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Predicting Bunching Costs for the Radio Horse 9 Winch

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Abstract

Data from field studies and a prebunching cost simulator have been assembled and converted into a general equation that can be used to estimate the prebunching cost of the Radio Horse 9 winch. The methods can be used to estimate prebunching cost for bunching under the skyline corridor for swinging with cable systems, for bunching to skid trail edge to be picked up by a skidder or forwarder, or bunching to roadside for stand cleanings and firewood sales. Costs can be determined easily with a hand calculator. The equation can also be incorporated into larger stump-to-mill desktop and mainframe computer programs.

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Introduction

Because timber harvesting is shifting to young-growth stands, forest managers and loggers are faced with the challenge of matching logging equipment to stand conditions in order to maximize productivity and minimize costs. Harvests in young-stands entail moving large numbers of small logs; production rates are lower and logging costs higher. One method for increasing production is to prebunch logs (bunch prior to yarding, skidding, or forwarding) into decks with small relatively inexpensive winches thus allowing the more expensive swing, skidding, or forwarding machine to develop larger payloads. The expensive and time consuming task of prebunching logs is charged to the less expensive winch, whereas the high payload of the more expensive machine is efficiently used during swinging, skidding, or forwarding. Methods are presented for estimating the bunching costs of such a prebunching winch, the Radio Horse 9.[1]

Background

Prebunching has been applied widely to: helicopters (Dykstra and others 1978), cable systems (Kellogg 1976; Gonsior 1978, 1979; Mason 1979; Keller 1979; Zielinsky 1980), the helistat (Gibson and others 1982); and ground-based systems (Harou and others[2]). A simulation model called THIN (LeDoux and Butler 1981) has been developed to simulate prebunching operations. Sensitivity analysis and equipment configuration evaluations have been conducted (LeDoux and Butler 1982). Prebunching cost estimating methods have been developed and implemented for west coast logging conditions (LeDoux and Starnes 1986).

Recently, prebunching tests were conducted for the Radio Horse 9 winch on five southern New England sites (Harou and others 1985) (Table 1). The field studies quantified the variables that significantly affect the productivity and cost of the Radio Horse 9 winch. A general equation was developed for estimating the prebunching cost of the Radio Horse 9 winch using the data provided by Harou and others[2]; 1986 new equipment, labor, and fuel costs (Table 2); and the THIN (LeDoux and Butler 1981) prebunching simulation model.

[1]The use of trade, firm, or corporation names in this paper 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.

[2]Harou, P. A.; Kling, B. W.; MacConnel, W.; Thompson, C.; Morin, D.; Zheng, C. Financial feasibility of the Radio Horse 9 winch. Cooperative Agreement 23–792. Final Report. Broomall, PA: 1985. U.S. Department of Agricultural, Forest Service, Northeastern Forest Experiment Station; 107 p.

Prebunching Cost Equation

Simulated, delay-free data points for prebunching cost were developed for the Radio Horse 9 winch under a wide range of diameter breast height (DBH), volume cut per acre (VOAC), and average slope yarding distance (SYD). The model stand contained 1,400 ft^3 per acre. The stand was thinned, using an arithmetic mean diameter of cut trees/arithmetic mean diameter of stand ratio (d/D ratio) of 1.0 to levels of 33 and 50 percent. The trees cut from each treatment were bucked into logs (LeDoux 1985) by d.b.h. and the pooled data points (Table 3) used to develop a general equation for prebunching cost by arithmetic mean DBH of cut trees, VOAC, and SYD:

$$\$/ft^3 = -0.12640 + 1.1965\,(1/DBH) + 0.00023\,(SYD) + 235.30853\,(1/(VOAC \cdot DBH))$$

$$R^2 = 0.867$$

where:

DBH = Arithmetic mean tree diameter at breast height, in inches; variable limits = 4 to 12.

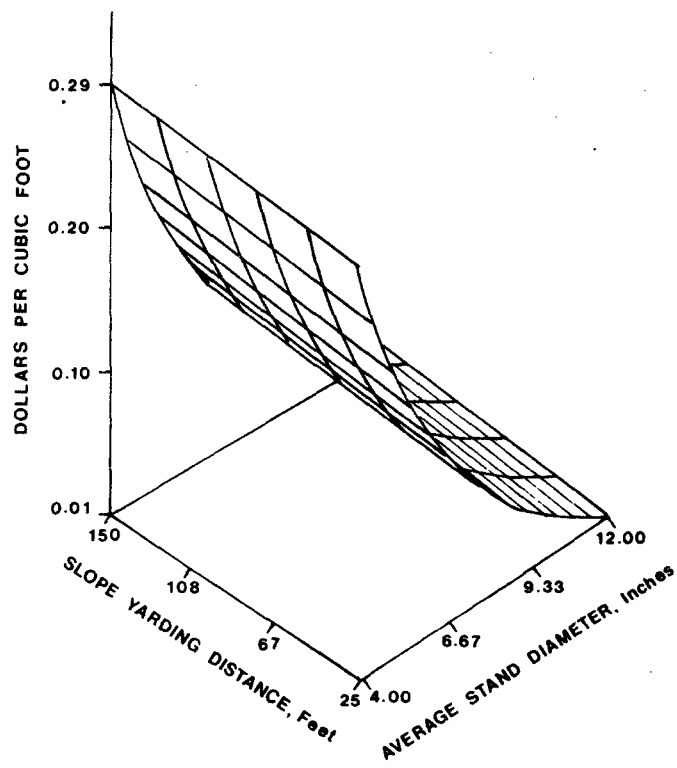

Figure 1.—Delay-free prebunching cost surface for the Radio Horse 9 winch, VOAC = 700 cubic feet.

Table 1.—Conditions for five field tests of bunching

Test and stand type	Average d.b.h.	Average stems removed	Average volume removed	Average side slope	Productivity	Cost per unit produced	Stand treatment
	Inches		*Cords/acre*	*Percent*	*Cords/hr*	*$/Cord*	
Test 1, White pine hardwood	9.5	132	11.2	0	1.9	12.17	Release cut to partially remove the overstory to enhance the growth of regeneration.
Test 2, Oak hardwood	7.5	176	11.0	47	1.9	12.78	Improvement cut bunched in a three-step process (included reyarding), downhill pull.
Test 3, Spruce pine plantation	7.8	162	4.7	22	0.4	60.58	Single tree selection thinning, brush made bunching across the hill difficult.
Test 4, Red maple swamp	8.1	247	11.0	0	2.0	11.06	Area wide thinning
Test 5, Hemlock hardwood	8.0	135	8.7	37	1.1	21.10	Improvement cut to make large hemlocks visible. Logs rolled downhill while being bunched.

Source: Harou, P. A.; Kling, B. W.; MacConnel, W.; Thompson, D.; Morin, D.; Zheng, C. Financial feasibility of the Radio Horse 9 winch. Cooperative Agreement 23-792. Final Report. Broomall, PA. U.S. Department of Agricultural, Forest Service, Northeastern Forest Experiment Station; 1985. 107 p.

Table 2.—Hourly bunching costs for the Radio Horse 9 winch[a]

Component	Cost
	Dollars/hr
Winch	12.55[b]
Chainsaw	2.65
Labor	*13.00*[c]
Total	28.20

[a]Includes all new equipment (1986 costs).
[b]Includes depreciation, insurance, interest, operating costs (fuel, oil, lubricants, maintenance, repair, and taxes) and rigging.
[c]One faller and a winch operator, rates obtained from cost guide for empirical appraisals, USDA Forest Service, Region 9, Amendment 112.

Table 3.—Log size parameters by d.b.h. for model stand

D.b.h.	Log size: Mean	Minimum	Maximum	Standard deviation
Inches	*Ft*^{3}			
3-4	1.75	0.24	4.36	0.89
5-6	4.62	1.36	10.40	2.04
7-8	7.71	1.60	15.35	3.21
9-10	11.65	2.20	28.27	5.22
11-12+	15.49	5.27	61.85	7.95

SYD = Average slope yarding distance, in feet; variable limits = 25 to 150.
VOAC = Average volume removed per acre, ft^3; variable limits = 462 to 700.

The equation is machine specific and the variable limits should be observed carefully. Figure 1 shows the delay-free prebunching cost surface for a volume removal of 700 cubic feet.

Delay-free costs must be adjusted to allow for nonproductive time. Delay percentage is the proportion of nonproductive time expressed as a percentage of total time. One minus the proportion of nonproductive time is the proportion of productive time. For example, if the delay is 10 percent, the proportion of nonproductive time is 0.1, and the proportion of productive time is 0.9. The delay-free cost is adjusted by dividing it by the proportion of productive time to get the cost with delay.

Prebunching Delays

Data for estimating delays are presented in Figures 2, 3, and 4. Generally, the Radio Horse 9 was productive (Fig. 2). Equipment, personnel, and hangup delays accounted for the bulk of the delay time. Closer inspection of the hangup delays (Fig. 3) reveals that most of the hangups were due to trees. Rocks, stumps, brush, and other logs made up the bulk of the hangup delays. Although the average slope yarding distance for the pooled data (all five sites) was 120.65 feet, most hangups occurred at a slope yarding distance of 75 feet (Fig. 4). The data from Figures 2 and 3 can be used to adjust the delay-free cost estimates. For example, a logger is estimating prebunching cost for a hardwood stand with an average arithmetic tree

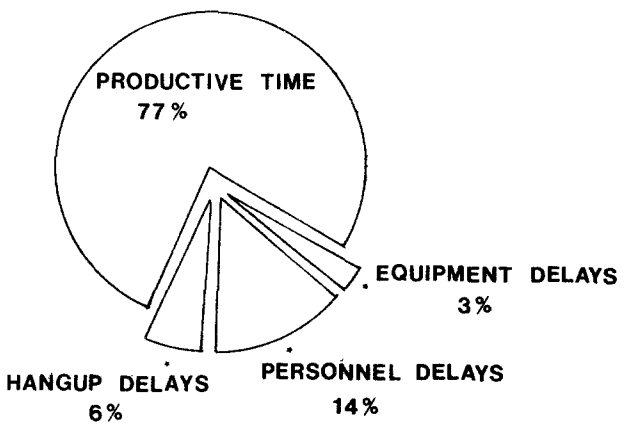

Figure 2.—Percentages of observed productive and delay time for the Radio Horse 9 winch.

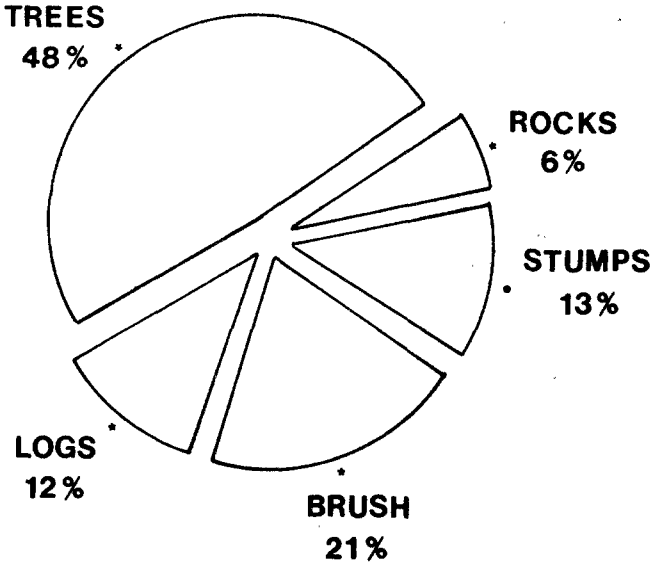

Figure 3.—Percentages of observed hangup delays for the Radio Horse 9 winch.

diameter at breast height of 8.0 inches, an average slope yarding distance of 100 feet, and an average volume removal of 700 ft^3. Delay-free bunching cost is:

$$
\begin{aligned}
= & - 0.12640 \\
& + 1.19650\ (1/8.0) \\
& + 0.00023\ (100) \\
& + 235.30853\ (1/(700*8.0)) \\
= & \ 0.088
\end{aligned}
$$

Adjusting delay-free cost with an average delay percentage of 0.23 (Fig. 2) = 0.088/(1-0.23) = 0.088/0.77 or \$0.114/ft^3. The delay percentages summarized in Figures 2, 3, and 4 are not exclusive, so users may wish to substitute their own delay percentage based on experience or observation.

Deck Spacing

The distance between prebunched decks significantly affects prebunching cost and productivity (LeDoux and Butler 1982). The farther apart the decks are constructed, the lower the productivity and the higher the prebunching costs. Constructing decks too close to each other could result in small decks and a substantial amount of time for moving and setting up the winch. An optimal deck spacing exists for each combination of stand operating conditions and winch configuration.

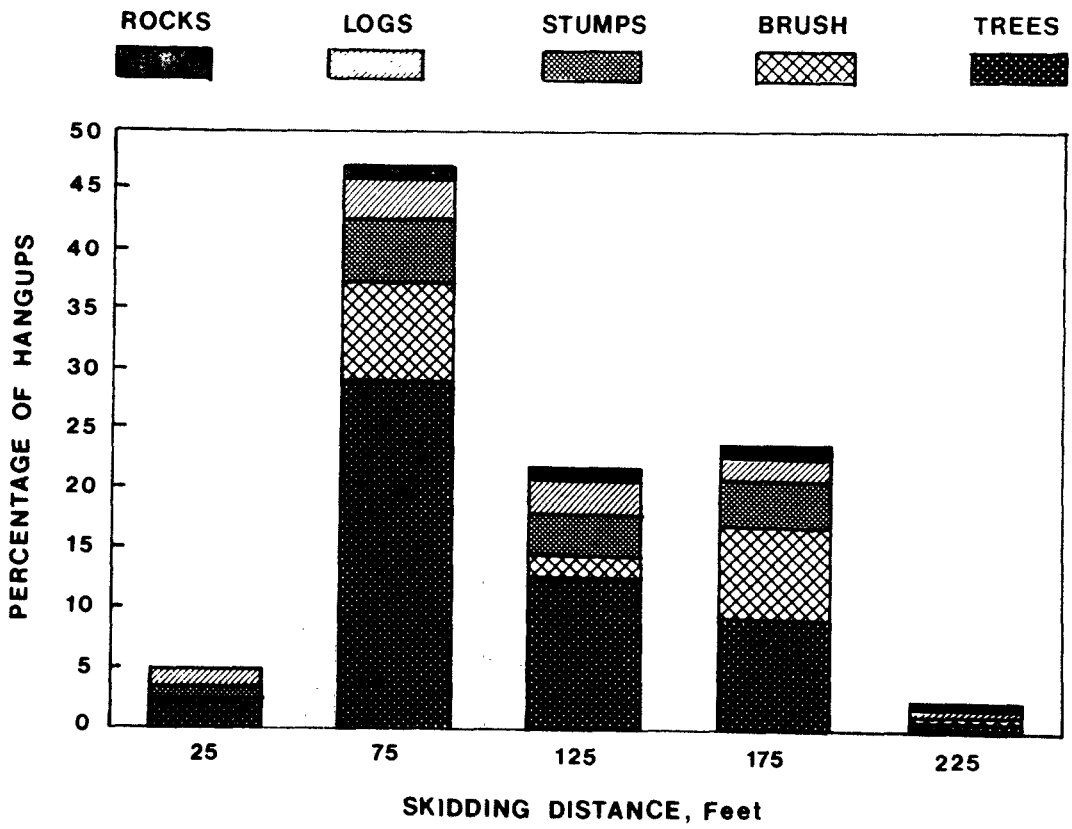

Figure 4.—Percentage of hangups by slope yarding distance for the Radio Horse 9 winch.

Accordingly, using the previously cited field data, stand conditions, and the THIN (LeDoux and Butler 1981) simulation model, we developed an optimal deck spacing for the Radio Horse 9 winch (Fig. 5). Results from the simulations suggest that deck spacings betwen 30 to 70 feet will result in maximum productivity and the minimum prebunching costs. Although the production rates and costs simulated for the extreme deck spacings may be optimistic, one would not normally expect to operate at the extremes.

Application of the Costing Methodology

To use the cost equation, the estimator will need to know (1) the arithmetic mean d.b.h. to be harvested; (2) the average volume cut per acre, in cubic feet; and (3) the average slope yarding distance. These items can be obtained from inventory data and cruise data, and the logging plan for the tract. The prebunching cost for a 10-acre tract is:

Delay-free cost (Dollars/ft^3)	*Average delay (Percent)*	*Cost with delay (Dollars)*
0.161	15	1,134

Cut trees are 6 inches d.b.h., the average volume cut per acre is 600 cubic feet, and the average slope distance is 100 feet.

Additional adjustments to these estimated costs may be necessary depending on their intended application. The estimated costs do not include an allowance for profit and risk, nor do they include recognition of the tax savings resulting from accelerated depreciation.

Consideration for Managers

The methods presented here provide a relatively complete packaging for estimating the cost for the Radio Horse 9 winch operating in most eastern hardwood stands. Estimates can be developed for prebunching under the skyline corridor for swinging with cable systems, for bunching to skid trail edge to be picked up by a skidder or forwarder, or bunching to roadside for stand cleanings and firewood sales.

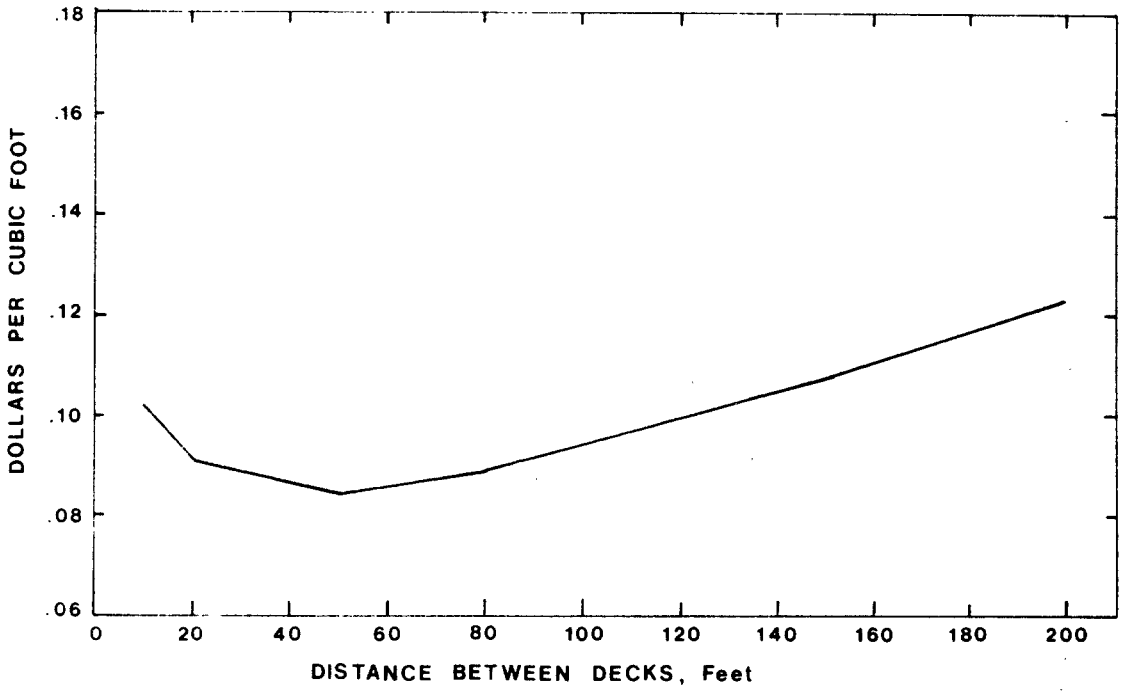

Figure 5.—Simulated total prebunching cost for various deck spacings for the Radio Horse 9 winch.

Production and related costs per unit produced will vary with stand and site conditions (Table 1). The methods presented here consider this variability in site and stand conditions. Although the methods likely will not produce bunching estimates that match actual outcomes exactly, reasonable estimates can be expected.

Prebunching winches have several advantages in that: (1) they are relatively inexpensive and labor requirements are minimal; (2) larger more expensive equipment is used most efficiently to swing, skid, or forward bunched decks to landings developing full payloads; (3) residual stand damage is kept to a minimum since the winches generally do not develop enough horsepower to "tear" things up; (4) soil compaction and understory vegetation disturbance is kept to a minimum because there is no equipment moving within the stand; (5) the small winches can be used in environmentally and esthetically sensitive areas eliminating in part the need for large noisy equipment; and the greatest advantage is that (6) prebunching improves the efficiency of the more expensive yarding, skidding, and forwarding equipment.

Prebunching should not be envisioned as the cure-all solution to harvesting in young stands. A considerable amount of planning and layout must be done to ensure an efficient prebunching operation. Deck locations must be identified and fallers instructed to gun trees toward the desired decking area to minimize hangups. Landing areas must be designed to handle the increased flow of logs during a swing, skidding, or forwarding operation. Hauling must be scheduled to avoid congested landings and to haul away the high volumes of prebunched logs arriving at the landing. Hooking and skidding crews must be instructed to load their respective systems close to capacity to ensure that any gains in prebunching are not offset by an improperly loaded system. Prebunching operations require as much planning as any other harvesting operation.

The blending of field test data, simulation methods, and nonlinear regression methods, such as those summarized here, will not provide all the answers a manager or logger needs on prebunching. Such methods, however, provide tools for estimating prebunching costs for managing young-growth hardwood stands.

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Keywords: Prebunching; deck spacing.

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