COST IMPLICATIONS OF MANAGING A DECK FOR A SMALL STRAIGHT TOWER YARDER

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ABSTRACT

A Koller Model K-300 yarder was operated on several cut units of the University of Idaho Experimental Forest. Operations pointed to the excellent yarding capabilities of the machine but also demonstrated a significant problem in managing and controlling the yarder deck. Delay times associated with management of the deck and movement of the yarder out of the way for loading represented a substantial portion of the operating day. A breakeven approach was used to compare the cost of operations with these delays with the cost of using a hot-loader or swing skidder to move material away from the deck. Breakeven values on the hourly rate that could be paid for a loader or swing skidder were surprisingly high. These results indicate that in many cases, use of an additional machine may be more cost effective than struggling with the deck manually.

KEYWORDS: Yarding costs; breakeven analysis.

INTRODUCTION

As timber sizes decrease, and logging costs increase, logging companies are finding that they must continually move more logs at less cost to stay in business. Loggers are also finding themselves working under more constraints with the types of cuts harvested and where roads and skid trails can be placed. These conditions are likely to continue indefinitely. If loggers are to stay in business over the long term, they must adjust their operations to comply with silvicultural and environmental constraints but must still remain profitable.

Small cable yarders are a fairly inexpensive way of moving logs over rough terrain. Most have yarding capabilities of 1000 feet or more and can work on convex slopes with little site damage through the use of intermediate supports. If used with a clamping carriage, small yarders are nearly ideal for selection cuts ranging from light commercial thinnings to seed tree cuts. With ease of mobility and relatively low initial cost, maintenance, and labor requirements, these machines can be very attractive to logging companies.

One of the major drawbacks of small cable yarders is the fact that they become quickly deckbound. Since the tower is fixed and fairly short, crews can rarely skid a full shift without the chute for log entry to the deck becoming plugged. The situation can be alleviated somewhat, especially in small timber, if the yarder operater, chaser, or both, continuously spread the deck with pevees. In many cases the deck still becomes plugged, however, and the machine must be moved out of the way until the logs can be loaded out, usually with a self-loading log truck.

Olsen, LeDoux, and McIntire (1983), assumed in their paper, "Determining Deck Size Limitations For Small Cable Yarders", that log loaders and skidders would not be cost effective for keeping the chute clean for this type of operation. Experience at the University of Idaho with a small yarder indicates that the assumption may not be valid in all cases. The object of this analysis is to provide a method to determine the point where swinging logs away with a skidder or hot loading with a separate loader becomes less expensive than continually trying to rearrange a deck manually during yarding.

DESCRIPTIVE INFORMATION

A Koller Model K 300 yarder with a Koller Model SKA1 carriage was made available to the University of Idaho, College of Forestry, Wildlife, and Range Sciences in June, 1984, by the Koller USA Corporation of Corvallis, Oregon. The yarder was loaned to the college for use in teaching and research, and as a demonstration tool. In the summer of 1984 the Koller yarder was used by the University of Idaho, Experimental Forest logging crew, to yard several cut units with varying site and harvesting conditions. While the yarding capabilities of the machine were excellent, one major drawback to the small tower yarder became apparent. A full setting could rarely be yarded without becoming deckbound.

The Koller Model K-300 is a trailer mounted, stationary tower yarder. The effective tower height of the yarder is twenty-three feet. Early models, such as the one used here, are powered by a fifty horsepower, Ford, gasoline engine. Newer models are powered by a 65.5 horsepower Perkins diesel engine and are available with an optional haulback drum. The yarder has a mainline drum capacity of 1150 feet of 3/8 inch cable and a skyline drum capacity of 1150 feet of 5/8 inch cable. A schematic of the machine is illustrated in Figure 1.

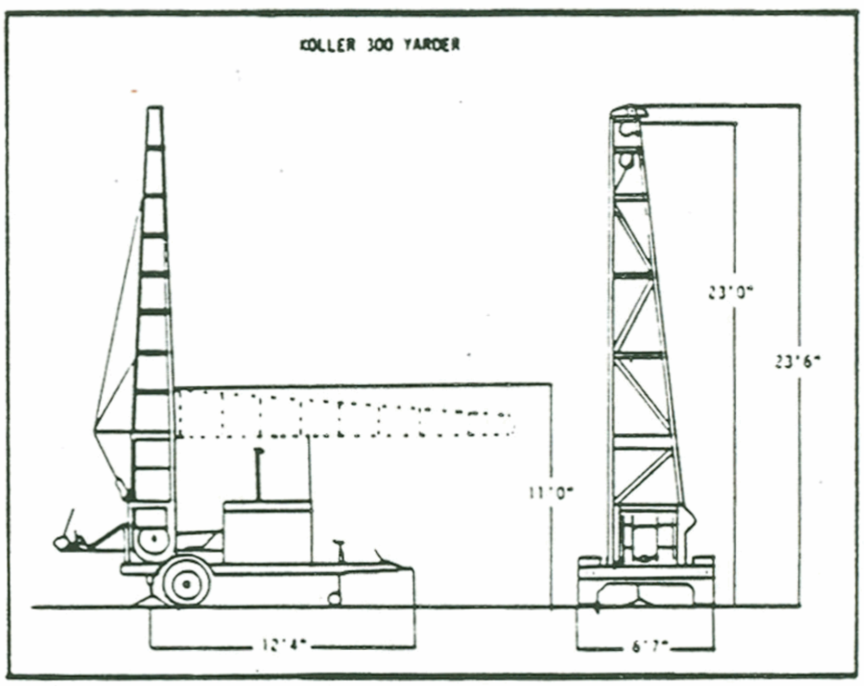

FIGURE 1: Schematic of the dimensions of the Koller Model K-300 yarder.

The carriage, a Koller Model SKA1, is a hydraulic, self-clamping carriage. It can be locked at any position along the skyline with a clamping system powered by an internal hydraulic pump. The pump is charged by movement of the carriage along the skyline. The carriage has the capability of utilizing intermediate supports. This allows more flexibility in the location of sets and permits larger turns because of greater clearance of the logs and shorter span segments.

Table 5: Yarding, loading and hauling production time and volume used in breakeven analysis

AVERAGE PRODUCTION TIMES	
YARDER	
Delay free time per turn	2.5 minutes
Other delay time per turn	1.5 minutes
Deck Delay time per turn	
Average	2.0 minutes
Range tested	0-3 minutes
Setup time per setting	3.83 hours
Reset time for loading per reset	
Average	.67 hour
Range tested	0-1 hour
LOADER	
Delay free time per load	.50 hours
Delay time per load from yarder deck	.12 hours
HAULING	
One-way hauling distance	13 miles
Hauling cost per round trip	$71.36
AVERAGE PRODUCTION VOLUMES	
Volume per setup	9.9 MBF
Volume per reset of yarder	6.8 MBF
Volume per yarder turn	.182 MBF
Volume per load with conventional truck	5.8 MBF
Volume per load for truck with self loader	4.8 MBF

The amount that could be committed to a swing skidder was consistently lower than the breakeven amount for a separate hot-loader. This trend indicates that for these conditions, hot-loading is likely to be more cost effective than using a swing skidder to clear the yarder deck.

The comparison between hot-loading and swing skidding was also structured in the form of a breakeven equation to determine the percentage of a skidder costing $48.54 per hour that could be dedicated to swing skidding from a yarder deck before hot-loading with a loader costing $43.20 per hour would become a preferred alternative. The equation reduced to

Percent of skidder time =

$$(VT*(L3+H2-L2-H1)/((YT+OD)/60) \qquad (15)$$

The breakeven value was calculated at 55%. With a skidder and loader both costing $43.20 per hour, the percentage use of the skidder could have risen to 61.4%.

SUMMARY

All of the alternatives for the management of the yarder deck for straight-towered yarders involve additional cost to the yarding system. The analysis presented here illustrates some of the trade-offs between deck management alternatives and the need to be aware of the point where one alternative becomes more cost effective than the other.

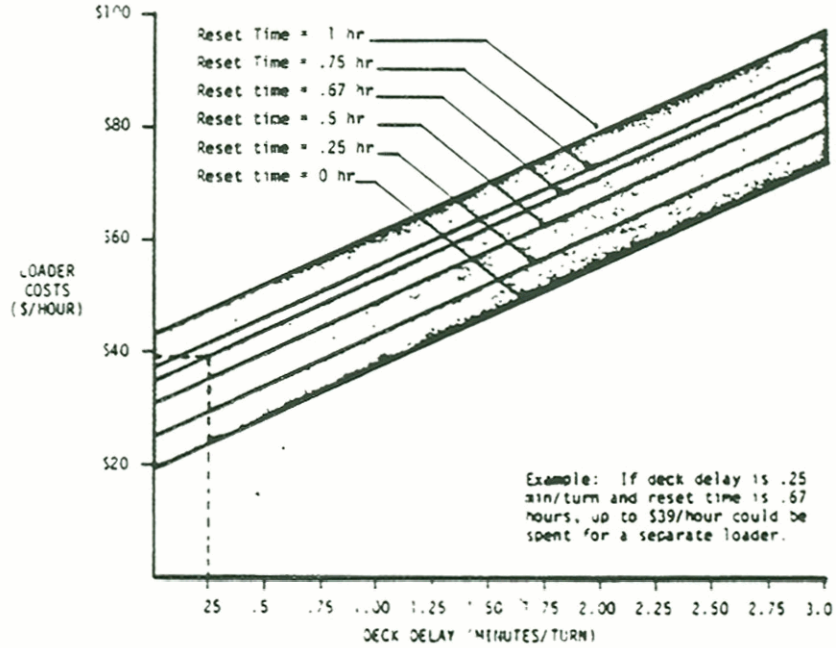

FIGURE 3: Breakeven curves of the hourly rate of loader plotted against the deck delay time in minutes.

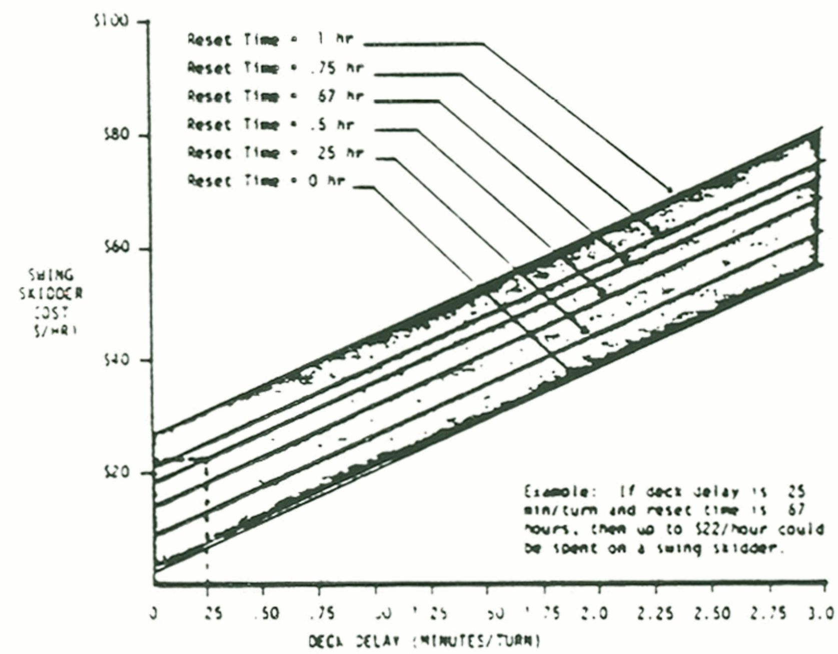

FIGURE 4: Breaker costs of the hourly rate of a swing skidder plotted against the deck delay time in minutes.

REFERENCES

KELLOGG, L.D. and E.D. OLSEN. Increasing the productivity of a small yarder: crew size, skidder swinging, hot thinning. Research Bulletin 46. Forest Research Lab, Oregon State University, Corvallis, OR (1984).

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Two crew members, a yarder operator and a choker setter, were used initially. The yarder operator would also act as a landing chaser and would spread the deck with a pevee while the next turn was being hooked. Large delay times were encountered because of the excessive amount of time spent by the yarder operator moving logs in the deck. The time required to manage the deck far exceeded the time required to set chokers. Since trees were skidded tree length, the operation was complicated and delays were increased by a bucking requirement at the landing.

The crew size was soon increased to three. The third member worked as a full time chaser and landing sawyer. Since two people are available to move logs at the deck more logs could be yarded before becoming deckbound. Deck delay and rigging times decreased, but even with three people on the crew a full set could not be yarded into one deck.

Several other methods were used to allow more logs to be yarded before moving the yarder. A rubber-tired choker skidder was brought to the yarder from a nearby ground skid unit once or twice a day during initial trials with the yarder. This was found to be an impractical solution once the line and ground operations became separated by large distances. Non-productive time for the skidder moving between sites represented a high cost even when the distance was relatively short. Two small machines, a shop-built mini-skidder and a chainsaw winch, were also used to break down the deck. Neither proved adequate. The mini-skidder did not have an integral winch needed to control direction of pull on the logs and the chainsaw winch lacked the power to efficiently spread the deck.

The yarder was also used to spread the deck. This was done by rigging the mainline through a block secured to a tree or stump at the side of the setting. Chokers were hooked to "key" logs in the deck. By tightening the mainline, logs could be moved to the side as shown in Figure 2. Although the operation worked successfully, it was very time consuming and costly because of the non-productive time of the yarder and choker setter. The method was also restricted to fairly level landings since logs could easily slip downhill and the procedure provided little control over movement of the logs. The extreme side pull on the skyline caused the skyline to be pulled off the intermediate support jack on occasion. Anchor stumps or trees are also needed in the right locations for the system to work well.

Experience with the Koller K-300 pointed to downtime and costs associated with all methods of deck management. Management of the deck by moving the yarder for loading and by moving logs by hand involves little capital outlay but can be very time consuming. The combination of times the system is down while waiting for loading and the production delays encountered when the operator and chaser move material away from the deck could justify some type of continuous swing skidding or hot loading. The analysis developed here will determine machine and labor rates of a skidder and loader that breakeven with the cost incurred when production is delayed because of deck management activities.

RESULTS OF FIELD OPERATIONS

The Koller yarder was used on four different cutting units. Three of these were clearcuts; one was a shelterwood selection cut. The average slope for all units was 35 percent and slope form ranged from concave to convex. Average

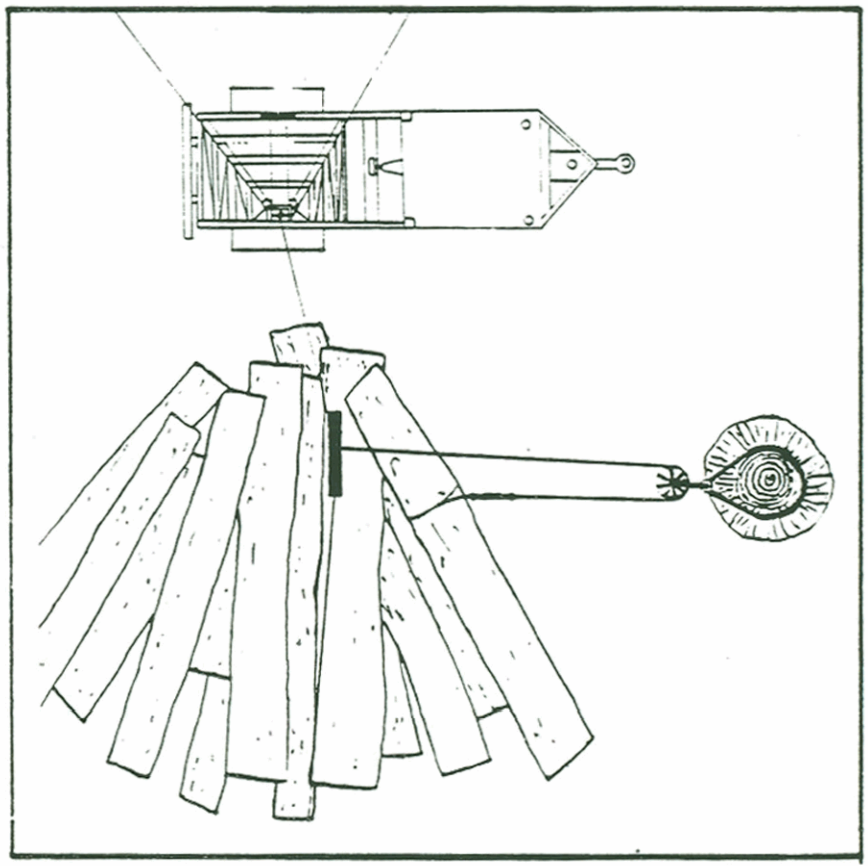

FIGURE 2: Schematic of rigging when yarder is used to move logs within the deck.

external yarding distance was 525 feet. Intermediate supports were used in three of the four units. Stand averages for the units are presented in Table 1.

Production estimates for the operations were based on the cruised and hauled volume per setting and a piece count of daily production. Major delays, their cause and duration were also recorded. Volume per setting averaged 9.9 MBF; volume per turn averaged 182 board feet. Turns averaged two commercial pieces per turn. This implies an average piece size of 93 gross board feet or 914 pounds. The yarder had to be moved away for loading between one and two times per setting. Time required to reset the yarder on these occasions averaged 40 minutes.

Elemental turn times were not recorded during the operation but they appeared to parallel those recorded by researchers at Oregon State University during similar operations with the same yarder. Times for the OSU study (Kellogg and Olsen, 1984) are abstracted amd recorded in Table 2.

Owning and operating costs of the Koller yarder and carriage are developed in Table 3. Owning costs totaled $11.66 per scheduled hour; operating costs were $6.28 per operating hour. Labor costs with a three person crew totaled $58.25/hour including benefits.

Analysis of the cost of small cable systems must include the cost of loading and hauling. Use of hot loading and the quality of the log deck in cold decking operations will influence the cost per unit of loading. Effective loading time per piece when hot loading will be limited by the production of the yarder and will generally be higher than loading times for a loader working independently from a deck.

Trucks with self-loaders are the only units that can cost-effectively service the small, scattered decks created by operation of a single small yarder. Hauling cost per unit of output will be affected by the presence of a self-loader on the truck. Since trucks are limited to a maximum allowable weight with a load, the

Table 1: Stand and site averages for the four experimental units yarded with the Koller K-300

Site Information on Koller Units				
Unit	A	B	C	D
Acres	5.1	2.0	1.3	4.2
Slope	20-40%	20-60%	20-36%	20-35%
Cut Type	CC	Strip CC	Strip CC	Shelter-wood
EYD	300'-475'	550'	575'	425'-500'
Intermediate Support used	NO	YES	YES	YES
Gross volume (MBF)	77.525	19.890	18.805	•
Net volume (MBF)	70.999	18.050	11.901	*
Total pieces	1020	195	188	*
Net pieces/ MBF	13.34	10.72	14.24	*
Gross pieces/ MBF	12.33	9.80	10.26	*
Average lbs/piece	867	1,047	829	*
Gross BF/ piece	81	102	97	*
Net BF/ piece	76	94	73	*

*Incomplete information on unit D at this time.

Table 2: Elemental turn and delay times for Koller Model K-300 yarder operating in a thinning operation.

	Minutes	% of total time
Delay free turn time	2.21	43.0%
Total delay time	3.27	42.0%
Reset time	- -	6.6%
Deck delay time	- -	4.4%
Other delay time	- -	31.0%
Total turn time	5.48	85.0%
Set up time (Road changes)		15.0%

Abstracted from Kellogg, L.D. and E.D. Olsen. 1984. Increasing productivity of a small yarder. Res Bull. 46. Oregon State University. Forest Research Lab. Corvallis, OR.

Table 3: Owning, operating and labor costs of Koller Model K-300

Delivered price with carriage and cable	:	$48,500
Communication system (radio)	:	4,950
Rigging equipment (cable, jacks, climbing gear)	:	1,400
Cable cost included in operating cost	:	1,725
Owning cost per scheduled hour		11.66
Operating cost per operating hour		6.28
Labor cost per person		12.00
Benefits at 40%		4.80
Total labor rate per person		16.80
Profit and risk at 20% of owning and operating cost		3.76
Total hourly rate with 2-member crew		~~41.45~~ 58.25
Total hourly rate with 3-member crew		~~58.25~~ 72.10

additional weight of a self loader takes directly away from the amount of wood that can be hauled.

Use of a skidder to swing logs away from the yarder will add all or part of the cost of the skidder and operator to the cost of the yarding system. Basic hourly rates of skidders, loaders, and trucks considered in the breakdown analysis are shown in Table 4.

BREAKEVEN ANALYSIS

At some point the time required to periodically move the yarder away for loading and the decking delays encountered continuously throughout a yarding cycle can become so large that it would be more cost effective to move material away from the yarder with a second machine. When a loader is used for this task, it can keep the area under the yarder clear of logs and can also accomplish the loading function. The loading rate will normally be decreased, however, to the production rate of the yarder. The additional cost to the yarding system is in underutilization of the loader.

A skidder could also be used for this task. If the skidder is also used for ground skidding on adjacent ground the cost to the yarder operation is equal to the percent of skidder time devoted to clearing the yarder landing. If adjacent ground skidding units are not available the full cost of the skidder and operator must be carried by the yarder operation. Moving material away from the yarder often involves underutilization of the skidding vehicle.

Loading and hauling costs can also be affected by the type of deck being processed. Decks created by the yarder are normally at a 90° angle to the haul road and are often quite tangled because of efforts to move logs away from the yarding corridor. Decks created by a swing skidder will be oriented parallel to the road, and should provide easier access to logs. Kellogg and Olsen (1984) found a 23% difference in loading times between yarder and skidder decks in favor of the skidder decks.

Trade-offs between these factors can be accounted for in a breakeven analysis. The equations can be structured to yield the amount of time that can be spent resetting the yarder or that can be spent in deck delays when the alternative involves hot loading with a separate loader or using a skidder to swing material away. The solution procedure could also use

TABLE 4: Hourly rates for additional equipment considered in the management of yarder decks

	Original cost	Life in Hours	Owning Cost $/Hr	Operating Cost $/Hr	Labor $/Hr	Total Cost $/Hr
Separate Loader	110,000	10,000	12.70	13.70	16.80	43.20
Self Loader on truck	30,000	10,000	3.46	13.70	16.80	33.96
Wheeled Skidder w/grapple	112,000	9,000	16.05	15.69	16.80	48.54
Truck	80,000	10,000	9.24	.38/mile paved 1.14/mile dirt	16.80	- -

observed values for deck delays and reset times to solve for the hourly machine rate that could be paid for a separate loader or swing skidder.

The analysis that follows will develop the equations used in the breakeven analysis and will illustrate solutions for the conditions encountered during operations of the Koller Model K-300 on the U of I Experimental Forest.

The breakeven equation when comparing operations with deck delays to hot loading will differ from the equation when the alternative is a swing skidder.

When a comparison is made to yarding with hot loading the breakdown equation is developed from:

$$RC + Y1 + L1 + H1 = Y2 + L3 + H2 \qquad (1)$$

where:

- RC = cost per MBF to reset yarder for loading
- Y1 = yarding cost per MBF when deck delays are encountered
- Y2 = yarding cost per MBF without deck delays
- L1 = loading cost per MBF with a self-loader operating from a yarder deck
- L3 = loading cost per MBF with a separate loader working at the yarder production rate
- H1 = hauling cost per MBF with reduced load capacity of a truck with a self-loader
- H2 = hauling cost per MBF with a conventional log truck and no reduction in load capacity

The equation used when the comparison is made to a swing skidder becomes --

$$RC + Y1 + L1 = Y2 + S1 + L2 \qquad (2)$$

where:

- S1 = skidder cost per MBF to swing material to a separate deck
- L2 = loading cost per MBF with a self-loader from a skidder deck
- RC, Y1, Y2, L1 As defined for equation (1)

Hauling costs do not enter into this equation since trucks with reduced load capability because of the self-loader will be used in both cases.

The dollar per MBF costs used in equations (1) and (2) are calculated from the hourly rates of the equipment, production times per turn and per setting, and the volume yarded and loaded. Equations to calculate costs of resetting the yarder, yarding, loading, and hauling are listed as follows:

<u>Costs Associated With Yarding</u>

Reset Cost $$RC = ((YOC + YLC) * HR)/VR \qquad (3)$$

Yarding Cost with deck delay $$Y1 = ((YOC+YOPC+YLC) * (YT+DD+OD))/(60*VT) \qquad (4)$$

Yarding Cost without deck delay $$Y2 = ((YOC+YOPC+YLC) * (YT+OD))/(60*VT) \qquad (5)$$

where:

- YOC = yarder owning cost in dollars per hour
- YOPC = yarder operating cost in dollars per hour
- YLC = labor cost associated with yarder in dollars per hour
- HR = reset hours required to move yarder to and from the deck for loading
- YT = average delay free yarder turn time in minutes per turn
- DD = average delay time associated with deck management in minutes per turn
- OD = average time of other yarder delays in minutes per turn
- VR = average volume that can be yarded to a deck before it is plugged and needs a yarder reset
- VT = average volume yarded per turn

<u>Costs Associated With Loading</u>

Loading cost with self-loader from yarder deck $$L1 = (LC1 *(HL1 + HLD))/VSL \qquad (6)$$

Loading cost with self-loader from skidder deck $$L2 = (LC1 * HL1)/VSL \qquad (7)$$

Loading cost with separate loader in hot-loading $$L3 = (LC3*(YT+OD))/(60*VT) \qquad (8)$$

where:

- LC1 = Owning, operating, and labor cost of self-loader in dollars per hour
- LC3 = Owning, operating, and labor cost of self-contained, separate loader in dollars per hour
- HL1 = Delay free hours required to load a log truck with self-loader

HLD = Hours of delay per truck load associated with the poor loading conditions at a yarder deck
VSL = Average volume per load on a truck with a self-loader
YT,OD,VT As defined for yarder costs

Costs Associated With Swing Skidder

Skidding cost from yarder to skidder deck   S1 = (SC * (YT+OD))/(60*VT)   (9)

where:

SC = Owning, operating, and labor cost of skidder dollars per hour
YT,OD,VT As defined for yarder costs

Costs Associated With Hauling

Hauling cost for truck with self-loader   H1 = HC / VSL   (10)

Hauling cost for truck without self-loader   H2 = HC / VL   (11)

where:

HC = Hauling cost in dollars per round trip
VSL = Average volume hauled per load on logging truck with a self loader
VL = Average volume hauled per load on logging truck without a self-loader

The general equations comparing conventional yarder operations with deck problems to those with hot loading and swing skidding can be manipulated in various ways to produce breakeven values for variables of interest to the analyst. Given the cost of a separate loader or swing skidder and an amount of time required to reset the yarder before and after loading, the breakeven equations can be adjusted to solve for the amount of deck delay time per turn that makes the two alternatives equal. Deck delays in excess of this value would point to cost effective use of a hot loader or swing skidder. The breakeven equation for deck delay time reduces to -

Deck Delay (min/turn) =

((60*VT*(Y2+L3+H2-RC-L1-H1))/(YOC+YOPC+YLC)) - YT - OD   (12)

The equation relates the volume per turn, hourly cost of the yarder, and delay free yarder turn time to the cost of loading and hauling with a self-loader and separate loader. As the hourly cost of the yarder (YOC+YOPC+YLC) increases the amount of time that can be spent in deck delays before justifying hot-loading decreases. An increase in other components of the yarder turn time (YT and OD) will also decrease time available for managing the deck. The variable RC is the time required to move the yarder away from the deck for loading. As expected, an increase in this time will cause a decrease in the breakeven time for deck delays.

An operator may not have control over deck delay and reset times, but given their average values, would like to know how much could be spent for a hot loader or swing skidder to move material away from the yarder deck. The breakeven equations would then be structured to yield the breakeven machine and labor rate for either a hot loader or swing skidder. Breakeven dollars per hour for a hot loader are calculated as -

Hourly rate of separate loader =

(VT*(RC+Y1+L1+H1-Y2-H2))/((YT+OD)/60)   (13)

The breakeven machine and labor rate for a swing skidder is calculated as -

Hourly rate of skidder =

(VT*(RC+Y1+L1-Y2-L2))/((YT+OD)/60)   (14)

An increase in yarding costs, reset costs, or loading costs when deck delays are part of the system will allow more dollars per hour to be spent for a hot-loader or swing skidder. The inter-relationships of variables in these equations indicate the need to evaluate the cost effectiveness of hot-loading or swing skidding on a case by case basis. Results from the conditions encountered during operations with the Koller Model K-300 on the UI Experimental Forest will be presented in the next section, but they are valid only for the machine costs and production times used as input to the equations.

RESULTS OF CASE STUDY

Equipment described earlier and the costs presented in Tables 3 and 4 were used as the cost basis for the analysis. Production times for the yarder were estimated from Koller operations and are presented in Table 5 along with estimates of loading and hauling times. Loading times were abstracted from the study performed by Kellogg and Olsen (1984). Hauling times were calculated from the timber sale appraisal procedure of the U.S. Forest Service.

Breakeven values for the hourly rates of a hot-loader and swing skidder were determined for a range of reset times and deck-delay times. Using the average times for the deck delay and resetting the yarder the breakeven value for a hot loader is $71.58 per hour. As much as $54.93 per hour could have been paid for a swing skidder. Both of the values are above the average costs calculated for the equipment shown in Table 3. Given conditions of these operations either method of moving material away from the yarder would have been more cost effective than encountering the deck and reset delays.

Reduction of the owning and operating cost of the yarder to $10.85 per hour reduces the breakeven values of the hot-loader to $64.60 per hour and the skidder to $47.94 per hour. A doubling of yarder costs to $43.40 per hour allows an increase in break-even hot-loading costs to $85.54 per hour and in swing-skidder costs to $68.89 per hour.

Breakeven curves were also plotted for the range of conditions shown in Table 5. These are illustrated in Figures 3 and 4.

The problems were structured for solution on an Apple IIe microcomputer using an electronic spreadsheet (Visicalc) to structure and solve for breakeven values. This allowed for quick re-calculation of the breakeven points for the various conditions tested.

If a full set could be yarded without moving the yarder for loading, reset time would be equal to 0. At this level a deck delay of 2.0 minutes per turn could justify an expense up to $55.00 per hour for a hot-loader and up to $38.37 per hour for a swing skidder. Deck delays of 1.0 minute per turn would decrease those hourly rates to $37.00 per hour and $20.34 per hour respectively for the loader and skidder.