HIGH-LEAD LOGGING COSTS

as related to LOG SIZE and other VARIABLES

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This study was conducted on Weyerhaeuser Co.'s Clemons Tree Farm, with cooperation by the company's Forestry Research Center at Centralia, Wash. Assistance by Weyerhaeuser Co. personnel at both locations is gratefully appreciated.

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Introduction

Logging managers and the firms or agencies of which they are a part are constantly seeking to reduce costs and to increase utilization of the available raw materials in the woods. Most managers in other types of business spend a good share of their time keeping track of manufacturing and marketing costs, and cost accounting methods are available for identification and control of specitic costs or individual items or classes. Yet when it comes to logging, frequently the only cost information available is an average cost for each function such as felling and bucking, yarding, loading, and hauling, derived by dividing the total functional cost by total volume of production. This information is useful, but even more useful would be knowledge of the range of logging costs and conversion values related to log volume, diameter, yarding distance, terrain features, and other variables (figs. 1 and 2).

Figure 1.—Large logs have relatively low logging costs per thousand board feet.

Figure 2.—Small pulpwood logs have relatively high logging costs. Economic studies are needed in each situation to determine conversion values for small-sized pieces.

A shortcoming of average costs is that they are a mixture of high and low costs. A given average cost may seem satisfactory and in line with profitable operations, yet a breakdown into component costs may reveal individual cost situations that are not satisfactory and not profitable.

This report presents the findings from a single study of high-lead logging covering several settings and crews. Results should be applicable to other operations having similar conditions of stand composition, available equipment, utilization outlets, and costs. The results are also a useful aid toward understanding the opportunities and limitations for more complete logging utilization throughout the region. They can provide a basis for determination of economic utilization limits over a wide variety of given conditions.

Of course, no simple rules can be laid down that will apply exactly to all operations and to all areas. There is a gradual transition from highly profitable logs down through those that are barely profitable or just barely unprofitable, and on to those that are definitely unprofitable. This report indicates the operating times, costs, and values that were developed for the conditions in this study and should provide a valuable guideline for modification of results or for new studies covering other operating conditions. A major objective has been to outline the principles and methodology on which such studies may be based.

Marginal Cost Concepts

Every logging operation has some logs so small that they are not worth the cost of logging. But how can the economic limits be identified? The answer lies in accurately determining the value of logs of different volume sizes and in comparing these values with the **extra** costs of harvesting these logs. The key question for any particular log concerns only the actual value of that log compared with the marginal or extra cost of taking it over not taking it. In particular, costs of overhead, road construction, preparation of landings, and other similar fixed costs have no bearing on this decision if these fixed costs are the same whether or not the log in question is taken. Variable costs or direct costs are those incurred only if a given log is taken.

These principles are frequently followed in practice but usually cannot be supported by any cost data, because accounting records are generally in terms of average or full costs which include both fixed and variable costs for all logs collectively.

Judgment and experience of the logging manager can do a great deal toward determining which logs to take and which to leave and toward selecting the operating method that best suits the timber and terrain conditions. However, explicit data developed from time studies can show some of the essential relationships more clearly and guide the logging manager toward sharpening his judgment and operating skills.

Time-study techniques together with modern regression analysis make it possible to work with definite measured or calculated values over the full range of individual variables and permit combining the effects of several variables in one mathematical formula.

In its simplest terms, the procedure of marginal cost analysis is to (1) calculate labor and equipment costs per hour or per minute, (2) measure operating times per turn or per log, (3) convert these to production per hour or per minute for different log sizes, and (4) divide direct cost per time unit by production per time unit to arrive at a direct cost per unit volume.

Labor and equipment costs are expressed in this study as hourly costs. Depreciation and related items of interest, taxes, and insurance are considered a part of the hourly equipment costs, and therefore are in this sense "direct" costs because they are directly related to choice of equipment and to a more or less fixed number of operating hours per year. This concept may be called the "fixed time convention." Such costs would be truly fixed costs and left out only if the equipment would otherwise be idle, in which case only the extra fuel cost, for example, might be charged for an extra hour's use of a yarder or loading machine.

Thus, the equipment costs may be considered direct or variable costs in the sense that there is a choice of remaining on the current setting an extra amount of time to remove an extra volume of smaller logs or of moving on to start another setting a little sooner.

Crew transportation and payroll overhead are similarly treated in this report as a part of direct hourly wage cost.[1] It may be helpful to visualize this treatment if one thinks of the smallest size class of logs as coming out all in the last few days of the year. Clearly, the extra costs of crew transportation and payroll overhead would apply to the extra full days' or weeks' time spent. Therefore, it should make no difference whether the small logs were removed all together in several full days or, as in actual practice, spread individually in mixture with larger logs all through the year; the small logs must still bear their share of crew transportation and payroll overhead costs, prorated on the basis of time (not volume).

Alternative cost concepts are discussed in Appendix B.

[1] As used here, payroll overhead includes social security, unemployment compensation, accident insurance, vacation pay, pension, and health and welfare programs. It excludes hiring and firing costs and costs of record keeping.

Description of Field Study near Cosmopolis, Wash.

This study was conducted on Weyerhaeuser Co.'s Clemons Tree Farm, near Cosmopolis, Wash., in the spring of 1961. Time-study observations were made on seven clearcut settings in 110-year-old western hemlock. Associated species included true firs, Sitka spruce, western redcedar, and a small amount of Douglas-fir. The settings varied from 5.7 to 14.0 acres in extent, with an average of 10.4 acres. External yarding distances ranged from 480 to 740 feet. The settings were located along a ridgetop at approximately 800 feet above sea level. Slopes of the settings were mostly 30 to 40 percent, although slope of individual turns ranged from level to more than 70 percent (all data were from uphill yarding).

Logging Methods and Utilization Standards

The study included two types of high-lead logging: (1) a two-stage relog method where, after clearcutting, all logs down to 10 inches in diameter by 26 feet in length were yarded by standard high-lead equipment and a seven-man crew and then, from the same spar tree, material down to 4 inches by 8 feet was relogged with lighter high-lead equipment and a five-man crew; (2) clean logging to a 4-inch by 8-foot minimum with a single seven-man operation.[2] In the balance of this report, both the terms "regular yarding" and "regular logging" will refer to the clean-logging method or the first stage of the two-stage method. The seven-man crew consisted of hook tender, rigging slinger, two choker setters, signalman, chaser, and yarder engineer. The five-man crew had no rigging slinger and only one choker setter.

Relogging in three settings was to a small cold deck (fig. 3); the fourth relog setting was "hot-loaded."

Loading for the regular logging operations was with a so-called 1-yard shovel-type loader

[2] Adams, Thomas C. Economic comparisan of relagging and clean logging in mature hemlock. 1965. (In preparatian for publicatian, Pac. NW. Forest & Range Expt. Sto., U. S. Forest Serv., Portland, Oreg.).

Figure 3.—Tops, small trees, and broken chunks for pulpwood may be cold-decked in a relogging operation.

equipped with heel boom and tong line. The relogging used a similar loader in the 3/4-yard size. A portable sled or crib arrangement was available at each landing for making up partial loads of pulpwood up to 20 feet in length.

Hauling was chiefly with standard diesel semitrailer log trucks. Relog hauling was with separated short truck and trailer combinations taking up to 26-foot lengths on the truck and up to 20-foot lengths on the trailer. An extra trailer was used in the relogging so that loading could be continued while the truck and trailer unit was enroute.

Both clean-logged and relog settings had a pulpwood crib or sled unit at the landing so that small pieces could be assembled into partial loads during free time.

Loaders were equipped for radio communication with the Cosmopolis office and field cars. This facilitated communication and coordinated dispatching of trucks. Also, the fact that two other logging sides were loading in the same vicinity gave flexibility to the hauling operations.

Study observations were made and recorded during the period from January through April. A good share of the days had rain, but crews were well adjusted to wet conditions and production was not considered to be slowed on this account.

Time Study of Yarding and Loading

Times were measured by stopwatch for the various elements of yarding and loading operations by number of logs, yarding distance, and size of logs. Felling and bucking times were not measured, as the study concerned only times and costs for individual logs after the felling and bucking operations. Most settings had at least 2 complete days of timing so as to include delay times and to avoid different production rates for different times of day. These detailed time data permitted calculation of individual time per turn and time per log.

In addition, gross time was recorded daily by the yarder and loader operators to indicate working hours on each setting, together with time and reason for all delays over 10 minutes.

YARDING TIMES.—The observer recorded the number of logs per turn, hauling distance, time out and in, unhooking time, and any delay time. Supplemental times of changing cable roads and corner blocks were also recorded. Delay times in yarding were not used in developing unit costs because they are considered to be haphazard in occurrence, unpredictable in amount, and unrelated to log size, at least in the smaller log sizes under examination where the critical economic margin lies. Supplemental times for changing cable roads and corner blocks were also excluded, as these are fixed costs per yarding sector and not related to the extra time to bring in any given log.

Although delay times and supplemental times were not used in developing unit costs, they were recorded and may be summarized as follows:

	Regular yarding	Relog yarding
	(Hours per 8-hour day)	
Operating delays[1]	0.512	0.233
Supplemental times for changing cable roads and corner blocks	.661	1.392
Actual yarding time	6.695	6.243
Machine time	7.868	7.868
Breakdown	.132	.132
Total all time	8.000	8.000

[1] Operating delays include hangups, changing guy lines, swinging blocks, moving yarder, and minor delays at the landing.

Or, expressed in hours and minutes:

	Regular yarding	Relog yarding
	(Hours and minutes per 8-hour day)	
Operating delays[1]	31 min.	14 min.
Supplemental time	40 min.	1 hr. 24 min.
Actual yarding time	6 hr. 41 min.	6 hr. 14 min.
Machine time	7 hr. 52 min.	7 hr. 52 min.
Breakdown	8 min.	8 min.
Total	8 hr. 0 min.	8 hr. 0 min.

[1] Operating delays include hangups, changing guy lines, swinging blocks, moving yarder, and minor delays at the landing.

These delay times were probably lower than might be expected on average operations in the region, because (1) maximum yarding distances were generally kept under 700 feet, (2) there were no unusual terrain difficulties, and (3) radio communication, plus the presence of a field supervisor and two other logging sides in the vicinity, gave flexibility to operations in case of breakdown or need for spare chokers or other parts, assistance in moving yarder, swinging blocks, etc.

Yarding distance was estimated to the nearest 10 feet up to 100 feet and by reference to colored markers at 100-foot intervals beyond. Diameter and length of each log were estimated by the observer, who made frequent check measurements at the landing when time permitted and when there was no interference with operations.

LOADING TIME.—The following elements were measured and recorded:

a. Loading time per "pickup" cycle
b. Number of pieces in each pickup (normally one piece)
c. Estimated diameter and length of each piece
d. Whether load was to truck, separate trailer, sled, deck, or other spot
e. Delay time with cause
f. Number of pieces per truckload and type of load (pulpwood, saw logs, etc.)
g. Times of arrival, beginning of loading, end of loading, and departure for each truck.

Regression Analysis

Factors determining yarding and unhooking times were analyzed by multiple regression techniques, using electronic data processing and standard statistical procedures. Loading time was analyzed by simple regression, relating loading time to log volume. Separate runs were made for regular yarding and for relog yarding elements.

Regression analysis included the following independent variables:

a. For yarding time,
- D = slope distance in feet
- D^2 = (slope distance)^2
- V = volume per turn, in cubic feet
- DV = slope distance times volume per turn
- S = slope, in percent
- VS = volume per turn times slope
- C = number of chokers
- N = number of logs per turn.

b. For unhooking time,
- C = number of chokers
- V = volume per turn, in cubic feet
- N = number of logs per turn
- CV = number of chokers times volume per turn.

c. For loading time,
- V = volume per log, in cubic feet.

Resulting Equations

From the above listing, only those elements were retained that contributed significantly toward explanation of total variance.

Resulting equations whose elements showed acceptable levels of significance were as follows (Y = round-trip turn time in minutes, including choker-set time but excluding unhooking time):

a. Regular yarding (fig. 4),[3]

$$Y_1 = 1.471 + 0.007237D - 0.000003448D^2 + 0.003771V + 0.000008633DV - 0.1402N.$$

b. Relog yarding (fig. 5),[4]

$$Y_2 = 1.963 + 0.006423D + 0.007297V + 0.1629N.$$

c. Unhooking time, regular yarding,

Y_3 = minutes unhooking time, from time line stops to the beginning of new turn cycle

$$= 0.2827 + 0.1150C + 0.001519V + 0.05806N.$$

This equation yields the following values:

Turn volume	Two chokers, two logs	Three chokers, three logs
(Cubic feet)	(Minutes)	(Minutes)
5	0.64	0.81
10	.64	.82
20	.66	.83
50	.70	.88
100	.78	.95
200	.93	1.11
300	1.08	1.26

d. Unhooking time, relog yarding,

No significant gain through regression; therefore, a simple mean was used of 0.8289 minute per turn for hot-loading settings and 1.177 minutes per turn for cold-decked settings.

e. Loading time, regular yarding,

No significant gain through regression; therefore, a simple mean was used of 0.7409 minute per log.

f. Loading time, relog yarding,

No significant gain through regression; therefore, a simple mean was used of 0.8539 minute per log for hot loading and 1.017 minutes per log for loading from cold deck.

[3] Elements S, VS, and C failed to accomplish a significant reduction in the variation of Y_1 and were therefore deleted. Negative sign for N factor is interpreted to mean a given turn volume takes more time in one log, for example, than in two or more smaller logs.

[4] Positive sign for N factor is related to the fact that the relogging crew had only one choker setter, and all turn volumes were relatively small.

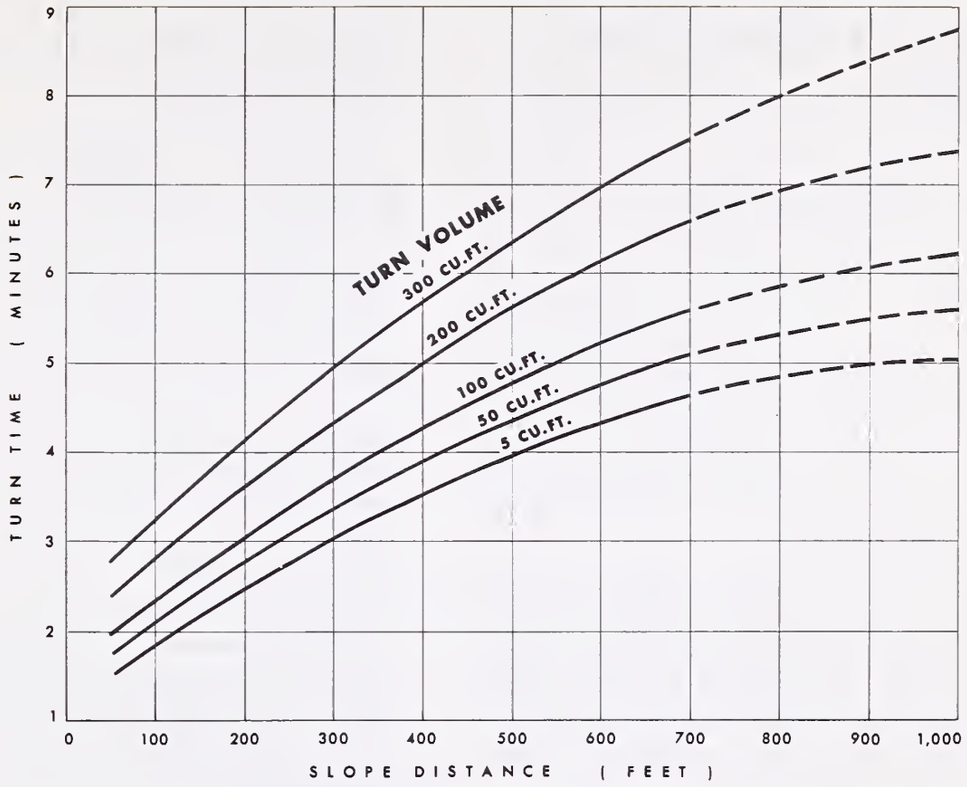

Figure 4.—Round-trip turn time, regular yarding, excluding unhooking time; two logs per turn.

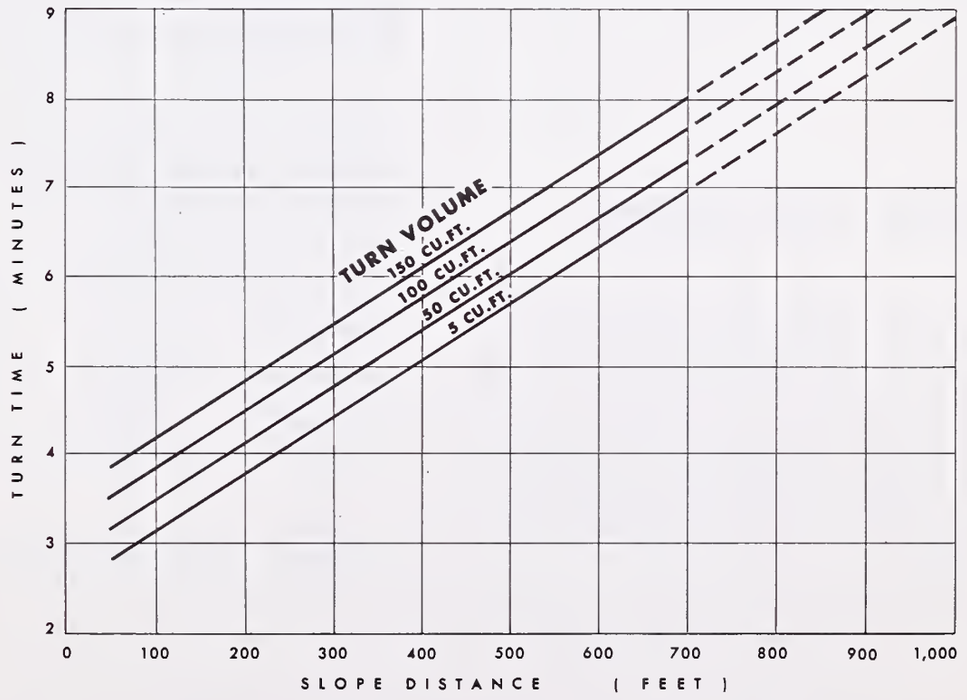

Figure 5.—Round-trip turn time, regular yarding, excluding unhooking time; three logs per turn.

Physical Production Rates

Total yarding cycle time per turn (tables 1 and 2[5]) was calculated directly from the results of regression analysis shown in the previous section. This is "marginal time," in the sense that it is the extra time for an extra turn that comes in cleanly without delays. Times for regular logging are for the standard high-lead equipment and a seven-man crew using two chokers, each with a single log. Times for relogging are for the lighter equipment and a five-man crew using three chokers and bringing in three logs per turn.

Loading time for regular logging was assumed to be the same as yarding time, because in normal high-lead operations the loader remains at the landing with the yarder; hence, it requires just as much of the loading machine's time as the yarder's time to handle an extra hour's work or an extra turn.

Since relogging is chiefly to a cold deck, calculated loading time for a relog operation was taken as 1.017 minutes per log, the average time observed.

Hourly Cost Rates

Labor costs and machine rates for yarding and loading are shown in tables 20 and 21. Machine rates are based on 42 weeks or 210 working days per year. An assumption is made that the remaining 10 weeks will be accounted for by holidays, vacation time, moving time between settings, breakdown, and daily or seasonal shutdowns due to bad weather or high fire danger.

Calculation of Unit Costs

Unit costs for the different turn volumes were developed by applying the hourly cost rates for yarding and loading to the physical production rates. In order to relate cost to individual log volume rather than to turn volume, calculations were on the basis of each choker carrying two or three logs of equal volume. In practice, of course, log sizes are mixed in any given turn, and up to the point where working load capacity of the rigging is reached, it should make no difference costwise whether small logs are mixed in with large logs or handled separately.

Costs were initially calculated in units of 100 cubic feet because small log sizes do not have a consistent board-foot to cubic-foot ratio. However, calculated board-foot costs are also shown (Scribner rule).

Yarding costs per turn and per unit volume are given in tables 3-6. Loading costs with regular yarding were related to yarding time because the loading machine normally remains on the landing all through the yarding operation including the extra time required to yard an extra volume of logs (tables 7, 8).

Relog loading was from cold decks and therefore costs were related to loading time per log, which averaged 1.017 minutes. At $0.2155 per minute (derived from table 21), relog loading cost was $0.2192 per log or, expressed in cost per hundred cubic feet, as follows:

Volume per log	Logs per 100 cu. ft.	Loading cost per 100 cu. ft.
(Cubic feet)	(Number)	(Dollars)
2.5	40	8.77
5.0	20	4.38
10.0	10	2.19
25.0	4	.88
50.0	2	.44

[5] All tables are contained in the appendixes.

The corresponding relog loading cost per thousand board feet was:

Volume per log	Logs per M bd. ft.	Loading cost per M bd. ft.
(Board feet)	(Number)	(Dollars)
10	100	21.92
20	50	10.96
50	20	4.38
100	10	2.19
200	5	1.10

Hauling costs were developed by using tables 8 and 10 of the "Logging Road Handbook" (Byrne et al. 1960)[6], with an adjustment for non-operating season, applying an adjustment factor of 1.12 for price changes since 1959. These costs apply to standard, on-highway, diesel logging trucks. The same hourly costs were used for relogging as for regular logging. Hauling costs were based on 5 miles of single-lane gravel road with 6- to 8-percent grade plus highway mileage to give total hauling distances of 20 to 70 miles. Delay time for scaling, unloading, and waiting at landing was calculated as 35 minutes per trip. Loading time was calculated as 0.74 to 1.0 minute per log, with a maximum of 60 minutes' loading time per load. Resulting hauling costs and related data are shown in tables 9-13.

Totals of direct yarding, loading, and hauling costs per hundred cubic feet are shown in tables 14 and 15. Attention is called to the very wide spread in logging costs, depending on log volume. For example, with a 300-foot yarding distance and 20-mile hauling distance, regular logging costs range from $7.45 to $62.33 per hundred cubic feet for logs 50 to 2.5 cubic feet, respectively, in volume. Corresponding figures for relogging are $6.12 and $41.03 per hundred cubic feet.

Similarly, regular logging costs for the same yarding and hauling distances range from $15.72 to $155.83 per thousand board feet for logs 200 to 10 board feet, respectively. For relogging, the corresponding figures are $12.65 and $102.06 per thousand board feet.

[6] Name and date in parentheses refers to publication listed in Bibliography, p. 17.

Other Factors affecting Yarding Time and Cost

Effect of Slope

The regression equation showing the greatest addition to explained variance for effect of slope employed the factor VS in the equation for regular logging:

$$Y_3 = 1.474 + 0.006989D - 0.000002930D^2 + 0.006938V + 0.00001024DV - 0.0001201VS - 0.1441N$$

Addition of this factor was not statistically significant at the 95-percent confidence level, but was nearly so. For anyone wishing to include the effect of slope, the calculated effect of this factor on turn time and cost per unit volume, compared with yarding on level ground, is:

Slope	Time differential per 100 cu. ft.	Cost differential	
		Per 100 cu. ft.	Per M bd. ft.[1]
(Percent)	(Minutes)	(Dollars)	
Level	0	0	0
10	-0.12	-0.09	-0.16
20	-.24	-.19	-.34
30	-.36	-.28	-.50
40	-.48	-.37	-.67
50	-.60	-.46	-.83
60	-.72	-.56	-1.01

[1] Calculated at 1 cubic foot = 5.556 board feet, or 1,000 board feet = 180 cubic feet.

The following time and cost differential for slope relates to data in the body of this report, which in turn is based on the equation on page 6 and average slope slightly under 30 percent:

Slope	Time differential per 100 cu. ft.	Cost differential	
		Per 100 cu. ft.	Per M bd ft.[1]
(Percent)	(Minutes)	(Dollars)	
Level	+0.32	+0.25	+0.45
10	+.20	+.15	+.29
20	+.8	+.07	+.13
30	-.04	-.02	-.04
40	-.12	-.12	-.22
50	-.28	-.21	-.38
60	-.40	-.30	-.54

[1] Calculated at 1 cubic foot = 5.556 board feet, or 1,000 board feet = 180 cubic feet.

Effect of slope when yarding downhill to the landing was not observed. There was no discernible effect of slope in relog yarding.

Number of Chokers

The chief reason, of course, for using three chokers instead of the customary two is that the yarding equipment can be used more closely to its weight capacity. That is, if the logs in the first two chokers do not make a full load, then the additional log (or logs) in the third choker may be carried at very little extra cost —usually just the extra cost of setting the choker and unhooking.

If the number of chokers is introduced, in addition to the factor VS, the regression equation for regular yarding becomes:

$$Y_3 = 1.132 + 0.007123D - 0.000003022D^2 + 0.007870V + 0.000009923DV - 0.0001505VS + 0.1920C - 0.1874N$$

Although addition of this factor did not add significantly to the amount of explained variance in the statistical analysis at the 95-percent confidence level, it has been included for the record.

With the above equation, yarding time and costs were found to be 27 percent less per unit volume if a third choker carried an additional volume the same as each of the other two, and 16 percent less if a third choker carried a load only half as great as the other two.

If the third choker carried a minimum size log, which did not add appreciably to the total load, or if the equivalent two-choker load were carried in three logs and three chokers, then by calculation the logging cost would be $0.17 greater per hundred cubic feet, or $0.31 greater per thousand board feet, than for the same volume in only two chokers. Thus, the economy of using a third choker depends in large measure on the extent a two-choker operation fails to carry a capacity load in each turn.

Economic Analysis

The direct costs of bringing a given log to the mill are the sum of direct yarding, loading, and hauling costs which have been calculated for different yarding distances, hauling distances, and log sizes. Curves of these direct logging costs for a hauling distance of 20 miles are shown in figures 6 and 7. The intersection of these curves with the horizontal line indicating equivalent mill-yard value of purchased wood indicates the marginal log for each method of operation.[7]

Equivalent Mill-Yard Value

Wood from company-owned lands should be preferred so long as its after-tax logging cost is less than the after-tax cost of purchased wood. The equivalent mill-yard value of company wood will include an adjustment for a 27-percent tax saving on any capital gains applicable to the company wood plus an adjustment for a 52-percent tax reduction on logging costs[8]. For example, a price of $18.50 per cord is equivalent to $22.71 per cord after taxes and after capital-gains tax savings, under the assumption of $8 per cord fair market value and $0.50 per cord depletion rate.

Similarly, a buying price of $37 per thousand board feet is equivalent to $45.44 per thousand board feet for company-produced wood, assuming $16 per thousand board feet fair market value and a $1 per thousand board feet depletion rate.

These values are calculated as follows:

	Per card	Per 100 cubic feet	Per M baard feet
a. Cast af purchased woad	$18.50	$20.56	$37.00
Tax reductian (x 0.52)	-9.62	-10.69	-19.24
After-tax cast	8.88	9.87	17.76
b. Equivalent after-tax cast af campany waad	8.88	9.87	17.76
Capital-gains tax saving, 0.27(FMV - depletian):			
0.27($8 - $0.50) =	+2.02	--	--
0.27($8.889 - $0.556) =	--	+2.25	--
0.27($16 - $1) =	--	--	+4.05
Equivalent value, before incame tax	10.90	12.12	21.81
c. Equivalent mill-yard value (EMYV), at 52-percent incame tax:			
EMYV - 0.52 (EMYV) =	10.90	12.12	21.81
EMYV - 0.48 (EMYV) =	10.90	12.12	21.81
EMYV =	22.71	25.25	45.44

[7] Far derivatian af cast per lag fram cast per turn, see discussion an p. 8.

[8] The carparate incame tax rate was 52 percent prior ta January 1, 1964. This rate was changed ta 50 percent fram January 1, 1964, and ta 48 percent after January 1, 1965. Calculatians are shawn at the 52-percent rate.

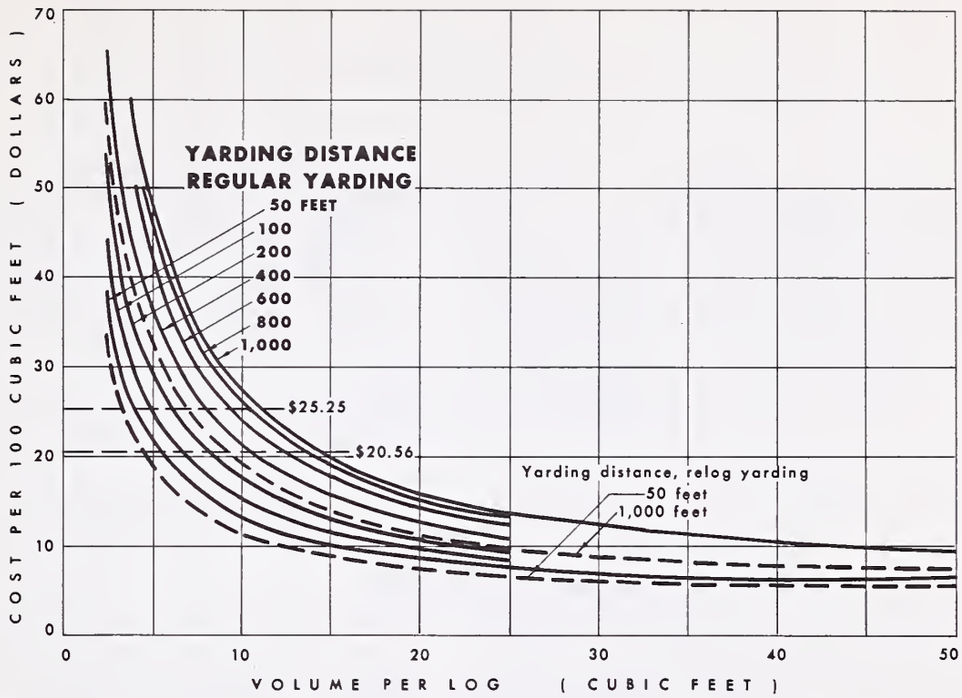

Figure 6.—Total direct logging cost per hundred cubic feet (yarding, loading, hauling). Hauling distance 20 miles.

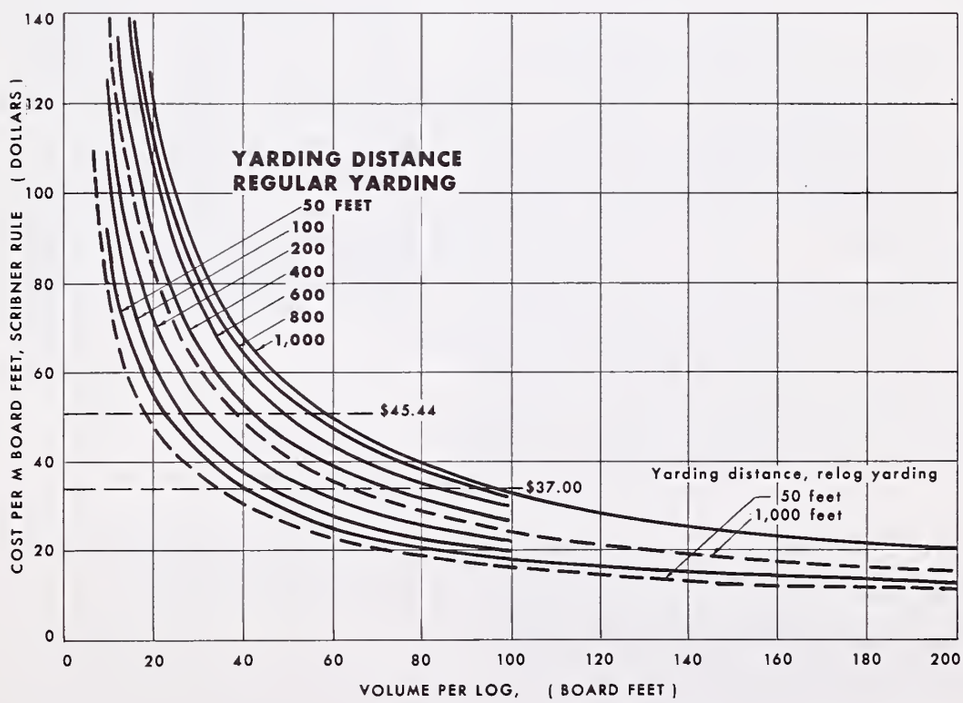

Figure 7.—Total direct logging cost per thousand board feet (yarding, loading, hauling). Hauling distance 20 miles.

The Conversion Surplus

The difference between equivalent mill-yard value and the direct logging costs may be termed the "conversion surplus." Note that fixed costs are excluded from this concept. It will be profitable to bring in any log that has a positive conversion surplus, even though fixed costs are not fully covered, because that log will cover out-of-pocket costs and will make at least some contribution toward meeting fixed costs.

The analysis of this study has been built around a situation where an industrial firm logs its own timber for which there is no direct stumpage charge. The method is valid, however, for any operator. If there is a stumpage charge based on scaled recovery, then the operator will normally view this stumpage charge as an addition to direct costs.[9] On the other hand, if the stumpage is purchased for a lump sum or on a tree-measurement basis, then there is no direct stumpage charge, and this method of analysis is directly applicable.

Whether or not stumpage price is considered as a direct cost, it is clear that the delivered value of each log should at least cover its own direct logging costs.

For an independent logging operator having no mill of his own, the capital-gains tax saving would not apply, and the comparison should be made with the available after-tax market price, taking into account the particular income tax rate for the operator in question.

[9] However, this viewpoint may not be entirely valid if only logs with a positive conversion surplus have been included in the sale, with a single average price charged within species as a practical working arrangement. Neither should this viewpoint be valid if any extra cost of individual small logs, removal of which may be required for silvicultural reasons, is spread among all logs of that species by reducing their total average stumpage value.

Marginal Log Sizes

Marginal log sizes according to the costs and price assumptions of this study may be determined by inspection from figures 8 and 9, and are shown in tables 18 and 19 for hauling distances of 20, 40, and 60 miles. Different marginal log sizes would result from different costs and price assumptions. The calculated marginal log sizes do not apply to bonus logs, i.e., those which may be simultaneously set in the same choker with another log. Small logs below the full economic margin may also be taken where no other logs are available to complete a load or where any other available log would overload the machine or rigging. In this case, the economic margin would be determined by the extra cost of setting the extra choker, unhooking, loading, and hauling.

Under observed conditions of this study, any logs smaller than the marginal log size do not pay their way out of the woods. As long as there is an alternative source of raw material for existing mill capacity, any removal of such material can be justified only by silvicultural, protective, or other reasons. Economic justification can only be accomplished by development of more efficient logging and milling methods, use of shorter average yarding distances, or by development of higher log values.

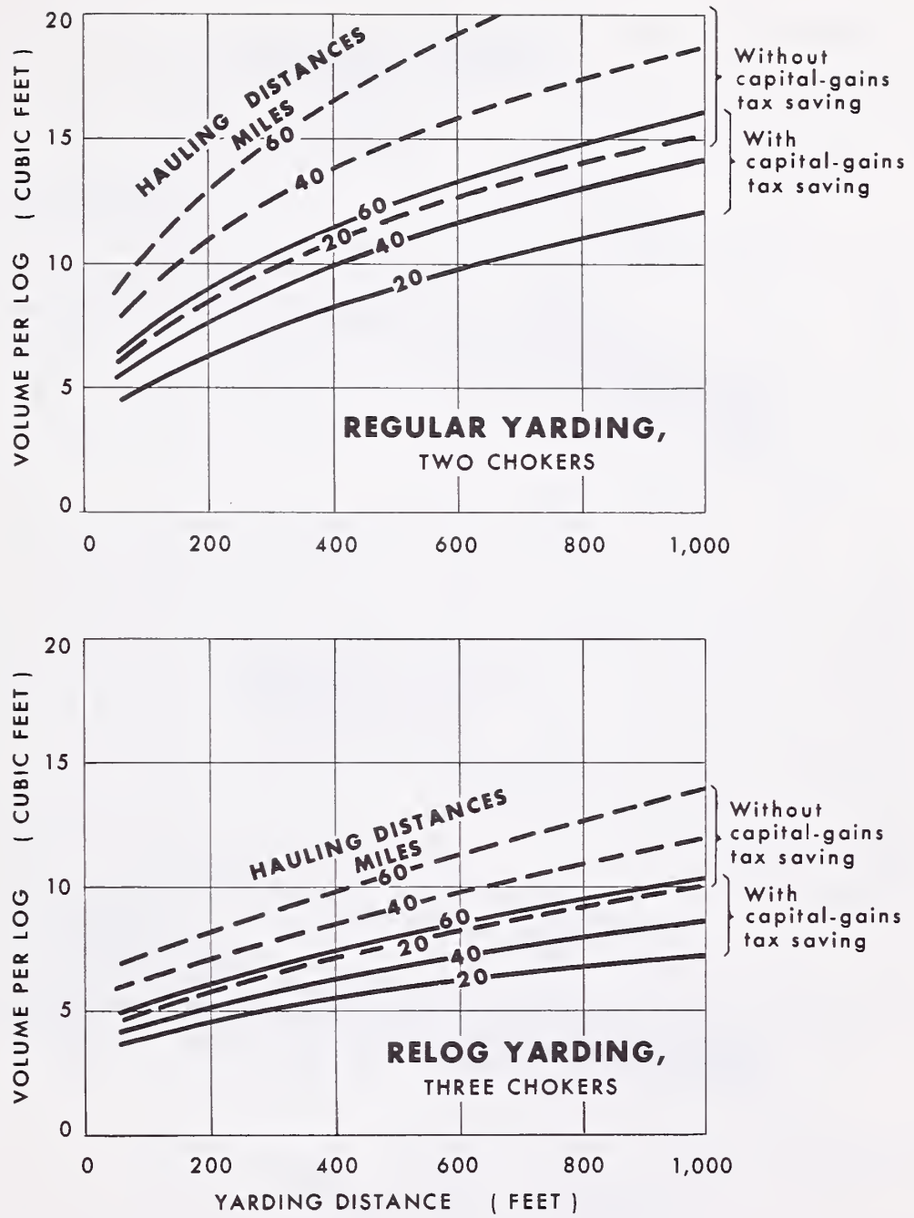

Figure 8.—Marginal log sizes (cubic feet), related to hauling distance, and based on log prices and equivalent mill-yard values described in text.

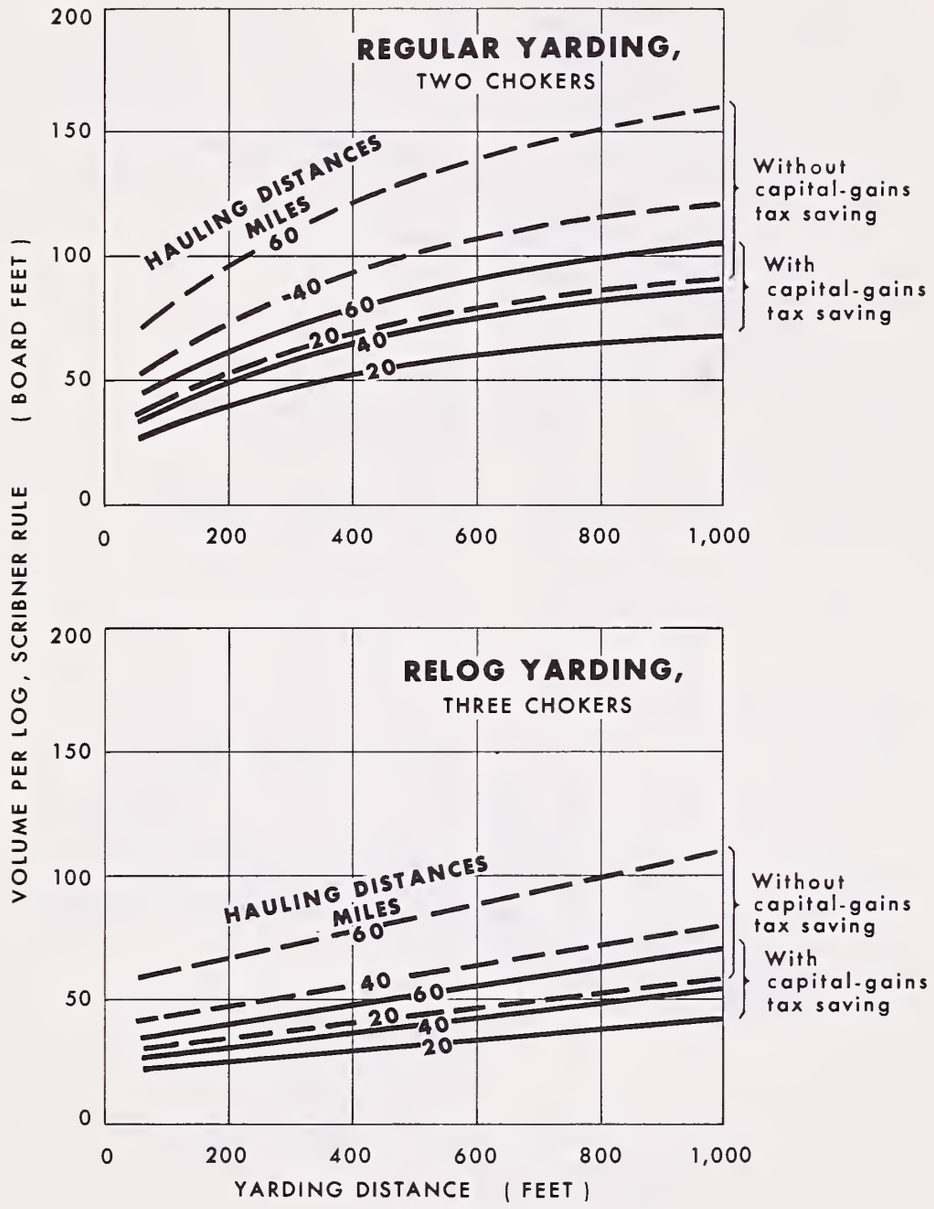

Figure 9.—Marginal log sizes (board feet), related to hauling distance, and based on log prices and equivalent mill-yard values described in text.

Interpretation of Results

Identification of marginal log size is of interest, particularly in a limited supply situation where an operator wishes to maximize the logging returns from a given area. Actually, when a firm owns both forest land and manufacturing plant, it might be advantageous to bring in additional wood below the margin, if this would produce profits in manufacturing that otherwise would not be possible, or if the firm's management decided closer utilization gave flexibility, kept control of wood supply, gave research and development experience for the future, or contributed toward a cleaner setting and a favorable public reaction.

On the other hand, although a general recommendation would be to utilize down to the marginal log wherever possible, there is no magic in earning just enough to cover costs. A case might be made for stopping a little short of the margin; that is, there is no logic in earning just pennies or just breaking even if there is an alternative for a firm to earn more with its manpower and capital equipment elsewhere. However, silviculture, protection, and other noneconomic factors will generally indicate a policy of utilization very close to the economic margin. The challenge to foresters for small log utilization continues to be aimed toward developing ways to utilize them efficiently rather than leaving them behind because they do not pay their way.

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Appendix A

Table 1.—Yarding cycle time in high-lead operations near Cosmopolis, Wash., 1961, by turn volume and slope distance (regular yarding)[1]

Turn volume	Slope distance (feet)										
	50	100	200	300	400	500	600	700	800	900	1,000
	Minutes per turn										
Cubic feet:											
5	2.20	2.54	3.17	3.72	4.21	4.63	4.98	5.26	5.47	5.61	5.68
10	2.23	2.57	3.20	3.76	4.25	4.67	5.02	5.31	5.52	5.67	5.74
20	2.29	2.63	3.27	3.84	4.34	4.77	5.13	5.42	5.65	5.80	5.89
50	2.45	2.81	3.48	4.07	4.50	5.05	5.44	5.76	6.01	6.19	6.30
100	2.74	3.12	3.83	4.47	5.04	5.54	5.97	6.33	6.62	6.85	6.98
200	3.31	3.74	4.53	5.25	5.91	6.49	7.01	7.46	7.84	8.15	8.39
300	3.88	4.35	5.23	6.04	6.78	7.45	8.06	8.59	9.06	9.45	9.78
Board feet (Scribner rule):											
20	2.20	2.54	3.17	3.72	4.21	4.63	4.98	5.26	5.47	5.61	5.68
40	2.23	2.57	3.20	3.76	4.25	4.67	5.02	5.31	5.52	5.67	5.74
100	2.32	2.67	3.30	3.88	4.38	4.82	5.18	5.48	5.71	5.87	5.96
200	2.41	2.78	3.43	4.02	4.54	4.99	5.38	5.69	5.93	6.11	6.21
400	2.60	2.96	3.65	4.26	4.81	5.29	5.70	6.04	6.30	6.51	6.64
1,000	3.16	3.57	4.34	5.04	5.67	6.22	6.73	7.15	7.51	7.79	8.01
2,000	3.96	4.43	5.32	6.14	6.90	7.58	8.19	8.74	9.22	9.62	9.96

[1] Sum of round-trip yarding time and unhooking time. Excludes delay time. Calculated for two chokers and two logs per turn.

Table 2.—Yarding cycle time in high-lead operations near Cosmopolis, Wash., 1961, by turn volume and slope distance (relog yarding)[1]

Turn volume	Slope distance (feet)										
	50	100	200	300	400	500	600	700	800	900	1,000
	Minutes per turn										
Cubic feet:											
5	3.99	4.31	4.95	5.59	6.24	6.88	7.52	8.16	8.81	9.45	10.09
7.5	4.01	4.33	4.97	5.62	6.26	6.90	7.54	8.19	8.82	9.46	10.11
10	4.02	4.35	4.99	5.63	6.27	6.92	7.56	8.20	8.84	9.48	10.13
15	4.06	4.38	5.02	5.67	6.31	6.95	7.60	8.24	8.88	9.52	10.16
20	4.10	4.42	5.06	5.70	6.35	6.99	7.63	8.27	8.92	9.56	10.20
30	4.17	4.49	5.14	5.78	6.42	7.06	7.70	8.35	8.99	9.63	10.27
50	4.32	4.64	5.28	5.92	6.56	7.21	7.85	8.49	9.13	9.78	10.42
75	4.50	4.82	5.46	6.10	6.75	7.39	8.03	8.67	9.32	9.96	10.60
100	4.68	5.00	5.64	6.29	6.93	7.57	8.22	8.86	9.50	10.14	10.78
150	5.05	5.38	6.01	6.65	7.30	7.94	8.58	9.22	9.86	10.51	11.15
Board feet (Scribner rule):											
20	3.99	4.31	4.95	5.59	6.24	6.88	7.52	8.16	8.81	9.45	10.09
30	4.01	4.33	4.97	5.62	6.26	6.90	7.54	8.19	8.82	9.46	10.11
40	4.02	4.35	4.99	5.63	6.27	6.92	7.56	8.20	8.84	9.48	10.13
60	4.06	4.38	5.02	5.67	6.31	6.95	7.60	8.24	8.88	9.52	10.16
100	4.13	4.45	5.10	5.74	6.38	7.02	7.66	8.31	8.95	9.59	10.23
150	4.22	4.54	5.19	5.81	6.47	7.11	7.76	8.40	9.04	9.68	10.33
200	4.27	4.59	5.23	5.87	6.52	7.16	7.80	8.44	9.08	9.73	10.37
300	4.42	4.75	5.39	6.03	6.67	7.32	7.96	8.60	9.24	9.88	10.53
400	4.48	4.80	5.45	6.09	6.73	7.37	8.02	8.66	9.30	9.94	10.59
600	4.76	5.08	5.72	6.37	7.01	7.65	8.29	8.94	9.58	10.22	10.86

[1] Sum of round-trip yarding time and unhooking time. Excludes delay time. Calculated for three chokers and three logs per turn, yarding to cold deck.

Table 3.—Yarding cost per turn in high-lead operations near Cosmopolis, Wash., 1961, by turn volume and slope distance (regular yarding)[1]

Turn volume	Slope distance (feet)										
	50	100	200	300	400	500	600	700	800	900	1,000
	Dollars per turn										
Cubic feet:											
5	1.12	1.29	1.62	1.90	2.15	2.36	2.54	2.68	2.79	2.86	2.90
10	1.14	1.31	1.63	1.92	2.17	2.38	2.56	2.71	2.81	2.89	2.93
20	1.17	1.34	1.67	1.96	2.21	2.43	2.61	2.76	2.88	2.96	3.00
50	1.25	1.43	1.77	2.07	2.29	2.57	2.77	2.94	3.06	3.16	3.21
100	1.40	1.59	1.95	2.28	2.57	2.82	3.04	3.23	3.37	3.49	3.56
200	1.69	1.91	2.31	2.68	3.01	3.31	3.57	3.80	4.00	4.15	4.28
300	1.98	2.22	2.67	3.08	3.46	3.80	4.11	4.38	4.62	4.82	4.98
Board feet (Scribner rule):											
20	1.12	1.29	1.62	1.90	2.15	2.36	2.54	2.68	2.79	2.86	2.90
40	1.14	1.31	1.63	1.92	2.17	2.38	2.56	2.71	2.81	2.89	2.93
100	1.18	1.36	1.68	1.98	2.23	2.46	2.64	2.79	2.91	2.99	3.04
200	1.23	1.42	1.75	2.05	2.31	2.54	2.74	2.90	3.02	3.11	3.17
400	1.33	1.51	1.86	2.17	2.45	2.70	2.91	3.08	3.21	3.32	3.38
1,000	1.61	1.82	2.21	2.57	2.89	3.17	3.43	3.64	3.83	3.97	4.08
2,000	2.02	2.26	2.71	3.13	3.52	3.86	4.17	4.45	4.70	4.90	5.08

Source: Times of table 1 multiplied by $0.5097 per minute, derived from table 20.
[1] Based on two logs per turn.

Table 4.—Yarding cost per unit volume in high-lead operations near Cosmopolis, Wash., 1961, by log and turn volumes and slope distance (regular yarding)[1]

Log volume	Turn volume	Slope distance (feet)										
		50	100	200	300	400	500	600	700	800	900	1,000
Cubic feet		Dollars per 100 cubic feet										
2.5	5	22.40	25.80	32.40	38.00	43.00	47.20	50.80	53.60	55.80	57.20	58.00
5	10	11.40	13.10	16.30	19.20	21.70	23.80	25.60	27.10	28.10	28.90	29.30
10	20	5.85	6.70	8.35	9.80	11.05	12.15	13.05	13.80	14.40	14.80	15.00
25	50	2.50	2.86	3.54	4.14	4.58	5.14	5.54	5.88	6.12	6.32	6.42
50	100	1.40	1.59	1.95	2.28	2.57	2.82	3.04	3.23	3.37	3.49	3.56
100	200	.84	.96	1.16	1.34	1.50	1.66	1.78	1.90	2.00	2.08	2.14
150	300	.66	.74	.89	1.03	1.15	1.27	1.37	1.46	1.54	1.61	1.66
Board feet[2]		Dollars per M board feet										
10	20	56.00	64.50	81.00	95.00	107.50	118.00	127.00	134.00	139.50	143.00	145.00
20	40	28.50	32.75	40.75	48.00	54.25	59.50	64.00	67.75	70.25	72.25	73.25
50	100	11.80	13.60	16.80	19.80	22.30	24.60	26.40	27.90	29.10	29.90	30.40
100	200	6.15	7.10	8.75	10.25	11.55	12.70	13.70	14.50	15.10	15.55	15.85
200	400	3.32	3.78	4.65	5.43	6.13	6.75	7.28	7.70	8.03	8.30	8.45
500	1,000	1.61	1.82	2.21	2.57	2.89	3.17	3.43	3.64	3.83	3.97	4.08
1,000	2,000	1.01	1.13	1.36	1.57	1.76	1.93	2.09	2.23	2.35	2.45	2.54

Source: Values of table 3 multiplied by number of turns per unit volume.
[1] Based on two logs per turn.
[2] Scribner rule.

Table 5.—Yarding cost per turn in high-lead operations near Cosmopolis, Wash., 1961, by turn volume and slope distance (relog yarding)[1]

Turn volume	Slope distance (feet)										
	50	100	200	300	400	500	600	700	800	900	1,000
	Dollars per turn										
Cubic feet:											
7.5	1.48	1.60	1.83	2.07	2.31	2.54	2.78	3.02	3.25	3.49	3.73
15	1.50	1.61	1.85	2.09	2.33	2.56	2.80	3.04	3.27	3.51	3.74
30	1.54	1.65	1.89	2.13	2.37	2.60	2.84	3.08	3.31	3.55	3.78
75	1.66	1.78	2.01	2.25	2.49	2.72	2.96	3.19	3.43	3.67	3.91
150	1.86	1.98	2.21	2.45	2.69	2.93	3.16	3.40	3.63	3.87	4.11
Board feet (Scribner rule):											
30	1.48	1.60	1.83	2.07	2.31	2.54	2.78	3.02	3.25	3.49	3.73
60	1.50	1.61	1.85	2.09	2.33	2.56	2.80	3.04	3.27	3.51	3.74
150	1.56	1.67	1.91	2.14	2.38	2.62	2.86	3.10	3.33	3.57	3.81
300	1.63	1.75	1.99	2.22	2.46	2.70	2.93	3.17	3.40	3.64	3.88
600	1.75	1.87	2.11	2.35	2.58	2.82	3.05	3.29	3.53	3.77	4.00

Source: Times of table 2 multiplied by $0.3685 per minute, derived from table 20.
[1] Based on three logs per turn.

Table 6.—Yarding cost per unit volume in high-lead operations near Cosmopolis, Wash., 1961, by log and turn volumes and slope distance (relog yarding)[1]

Log volume	Turn volume	Slope distance (feet)										
		50	100	200	300	400	500	600	700	800	900	1,000
Cubic feet		Dollars per 100 cubic feet										
2.5	7.5	19.68	21.28	24.34	27.53	30.72	33.78	36.97	40.17	43.23	46.42	49.61
5	15	10.00	10.74	12.34	13.94	15.54	17.08	18.68	20.28	21.82	23.41	24.95
10	30	5.13	5.49	6.29	7.09	7.86	8.66	9.46	10.26	11.02	11.82	12.59
25	75	2.21	2.37	2.67	2.99	3.31	3.62	3.94	4.24	4.56	4.88	5.20
50	150	1.24	1.32	1.47	1.63	1.79	1.95	2.11	2.27	2.42	2.58	2.74
Board feet[2]		Dollars per M board feet										
10	30	48.84	52.80	60.39	68.31	76.23	83.82	91.74	99.66	107.25	115.17	123.09
20	60	25.05	26.89	30.90	34.90	38.91	42.75	46.76	50.77	54.61	58.62	62.46
50	150	10.45	11.19	12.80	14.34	15.95	17.55	19.16	20.77	22.31	23.92	25.53
100	300	5.38	5.78	6.57	7.33	8.12	8.91	9.67	10.46	11.22	12.01	12.80
200	600	2.92	3.12	3.52	3.92	4.31	4.71	5.09	5.49	5.90	6.30	6.68

Source: Values of table 5 multiplied by number of turns per unit volume.
[1] Based on three logs per turn.
[2] Scribner rule.

Table 7.—Loading cost per turn in high-lead operations near Cosmopolis, Wash., 1961, by turn volume and slope distance (regular yarding)

Turn volume	Slope distance (feet)										
	50	100	200	300	400	500	600	700	800	900	1,000
	Dollars per turn										
Cubic feet:											
5	0.58	0.67	0.83	0.98	1.11	1.22	1.31	1.38	1.44	1.47	1.49
10	.59	.67	.84	.99	1.12	1.23	1.32	1.39	1.45	1.49	1.51
20	.60	.69	.86	1.01	1.14	1.25	1.35	1.42	1.48	1.52	1.55
50	.64	.74	.91	1.07	1.18	1.33	1.43	1.51	1.58	1.63	1.66
100	.72	.82	1.01	1.17	1.32	1.46	1.57	1.66	1.74	1.80	1.83
200	.87	.98	1.19	1.38	1.55	1.70	1.84	1.96	2.06	2.14	2.20
300	1.02	1.14	1.37	1.59	1.78	1.96	2.12	2.26	2.38	2.48	2.57
Board feet (Scribner rule):											
20	.58	.67	.83	.98	1.11	1.22	1.31	1.38	1.44	1.47	1.49
40	.59	.68	.84	.99	1.12	1.23	1.32	1.39	1.45	1.49	1.51
100	.61	.70	.87	1.02	1.15	1.27	1.36	1.44	1.50	1.54	1.57
200	.63	.73	.90	1.06	1.19	1.31	1.41	1.49	1.56	1.61	1.63
400	.68	.78	.96	1.12	1.26	1.39	1.50	1.59	1.66	1.71	1.74
1,000	.83	.94	1.14	1.32	1.49	1.63	1.77	1.88	1.97	2.05	2.10
2,000	1.04	1.16	1.40	1.61	1.81	1.99	2.15	2.30	2.42	2.53	2.62

Source: Yarding times of table 1 multiplied by $0.2627 per minute, derived from table 21.

Table 8.—Loading cost per unit volume in high-lead operations near Cosmopolis, Wash., 1961, by log and turn volumes and slope distance (regular yarding)

Log volume	Turn volume	Slope distance (feet)										
		50	100	200	300	400	500	600	700	800	900	1,000
Cubic feet		Dollars per 100 cubic feet										
2.5	5	11.60	13.40	16.60	19.60	22.20	24.40	26.20	27.60	28.80	29.40	29.80
5	10	5.90	6.70	8.40	9.90	11.20	12.30	13.20	13.90	14.50	14.90	15.10
10	20	3.00	3.45	4.30	5.05	5.70	6.25	6.75	7.10	7.40	7.60	7.75
25	50	1.28	1.48	1.82	2.14	2.36	2.66	2.86	3.02	3.16	3.26	3.32
50	100	.72	.82	1.01	1.17	1.32	1.46	1.57	1.66	1.74	1.80	1.83
100	200	.44	.49	.60	.69	.78	.85	.92	.98	1.03	1.07	1.10
150	300	.34	.38	.46	.53	.59	.65	.71	.75	.79	.83	.86
Board feet[1]		Dollars per M board feet										
10	20	29.00	33.50	41.50	49.00	55.50	61.00	65.50	69.00	72.00	73.50	74.50
20	40	14.75	17.00	21.00	24.75	28.00	30.75	33.00	34.75	36.25	37.25	37.75
50	100	6.10	7.00	8.70	10.20	11.50	12.70	13.60	14.40	15.00	15.40	15.70
100	200	3.15	3.65	4.50	5.30	5.95	6.55	7.05	7.45	7.80	8.05	8.15
200	400	1.70	1.95	2.40	2.80	3.15	3.48	3.75	3.98	4.15	4.28	4.35
500	1,000	.83	.94	1.14	1.32	1.49	1.63	1.77	1.88	1.97	2.05	2.10
1,000	2,000	.52	.58	.70	.81	.91	1.00	1.08	1.15	1.21	1.27	1.31

Source: Values of table 7 multiplied by number of turns per unit volume.
[1] Scribner rule.

Table 9.—Basic hauling cost per trip in high-lead operations near Cosmopolis, Wash., 1961

Distance		Road type[1]	Time per round-trip mile	Travel time	Cumulative travel time	Cumulative operating cost[2]	Cumulative tire cost[3]	Federal-State highway use tax[4]	Delay cost[5]	Adjustment for nonoperating season[6]	Total basic cost	Adjusted basic hauling cost[7]
Sectional	Cumulative											
Miles	Miles		Minutes	Minutes	Minutes							
0.5	0.5	G1	6.33	3.2	3.2	$0.67	$0.05	--	$3.11	$0.27	$4.10	$4.59
4.5	5.0	G2	5.01	22.5	25.7	5.37	.47	--	3.11	.43	9.38	10.51
5.0	10.0	P1	3.65	18.2	43.9	9.18	.62	$0.51	3.11	.56	13.98	15.66
10.0	20.0	P1	3.65	36.5	80.4	16.80	.94	1.52	3.11	.82	23.19	25.97
10.0	30.0	P2	3.33	33.3	113.7	23.76	1.24	2.54	3.11	1.06	31.71	35.52
10.0	40.0	P3	3.18	31.8	145.5	30.41	1.56	3.55	3.11	1.28	39.91	44.70
10.0	50.0	P3	3.18	31.8	177.3	37.06	1.86	4.56	3.11	1.51	48.10	53.87
10.0	60.0	P3	3.18	31.8	209.1	43.70	2.18	5.58	3.11	1.73	56.30	63.06
10.0	70.0	P3	3.18	31.8	240.9	50.35	2.48	6.59	3.11	1.96	64.49	72.23

[1] Road types: G1 Gravel, single lane, 8-percent slope; G2 Gravel, 1½ lane, 6-percent slope; P1 Paved highway, 4-percent slope; P2 Paved highway, 3-percent slope; P3 Paved highway, 2-percent slope

[2] Operating cost = $0.2090 per minute ($0.0298 fixed cost + $0.1202 operating cost + $0.0590 labor cost); excludes tire cost.

[3] Tire cost = $0.094 per mile on gravel road, $0.0310 per mile on paved road.

[4] Federal-State highway use tax taken as $0.1014 per mile.

[5] Delay cost = $0.0888 per minute for average of 35 minutes for scaling, waiting at landing, etc., or $3.11 per trip.

[6] Cost adjustment for nonoperating season derived from Logging Road Handbook (Byrne et al. 1960).

[7] Based on adjustment factor of 1.12 for price changes 1959-61.

Table 10.—Supplemental hauling cost per load in high-lead operations near Cosmopolis, Wash., 1961[1]

Log volume	Ratio: bd. ft./ cu. ft.	Volume per load	Logs per load	Time per load[2]		Supplemental hauling cost per load	
				Regular logging	Relogging	Regular logging	Relogging
		Feet	Number	Minutes	Minutes	Dollars	Dollars
Cubic feet:							
2.5	--	675	270	[3]60	[3]60	5.97	5.97
5	--	675	135	[3]60	[3]60	5.97	5.97
10	--	675	68	50	[3]60	4.98	5.97
25	--	675	27	20	27	1.99	2.69
50	--	675	14	10	14	1.00	1.39
100	--	675	6.8	5	--	.50	--
150	--	675	4.5	[4]4.5	--	.45	--
Board feet, Scribner rule:							
10	4.0	2,700	270	[3]60	[3]60	5.97	5.97
20	4.0	2,700	135	[3]60	[3]60	5.97	5.97
50	4.0	2,700	54	40	55	3.98	5.47
100	4.6	3,100	31	23	32	2.29	3.18
200	5.4	3,640	18	13	18	1.29	1.79
500	5.8	3,920	7.8	5.8	--	.58	--
1,000	6.4	4,320	4.3	3.2	--	.32	--
1,500	6.8	4,590	3.1	[4]2.3	--	.23	--

[1] Supplemental hauling cost is the cost of truck and driver during loading time ($0.0995 per minute).

[2] At 0.74 minute per piece for regular logging, 1.02 minutes per piece for relog from cold deck.

[3] Maximum time per load taken as 60 minutes due to use of sled or other bunching arrangement for small logs.

[4] At 1.0 minute per piece.

Table 11.—Total hauling costs, related to cubic-foot log volumes, in high-lead operations near Cosmopolis, Wash., 1961 (regular logging)

Cost basis and hauling distance (miles)	For log volumes (cubic feet) of —						
	2.5	5	10	25	50	100	150
	Dollars						
A. Per trip:							
10	21.63	21.63	20.64	17.65	16.66	16.16	16.11
20	31.94	31.94	30.95	27.96	26.97	26.47	26.42
30	41.49	41.49	40.50	37.51	36.52	36.02	35.97
40	50.67	50.67	49.68	46.69	45.70	45.20	45.15
50	59.84	59.84	58.85	55.86	54.86	54.37	54.32
60	69.03	69.03	68.04	65.05	64.06	63.56	63.51
70	78.20	78.20	77.21	74.22	73.23	72.73	72.68
B. Per 100 cubic feet:							
10	3.20	3.20	3.06	2.61	2.47	2.39	2.39
20	4.73	4.73	4.59	4.14	4.00	3.92	3.91
30	6.15	6.15	6.00	5.56	5.41	5.34	5.33
40	7.51	7.51	7.36	6.92	6.77	6.70	6.69
50	8.87	8.87	8.72	8.28	8.13	8.05	8.05
60	10.23	10.23	10.08	9.64	9.49	9.42	9.41
70	11.59	11.59	11.44	11.00	10.85	10.77	10.77

Source: A, sum of tables 9 and 10. B, data of part A divided by 675 cubic feet per load.

Table 12.—Total hauling costs, related to board foot log volumes, in high-lead operations near Cosmopolis, Wash., 1961 (regular logging)

Cost basis and hauling distance (miles)	For log volumes (board feet, Scribner rule) of —						
	10	20	50	100	200	500	1,000
	Dollars						
A. Per trip:							
10	21.63	21.63	19.64	17.95	16.95	16.24	15.98
20	31.94	31.94	29.95	28.26	27.26	26.55	26.29
30	41.49	41.49	39.50	37.81	36.81	36.10	35.84
40	50.67	50.67	48.68	46.99	45.99	45.28	45.02
50	59.84	59.84	57.85	56.16	55.16	54.45	54.19
60	69.03	69.03	67.04	65.35	64.35	63.64	63.38
70	78.20	78.20	76.21	74.52	73.52	72.81	72.55
B. Per M board feet:							
10	8.01	8.01	7.27	5.79	4.66	4.14	3.70
20	11.83	11.83	11.09	9.12	7.49	6.77	6.09
30	15.37	15.37	14.63	12.20	10.11	9.21	8.30
40	18.77	18.77	18.03	15.16	12.63	11.55	10.42
50	22.16	22.16	21.43	18.12	15.15	13.89	12.54
60	25.57	25.57	24.83	21.08	17.68	16.23	14.67
70	28.96	28.96	28.23	24.04	20.20	18.57	16.79

Source: A, sum of tables 9 and 10. B, data of part A divided by board-foot volume per load.

Table 13.—Total hauling costs in high-lead operations near Cosmopolis, Wash., 1961, by log volume and hauling distance (relogging)

Log volume	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dollars per 100 cubic feet						
Cubic feet:							
2.5	3.20	4.73	6.15	7.51	8.87	10.23	11.59
5	3.20	4.73	6.15	7.51	8.87	10.23	11.59
10	3.20	4.73	6.15	7.51	8.87	10.23	11.59
25	2.72	4.25	5.66	7.02	8.38	9.74	11.10
50	2.53	4.05	5.47	6.83	8.19	9.55	10.91
	Dollars per M board feet						
Board feet (Scribner rule):							
10	8.01	11.83	15.37	18.77	22.16	25.57	28.96
20	8.01	11.83	15.37	18.77	22.16	25.57	28.96
50	7.83	11.64	15.18	18.58	21.98	25.38	28.78
100	6.08	9.40	12.48	15.45	18.40	21.37	24.33
200	4.79	7.63	10.25	12.77	15.29	17.82	20.34

Table 14.—Total direct logging costs per hundred cubic feet in high-lead operations near Cosmopolis, Wash., 1961, by log volume, yarding distance, and hauling distance (regular yarding)[1]

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dollars						
Log volume, 2.5 cu. ft.:							
50	37.20	38.73	40.15	41.51	42.87	44.23	45.59
100	42.40	43.93	45.35	46.71	48.07	49.43	50.79
200	52.20	53.73	55.15	56.51	57.87	59.23	60.59
300	60.80	62.33	63.75	65.11	66.47	67.83	69.19
400	68.40	69.93	71.35	72.71	74.07	75.43	76.79
500	74.80	76.33	77.75	79.11	80.47	81.83	83.19
600	80.20	81.73	83.15	84.51	85.87	87.23	88.59
700	84.40	85.93	87.35	88.71	90.07	91.43	92.79
800	87.80	89.33	90.75	92.11	93.47	94.83	96.19
900	89.80	91.33	92.75	94.11	95.47	96.83	98.19
1,000	91.00	92.53	93.95	95.31	96.67	98.03	99.39
Log volume, 5 cu. ft.:							
50	20.50	22.03	23.45	24.81	26.17	27.53	28.89
100	23.00	24.53	25.95	27.31	28.67	30.03	31.39
200	27.90	29.43	30.85	32.21	33.57	34.93	36.29
300	32.30	33.83	35.25	36.61	37.97	39.33	40.69
400	36.10	37.63	39.05	40.41	41.77	43.13	44.49
500	39.30	40.83	42.25	43.61	44.97	46.33	47.69
600	42.00	43.53	44.95	46.31	47.67	49.03	50.39
700	44.20	45.73	47.15	48.51	49.87	51.23	52.59
800	45.80	47.33	48.75	50.11	51.47	52.83	54.19
900	47.00	48.53	49.95	51.31	52.67	54.03	55.39
1,000	47.60	49.13	50.55	51.91	53.27	54.63	55.99

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dollars						
Log volume, 50 cu. ft.:							
50	4.59	6.12	7.53	8.89	10.25	11.61	12.97
100	4.88	6.41	7.82	9.18	10.54	11.90	13.26
200	5.43	6.96	8.37	9.73	11.09	12.45	13.81
300	5.92	7.45	8.86	10.22	11.58	12.94	14.30
400	6.36	7.89	9.30	10.66	12.02	13.38	14.74
500	6.75	8.28	9.69	11.05	12.41	13.77	15.13
600	7.08	8.61	10.02	11.38	12.74	14.10	15.46
700	7.36	8.89	10.30	11.66	13.02	14.38	15.74
800	7.58	9.11	10.52	11.88	13.24	14.60	15.96
900	7.76	9.29	10.70	12.06	13.42	14.78	16.14
1,000	7.86	9.39	10.80	12.16	13.52	14.88	16.24
Log volume, 100 cu. ft.:							
50	3.67	5.20	6.62	7.98	9.33	10.70	12.05
100	3.84	5.37	6.79	8.15	9.50	10.87	12.22
200	4.15	5.68	7.10	8.46	9.81	11.18	12.53
300	4.42	5.95	7.37	8.73	10.08	11.45	12.80
400	4.67	6.20	7.62	8.98	10.33	11.70	13.05
500	4.90	6.43	7.85	9.21	10.56	11.93	13.28
600	5.09	6.62	8.04	9.40	10.75	12.12	13.47
700	5.27	6.80	8.22	9.58	10.93	12.30	13.65
800	5.42	6.95	8.37	9.73	11.08	12.45	13.80
900	5.54	7.07	8.49	9.85	11.20	12.57	13.92
1,000	5.63	7.16	8.58	9.94	11.29	12.66	14.01

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dollars						
Log volume, 10 cu. ft.:							
50	11.91	13.44	14.85	16.21	17.57	18.93	20.29
100	13.21	14.74	16.15	17.51	18.87	20.23	21.59
200	15.71	17.24	18.65	20.01	21.37	22.73	24.09
300	17.91	19.44	20.85	22.21	23.57	24.93	26.29
400	19.81	21.34	22.75	24.11	25.47	26.83	28.19
500	21.46	22.99	24.40	25.76	27.12	28.48	29.84
600	22.86	24.39	25.80	27.16	28.52	29.88	31.24
700	23.96	25.49	26.90	28.26	29.62	30.98	32.34
800	24.86	26.39	27.80	29.16	30.52	31.88	33.24
900	25.46	26.99	28.40	29.76	31.12	32.48	33.84
1,000	25.81	27.34	28.75	30.11	31.47	32.83	34.19
Log volume, 25 cu. ft.:							
50	6.39	7.92	9.34	10.70	12.06	13.42	14.78
100	6.95	8.48	9.90	11.26	12.62	13.98	15.34
200	7.97	9.50	10.92	12.28	13.64	15.00	16.36
300	8.89	10.42	11.84	13.20	14.56	15.92	17.28
400	9.55	11.08	12.50	13.86	15.22	16.58	17.94
500	10.41	11.94	13.36	14.72	16.08	17.44	18.80
600	11.01	12.54	13.96	15.32	16.68	18.04	19.40
700	11.51	13.04	14.46	15.82	17.18	18.54	19.90
800	11.89	13.42	14.84	16.20	17.56	18.92	20.28
900	12.19	13.72	15.14	16.50	17.86	19.22	20.58
1,000	12.35	13.88	15.30	16.66	18.02	19.38	20.74

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dollars						
Log volume, 150 cu. ft.:							
50	3.39	4.91	6.33	7.69	9.05	10.41	11.77
100	3.51	5.03	6.45	7.81	9.17	10.53	11.89
200	3.74	5.26	6.68	8.04	9.40	10.76	12.12
300	3.95	5.47	6.89	8.25	9.61	10.97	12.33
400	4.13	5.65	7.07	8.43	9.79	11.15	12.51
500	4.31	5.83	7.25	8.61	9.97	11.33	12.69
600	4.47	5.99	7.41	8.77	10.13	11.49	12.85
700	4.60	6.12	7.54	8.90	10.26	11.62	12.98
800	4.72	6.24	7.66	9.02	10.38	11.74	13.10
900	4.83	6.35	7.77	9.13	10.49	11.85	13.21
1,000	4.91	6.43	7.85	9.21	10.57	11.93	13.29

[1] Sum of tables 4, 8, and 11.

Table 15.—Total direct logging costs per hundred cubic feet in high-lead operations near Cosmopolis, Wash., 1961, by log volume, yarding distance, and hauling distance (relogging)[1]

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dollars						
Log volume, 2.5 cu. ft.:							
50	31.65	33.18	34.60	35.96	37.32	38.68	40.04
100	33.25	34.78	36.20	37.56	38.92	40.28	41.64
200	36.31	37.84	39.26	40.62	41.98	43.34	44.70
300	39.50	41.03	42.45	43.81	45.17	46.53	47.89
400	42.69	44.22	45.64	47.00	48.36	49.72	51.08
500	45.75	47.28	48.70	50.06	51.42	52.78	54.14
600	48.94	50.47	51.89	53.25	54.61	55.97	57.33
700	52.14	53.67	55.09	56.45	57.81	59.17	60.53
800	55.20	56.73	58.15	59.51	60.87	62.23	63.59
900	58.39	59.92	61.34	62.70	64.06	65.37	66.78
1,000	61.58	63.11	64.53	65.89	67.25	68.61	69.97
Log volume, 5 cu. ft.:							
50	17.58	19.11	20.53	21.89	23.25	24.61	25.97
100	18.32	19.85	21.27	22.63	23.99	25.35	26.71
200	19.92	21.45	22.87	24.23	25.59	26.95	28.31
300	21.52	23.05	24.47	25.83	27.19	28.55	29.91
400	23.12	24.65	26.07	27.43	28.79	30.15	31.51
500	24.66	26.19	27.61	28.97	30.33	31.69	33.05
600	26.26	27.79	29.21	30.57	31.93	33.29	34.65
700	27.86	29.39	30.81	32.17	33.53	34.89	36.25
800	29.39	30.92	32.34	33.70	35.06	36.42	37.78
900	30.99	32.52	33.94	35.30	36.66	38.02	39.38
1,000	32.53	34.06	35.48	36.84	38.20	39.56	40.92

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dollars						
Log volume, 10 cu. ft.:							
50	10.52	12.05	13.47	14.83	16.19	17.55	18.91
100	10.88	12.41	13.83	15.19	16.55	17.91	19.27
200	11.68	13.21	14.63	15.99	17.35	18.71	20.07
300	12.48	14.01	15.43	16.79	18.15	19.51	20.87
400	13.25	14.78	16.20	17.56	18.92	20.28	21.64
500	14.05	15.58	17.00	18.36	19.72	21.08	22.44
600	14.85	16.38	17.80	19.16	20.52	21.88	23.24
700	15.65	17.18	18.60	19.96	21.32	22.68	24.04
800	16.41	17.94	19.36	20.72	22.08	23.44	24.80
900	17.21	18.74	20.16	21.52	22.88	24.24	25.60
1,000	17.98	19.51	20.93	22.29	23.65	25.01	26.37
Log volume, 25 cu. ft.:							
50	5.81	7.34	8.75	10.11	11.47	12.83	14.19
100	5.97	7.50	8.91	10.27	11.63	12.99	14.35
200	6.27	7.80	9.21	10.57	11.93	13.29	14.65
300	6.59	8.12	9.53	10.89	12.25	13.61	14.97
400	6.91	8.44	9.85	11.21	12.57	13.93	15.29
500	7.22	8.75	10.16	11.52	12.88	14.24	15.60
600	7.54	9.07	10.48	11.84	13.20	14.56	15.92
700	7.84	9.37	10.78	12.14	13.50	14.86	16.22
800	8.16	9.69	11.10	12.46	13.82	15.18	16.54
900	8.48	10.01	11.42	12.78	14.14	15.50	16.86
1,000	8.80	10.33	11.74	13.10	14.46	15.82	17.18

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dollars						
Log volume, 50 cu. ft.:							
50	4.21	5.73	7.15	8.51	9.87	11.23	12.59
100	4.29	5.81	7.23	8.59	9.95	11.31	12.67
200	4.44	5.96	7.38	8.74	10.10	11.46	12.82
300	4.60	6.12	7.54	8.90	10.26	11.62	12.98
400	4.76	6.28	7.70	9.06	10.42	11.78	13.14
500	4.92	6.44	7.86	9.22	10.58	11.94	13.30
600	5.08	6.60	8.02	9.38	10.74	12.10	13.46
700	5.24	6.76	8.18	9.54	10.90	12.26	13.62
800	5.39	6.91	8.33	9.69	11.05	12.41	13.77
900	5.55	7.07	8.49	9.85	11.21	12.57	13.93
1,000	5.71	7.23	8.65	10.01	11.37	12.73	14.09

[1] Sum of tables 6, 13, and loading costs in text.

Table 16.—Total direct logging costs per thousand board feet, Scribner rule, in high-lead operations near Cosmopolis, Wash., 1961, by log volume, yarding distance, and hauling distance (regular logging)[1]

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dollars						
Log volume, 10 bd. ft.:							
50	93.01	96.83	100.37	103.77	107.16	110.57	113.96
100	106.01	109.83	113.37	116.77	120.16	123.57	126.96
200	130.51	134.33	137.87	141.27	144.66	148.07	151.46
300	152.01	155.83	159.37	162.77	166.16	169.57	172.96
400	171.01	174.83	178.37	181.77	185.16	188.57	191.96
500	187.01	190.83	194.37	197.77	201.16	204.57	207.96
600	200.51	204.33	207.87	211.27	214.66	218.07	221.46
700	211.01	214.83	218.37	221.77	225.16	228.57	231.96
800	219.51	223.33	226.87	230.27	233.66	237.07	240.46
900	224.51	228.33	231.87	235.27	238.66	242.07	245.46
1,000	227.51	231.33	234.87	238.27	241.66	245.07	248.46
Log volume, 20 bd. ft.:							
50	51.26	55.08	58.62	62.02	65.41	68.82	72.21
100	57.76	61.58	65.12	68.52	71.91	75.32	78.71
200	69.76	73.58	77.12	80.52	83.91	87.32	90.71
300	80.76	84.58	88.12	91.52	94.91	98.32	101.71
400	90.26	94.08	97.62	101.02	104.41	107.82	111.21
500	98.26	102.08	105.62	109.02	112.41	115.82	119.21
600	105.01	108.83	112.37	115.77	119.16	122.57	125.96
700	110.51	114.33	117.87	121.27	124.66	128.07	131.46
800	114.51	118.33	121.87	125.27	128.66	132.07	135.46
900	117.51	121.33	124.87	128.27	131.66	135.07	138.46
1,000	119.01	122.83	126.37	129.77	133.16	136.57	139.96

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dollars						
Log volume, 200 bd. ft.:							
50	9.68	12.51	15.13	17.65	20.17	22.70	25.22
100	10.39	13.22	15.84	18.36	20.88	23.41	25.93
200	11.71	14.54	17.16	19.68	22.20	24.73	27.25
300	12.89	15.72	18.34	20.86	23.38	25.91	28.43
400	13.94	16.77	19.39	21.91	24.43	26.96	29.48
500	14.89	17.72	20.34	22.86	25.38	27.91	30.43
600	15.69	18.52	21.14	23.66	26.18	28.71	31.23
700	16.34	19.17	21.79	24.31	26.83	29.36	31.88
800	16.84	19.67	22.29	24.81	27.33	29.86	32.38
900	17.24	20.07	22.69	25.21	27.73	30.26	32.78
1,000	17.46	20.29	22.91	25.43	27.95	30.48	33.00
Log volume, 500 bd. ft.:							
50	6.58	9.21	11.65	13.99	16.33	18.67	21.01
100	6.90	9.53	11.97	14.31	16.65	18.99	21.33
200	7.49	10.12	12.56	14.90	17.24	19.58	21.92
300	8.03	10.66	13.10	15.44	17.78	20.12	22.46
400	8.52	11.15	13.59	15.93	18.27	20.61	22.95
500	8.94	11.57	14.01	16.35	18.69	21.03	23.37
600	9.34	11.97	14.41	16.75	19.09	21.43	23.77
700	9.66	12.29	14.73	17.07	19.41	21.75	24.09
800	9.94	12.57	15.01	17.35	19.69	22.03	24.37
900	10.16	12.79	15.23	17.57	19.91	22.25	24.59
1,000	10.32	12.95	15.39	17.73	20.07	22.41	24.75

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
				Dollars			
Log volume, 50 bd. ft.:							
50	25.17	28.99	32.53	35.93	39.33	42.73	46.13
100	27.87	31.69	35.23	38.63	42.03	45.43	48.83
200	32.77	36.59	40.13	43.53	46.93	50.33	53.73
300	37.27	41.09	44.63	48.03	51.43	54.83	58.23
400	41.07	44.89	48.43	51.83	55.23	58.63	62.03
500	44.57	48.39	51.93	55.33	58.73	62.13	65.53
600	47.27	51.09	54.63	58.03	61.43	64.83	68.23
700	49.57	53.39	56.93	60.33	63.73	67.13	70.53
800	51.37	55.19	58.73	62.13	65.53	68.93	72.33
900	52.57	56.39	59.93	63.33	66.73	70.13	73.53
1,000	53.37	57.19	60.73	64.13	67.53	70.93	74.33
Log volume, 100 bd. ft.:							
50	15.09	18.42	21.50	24.46	27.42	30.38	33.34
100	16.54	19.87	22.95	25.91	28.87	31.83	34.79
200	19.04	22.37	25.45	28.41	31.37	34.33	37.29
300	21.34	24.67	27.75	30.71	33.67	36.63	39.59
400	23.29	26.62	29.70	32.66	35.62	38.58	41.54
500	25.04	28.37	31.45	34.41	37.37	40.33	43.29
600	26.54	29.87	32.95	35.91	38.87	41.83	44.79
700	27.74	31.07	34.15	37.11	40.07	43.03	45.99
800	28.69	32.02	35.10	38.06	41.02	43.98	46.94
900	29.39	32.72	35.80	38.76	41.72	44.68	47.64
1,000	29.79	33.12	36.20	39.16	42.12	45.08	48.04

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
				Dollars			
Log volume, 1,000 bd. ft.:							
50	5.23	7.62	9.83	11.95	14.07	16.20	18.32
100	5.41	7.80	10.01	12.13	14.25	16.38	18.50
200	5.76	8.15	10.36	12.48	14.60	16.73	18.85
300	6.08	8.47	10.68	12.80	14.92	17.05	19.17
400	6.37	8.76	10.97	13.09	15.21	17.34	19.46
500	6.63	9.02	11.23	13.35	15.47	17.60	19.72
600	6.87	9.26	11.47	13.59	15.71	17.84	19.96
700	7.08	9.47	11.68	13.80	15.92	18.05	20.17
800	7.26	9.65	11.86	13.98	16.10	18.23	20.35
900	7.42	9.81	12.02	14.14	16.26	18.39	20.51
1,000	7.55	9.94	12.15	14.27	16.39	18.52	20.64

[1] Sum of tables 4, 8, and 12.

Table 17.—Total direct logging costs per thousand board beet, Scribner rule, in high-lead operations near Cosmopolis, Wash., 1961, by log volume, yarding distance, and hauling distance ((relogging)[1]

Log volume and yarding distance (feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dollars						
Log volume, 10 bd. ft.:							
50	78.77	82.59	86.13	89.53	92.92	96.33	99.72
100	82.73	86.55	90.09	93.49	96.88	100.29	103.68
200	90.32	94.14	97.68	101.08	104.47	107.88	111.27
300	98.24	102.06	105.60	109.00	112.39	115.80	119.19
400	106.16	109.98	113.52	116.92	120.31	123.72	127.11
500	113.75	117.57	121.11	124.51	127.90	131.31	134.70
600	121.67	125.49	129.03	132.43	135.82	139.23	142.62
700	129.59	133.41	136.95	140.35	143.74	147.15	150.54
800	137.18	141.00	144.54	147.94	151.33	154.74	158.13
900	145.10	148.92	152.46	155.86	159.25	162.66	166.05
1,000	153.02	156.84	160.38	163.78	167.17	170.58	173.97
Log volume, 20 bd. ft.:							
50	44.02	47.84	51.38	54.78	58.17	61.58	64.97
100	45.86	49.68	53.22	56.62	60.01	63.42	66.81
200	49.87	53.69	57.23	60.63	64.02	67.43	70.82
300	53.87	57.69	61.23	64.63	68.02	71.43	74.82
400	57.88	61.70	65.24	68.64	72.03	75.44	78.83
500	61.72	65.54	69.08	72.48	75.87	79.28	82.67
600	65.73	69.55	73.09	76.49	79.88	83.29	86.68
700	69.74	73.56	77.10	80.50	83.89	87.30	90.69
800	73.58	77.40	80.94	84.34	87.73	91.14	94.53
900	77.59	81.41	84.95	88.35	91.74	95.15	98.54
1,000	81.43	85.25	88.79	92.19	95.58	98.99	102.38

Table 18.—Marginal log volumes, cubic feet, in high-lead operations near Cosmopolis, Wash., 1961, by logging method, slope distance, and hauling distance[1]

Logging method and slope distance (feet)	Marginal log with capital-gains tax saving and hauling distance of —			Marginal log without tax saving and hauling distance of —		
	20 miles	40 miles	60 miles	20 miles	40 miles	60 miles
Regular logging:						
50	5	5	6	6	7	9
100	5	6	7	7	9	10
200	7	8	9	8	11	13
300	7	9	10	10	12	15
400	8	10	12	11	14	16
500	9	11	13	12	15	18
600	10	12	13	13	16	19
700	10	12	14	13	17	20
800	11	13	15	14	17	20
900	11	13	15	14	18	21
1,000	12	14	16	15	18	21
Relogging:						
50	4	4	5	5	6	7
100	4	5	5	5	6	7
200	4	5	6	6	7	8
300	5	6	7	6	8	9
400	5	6	7	7	8	10
500	5	7	8	7	9	10
600	6	7	8	8	10	11
700	6	7	9	8	10	12
800	7	8	9	9	11	13
900	7	8	10	9	11	13
1,000	7	9	10	10	12	14

[1] Based on log prices and equivalent mill-yard values described in text.

Log volume, 50 bd. ft.:							
50	22.66	26.47	30.01	33.41	36.81	40.21	43.61
100	23.40	27.21	30.75	34.15	37.55	40.95	44.35
200	25.01	28.82	32.36	35.76	39.16	42.56	45.96
300	26.55	30.36	33.90	37.30	40.70	44.10	47.50
400	28.16	31.97	35.51	38.91	42.31	45.71	49.11
500	29.76	33.57	37.11	40.51	43.91	47.31	50.71
600	31.37	35.18	38.72	42.12	45.52	48.92	52.32
700	32.98	36.79	40.33	43.73	47.13	50.53	53.93
800	34.52	38.33	41.87	45.27	48.67	52.07	55.47
900	36.13	39.94	43.48	46.88	50.28	53.68	57.08
1,000	37.74	41.55	45.09	48.49	51.89	55.29	58.69
Log volume, 100 bd. ft.:							
50	13.65	16.97	20.05	23.02	25.97	28.94	31.90
100	14.05	17.37	20.45	23.42	26.37	29.34	32.30
200	14.84	18.16	21.24	24.21	27.16	30.13	33.09
300	15.60	18.92	22.00	24.97	27.92	30.89	33.85
400	16.39	19.71	22.79	25.76	28.71	31.68	34.64
500	17.18	20.50	23.58	26.55	29.50	32.47	35.43
600	17.94	21.26	24.34	27.31	30.26	33.23	36.19
700	18.73	22.05	25.13	28.10	31.05	34.02	36.98
800	19.49	22.81	25.89	28.86	31.81	34.78	37.74
900	20.28	23.60	26.68	29.65	32.60	35.57	38.53
1,000	21.07	24.39	27.47	30.44	33.39	36.36	39.32
Log volume, 200 bd. ft.:							
50	8.81	11.65	14.27	16.79	19.31	21.84	24.36
100	9.01	11.85	14.47	16.99	19.51	22.04	24.56
200	9.41	12.25	14.87	17.39	19.91	22.44	24.96
300	9.81	12.65	15.27	17.79	20.31	22.84	25.36
400	10.20	13.04	15.66	18.18	20.70	23.23	25.75
500	10.60	13.44	16.06	18.58	21.10	23.63	26.15
600	10.98	13.82	16.44	18.96	21.48	24.01	26.53
700	11.38	14.22	16.84	19.36	21.88	24.41	26.93
800	11.79	14.63	17.25	19.77	22.29	24.82	27.34
900	12.19	15.03	17.65	20.17	22.69	25.22	27.74
1,000	12.57	15.41	18.03	20.55	23.07	25.60	28.12

[1] Sum of tables 6, 13, and loading costs in text.

Table 19.—Marginal log volumes, board feet (Scribner rule), in high-lead operations near Cosmopolis, Wash., 1961, by logging method, slope distance, and hauling distance[1]

Logging method and slope distance (feet)	Marginal log with capital-gains tax saving and hauling distance of —			Marginal log without tax saving and hauling distance of —		
	20 miles	40 miles	60 miles	20 miles	40 miles	60 miles
Regular logging:						
50	26	34	46	36	49	68
100	31	40	52	41	55	78
200	39	50	63	50	70	94
300	45	58	73	58	84	110
400	50	65	81	66	92	122
500	55	70	87	72	100	132
600	59	75	92	77	106	140
700	62	79	96	81	110	146
800	64	82	99	85	114	150
900	66	85	102	88	117	155
1,000	68	87	105	90	120	160
Relogging:						
50	22	29	37	30	41	60
100	23	31	39	31	43	62
200	25	33	42	34	47	68
300	28	36	46	37	51	73
400	30	39	50	40	54	78
500	32	41	53	43	58	83
600	35	44	57	46	62	88
700	37	47	60	49	66	94
800	39	50	64	51	69	99
900	42	52	67	54	73	104
1,000	44	55	71	57	76	110

[1] Based on log prices and equivalent mill-yard values described in text.

Table 20.—Summary of yarding costs in high-lead operations near Cosmopolis, Wash., 1961

Item	Regular yarding		Relag yarding	
	Per day	Per haur	Per day	Per hour
	Dallars			
Yarder,[1]				
3-drum crawler unit:				
Depreciation @ 15,000 haurs	16.08	--	11.36	--
Interest, 6 percent af average investment	5.26	--	3.71	--
Fuel and lubrication[2]	7.67	--	5.97	--
Repairs, 50 percent of depreciation	8.04	--	5.68	--
Taxes, 2 percent of average investment	1.75	--	1.24	--
Insurance, 1 percent of average investment	.88	--	.62	--
Subtatal	39.68	4.96	28.58	3.57
Labor:				
7-man crew	144.08	--	--	--
5-man crew	--	--	104.20	--
Payrall averhead (22 percent)	31.70	--	22.92	--
Crew transpartation	15.51	--	11.09	--
Subtatal	191.29	23.91	138.21	17.28
Wire rope:[3]				
1,000 feet, 1-1/8-inch main line	2.89	--	--	--
1,000 feet, 1-inch main line	--	--	2.33	--
3,000 feet, 5/8-inch haulback	3.20	--	--	--
3,000 feet, 1/2-inch haulback	--	--	3.00	--
3,000 feet, 3/8-inch straw line	.78	--	--	--
3,000 feet, 5/16-inch straw line	--	--	.69	--
Straps	.42	--	.42	--
Chakers, 7/8-inch	4.26	--	--	--
Chakers, 3/4-inch	--	--	1.64	--
Subtatal	11.55	1.44	8.08	1.01
Blacks:				
Butt rigging, shackles, fire taals, fuel tank, sled, signal unit, pawersaw	2.09	.26	1.98	.25
Tatal yarding cost	244.61	30.58	176.85	22.11

[1] Clean lagging used 235-horsepawer tarque canverter crawler tractar, estimated delivered price, new = $42,700. Estimated used price (ane-third af new) = $14,233 plus 3-drum yarding winch ($19,225) = $33,458 — 10 percent salvage value = $30,112 amaunt ta be depreciated.

Relagging used 125-harsepawer crawler tractor, estimated delivered price, new = $30,815. Estimated used price (one-third af new) = $10,272 plus 3-drum yarding winch ($13,350) = $23,622 — 10 percent salvage value = $21,260 amaunt to be depreciated.

All calculations are based on 210 aperating days per year.

[2] Develaped from Caterpillar Tractar Ca. Perfarmance Handbaak.

[3] Estimated life af main and haulback lines is 9 millian baard feet, ar 225 days (1,800 haurs) at 40,000 baard feet per day. Estimated life of straw line is approximately 2 years (480 days); straps, approximately 1 year (240 days). Estimated life af 7/8-inch chokers, 15 days, and 3/4-inch chokers, 30 days, with salvage af half the ferrules and haaks.

Table 21.—Summary of loading costs in high-lead operations near Cosmopolis, Wash., 1961

Item	Regular yarding (1-yard model)		Relog yarding (3/4-yard model)	
	Per day	Per hour	Per day	Per hour
	Dollars			
Loader,[1] rubber-mounted unit with power tongs:				
Depreciation @ 20,000 hours	25.84	--	16.16	--
Interest, 6 percent of average investment	13.83	--	8.64	--
Fuel and lubrication	8.00	--	6.80	--
Repairs, 25 percent of depreciation	6.46	--	4.04	--
Cable replacement, every 20 days	.45	--	.26	--
Taxes, 2 percent of average investment	4.61	--	2.88	--
Tire replacement @ 10,000 hours	2.48	--	1.12	--
Insurance, 1 percent of average investment	2.30	--	1.44	--
Subtotal	63.97	8.00	41.34	5.17
Labor:				
Two men	47.24	--	47.24	--
Payroll overhead (22 percent)	10.39	--	10.39	--
Crew transportation	4.47	--	4.47	--
Subtotal	62.10	7.76	62.10	7.76
Total	126.07	15.76	103.44	12.93

[1] Estimated delivered price, new, for 1-yard model = $53,000 — 20 percent salvage value = $42,400 + fuel tank and radio @ $430 = $42,830 amount to be depreciated.

Price for 3/4-yard model = $32,000 — 20 percent salvage value = $25,600 + fuel tank and radio @ $430 = $26,030 amount to be depreciated.

All calculations based on 210 operating days per year.

Appendix B

Labor and equipment costs have been treated in the main body of this report as direct hourly costs. This is in keeping with the concept that such costs may be varied according to number of hours worked per day (for labor) or to choice of equipment and number of hours or days worked per year (for equipment).[10] This conceptual framework is intended to represent the practical situation where a machine rate is calculated for each piece of equipment to represent its hourly cost, with straight-line depreciation occurring with hourly use and with costs of interest, taxes, and insurance also considered a part of the hourly machine rate.

Under such conditions, the operator will continue to remove smaller material up to the point where he just covers his hourly labor and equipment costs. He has just so many working hours available per year and, normally, he has the alternative of moving on to another setting.

There may be times, however, when a more limited concept of direct costs would be considered, and the analysis may be extended to two more limited situations: (1) maximizing returns per setting, where men and equipment would otherwise be idle, or (2) maximizing returns from all possible settings, from a given set of equipment and crew, where there is always the opportunity to move on to another setting.

Maximizing Returns Per Setting

In the first of these more limited situations, capital equipment costs may be regarded largely as fixed or sunk costs which were incurred when the decision was made to purchase and operate the equipment. Specifically, costs of depreciation, interest, taxes, and insurance are **not** considered here as related to hours worked. This would be the case for extra work in otherwise slack time when the machine would be idle — as might be the case with a loader, for example, committed to remain on the landing for the duration of yarding — or for overtime work. If the loading crew would otherwise be idle, as often occurs between yarding turns or when there is no truck available for loading, then even the wages of these men would not be applicable to their increment of extra work.

Cost of repairs could also be considered as fixed costs, unrelated to a given extra log output. For extra work in overtime periods or in otherwise slack time, there would also be no extra cost for crew transportation, since there would be no extra travel time involved.

Omitting from machine rates the costs of depreciation, interest, taxes, insurance, repairs, and crew transportation, the hourly rates for yarding, loading, and hauling may be calculated as shown in tables 22, 23, and 24. These may be applied to times per turn or per load to give corresponding costs which can then be divided by volume output to give cost per unit volume. Resulting costs are shown graphically in figure 10.

This type of marginal log analysis will minimize losses from sunk costs when there is no alternative use of the equipment (or men). Occasionally such a situation might arise temporarily as, for example, a result of some emergency or poor planning. If this situation persisted, the operator would probably be better off to sell the equipment so as to recover whatever capital value remained and reinvest in more profitable types of equipment or enterprise.

[10] See Matthews' discussion of unit costs and machine rates (1942, pp. 45-61).

Maximizing Returns from All Possible Settings

In the second limited situation, it may be considered that operations could always be shifted to another setting up to the point where the gain in lower unit operating costs, achieved through leaving more and more of the lower value logs, would be offset by the extra costs of moving, hangups and breakage in yarding through the material to be left, and by the extra costs of developing extra settings.

This method aims at maximizing by equating marginal net revenues from all possible settings over the fixed working life of the equipment. This situation would lead toward maximum high grading, with a given set of equipment and crew. It is difficult to visualize such a situation. As soon as appreciable amounts of small or medium-sized merchantable pieces were left, it would pay to add additional equipment and crew to go in and relog the setting. That is, there would no longer be a fixed amount of equipment and crew from which to try to maximize returns.

The conclusion is that neither of the alternative conditions described in this appendix fits the day-to-day situations faced by most operators, and the marginal analysis described in the main body of this report, which is built around an hourly machine rate that includes capital equipment costs as well as labor and fuel costs, is a more satisfactory framework for determination of marginal log size.

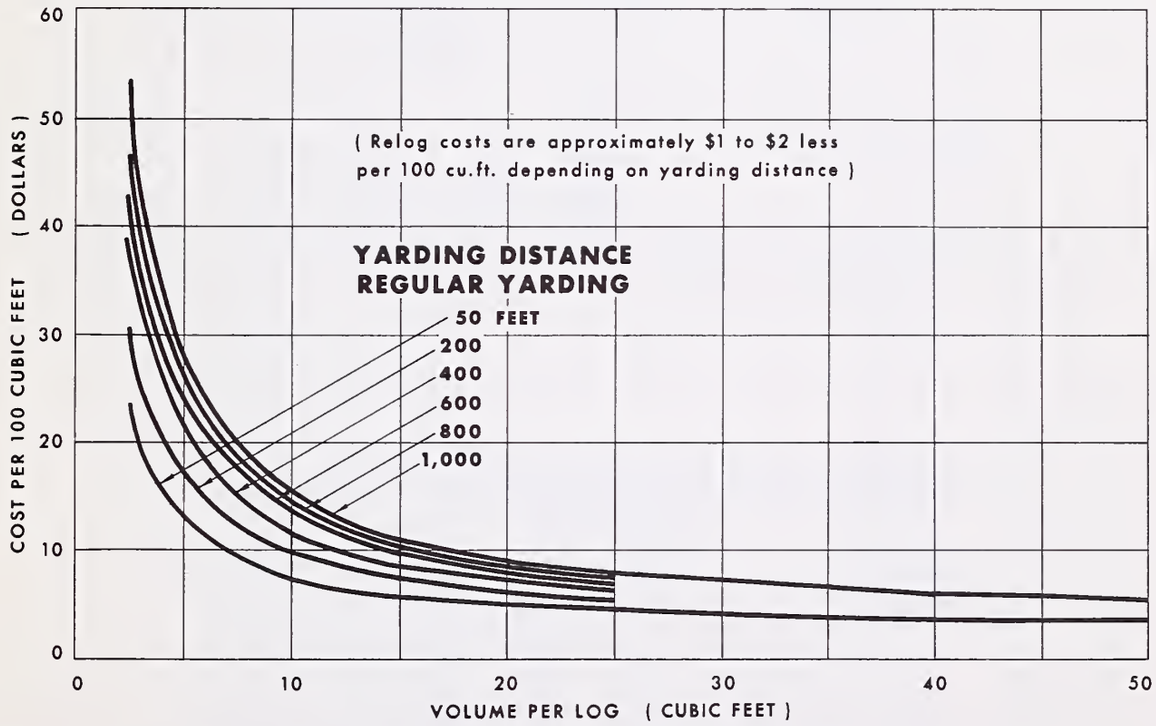

Figure 10.—Direct logging cost per hundred cubic feet (yarding, loading, hauling), excluding depreciation and related items. Hauling distance 20 miles.

Table 22.—Direct yarding costs for fuel and labor in high-lead operations near Cosmopolis, Wash., 1961

Item	Regular yarding		Relog yarding	
	Per day	Per hour	Per day	Per haur
	Dollars			
Yarder[1]:				
Fuel and lubrication	7.67	0.96	5.97	0.75
Labor:				
7-man crew	144.08	18.01	--	--
5-man crew	--	--	104.20	13.03
Payroll overhead	31.70	3.96	22.92	2.86
Subtotal	175.78	21.97	127.12	15.89
Total	183.45	22.93	133.09	16.64

[1] Same equipment as in table 20.

Table 23.—Direct loading costs for fuel and labor in high-lead operations near Cosmopolis, Wash., 1961

Item	Regular yarding (1-yard madel)		Relog yarding (3/4-yard model)	
	Per day	Per hour	Per day	Per hour
	Dollars			
Loader[1]:				
Fuel and lubrication	8.00	1.00	6.80	0.85
Labor:				
Twa men	47.24	5.90	47.24	5.90
Payroll averhead	10.39	1.30	10.39	1.30
Subtotal	57.63	7.20	57.63	7.20
Tatal	65.63	8.20	64.43	8.05

[1] Same equipment as in table 21.

Table 24.—Hauling cost per trip, excluding depreciation and related items, in high-lead operations near Cosmopolis, Wash., 1961, by average log volume and hauling distance[1]

Average log volume (cubic feet)	Hauling distance (miles)						
	10	20	30	40	50	60	70
	Dallars						
2.5-5	13.04	21.51	29.36	36.93	44.48	52.05	59.60
10	12.48	20.95	28.80	36.37	43.92	51.49	59.04
25	10.78	19.25	27.10	34.67	42.22	49.79	57.34
50	10.22	18.69	26.54	34.11	41.66	49.23	56.78
100	9.93	18.40	26.25	33.82	41.37	48.94	56.49
150	9.88	18.35	26.20	33.77	41.32	48.89	56.44

[1] Developed from data of tables 9 and 10.

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1965. High-lead logging costs as related to log size and other variables. U. S. Forest Serv. Res. Paper PNW-23, 38 pp., illus. Pacific Northwest Forest & Range Experiment Station, Portland, Oreg.

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