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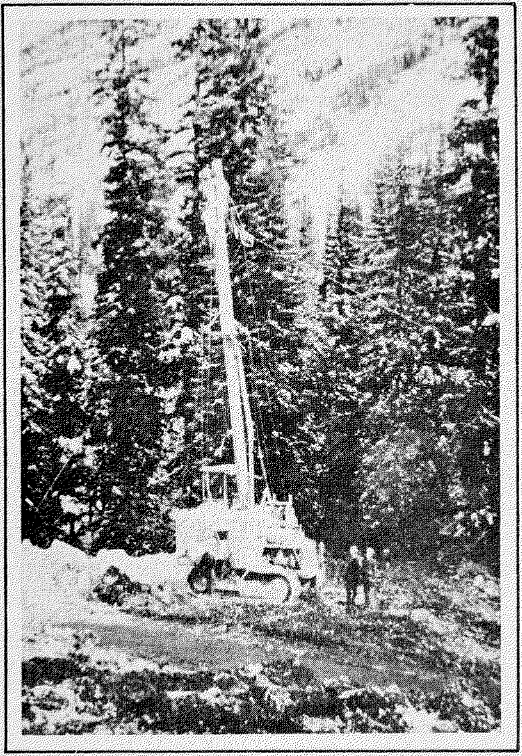
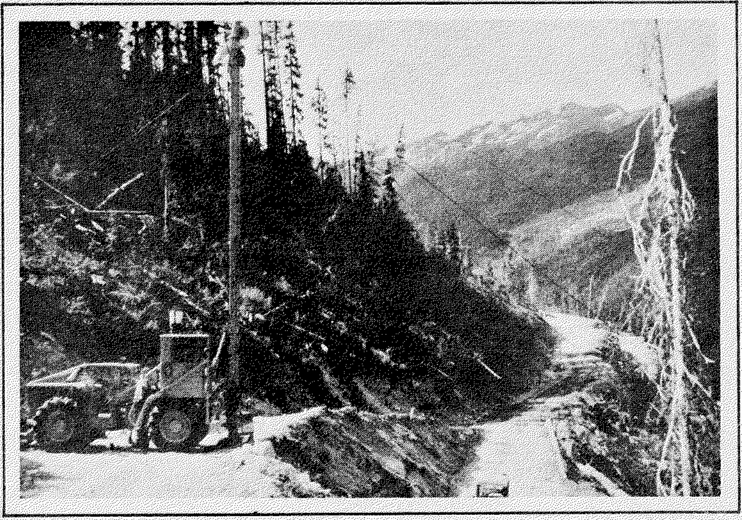
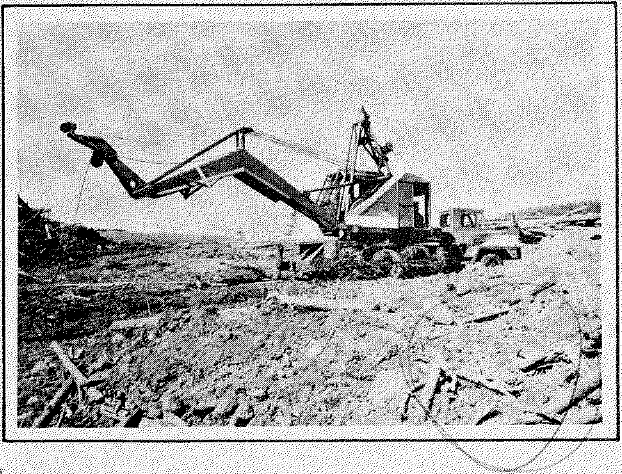
Evaluation of Cable Logging Systems in Interior B.C. and Alberta

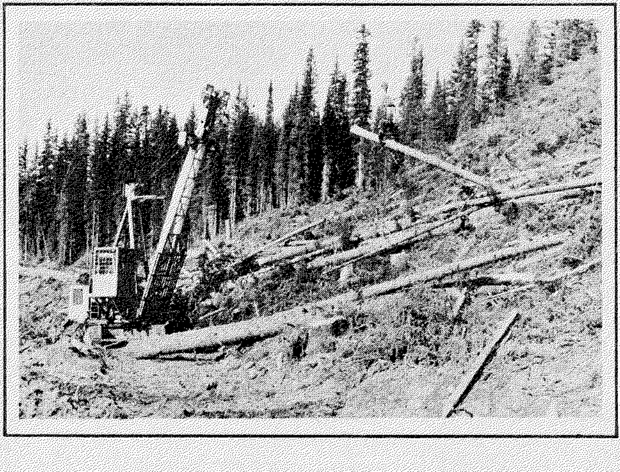
P.L. Cottell, B.A. McMorland, G.V. Wellburn

Technical Report No. TR-8
September 1976









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Foreword

This report presents the results of case studies of cable-logging operations in Interior British Columbia and Alberta. The work was prompted by the need for factual information on the performance of cable systems because, increasingly, public concern for the environmental impact of ground skidding is leading to restriction of traditional logging methods in mountainous terrain. The well developed cable techniques of Coastal British Columbia cannot be readily transferred to the smaller timber stands of the Interior.

Initially, this project was part of the program of the Logging Research Division, Pulp and Paper Research Institute of Canada. With the establishment of FERIC in April 1975, the project and its staff transferred to FERIC's program. The study was strongly influenced by industry representations through the Interior Lumber Manufacturers Association, Penticton, B.C., and by members of the "Steep Slope Committee", Mr. J.A. McIntosh (Western Forest Products Laboratory, Canadian Forestry Service), Chairman.

Project field work began in June 1974, and continued until April 1976. People who assisted directly in this work include: students B. Willson, C. Lodge, J. McDonald and R. Dawson (Faculty of Forestry, University of British Columbia) and R. Ali (Faculty of Forestry, University of New Brunswick); P.P. Tse of FERIC (programming and computer analysis); and, Dr. D.A. Scott, now at the University of Saskatchewan. The authors thank particularly the many individuals associated with the following companies who co-operated in the case studies:

Canadian Cellulose Co., Ltd.
Crown Zellerbach Co., Ltd. (Interior Operations)
Jacobson Bros. Forest Products, Ltd.
Kootenay Forest Products, Ltd.
North Canadian Forest Industries, Ltd.
Revelstoke Sawmills, Ltd.
Triangle Pacific Forest Products, Ltd.

Preliminary results of the study were reported at the Annual Meeting, Woodlands Section, Canadian Pulp and Paper Association in Montreal, March 1976.

The use of trade names of various machines in this report implies no recommendation or endorsement by FERIC. Equipment is in a continual state of change, and manufacturers have already made substantial improvements to machines examined in this study. Readers should contact the manufacturers directly for full, current specifications.

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Summary

In Canada, cable logging systems have gained general acceptance only in the large-timber stands of the Pacific coastal forest. However, cable logging is being considered in other areas to meet two problems: the inaccessibility of significant quantities of merchantable timber to ground skidding or mechanical harvesting methods; and, the need to reduce soil disturbance on steep or otherwise sensitive sites. Several logging companies in the southern interior of British Columbia and northern Alberta have recently been conducting operational trials of cable systems, to adapt machines and methods to their conditions.

FERIC studied eight of these operations over the period June 1974 to March 1976. The objectives were: (1) to develop study methods suitable for evaluating cable systems; and (2) to obtain information on machine characteristics and limitations, crew requirements, operational methods, productive and delay times, and output performance. The following machines were examined: Rosedale Ecologger; Madill 071 Skidder Tower (two cases); Koehring Bantam (loader converted for yarding); older model 70-foot Madill tower (two cases); Washington 078 grapple yarder; and Skagit GT3 grapple yarder.

The observations represent up to a week of detailed measurement of yarded piece sizes (logs or tree lengths), and elemental times (or work samples) at each operation. In addition, personnel in the co-operating firms completed and returned more than 500 shift reports on cable yarding activity.

The results are presented in detail for each case study, then summarized to allow comparison of the different operations. Mechanical Availability of the yarding machines was generally high, and it seems reasonable to aim for figures of 90% or greater. Machine Utilization varied from 42% to 87% of scheduled time, reflecting organizational effectiveness — particularly crew experience and motivation. Non-mechanical delays varied from 4% to 32% of scheduled time. These delays were largely the results of personnel and planning problems; controlling such delay requires close supervisory support.

Average total time per turn (work cycle) ranged from 2.6 min for the Skagit GT3 to 12.6 min for one of the Madill Mini-Spars. The net yarding cycle (outhaul, hook-up, inhaul, deck and unhook) comprised 50-60% of total time, yarding road changes 10-15% and delays 15-40%.

Average gross volume per piece yarded ranged from a low of 13 ft^3 (0.4 m^3) for the Koehring Bantam area to a high of 38 ft^3 (1.1 m^3) for one of the older, 70-foot Madill towers. The grapple yarders seldom produced more than one piece per turn, but the other machines averaged 2.1-3.1 pieces per turn. Only two operations achieved average (gross) turn volumes of 1 cunit (2.8 m^3).

Average log production ranged from below 100 to over 200 pieces per shift (8-hour basis), with the Skagit GT3 (223 pieces) and the Koehring Bantam (219 pieces) well in the lead. However, the small average piece size on the Koehring operation resulted in the lowest production recorded — 28 cunits (79 m^3) gross volume per 8-hour shift. On the same basis, the Skagit GT3 gross production was 67 cunits (193 m^3) per shift, and the other machines were in the 30-40 cunits (85-113 m^3) per shift range. The outstanding performance using the Skagit GT3 was achieved by a stable, though not long experienced, company crew working in blocks of relatively high volume per acre and per tree that had been specifically planned for grapple yarding.

Estimated yarding costs for the different systems ranged from \$14-20 per cunit (\$5-7/m^3). The estimated cost of logs loaded on the truck ranged from \$22-31 per cunit (\$8-11/m^3). The grapple yarders occupied the low end of this range, while the two older 70-foot towers had the highest costs. These cable logging costs compare with current local costs for ground skidding systems of about \$12-16/cunit (\$4-6/m^3) on the truck (excluding access road cost in both cases).

Several problems delay the introduction of cable yarding systems in Interior B.C., including: lower productivity and higher cost compared to conventional ground skidding, which affect appraisals and stumpage payments; the scarcity of required planning skills and maps; the reluctance of contract loggers to invest in expensive, unfamiliar equipment in a cyclical and seasonal industry; insufficient numbers of experienced crewmen for the operations; and the lack of suitable methods for loading logs from small, sidehill landings.

FERIC plans to continue working with co-operating forest companies to monitor the performance of new cable logging systems as they are introduced.

Sommaire

Au Canada, les systèmes téléphériques sont d'usage courant dans l'industrie forestière de la côte du Pacifique, mais leur utilisation dans d'autres régions serait profitable pour surmonter l'inaccessibilité d'une quantité significative de peuplements marchands, au débusquage ou à l'exploitation mécanisée et pour réduire les dommages au sol sur les sites accidentés et sensibles. Plusieurs compagnies forestières du sud-intérieur de la Colombie Britannique et Alberta ont fait récemment des essais de systèmes téléphériques, dans le but d'adapter machines et méthodes à leurs situations particulières.

FERIC à étudié huit opérations de juin 1974 à mars 1976. Les buts étaient: (1) développer des méthodes d'étude propres à l'évaluation des systèmes téléphériques et (2) obtenir des informations valables sur les caractéristiques des machines et leurs capacités, sur les besoins en personnel et sur les temps productifs, les délais et le rendement. Les machines suivantes furent étudiées: le "Rosedale Ecologger"; la débusqueuse "Madill 071" (2 cas); le "Koehring Bantam" (chargeur converti pour téléphérage); la tour "Madill" de 70 pieds, modèle plus ancien (2 cas); le "Washington 078" et le "Skagit GT3" (débardeuse à grappins).

Ces observations comprennent des mesures détaillées de billes et grumes cordées sur la jetée et des éléments de travail de chaque opération. En plus, le personnel des organisations collaborant à cette étude a complété et soumis plus de 500 rapports de quarts sur les activités de téléphérage.

Les résultats, présentés en détail pour chaque cas étudié, sont aussi présentés sous forme de résumé pour permettre la comparaison entre chaque opération. La disponibilité mécanique des machines est généralement élevée et il semble raisonnable de viser un chiffre de 90% et plus. L'utilisation des machines varie entre 42% et 87% du temps cédulé, ce qui reflète une efficacité organisationnelle — particulièrement au niveau de l'expérience et de la motivation des travailleurs. Les retards non-mécaniques ont varié de 4% à 32% du temps cédulé. Ces délais sont imputables surtout au personnel et aux problèmes de planification; le contrôle de ces délais nécessite une surveillance étroite des opérations.

La moyenne du temps total par cycle complet s'échelonne de 2.6 min pour le "Skagit GT3" à 12.6 min pour une des "Madill Mini-Spars". Le cycle de débardage (retour à vide, chargement, halage, empilement, déchargement) comprend 50-60% du temps total, les changements de sentier de débardage 10-15% et les délais 15-40%.

Le volume brut moyen par pièce varie d'un minimum de 13 pi^3 (0.4 m^3) pour le "Koehring Bantam" à un maximum de 38 pi^3 (1.1 m^3) pour une des anciennes tours "Madill" de 70 pi. Les débusqueuses ont rarement transporté plus d'une pièce par cycle, tandis que les autres machines ont obtenu une moyenne de 2.1 à 3.1 pièces par cycle. Seulement deux opérations ont obtenu une moyenne de volume brut par cycle de 1 ct (2.8 m^3).

La production moyenne de grumes a varié de moins de 100 à plus de 200 pièces par quart (base de 8 h); le "Skagit GT3" (223 pièces) et le "Koehring Bantam" (219 pièces) étant bons premiers. Toutefois, la petite dimension des arbres sur les opérations du "Koehring Bantam" est cause de sa basse production — volume brut de 28 ct (79 m^3) par quart de 8 h, tandis que la production brute du "Skagit GT3" fut de 67 ct (193 m^3) par quart et les autre machines de 30-40 ct (85-113 m^3) par cycle.

Un estimé établit les coûts de débardage pour les différents systèmes entre \$14-\$20 par ct (\$5-7/m^3). Le coût estimé pour le chargement des grumes sur camion est de \$22-\$31 par ct (\$8-\$11/m^3). Les coûts de débardeuses sont les plus bas, et ceux des vieux mâts de 70 pi les plus élevés. Ces coûts de téléphérage se comparent aux coûts locaux courants des systèmes de débusquage soit de \$12-\$16 par ct (\$4-\$6/m^3), comprenant chargement sur camion, mais excluant le coût des chemins d'accès dans les deux cas.

Plusieurs facteurs ralentissent l'introduction des systèmes téléphériques dans les régions intérieures de la Colombie Britannique; leurs basse productivité et leur coût plus élevé en comparaison au débusquage conventionnel; la pénurie de planificateurs compétents, et l'absence de cartes pour ce genre d'opération; la crainte des contracteurs d'investir dans des équipements coûteux et peu familiers, dans une industrie cyclique et saisonnière; le nombre insuffisant de travailleurs expérimentés pour ces opérations et l'absence de méthodes adéquate de chargement des grumes empilées sur des petites jetées en terrain accidenté.

FERIC entend poursuivre l'étude des nouveaux systèmes téléphériques au fur et à mesure qu'ils seront introduits sur les opérations forestières.

Introduction

Logging operations in B.C. are increasingly moving into higher elevations and steeper terrain where forest sites are more easily damaged. The public and industry resource managers alike are expressing their concern for the protection of soils and other non-timber resource values (recreation, fisheries, wildlife) in these areas. This has led to efforts at improving logging methods, through reducing the size of cut blocks, doing a better job of road construction, and limiting conventional ground skidding to the less easily disturbed forest sites.

The most common logging method in the Southern Interior of B.C. is to skid logs from stump to roadside landing using wheeled skidders or tractors. In gentle terrain, this can be done without the need for skid trails. Soil disturbance is limited to some compaction from the passage of the machines, and surface scuffing from the logs. In steeper terrain, rough skid trails must be prepared by tractors. One would expect that the skid trail steepness would increase with the steepness of the terrain. However, Smith (1975) found that this was not the case in practice, possibly because supervisors pay less attention to trail planning on the easier areas, and operators wander about, choosing their own route. On steeper slopes (over 70%) tractor and skidder logging is still possible. The distance between skid trails is then defined by the length of the skidder mainline, since the skidder cannot safely leave the skid trail. The land can become almost terraced by skid trails. This produces a poor visual impression, exposes soils to erosion, and may have longer-term effects on forest site.

Dyrness (1971) and others have found that roads and skid trails are the most frequent sources of serious erosion. Logging systems that require a less dense road network would produce less disturbance on sensitive forest sites. In 1974, the B.C. Forest Service issued a directive that on areas where slopes exceed 70%, only cable systems or other non-ground skidding logging methods were to be used. Areas with slopes in the range 50-70% would be critically examined, and, if soil types or other factors suggested the site was sensitive to logging damage, cable systems could be required. The slope criterion admittedly over-simplifies the situation, for the purpose of making a start in the application of appropriate logging methods. Other factors (e.g., soil type, rainfall) should also be considered in this decision, and probably will in the future as their contribution to the site's susceptibility to logging damage is evaluated.

The Interior B.C. logging industry is not altogether unfamiliar with cable-logging techniques. For 20 years and more, operations have been conducted using "Idaho jammers" (home-made, A-frame yarders mounted on tractors or trucks), wooden spars, full-size steel towers and, more recently, grapple yarders. While performance records are lacking, some of these operations were successful in special applications. Nevertheless, cable logging constitutes a small proportion of the total logging activity in the area. For the bulk of the industry, cable systems are new and unfamiliar. In addition to a natural reluctance to change from methods that are familiar, there is the problem of investment in a costly, less flexible technology, and the training of new crew members. This is aggravated by the fact that little equipment development has so far aimed at cable-logging machines for the smaller timber and lower per-acre volumes encountered in the non-coastal forests. The mobile spars and grapple yarders used on the coast are too large and expensive to be economically used in the Interior.

Physical criteria need to be established for successful cable-logging machines and systems in the region. Where cable operations are under way, there is a need to observe techniques and measure performance levels. This must be done according to a standard procedure, so that it is possible to compare results of different alternatives. Such comparisons can assist in the evaluation of alternative methods, point out the more successful approaches, and, as well, indicate the incremental logging costs incurred in the interest of conserving the forest site.

The Study

Objectives

1. In co-operation with Interior B.C. firms undertaking operational trials, to conduct a pilot study to develop methods for evaluating the performance of cable systems in steep or otherwise sensitive forest sites.
2. To provide, in response to expressed Industry needs, performance data on time, productivity and cost from current trials of cable systems for use in operational planning.

Approach and Procedures

Review of published production studies of coastal cable-logging operations in Western North America (Brandstrom, 1933; Tennas, Ruth & Berntsen, 1955; Carow, 1959; Dykstra, 1975) provided a background in study methods, and a bench mark against which to compare the performance of Interior systems. The approach in these studies has been to define and measure the productive time elements of each work cycle. Delays were separated and analysed, and settings were mapped. Variables such as log volume, turn volume, yarding distance and slope were measured. Then relationships were sought (through graphical analysis or multiple regression) between yarding time elements and the measured variables. Total time per turn, or per unit volume, was derived by adding up the coefficients in element time equations. Necessary delays were pro-rated and added on. The resulting expressions provided a basis for cost estimation, and comparison among alternative yarding methods.

There are two problems (not necessarily faults) with this approach:

1. The relationships calculated between element times and measured conditions of the operation are weak.
2. Field work in these studies is expensive, and usually is performed over a relatively short period of time — several days to a week or two for each operation. It is difficult to know whether the observed period is "typical" of the general operation, especially with regard to the occurrence of various types of delays.

A "case study" approach was selected for the Interior B.C. cable-logging studies utilizing some of the features of the work discussed above. The 1974 field work employed two levels of data collection. The first level involved detailed measurement of time elements[1] for each turn, and operating conditions such as log volume, turn volume and distance. This was continued for 1 week at each of 3 different operations. The second level involved shift reports summarizing productive time[2], delay times and causes, and total production (number of pieces and average piece size). These reports were completed by the yarding engineer or the foreman once each shift, and continued over a longer period — up to several months. Shift-level data were obtained for the same three operations and for a new grapple yarder.

The detailed timing approach produced regression results (available from FERIC on request) that explained little of the observed variation in yarding cycle times. It seems unlikely that increased detail in timing or in the measurement of stand and terrain factors would significantly improve these results. For this reason, the detailed timing was dropped in the 1975 field work, in favour of a work sampling[3] approach for estimating element times. The procedure called for instantaneous observations of yarding activity at randomly-selected intervals of from 2 to 8 minutes, resulting in about 100 observations per shift. Work sampling continued for 2 to 3 shifts, so the estimated percent time distribution for each case study was based on over 200 observations. This would assure that a work element consuming 30% of total time, for example, would be estimated with absolute accuracy of ± 6%, at the 95% confidence level (Barnes, 1964, p.39). All logs were scaled as before, and the shift reports were continued in slightly modified form. Five operations, including one that had been included in the 1974 field work, were studied in 1975. These are summarized in Table 1.

Results

The case studies are summarized individually in the following sections. Each case covers: a general description of the logging system; basic machine specifications and forest site characteristics; production study results from short-term, intensive time studies (time distribution, log sizes, turn volumes); and longer-term performance (production, availability and machine utilization) from the shift reports.

[1] Definitions of time element end points are given in Appendix I.

[2] Time definitions based on: Bérard, J.A., Dibblee, D.H.W., and Horncastle, D.C. Standard definitions for machine availability and utilization. W.S.I. No. 2428 (B-1), Can. Pulp Pap. Assoc., Montreal. 1968. 2pp.

[3] Procedures described in: Barnes, R.M. Work sampling. (Second Ed.) Wiley, N.Y. 1976. x + 283 pp.

TABLE 1. Summary of cable logging case studies.

COMPANY	APPROX. LOCATION	MACHINE	SYSTEM CONFIGURATION	STUDY PERIOD
A	East side Purcell Mountains	RMS Ecologger	High lead and two-line running skyline[1]	Summer 1974 - Spring 1975
B	West side Purcell Mountains	Madill 70-foot tower	High lead	Summer 1974
C-i	West side Selkirk Mountains	Madill 071 Mini-Spar	High lead and two-line running skyline	Summer 1974 & Summer 1975
C-ii	East side Monashee Mountains	Madill 70-foot tower	High lead	Summer 1975
D	East side Monashee Mountains	Washington Iron Works Model 78	Grapple yarding	Winter 1974 - 1975
E	Cariboo "wet belt"	Skagit GT3	Grapple yarding	Summer 1975 - Spring 1976
F	Thompson Plateau Okanagan	Koehring Bantam	High lead and two-line running skyline	Summer & Fall 1975
G	Near Grande Prairie, Alberta	Madill 071 Mini-Spar	High lead	Summer & Fall 1975

[1] Also known as "scab skyline", or "Grabinsky".

Company A

Logging System

The operation, located on the east side of the Purcell Mountains, employed a contractor-owned Rosedale Machine Shop Ecologger (Fig. 1). The Ecologger was logging small 6-10 acre (2-4 ha) patches in difficult portions of established cutting permits. The balance of the 40-200 acre (16-80 ha) cut blocks were logged with conventional tractors and skidders. Because cut blocks had originally been designed for ground skidding, the Ecologger crew had a number of problems to contend with: small or narrow landings on secondary roads; slopes between 55 and 80%; terrain conditions ranging from steep, even slopes with no rock, to broken ground with rock cliffs; deflection problems; and frequent machine moves. Figure 2 shows one machine location during the study period, where landing space was better than usual.

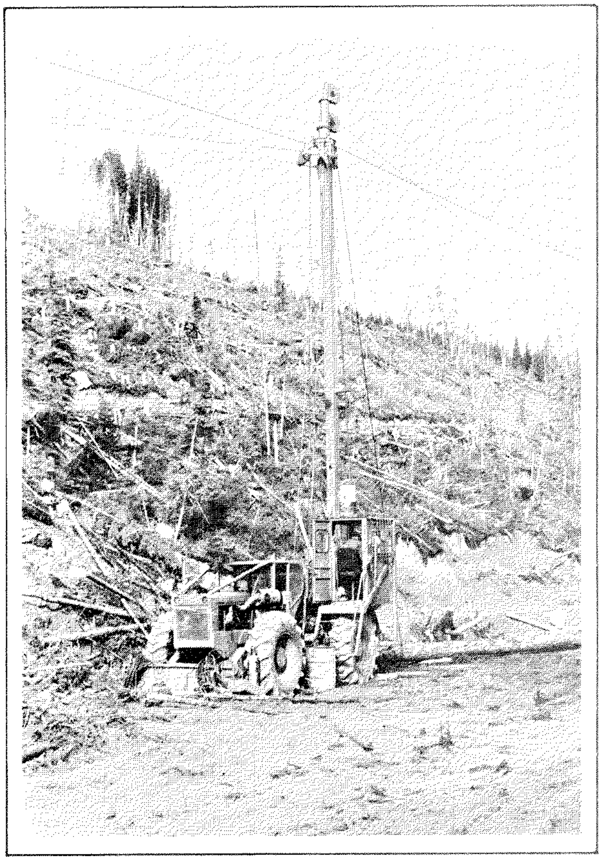


FIG. 1. RMS Ecologger, mounted on Timberjack 404 Skidder.

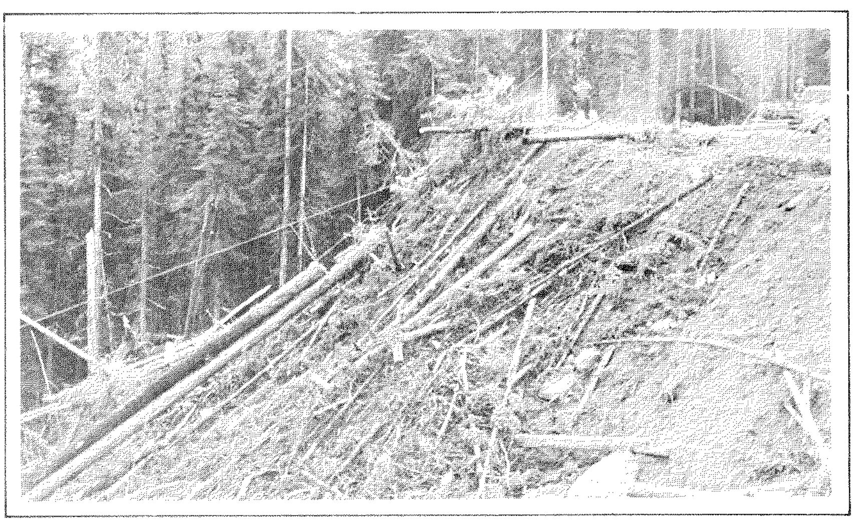


FIG. 2. Ecologger landing.

The Ecologger crew used either a standard high lead configuration with two or three chokers, or a two-line running skyline depending upon the deflection and piece size. In some instances, a squirrel block (sometimes called monkey block in the United States) was incorporated with the high lead system to enable chokermen to pull mainline and chokers further to the side, in uphill yarding. Yarding distance ranged to 650 ft (195 m) horizontal distance, and averaged 350-400 ft (105-120 m).

The four-to-five-man crew yarded tree-length pieces both uphill and downhill to the landing. At the landing, a choker skidder immediately swung the tree-lengths to a lower landing to be bucked and decked (Fig. 3). Loading of highway trucks employed a front-end loader, self-loading truck, and, most recently, a Prentice hydraulic heel-boom. Haul distance to the sawmill ranged from 20 to 52 miles (32 to 83 km).

Table 2 summarizes machine specifications for the Ecologger and forest site characteristics.

TABLE 2. Machine Specifications and Forest Site Characteristics: Company A Ecologger, 1974 & 1975.

Machine Specifications	Year manufactured	1973
	Tower height	42 ft (13 m)
	Engine size	130 hp (97 kW)
	Number of winches	3 (mechanical)
	Type of carrier	Timberjack 404 skidder
Forest Site Characteristics[1]	Volume/acre	30-38 cunits (210-266 m³/ha)
	Species[2] Composition:	
	Spruce	44%
	Douglas fir	32%
	Lodgepole pine	15%
	Balsam fir	8%
	Larch	1%
	Average butt diameter	11 in (28 cm)
	Maximum butt diameter	30 in (76 cm)

[1]Averaged over 1974 and 1975 study locations.
[2]Scientific names appear in Appendix II.

FIG. 3.
Decked logs at lower Ecologger landing.

Time and Productivity Results

Three sets of data were obtained from this operation:

1. Time distribution estimates:
   July 1974 — based on 1 week (5 shifts) of detailed continuous timing of work cycles;
   December 1975 — from work sampling over a 2-day period.
2. Volume estimates of pieces yarded during detailed time samples, 1974 and 1975.
3. Shift-level time and production estimates, from the Shift Monitoring Program (July-September 1974).

Table 3 summarizes the production study results.

TABLE 3. 1974 Production Study Results: Company A Ecologger.

	Average time min/turn	Standard Deviation
Outhaul time[1]	.36	.22
Hookup	1.57	.76
Inhaul	.63	.25
Deck	.14	.26
Unhook	.37	.18
Road changes[2] (pro-rated)	.35	—
Sub-total: Productive time/turn	3.42	—
Delay time/turn (pro-rated)	2.12	—
Total Turn Time	5.54	.97

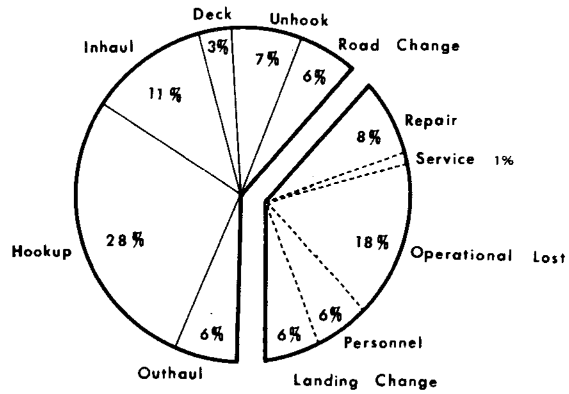
	Average	Standard Deviation
Yarding distance, ft	250 (75 m)	130 (40 m)
Number of pieces/turn	2.2	.9
Gross volume/turn, ft³	46 (1.3 m³)	31 (.9 m³)
Number of turns in sample	426	

Figure 4 shows the percent distribution of time (including moves) for the same period. Comparative information for the 1975 data is shown in Figure 5.

Table 4 itemizes the major delays, by categories, from the detailed time study.

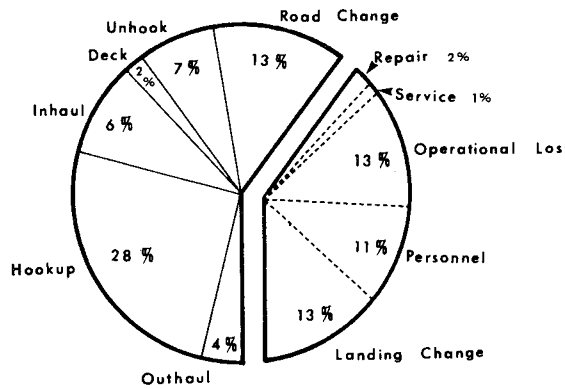
[1] Time definitions appear in Appendix I.

[2] Road change is considered equivalent to "move within the stand" in the CPPA standard definitions, and thus a productive work element rather than a delay.



PRODUCTIVE TIME : 61 % DELAY TIME : 39 %

FIG. 4. 1974 Percent Distribution of Scheduled Time: Company A Ecologger.



PRODUCTIVE TIME : 60 % DELAY TIME : 40 %

FIG. 5. 1975 Percent Distribution of Scheduled Time: Company A Ecologger.

TABLE 4. 1974 Summary of Major Delays: Company A Ecologger.

Delay Category	Description	Number of Occurrences	% of Total Delay Time
Repair	repair to winch brake	11	14
	adjust or repair tail-blocks	1	3
	tighten shackles on butt rigging	11	2
	other	6	2
	Total	29	21
Service	grease yarder	2	1
	re-fuel	2	1
	refill container for water-cooled brakes	1	1
	Total	5	3
Personnel	late start/early quit	8	7
	coffee breaks, etc.	7	6
	crewman not ready at signal	17	1
	other	8	1
	Total	40	15
Operational Lost	hangups	95	16
	wait for skidder to move	76	13
	untangle chokers	99	7
	buck log at landing	91	6
	other	124	5
	Total	485	47
Move	landing change	1	14

Figures 6 and 7 show piece-size (gross volume) distributions for the two study periods.

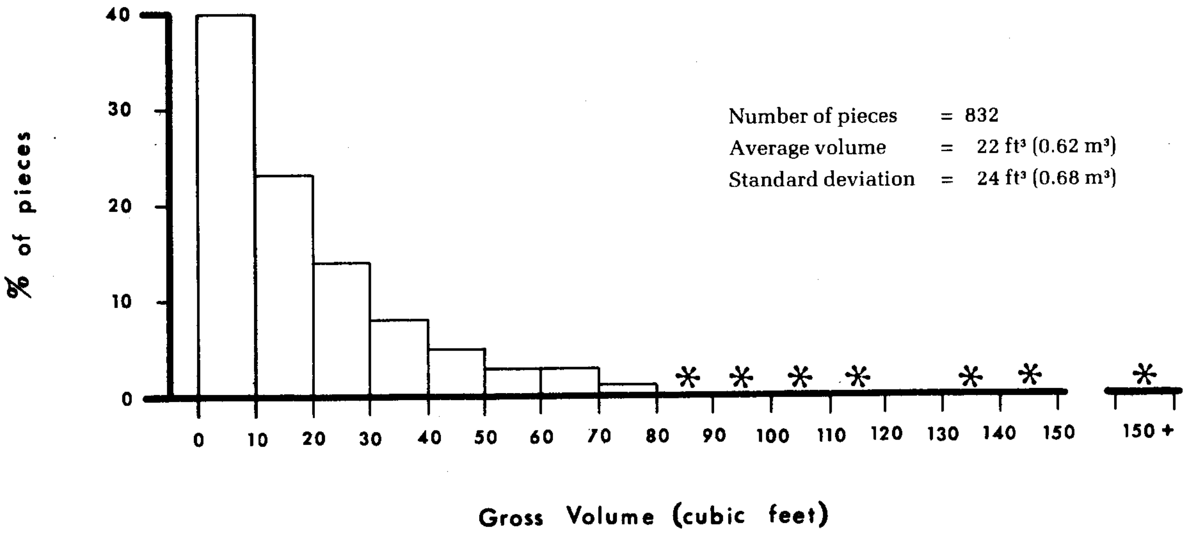


FIG. 6. 1974 Piece-Size Distribution: Company A Ecologger.
* = *less than 1%*

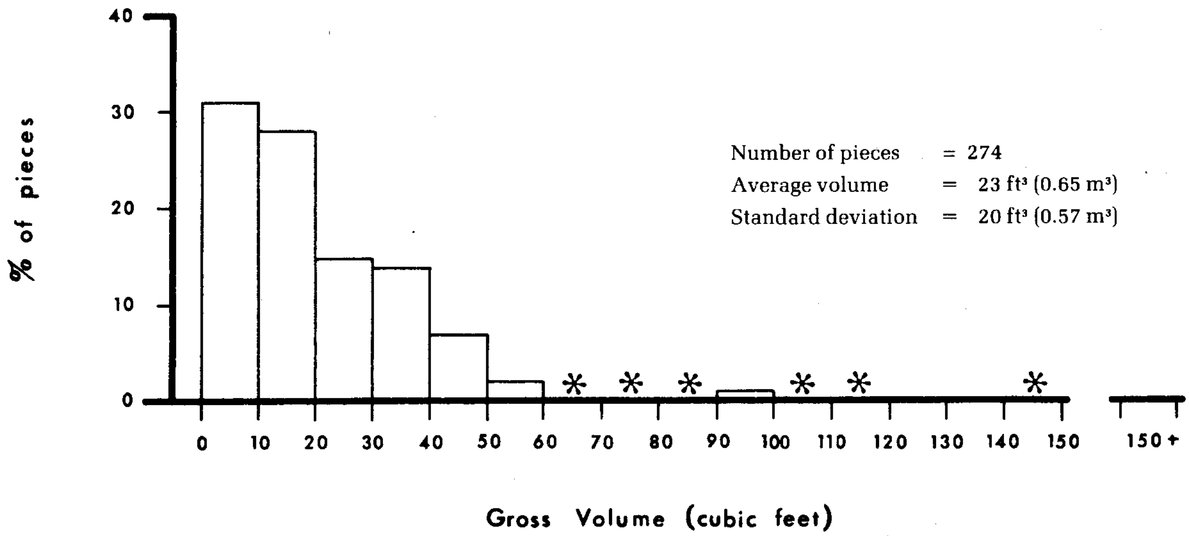


FIG. 7. 1975 Piece-Size Distribution: Company A Ecologger.
* = *less than 1%*

Average volume per piece was about the same for the two samples, although the distributions differed somewhat. Even so, most of the pieces yarded in both periods were less than 20 ft^3 (0.57 m^3) in volume. In the 1974 data, 63% of logs were less than 20 ft^3; in 1975, 59% were less than 20 ft^3.

Results from the shift-level monitoring are shown in Tables 5 and 6. No wholly non-productive shifts (PMH = 0, and piece-count = 0) occurred during the study period. There were 130 yarding-road changes, averaging 10 min each. Four landing changes required an average of 3 hr 20 min each.

TABLE 5. Time Summary: Company A Ecologger.

	Average Hours/Shift	Standard Deviation
Productive time:		
Yarding	5.8	1.1
Yarding Road Change	0.6	0.7
Delays:		
Mechanical	0.5	0.5
Landing Change	0.4	1.0
Other Non-Mechanical	0.7	0.8
Total: Scheduled Machine Hours	8.0	
Mechanical Availability[1]	94%	
Machine Utilization[2]	80%	
Number of Scheduled Shifts	33	

[1]Mechanical Availability

$$= 100\left\{\frac{\text{Scheduled Machine Hours per Shift} - \text{Mechanical Delays}}{\text{Scheduled Machine Hours per Shift}}\right\}$$

[2]Machine Utilization $= 100\left\{\frac{\text{Productive Hours per Shift}}{\text{Scheduled Machine Hours per Shift}}\right\}$

TABLE 6. Production Summary: Company A Ecologger.

Avg. piece size, all landings, ft³	22 (.62 m³)
Piece count per shift	163 (S.D. = 49)
Piece count during study	5,384
Gross volume per shift, cunits	36 (102 m³)
Gross volume during study, cunits	1,184 (3,351 m³)
Productivity:	
Cunits/Scheduled Machine Hour	4.49 (12.7 m³)
Cunits/Productive Machine Hour	5.58 (15.8 m³)
Number of Shifts worked	33

Company B

Logging System

The operation, located on the west side of the Purcell Mountains, employed two company-owned, 70-foot Madill steel towers. One of these machines was included in the study. (Fig. 8). Both spars were purchased in 1960 and have been used each year since that time. The spars worked only during the summer and fall, and were budgeted to produce 5,000 cunits (14,000 m³) each per year.

Skidding on this operation was mainly by tractor, so the two towers were located in the areas that tractors would have difficulty logging. These included very wet, low elevation cedar-hemlock sites, and areas of 50% slope and greater.

Both machines used the standard high-lead line configuration, with two or three chokers. Setting size varied, but rarely exceeded 15 acres (6 ha). The longest horizontal yarding distance was 800 ft (240 m), although the preferred maximum was 500 ft (150 m), and the average 400 ft (120 m).

Yarding of the log-length timber was mainly in the uphill direction (about two-thirds of the time). The system operated with a five or six

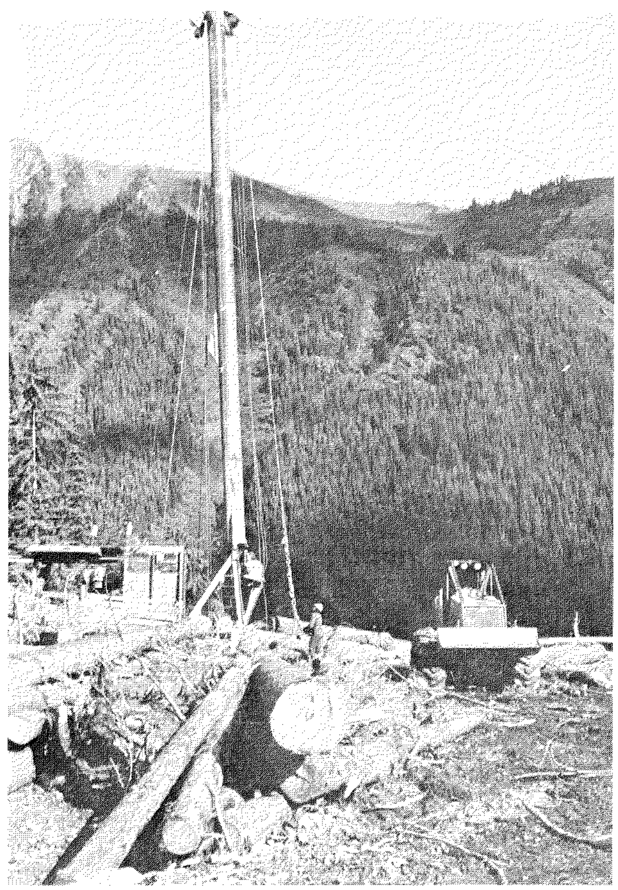


FIG. 8. Madill 70-foot Tower, Company B.

man crew — the sixth man operated the skidder at the landing. Small landings and/or high log decks required that up to three-quarters of the wood be repiled at roadside (Fig. 9). A Koehring hydraulic heel-boom machine loaded highway trucks for the 32-mile (51 km) average haul to the log dump. There logs were boomed, then towed 65 miles (104 km) to the sawmill.

FIG. 9.
Swinging logs to roadside deck.

Table 7 summarizes machine specifications and forest site characteristics for the study operation.

TABLE 7. Machine Specifications and Forest Site Characteristics: Company B 70-foot Madill Tower.

Machine Specifications	Year manufactured	1960
	Tower height	70 ft (21 m)
	Engine size	180 hp (134 kW)
	Number of winches	3
	Type of carrier	truck-mounted
Forest Site Characteristics	Volume/acre	80 cunits (560 m³/ha)
	Species composition:	
	Cedar	60%
	Spruce/Balsam fir	40%
	Average butt diameter	16 in (41 cm)
	Maximum butt diameter	34 in (86 cm)

A 1-week production study was conducted on the Company B operation in June 1974, and shift monitoring during June-July 1974. Table 8 summarizes results from the production study.

TABLE 8. 1974 Production Study Results: Company B 70-foot Madill Tower.

	Average time min/turn	Standard Deviation
Outhaul time	.57	.27
Hookup	2.81	1.50
Inhaul	1.06	.50
Deck	.61	.76
Unhook	1.19	.89
Road changes (pro-rated)	1.17	—
Sub-total: Productive time/turn	7.41	—
Delay time/turn (pro-rated)	2.58	—
Total turn time	9.99	2.24

	Average	Standard Deviation
Yarding distance, ft	350 (105 m)	170 (52 m)
Number of pieces/turn	2.8	1.0
Gross volume/turn, ft³	100 (2.8 m³)	64 (1.8 m³)
Number of turns in sample	214	

Figure 10 shows the percent distribution of scheduled time for the same period.

Delays observed during the production study are itemized in Table 9.

TABLE 9. 1974 Summary of Major Delays: Company B 70-foot Madill Tower.

Delay Category	Description	Number of Occurrences	% of Total Delay Time
Repair	repair to whistle	1	22
	adjust winch brake	2	3
	other	19	17
	Total:	22	42
Service	—	—	—
Personnel	late start/early quit, etc.	15	17
	other	8	2
	Total:	23	19
Operational Lost	re-pile logs at landing	14	12
	hangups	17	4
	other	83	23
	Total:	114	39
Move	—	—	—

Figure 11 shows the piece-size (gross volume) distribution for logs yarded during the 1-week study.

Tables 10 and 11 summarize the results from monitoring this machine over 15 shifts. There were 22 yarding road changes observed, averaging 27 min each. No landing changes occurred during the study period.

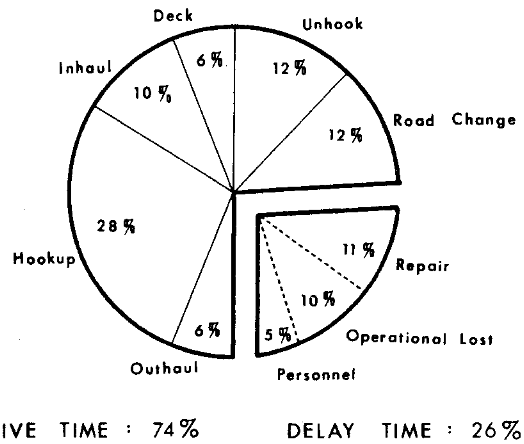


FIG. 10. Percent Distribution of Scheduled Time: Company B 70-foot Madill Tower.

TABLE 10. Time Summary: Company B 70-foot Madill Tower.

	Average Hours/Shift	Standard Deviation
Productive time:		
Yarding	3.8	2.0
Yarding Road Change	0.7	0.6
Delays:		
Mechanical	0.9	1.9
Landing Change	0	
Other Non-Mechanical	2.6	2.4
Total: Scheduled Machine Hours	8.0	
Mechanical Availability	88%	
Machine Utilization	55%	
Number of Scheduled Shifts	15	

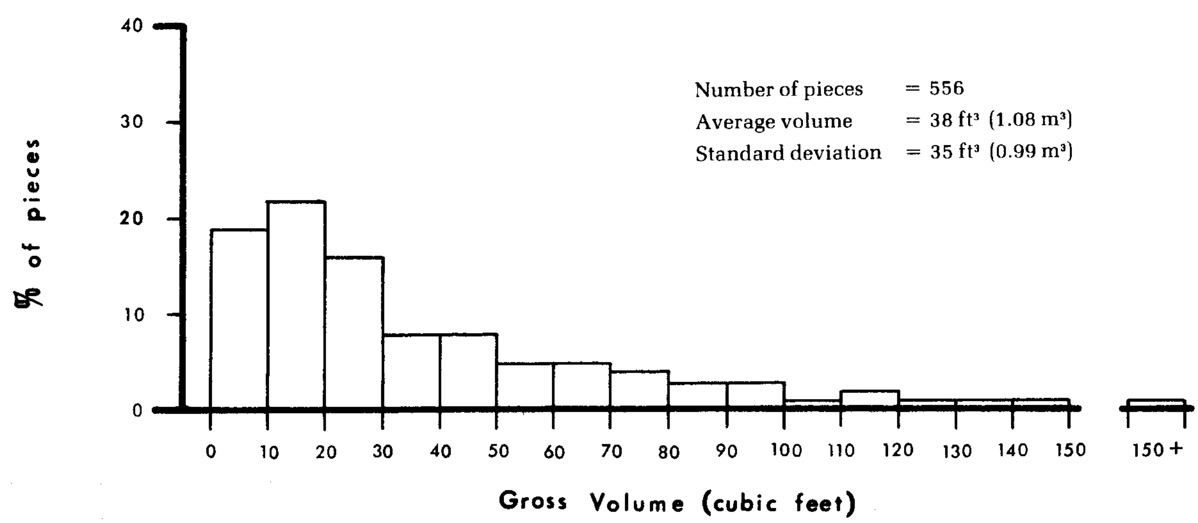


FIG. 11. Piece-Size Distribution: Company B 70-foot Madill Tower.

TABLE 11. Production Summary: Company B 70-foot Madill Tower.

Avg. piece size, all landings, ft^3	38 (1.08 m^3)
Piece count per shift	99 (S.D. = 56)
Piece count during study	1,488
Gross volume per shift, cunits	38 (108 m^3)
Gross volume during study, cunits	565 (1599 m^3)
Productivity:	
Cunits/Scheduled Machine Hour	4.71 (13.3 m^3)
Cunits/Productive Machine Hour	8.50 (24.1 m^3)
Number of Shifts worked	15

There was considerable difference between the productive time estimate of 74% (pie chart, Fig. 10) from the short-term study, and the utilization estimate of 55%, from the shift-level study. Reasons for this difference include: crew leaving early so log decks could be loaded out (two occasions); and, early shutdown due to personnel problems (once for an injury, once for illness). These delays occurred outside the detailed time study period, but within the shift monitoring period.

Company C

The company owns and operates three steel towers, as well as conventional ground skidding equipment in the Selkirk Mountains of Southern B.C. They have two older Madill 70-foot towers, and one new Madill 071 Skidder Tower, or "Mini-Spar". The Mini-Spar and one of the Madill 70-foot towers were included in the study; results are presented for each of the machines separately below.

Mini-Spar: Logging System

The Mini-Spar was yarding in a salvage area for much of the 1974 study period (Fig. 12). Tree-length and log-length pieces were yarded downhill to the landing. The yarding roads were parallel in some cases (the machine and tailholds were moved together), but generally they radiated from the landing (the machine stationary as the tailholds were moved), in the conventional way. The first method produced low continuous log decks along the roadside (Fig. 13). The second produced high fan-shaped decks on the landings and at roadside.

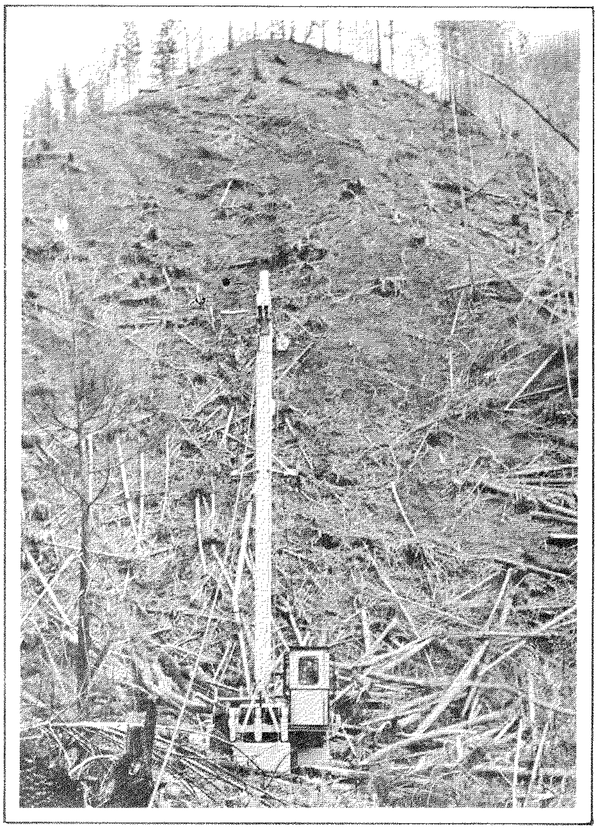


FIG. 12.
Mini-Spar (Madill 071 Skidder Tower).

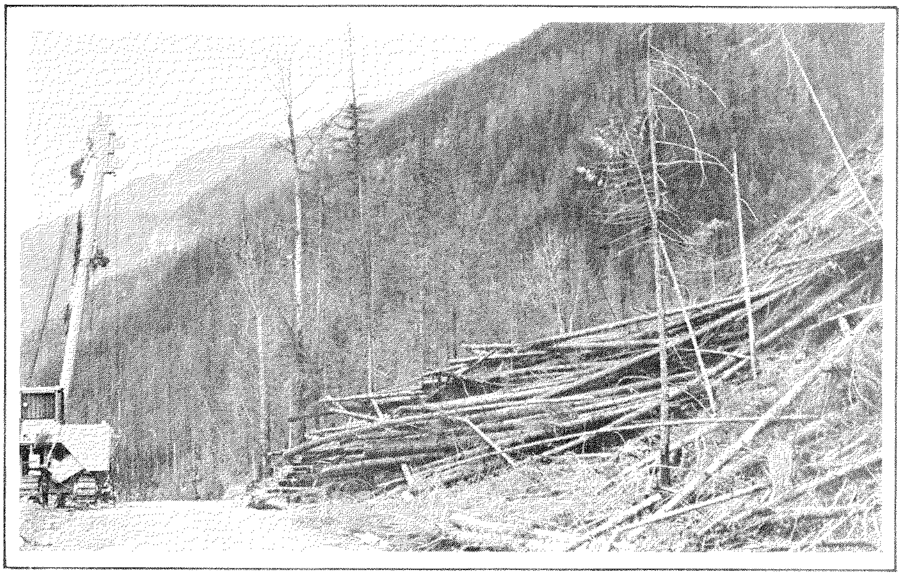


FIG. 13. Mini-Spar Log Deck.

Both high-lead and two-line running skyline (Fig. 14) rigging configurations were used. Yarding distance did not exceed 550 ft (165 m) horizontal distance (average 200 ft (60 m)).

Slopes as high as 82% were measured, but generally the slope was between 45% and 60%. There were usually four crew members.

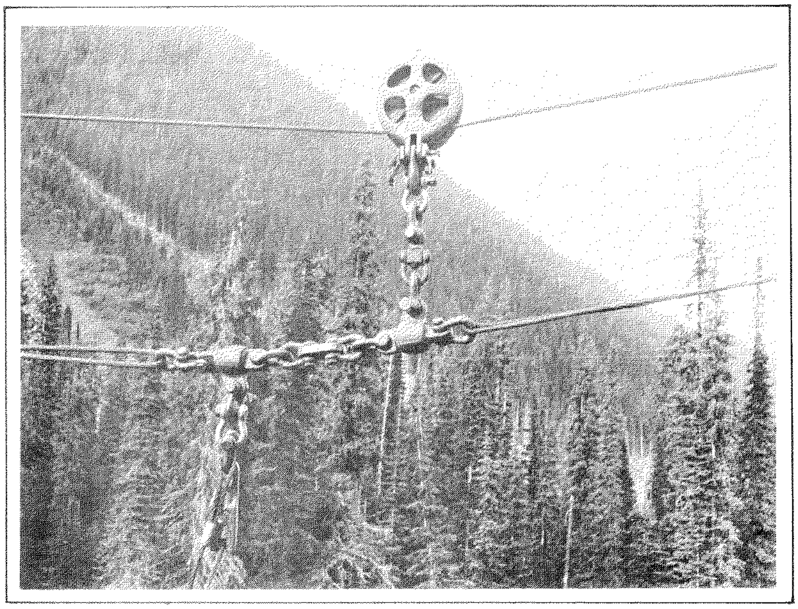


FIG. 14. Two-line running skyline rigging.

Both cable and hydraulic heel-boom loaders have been used to load highway trucks. High decks of full-tree and tree-length pieces were difficult to buck and load. The haul distance averaged 18 miles (29 km). Logs were sorted and bundled at the dump, then towed 20 miles (32 km) to the sawmill.

Table 12 summarizes basic machine specifications and forest site characteristics for this operation.

TABLE 12. Company C Mini-Spar: Machine Specifications and Forest Site Characteristics.

Machine Specifications	Year manufactured	1973
	Tower height	49 ft (15 m)
	Engine size	220 hp (164 kW)
	Number of winches	5
	Type of undercarriage	tractor
Forest Site Characteristics	Volume/acre	36 cunits (252 m³/ha)
	Species Composition:	
	Balsam fir	68%
	Spruce	32%
	Average butt diameter	13 in (33 cm)
	Maximum butt diameter	33 in (84 cm)

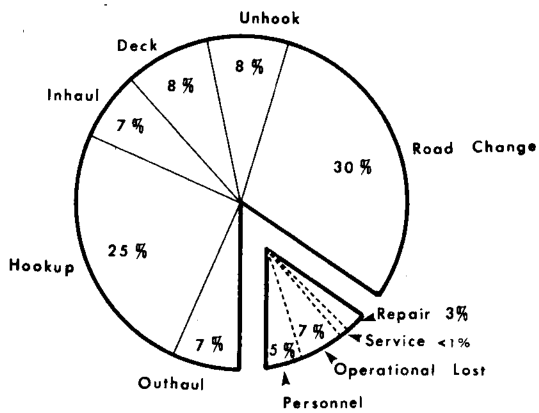
Time and Productivity Results

Three types of data were obtained for this operation:

1. Time distributions:
   July 1974 — a 1-week production study, with detailed continuous timing;
   July, August 1975 — work sampling on 4 separate days.
2. Volume estimates of pieces yarded during detailed time samples, 1974 and 1975.
3. Shift-level time and production estimates from shift monitoring (June-August 1974; July-August 1975).

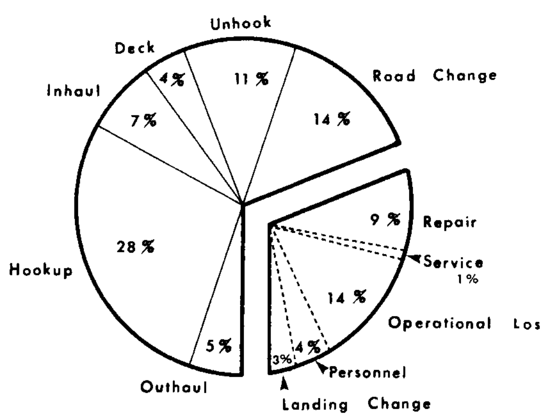
Table 13 summarizes the 1974 production study results.

Figure 15 shows the percent distribution of scheduled time for the same period. Comparative information from the 1975 work sampling data is shown in Figure 16.



PRODUCTIVE TIME : 85% DELAY TIME : 15%

FIG. 15. 1974 Percent Distribution of Scheduled Time: Company C Mini-Spar.



PRODUCTIVE TIME : 69% DELAY TIME : 31%

FIG. 16. 1975 Percent Distribution of Scheduled Time: Company C Mini-Spar.

TABLE 13. 1974 Production Study Results: Company C Mini-Spar.

	Average time min/turn	Standard deviation
Outhaul time	.63	.59
Hookup	2.46	.96
Inhaul	.70	.46
Deck	.77	.76
Unhook	.81	.46
Road changes (pro-rated)	2.87	—
Sub-total: Productive time/turn	8.24	—
Delay time/turn (pro-rated)	1.42	—
Total turn time	9.66	1.77

	Average	Standard deviation
Yarding distance, ft	190 (57 m)	120 (36 m)
Number of pieces/turn	2.5	1.0
Gross volume/turn, ft³	69 (1.9 m³)	57 (1.6 m³)
Number of turns in sample	189	

Table 14 itemizes the major delays by categories, from the 1974 detailed time study.

TABLE 14. 1974 Summary of Major Delays: Company C Mini-Spar.

Delay Category	Description	Number of Occurrences	% of Total Delay Time
Repair	adjust guylines	6	12
	replace broken choker	2	6
	other	2	1
	Total	10	19
Service	re-fuel	1	1
Personnel	extra lunch	4	18
	late start/early quit	7	12
	other	6	2
	Total	17	32
Operational Lost	repile logs at landing	11	9
	buck log at landing	5	9
	re-attach choker to butt rigging	1	6
	untangle chokers	10	6
	all others	46	18
	Total	73	48
Moves	—	—	—

Figures 17 and 18 show that the piece-size (gross volume) distributions were much the same for the two study periods.

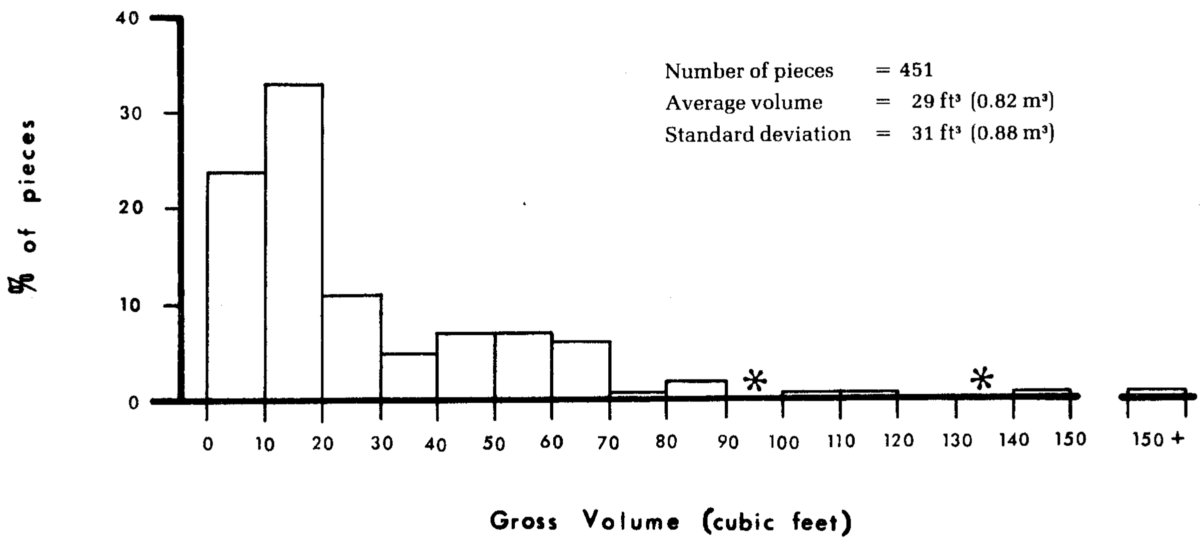


FIG. 17. 1974 Piece-Size Distribution: Company C Mini-Spar.
* = *less than 1%*

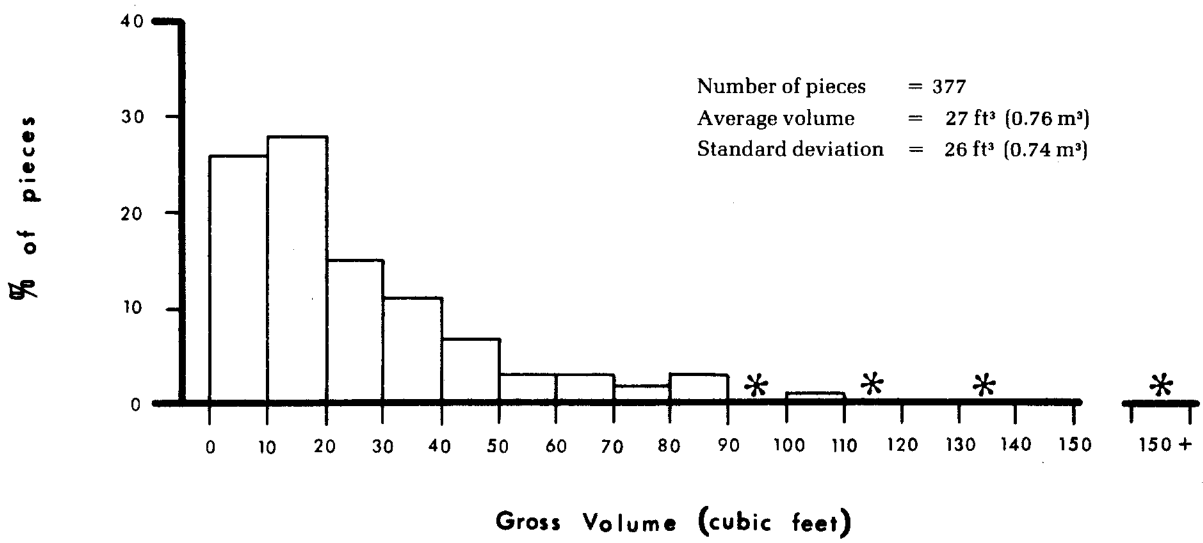


FIG. 18. 1975 Piece-Size Distribution: Company C Mini-Spar.
* = *less than 1%*

Tables 15 and 16 summarize 1974 and 1975 results from the shift-level monitoring program. There were 55 yarding road changes observed during the 1974 period, averaging 34 min each. The one landing change observed took 4 hr 20 min. There was one non-productive shift because the crew pick-up truck broke down.

TABLE 15. Time Summary: Company C Mini-Spar.

	1974		1975	
	Average hours/shift	Standard deviation	Average hours/shift	Standard deviation
Productive Time:				
Yarding	4.5	1.5	2.9	2.9
Yarding Road Change	1.1	0.4	0.3	0.6
Delays:				
Mechanical	0.4	1.0	1.0	1.6
Landing Change	0.1	—	0.2	—
Total: Scheduled Machine Hours	8.0		8.0	

	1974	1975
Mechanical Availability	96%	87%
Machine Utilization	70%	39%
Number of Scheduled Shifts	30	15

TABLE 16. Production Summary: Company C Mini-Spar.

	1974	1975
Avg. piece size, all landings, ft^3	29 (0.82 m^3)	26 (0.74 m^3)
Piece count per shift	106 (S.D. = 40)	101 (S.D. = 42)
Piece count during study	3,085	1,013
Gross volume per shift, cunits	31 (88 m^3)	26 (74 m^3)
Gross volume during study, cunits	895 (2,532 m^3)	263 (744 m^3)
Productivity:		
Cunits/Scheduled Machine Hour	3.86 (10.9 m^3)	3.28 (9.3 m^3)
Cunits/Productive Machine Hour	5.33 (15.1 m^3)	5.55 (15.7 m^3)
Number of Shifts worked	29	10

The Mini-Spar lost five shifts during the 1975 monitoring period, because the yarding crew had caught up with the fallers. Yarding operations were suspended until more timber was felled. There were 11 yarding road changes averaging 28 min each. In addition, one landing change required 3 hr 20 min.

70-Foot Madill Tower: Logging System

The study machine (Fig. 19) worked in close proximity to the other tower, so that one foreman could supervise both crews. The two 70-foot towers together were responsible for 10% of Company C's 1975 logging.

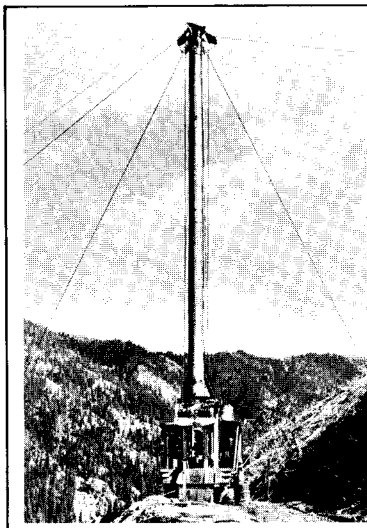


FIG. 19.
70-foot Madill Tower, Company C.

Logs were bucked in woods, then yarded uphill or downhill to the machine. The longest yarding distance (horizontal) was 800 ft (240 m) with an average of 450 ft (135 m). Slopes ranged between 30% and 85%. The standard high-lead system was used, with two chokers.

Since landing space was inadequate, the decking area was usually on a sidehill or on the road. A tractor had to swing each turn of logs down the road for decking. There were five men on the yarding crew, and another operating the tractor. Logs were loaded onto highway trucks with a company-owned, cable heel-boom loader. Haul distance to the mill averaged about 37 miles (59.2 km).

Table 17 summarizes machine specifications and forest site characteristics during the study.

TABLE 17. Machine Specifications and Forest Site Characteristics: Company C 70-foot Madill Tower.

Machine Specifications	Year manufactured	1960
	Tower height	70 ft (21 m)
	Engine size	155 hp (116 kW)
	Number of winches	3
	Type of undercarriage	tracked (tank)
Forest Site Characteristics	Volume/acre	54 cunits (378 m³/ha)
	Species Composition:	
	Spruce	56%
	Balsam fir	17%
	Lodgepole pine	11%
	Western hemlock	10%
	Cedar	3%
	Other	3%
	Average butt diameter	13 in (33 cm)
	Maximum butt diameter	36 in (91 cm)

Time and Productivity Results

Time distributions and piece-size distributions were obtained during 5 separate days of work sampling and scaling, in July and August 1975. Shift-level monitoring was for the period July 22 to August 15, 1975, ending when the operation shut down for the year.

Figure 20 shows the percent distribution of time for the machine. The high proportion of productive time was the result of the crew's consistent (though not hurried) pace. The considerable experience of both hooktender and yarding engineer appeared to be an important factor in keeping the operation going, and few delays were observed. The machine itself, although old, was quite reliable. It has required no major repairs for several years.

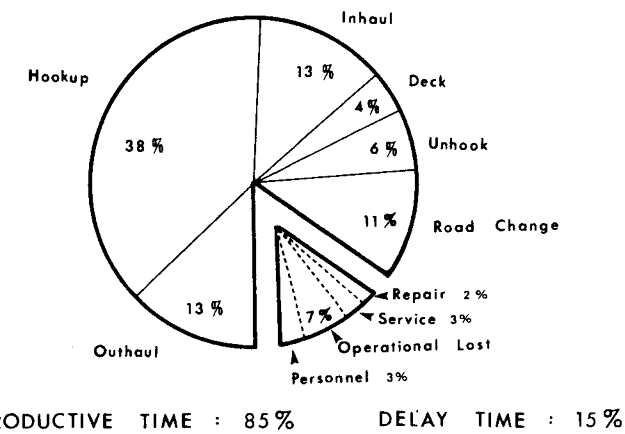


FIG. 20. Percent Distribution of Scheduled Time: Company C 70-foot Madill Tower.

Figure 21 shows the piece-size (gross volume) distribution, based on logs yarded during 5 shifts. An average of 2.1 logs was yarded per turn, for an average turn volume of 57 ft³ (1.61 m³).

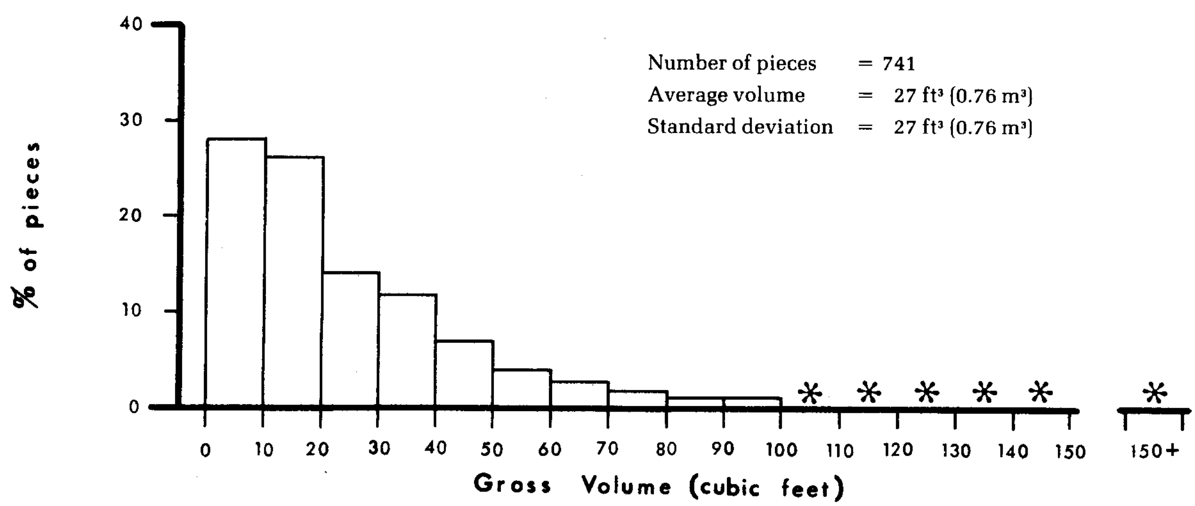


FIG. 21. Piece-Size Distribution: Company C 70-foot Madill. *= less than 1%

Tables 18 and 19 summarize results from shift-level monitoring. The general pattern of high machine utilization seen in the work sampling results continued over the longer term. There were 30 yarding road changes, averaging 30 min each. No wholly unproductive shifts occurred during the study period. One landing change of 4 ½ hr was observed.

TABLE 18. Time Summary: Company C 70-foot Madill Tower.

	Average Hours/shift	Standard Deviation
Productive time:		
Yarding	6.1	0.8
Yarding Road Change	0.9	0.4
Delays:		
Mechanical	0.2	0.4
Landing Change	0.2	—
Other Non-Mechanical	0.6	0.4
Total: Scheduled Machine Hours	8.0	
Mechanical Availability	97%	
Machine Utilization	87%	
Number of Scheduled Shifts	18	

TABLE 19. Production Summary: Company C 70-foot Madill Tower.

Avg. piece size, all landings, ft^3	28 (0.79 m^3)
Piece count per shift	144 (S.D. = 28)
Piece count during study	2,584
Gross volume per shift, cunits	40 (113 m^3)
Gross volume during study, cunits	715 (2,023 m^3)
Productivity:	
Cunits/Scheduled Machine Hour	4.96 (14.0 m^3)
Cunits/Productive Machine Hour	5.70 (16.1 m^3)
Number of Shifts worked	18

Company D

Logging System

This operation, located on the east side of the Monashee Mountains, employed a company-owned Washington 078 Skylok Grapple Yarder (Fig. 22).

This machine was purchased in the fall of 1974. Company personnel chose a grapple yarder because of the reduced manpower requirement compared to other cable-logging systems.

During its first year, the Washington operated in older cutting permits designed for tractor logging. More recently, the machine has moved into areas designed to suit its capabilities.

The yarder moved along the roadside yarding log-length timber both up and downhill. Horizontal yarding distance rarely exceeded 500 ft (150 m), on slopes of up to 70%. The mobile backspar used was a Euclid 8240. (The first backspar, an International TD 15, was found to be too light.)

From the roadside piles, a Washington hydraulic loader loaded off-highway trucks, with both 10 and 12 ft (3.0 and 3.7 m) bunks. One-way haul distance to the sort yard and reload area was about 15 miles (24 km). Logs were then trucked

FIG. 22. Washington 078 Skylok Grapple Yarder.

a short distance to the dump where they were bundled and towed 90 miles (145 km) to the mill.

Table 20 summarizes machine specifications for the Washington 078, and forest site characteristics.

TABLE 20. Machine Specifications and Forest Site Characteristics: Company D Washington 078 Grapple Yarder.

Machine Specifications	Year manufactured	1974
	Tower height	44 ft (13.4 m)
	Engine size	185 hp (138 kW)
	Number of winches	4
	Type of undercarriage	tracked
Forest Site Characteristics	Volume/acre	50-65 cunits (350-455 m³/ha)
	Species Composition:	
	Douglas fir, larch, white pine	60%
	Cedar	20%
	Hemlock	20%
	Average butt diameter	16 in (41 cm)
	Maximum butt diameter	30 in (76 cm)

Time and Productivity Results

No detailed time distributions or scale data were obtained for this case. The machine was not operational during FERIC field studies (1974 — late fall start-up; 1975 — strike closures). However, the long term monitoring program was instituted for the Washington 078 in October 1974. The machine's progress was followed on this basis until the end of February 1975. Since that time, internal company records have been used to obtain estimates of the yarder's performance.

Table 21 summarizes shift-level results over a 56-week period ending November 21, 1975. The data are presented in two groups; one covering the FERIC study period and the other containing information processed from company records.

The two data groupings show differences in Availability and Utilization figures. One reason is that more detailed information was obtained from the Servis Recorders used during the FERIC study period, with the result that more time was assigned to delay categories. A second reason is that both supervisors and yarding crew members improved their performance with experience. The FERIC monitoring program began a week and a half after the company first obtained the machine; the effect was to include a number of start-up problems, as well as winter conditions. After a year of experience, the yarding crew has increased the average piece count/shift by 60 pieces, compared to their production rate after 4 months.

During the FERIC study period, there were 103 yarding road changes averaging 33 min each, and 5 landing changes averaging 8 hr each.

Explanation of Non-Productive Shifts

SUMMARY A: FERIC Monitoring Period

Total scheduled shifts = 73
Productive Shifts = 50
Non-Productive Shifts 23

Reasons:

Mechanical Delays

Repair yarder or tail cat	3 shifts
Wait parts or mechanics	6

Non-Mechanical Delays

Change landings	2
Operator sick	4
No road ready	4
No trees felled	2
Road blocked — wait for cat	1
Operator driving truck	1
Total:	23 shifts

Non-Scheduled Time: 2 weeks Christmas break

SUMMARY B: Company Reports

Total Scheduled Shifts = 111
Productive Shifts = 108
Non-Productive Shifts 3

Reasons:

Non-Mechanical Delays

Fell and skid anchor trees	2 shifts
No trees felled	1
Total:	3 shifts

Non-Scheduled Time: 3 weeks spring break-up
5 weeks strike closure
7 weeks strike closure

TABLE 21. Shift level results: Company D Washington 078 Grapple Yarder.

	SUMMARY A FERIC Study Period Oct. 29/74 to Feb. 28/75		SUMMARY B Company Reports March 3/75 to Nov. 21/75	
	Average hours/shift	Standard Deviation	Average hours/shift	Standard Deviation
TIME SUMMARY				
Productive time:				
Yarding	2.4	2.0	5.1	1.5
Yarding Road Change	0.8	0.9	1.1	0.9
Delays:				
Mechanical	2.4	2.6	1.3	1.2
Landing Change	0.5	3.0	0.2	0.8
Other Non-Mechanical	1.9	2.7	0.3	1.4
Total: Scheduled Machine Hours	8.0		8.0	
Mechanical Availability	69%		84%	
Machine Utilization	39%		78%	
Number of Scheduled Shifts	73		111	
PRODUCTION SUMMARY				
Avg. Piece Size, all landings, ft^3	32 (0.91 m^3)		31 (0.88 m^3)	
Piece Count per Shift	95 (S.D. = 41)		155 (S.D. = 56)	
Piece Count during Study	4,738		16,746	
Gross Volume per Shift, cunits	30 (85 m^3)		48 (136 m^3)	
Gross Volume during Study, cunits	1,520 (4,302 m^3)		5,191 (14,691 m^3)	
Productivity:				
Cunits/Scheduled Machine Hour	3.80 (10.7 m^3)		6.01 (17.0 m^3)	
Cunits/Productive Machine Hour	6.64 (18.8 m^3)		7.48 (21.2 m^3)	
Number of Shifts worked	50		108	

Company E

Logging System

The operation, located in the Cariboo wet belt of central British Columbia, employed a company-owned Skagit GT3 Grapple Yarder (Fig. 23).

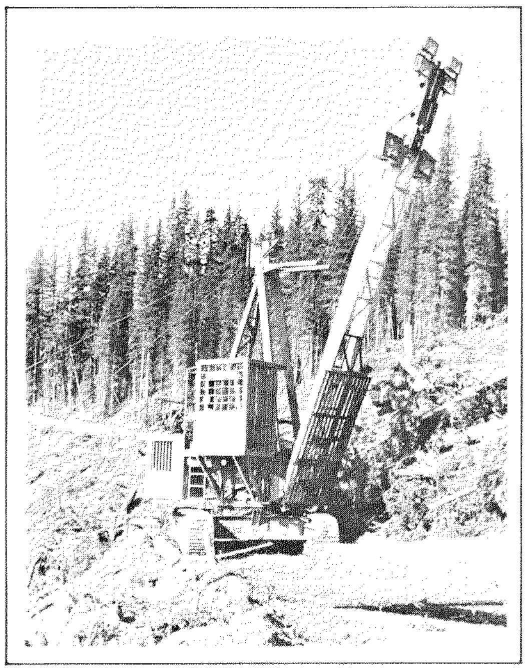


FIG. 23. Skagit GT3 Grapple Yarder.

Forty-acre (16 ha) cut blocks have been developed specifically for the grapple yarder. The road system, landings for truck loading and back-trails for the tail-hold machine were prepared in advance of yarding.

The GT3 logged the complete clearcut areas, including flat ground and sidehills. Yarding was usually downhill, bringing tree-lengths to road-side decks. Yarding roads were usually not perpendicular to the contour; instead, they were offset as much as 30° so that timber was brought downhill at an angle. As a result, the decked tree-lengths lay at 30° to the truck road, simplifying the skidder operator's job in swinging the wood to the landings. Yarding distance averaged 300-350 ft (91-107 m) (maximum about 600 ft (183 m)) and swinging from the roadside deck to the landing did not exceed 1,500 ft (457 m). Slopes varied from level to 60%. The wood was bucked at the landing and loaded onto highway trucks with a front-end loader. The average one-way haul distance to the sawmill was 85 miles (137 km).

The mobile tail-hold (Fig. 24) was a tractor with a 15-ft (4.6 m) A-frame welded to the blade for added line lift.

Six 1000-watt mercury vapour lamps on a rubber-mounted light bar provided illumination for night work. The lights could be adjusted by means of a manual winch installed at the base of the boom. (The original two 1000-watt lamps gave inadequate illumination and filaments were frequently broken because of the continual machine vibration.) After a short trial period, the second shift was discontinued because of a shortage of fallers.

Another modification to the GT3 was steel guarding mounted on the boom to protect the operator's cab and air lines from run-away logs when yarding downhill.

The grapple yarder operated with a three-man crew — the operator, the spotter (who also moved the tail-hold and hooked up logs that were out of reach of the grapple), and the landing helper (who moved guylines during landing changes and yarding road changes, and unhooked logs at the machine when chokers were used).

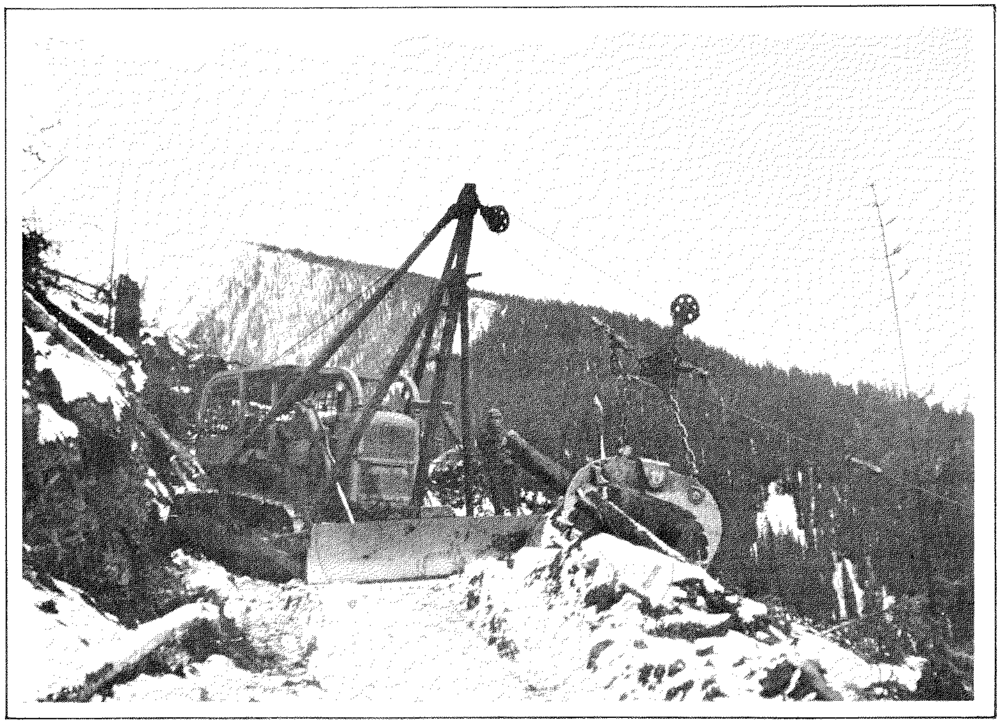


FIG. 24. Tail-hold machine for Skagit GT3.
(The D7E Caterpillar tractor was replaced by a heavier D8H model to eliminate up-ending of the tail-hold during yarding. The illustration shows the grapple being positioned on a log as the crew member gives radio directions to the grapple operator.)

Table 22 summarizes machine specifications for the GT3 and forest site characteristics observed.

TABLE 22. Machine Specifications and Forest Site Characteristics: Company E, Skagit GT3 Grapple Yarder.

Machine Specifications	Year manufactured	1974
	Tower height	44 ft (13.4 m)
	Engine size	220 hp (164 kW)
	Number of winches	4
	Type of undercarriage	track
Forest Site Characteristics	Volume/acre	55-65 cunits (385-455 m³/ha)
	Species Composition:	
	Spruce	73%
	Balsam fir	25%
	Other	2%
	Average butt diameter	12 in (30 cm)
	Maximum butt diameter	39 in (99 cm)

Time and Productivity Results

Data from this operation include:

1. Time distribution estimates from work sampling during 7 separate shifts (August to December 1975);
2. Volume estimates of pieces yarded for the same 7 shifts;
3. Shift-level time and production estimates from the Shift Monitoring Program (August 7, 1975 to February 27, 1976).

Figure 25 shows the percent distribution of time (including moves) for the Skagit GT3. "Hookup" refers to time spent positioning the grapple on logs, as well as the few occasions when a choker was utilized. "Unhook" is the time spent removing the choker from yarded logs (Appendix I).

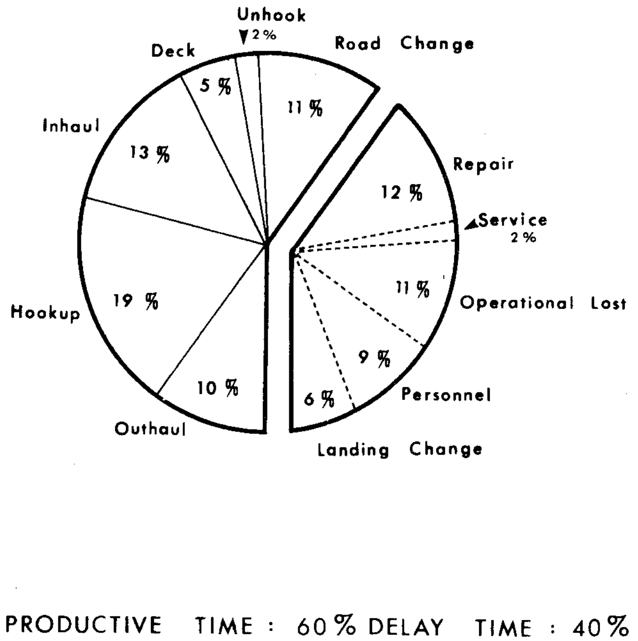


FIG. 25 Percent Distribution of Scheduled Time: Company E Skagit GT3.

Figure 26 presents the piece-size (gross volume) distributions. The average turn size was 1.2 logs, or 37 ft³ (1.05 m³).

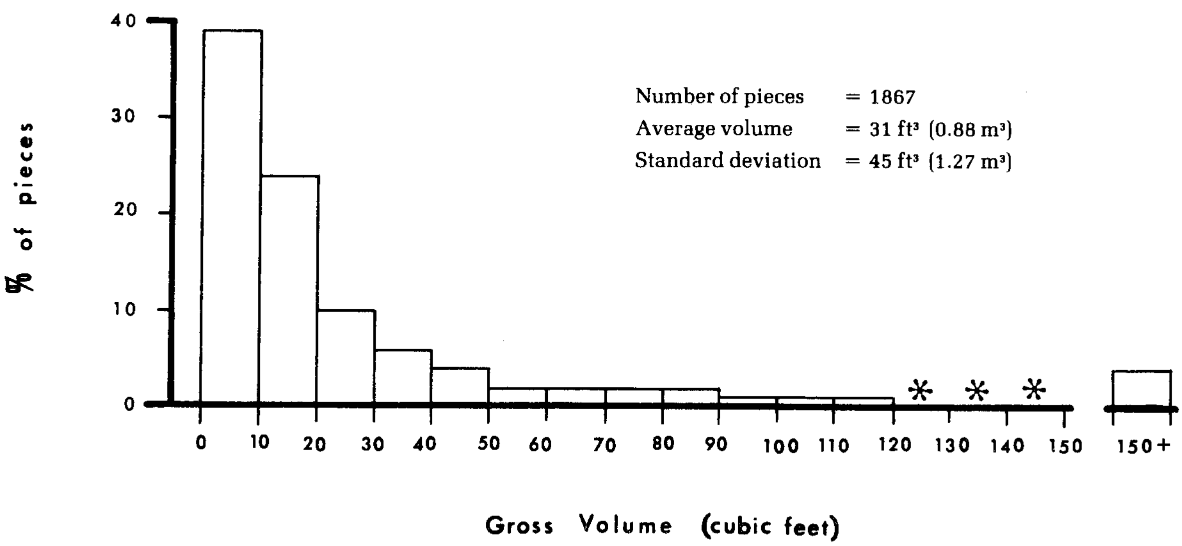


FIG. 26 Piece-Size Distribution: Company E Skagit GT3.
* = *less than 1%*

Results from the shift-level monitoring of the GT3 are shown in Tables 23 and 24. Out of the 165 scheduled shifts during the study period, 10 were lost for the following reasons: regular service periods (5 shifts); change interlock brake (2 shifts); track clutch repair (1 shift); repairs to haul-back line (1 shift); and, move to new cutting permit (1 shift).

TABLE 23. Time Summary: Company E Skagit GT3 Grapple Yarder.

	Average hours/shift	Standard Deviation
Productive time:		
Yarding	5.5	2.3
Yarding Road Change	1.0	0.6
Delays:		
Mechanical	1.4	2.5
Landing Change	0.6	1.6
Other Non-Mechanical	0.9	1.1
Total: Scheduled Machine Hours	9.4	
Mechanical Availability	85%	
Machine Utilization	70%	
Number of Scheduled Shifts	165	

TABLE 24. Production Summary: Company E Skagit GT3 Grapple Yarder.

Avg. piece size, all landings, ft³	30 (0.85 m³)
Piece count per shift	263 (S.D. = 96)
Piece count during study	40,694
Gross volume per shift, cunits	80 (227 m³)
Gross volume during study, cunits	12,348 (34,945 m³)
Productivity:	
Cunits/Scheduled Machine Hour[1]	8.47 (23.9 m³)
Cunits/Productive Machine Hour	11.44 (32.4 m³)
Number of Shifts worked	155

[1]Scheduled Time = 9.4 hours/shift.

A total of 1440 yarding road changes occurred during the monitoring period, averaging 7 min each. There were 37 landing changes, averaging 2½ hr each.

Company F

Logging System

The operation, located west of Okanagan Lake on the Thompson Plateau in south-eastern British Columbia, employed a contractor-owned Koehring Bantam loader, converted to a cable yarder (Fig. 27). The company harvested timber from areas infested with mountain pine beetle, to salvage the trees and to prevent further spreading of the beetles. The B.C. Forest Service has required the use of cable systems for harvesting beetle-killed areas where the slope exceeds 40%.

A suitable system had to meet certain requirements with regard to size, mobility and manpower. For the foreseeable future, the timber to be harvested will be small — between 13 and 17 ft³ (0.4 to 0.5 m³) per tree. This meant that a small, light and inexpensive machine could be utilized. Mobility was important, because the unpredictability of beetle outbreaks meant the machine would have to move frequently to log small areas. The system had to operate with a small crew to achieve reasonable costs.

FIG. 27. Koehring Bantam loader, converted for yarding.

Yarding operations with the Bantam commenced in September 1973 and closed for the winter in mid-December. In 1974, the unit worked only 5 months during summer and fall before it was shut down because of poor market conditions. In 1975, operations lasted 7 months, until closed for the winter at the end of December.

Although the engineering layout was intended for ground-skidding, the Koehring Bantam crew experienced only minor problems in accommodating the yarding system to the road network. The machine is mobile, being stabilized with hydraulic outriggers, rather than guylines. Company personnel indicated that 80% of the road system was suited to yarding with the Koehring Bantam; however, some additional short spur roads were required. The horizontal yarding distance rarely exceeded 450 ft (137 m), and averaged about 300 ft (91 m). The contractor tried a variety of line configurations over the three operating seasons, including: gravity slackline ("shotgun") for uphill yarding; two-line running skyline; regular high lead; and a squirrel block on the haulback line (Fig. 28). The crew varied from three to four — the yarding engineer, the chaser at the landing, and one or two chokermen.

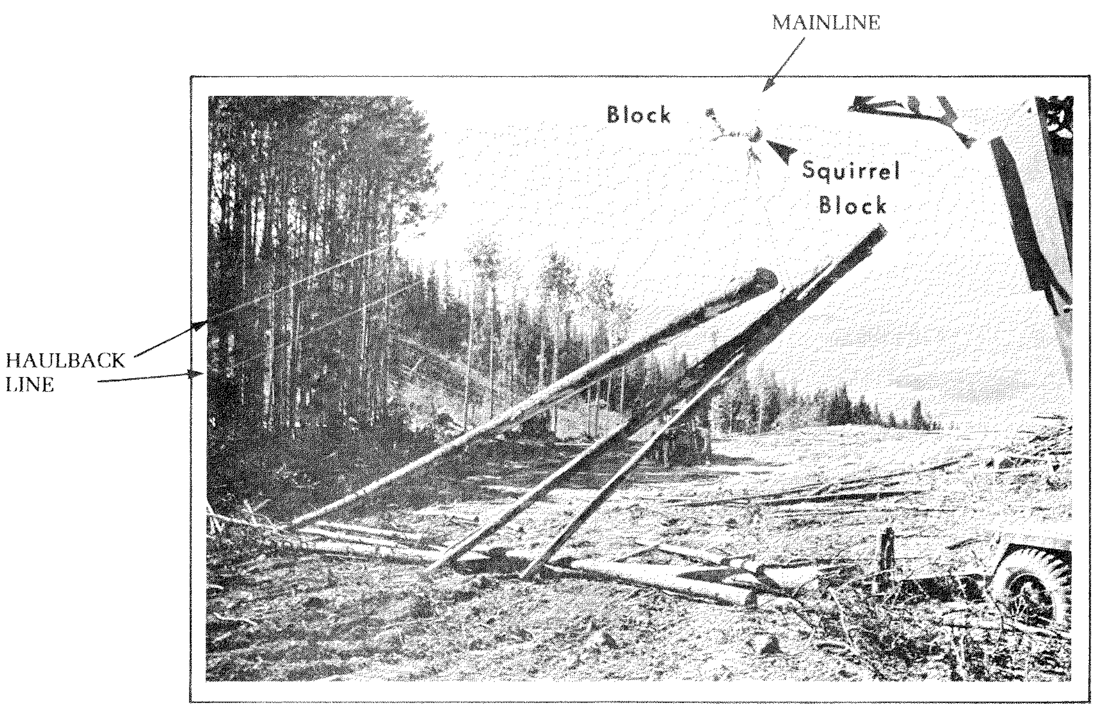


FIG. 28. Butt-rigging configuration on Koehring Bantam.

The upper block is attached to the butt rigging and rides on the haulback line. This provides extra line-lifting capacity. The squirrel block is fastened to the end of the haulback line and the mainline passes through the block. This allows the chokerman to pull out more of the mainline, to obtain extra reach to the side of the yarding road. Sliding chokers on the mainline add to the flexibility of the system.

For the first two years, the yarder brought tree-lengths to roadside decks. The logs were re-skidded to central landings for limbing and bucking, and trucks were loaded by front-end loader. Because re-skidding was too costly, the contractor changed his system in 1975 to eliminate this phase. Trees were felled, then limbed and bucked at the stump, and the Koehring Bantam yarded log-lengths. The machine's ability to swing was used to pull logs as far onto the truck road as possible. A front-end loader then loaded trucks directly from these piles. The increased loading cost was more than offset by the elimination of re-skidding. Off-highway trucks (both 10-ft and 12-ft (3.0 and 3.7 m) bunks) hauled logs about 14 miles (23 km) to the dump. The bundled logs were then towed 3 miles (5 km) to the mill.

Whenever possible, activities affecting machine utilization were performed outside of the scheduled shift. Maintenance checks, regular service, repair work and machine moves occurred during the evenings and on weekends.

Table 25 summarizes machine specifications for the Koehring Bantam, and forest site characteristics.

TABLE 25. Machine Specifications and Forest Site Characteristics: Company F Koehring Bantam.

Machine Specifications[1]	Year manufactured	1971
	Tower height	29 ft (8.8 m)
	Engine Size	90 hp (67 kW)
	Number of winches	2
	Type of undercarriage	truck-mounted
Forest Site Characteristics	Volume/acre	45 cunits (315 m³/ha)
	Species Composition:	
	Lodgepole pine	95%
	Spruce/Balsam fir	3%
	Douglas fir	2%
	Average butt diameter	9 in (23 cm)
	Maximum butt diameter	21 in (53 cm)

[1]Contractor modifications at the time of the study included: operator's cab elevated 4 ft (1.2 m); mainline gear ratio changed to increase speed by 25% (haulback remained standard); haulback fairlead raised 6 ft (1.8 m) to separate lines when using running skyline; drum sizes increased to hold 800 ft (240 m) of ¾-inch (190 mm) mainline; and 1,600 ft (490 m) of 7/16-inch (107 mm) haulback.

Time and Productivity Results

Time-distribution estimates and volume estimates of pieces yarded were obtained from work sampling and scaling for 6 separate shifts between August and November 1975. Shift-level time and production estimates were developed from reports covering the period July 30 to November 4, 1975.

Figure 29 shows the percent distribution of time for the Koehring Bantam. The practice of scheduling regular machine maintenance, service and moves out-of-shift contributed to the high proportion of productive time.

The piece-size (gross volume) distribution (Fig. 30) shows the predominance of small logs being harvested. The average turn comprised 2.6 pieces, for a turn volume of 30 ft³ (0.84 m³).

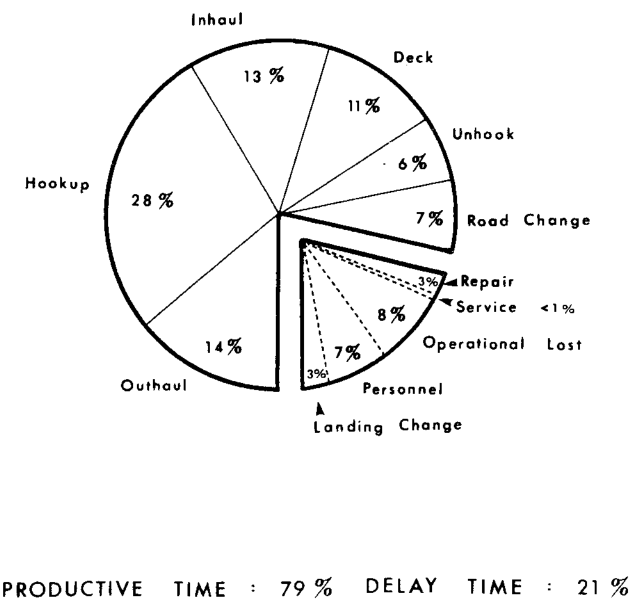


FIG. 29. Percent Distribution of Scheduled Time: Company F Koehring Bantam.

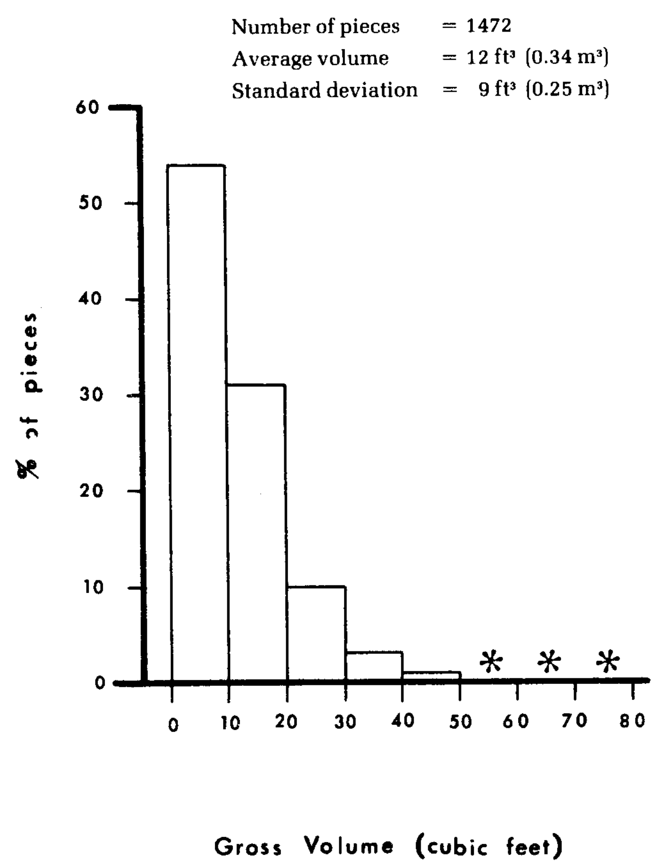


FIG. 30. Piece-Size Distribution: Company F Koehring Bantam.
* = *less than 1%*

Results from the shift-level monitoring are shown in Tables 26 and 27. During the study, the crew performed 169 yarding road changes, averaging 16 min each. Five landing changes during scheduled time averaged 1 hr 10 min each.

TABLE 26. Time Summary: Company F Koehring Bantam.

	Average hours/shift	Standard Deviation
Productive time:		
Yarding	5.7	2.0
Yarding Road Change	0.8	0.4
Delays:		
Mechanical	0.5	1.5
Landing Change	0.1	0.4
Other Non-Mechanical	0.8	1.2
Total: Scheduled Machine Hours	7.9	
Mechanical Availability	93%	
Machine Utilization	82%	
Number of Scheduled Shifts	57	

TABLE 27. Production Summary: Company F Koehring Bantam.

Avg. piece size, all landings, ft^3	13 (0.37 m^3)
Piece count per shift	219 (S.D. = 57)
Piece count during study	11,821
Gross volume per shift, cunits	28 (0.80 m^3)
Gross volume during study, cunits	1,531 (4,333 m^3)
Productivity:	
Cunits/Scheduled Machine Hour	3.59 (10.2 m^3)
Cunits/Productive Machine Hour	4.14 (11.7 m^3)
Number of Shifts worked	54

Three of the 57 scheduled shifts were non-productive: radio whistle broken (2 days); operator absent (1 day).

Company G

Logging System

The operation, located in the foothills south of Grande Prairie, Alberta, utilized a Madill 071 Skidder Tower (Mini-Spar) (Fig. 31).

The machine was leased in the fall of 1973 to log areas classified by the Alberta Forest Service as inaccessible to ground skidding techniques. These were mainly high-quality stands on steep slopes with fine-textured soils.

Lack of familiarity with cable-logging techniques, combined with mechanical and parts supply difficulties caused experimental trials to fall short of expectations in 1974. Plans for 1975 called for a 100-acre (40 ha) clearcut, to be jointly logged by cable and ground-skidding methods (40 acres (16 ha) of high lead and 60 acres (24 ha)

FIG. 31. Madill 071 Skidder Tower (Mini-Spar), Company G.

of ground skidding). The skidders operated on the primarily flat terrain and the Mini-Spar logged the steep slope area.

Tree lengths were yarded uphill to the yarder landing, located on flat ground above slopes that ranged between 35% and 75%, averaging about 50%. Maximum yarding distance averaged 400 to 450 ft (118 to 135 m) horizontal distance, although two particularly long yarding roads of 950 ft (285 m) were observed. The crew usually comprised four men.

Climatic and ground conditions in the region dictate summer logging and winter hauling. The winter haul season extends from November until mid-March. Yarded logs must be neatly piled in large landings for efficient loading during the winter. Wheeled skidders and tractors forwarded tree-lengths from the Mini-Spar to these central landings, where they were limbed, bucked and piled. In the winter, off-highway trucks (10-ft (3 m) bunks) were loaded by front-end loader, for the 75-80-mile (120-130 km) haul to the sawmill.

Table 28 summarizes machine specifications for this Mini-Spar, and forest site characteristics.

TABLE 28. Machine Specifications and Forest Site Characteristics: Company G Mini-Spar.

Machine Specifications	Year manufactured	1971
	Tower height	49 ft (15 m)
	Engine size	220 hp (164 kW)
	Number of winches	5
	Type of undercarriage	tractor
Forest Site Characteristics	Volume/acre	25-35 cunits (175-245 m³/ha)
	Species Composition:	
	Lodgepole pine	80%
	White spruce	20%
	Average butt diameter	13 in (33 cm)
	Maximum butt diameter	35 in (89 cm)

Time and Productivity Results

Time distributions and piece-size estimates were obtained from work sampling and scaling on 4 separate shifts in August and September 1975. Shift-level monitoring extended from August 7 to November 7, 1975.

Figure 32 shows the percent distribution of time for the Mini-Spar. Most of the repair delay was due to a broken air hose.

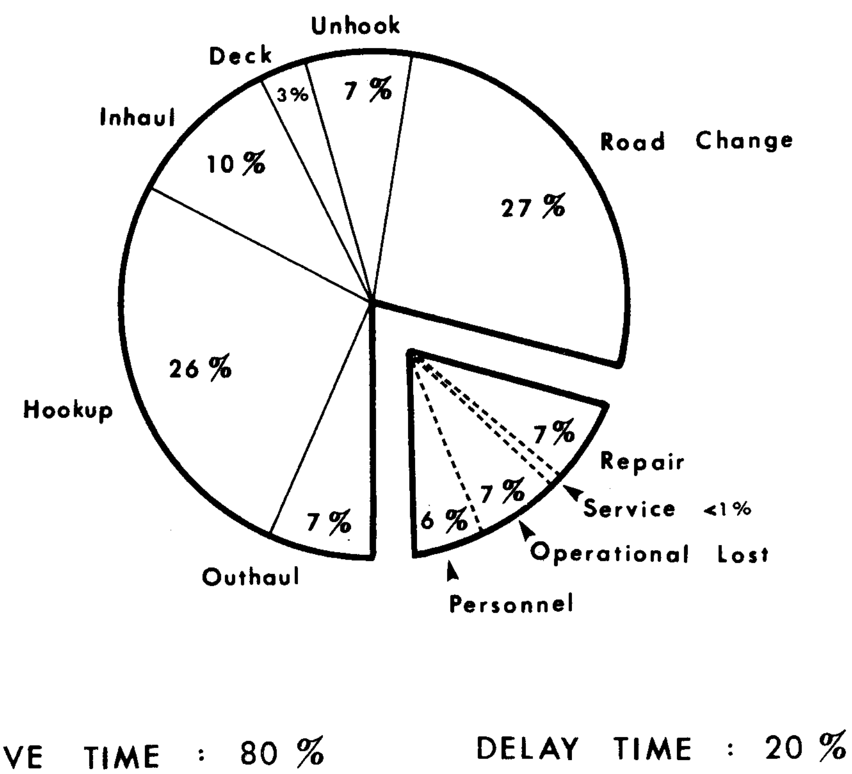


FIG. 32. Percent Distribution of Scheduled Time: Company G Mini-Spar.

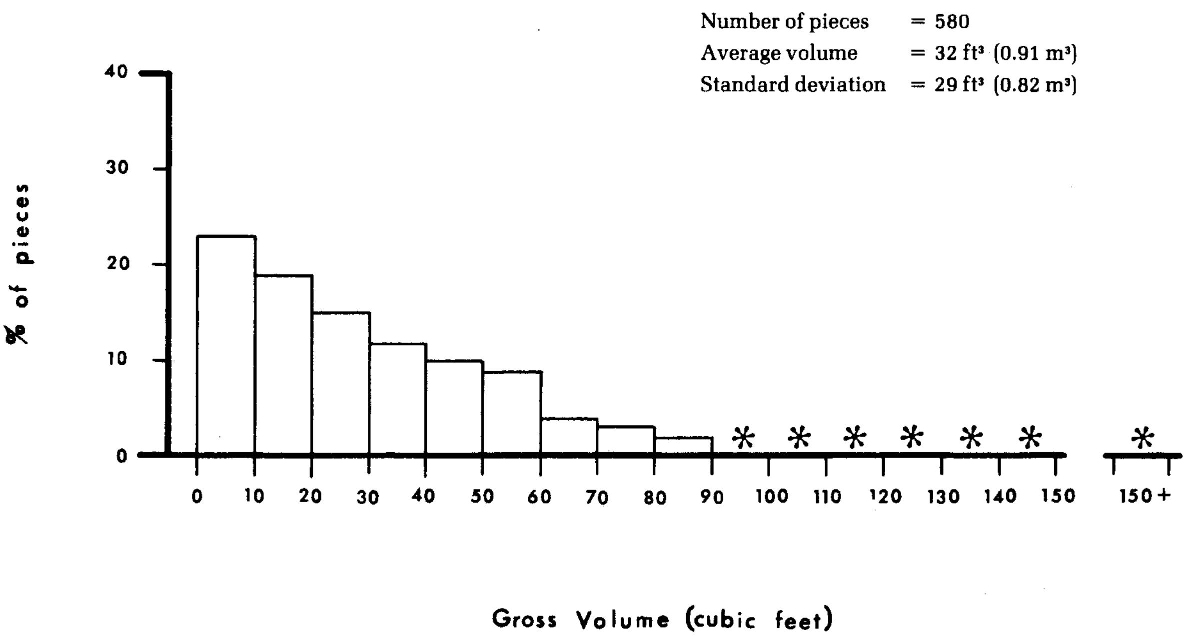


FIG. 33. Piece-Size Distribution: Company G Mini-Spar.
* = *less than 1%*

The piece-size distribution (Fig. 33) illustrates the wide variation observed. The average turn size was 3.1 logs, or 101 ft³ (2.86 m³).

Tables 29 and 30 summarize the shift-level results for this machine. There were 81 yarding road changes, averaging 33 min each. In addition, 5 landing changes during the period required an average of 3 hr 20 min each.

TABLE 29. Time Summary: Company G Madill Mini-Spar.

	Average hours/shift	Standard Deviation
Productive time:		
Yarding	3.2	2.9
Yarding Road Change	0.7	0.9
Delays:		
Mechanical	4.6	4.3
Landing Change	0.3	0.9
Other Non-Mechanical	0.5	0.7
Total: Scheduled Machine Hours	9.3	
Mechanical Availability	50%	
Machine Utilization	42%	
Number of Scheduled Shifts	64	

TABLE 30. Production Summary: Company G Madill Mini-Spar.

Avg. piece size, all landings, ft³	30 (0.85 m³)
Piece count per shift	138 (S.D. = 46)
Piece count during study	5,252
Gross volume per shift, cunits	42 (119 m³)
Gross volume during study, cunits	1,597 (4,520 m³)
Productivity:	
Cunits/Scheduled Machine Hour[1]	4.52 (15.8 m³)
Cunits/Productive Machine Hour	6.46 (18.3 m³)
Number of Shifts worked	38

[1]Scheduled Time = 9.3 hours/shift.

In all, 64 shifts were observed on this Mini-Spar operation. Non-productive shifts included:

— 16 consecutive shifts lost after guyline stumps pulled loose causing the tower to topple. Repairs to the base of the tower were required.

— 10 consecutive shifts lost when a drum shaft broke. The operation closed for the winter after the same shaft broke a second time, 2 weeks later.

Cable Yarding Performance: A Comparison of the Cases Studied

A primary objective in carrying out the case studies, of course, is to enable comparisons among the different machines and systems. Since conditions and the arrangement of systems varied, it is necessary to keep in mind the main characteristics of each operation when interpreting the following tabulations of time, productivity and cost.

i) Time

Table 31 summarizes shift-level time distributions for each case studied, comprising 581 scheduled shifts in all. The number of reported shifts for each machine varied because of shutdowns for weather, market conditions, strikes and major mechanical breakdown. Several of the co-operating firms decided to continue data recording on their own, extending the sample size.

Mechanical Availability of the yarding machines was generally high, and it seems reasonable for companies to aim for figures of 90% or greater. Exceptions during the study were the Company D Washington 078 (9 scheduled shifts lost), and the Company G Madill Mini-Spar (16 shifts lost), for reasons previously explained. It is necessary for both the manufacturer and the using company to provide sufficient maintenance support to keep mechanical availability at a high level. Availability should also improve as crew experience increases, enabling them to anticipate or prevent mechanical problems.

Machine Utilization is a measure of the organization's effectiveness in using scheduled time for productive work. Utilization varied from 42% to 87%. The figures are strongly influenced by crew experience and motivation. The contractor crews at Companies A and F both included individuals with previous cable yarding experience. The Company C 70-foot Madill crew included two long-experienced cable loggers, and had the highest machine utilization. Company D's machine utilization doubled in period B compared to period A, probably a result of increased crew experience and system improvements.

A relatively small proportion of time was spent moving between landings. However, companies will want to minimize this time expenditure by increasing the efficiency of landing changes. One way to do this is to plan and prepare for moving the machine well in advance.

The remaining differences between machines' Mechanical Availability and Utilization were attributed to "other non-mechanical delays". These varied from 4% to 32% of scheduled time for the cases studied. Review of the recorded causes of these delays suggests that personnel and planning problems were largely responsible. Their control requires close supervisory support, including attention to: having an adequate crew size to operate the system; loading out log decks

TABLE 31. Summary of machine time, availability and utilization from shift reports.

			Time: Hours Per Shift						
			Productive		Delays				
Company	Machine	No. of Shifts	Regular Cycle	Change Yarding Roads	Mechanical	Move (Landing)	Other Non-Mechanical	Mechanical Availability %	Utilization %
A	Ecologger	33	5.8	0.6	0.5	0.4	0.7	94	80
B	70-foot Madill	15	3.8	0.7	0.9	—	2.6	88	55
C	Mini-Spar	45	3.9	0.8	0.6	0.1	2.5	93	59
C	70-foot Madill	18	6.1	0.9	0.2	0.2	0.6	98	87
D	Washington 078	A: 73	2.4	0.8	2.4	0.5	1.9	69	39
		B: 111	5.1	1.1	1.3	0.2	0.3	84	78
E	Skagit GT3	165	5.5	1.0	1.4	0.6	0.9	85	70
F	Koehring Bantam	57	5.7	0.8	0.5	0.1	0.8	93	82
G	Mini-Spar	64	3.2	0.7	4.7	0.2	0.5	50	42

on schedule; having sufficient access roads and back spar trails prepared; felling sufficient trees ahead of the yarding operation; and preparing a thorough layout plan (landings, roads, decking areas) in advance of the logging.

Table 32 compares time distributions (in minutes and percent) for a total of 41 sample days (3,779 completed turns) on 7 of the operations studied. The data include only complete shifts, so that large delays do not distort the cycle time estimates. Average total cycle time ranged from 2.59 min (GT3 grapple yarder) to 12.61 min for the Company G Mini-Spar. (Of course, yarding distance, log and turn volumes varied within and between operations, as described in the case studies.) Pro-rated delays of all kinds were as little as 26% (Company C 70-foot Madill) and as high as 53% (Ecologger 1975 study) of average total cycle time.

Estimates of average net cycle time varied from 1.27 min (GT 3) to 6.68 min (Company G Mini-Spar), while most of the other operations fell in the range 3 to 5 min. A comparison of element times within the work cycle shows the Skagit GT3 grapple yarder to be significantly faster than any of the choker machines in practically every function. This must be balanced against the fact that most turns for the grapple produce only one log. For most operations, inhaul was slightly slower than outhaul and these time elements generally averaged less than a minute. Hookup was the largest time element, varying from ½ min (GT3) to more than 3 min (Company G Mini-Spar). Roughly ¼ of scheduled time was spent in hookup on the choker machines. Within the limitations of each machine and the particular circumstances, it is probably worthwhile to spend extra time in hookup to achieve higher turn volumes. Deck and unhook were relatively small time elements, averaging much less than 1 min each for most of the cases.

TABLE 32. Average yarding cycle times estimated from continuous timing and work sampling.

Company	Machine	Year/No. of Days	No. of Turns	Out-Haul	Hook Up	In-Haul	Deck	Un-Hook	Net Cycle	Yarding Road Change	Delay	Total Time/ Turn
				All times in minutes (percent in parenthesis)								
A	Ecologger	1974: 5	426	.36 (6)	1.57 (28)	.63 (11)	.14 (3)	.37 (7)	3.07 (55)	.35 (6)	2.12 (39)	5.54
		1975: 2	117	.33 (4)	2.30 (28)	.49 (6)	.16 (2)	.57 (7)	3.85 (47)	.57 (13)	3.28 (40)	8.20
B	70-foot Madill	1974: 5	214	.57 (6)	2.81 (28)	1.06 (10)	.61 (6)	1.19 (12)	6.24 (62)	1.17 (12)	2.58 (26)	9.99
C	Mini-Spar	1974: 5	189	.63 (7)	2.46 (25)	.70 (7)	.77 (8)	.81 (8)	5.37 (55)	2.87 (30)	1.42 (15)	9.66
		1975: 3	194	.37 (5)	2.08 (28)	.52 (7)	.30 (4)	.82 (11)	4.08 (55)	1.03 (14)	2.30 (31)	7.42
C	70-foot Madill	1975: 5	357	.87 (13)	2.55 (38)	.87 (13)	.27 (4)	.40 (6)	4.96 (74)	.74 (11)	1.01 (15)	6.71
D	Washington 078	(No Data)										
E	Skagit GT3	1975: 7	1,537	.26 (10)	.49 (19)	.34 (13)	.13 (5)	.05 (2)	1.27 (49)	.28 (11)	1.04 (40)	2.59
F	Koehring Bantam	1975: 5	568	.58 (14)	1.17 (28)	.54 (13)	.46 (11)	.25 (6)	3.00 (72)	.29 (7)	.88 (21)	4.17
G	Mini-Spar	1975: 4	177	.88 (7)	3.28 (26)	1.26 (10)	.38 (3)	.88 (7)	6.68 (53)	3.41 (27)	2.52 (20)	12.61

ii) Productivity

Table 33 summarizes reported production figures for each case study. These include only shifts during which some log yarding occurred. The number of logs produced per shift varied considerably within each operation, which is characteristic of a process subject to a large number of potentially disturbing influences. The Company E GT3 produced the highest average number of logs per shift (263), followed by the Company F Koehring Bantam (219). These were the only operations studied that averaged more than 200 logs per shift, which illustrates the difficulty of achieving consistently high piece counts. Figure 34 shows why this is difficult: producing 200 logs in an 8-hour scheduled shift allows only 5 minutes per turn, if there is an average of 2 logs per turn. The operation has to go very smoothly to average 5 minutes per turn, including pro-rated yarding road changes and delays.

Average log size varied from a low of 13 ft³ (0.37 m³) for Company F, to a high of 38 ft³ (1.08 m³) for Company B. In cable yarding, production is limited more by the number of pieces that can be handled, than by the piece size. This obviously makes piece size a key factor in volume production.

The last columns in Table 33 show average production (gross volume) per shift, and per scheduled machine hour, for each operation. Most were in the range of 30-40 cunits (85-113 m³) per shift, except for the grapple yarders. The Washington 078 (period B) averaged 48 cunits (136 m³) per shift. The GT3 performance was by far the highest observed, averaging 80 cunits (227 m³) per 9-hour shift, or 67 cunits (193 m³) per 8-hour shift, for comparative purposes.

Production per scheduled machine hour (SMH) ranged (among choker machines) from about 3½ cunits/SMH (10 m³/SMH) for the Koehring Bantam to nearly 5 cunits/SMH (14 m³/SMH) for the Company C 70-foot Madill Tower. The grapple yarders again were higher, averaging 6 cunits/SMH (17 m³/SMH) for the Washington 078 and over 8 cunits/SMH (24 m³/SMH) for the GT3.

Productivity measures from the detailed production studies (Table 34) show how the operations differed in number of logs per turn, and volume per turn. Average number of logs per turn ranged from 1.2 (GT3) to 3.1 (Company G Mini-Spar). Despite the small average piece size for the Company F operation, the crew did not hook up an outstandingly high number of pieces each turn. Estimated average gross volume per turn ranged from 30 to 101 cubic feet (.85-2.86 m³). The crews of both the Company B 70-foot Madill and the Company G Mini-Spar combined a reasonably good average piece size with the highest number of pieces per turn to achieve average turn volumes of about 1 cunit (2.8 m³). The lighter machines (the Ecologger; Koehring Bantam) may not be able to consistently pull the heavy loads necessary to achieve these high average turn volumes.

iii) Costs

Cost estimates for the different yarding systems were developed from the shift-level information on time consumption and productivity, together

TABLE 33. Summary of Cable Yarding Production[1] from Shift Reports (8-hour Shift basis[2])

Company	Machine	No. Shifts	Avg. No. of logs/8-hour Shift	Avg. Log Volume ft³	Avg. Gross Vol./Shift Cunits	Production Per SMH Cunits
				(m³ in parentheses)		
A	Ecologger	33	163	22 (.57)	36 (102)	4.49 (12.7)
B	70-foot Madill	15	99	38 (1.08)	38 (108)	4.76 (13.5)
C	Mini-Spar	39	105	28 (.79)	30 (85)	3.71 (10.5)
C	70-foot Madill	18	144	28 (.79)	40 (113)	4.97 (14.1)
D	Washington 078 (A)	52	91	32 (.91)	29 (82)	3.65 (10.3)
D	Washington 078 (B)	108	155	31 (.88)	48 (136)	6.01 (17.0)
E	Skagit GT3	155	223	30 (.85)	67 (193)	8.38 (24.1)
F	Koehring Bantam	54	219	13 (.37)	28 (79)	3.57 (10.1)
G	Mini-Spar	38	119	30 (.86)	36 (102)	4.46 (12.9)

[1]Gross volumes would be reduced by the amount of defect to estimate net volume produced.

[2]Because shift length varied from one operation to another, all comparisons have assumed a standard 8-hour shift.

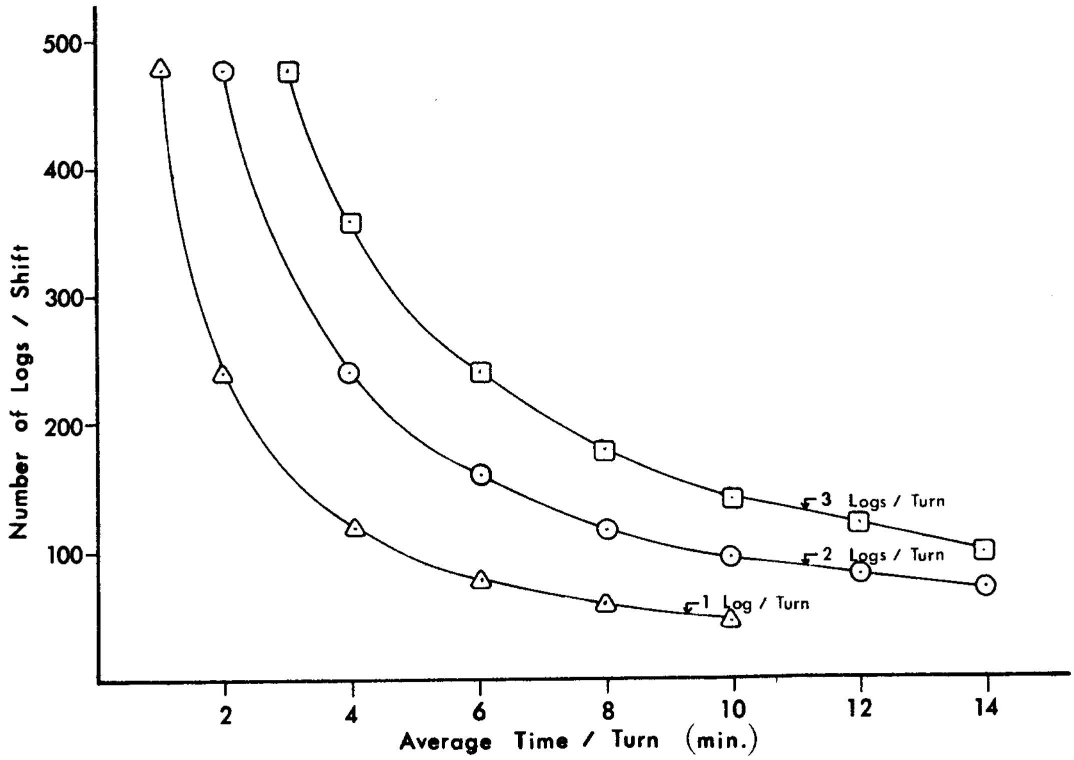


FIG. 34. Number of Logs Produced per Shift as a function of Average Time per Turn and Number of Logs per Turn.
(Based on 8 hr scheduled time. Includes move delays).

TABLE 34. Average Turn Size from Production Studies.

Company[1]	Machine	Avg. No. Logs/Turn	Avg. Gross Volume/Turn ft³
			(m³ in parenthesis)
A	Ecologger	2.5	53 (1.50)
B	70-foot Madill	2.8	100 (2.83)
C	Mini-Spar	2.2	60 (1.70)
C	70-foot Madill	2.1	57 (1.61)
E	Skagit GT3	1.2	37 (1.05)
F	Koehring	2.6	30 (0.85)
G	Mini-Spar	3.1	101 (2.86)

[1]No data for Company D Washington 078.

with assumed hourly costs for machines and crews. To enable comparison among the different systems, it was necessary to calculate the cost of logs loaded on the truck. The production (8-hour shift basis) and estimated costs[1] for each yarding operation are shown in Tables 35 and 36. Capital costs are for 1976 machines (where available) even though new machines differ in some respects from those observed. For example, the Ecologger reported was an early model whose total price was actually less than $50,000.

The cost range of about $22-31 per cunit ($8-11 per m³) (loaded on the truck, including felling, but not roads) compares with current local costs for ground skidding systems of about $12-16 per cunit ($4-6 per m³) loaded on the truck. Cable yarding costs are not necessarily prohibitive, since some of the areas harvested would be inaccessible to tractors and skidders. Also, if the cable systems were operating on some of the easier ground along with the tractors their production would probably be higher and their costs would be more competitive.

[1]Cost assumptions:

Purchase price	: 1976 new price (except 70-foot Madill), $C.
Depreciation	: straight line, 5-year life with a 20% residual, 200 operating days per year.
Interest	: 10% of half the purchase price per year.
Repairs and Maintenance	: 8% of the purchase price per year.
Labour	: $80.00 per man-day including fringe benefits.

The cost figures are based on the actual production and hypothetical machine costs. They are not recorded company costs and should be used for comparative purposes only. There is no allowance for engineering, roads, supervision, employee transportation, overhead or profit.

TABLE 35. Production and cost estimates for cable yarding systems (8-hour shift basis).

Company	Machine	Crew	Log. Avg. ft³	Defect %	Production per 8-hour shift: pcs	Production per 8-hour shift: Gross cunits	Production per 8-hour shift: Net cunits	Machine Price 1976 $	Cost per 8-hour shift: Owning $/shift	Cost per 8-hour shift: Operating $/shift	Cost per 8-hour shift: Total $/shift	Yarding Cost $/cunit	Fell, Limb, Buck Cost $/cunit	Skidder Swing $/cunit	Loading Cost $/cunit	Total Cost on truck $/cunit
A	Ecologger	4	22	8.0	163	36	33	100,000	105	410	515	15.60	4.40	5.30	3.40	28.70
B	70-foot Madill	5	38	15.0	99	38	32	60,000	63	540	603	18.90	3.60	4.10	4.25	30.85
C	Mini-Spar	4	29	14.0	105	30	27	125,000	132	430	562	20.80	3.50	—	4.60	28.90
C	70-foot Madill	6	28	11.8	144	40	35	60,000	63	620	683	19.50	3.40	4.10	4.60	31.60
D	Washington 078	2	31	7.5	155	52	48	250,000	262	360	622	12.96				
	Backspar							30,000	37	32	69	1.44				
	Roads											1.15				
	Total							280,000				15.55	2.50	—	4.60	22.69
E	Skagit GT3	3	30	6.7	221	67	63	260,000	273	444	717	11.38				
	Backspar							30,000	37	32	69	1.10				
	Roads											1.20				
	Total							290,000				13.68	4.50	4.60	2.60	25.38
F	Koehring Bantam	3	13	5.8	219	28	26	140,000	147	346	493	18.96	5.50	—	3.40	27.86
G	Mini-Spar	4	30	6.0	119	37	35	125,000	132	430	562	16.06	3.20	5.00	2.60	26.86

Note: The cost estimates are for yarding system comparisons only. They include only cost items relevant to these comparisons. The figures are incomplete and inadequate for the purpose of logging cost appraisal.

TABLE 36. Production and cost estimates for cable yarding systems. (8-hour shift basis).

Company	Machine	Crew	Log Avg. m³	Defect %	Production per 8-hour shift: pcs	Gross m³	Net m³	Machine Price 1976 $	Cost per 8-hour shift: Owning $/shift	Operating $/shift	Total $/shift	Yarding Cost $/m³	Fell, Limb, Buck Cost $/m³	Skidder Swing $/m³	Loading Cost $/m³	Total Cost on truck $/m³
A	Ecologger	4	.62	8.0	163	101	92	100,000	105	410	515	5.57	1.57	1.89	1.21	10.24
B	70-foot Madill	5	1.06	15.0	99	106	90	60,000	63	540	603	6.73	1.29	1.46	1.52	11.00
C	Mini-Spar	4	.81	14.0	105	85	76	125,000	132	430	562	7.43	1.25	—	1.64	10.32
C	70-foot Madill	6	.78	11.8	144	112	98	60,000	63	620	683	6.97	1.21	1.46	1.64	11.28
D	Washington 078	2	.87	7.5	155	146	134	250,000	262	360	622	4.63				
	Backspar							30,000	37	32	69	.51				
	Roads											.41				
	Total							280,000				5.55	.89	—	1.64	8.08
E	Skagit GT3	3	.84	6.7	221	188	176	260,000	273	444	717	4.06				
	Backspar							30,000	37	32	69	.39				
	Roads											.43				
	Total							290,000				4.88	1.52	1.53	.93	8.86
F	Koehring Bantam	3	.36	5.8	219	78	72	140,000	147	346	493	6.77	1.96	—	1.21	9.94
G	Mini-Spar	4	.84	6.0	119	104	98	125,000	132	430	562	5.74	1.14	1.79	.93	9.60

Note: The cost estimates are for yarding system comparisons only. They include only cost items relevant to these comparisons. The figures are incomplete and inadequate for the purpose of logging cost appraisal.

The cost range in Tables 35 and 36 ($9/cunit; $3/m³) is not great, considering the variety of conditions observed. This suggests that the companies have been successful in selecting correct combinations of machines for their conditions. It is also interesting that the most expensive machines (Skagit GT3 and Washington 078) had relatively low estimated costs per unit volume, while the least expensive machines (older, 70-foot Madill towers) had the highest estimated cost per unit volume. Of course, these costs reflect the abilities of crews and effectiveness of supervision as much as they do the performance of specific machines.

The productivity and costs of various cable yarders have to be balanced against their performance in meeting their original objective — reducing site disturbance compared to tractor logging in steep ground. Smith (1976) showed that soil disturbance following high lead operations was significantly less than that associated with tractor skidding. However, grapple yarding produced more soil disturbance than ordinary high lead, because of the need for back-spar roads. Performance trade-offs will have to be made, which take account of operating requirements and the sensitivity to damage of specific forest sites.

iv) Recent experience and modifications

Representatives of each firm co-operating in the study took part in a seminar in May 1976, to compare operating experience and system modifications to that time. The main points are summarized below, by cases.

COMPANY A.

The greatest problem continued to be lack of suitable space for log landings on steep hillsides. There is need for a swing-boom machine that can land logs on the road. The Ecologger winch has been repaired since the study was done, and the machine is working better. Mechanical availability remains satisfactory.

The tower fell once during winter yarding when a guyline pulled off a notched, frozen stump. A fifth guyline has since been added for greater stability and safety. Another drum for a skyline would be useful, as would more line capacity. They now carry 800 ft (244 m) of ¾-inch (190 mm) mainline and 2000 ft (610 m) of ½-inch (127 mm) haulback. The machine has sufficient power — more power would require bigger lines and probably would lead to more frequent pulling of tail-hold stumps.

The contractor has been able to operate almost all year, with only a short shutdown for maintenance in the spring. Fire hazard during the dry season has not been a problem, although care is taken to keep running lines from rubbing on logs or stumps.

Work has continued with good production through the winter on steep slopes to snow depth of 4 ft (1.2 m), and temperature of -20 °F (-29 °C). Fallers, shovelling around trees to reduce stump heights, keep a maximum of 2 days ahead of the yarding crew. An extra chokerman on the crew in winter proved worthwhile. Shovelling was tried to retrieve felled trees from under the snow, but this was slow and hazardous for the yarding crew who could not see how the logs lay. In spring, trees were frequently frozen into the snow in the morning and difficult to move. An advantage in winter yarding has been the near elimination of hangups. In both winter and summer, trees were felled directly downhill to facilitate yarding. Felling across the slope to minimize log breakage was the main cause of the high incidence of hangups during the FERIC study.

Downhill yarding has worked well, although yarding road changes are more frequent because the squirrel block cannot be used. In winter, downhill yarding can sometimes cause other logs to slide, so positioning the machine for crew safety is important.

COMPANY B.

Improved planning was seen as a key factor in working with cable systems, so new maps with 25-ft (7.6 m) contour interval, and scale 400 ft to the inch (1:4800) are being prepared for operating areas. Continuing problems included turnover of trained crewmen, lack of adequate landing space, the difficulty of moving the spars and getting loaded trucks past the landings on main haul roads, and the short snow-free season (mid-June to mid-December). The large proportion of cull volume (80 cunits per acre (560 m³/ha) gross, 38-45 cunits per acre (265-315 m³/ha) net, on the average) contributed to high costs. The company is considering converting a small loader for short-distance yarding (maximum 250 ft; 76 m).

COMPANY C.

The older Madill towers have operated 6 months each year, with steady, experienced crews. The machines seem most suitable for steep, bouldery conditions where trees are relatively big. The large towers are difficult to move, and one will likely be replaced with a smaller, swing-boom machine.

The main problem on the Mini-Spar has been developing and keeping a crew. Different crew arrangements have been tried (e.g., labour contract; company crew; experienced coastal loggers). The current results of training young local people under a Canada Manpower grant appear the most promising.

The Euclid tractor undercarriage has been subject to breakdowns; newer, tank-mounted models should be much better. The three guylines seemed insufficient, and at least one more is required. Frequently the skyline was used as an extra guyline. Recently, the skyline and carriage with a grapple and mobile tailhold machine have been used with encouraging results. A 3-week thinning trial was also reasonably successful; in future, thinning could help to extend the logging season. Further attempts at logging in the snow are planned, and the the company expects to increase the proportion of cable logging in the future.

COMPANY D.

There have been no major mechanical problems with the Washington 078 grapple yarder, other than first year start-up difficulties, particularly with the air controls. Small, portable ramps have been made to go under the tracks to level the machine. This decreases strain on the swing mechanism. The need to change guyline stumps each time the machine is moved led to a serious loss of effective yarding time. Truck roads are still mainly located with tractor skidding in mind, but improved topographic mapping and layout for grapple yarding are planned. Road location is important if logs are to be decked along the road. Logs that escape downhill have been retrieved using a tagline on the hydraulic loader. The company has numerous areas (including swampy sites) that are suitable for the machine, and expected to be able to operate 8½ to 9 months per year. The two trained operators were performing well.

Felling across the slope has been most successful, because logs are then properly oriented to the grapple. Maximum skidding distance of 500 ft (150 m), with adequate provision for deflection, has reduced the need to use chokers. The mobile back spar allows for mounting the tail block at different heights (14, 16, or 18 ft (4.3, 4.9, 5.5 m)) — it is mounted lower if clearance is adequate.

Grapple yarding in winter has been a problem: logs and stumps could not be located in the snow, and clearance for the grapple was reduced by the amount of the snow depth. However, if logs were on the surface of the snow (e.g., in spring) their visibility to the grapple operator was better than at any other time.

COMPANY E.

The trained GT3 crew has operated year round, including winter yarding in 6 ft (1.8 m) of snow and -20 °F (-29 °C) temperatures. Below -10 °F (-23 °C) there were problems with water condensation and freezing in air lines. Winter felling was usually 2 days ahead of the yarding.

Yarding distance was kept below 450 ft (140 m) because the operator had difficulty grappling the logs at greater distances and production decreased. Initially, bucked logs were yarded, but it was found that chokers had to be set on 20% of the pieces. In tree-length yarding, only 5% of pieces required choking. Uphill yarding was faster than downhill (higher gear and less braking required), but downhill yarding was better for landing logs for re-skidding. The company will experiment with a grapple skidder for swinging logs a maximum of 1000 ft (300 m) to the loading area.

An improvement to the mobile tail-hold machine was a 360° swivel on the tail block, which has cut yarding road change time by 50% by eliminating much of the manoeuvring and backing up required.

COMPANY F.

The main problem has been training and keeping crewmen (28 men passed through the operation in 3 months during the first year), but the situation has improved with the training of local people. The contractor stressed the need to be fully competitive in the labour market.

The Koehring Bantam originally had all mechanical controls, but the swing and live boom have recently been changed to air control. The boom height has been increased by 2 ft (0.6 m), to 30 ft (9.2 m). A third drum (air controlled) has recently been added which can be used as a tagline for loading, or a strawline for yarding. A larger motor (4 cylinder, 120 hp (89 kW)) would be useful together with an automatic transmission, with the main object being to increase line speed, rather than power. A skyline drum would increase the versatility of the machine, and reduce reliance on the two-line running skyline system. A D-8 Caterpillar tractor is being prepared for use as a mobile tail-hold in some situations.

All brake and friction linings on the machine have been changed to the hardest brass-impregnated linings available. This gives longer lining life and still provides enough brake and friction power.

The contractor has experimented with two chokermen on the crew, but found it more efficient with one. He has used up to five chokers to try to increase turn volume, but found that excessive time was lost untangling them.

Snow depth greater than 1 ft (0.3 m) closed the operation because of difficulty finding felled trees, breaking lines, etc. The cost of later clean-up operations to collect trees missed in the snow would be prohibitive.

The machine has also been used as a loader, to extend the logging season.

COMPANY G.

The Mini-Spar has been yarding peeler-quality pine on 50-70% slopes. Rain on the fine-textured soils can create impassable mud conditions, and also contributes to loosening of the guyline stumps and tail-hold stumps. The tower fell once because of a pulled stump. The soil type is also susceptible to erosion, so the use of a mobile tail-hold machine that would require trails is prohibited.

The crew has tried a variety of rigging methods, but the squirrel block used with two sliding chokers was preferred. The machine has had considerable mechanical downtime (cracked tower base; broken strawline drumshaft), but the availability of a nearby conventional skidding operation has minimized lost time for the crew.

By the fall of 1976, planned operations in the area for the Mini-Spar will be completed, and the machine will likely be transferred to another division of the company.

Discussion: Problems of Introducing Cable Logging

Several companies in the B.C. Interior and Alberta operated cable yarders during 1974 and 1975. Unfortunately, no new cable machines were purchased in 1975, due to poor economic conditions in the industry. Foresters in both the companies and the provincial forest services agree that cable logging must be introduced, and that it would be desirable to phase in these machines before all the better ground skidding areas are logged. In spite of this conviction, progress will be slow because many of the basic problems associated with cable logging on steep ground and small timber are unsolved.

i) Costs and Appraisals

A basic problem delaying the introduction of cable logging into the Interior is financial. It costs more to log by any method on steep slopes than on the flatter ground. Additional funds are required to purchase equipment to introduce the new system. During 1975, the value of logs was not high enough to cover these costs. Until market values increase to a point where all costs can be covered above a minimum stumpage, there can be little progress.

Even with buoyant markets it is essential that a fair method is used to appraise costs and in determining stumpage payment to the Crown, so that full co-operation can be encouraged between the forest service and companies. The case study data can help in this regard by giving a general indication of the productivity of cable logging systems currently operating in Interior British Columbia.

ii) Planning

Most Interior cutting areas are planned for ground skidding, and the inaccessible areas are being left for cable logging. This planning method results in inefficient cable logging and requires the construction of extra roads. It is essential for the planner to start with the most difficult parts of the forest and work towards the easier, when planning areas which require a combination of systems. He can then be sure that all of the merchantable timber is accessible, and that roads are located to produce the most efficient logging layout.

Good topographic maps are a valuable aid to planning in mountainous regions. Many of the maps now in use are inadequate and should be improved.

It is desirable that both ground skidding and cable equipment work as many days a year as possible to reduce the fixed cost per hour of equipment, and to encourage crews to specialize and become skilled in one system. Planning logging to achieve maximum utilization is complex because the two systems are affected differently by seasonal changes. The logging planning team must have fundamental knowledge of all the systems to be used. Government departments and industry should encourage their personnel to visit and observe the logging system proposed for their area.

iii) Contractor-Company Relationships

Most cable logging machines operating in the Interior are owned by the larger companies. This is a departure from the usual practice in ground skidding where the logging equipment is owned by contractors. Contractors are available who are interested in cable logging. They should be encouraged to purchase yarding machines, because they can provide the interest and attention that the systems require.

To encourage contractors it is necessary to make two changes in the traditional contractual arrangement with the companies:

1. The seasonal contract must be replaced by a longer-term contract with a guaranteed minimum annual production. This guarantee will enable the contractor to finance his investment.
2. The company must recognize that cable logging costs more than ground skidding, and must make adequate cost allowance in the contract price. Naturally, most logging supervisors are reluctant to pay a higher than average price and are always interested in ways to eliminate high cost portions of their operations. This creates an unstable position for the contractor.

iv) Loading and Trucking

The loading of cable-yarded logs onto trucks is inefficient, and contributes substantially to the high cost of the total operation. Except in unusual topographic conditions, it is impossible to locate a landing where the yarder can pile the logs so they can be directly loaded with a front-end loader. The following alternatives are available:

1. A heel-boom loader stays with the yarder and loads logs as they are yarded. This method is commonly used where logs are large and yarder production is high. Where yarder production is low, loader production is correspondingly low. Normally logs are handled one at a time so that the loading of small logs is slow and trucking efficiency is reduced. Loading is improved when the yarder can pile logs on or along the road, but heel-boom loaders have a limited reach and logs that escape out of the pile are difficult to recover.

2. A skidder pulls logs away from the yarder and swings them to a landing where they can be loaded with a front-end loader. If the skidder takes the logs away as they are yarded, costs are high because the skidder production is limited by the yarder production. If the yarder piles the logs, skidding production can be increased but the skidder will break logs when attempting to get them out of the pile. This method may be preferable to using a heel-boom loader, because the skidder is less expensive and easier to operate than the loader.

3. A long-boom grapple-crane loads logs from yarder piles. This is the system commonly used in the Rocky Mountain area of the United States. These cranes are fast, can load several logs at one time, and can reach 100 ft (30 m) below the level of road. They are expensive, difficult to operate and require a large volume of logs to maintain operating efficiency. Usually one crane will service three or more yarders.

Unfortunately, none of the three alternatives is fully satisfactory; therefore, it is essential that operators, equipment manufacturers and research groups continue to work on this problem. The apparent answer is a substitute for the long-boom crane which would reach above and below the road, would be easy and safe to operate, light enough to travel on steep, narrow roads and inexpensive enough to produce an acceptable operating cost. Several manufacturers of truck-mounted hydraulic cranes are working towards this objective.

v) Yarding machine design for small timber.

None of the machines included in this report was designed to log very small timber. The Koehring Bantam, a modified truck crane, was the only machine operating in small timber: it produced well on short yarding distances. The older Madill spars and the two grapple yarders are versions of coast machines reduced in size to operate in medium sized timber. The Madill Mini-Spar was specifically designed to operate in medium sized timber. The Ecologger operates best in medium sized timber at short yarding distances.

There is a need for a machine which will yard small timber efficiently on steep slopes to a maximum distance of 1,800 ft (600 m). Other systems are available for distances beyond this but the opinion of many foresters is that road spacing should not exceed 3,000 ft (1,000 m) because of the required access for all forest management functions, the safety of the crew and for fire protection.

Small cable machines and systems are being developed in the United States, Scotland, Norway, Austria and Japan, as well as in British Columbia. The U.S. Forest Service's running skyline systems on small interlocked yarders shows good promise for extending yarding distance. Tests are being made in British Columbia of the Igland Jones Mini-Alp from Scotland. This machine appears to have potential for thinning. The Norwegian radio-controlled winches are operating well and have increased the efficiency of their tractor-mounted cable systems. Both the Austrians and Japanese are experimenting with endless-line systems for thinning. In British Columbia, several equipment manufacturers are continuing to develop multi-drum yarders to log small timber on longer yarding distances. FERIC will watch these developments and will report periodically on their progress.

Conclusion

Observations covering more than 500 shifts of cable yarding activity by 8 different machines indicate that these systems are at an early, but promising stage of development. Although mechanical availability was generally high, considerable improvement in utilization and productivity is necessary before cable logging methods become widely accepted in Interior British Columbia. This requires critical examination of machines, systems, supervision and planning.

In addition to helping to develop methods for evaluating cable systems, the study has provided some specific lessons:

1. The proper location of roads, landings and cutting boundaries is important for efficient production. Two study machines were used to clean up logging areas where tractors had failed. Their efficiency would have improved if the settings had been properly located. Cable logging is more expensive than ground skidding, so areas for cable systems must be identified first in the planning to achieve an efficient combination of systems. Efficient planning is not possible in the absence of suitable topographic maps.
2. The total logging system must be considered before introducing cable logging. In some operations, getting logs to the roadside was only part of the problem, because the logs were not piled in a position where a front-end loader could load them onto a truck. This resulted in expensive re-handling or investing in a special loader.
3. Basic training of crews in operating methods and safety is essential, but beyond this, on-the-job experience is a most effective way to train crews. There was noticeable improvement in morale and efficiency as crew confidence increased over the 1974-76 study period.

   Cable logging is not an academic subject and there is little written about how to do it. FERIC proposes to assemble and publish handbooks to fill this need.

   Forest planners and technicians often lack knowledge about cable logging, and steps must be taken to fill this gap. Logging supervisors should encourage planners to visit and observe a wide variety of cable operations.
4. Better use of scheduled working time is obtainable with current systems through

improved supervision, training and scheduling. Yarding road changes, while considered part of productive time, can be shortened by: taking advantage of light-weight lines to reduce the need for using the strawline; having sufficient crew members to handle this relatively heavy work; modifying the yarding system to suit ground conditions.

5. It is unusual for any cable machine to average more than 220 pieces per shift, so piece size is critical. Log bucking policy should attempt to maximize piece size, within the physical limitations of the machine and landing. To reduce costs in small timber it is necessary to choose an inexpensive machine that can operate with a small crew.

6. Year-round employment is essential to encourage skilled, interested workers and contractors who have special cable logging experience. Where it is not possible to log with cable systems all year, there should be provision for alternative employment. A guarantee of regular work would also help contractors to purchase cable yarders.

7. Productivity relationships: The approach in these case studies has been to describe operating conditions, and report the time and production results. Statistical relationships between time, production and variables describing operating conditions were not specifically sought. It is well known that factors such as slope, terrain roughness, brushiness, volume per acre, yarding distance and landing size can affect yarding productivity, but a different approach would be needed to establish these relationships.

   First, better theoretical models of how the systems behave would have to be developed, to effect significant improvement over the weak statistical relationships that are usually detected in cable logging studies. Second, a wider sample would be required in order to observe sufficient range in each factor. As a start, several co-operating companies will begin to accumulate production records and descriptions of each area logged, for analysis (Appendix III).

Many high quality timber stands in Canada are inaccessible to mechanized logging or ground skidding because of excessive slope. None of the study machines provides the final answer for efficiently logging this timber. Further improvement is needed, and developments taking place in other parts of the world should be watched. FERIC and the co-operating companies will continue to seek ways to improve the efficiency of present systems, and to develop new methods to make timber on steep slopes an economic part of the forest resource.

References

1. Adams, T.C. Economic comparison of re-logging and clean logging in mature hemlock. Res. Paper PNW-24, Pacific Northwest Forest and Range Expt. Sta., Forest Service, USDA, Portland. 1965. 20 pp.

2. Anon. Symposium on forest operations in mountainous regions. Technical Report GE 73-26364, Logging Transport Branch, FAO Forestry Department, Norwegian Forest Research Institute, Oslo. 1973. 90 pp.

3. Brandstrom, A.J.F. Analysis of logging costs and operating methods in the Douglas-fir region. Res. Paper, Pacific Northwest Forest and Range Expt. Sta., Forest Service, USDA, Washington, D.C. 1933. 117 pp.

4. Carow, J. Yarding and loading costs for salvaging in old growth Douglas-fir with a mobile highlead yarder. Res. Paper PNW-32, Pacific Northwest Forest and Range Expt. Sta., Forest Service, USDA, Portland. 1959. 26 pp.

5. Dykstra, D.P. Production rates and costs for cable, balloon and helicopter yarding systems in old-growth Douglas-fir. Res. Bull. 18, Forest Research Laboratory, School of Forestry, Oregon State Univ., Corvallis. 1975. iv + 57 pp.

6. Dyrness, C.T. Soil surface condition following tractor and highlead logging in the Oregon Cascades. Jour. of Forestry 63(4): 272-275. 1965.

7. ________. Soil surface conditions following skyline logging. Res. Paper PNW-55, Pacific Northwest Forest and Range Expt. Sta., Forest Service, USDA, Portland. 1967. 8 pp.

8. Green, G., and Henderson, L. Ecologger. Machine Evaluation No. 2, Harvesting Research Group, For. and Timber Bur., C.S.I.R.O., Yarralumla, Australia. 1975. 4 pp.

9. Lisland, T. Cable logging in Norway: a description of equipment and methods in present use. School of Forestry, Oregon State Univ., Corvallis. 1975. vii + 52 pp.

10. Lysons, H.H. Yarding systems capabilities. Skyline Logging Symposium, University of Washington, Seattle. 1974. 11 pp.

11. Maxwell, H.G., and Oswald, D. Cable yarder thinning proves successful in British Columbia. Reprinted from: Can. For. Ind., September 1975. 4 pp.

12. McIntosh, J.A., and Gunn, D.C. Salvage yarding on the B.C. coast. Reprinted from: B.C. Lumberman. Jan. 1959. 4 pp.

13. ________. Pre-logging in a west coast cedar-hemlock stand. Pub. No. 1028, Canada Dept. of Forestry, Ottawa. 1963. 39 pp.

14. Smith, R.B. A survey of soil disturbance, vegetative cover and regeneration on clearcuts in the Nelson Forest District: two year summary. Pacific Forest Research Centre, Victoria. (Unpublished.) 1976. 57 pp.

15. Studier, D.D., and Binkley, W.V. Cable logging systems. Division of Timber Management, Forest Service, USDA, Portland. 1974. 205 pp.

16. ________. Yarding systems operational constraints: physical, environmental, and economical. Skyline Logging Symposium, Univ. of Washington. 1974. 5 pp.

17. Swanston, D.N. Slope stability problems associated with timber harvesting in mountainous regions of the western United States. Tech. Report PNW-21. Pacific Northwest Forest and Range Expt. Sta., Forest Service, USDA, Portland. 1974. 14 pp.

18. ________, and Dyrness, C.T. Impact of clearcutting and road construction on soil erosion by landslides in the western Cascade Range, Oregon. Geology 3(7): 393-396. 1975.

19 Tennas, M.E., Ruth, R.H., and Berntsen, C.M. An analysis of production and costs in highlead yarding. USDA Forest Serv. Res. Paper No. 11, Pacific Northwest Forest and Range Expt. Sta., Portland. 1955. 37 pp.

20. Wellburn, G.V. Alternative methods for logging steep slopes in the Nelson Forest District of British Columbia. Information Report FMR-X-76. Forest Management Inst., Can. For. Serv., Dept. of the Environment, Ottawa. 1975. 57 pp + Appendices.

APPENDIX I:
Definitions and Study Forms

1) Definition of Time Categories

TIME ELEMENT	BEGINS	ENDS
Outhaul	when the chokers have pulled free from the log deck	when the signal to 'Stop Rigging' is given
Hookup	end of outhaul (for grapple yarding, includes time to position on logs)	when the signal to 'Begin Yarding' is given
Inhaul	end of hookup	when the incoming turn reaches the back end of the log deck
Deck	end of inhaul	when the logs have finally come to rest on the deck
Unhook	end of deck	when the chokers have pulled free from the log deck
Road Change	when crewman signals start of road change	at start of outhaul for first turn on the new yarding road
Delay	when a productive function is interrupted	when the productive function is re-commenced

PROJECT 400

FERIC

DETAILED TIMING

PROJ			PH		FN		FID		MN		Setno		Lndno			DA		MO		YR		RD	
01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
4	0	0	0	1	0	2																	

End Time ____________ Page ____ of ____

Start Time ____________ Recorder: ____________

Elapsed Time ____________

C N		T N		Logs	Distance (100 ft.)			1 Out Haul			2 Hookup			3 In Haul			4 Decking			5 Un Hooking			Code	Delays					Ind Code		REMARKS: HB = Haulback ML = Mainline TB = Tailblock BR = Butt Rigging RS = Rigging Slinger H = Hooktender CM = Chokermen
25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	

FERIC

Proj.			Firm		Mac.			Set.		Lnd.		S		Day		Mo.		Year	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

SCALE FORM

Page ___ of ___

Recorder ______

Company ______________

Turn			Log			Top			Butt			Length		
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35

Turn			Log			Top			Butt			Length		
36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

Turn			Log			Top			Butt			Length		
51	52	53	54	55	56	57	58	59	60	61	62	63	64	65

Turn			Log			Top			Butt			Length		
66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

Dec. 15/75

INSTRUCTIONS

I. Please complete one SHIFT REPORT FORM for each shift including short shifts.

Attach the SERVIS RECORDER CHART for the shift to the completed SHIFT REPORT FORM. (Write the **date** and **delays** on the SERVIS RECORDER CHART. Store these charts and reports for later pickup.

II. Steps in filling out SHIFT REPORT FORMS:

1. Complete all Identification items. If windrowing logs, write "ROADSIDE" in the space beside Landing Number ____________.

2. Write in the Number of Persons working in each job category for the shift, and the Man-hours in each job category. (Man-Hours is the same as time submitted for payroll, **excluding** travel time).

3. Check the Yarding System that is in use for more than ½ of the shift.

4. Write in DELAYS (including cause, and duration to the nearest 10 minutes) occurring during the shift.

   Mechanical Delays include repair and service.

   a) Repair — replacing or mending a part which broke or failed.

   b) Service — fueling, lubricating, replacing filters and so on.

   Non-Mechanical Delays include:

   a) Moving — machine travel time between settings, between landings.

   b) Personnel — crew member sick, late, injured which stops operation.

   c) Lost Time — caused by weather, machine stuck, waiting for another machine (such as a loader) and so on.

   Scheduled Machine Operating Time is the period between regular start of shift and regular end of shift. (It does NOT include lunch period).

5. Write the Number of Merchantable Pieces yarded during the shift. If trucks are loaded from active landing during the shift, write in the load slip numbers.

6. Check the boxes that best describe the Operating Conditions for most of the shift.

7. Check or write in the Weather Conditions that best describe the shift. Estimate the Precipitation Duration to the nearest half hour. Estimate the Snow Depth (in an undisturbed, undrifted area) to the **nearest foot** in the current yarding area.

APPENDIX II

Scientific Names of Tree Species

Western white spruce	*Picea glauca* (Moench) Voss
Engelmann spruce	*Picea engelmanni* Parry
Douglas fir	*Pseudotsuga menziesii* (Mirb.)
Lodgepole pine	*Pinus contorta* Dougl. var. *latifolia* Engelm.
Western white pine	*Pinus monticola* Dougl.
Balsam fir	*Abies lasiocarpa* (Hook.) Nutt.
Western larch	*Larix occidentalis* Nutt.
Western red cedar	*Thuja plicata* Donn
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.

APPENDIX III

Sample form showing information required from each identifiable logging area to conduct a continuing analysis of cable logging performance.

LOGGING AREA DATA FORM

Company ______________________________

Area Number ______________________________

Size (acres) ______________________________

Species ______________________________

Volume per acre ______________________________

% defect ______________________________

Piece size (specify tree size or log) ______________________________

Topography — slope % ______________________________

terrain ______________________________

Landings ______________________________

Logging direction uphill or down ______________________________

Yarding distance — average external ______________________________

— maximum ______________________________

Machine days to log area

yarder days ______________ type, crew size ______________

skidder ______________

loader ______________

Felling: man-days to fall area ______________________________