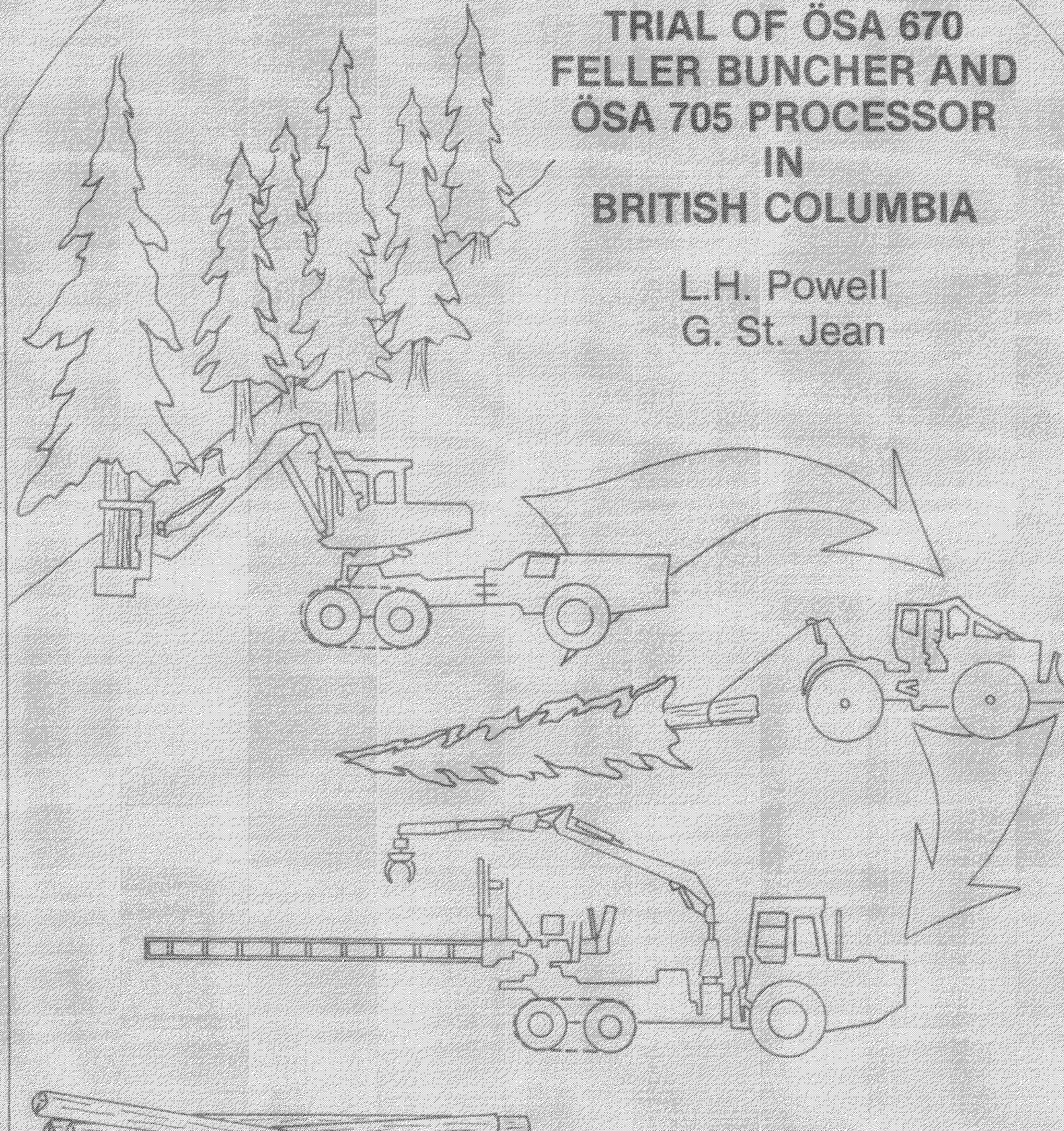
FERIC *FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA*
INSTITUT CANADIEN DE RECHERCHES EN GÉNIE FORESTIER

June 1979 Technical Report TR-31

TRIAL OF ÖSA 670 FELLER BUNCHER AND ÖSA 705 PROCESSOR IN BRITISH COLUMBIA

L.H. Powell
G. St. Jean



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International Log Harvesting Institute Ltd. (ILHIL)

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FOREWORD

The trial of two ÖSA machines was carried out as a cooperative venture in which the International Log Harvesting Institute Ltd. (ILHIL), three forest companies, a firm of consulting engineers, the manufacturer and FERIC participated. This arrangement allowed controlled monitoring over a wide range of conditions without major expenditures by any single member. FERIC was required to monitor the trial and report the findings. Interim reports were presented to the group at its final meeting June 6, 1978.

This report combines the results from FERIC's monitoring of productivity and performance and from ILHIL's report on mechanical aspects of the trial. FERIC gratefully acknowledges the help and cooperation of ILHIL personnel throughout the study, and this group includes the following:

W.R. Higgins (field supervision and record keeping)
C.H. Anderson (machine design, supervision, trial organization).

FERIC is grateful for the help and cooperation of many individuals associated with the following companies cooperating in the study.

C.H. Anderson & Associates, Ltd.
Crestbrook Forest Industries, Ltd.
Illnicki Brothers Logging, Ltd.
Northwood Pulp and Timber Ltd.
Pinette & Therrien Mills, Ltd.

We would also like to thank the following FERIC personnel:

I.B. Hedin
R.K. Krag
M.J. McDonald

and those involved in the field work and analyses.

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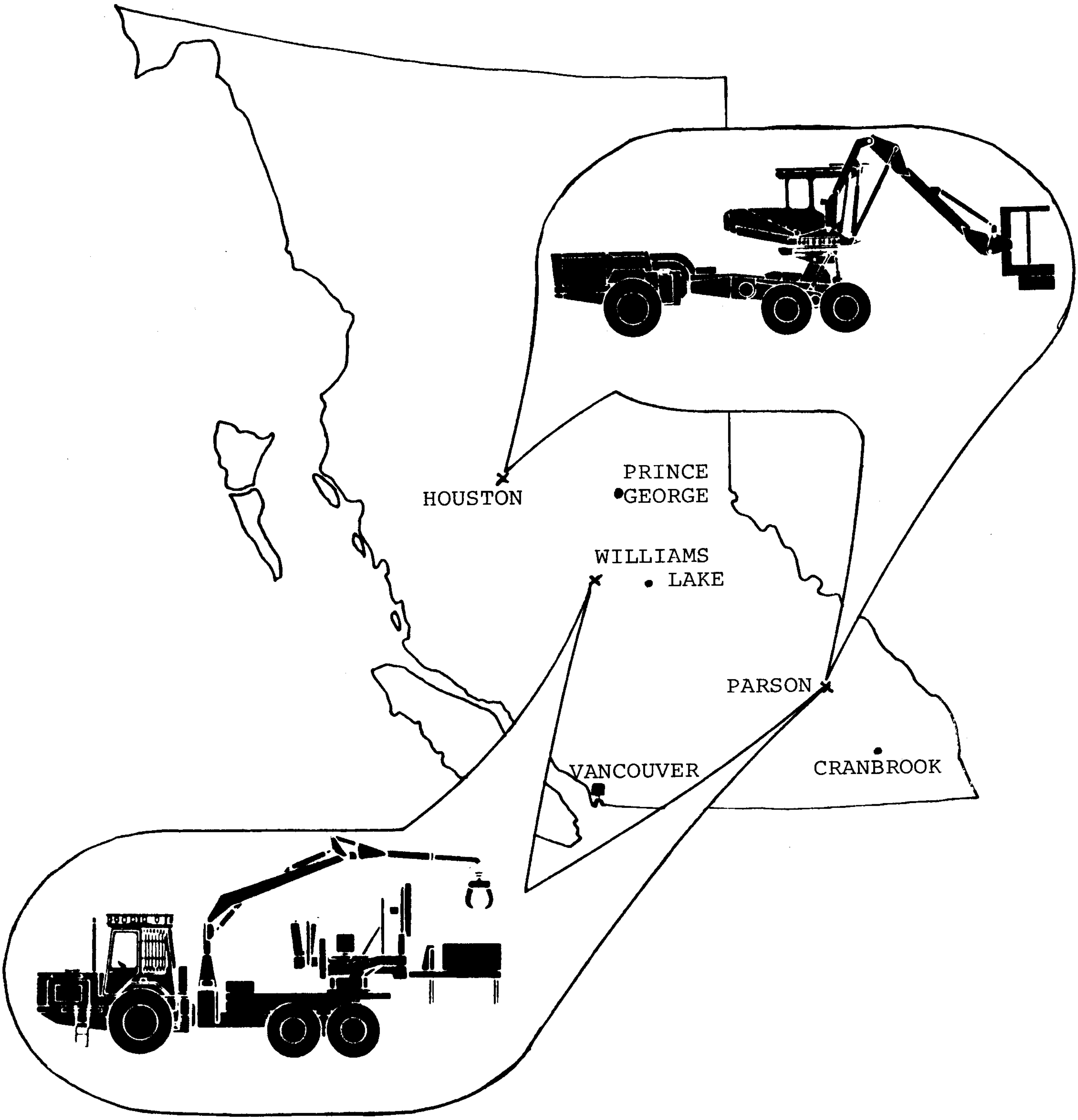

KEY MAP SHOWING LOCATIONS OF TRIAL SITES (x).

ABSTRACT

An ÖSA 670 feller buncher and an ÖSA 705 processor were assessed under various B. C. Interior terrain and operating conditions in a trial arranged by the International Log Harvesting Institute Ltd. (ILHIL). The trial involved three forest companies and a firm of consulting engineers and was monitored by FERIC. It yielded performance data on time, productivity, and mechanical reliability for the two machines as they worked on the three operations. The machines worked together at Parson for the first half of the study and separately at the other two locations during the last half. Productivity results suggest that one feller buncher and one processor complement each other in a system. The feller buncher handled trees up to 28 inches (71 cm) in diameter at the stump and operated on slopes of 45 percent. The processor had been modified to cope with the longer and heavier trees found in B. C. and worked at landings. Timber size affected the productivity of both machines, and although using the chainsaw feller buncher improved log quality and virtually eliminated butt damage, productivity figures suggest that the machine could not operate profitably in small-sized timber. This was also true of the processor; costs appeared too high for the improvement in quality of small logs despite its clean limbing and bucking.

RÉSUMÉ

Le groupe "International Log Harvesting Institute Ltd. (ILHIL)" a procédé à la mise à l'essai de deux engins forestiers, une abatteuse-empileuse ÖSA 670 et une ébrancheuse-tronçonneuse ÖSA 705, sous des conditions variables à l'intérieur de la Colombie-Britannique. Ces essais impliquaient trois compagnies forestières, une firme d'ingénieurs consultants et étaient contrôlés par FERIC. Des données de performance sur le temps, la productivité et la disponibilité mécanique ont été cueillies pour ces deux engins. Les engins fonctionnaient ensemble à Parson durant la première moitié de l'étude et séparément aux deux autres endroits durant la deuxième. Les résultats de la productivité indiquent qu'une abatteuse-empileuse et une ébrancheuse-tronçonneuse se complètent dans un système.

L'abatteuse-empileuse manipulait des arbres dont le diamètre à la souche atteignait jusqu'à 28 pouces (71 cm) et évoluait sur des pentes de 45 pour cent. L'ébrancheuse-tronçonneuse travaillant à la jetée avait été modifiée afin de l'adapter aux arbres plus longs et lourds de la C.-B. La dimension des arbres affectait la productivité des deux engins, et bien que l'utilisation de l'abatteuse-empileuse équippée d'une scie à chaîne améliorait la qualité des billes en élimiant le dommage au pied, les résultats suggèrent que cet engin ne pourrait être utilisé avantageusement avec des arbres de petite dimension. Cela s'applique aussi à l'ébrancheuse-tronçonneuse; malgré un ébranchage et un tronçonnage amélioré les coûts sont trop élevés.

INTRODUCTION

The Interior of British Columbia presents a number of terrain and stand conditions which could be more effectively logged with more versatile felling machines. Current models are usually limited to small stems (stump diameter up to 18 inches (45 cm) and gentle slopes (0% to 25%). In many areas, a felling head capable of handling larger stems (to 28 inches (71 cm)) on an undercarriage able to negotiate obstacles and increased slopes would extend the usefulness of a felling machine and reduce the need for hand fallers.

The ÖSA 670 feller buncher was designed for steeper slopes and larger trees. In addition, since it cuts with a chain-saw head rather than a tree shear, the butt shatter to saw-logs associated with shears can be reduced (Sondell 1975).

Full trees skidded to the roadside can be delimbed and bucked to log lengths manually by chainsaw, but another machine, the ÖSA 705 tree processor, has performed this function successfully in Sweden. Both machines were tested on operations in Eastern Canada during 1976 and 1977 (Skory 1977, Armstrong 1977), and are still running on a production basis in Ontario. From July 1977 to March 1978, these two machines were used in a trial to measure their success if used in British Columbia (Anon. 1978, Overend 1978).

The International Log Harvesting Institute Ltd. (ILHIL) was responsible for organizing the trial through negotiations with the Swedish manufacturer, Östbergs Fabriks AB of Alfta, Sweden, a firm of consulting engineers, C. H. Anderson & Associates Ltd., and three cooperating companies in British Columbia: Crestbrook Forest Industries Ltd., Cranbrook; Northwood Pulp and Timber Ltd., Prince George; and Pinette and Therrien Mills Ltd., Williams Lake. The group shared the expense of importing machines, modifying them for B. C., and supervising the trial. The three company operations represented a wide variety of conditions for the study.

The trial had three major objectives: to evaluate the machines under different terrain and stand conditions in British Columbia; to determine the mechanical performance, productivity and costs; and to evaluate the ÖSA system and the interactions of the two machines working as a unit. FERIC was asked to monitor and report on the results of the trial.

C. H. Anderson & Associates Ltd. modified the two machines before shipping them to the woods. The feller buncher needed extra window guards to comply with Workers' Compensation Board Regulations and it also required local supplies of saw bars and chains.

The processor required two major alterations. The outfeed tray was lengthened to increase the measured length capability from 33 feet to 85 feet (10 m to 26 m). An electronic relay box was added for length-measuring control. Kickers were included on the outfeed tray for log sorting and required hydraulic cylinders to be mated with the existing system. The standard topping knife on the machine was limited to diameters of 5 inches (12.7 cm) and produced severe top shatter. It was replaced later by a topping device that could handle 14 inches (35.6 cm) and trim larger broken tops.

This report describes the performance of these two machines after modifications.

TECHNICAL DESCRIPTIONS OF MACHINES

670 Feller Buncher

The ÖSA 670 is a Feller Buncher that can readily fell and bunch trees up to 22 inches (56 cm) in diameter (see Figure A). It is optionally available with a 28-inch (71-cm) diameter opening and saw. The felling head is of light construction (approximately 2300 lb (1 043 kg)) and uses standard .404-in. chain and bar for tree cutting (see Figure B). This light construction is possible because of the levelling capability of the unit, parallelogram motion of the boom, and a special system to prevent bar jamming.

The undercarriage is an articulated-frame chassis with 6-wheel rubber-tired, tandem bogie drive. The bogies are equipped with tracks and are mounted on pendulum arms, assisting the machinery-deck levelling and terrain capability. Front tires require chains at all times for mud, snow or climbing in steep ground. This carrier will climb over large rocks, stumps and windfalls, and can work up slopes of 45% and down slopes of 60%.

The cab is mounted on a tilting platform that can be levelled automatically to a maximum of ±30% laterally and ±35% fore-and-aft (see Figure C).

The main hydraulic oil supply is used as felling chain lubricant. Usage is approximately two gallons (9 litres) per day. An electric pump is mounted as standard equipment to refill the hydraulic tank from a reserve tank, or in turn from oil barrels to the reserve tank when the reserve tank is low.

All assemblies of this machine were developed around the concept that chainsaw felling was practical and higher terrain capability was possible. The felling head is a case in point. Automated levelling for steep slopes and rough terrain is provided so that the machinery deck is always level when cutting. This removes stress from the boom and felling head. It also allows for lighter construction and higher capacities, (up to 28 in. (71 cm)).

More detailed manufacturer's specifications are presented in Appendix I.

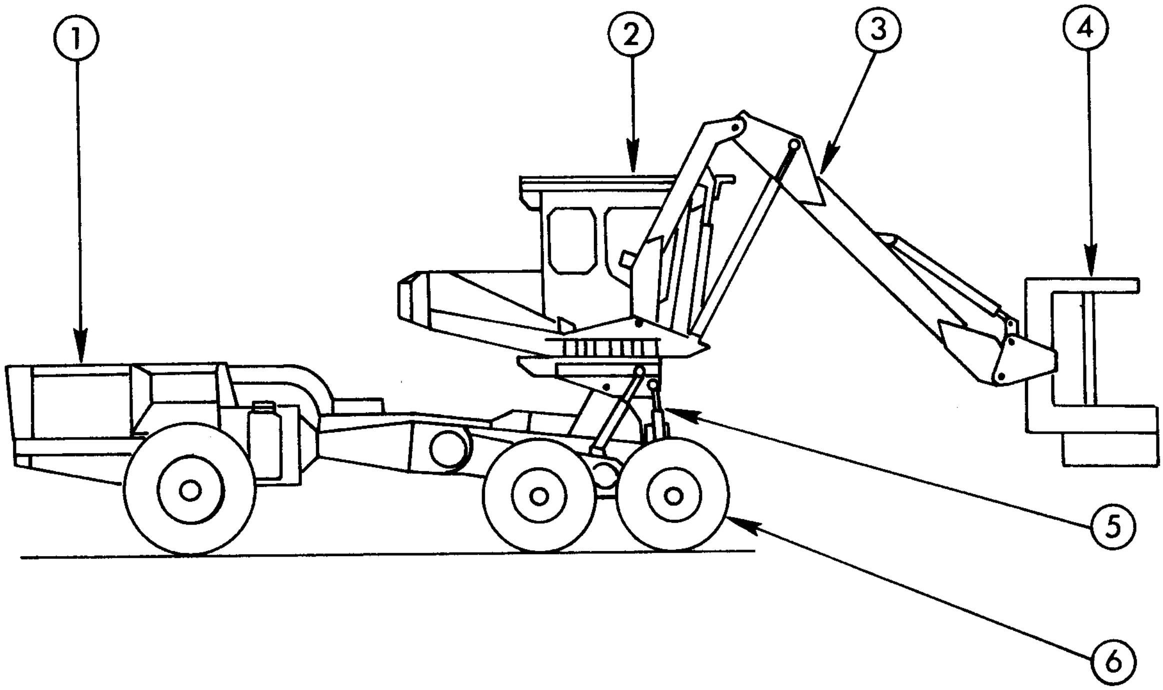

Figure A. ÖSA 670 Feller Buncher. The main components of the machine are (1) 163-hp (120-kW) 6-cylinder Scania D8 diesel engine; (2) fully-enclosed all-weather cab; (3) parallel-steered knuckle-boom crane; (4) chainsaw felling head; (5) hydraulically-operated pendulum arms for levelling cab and boom platform; (6) tandem bogie drive (tracks not illustrated).

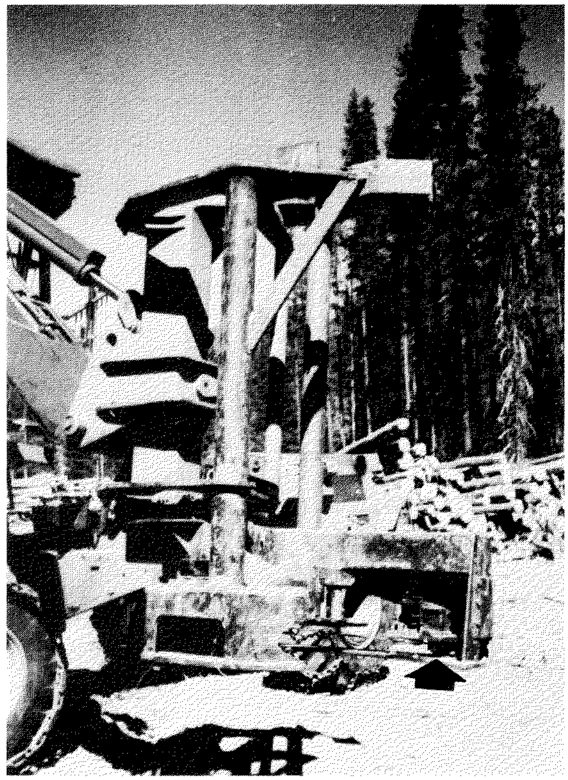

Figure B. Closeup view of felling head. Arrow indicates chainsaw motor and pivot point.

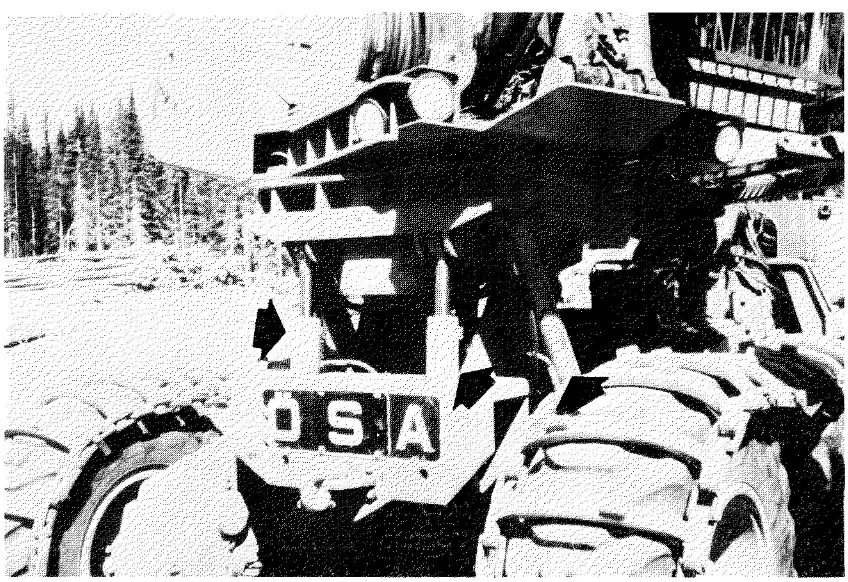

Figure C. Closeup view of turntable levelling system. Arrows indicate hydraulic cylinders used to achieve levelling of cab and turntable up to 30%.

705/260 Processor

The 705 Processor is mounted on the basic machine: the ÖSA 260 forwarder chassis (Figure D). The forwarder chassis is a rubber-tired, tandem bogie drive undercarriage, similar to that of the feller buncher.

The loading mechanism is a knuckle-boom crane with a reach of 25 feet (7.6 m). It has the capacity to lift the butt of a tree 28 inches (71 cm) in diameter and load the tree in the processor.

The feed rollers have cup-shaped teeth which give minimal slip and a length accuracy of ±3 inches (7.6 cm) in 25 feet (7.6 m) or ±5 inches (12.7 cm) in 50 feet (15.2 m).

The delimbing knife-belts cover 95% of the tree's circumference. These knives require occasional lubrication (see Figure E).

The slashing saw is a 48-inch (122-cm) circular saw and is used for long butting to remove rot and defects and bucking off the butt logs. It must be kept sharp. A backup of two saws is required at all times. Bent saws must be removed or they will eventually "explode."

The topping saw is a 25-inch (63.5-cm) chainsaw which trims broken logs and tops the trees. A backup of three bars and three chains is required. This saw replaced the original topping shear designed to handle tops up to 5 inches (12.7 cm) in diameter.

A special 30-foot (9.1-m) outfeed tray was designed for handling the longer and heavier trees. It was attached in place of the standard package (see Figure F). This supported the tree while 33- and 41-foot (10.1- and 12.5-m) logs were bucked. The tray was fitted with kickers to separate butt logs to one side and tops to the other. The kickers required hydraulic cylinders mated to the original system. An electronic relay box was added for length-measuring control. More details of the manufacturer's specifications are given in Appendix I.

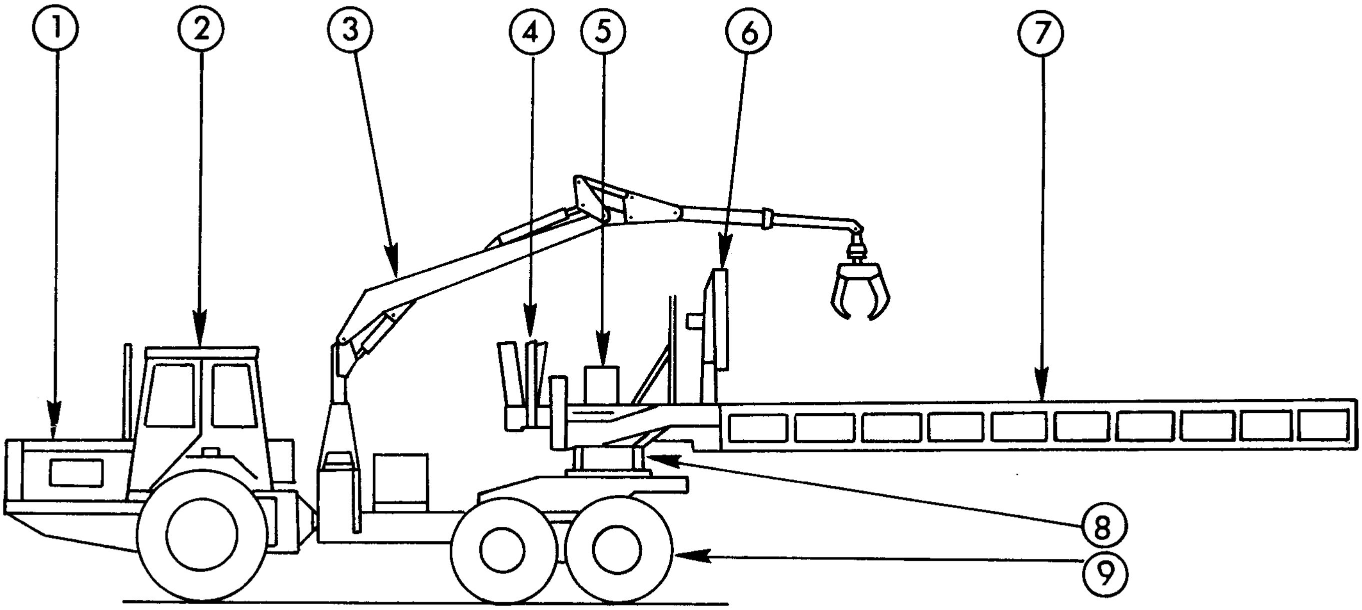

Figure D. ÖSA 705/260 Processor. The main components of the machine are (1) 163-hp (120-kW) 6-cylinder Scania D8 diesel engine; (2) fully-enclosed all-weather cab; (3) ÖSA 399 knuckle-boom loader; (4) wrap-around knife-belt delimber with topping shear; (5) spiked feed rollers; (6) circular-saw slasher unit; (7) 30-foot (9.1-m) outfeed tray with kickers for log sorting; (8) turntable for processing unit with 270° rotation; (9) tandem-bogie drive.

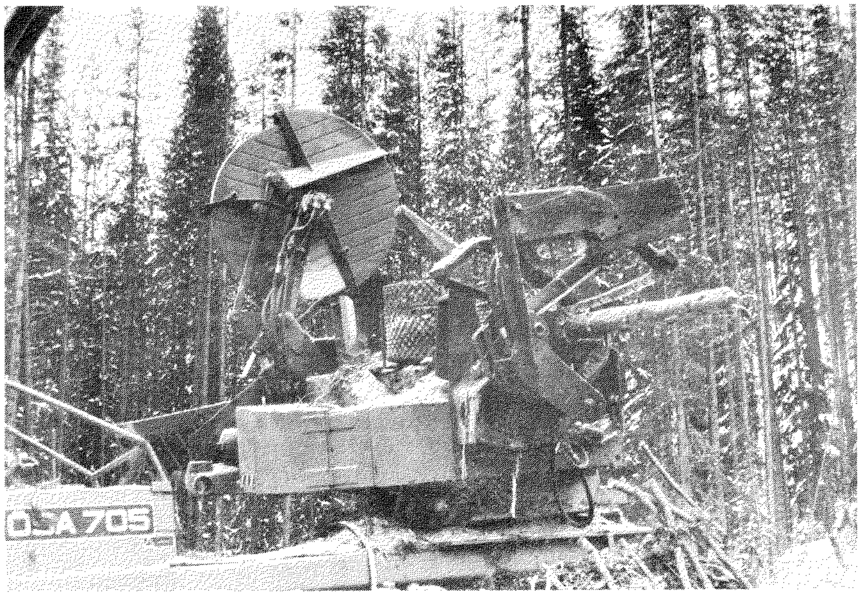

Figure E. ÖSA 705 Processor Unit showing wraparound knife-belt delimber, topping saw, spiked feed rollers and circular slashing saw.

Figure F. Outfeed tray for processor. Arrow indicates rubber flap which activates the log-length measuring device.

STUDY AND APPROACH

ILHIL personnel collected shift level information according to uniform procedures developed by FERIC. Each machine was equipped with a Model DSR Servis Recorder. Daily report forms for each machine were forwarded together with the Servis Recorder chart to FERIC for compilation and analysis.

FERIC carried out detailed timing on both machines at the different locations to measure the effect of stand and terrain conditions on productivity.

ILHIL collected information on mechanical problems and their solutions and was responsible for the day-to-day operation of the machines.

RESULTS AND DISCUSSION

Table 1 describes the stand and terrain characteristics for the trial areas at Parson, Williams Lake and Houston.

Table 1. Description of Trial Areas

	Parson Block 71	Parson Block 73	Williams Lake	Houston
Species composition (in order by volume %)	lodgepole pine alpine fir Engelmann spruce	lodgepole pine Engelmann spruce alpine fir	lodgepole pine	lodgepole pine white spruce alpine fir
Net stand volume cunits/acre m^3/ha	 15 to 50 105 to 350	 25 to 40 175 to 280	 19 131	 60 to 65 420 to 455
Volume per tree ft^3 m^3	 15.0 0.42	 18.7 0.53	 6.9 0.20	 25.0 0.71
Average tree height ft m	 85 26	 75 23	 55 17	 93 29
Range of slopes %	0 to 61+	0 to 50	0 to 10	0 to 15
Terrain type	steep rough terrain, with some flatter benches	sloping terrain with some steep sections	flat and gently rolling terrain	gentle slopes with a few steep sections

ÖSA 670 FELLER BUNCHER

Actual Productivity

Table 2 summarizes the ILHIL shift report information. The feller buncher did not operate at Williams Lake.

Table 2. ÖSA 670 Feller Buncher Time Summary

	Average Hours per Shift				
	Parson Block 73	Parson Block 71	Houston	Total	
					% of SMH
Productive Time	7.8	5.6	3.7	5.0	60.8%
Delays:					
Mechanical--Repair	2.3	3.0	2.2	2.5	29.7%
--Service	0.3	0.1	0.1	0.2	1.8%
Other Non-mechanical	0.1	0.8	0.8	0.6	7.6%
Total Scheduled Machine Hours	10.5	9.5	6.8	8.3	100%
Machine Availability*	75.0	67.5	65.6	68.4	
Machine Utilization*	74.4	59.3	54.6	60.8	
Number of Scheduled Shifts	36	62	102**	200	

*Definitions based on CPPA Standards (Bérard, Dibblee and Horncastle, 1968, "Standard Definitions for Machine Availability and Utilization," W.S.I. No. 2428 (B-1), Can. Pulp Pap. Assoc., Montreal).

**Includes 27 days with a second shift, and 48 days with only one shift.

Table 3 summarizes the production data from the shift reports.

Table 3. ÖSA 670 Feller Buncher Production Summary

Description	Parson		Houston	Complete Trial
	Block 73	Block 71		
Av. piece size, ft^3	18.7	14.6	23.1	19.4
m^3	0.53	0.41	0.65	0.55
Piece count, trees	11596	23944	34455	69995
Volume felled, cunits	2158	3496	7957	13612
m^3	6 112	9 899	22 533	38 544
Number of shifts worked	36	54	87	177
Piece count per 8-hr shift worked*	245	373	466	381
Volume per 8-hr shift worked,* cunits	46	54	108	74
m^3	129	154	305	210
Productivity: trees/PMH	41	67	91	69
cunits/PMH	7.6	10.0	21.0	13.5
m^3/PMH	21.5	28.4	59.5	38.1

*Piece count and volume are pro-rated to an 8-hr shift basis because of the variation in shift length encountered during the trial.

Figure G shows the monthly average productivity over the study period (as trees per PMH). The Canadian operator (3) shows a continued improvement over the study from his start in September to the end of the trial in March. This trend does not allow for the different conditions encountered between Parson and Houston--nor for the addition of a second shift at Houston, where a Swedish trainer was operating the machine.

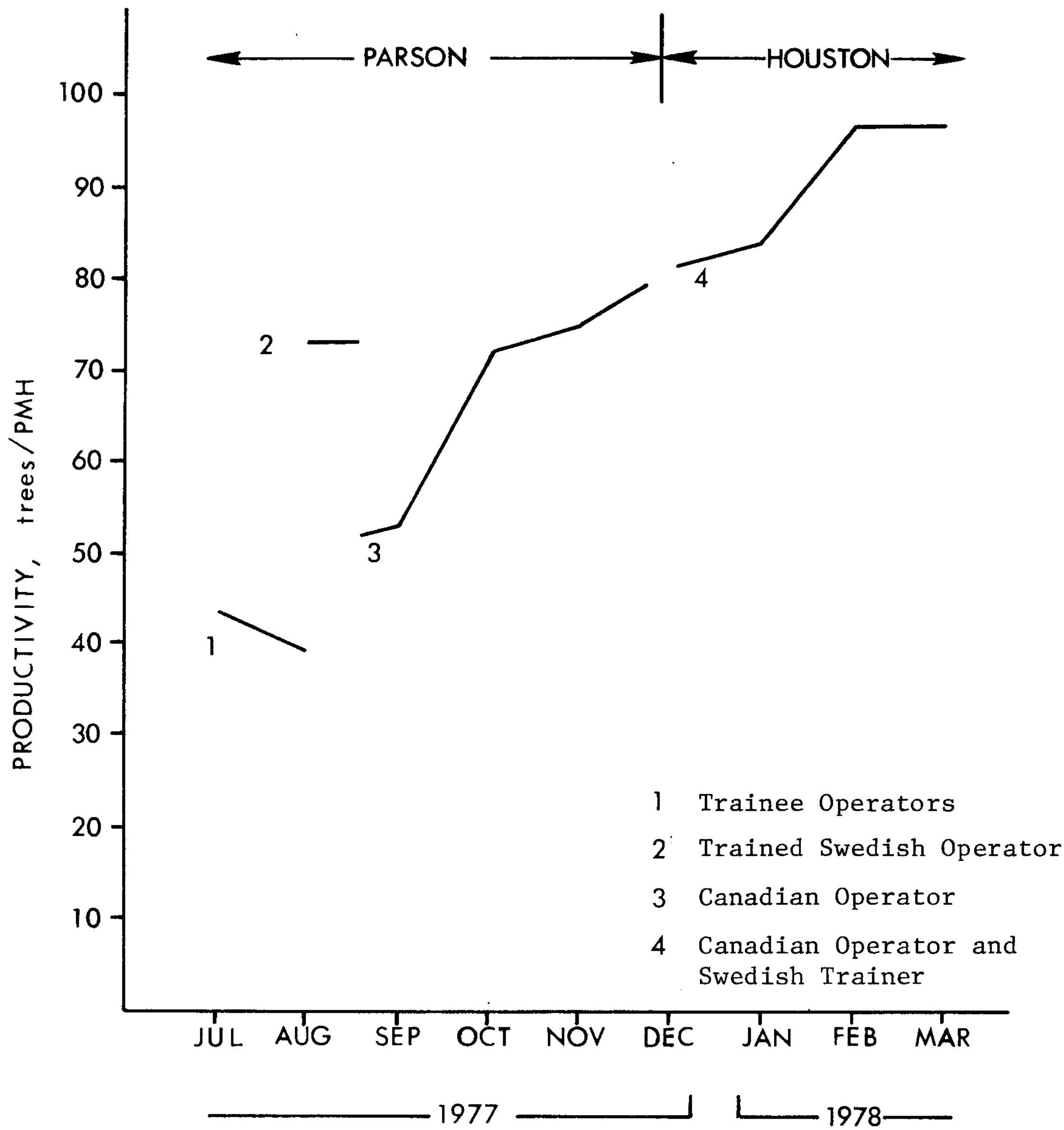

Figure G. ÖSA 670 Feller Buncher. Monthly productivity over study period showing different operators' productivity.

Potential Productivity

Detailed timing results give some indication of the potential of the machine under known conditions.

Table 4 summarizes the detailed timing results, giving times per merchantable tree in minutes. Table 5 summarizes the average condition and operating factors which were measured during the detailed timing.

On the flat terrain found at Houston, potential productivity was 125 and 118 trees per PMH for the Swedish and Canadian operators, respectively. The shift-level productivity averaged 91 trees per PMH for the two operators. Actual productivity reported has achieved about 75 percent of the potential estimated from detailed timing.

On the steeper ground at Parson, potential productivity was estimated at 85 to 87 trees per PMH. Actual productivity for Block 71 averaged 67 trees per PMH, showing that 77 percent of potential productivity had been achieved. A comparison for Block 73 is not made because the average productivity includes the initial period of the study when several trainee operators were working and the productivity was correspondingly low.

Table 4. ÖSA 670. Summary of Times per Merchantable Tree (minutes)

Time Element	Parson CP 73 Swedish Operator		Parson CP 71 Canadian Operator		Houston			
					Canadian Operator		Swedish Operator	
	Mean	%	Mean	%	Mean	%	Mean	%
Moving in the Stand	.12	17	.13	19	.08	16	.07	15
Felling Cycle	.44	62	.34	49	.30	59	.31	65
Brushing Time	.04	6	.06	9	.11	21	.04	8
Delay Time	.11	15	.16	23	.02	4	.06	12
Total Time per Tree	.71	100	.69	100	.51	100	.48	100
Productivity, trees per PMH	84.5		87.0		117.6		125.0	
Sample size, number of trees timed	343		375		170		265	

Table 5. ÖSA 670. Summary of Average Conditions and Operating Factors

Factor	Parson		Houston	
	CP 73 Swedish Operator	CP 71 Canadian Operator	Canadian Operator	Swedish Operator
Number of merchantable trees/acre	490	394	140	123
/hectare	1 211	974	346	304
Number of saplings/acre	275	557	95	88
/hectare	680	1 376	235	217
Number of unmerchantable trees/acre	69	52	15	18
/hectare	170	128	37	44
Volume per tree, ft^3	12.8	26.8	15.4	17.0
m^3	0.36	0.76	0.44	0.48
Slope, % (in direction of travel)	+21	+23	0	0

Data were taken from sample plots used for detailed timing. Note that the volumes do not coincide with stand averages from Table 1.

Mechanical Performance

Table 2 shows that 29.7 percent of scheduled machine hours was spent on repair and 1.8 percent on service. Table 6 shows the downtime attributed to machine components and Table 7 the same downtime related to machine assemblies.

No out-of-shift repairs were reported during the trial although undoubtedly some occurred. Out-of-shift service was reported on only three occasions, and each of these was on unscheduled days. Again there was additional time for such items as sharpening chains, refurbishing chain bars, etc., which was not included, so the reported downtime does not present the total picture of the mechanical support which was required by the feller buncher.

Table 6. ÖSA 670. Summary of Repair Downtime by Machine Component

Component	% of Repair Downtime
Hoses, fittings and filter failures	29
Boom head failures	19
Cylinder failures	15
Engine accessory failures	12
Cab and guard problems	8
Undercarriage failures	6
Boom failures	3
Swing failures	2
Unknown	6
Total	100

Table 7. ÖSA 670. Summary of Repair Downtime by Machine Assembly

Machine Function		Percentage
1. Mechanical	Boom head (bracket)	15
	Boom complete	3
	Swing and swivel	2
	Cab tilt mechanism	-
	Undercarriage	>1
	Engine & accessory (starter)	8
	Cab and guards	3
		33%
2. Hydraulic	Cylinders	15
	Hoses, gaskets	24
	Filters, oil	4
	Change oil pump (accessory)	1
		44%
3. Electrical	Switch, solenoid, wiring	4
		4%
4. Air System	Air tanks, lines	3
		3%
5. Wearable Parts	Replace bars and chains	3
	Replace chain sprockets	>1
	Flat tire, chains	>1
		6%
6. General	Cold start	3
	Fire	>1
	Unknown	6
		10%
Total		100%

A major portion of the repair downtime was related to hydraulic hose, fitting and cylinder failures (Tables 6 and 7). While much of this can be considered normal for a feller buncher, it was evident that additional guarding on some of the more exposed locations would have decreased the repair time. This lack of guarding is attributable to the Swedish conditions (for which the machine was designed) where there is considerably less underbrush and debris on the forest floor.

Two accidents caused major repair downtime. The first was due to operator error in cutting a tree positioned close to the engine. The felling head and boom twisted during felling of a large tree (22 in. (56 cm)) because a hydraulic ram released on the levelling mechanism. The result was a loss of 24 hours for repair. More repair downtime occurred when the machine rolled over while cutting a 20-in. (50-cm) tree which had considerable lean. Lost time for repairs covered 8½ days.

Excluding these two major areas of repair downtime, the figures can be considered as acceptable. It is interesting to note that undercarriage-related repairs account for only 5% of repair time. This indicates that the feller buncher is mounted on a very reliable chassis, well suited to operating in steep terrain.

It must be remembered that this was a trial. The machine's rank in the repair and maintenance priority lineup will be higher when it is rated as a production unit. This would undoubtedly result in lower repair downtime and improved availability.

ILHIL's mechanical report outlined some problems encountered with the feller buncher and recommended solutions to overcome them. These are given in more detail in Appendix II.

General Observations on Feller Buncher Trial

1. The early stages of the trial were hampered by the frequent changes in operators. Six operators worked briefly on the machine during the first two months of the trial at Parson. In succession there were a local operator with Drott shear experience, a Swedish trainer/mechanic/operator provided by ÖSA, three unsuccessful trainees who were not retained, and a New Brunswick operator familiar with the machine who successfully demonstrated its potential, but only for one week. The operator who succeeded the New Brunswick operator was

a local person with no previous feller buncher experience. He continued to operate the 670 for the remainder of the trial at Parson and together with another ÖSA trainer/ mechanic from Sweden, completed the trial at Houston as well. For this last operator, the daily shift reports show a productivity in trees per PMH which improves from 53 in September 1977 to 97 in February 1978. This remains unchanged in March and indicates that the operator had achieved a competent and experienced level of production. The potential productivity indicated by the detailed time study exceeds this level by about 20 percent, and indicates that the machine was producing at an acceptable operational level.

2. Mechanical availability and utilization of the machine did not reach acceptable levels throughout the period of the trial. Periods when availability exceeded 80% were fewer than expected for this machine. These are areas, however, where effective supervision and maintenance facilities could make improvements within a regular operation.

3. The feller buncher performed well and produced trees at a rate of up to 100 trees per hour (PMH). The trial at Parson also proved the machine's capability for operating on slopes of 45%. Production on the steeper slopes was lower but the machine did work on areas where other available feller bunchers could not operate. The levelling mechanism for the felling head and cab showed definite advantages, but there is one potential danger. This occurs especially at night, when the operator in his "level" cab is unaware that the machine itself is approaching a critical position. The terrain capability of the undercarriage was proved. Chainsaw felling left less butt damage in comparison with damage from shear-type feller bunchers.

4. Separation of the two machines for the second part of the trial caused some problems in supervision and mechanical support which affected the results, but these should not occur on a regular operation.

5. The conditions for recording data were not considered ideal from FERIC's standpoint and consequently some information on the support effort required by the

machines is incomplete. In retrospect it seems that the trial of the system should have had better organization and stricter control. This applies to both machine trials and is not meant as criticism of any individual.

Operational Layout

The 670 was expected to operate on steeper terrain than other feller bunchers and careful planning and layout of the cut blocks was important. FERIC conducted pre-logging site inspections of the areas which the 670 would harvest, both at Parson and at Houston. The primary objectives of the pre-logging inspections[1] are as follows:

--to provide a general description of soils, topographic and ecological characteristics of the sites;

--to identify and explain the causes of potentially sensitive sites and/or expected operational problems;

--to assess the effects of the proposed harvesting techniques on the site.

The significant results of these inspections were summarized as the limitations of harvesting equipment and the harvesting impacts.

LIMITATIONS OF THE FELLER BUNCHER FOR HARVESTING

i) The maximum slope it can work is about 40 to 45% cutting up and downhill, and 20 to 25% cutting across the hill.

ii) Its optimum harvesting patterns follow strips twice the reach of the felling boom at right angles to the contours. Each strip could be up to 50 feet (15 m) wide.

iii) Its felling head can accommodate at most a stump diameter of 28 in. (71 cm). For stump diameters between 22 and 28 in. (56 and 71 cm), trees should be directionally felled only.

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[1]The work on pre-logging site inspection forms part of FERIC's project on Interior Logging Site Hazard Rating. This is a study to develop a method for determining the potential damage from using various logging methods to log a particular forest site.

HARVESTING IMPACTS

A. Constraints on Harvesting Efficiency at Parson

A review of the site conditions and machine limitations before cutting suggested the following probable consequences of harvesting. More details of sites are given in Appendix III.

1. Block 73: This block had generally good topography and well-drained, coarse-textured soils. Most of the block, with the exception of minor steep pitches, was well within the capabilities of the feller buncher. Block 73 provided excellent operating conditions.

2. Block 71: This block imposed more serious harvesting constraints due to slope steepness, rough local terrain and poor drainage conditions on some of the gentler benches (Figure H). Fifty-eight percent of the area had slopes of less than 40% and could be harvested by the feller-buncher. The remaining 42% had slopes greater than 40% and would have to be logged by conventional methods, involving the construction of an extensive network of skid roads.

B. Harvesting Impacts on Study Sites at Parson

1. Block 73: The gentle terrain and coarse-textured, well-drained soils of this block provided excellent operating conditions. The soils were relatively non-erodible and slopes were gentle and stable. Impact would be minimal. The block appeared well-suited to mechanised harvesting.

2. Block 71: The need to use conventional logging machinery on steep sections of Block 71 would result in considerable localized soil disturbance. Moderate disturbance could be anticipated from the use of the feller buncher because of the thin litter layers on the block. The steep slopes and generally loose soils created a high potential for soil erosion. Some soil erosion would probably occur, and would be compounded by skid road construction on the steeper slopes.

   The only indication of slope instability in the area was some dry-ravelling on very steep slopes. Skid road

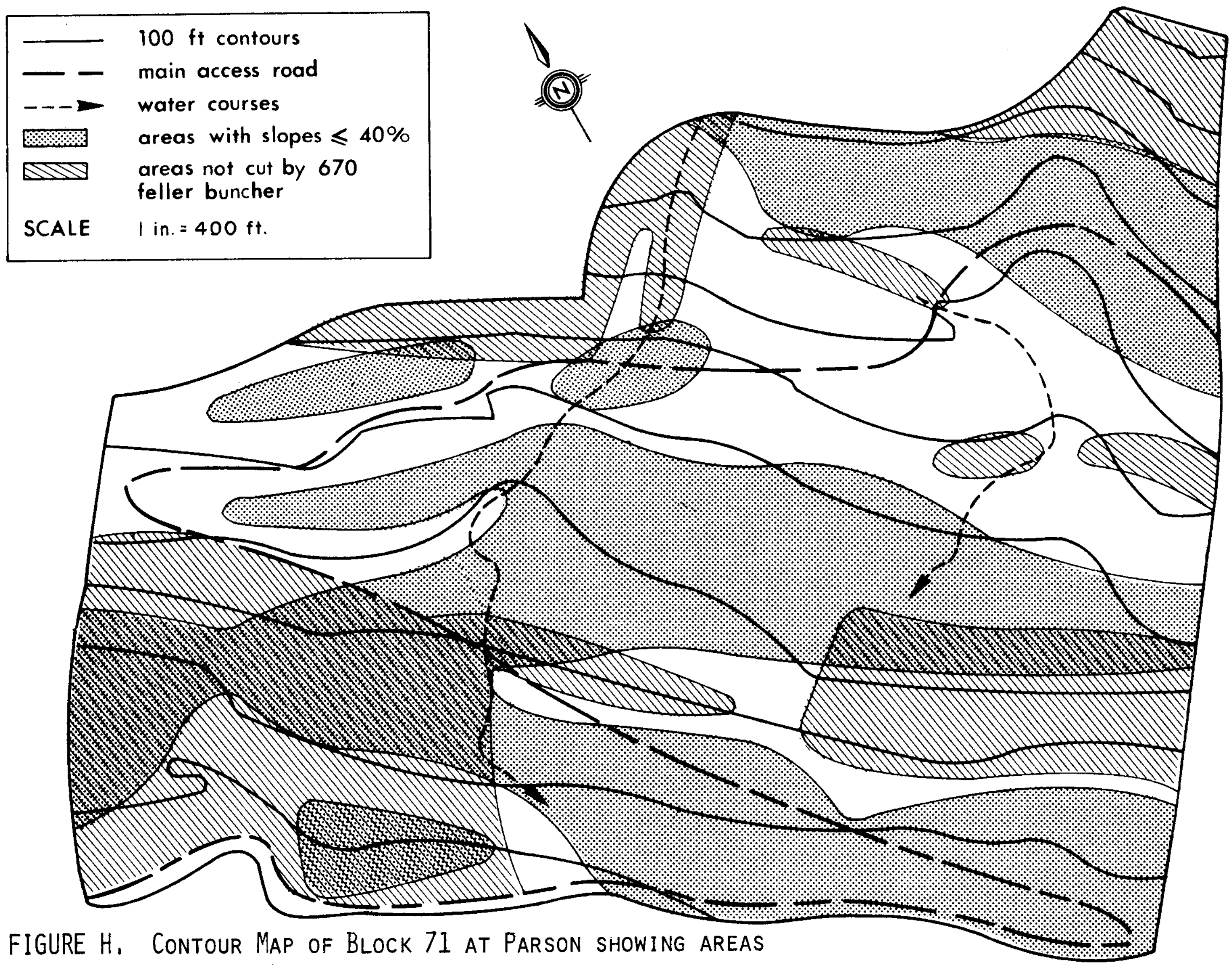


FIGURE H. CONTOUR MAP OF BLOCK 71 AT PARSON SHOWING AREAS (STIPPLED) MOST SUITABLE FOR THE FELLER BUNCHER TO HARVEST AND AREAS (HATCHED) NOT CUT BY THE FELLER BUNCHER.

construction was considered unlikely to alter the general stability significantly. Haul road construction, however, might have a significant effect. There was already evidence of instability on the main road at lower elevations--the result of some large cuts and fills, and the presence of deeper, finer-textured soils. Some problems were anticipated.

i) There would be slumping of cut banks in the fine-textured, deep soils (already evident);

ii) There would be failures of some large fills on steep slopes (tension cracks are evident on the road surface in several areas);

iii) There would be continual dry-ravelling and sloughing of cut bank materials in the shallower, coarser soils. If roads are not maintained, sloughing and slumping would eventually block ditches and culverts.

C. Post-Logging Inspection at Parson

Inspection of Block 73 for slope limitations revealed no problem areas for the feller buncher. Post-logging showed that a few trees (too big for the felling head) had been cut manually with power saws. The area had already been scarified at the time of post-logging inspection.

Post-logging inspection in Block 71 could not identify the area which had in fact been cut by the feller buncher. Residual timber was at that time being felled manually and skidded with small tracked skidders. The volume harvested by the feller buncher suggests that almost half the block was cut. Harvesting impact was not considered worse than from conventional hand falling and ground skidding. Surface scuffing of the organic layer was noted throughout the feller buncher areas, but was not considered to be detrimental.

D. Pre-Logging Inspection of Harvesting Impacts on Study Site at Houston

The block looked favourable for the test. The timber was a mixture of spruce, balsam and pine, averaging about 60 to 65 cunits per acre (420 to 455 m^3 per hectare). The pine was about 8 to 10 inches (20 to 25 cm) at the stump, and the spruce and balsam were 16 to 18 inches (41 to 46 cm). Overall average was about 4 trees per cunit (1.4 per m^3). A few trees were larger than 28 inches (71 cm) and would have to be felled by hand. The stand was also much taller than at Parson, with heights averaging 93 feet (29 m).

The topography here was favourable compared to Block 71 at Parson. Slopes ranged from 0% to 15%. A couple of pitches were about 30%, but these were very short.

The site was rather wet. Northwood Pulp & Timber hoped that the area would freeze before the snow fell, but heavier-than-normal snowfall and mild temperatures delayed freeze-up. The block already had 15 to 18 inches (38 to 46 cm) of snow on it in early November. Winter snowpacks commonly reach 6 or 7 feet (1.8 to 2.1 m).

Inspection of the block indicated that the feller buncher would be able to operate throughout the whole area with no problems arising from topography or site moisture if harvesting were carried out in winter.

No adverse environmental effects were anticipated from mechanical felling on this area of low relief, and none were noted later during winter cutting.

ÖSA 705 PROCESSOR

ACTUAL PRODUCTIVITY

Modifications to the processor took longer than planned and the start of the processor trial was delayed until early September. The feller buncher worked for almost 2 months before the processor started, and consequently not all the feller buncher production was processed by the ÖSA 705.

Table 8 summarizes the ILHIL shift report results for the trial. Production information for the same period is summarized in Table 9. The processor was not tried at Houston.

Table 8. ÖSA 705 Processor. Time Summary

	Average Hours per Shift			
	Parson Block 71	Williams Lake	Complete Trial	% of SMH
Productive time	5.0	4.4	4.8	59
Delays: Mechanical--Repair / --Service	1.5	2.1 / 0.3	1.8	23
Other Non-mechanical	1.9	0.7	1.5	18
Total Scheduled Machine Hours	8.4	7.5	8.1	100
Machine Availability	81.5	69.0	77.1	
Machine Utilization	59.1	59.0	59.0	
Number of Scheduled Shifts	63	38	101	

Table 9. ÖSA 705 Processor. Production Summary

Description	Parson Block 71	Williams Lake	Total Study
Average piece size, ft^3	26.8	8.3	19.2
m^3	0.76	0.24	0.54
Piece count, trees	25350	17755	43105
Volume processed,			
cunits	6794	1480	8273
m^3	19 238	4 190	23 428
Number of shifts worked	59	35	94
Piece count per 8-hr shift worked*	410	541	453
Volume per 8-hr shift			
worked* - cunits	110	45	87
- m^3	310	128	246
Productivity:			
trees/PMH	81	105	90
cunits/PMH	21.8	8.8	17.2
m^3/PMH	61.7	24.9	48.8

*Piece count and volume are pro-rated to an 8-hr shift basis because of the variation in shift length encountered during the trial.

Note: Comparison of volume per shift and volume per PMH indicates the level of machine utilization and reflects the effect of both mechanical and non-mechanical delays.

During most of the trial the processor was run by a Swedish operator supplied by ÖSA. Later in the trial a Canadian operator was trained and worked the machine at Parson and also at Williams Lake.

At Parson, the processor worked at landings supplied with wood by up to 5 skidders. The organization of the landing was not optimal for the processor and congestion occurred frequently. The amount of waiting time shown as other non-mechanical delays in Table 8 indicates that for 22% of the total hours the processor was available to work, but did not in fact process any trees. Most of this waiting time is unexplained in the records, and the remainder is attributed to a scarcity of skidders. The loader and trucks also contributed to landing congestion. These often worked close to the processor and limited processing until loading had finished.

During the second phase of the trial at Williams Lake, the processor worked on a contractor operation and replaced a flail delimber and manual topping.

The period of the trial was shortened because of machine breakdowns and problems maintaining an adequate supply of trees to be processed. The machine worked for a total of only 38 shifts in 26 days. Machine availability and utilization declined over this period, and so did productivity. The machine processed trees at a rate similar to the potential of 2 trees per minute (as indicated by the detailed time studies made at Parson). The volume produced, however, was not sufficient to make the processor viable. Because of the small tree size, production was equivalent to one truckload per hour and advantages in wood quality over hand-bucked and flail-limbed trees did not appear to justify the processor costs. (More details of the wood quality are presented later in a separate section.)

Potential Productivity

The processor is able to load trees into the processing unit for limbing, bucking and topping. Detailed timing was recorded for the loading and processing phases of the processor's operation at Parson to determine which phase limited the machine's productivity. Table 10 summarizes the results for the loading phase and Table 11 the results for the processing phase.

Table 10. ÖSA 705 Processor. Summary of Detailed Timing--Loading Cycle (Block 71, Parson)

Loading Cycle	Average Time, min	%	Range
Load	.20	39	.07 - .55
Move	.01	2	0 - .76
Wait for Processor	.15	29	0 - .83
Delays	.16	30	0 - 8.60
Loading Cycle	.52	100	.23 - 1.12

Average tree size = 19.1 ft^3 (= 10.9 in., minimum butt dia.)
= 0.54 m^3 (= 28 cm)

Productivity = 114.9 trees/PMH
= 21.95 cunits/PMH (= 62.16 m^3/PMH)

Tree branchiness* = Class 1 - 98% of trees
= Class 2 - 1%
= Class 3 - 1%

Sample size = 238 trees

*Tree branchiness is defined as follows (Bennett, 1970):
Class 1: 0- 33% of stem bearing live branches
Class 2: 34- 66% of stem bearing live branches
Class 3: 67-100% of stem bearing live branches

Tables 10 and 11 show that the loading cycle used more time waiting for the processing to complete the previous tree (.15 min) than the processing cycle uses waiting for trees (.06 min).

The processing cycle is the limiting factor in machine production for areas with timber similar to that found in Block 71. The slight difference in total times for the two cycles (0.52 and 0.54 minutes per tree) is due to differences in the samples observed. There was also a difference in average tree size between the two samples and this influenced the productivity in cunits (m^3) per productive machine hour. The machine's potential was found to be very close to 2 trees per minute.

Table 11. ÖSA 705 Processor. Summary of Detailed Timing--Processing Cycle (Block 71, Parson)

Processing Cycle	Average Time, min	%	Range
Processing	.37	69	.16 - .91
Moving	.01	1	0 - .49
Wait for tree	.06	11	0 - .45
Delays	.10	19	0 - 3.07
Processing Cycle	.54	100	.26 - 1.17

Average tree size = 16.6 ft^3 (= 10.2 in. minimum butt dia.)
= 0.47 m^3 (= 26 cm)

Productivity = 111.5 trees/PMH
= 18.5 cunits/PMH (= 52.39 m^3/PMH)

Tree branchiness* = Class 1 - 92% of trees
= Class 2 - 6%
= Class 3 - 2%

Sample size = 263 trees

*Tree branchiness is defined as follows (Bennett, 1970):
Class 1: 0- 33% of stem bearing live branches
Class 2: 34- 66% of stem bearing live branches
Class 3: 67-100% of stem bearing live branches

Actual productivity shown by the shift level information indicates 81 trees per PMH for Parson and 105 trees per PMH for Williams Lake. These figures suggest that the potential of the machine's productivity was not fully achieved until late in the trial. Normally this could be anticipated when an operator is gaining experience. Most of the time the processor was worked by the Swedish operator, who was also a trainer/mechanic supplied by ÖSA.

Mechanical Performance

Table 8 shows that 23 percent of scheduled machine hours was spent on repair and service. The repair and service hours are not shown separately because of the initial problems of shift level reporting.

This total downtime was broken down as follows:

processor failures	42%
new outfeed tray problems	38%
new topping saw problems	19%
260 carrier failure (flat tire)	1%

A further breakdown of the same total downtime by machine assemblies is given in Table 12.

Table 12. ÖSA 705 Processor. Summary of Repair and Service Downtime by Machine Assembly

Function			% of Repair Downtime	
1.	Mechanical	Boom	2	
		Delimbing arms (new saw)	11	
		Circular saw (change)	6	
		Engine & accessory	1	
		Anvil and chain	3	
		New outfeed tray	19	
				42%
2.	Hydraulics	Valves	2	
		Cylinders (processor, boom)	3	
		Hoses, fittings (processor)	20	
		New outfeed tray	3	
		New top saw	3	
				31%
3.	Electrical	Processor	6	
		New outfeed tray	16	
		New top saw	3	
		New measuring device	1	
				26%
4.	Undercarriage	Flat tire	1	
				1%
	TOTAL			100%

Table 12 shows that a major portion of the downtime is related to hose and fitting failures in the hydraulics. This problem was also noted for the feller buncher. The new outfeed tray was the source of much downtime, particularly the kicker mechanism used to sort logs. As this outfeed tray was a modification for B. C. logging conditions, it can be expected that further refinements will be necessary. Some recommendations were made after the trial finished. These suggest two major changes:

--the outfeed tray should come in optional lengths of 20, 30 and 45 feet (6, 9 and 14 m).

--there should be no sorting function, and the tray should only provide support until the log is discharged.

Sorting of the butt logs and random-length top logs was originally considered to be a prime advantage of the processor, as is the sorting of sawlogs and pulpwood by the standard version of the machine. The planned sorting did not occur with the landing arrangements used however, and the idea became less practical as the trial concluded.

The undercarriage for the processor experienced minimal downtime. This again demonstrates the excellence of the carrier used for both machines.

Appendix II gives more details from ILHIL's mechanical report on the problems and recommended solutions.

General Observations on Processor Trial

1. The 705 Processor with the long outfeed tray-attachment and topping-saw works well in a fixed landing with relatively flat ground and space for the buffer storage of processed and unprocessed trees. The outfeed configuration limits access to unprocessed trees to one direction only, however. Trees must be decked, in-field or at the landing, to reduce the processor moving time. Processing in-field is limited to slopes under 20% because the long outfeed tray becomes unwieldy when slopes are steeper.

2. The Processor was run by an experienced Swedish operator/trainer for most of the trial. It was disappointing to see the trials end without a fully-trained Canadian operator or mechanic available for future

applications of the machine in B. C. Operator problems (like those which affected the start of the feller buncher trial) did not occur.

3. There were organizational problems during both parts of the trial which influenced the results. These included operational layouts (see Figures I and J) and conflicts in judgment between people involved in the logging areas. Such problems are always a hindrance to this type of trial.

4. The wood decked in the first area at Parson (Block 73) was manually limbed and bucked and then trucked out before the processor started its trial, leaving no opportunity to see how the processor would perform with a continuous supply of wood.

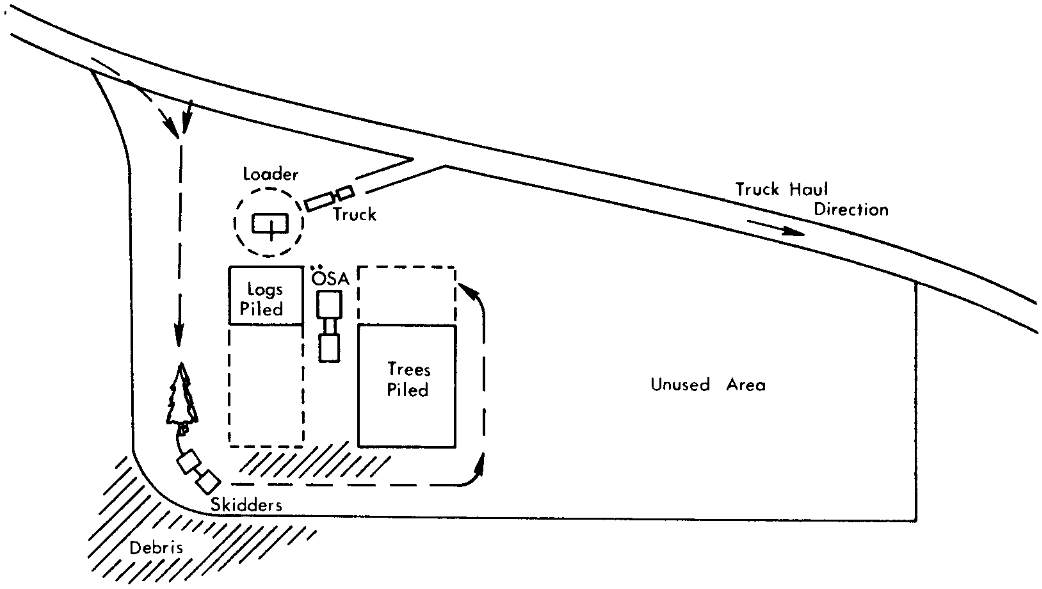
5. There were several minor mechanical problems during the second part of the processor trial. These involved the basic machine and modifications made in Canada. Parts and facilities for repair were not readily available. A major obstacle to a test of the system resulted from the separation of the two machines for the second phase of the trial, with the feller buncher at Houston and the processor at Williams Lake.

6. The processor shows more potential for areas with timber similar to that encountered at Parson. The tree size offsets the limitations of the machine as a single-tree processor. However, better organization of the working area and adequate support facilities must be provided. The processor does not seem to offer the potential required in areas like those encountered at Williams Lake. Production suffers from the smaller tree size and poor tree quality, and advantages to trucking and conversion at the mill are not sufficient to offset the cost of processor-produced wood.

7. The sorting mechanism of the outfeed tray separated the wood into two sorts, but these became intermingled as the machine moved along its path. If the machine is set up to process piles of trees using a single pass, the resulting log piles are neat (Figure K). The processor made multiple passes on the same tree pile under cramped landing arrangements, however, and the logs were jack-strawed in the pile (Figure L). Log

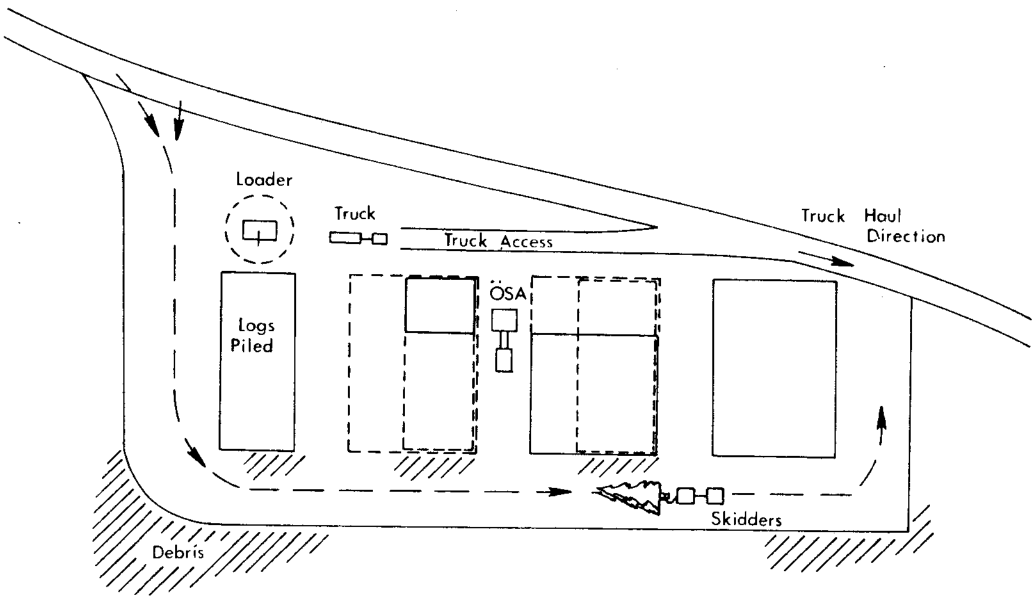
piles of smaller trees at Williams Lake contained up to five different log lengths so that sorting by length was not feasible.

8. The topping saw should become standard in place of a topping knife. (The quality of topping improved after the topping saw was mounted.)



ACTUAL LAYOUT — POOR

Figure I. Layout of Landing at Parson. Layout is considered poor due to crowding of work into a small area with only one pile of trees for processing. Lack of enough road access to the landing limits area of use and causes congestion. This meant that the processor, skidders (as many as 5 at times), the loader and trucks were crowded into the same area, disrupting work and creating safety problems.



PLANNED LAYOUT — GOOD

Figure J. A theoretical landing layout. In this alternative the whole landing area is used. This allows skidders to pile trees, the processor to limb, buck and top trees to produce piles of logs, and the loader to put the logs onto trucks. Each phase of the landing operation can work independently and safely without interruption. Road access here serves the whole landing area and eliminates congestion. A well-planned landing layout is essential for optimal use of the processor. This is especially true on steep terrain. Here landings will be smaller and potential for interference between skidders, processor, loader and trucks will be greater.

Figure K. Pile of processed logs at landing after single pass by processor. Note the excellent limbing quality.

Figure L. Pile of processed logs after multiple passes in a congested landing. Limbing quality is excellent, but butt and top logs are mixed and piling quality is poor.

Effect of Processor Wood on Trucking

Improved log quality for truck hauling was considered as a potential advantage of processor wood over conventionally-processed wood. Log quality was defined in terms of limbing quality, accuracy of length and exclusion of butt defects (i.e., shatter, rot, root flare, etcetera).

Limbing quality was excellent, with no branch stubs left on processor wood. Topping improved greatly after the topping shear was replaced by a chainsaw attachment. Comparison of the precision of log lengths between the processor and conventional hand-bucking showed that 85% to 95% of the logs from the processor were within plus or minus 12 inches (.3 m) of the desired length. For hand-bucked wood, only 23% fell within these limits. The best log lengths for the mill were multiples of 8 feet (2.4 m) plus a trim allowance. Top diameters of wood from the processor and conventional systems were similar and averaged 4.6 and 4.5 inches (117 and 114 mm), respectively.

Two further aspects were examined in detail: differences in loader activity between conventional and processor wood, and truck weight/volume conversion ratios.

On this operation, front-end loaders forwarded logs from stump area to landing area and loaded trucks. Loader activity for both conventional wood and processor wood involved the same steps: bunching full trees prior to limbing and topping; forwarding logs to landing; loading trucks, and miscellaneous (including moving between landings, waiting, delays, etcetera). The distribution of loader time by activity is as follows:

Activity	Processor Wood % of Time	Conventional Wood % of Time
Bunching	10	17
Forwarding	22	34
Loading	48	34
Miscellaneous	20	15

Although individual activities differed significantly in the two systems, differences were not necessarily due to the different types of processing. Forty-eight percent of the loader time was spent loading 9 trucks with processor wood. This equals 26 minutes per truck in an 8-hour shift. For conventional wood, 6 trucks were loaded in 34% of the shift time, or 27 minutes per truck. It does not appear that processor wood offers important time-saving advantages over conventional wood.

Pinette and Therrien carried out a scaling test on ten processor and twelve hand-bucked (conventional) truckloads to compare the weight-to-soundwood-volume conversion ratios derived from the two methods. The wood came from similar stands in the same area. Average conversion ratios were 52.39 lb/ft^3 (839.2 kg/m^3) for processor wood and 54.98 lb/ft^3 (880.7 kg/m^3) for hand-bucked wood. These results show a lower weight per cubic foot (m^3) for processor wood, indicating fewer limbs, less debris and rot in the load and more usable wood. On a load of 55000 lb (24 950 kg), the difference in volume would be 50 cubic feet (1.4 m^3), (approximately 5% more volume than for hand-bucked wood), resulting in a reduction of almost 5% in hauling cost per cunit. This would be especially important for costly long-haul situations. In addition, the number of small tops (less than 4 inches (100 mm)) and reject logs was reduced in the processor loads.

Mill Yard Study of Processor

After the processor finished the field trial at Williams Lake, it was tried at the sawmill yard to simulate work in a central processing area. Instead of processing full trees, however, the machine handled the normal log-length inputs for the mill which were piled in the yard. Logs had already been limbed, topped and bucked by conventional methods. The piles contained a mixture of species and log sizes, with butts and tops mixed, and were up to 8 feet (2.4 m) high. Conditions were not representative of those expected in a central processing area. The processor performance was poor and there were many breakdowns. The inexperience of the operator and the condition of the log piles led to low productivity. No definite conclusions about processor application in central processing areas could be drawn from this short test.

EXPECTED COSTS

The machine costs presented below show a realistic range of costs that may be expected with the ÖSA 670 Feller Buncher and 705 Processor, in view of the uncertainties entering into some of the estimated values.

The total cost in \$ per cunit (\$ per m^3) for the feller buncher and the processor is calculated by this equation:

$$\$/\text{cunit} = \left[\left[\frac{I-R}{L}\left(1+\frac{i(N+1)}{2}\right) + \frac{iRN}{L} + M + W \right] \frac{100}{U} + F \right] \frac{1}{P}$$

where the items are identified for each machine below.

FELLER BUNCHER COSTS

Known values include:

- I = purchase price: \$210,000 f.o.b. Vancouver
- F = fuel & lubricant costs (including hydraulic fluid): \$3.50/PMH
- W = operator's wage: \$12.00/SMH (including fringe benefits)
- N = depreciation period: 4 years
- i = interest and insurance factor: 0.13

Estimated values (based on Western Canadian conditions) include:

	Favourable	Unfavourable
R = residual value, \$	21,000	21,000
L = economic life of machine, SMH	16,000	12,000
U = utilization percent	80%	60%
M = maintenance cost (100% and 150% of fixed costs) \$/SMH	16.33	32.67
P = productivity (based on tree volumes of 20 ft^3 and 10 ft^3), cunits/PMH (m^3/PMH)	14.5 (41.1)	7.2 (20.4)

Using the above values in the equation gives the following results:

	Favourable	Unfavourable
Total cost, \$/PMH	59.33	114.25
Total cost, \$/cunit ($\$/m^3$)	4.09 (1.44)	15.87 (5.60)

Processor Costs

Known values include:

I = \$220,000 f.o.b. Vancouver
F = \$3.50 per PMH
W = \$12.00 per SMH
N = 4 years
i = 0.13

Estimated values (based on Western Canadian conditions) include:

	Favourable	Unfavourable
R in \$ =	22,000	22,000
L in SMH =	16,000	12,000
U in percent =	80%	60%
M in \$/SMH =	17.11	34.23
P in cunits/PMH = (m^3/PMH)	22.3 (63.1)	11.2 (31.6)

Using the above values in the equation gives the following results:

	Favourable	Unfavourable
Total cost, \$/PMH	61.28	118.58
Total cost, \$/cunit ($\$/m^3$)	2.75 (0.97)	10.59 (3.75)

The calculations show that the ÖSA machines can achieve reasonable costs per cunit (m^3) if they operate at a high level of utilization in favourable stand conditions.

Compared to either hand-felling or felling and bunching with shears, slightly higher felling and bunching costs per cunit (m^3) may be acceptable for the ÖSA 670 feller buncher in view of its ability to reduce butt damage and its improved terrain capabilities. Comparing the processor with manual limbing and bucking, we found that safer conditions at the landing and improved log quality (with its effects on hauling costs and mill recovery) may offset slightly higher costs-per-cunit (m^3).

CONCLUSION

The trial produced valuable information about the ÖSA machines and showed that companies, consultants and a research group can work together, even though it was not possible to realize every goal.

The processor trial finished in mid-February and the feller buncher stopped in March 1978. Reports on the production, mechanical, and financial results were prepared by FERIC and ILHIL and presented at a meeting in early June. At that time, the three companies agreed to terminate the agreement with ILHIL and balance the books. FERIC agreed to combine the production and mechanical findings and publish the results.

The two machines in the system had similar productivities during the trial, indicating that one feller buncher works effectively with one processor. The number and type of skidders or forwarders needed to keep the processor supplied with trees can be decided by the supervisor, taking into account local conditions and machine performance. Using the actual production figures and expected costs, it appears that neither the feller buncher nor the processor can operate profitably in extremely small timber. Butt damage is not so significant and log quality cannot be substantially improved to offset the higher costs. The timber size at Parson and Houston was considered suitable; at Williams Lake it was considered too small to show economic benefits for the ÖSA system.

The feller buncher was able to operate on slopes of 45%, performed well, and produced trees at a rate up to 100 trees per PMH. The terrain capability of the undercarriage was proved, and we found chainsaw felling more effective than shear felling in reducing butt damage. The mechanical performance of the feller buncher was not as high as expected; availability averaged 68% over the trials.

The processor produced trees at a rate up to 105 per PMH. The logs were cleanly limbed and accuracy of length was good. Mechanical performance was disappointing, however. Availability averaged 77% over the trial, but showed a declining trend from its initial level over 80 percent. Most of the problems were associated with the processing unit and the new outfeed tray. Non-mechanical delays (resulting in part from the organization problems) accounted for 18% of shift time and resulted in the low machine utilization. A comparison of the volume produced per shift with the volume per productive machine hour reflects this low utilization percentage.

There were many minor mechanical breakdowns on both machines and this resulted in low availability and utilization. The extra handling over the long shipping distance from Eastern Canada was thought to have been the cause of many of these breakdowns. Machines must be thoroughly checked and overhauled before going to woods locations, especially if there has been long-distance transportation by road or rail to the test sites.

Parts logistics and mechanical support must be recognized as problem areas which will influence machine downtime during a trial. If dealer networks establish parts, supplies, and personnel-training facilities for operators and mechanics, these problems will be better handled. Acceptance of a new machine into regular operations will raise its rank in mechanical support priority and should improve its reliability.

Modifications to adapt the processor to B. C. conditions took longer than expected and reduced the time planned for the two machines to work as a system at Parson. Separation of the two ÖSA machines in December 1977 put a halt to the combined system for the rest of the trial and this is one factor which made supervision, maintenance, and data collection more difficult.

Another phase which took longer than planned was the selection and training of suitable operators. Five different operators worked the feller buncher in the first seven weeks of the trial and the sixth operator worked the machine for the remainder of the time. No Canadian became fully-trained on the processor and the Swedish operator/trainers seemed to lose interest in the trial.

Tests of new machines and systems should be separate from the work of regular production to avoid premature judgment on performance and reliability. When this is not possible and new machines are part of regular production plans, allowances must be made for inexperience and problems during shakedown periods.

Another important aspect of machine/system trials is the establishment of and adherence to well-defined lines of control and detailed trial plans. It is essential that the company woods supervisors, the persons running the experiment and the machine operators all have a clear definition of their responsibilities and they must agree at the outset on the priority that will be given the experiment in case of breakdown or in case of a conflict between it and the normal production equipment.

The processor was shipped back to Eastern Canada during the summer of 1978. There was considerable interest from two of the three companies in continuing to operate both machines in B. C. The major condition which they imposed, however, concerned the future involvement of the manufacturer to provide adequate local support facilities and training programs. (In April 1979 FERIC learned that Northwood Pulp and Timber was in the process of purchasing the feller buncher.)

No further studies of these machines are planned at present.

The lessons learned from the ILHIL trials should make future cooperative studies easier to conduct, with more rewarding results.

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APPENDIX I

Manufacturer's Specifications before B.C. Modifications

(All measurements in metric units with Imperial equivalents in parentheses)

ÖSA 670 FELLER BUNCHER

Engine

Type: Scania D8
Max. output: 120 kW (163 hp) at 2400 rpm
Max. torque: 560 Nm (56 kgf m DIN) at 1500 rpm
Max. engine speed: 2400 rpm

Fuel Tank

Volume: 550 ℓ (121 gal)

Power Transmission

Type: Hydrostatic gearbox on high and low gear
Speed: Cross-country, 6-wheel drive 0-5.6 km/h (0-3.5 mph) On road, 2-wheel drive 0-20.4 km/h (0-13 mph)
Max. drawbar power net: 145 KN (14.5 T)

Wheel Equipment

Front axle: 23.5x25"/16
Bogie: 17.5x25"/16
The bogie can be provided with tracks.

Electrical System

Voltage: 24 V
Battery capacity: 150 Ah
Generator for AC: 980 W, 2 pcs.
Working lights: 8 pcs.

Steering System

Type: Hydraulic frame steering
Steering angle: ±40°
Distance front axle-steering link 64 cm (25.2 in.)
Manoeuvring: Impulse steering for cross-country running, proportional steering by wheel for road driving.

Brakes

Type: Compressed-air-controlled disc brakes with spring-action emergency- and manoeuvring-brakes. During driving, the machine is braked by the hydrostatic transmission.

Hydraulic System

1 gear pump for steering.
1 axial piston pump for felling-unit and horizontalizing devices. Operates as a constant pressure pump.
1 axial piston pump for forward driving.

Operating valves: Two-lever hydraulic servo with on-off functions electropneumatically controlled.

Hydraulic oil tank: 200 ℓ (44 gal)
Extra tank: 200 ℓ (44 gal)

Slewing Assembly

Type: Slew ring with direct-drive low-rpm radial piston engine.
Slewing speed: 0-6 rpm
Slewing torque: 25 KNm (2500 kgf m)

Crane

Type: Parallel-steered knuckle-boom crane.
Reach: 7.5 m (24.6 ft)

Felling Mechanism

Type: Chain saw
Max. felling-diameter: 56 cm (22 in.)
Saw chain: 1/2"
Weight: approx. 900 kg (2000 lb)

Weight

Total: 21 900 kg (48,300 lb) including counterweight 1 600 kg (3500 lb)
Front: 7 540 kg (16,600 lb)
Ground pressure: 0.78 kp/cm^2 (11.1 psi)
Rear: 14 360 kg (31,700 lb)
Ground pressure: 0.54 kp/cm^2 (7.7 psi)

Dimensions

Width: 290 cm (114 in.)
Wheelbase: 480 cm (189 in.)
Track gauge: rear 240 cm (94 in.) front 220 cm (87 in.)

Clearance

Front: 78 cm (31 in.)
Rear: variable 73-115 cm (29-45 in.)

Extra Equipment

Spare parts set
Tool kit 1
Engine heater
Compressed-air equipment
Fire extinguisher
Air conditioning
Roof fan
Vibrometer
Communication radio
Car radio
Lighting-ramp

The manufacturer reserves the right to alter specifications and designs.

ÖSA 705/260 PROCESSOR

BASIC CARRIER

ÖSA 260 FORWARDER

ENGINE

Scania D8, DIN output at 40 r/s	120 kW (163 hp)

POWER TRANSMISSION

Hydrostatic transmission continuously variable in combination with the transfer case.

SPEED RANGE

Off-road	0-1.94 m/s (0-4.3 mph)
Road driving	0-8.05 m/s (0-18 mph)

STEERING

Steering wheel used for road driving
High speed electronic pulse steering with steering lever for off-road driving

Turning radius	8 450 mm (27.7 ft)
Maximum steering angle	40°
Gross steering torque	44.1 kNm (32550 ftlbf)

TIRES

Front	23.1x34"--14 ply
Rear	17.5x25"--16 ply

BRAKES

Air-operated disc brakes and parking brake on all wheels

DIFFERENTIAL LOCK

Air-operated rear, automatic front

HYDRAULIC SYSTEM

Constant-pressure type	13.73 MPa (2000 psi)

Electrical System

Four batteries	140 Ah (24 v)
Two AC alternators 45 A, 24 V	tot 2 160 W
Sixteen working lights	tot 1 120 W
Two head lights	tot 140 W

Fuel Tank

Tank capacity	500 ℓ (110 gal)

Cab

Rubber anti-vibration mountings, thermal and sound insulation, flat floor, noise level beneath N85, safety belt, radio, air conditioner/heater unit, windshield wipers and sunvisors. The cab can be tilted for easier access to components.

Processor Unit

Loader

ÖSA 399 with telescopic extension
Reach: 7.45 m (24.44 ft)

Delimbing Tool

Type	knife belts
Delimbing diameter	50-560 mm (1.97-22.05 in.)
Opening time	1 s
Closing time	1 s
Min. limbless log length needed for feed	1.2 m (3.9 ft)
Distance between feed rollers	630 mm (24.8 in.)

Feed Rollers

Number (2 for feeding, 1 for discharging)	3
Type	spike rollers
Diameter	500 mm (19.7 in.)
Normal feed speed	2.8 m/s (9.2 ft/sec)
Normal tractive power	35.3 kN (7940 lbf)
Maximum tractive power	43.2 kN (9700 lbf)

Power Transmission to Feed Rollers

Hydrostatic drive, forward and reverse

Slasher Unit

Type: Circular cut-off saw with saw guard for full protection

Saw diameter	1 200 mm (47.2 in.)
Maximum cutting diameter	500 mm (19.7 in.)
Maximum feed speed	0.5 m/s (1.6 ft/sec)

Topping Unit

Type	shear
Maximum topping diameter	125 mm (4.9 in.)

Optional Equipment for ÖSA 705

Feed rollers with "floating" spike sections
Extra programming device for 5 additional lengths
Baskets for sawlogs
Cold weather starter
Powder fire extinguisher
Compressed air equipment
Spare Part Kit I and II
Tool Kit I and II
Hand-operated barrel pump
Warning lights for road-driving
Cassette car radio (mounted)
Extra electric counter for logs or pulpwood

The manufacturer reserves the right to alter specifications and designs.

APPENDIX II

Details of Mechanical Problems and Recommended Solutions

The detailed mechanical report prepared by ILHIL contained two sections dealing with itemized problems encountered with each machine and giving recommended solutions. These are briefly summarized below and more details are available on request.

ÖSA 670 Feller Buncher

AREA	PROBLEM	RECOMMENDED SOLUTION
Engine	--lack of horsepower at elevations over 3000 ft (914 m)	--use turbo-charger option
	--collapse air cleaner inlet pipe	--check rubber adapter fitting
	--overheating of engine coolant and hydraulic oil in summer	--increase coolant capacity or air flow
	--overflow valve malfunction	--change valve or remove it
	--freezing of air system	--add air dryer and modify system
Hydraulics	--filters too expensive	--use local source of cheaper units
	--incompatibility of metric and SAE couplings	
	--ice problems with boom hoses	--use ÖSA kit to reroute hoses
	--hose from LINDE valve has 90° bend which breaks	--change end to stronger type and add support
	--level-control hydraulic directional valve (HUSCO) is of poor quality	--upgrade using good quality valve

AREA	PROBLEM	RECOMMENDED SOLUTION
Hydraulic Cylinders	--boom head tilt cylinder (fore/aft) failure	--manufacturer to check all parts of this cylinder
	--jib lift cylinders cannot be repaired onsite	--redesign cylinder for onsite repairs
	--boom head tilt cylinder (sideways) bushing failures	--use high strength steel for bushing
	--special tools necessary for cylinder cap repairs	--expand parts and service manual to cover this
Boom Head & Bracket	--closing arm on felling head problems	--add second cylinder and split closing arm into two sections, and strengthen design
	--tree moves in head	--add teeth to clamping area
	--felling head holding bracket is too weak	--strengthen and redesign
	--hose for saw motor failures	--more research needed by ÖSA
	--unguarded accumulator	--add guarding
	--chain drive sprocket breaks through drive dowel holes in cold weather	--redesign to eliminate dowel holes
Cab Assembly	--guarding below standard set by W.C.B. in B. C.	--add new guards
Undercarriage	--driving chain climbed sprocket and separated	--more explicit maintenance instructions needed
	--wheel slippage in tracks on slopes	--weld chains diagonally across inside of tracks
	--front chains are needed at all times	--chains should be part of machine package or specifications given for ordering

AREA	PROBLEM	RECOMMENDED SOLUTION
Undercarriage cont.	--inadequate guarding	--add extra guarding where necessary
	--tool box/chain/bar holder combination needed	--optional toolbox should become standard for B. C. machines

ÖSA 705/260 Processor

AREA	PROBLEM	RECOMMENDED SOLUTION
Guards & Ladders	--front ladder damage	--use welded chain type to avoid damage to rigid type
	--saw guard will not work with long out-feed tray	--remove saw guard and use new style built and welded to cradle
Boom	--telescopic extension cylinder failures	--strengthen cylinder
	--grapple rotator fit-tings too vulnerable	--use larger thread size and use steel "O" ring fittings
Feed Rollers	--bumper block failures	--build new block with gusset for strength-ening
Delimbing Arms	--delimbing arm with topping saw failures	--redesign arm to accom-modate topping saw
	--cradle drops when handling larger trees	--redesign cradle attach-ment to main frame
	--rubber bumper block failures	--use bigger size or solid unit
	--brackets carrying topping saw too light	--redesign
Hydraulic Components	--hose crowding on valve assembly	--necessary to redesign with better access parts
	--valve for kickers of substandard quality for this purpose	--replace with better quality valve

AREA	PROBLEM	RECOMMENDED SOLUTION
Electrical Components	--microswitches for topping saw are poorly located	--relocate switches and wiring
	--slippage of length measuring pulse counter	--add maintenance instructions
	--microswitches for outfeed tray are too vulnerable	--redesign kicker arrangement and properly locate and guard microswitches

APPENDIX III

Details of Pre-Logging Site Inspection at Parson

Table AIII-1. Stand Descriptions, Parson Study Area

	Block 73	Block 71
Stand Type	$P_{\ell}S$	P_{ℓ}
Age (years)	∿80	∿80
Condition	mature	mature
Diameters:		
Range	4-10 in. (10-25 cm)	4-16 in. (10-41 cm)
Average	6- 8 in. (15-20 cm)	9-10 in. (23-25 cm)
Heights:		
Range	55-85 ft (17-26 m)	60-95 ft (18-29 m)
Average	75 ft (23 m)	85 ft (26 m)
Volumes/Acre (ha):		
Range, cunits (m3)	25-40 (175-280)	15-50 (105-350)
Average, cunits (m3)	30-35 (210-245)	40 (280)

Table AIII-2. Slope Distributions, Parson Study Area

Slope Class	Block 73			Block 71		
	acres	hectares	% of area	acres	hectares	% of area
0-10%	17.2	7.0	28.6	22.4	9.1	12.8
11-20%	24.0	9.7	40.0	22.9	9.3	13.1
21-30%	11.2	4.5	18.7	28.5	11.5	16.3
31-40%	4.9	2.0	8.1	27.7	11.2	15.8
41-50%	2.7	1.1	4.6	30.3	12.3	17.3
51-60%	-	-	-	28.0	11.3	16.0
61%+	-	-	-	15.2	6.2	8.7
Total	60.0	24.3	100.0	175.0	70.8	100.0