour)
(90 field hours per month)

	Net Stumpage Price ($ per Ton)						
Round-trip Distance (miles)	$20.00	$22.00	$24.00	$26.00	$28.00	$30.00	$32.00
10	$839	$974	$1,109	$1,244	$1,379	$1,514	$1,649
20	$705	$840	$975	$1,110	$1,245	$1,380	$1,515
30	$572	$707	$842	$977	$1,112	$1,247	$1,382
40	$438	$573	$708	$843	$978	$1,113	$1,248
50	$305	$440	$575	$710	$845	$980	$1,115
60	$171	$306	$441	$576	$711	$846	$981
70	$38	$173	$308	$443	$578	$713	$848

Sensitivity Analysis

Assuming field variable cost has stabilized at $1.50 per hour, examination of Equation (6) reveals that monthly pre-tax income is a function of four factors: 1) net stumpage price, 2) productivity, 3) distance to the site, and 4) number of field hours worked. Similarly, Equation (10) shows that the wage rate is a function of the above four factors plus time utilization.

Using average values from the five project sites, expected monthly income and wage rate is calculated as follows:

Net stumpage price (S) = $23.39 per ton
Productivity (P) = 0.65 tons per field hour
Round-trip Distance (D) = 15 miles
Field Hours Worked (H_f) = 75 hours per month
Time Utilization (U) = 70% (field hours / total hours)

I = 75[$23.39(0.65) – $1.50 – 0.14833(15)] – 243 = <u>$617.89 per month</u>.

W = 0.7[$23.39(0.65) – $1.50 – 0.14833(15)] – [243(0.7) / 75] = <u>$5.77 per hour</u>.

Income can be increased by improving any of the first four factors, while wage rate can be improved by increasing any of the five factors (although increasing the number of field hours worked will usually have only a minor effect on wage rate). Sensitivity analysis examines the impact of changing one of these factors, while holding the other factors constant.

Table 22 presents the results of sensitivity analysis for each of the five factors, assuming project average values for the remaining factors.

Table 22 – Changes in predicted monthly pre-tax income and hourly wage rate in response to changes in net stumpage price, productivity, distance, field hours worked, and time utilization.

Factor	Change in Factor	Resulting Change in … Monthly Income	Hourly Wage Rate
Net Stumage Price	+ $1.00 per ton	+ $48.75	+ 0.46
Productivity	+ 0.10 tons per hour	+ $175.42	+ $1.64
Distance	+ 10 miles	- $111.25	- $1.04
Field Hours	+ 1 hour per month	+ $11.48	*
Time Utilization	+ 10 percentage points	$0	+ $0.82

* - non-linear change, ranging from $0.08 to $0.01 per hour

For example, as stumpage price increases by $1.00 per ton, monthly income should increase $48.75 and the hourly wage rate should increase by $0.46 per hour. Likewise, as productivity increases from 0.65 tons per hour to 0.75 tons per hour, monthly income should increase $175.42 and the wage rate should increase by $1.64 per hour.

It should be noted that these responses were calculated using project averages for all factors other than the factor being examined. If other values are used for the constant factors, the change in income or wage rate caused by altering the factor being examined will be different from that shown in Table 22. For example, if productivity is assumed to be 0.75 tons per hour (rather than 0.65 tons per hour), an increase in stumpage price of $1.00 per ton would cause income to increase by $56.25 per month (rather than $48.75) and the wage rate to increase by $0.53 per hour (rather than $0.46). The purpose of this analysis is simply to demonstrate the relative magnitude of changes in income and wage rate with changes in the important determinants.

IV. – Discussion and Recommendations

Overall, the financial performance of the small-scale harvesting operation was disappointing. Net income for the entire project averaged $360 per month with an equivalent wage rate of $5.46 per hour, below the federal minimum wage standard. Even excluding idle time between sites, which was probably more than would be experienced operationally, net income was only $719 per month with an equivalent wage rate of $6.75 per hour. This wage rate implies that if the owner-operator paid himself and his part-time assistant $6.75 per hour, the business would have broken even. Generally, this would be considered unacceptable financial performance for a business, as it provides the owner-operator with no return on his capital investment and no compensation for the risk taken by engaging in business activity. At a wage rate greater than $6.75 per hour, which is probably a reasonable assumption, the business actually lost money.

Despite rather dismal financial performance, there is reason to be cautiously optimistic about the prospects for profitable small-scale timber harvesting operations. On Sites 3 -5, which had a higher proportion of sawlog material marked for harvest, net income averaged $1,168 per month with an equivalent wage rate of $10.70 per hour (ignoring idle time between sites). At a wage rate of $9.00 per hour, the business would have generated a profit of nearly $200 per month on these sites. This indicates at least some potential for profit, although profitability is by no means assured and may be difficult to achieve in many instances.

By carefully examining the factors influencing productivity and costs, it is possible to identify the factors controlling profitability and develop guidelines for managing these factors. Carefully managing each of these factors will greatly improve the prospects for a profitable operation on each site, as discussed below.

<u>Productivity</u>

Productivity, measured as tons produced per field hour, is a fundamental determinant of profitability. Over the term of this project, the operator averaged 0.65 tons per field hour, a rate that seems sustainable over the long-term (Table 6). On sites with large average tree size, productivity of 0.75 tons per hour is achievable, as demonstrated on Sites 4 and 5.

Although it was not possible to measure the impact of the skidding arch on productivity during this project, it is reasonable to recommend its use on sites with larger tree sizes, due to the expected difficultly of flat-skidding large trees.

Since productivity is strongly influenced by average tree size, attention should be paid to this important variable. Productivity of 0.65 tons per hour should be obtainable on sites with an average tree size of 0.60 tons per tree (Figure 1). Although less important, harvest volume per acre can also influence productivity (Figure 2). In general, harvest volumes of 20 tons per acre or more should not seriously limit productivity, provided average tree size is adequate.

Target: **Productivity of at least 0.65 tons per field hour.**

Net Stumpage Price

Net stumpage price (gross price received from the mill(s) minus transportation expense and stumpage fees paid to the landowner) was one of the most important determinants of income and wage rate for this project. Transportation expense is largely a function of distance from the site to the mill(s). Accordingly, distance to the mill must be factored into any estimate of net stumpage price.

Stumpage fees paid to the landowner are subject to negotiation between the operator and the landowner and/or the landowner's agent. Payment of stumpage fees may be necessary to secure business and is reasonable when the timber is relatively valuable (high proportion of sawlogs and/or high proportion of valuable species). However, on sites with relatively low stumpage value, due to tree quality, species, etc., payment of stumpage fees must be carefully considered. This is especially true as distance to the site increases.

Based on data from this project, a gross stumpage price of $35 per ton or more significantly increases the profitability of the operation. Sites on which at least 40% of the harvest volume is comprised of sawlogs, and at least 40% of the sawlogs are of valuable species, should generate a gross stumpage value of at least $35 per ton. On sites with lower proportions of sawlog material and valuable species, the operator should consider paying lower (or no) stumpage fees. On sites with little sawlog material, it will be exceedingly difficult to generate satisfactory profit, particularly as distance to the site increases.

Target: **Net stumpage price of $25 per ton for sites less than 5 miles from the operator's place of business. Net stumpage price should increase $2-3 per ton with each 5-mile increase in one-way distance.**

Average Tree Size

Average tree size, measured as tons per tree, is an important variable that impacts two determinants of profitability. First, average tree size has a very strong influence on productivity (Figure 1). Secondly, a large average tree size generally means a higher proportion of sawlog material, provided the trees are of satisfactory quality. Both of these factors strongly affect income and wage rate. Since sites with larger tree sizes are preferable, use of the skidding arch is also recommended.

Target: **Average tree size of at least 0.60 tons per tree.**

Field Hours Worked

Income is directly affected by the number of productive hours worked each month. The operator averaged 90 field hours per month on Sites 3 – 5 (after the operator began concentrating on harvesting operations, rather than firewood sales). This level of activity represents about 50% of the potential working hours in a month, and is reasonable for a yearly average, provided sufficient business is available. However, it is recommended that the operator exceed 90 field hours per month when weather and site conditions are ideal (late spring through early fall) in order to compensate for months when working conditions might prevent the operator from working 90 hours per month in the field.

Target: **Yearly average of 90 field hours worked per month (> 90 hours per month when weather and site conditions permit).**

Time Utilization

Non-productive time does not affect income *per se*, unless non-productive hours become so great that they limit the number of hours available for productive field work. However, non-productive time does impact the equivalent wage rate. Since no income is generated by non-productive work, income must be spread out over a larger number of total hours, reducing the hourly wage rate.

On Sites 3 – 5, the operator consistently kept field hours at 80 - 83% of total hours worked. Thus, it appears that this rate of time utilization is sustainable over the long-term. With a field productivity level of 0.65 tons per hour, 80% time utilization will result in a productivity level of 0.52 tons per total hour worked. This level of total productivity should keep per-ton operating costs at a reasonable level (Figure 5).

Target: **Time utilization (field hours divided by total hours) of at least 80%.**

Distance to the Site

Driving distance from the operator's place of business to the site impacts both net income and the resulting hourly wage rate. Assuming average productivity, stumpage price, and field hours worked, increasing the round-trip distance to the site from 10 to 50 miles reduces net income by $200 per month and the equivalent wage rate by $1.50 per hour. On sites where low expected stumpage price (or low productivity due to small average tree size) already makes the operation marginally profitable, distance to the site can easily make the operation unprofitable.

Target: **Limit distance to the site to 5 miles one-way, unless expected net stumpage price is above $25 per ton. Increase net stumpage price by $2-3 per ton for each 5-mile increase in one-way distance.**

Overall Conclusion

If all of the above minimum targets are met, expected monthly pre-tax income (from Equation 6) is:

I = 90[$25.00(0.65) – $1.50 – 0.14833(10)] – 243 = <u>$951 per month</u>.

The equivalent wage rate (from Equation 10) is:

W = 0.8[$25.00(0.65) – $1.50 – 0.14833(10)] – [243(0.8) / 90] = <u>$8.45 per hour</u>.

Improvement in any of the above areas would be expected to increase monthly pre-tax income and the wage rate. For example, on sites with a large average tree size and corresponding high proportion of sawlog volume to be harvested, productivity of 0.75 tons per hour can be achieved (productivity on Sites 4 and 5 averaged 0.75 tons per hour). Likewise, a net stumpage price of $35 per ton might be possible on such sites (net stumpage price exceeded $35 per ton on Site 4). With good weather and site conditions, as might be expected during summer and early fall, 110 field hours per month is a realistic goal (the operator averaged 110 field hours per month on Sites 4 and 5).

In this case, the expected monthly pre-tax income and wage rate are:

I = 110[$35.00(0.75) – $1.50 – 0.14833(10)] – 243 = <u>$2,316 per month</u>.

W = 0.8[$35.00(0.75) – $1.50 – 0.14833(10)] – [243(0.8) / 110] = <u>$16.85 per hour</u>.

This scenario results in a satisfactory financial performance. Although this scenario is somewhat of a "best case" scenario, it is not unrealistic. Financial performance on Site 4 of this project actually exceeded this level.

Conversely, failure to meet any of the targets will be expected to reduce income and wage rate. On sites with small average tree size and a low proportion of sawlogs (such as Sites 1 and 2), productivity could drop to 0.60 tons per field hour and net stumpage price might be only $15 per ton. Further, inclement weather or other factors might reduce field hours to 70 per month. In this case, the expected monthly pre-tax income and wage rate are:

I = 70[$15.00(0.6) – $1.50 – 0.14833(10)] – 243 = <u>$178 per month</u>.

W = 0.8[$15.00(0.6) – $1.50 – 0.14833(10)] – [243(0.8) / 70] = <u>$2.04 per hour</u>.

This scenario yields an unacceptable income and wage rate, despite good time utilization and a short distance to the site. The financial performance on Sites 1 and 2 was comparable to this scenario.

As can be seen from this analysis, satisfactory profit and wages can be earned from a small-scale harvesting operation. However, close attention must be paid to the important determinants of profitability, as outlined in this paper. As the operator settles into a routine performance level (which has probably already occurred), variable field cost and time utilization are likely to stabilize at fairly consistent levels. Furthermore, productivity will primarily become a function of average tree size. Therefore, the variables that are most likely to influence profitability on a site are average tree size, the proportion of sawlogs to total harvest volume, and distance to the site. Idle time between sites will also affect income. Since the operator's fixed costs are low, the maximum loss due to idle time is $243 per month. However, the true impact of idle time is the income lost by not engaging in productive work. As with virtually any business, satisfactory income will depend on the ability of the operator to maintain a steady flow of work.