

DEVELOPMENT OF REGIONAL STUMP-TO-MILL LOGGING COST ESTIMATORS¹

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ABSTRACT

Planning logging operations requires estimating the logging costs for the sale or tract being harvested. Decisions need to be made on equipment selection and its application on terrain. In this paper a methodology is described that has been developed and implemented to solve the problem of accurately estimating logging costs by region. The methodology blends field time and motion data, simulation analysis, non-linear regression models, and detailed feedback loops.

INTRODUCTION

The planning of logging operations requires estimating logging costs for the sale or tract being harvested. Decisions need to be made on equipment selection and its application on various types of terrain. The major challenge is accurately estimating costs for alternate machines. Traditionally, planners use some combination of time-study data, personal experience, or rules of thumb. Such approaches are cumbersome and time consuming, and the estimates generally are not detailed or accurate. In this paper we describe a methodology that has been developed and implemented to estimate regional logging costs. This methodology integrates field time and motion data, simulation analysis, non-linear regression methods, and detailed feedback loops. The results should be useful for forest managers and planners as well as commercial loggers.

METHODOLOGY

Estimating logging costs requires detailed time and motion data, simulation techniques, and multiple linear and non-linear regression analysis. The general methodology is outlined in Figure 1. Detailed time and motion data are gathered for the machine or machines and range of conditions of interest. The results then are summarized as machine-specific cycle-time equations. Cycle time is the time required to hook and move a turn of logs from the stump to the landing. Cycle-time equations and distributions from the time and motion studies are

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used as inputs to selected simulation models. The simulation models are run repeatedly over the range of operating conditions to develop individual point estimates of cost or production. Finally, the numerous machine-specific point estimates are summarized in equation form by linear or non-linear multiple regression methods. The resulting equations not only are machine-specific, but also include the production variables available to the planners. To summarize:

1. Select the machine or machines to be time studied.
2. Conduct time and motion studies by machine for the expected range of conditions and summarize the data in terms of cycle-time estimators.
3. Choose an appropriate simulation model or models.
4. Input the cycle-time and motion data into the chosen simulation model and conduct numerous runs for the desired conditions to develop cost or production-point estimates.
5. Summarize the point estimates in equation form by regression methods.
6. Validate the equations with actual field data.
7. Program the resulting equations on suitable computers for quick and easy implementation.

The transition from machine to stand parameters is the primary key to successful implementation of stump-to-mill methods and their use by planners. Traditionally, time-study data are summarized in regression equations. The variables used usually include (for cable systems) slope yarding distance, lateral yarding distance, logs per turn, volume per turn, crew size, and percent sideslope. Yet planners and managers usually do their planning with stand parameters such as average diameter of the wood cut, the volume removed per unit area, and some measure of how far the wood must be transported from the stump to the landing and the distance or mileage to mills or processing centers. Most integrated research also requires stand parameters, not cycle-time or machine parameters. The challenge is to transform the cycle-time estimators with machine parameters to cost and production estimators that are sensitive to stand parameters. This transition takes place during the simulations (Fig. 1).

IMPLEMENTATION

The methodology has been applied successfully in the Pacific Northwest to develop stump-to-truck estimators (Fight et al. 1985, LeDoux et al. 1986) and thinning production estimators (LeDoux and Starnes 1986). The methodology has also been used in the eastern hardwood region of the United States (LeDoux 1985a,b, LeDoux 1986). Although these applications have resulted in estimators for cable-logging systems, they also can be used to develop estimators for ground-based, aerial, or other systems.

The estimators are being used by planners and researchers for equipment selection, timber-stand-prescription planning, optimization of silvicultural decisions, break-even analysis, and silvicultural investment analysis.

HARVESTING COST ESTIMATOR

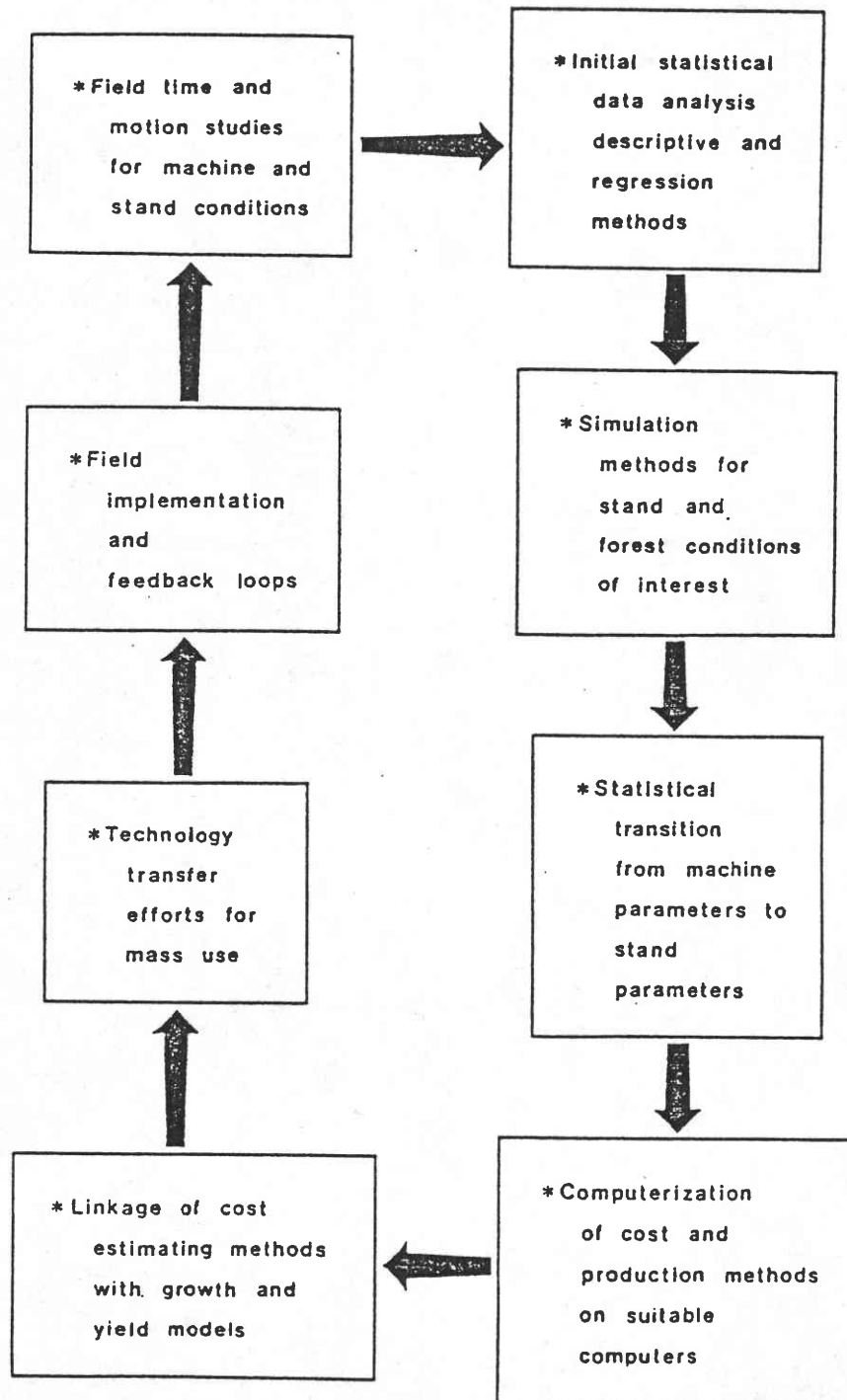


Figure 1. Diagram of stump-to-mill cost estimator methodology.

EXAMPLES OF APPLICATIONS

The methods can be used to compare logging systems. For example, Figure 2 shows the relative skidding/yarding/winchng cost for two cable yarders, a rubber-tired skidder, and a portable bunching winch. The system costs were projected using ECOST (LeDoux 1985a). In all cases, extraction costs decrease with increasing average tree d.b.h. The Radio Horse 9² winch is competitive with the John Deere 540B skidder for a d.b.h. range of 7 to 8. Otherwise, the Radio Horse 9 winch is cheapest to operate, given very short skids, followed by the John Deere 540B skidder and the more expensive cable systems such as the Bitterroot and Clearwater yarders. Although factors such as roading costs, production quotas, and available service facilities also must be considered, comparisons such as those in Figure 2 allow managers and planners to visualize the cost differences of alternative logging systems and technologies.

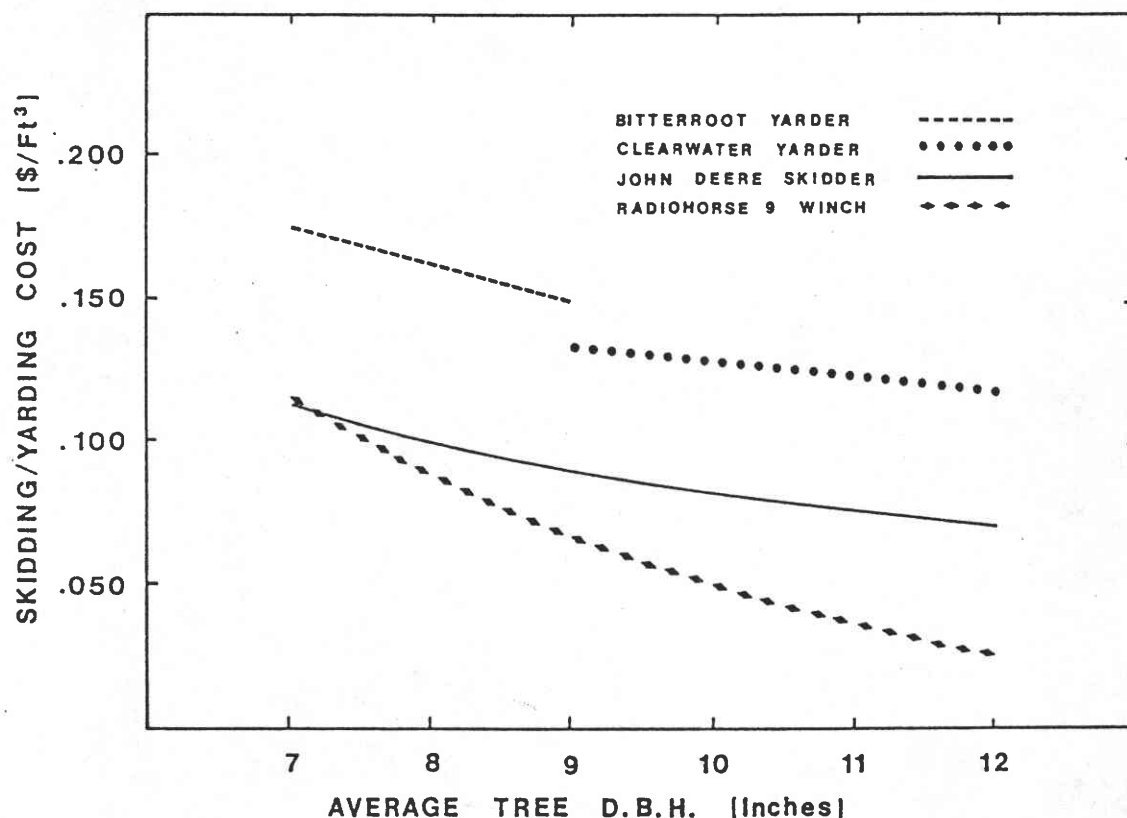


Figure 2. Simulated comparative yarding/skidding/winchng costs for Bitterroot and Clearwater yarders, John Deere 540B skidder, and Radio Horse 9 bunching winch by average d.b.h. of cut trees; conditions: slope yarding distance, 300 feet for Bitterroot and Clearwater; 100 feet for Radio Horse 9; 500 feet for John Deere 540B; volume removed, 3000 ft³/acre for Bitterroot, Clearwater, and John Deere 540B; 700 ft³/acre for Radio Horse 9.

² The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

The methods can be linked with product revenues and market conditions to evaluate stands for thinning feasibility (Fig. 3) and/or what is economical to salvage following mortality resulting from insect pests and natural catastrophes (Fig. 4). For example, Figure 3 links stump-to-mill cost data with product market demand and prices to evaluate what is economically feasible to thin on hardwood sites (LeDoux and Baumgras 1988). Generally, thinning eastern hardwoods with cable systems is economically feasible if market prices are at high levels and the stands to be thinned are close to markets (Fig. 3). For the same conditions, as the average tree d.b.h. of wood harvested increases, thinning becomes economical at high-, medium-, and low-price levels provided the stands are within 20 to 40 miles of the mill or processing center. Matrices such as Figure 3 can help managers and planners understand the impact of considering regional stump-to-mill costs on stand management.

VOLUME HARVESTED	HAUL DISTANCE	AVERAGE TREE D.B.H. (INCHES)					
		7	8	9	10	11	12
-Ft ³ /Acre-	-Miles-						
1000	20	N	N	H	H-M	NA	NA
	40	N	N	N	H		
	60	N	N	N	N		
1500	20	N	H	H	H-M	H-M	H-M-L
	40	N	N	N	H	H	H-M
	60	N	N	N	N	N	H
2000	20	NA	H	H	H-M	H-M	H-M-L
	40		N	N	H	H	H-M
	60		N	N	N	N	H
2500	20	NA	NA	H	H-M	H-M	H-M-L
	40			N	H	H	H-M
	60			N	N	N	H
3000	20	NA	NA	NA	NA	H-M	H-M-L
	40					H	H-M
	60					N	H

Figure 3. Price levels for economically feasible thinning operations. Candidate stands stratified by volume available for removal, average d.b.h. of trees removed, and stand location defined by haul distance (H = high prices; M = medium prices; L = low prices; N = not feasible at high prices, NA = nonexistent d.b.h.-volume combination).

Figure 4 shows what is economical to salvage following gypsy moth mortality for red and white oak using ground-based technology³. Inspection of the matrix suggests that stands averaging 9 inches d.b.h. are not economical to salvage at any price level. Stands averaging

³ LeDoux, C. B. 1989. What's possible, practical, and profitable in salvaging hardwood gypsy moth mortality. USDA For. Serv. Res. Pap. In preparation.

10, 11, and 12 inches d.b.h. are economical to salvage if price levels are high and the stands are close to markets. Stands averaging more than 13 inches d.b.h. are economical to salvage at all combinations of price level and haul distance. This is likely due to the fact that as the average d.b.h. increases, more larger quality logs are produced. Larger logs are cheaper to salvage and also fetch higher market prices.

VOLUME SALVAGED	HAUL DISTANCE	AVERAGE D. B. H. (Inches)								
		7	8	9	10	11	12	13	14	15
1500	20	N	N	N	N	H	H	H M L	H M L	H M L
	40	N	N	N	N	N	N	H M L	H M L	H M L
	60	N	N	N	N	N	N	H M L	H M L	H M L
2000	20	N	N	N	N	H	H	H M L	H M L	H M L
	40	N	N	N	N	N	N	H M L	H M L	H M L
	60	N	N	N	N	N	N	H M L	H M L	H M L
2500	20	N	N	N	N	H	H M	H M L	H M L	H M L
	40	N	N	N	N	N	N	H M L	H M L	H M L
	60	N	N	N	N	N	N	H M L	H M L	H M L
3000	20	N	N	N	H	H	H M	H M L	H M L	H M L
	40	N	N	N	N	N	N	H M L	H M L	H M L
	60	N	N	N	N	N	N	H M L	H M L	H M L

Figure 4. Price levels for economical salvage operations for red and white oak and ground-based logging technology. Candidate stands stratified by volume available for salvage, average d.b.h. of trees cut, and haul distances (H = high prices; M = medium prices, L = low prices; N = not feasible at any price level).

FEEDBACK LOOPS

Developers of stump-to-mill costing methods should concentrate their software development on the needs of prospective users. And as individual user needs change over time, the software should change accordingly. As a result, feedback loops must be established and maintained by the software developers. Our experience has shown that it is the lack of feedback loops between developer and user that generally explains the failure of most logging cost software in the applied setting. The bottom line is that users should be brought into the software development effort early and feedback loops established once the software is implemented.

CONSIDERATIONS FOR USERS

The major advantages of the methodology are that it: (1) can use available time and motion data, (2) brings together volumes of data in general, detailed, accurate, and much

needed form, (3) can be constructed in components for easy updating and validation, (4) is easily computerized for wide distribution and use, and (5) is user friendly and interactive.

The methodology does have disadvantages, the major one being that the development of the necessary time and motion data, the required simulation analysis, and the application of regression tools may be difficult for individual stations, forests, or localized management units. However, these units can and should cooperate with research units to gather data and develop a coordinated program.

Potential users of the developed equations should study them carefully and compare them with current methods in use. Adjustments, refinements, and updates can be incorporated.

To adopt the method, users should choose the equipment types and components they want analyzed. Once these choices have been made, detailed time and motion studies should be conducted. A cooperative effort with a research organization can aid in conducting the simulations and regression analysis, and in computerization efforts. Also, time and motion data from applicable literature can be used to save money and effort.

Blending field time and motion data, simulation analysis, and regression methods will not solve all of the problems in estimating logging costs. However, such methods can simplify the analysis and decisionmaking process for the planner, resulting in more time for better harvesting decisions.

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