Timber Marking Costs in Spruce-Fir: Experience on the Penobscot Experimental Forest

Paul E. Sendak, *USDA Forest Service Northeastern Research Station, P.O. Box 640, Durham, NH 03824-0640.*

ABSTRACT: *In the application of partial harvests, time needs to be allocated to marking trees to be cut. On the Penobscot Experimental Forest located in Maine, eight major experimental treatments have been applied to northern conifer stands for more than 40 yr. Data recorded at the time of marking were used to estimate the time required to mark trees for harvest. A simple linear regression equation is presented that estimates labor hours per acre marked from data on volume marked per acre. North J. Appl. For. 19(1):22–24.*

Key Words: Timber marking, timber harvesting, spruce-fir, Maine.

With the shift in emphasis from strictly timber management to forest management with emphasis on ecosystem functions, partial harvests of timber such as practiced in even-age management with shelterwood systems and uneven-age management with selection systems have gained favor over clearcutting or strict diameter-limit methods. There is also a current emphasis on commercial thinning. In the application of partial harvests, time needs to be devoted to marking trees to be cut or, alternatively, marking trees to leave. According to one school of thought, harvesting crews can be trained to apply a simplified set of rules that eliminates stand marking and results in the residual stand called for in the stand prescription.

On the Penobscot Experimental Forest (PEF) located in east-central Maine, eight major experimental treatments have been applied to northern conifer stands for more than 40 yr [see, for example, Brissette (1996), Seymour and Kenefic (1998)]. These stands of predominantly red spruce (*Picea rubens*), balsam fir (*Abies balsamea*), eastern hemlock (*Tsuga canadensis*), and eastern white pine (*Pinus strobus*) are managed under two shelterwood treatments, three variants of the selection system, clearcutting, and two diameter-limit methods. Prior to cutting, a professional crew marked all harvested trees except for those cut in the clearcut harvests and final shelterwood cuts. Data recorded at the time of marking and additional data from a time study of marking for a selection harvest in 1997 were used to estimate the time required to mark trees for harvest. The results are presented and discussed.

NOTE: The author can be reached at (603) 868-7672; Fax: (603) 868-7604; E-mail: psendak@fs.fed.us.

Methods

Data

Field data were collected for diameter-limit cuts (n = 7) and selection harvests (n = 16). The sample of 23 represents all the partial harvests of compartments with complete data on file. When trees in each stand were marked for harvest, numbers of trees marked, total volume marked, total area marked, and total labor time, were recorded. Marking crews on the PEF usually consisted of three people, though a two-person crew was used occasionally. The crew leader kept the tally of marked trees. The time study included recording the time required to measure each tree (with a diameter tape) and mark it (with a paint gun). Nonproductive time was also recorded. On the forest, trees are marked on opposite sides at operator level and on the stump. The total amount of paint used also was recorded.

Statistical

Several variables were calculated from the data collected in the field. These included labor hours per acre marked, volume marked per hour of labor, trees marked per acre, volume marked per acre, type of harvest (diameter limit or selection), and average distance between marked trees (in feet)

$$\sqrt{43{,}560 / trees / ac}\,.$$

Descriptive statistics are provided in Table 1. A regression analysis was conducted to estimate labor hours per acre marked based on stand characteristics.

Table 1. Descriptive statistics of field data and calculated variables (n = 23).

Variable	Unit	Mean	SD
Field data by compartment			
Volume marked	ft^3	12,485.13	10,587.74
Trees marked	no.	1,150.96	963.76
Area marked	ac	22.66	5.41
Labor	hr	32.58	17.48
Calculated from field data [a]			
Volume marked per hour labor	ft^3/hr	344.07	184.31
Volume marked per acre	ft^3/ac	510.91	397.04
Labor hours per acre marked	hr/ac	1.40	0.61
Trees marked per acre	no./ac	46.78	35.90
Average distance between marked trees	ft	39.17	20.12
Dummy variable			
Type: 1 = selection, 0 otherwise	Proportion	0.70	0.47

[a] Data calculated for each compartment then averaged over compartments.

Results

In estimating labor hours per acre marked based on stand characteristics, all potential independent variables were significantly correlated ($P \leq 0.05$) with the dependent variable. However, the simple linear regression equation with volume marked per acre as the *x*-variable yielded both the greatest r^2, 0.49, and an easy model to interpret (Table 2). In addition, a dummy variable approach (Table 1), determined that type of harvest was not significant.

The following equation for estimating the labor cost of marking was derived using the equation in Table 2:

$$Labor\ Cost = Hourly\ Rate\ [0.844 + 0.00108\ (Volume)] \quad (1)$$

where

Labor Cost = cost of marking ($/ac)

Hourly Rate = average crew cost ($/hr)

Volume = volume to be marked (ft^3/ac)

For example, a three-person crew with two markers at $7.50/hr and one leader/tally person at $15/hr would average $10 for *Hourly Rate*. If the sample average volume per acre of 510.91 ft^3/ac were to be marked, *Labor Cost* would be $13.96/ac ± $1.93, the 95% confidence interval (see Appendix). Assuming stumpage at $0.32/$ft^3$, typical for the PEF, labor cost for marking would represent 8.5% of the value marked.

For the case study of a selection harvest in 1997, 218 trees (3,022 ft^3) were marked on 14.7 ac. A three-person crew, two markers and a tally person, spent 18.5 hr in productive time marking for harvest. It took approximately 0.5 min per tree on average to measure diameter with a tape and mark the tree. Assuming 1.8 hr to measure and mark by the two markers, 10.5 hr was spent traveling between trees looking for those that met the marking criteria. The average distance between marked trees was 54 ft. In addition to productive time, there were 3.7 hr of nonproductive time tallying cruise strips, traveling to the site from the vehicle, and traveling between cruise strips. The crew used 4.5 qt of paint, or 0.66 oz per tree marked, which at $11 per gal would add another $12.38 or $0.84/ac.

Table 2. Results of regression analysis (dependent variable: labor hours per acre marked).

Variable	Coefficient	SE
Constant	0.844*	0.153
Volume marked per acre	0.00108*	0.00024
$F(1,21) = 20.57$ ($P = 0.0002$)		
SE of estimate = 0.44434		
S_{xx} = 3,468,122.043		

* Significant at 1% level.

Discussion

Equation (1) can be used to estimate marking costs in stands similar to those on the PEF if the hourly rates for labor and volume to be marked are known. For example, if the prescription required marking 1,000 ft^3/ac, *Labor Cost* would be $19.24/ac ± $9.75, the 95% prediction interval (see Appendix). The prediction interval always is wider than the confidence interval because both the error associated with future observations and the error from the estimated equation must be taken into account.

The selection compartments on the PEF are managed to BDQ guidelines (basal area, diameter, and *q*-factor). Even the diameter-limit methods applied probably are more complex than most commercial diameter limits, with limits depending on species and tree condition and vigor in some cases. It is possible that more care was taken in marking for harvests than might be the case in a commercial operation. If that is true, cost estimates based on PEF data probably will be greater than those for a commercial operation. For example, a commercial operation might not require trees to be marked on two sides and on the stump; markers might keep their own tally and use ocular estimates of diameter rather than physically measure each tree. Regardless, it is recognized that there is a cost associated with tree marking but that allowing operators to select trees to harvest avoids this cost. However, there may be costs associated with training operators, in the increased time required for them to select trees to cut, and possibly in less than desirable silvicultural results.

APPENDIX

The following is an example of calculating marking cost, confidence limits, and prediction limits. The estimate of cost of marking the sample mean was calculated by substituting

510.91 ft^3/ac for *Volume* and \$10/hr for *Hourly Rate* in Equation (1) and solving to obtain a *Labor Cost* of \$13.96/ac. The 95% confidence interval is estimated by estimating the 95% confidence interval for labor hours per acre marked (Table 2) using

$$t_{0.025,n-2}\sqrt{MS_E\left(\frac{1}{n}+\frac{\left(x_0-\bar{x}\right)^2}{S_{xx}}\right)} \qquad (2)$$

The value of t from a table of the t-distribution is 2.08 with $n - 2 = 21$ df, MS_E is the square of the standard error (SE) of estimate from Table 2. S_{xx} is the corrected sum of squares of the x observations (Table 2) and n is the sample size, 23. In this case, the second term in parentheses is zero because x_0 is the mean. Solving (2) with the appropriate values yields a 95% confidence limit of 1.396 hr/ac ± 0.193. Multiplying by *Hourly Rate* (\$10.00) results in a 95% confidence limit of \$13.96/ac ± \$1.93 for *Labor Cost*.

The prediction interval is calculated in the same manner as the confidence interval except that 1 is added to the quantity within the parentheses in (2). This compensates for the additional error associated with a future observation of volume to be marked, i.e., an observation not used to estimate the regression model in Table 2.

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