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Whole-Tree Chipping with the Morbark Model 22 Chiparvestor

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Une traduction française de ce rapport est disponible.

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FOREWORD

In response to requests from member companies, FERIC undertook two short-term studies of whole-tree chipping operations. The studies were intended to provide some basic information on productivity and the factors affecting it. Both operations studied used the Morbark Model 22 Chiparvestor, the most common whole-tree chipper in Canada.

At the time of writing, five or six Canadian pulp mills used whole-tree chips for part of their furnish. Another five mills were using whole-tree chippers for yard clean-up or as a back-up for their regular chipping facilities. As the demand for wood fibre increases, it is likely that more Canadian mills will consider whole-tree chips to supplement their normal wood supply. Whole-tree chips may also be used to supplement hogged residues as a fuel, particularly if fuel costs continue to rise.

The limitations of these studies should be recognized. The results do not include information on factors such as machine operating costs, chip quality or the fibre yield gain over conventional logging in the same stands. Moreover, the short 4-day observation period may not be representative of the longer-term performance at these particular operations. In particular, the Company B system was in a transition stage and has since been converted to hot logging with a subsequent increase in productivity.

However, because these two operations were very different, they do demonstrate the potential benefits of certain practices and the magnitude of the penalties of others which might still have to be followed because of external constraints. These very differences should make the results of this study particularly useful to companies seriously considering or planning a full-tree chipping operation.

To supervisors and operators involved with both studies, we express grateful appreciation for their patience and co-operation. Thanks are also due to FERIC technicians E. L. Vajda and B. Sutherland, and particularly to R. L. Legault, a former member of the FERIC staff who initiated the study and conducted much of the field work.

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SUMMARY

Chipping whole trees in the woods is becoming increasingly common in eastern Canada. This Note presents the results of the first FERIC study of the process, based on 4-day periods of observation and timing of two operations that used the Morbark Model 22 (two-knife) Chiparvestor. The study was intended to measure and explain the difference in productivity between the operations, mainly the result of two fundamentally different logging systems - cold and hot - in mixed hardwood stands.

The results of the time studies (shown in Table 1) include a productivity of 29 tons (27 tonnes) per scheduled machine hour (SMH) in hot logging at Company A; this was 79% higher than the 16 tons (15 tonnes) per SMH achieved at Company B, with its cold-logging system. Based on productive machine hours (PMH), the difference was less striking, but still important: Company A attained 45 tons (41 tonnes) per PMH, while Company B productivity was 34 tons (31 tonnes) per PMH.

The two operations showed many similarities: Average tree size was comparable, both operations had muddy ground conditions during the study, and the two crews were experienced. Differences in species composition appeared to have little effect on productivity. Further, both Chiparvestors showed similar levels of availability (75% and 77% respectively).

The higher productivity at Company A appeared to be the result of several factors, including: inherent differences between potential productivity of cold and hot logging; imbalances of truck and van scheduling; the types of supervision; difference between operators; differences in the response of the two operations to adverse weather and ground conditions; and the proportion of "hard" hardwoods in the stands.

Since the study was made, in July 1976 for Company A and October 1976 for Company B, Company A has retained its system and practices with continuing high productivity. Company B has modified its Chiparvestor operation to include many more aspects of a hot logging system.

TABLE 1. STAND FACTORS AND PRODUCTIVITY

	Company A		Company B	
Volume in stand, trees >4 in (10 cm) dbh,ct/acre (m^3/ha)	19.9	(139)	16.1	(112)
Volume per tree, trees >4 in (10 cm) dbh, ft^3 (m^3)	3.6	(0.10)	3.5	(0.10)
Scheduled machine hours (SMH)	33.0		31.5	
Productive machine hours; chipping (PMH)	21.3		15.2	
Production, number of van loads	37		21	
Load per van,(green tons (tonnes))	26.19	(23.76)	24.61	(22.33)
Time required per van load (based on SMH)	0.89 hr		1.50 hr	
Time required per van load (based on PMH)	0.58 hr		0.72 hr	

INTRODUCTION

The Morbark Model 22 Chiparvestor is marketed in Canada by Canadian Morbark Limited at North Bay, Ontario. Model 22 has been in regular use for about 5 years and is currently the most widely used whole-tree chipper in Canada and the U.S.

The two units studied were purchased in 1973; they were powered by 380 hp (283 kW) diesel engines and equipped with two-knife chipper discs. Mounted on tandem axle semi-trailers, the Chiparvestors were not self-propelled and required a powered haul unit for moves.

The knuckle-boom loaders on the Model 22's have proved troublesome to many of the users. The latest (1977) Model 22's can be equipped with a slide-boom loader in an attempt to correct this problem. The slide-boom loader, however, is not suitable for applications (such as Company A) where sawlogs are extracted from suitable whole trees. The Model 22 Chiparvestor currently sells for about $175,000.

THE STUDIES

The objectives of the studies were to provide interested companies and other potential users with useful information on productivity and the factors affecting productivity.

To achieve these objectives, time studies were carried out on two operations in eastern Canada. On each operation the activities of a Morbark Model 22 Chiparvestor were observed and timed. The net weight of the chips in each van load was recorded. Sample plots were established in each harvesting area to obtain information on stand conditions.

COMPANY 'A' STUDY

Description of the Operation

Company A was a contractor operation producing whole-tree chips for a pulpmill located 75 miles (120 km) away. A Model 22 Chiparvestor with a two-knife chipper was used for clear-cutting a 200-acre (80 ha) stand of mixed hardwoods. Sawlogs were also produced on this operation and comprised about 5% of the total wood harvested. Table 2 provides information on stand factors in the harvesting area.

Felling was carried out by a Drott 40 feller-buncher and a Melroe Bobcat feller-buncher. Some large residual trees required power saw felling. Skidding was done by two Volvo SM-868 bunk grapple skidders, and by two Tree Farmer cable skidders. The large load capacity of the Volvo skidders (3-5 ct (8-14 m^3) depending on tree size) permitted longer skidding distances than for the Tree Farmer skidders, which were used mostly for larger trees.

At the landing the whole trees were dropped on both sides of the Chiparvestor (see Figs. 2, 3). At this point, the deckman sawed any large branches to allow easier feeding into the Chiparvestor. Any suitable sawlogs were also sawn by the deckman. These sawlogs were later piled on the side of the landing by the deckman, using a stick-boom loader.

The Chiparvestor was equipped with a debris chute, a modification which permits loose bark, twigs, and other debris to fall from the wood before chipping. This device, now available as an option on new Chiparvestors, originated on this operation. Debris deposited near the Chiparvestor was usually cleared with the Chiparvestor's grapple (see Fig. 1).

Company A used a hot logging system, where trees were chipped immediately after skidding. A spare van, used as a back-up unit, was filled during van changes or while waiting for a truck to arrive.

By most standards, Company A could be described as an efficient contractor operation. The work phases (skidding, chipping, and trucking) were well synchronized. Most of the nine crew members had worked together since the Chiparvestor operation started up 3 years earlier. Although their hourly wages included no provisions for a bonus, crew members showed an ability and willingness to promote productivity, by performing repairs on their machines and by helping each other overcome problems. The contractor-owners often handled repairs, and they served as operator-supervisors on the operation.

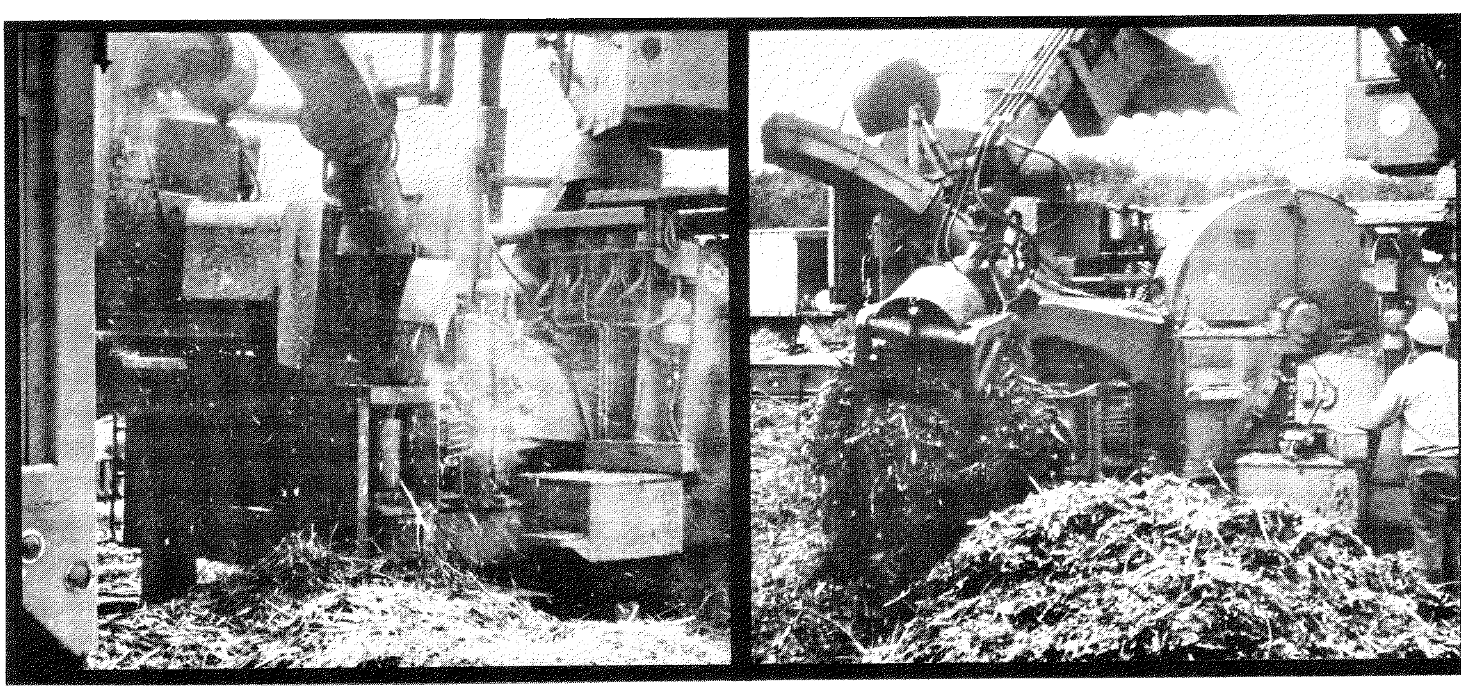

Fig. 1. Company A - The debris chute on this Chiparvestor deposited twigs, bark, and other debris near the machine.

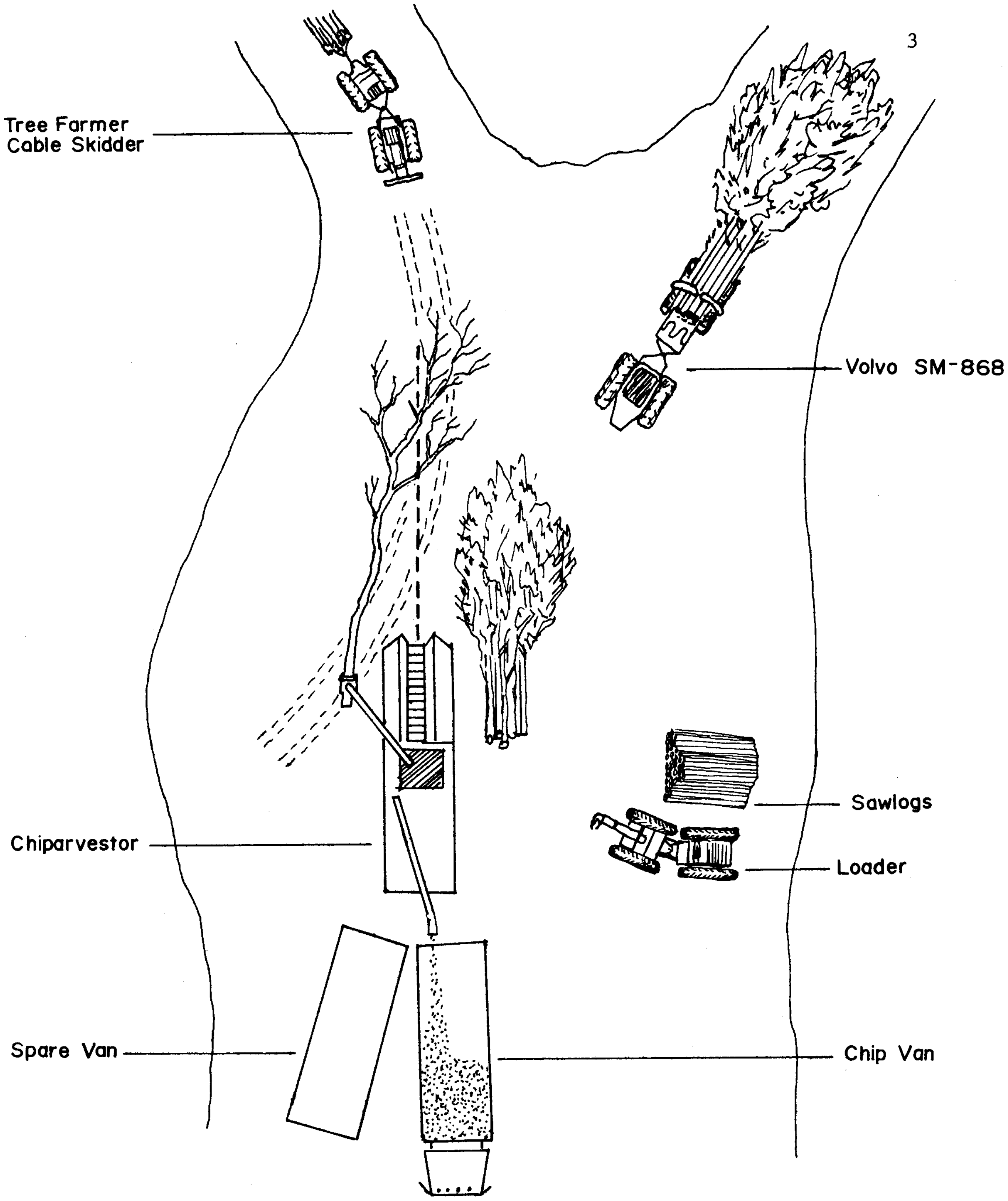

Fig. 2. 'Hot' logging at Company A. Large trees (50 ft (17 m) or longer) not suitable for sawlogs were skidded in a gentle curve toward the Chiparvestor in a manner so as to align the tree top with the center line of the infeed of the Chiparvestor. The tree could then be lifted onto the infeed deck without the use of the heel on the loader boom. This method reduces strain on the knuckle-boom loader, a frequent cause of downtime on some Chiparvestor operations and is recommended by Morbark.

Fig. 3. Operating sequence at Company A: (1) whole-trees skidded by Volvo SM-868, (2) Chiparvestor loading whole-trees onto infeed conveyor, (3), (4) sawlogs separated and piled at the landing.

COMPANY 'B' STUDY

Description of the Operation

Company B was a company-run, whole-tree chipping operation producing chips for a pulpmill located 39 miles (60 km) away. On this operation two Chiparvestors worked in the same area. One, a Model 22 with a two-knife chipper, but with no debris chute, was studied by FERIC.

On this operation conifers, comprising about 8% of the stand, were piled separately and were not chipped. Also, hardwood trees too large for the feller-buncher (and for the Chiparvestor) were left standing for later felling by power saw. Table 2 provides information on stand factors in the harvesting area.

At Company B, the Chiparvestor operated mainly on a cold logging basis, i.e. subsequent chipping of whole trees piled in decks along the road-side (see Fig. 4, 5). The operating procedure was as follows: The Chiparvestor would chip all the trees that could be reached with the grapple. Then, a Clark grapple skidder moved the Chiparvestor to the next deck (or position), using a fifth-wheel dolly (see Fig. 5). The frequent delays caused by moving the Chiparvestor and the vans proved to be a major cause of unproductive time on this operation.

Mechanical felling was carried out with an International 3964 feller-buncher; subsequent skidding was done with a Clark grapple skidder. Two manual cutting crews using power saws and cable skidders also produced whole trees for the Chiparvestors. Most of the crew members, including the Chiparvestor operator, had several years of experience with the whole-tree chipping operation. The crew members were paid on an hourly basis with no bonus.

During the study, seven 40-ft (12 m) vans, having a chip capacity of 8 ct (23 m^3) served the two Chiparvestors.

Muddy conditions resulted from rain which fell prior to and during the first day of the study. The mud observed on many of the whole trees was expected to reduce the potential productivity of the Chiparvestor, due to more frequent knife changes.

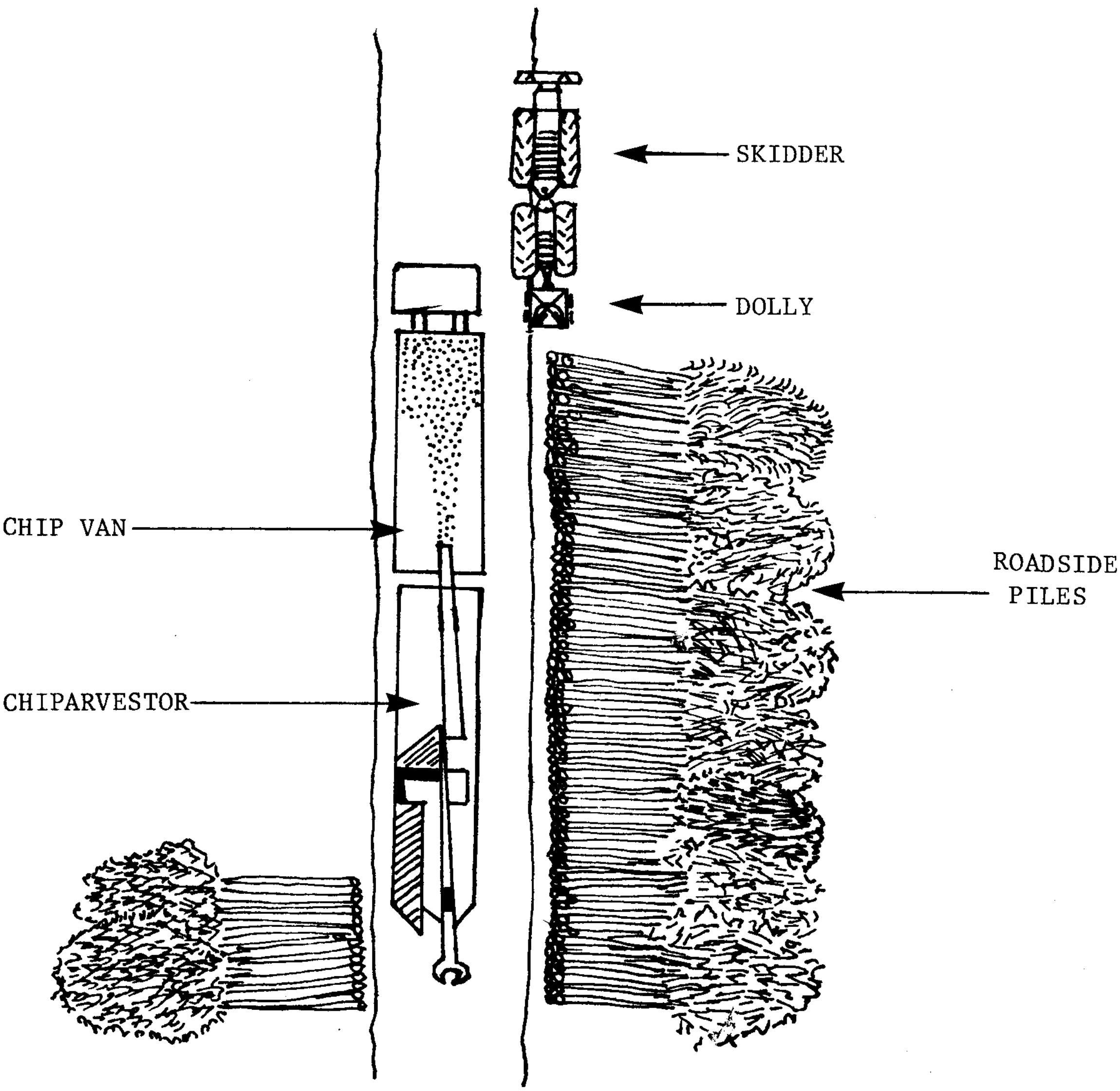

Fig. 4. 'Cold' logging at Company B. Using this method results in a high strain factor on the knuckle-boom loader due to constant 'heeling' and the high 'tangle' factor incurred due to interlacing of branches in whole tree stock piles.

STAND FACTORS

Table 2 summarizes stand factors prevailing in the harvesting areas for the two operations.

Table 2. Average Stand Factors

	Company A		Company B	
Trees per acre (ha) > 4 in (10 cm) dbh	533	(1366)	460	(1137)
Volume in stand, trees > 4 in (10 cm) dbh, ct/acre (m^3/ha)	19.9	(139)	16.1	(112)
Trees per acre (ha) > 1 in (3 cm) dbh	850	(2100)	647	(1599)
Volume in stand, trees > 1 in (3 cm) dbh, ct/acre (m^3/ha)	20.4	(143)	16.4	(115)
Volume per tree, trees > 4 in (10 cm) dbh, ft^3 (m^3)	3.6	(0.1)	3.5	(0.1)
Slope	negligible		negligible	
Species, by volume				
"Hard" hardwoods	23% Elm spp. Cherry spp. Sugar maple		51% American beech Yellow birch Ash spp. Sugar maple	
"Soft" hardwoods	77% Red maple Poplar spp.		41% Red maple	
Softwoods	0%		8% Spruce spp. Eastern hemlock	

Volumes calculated using local volume tables

Fig. 5. A fifth-wheel dolly hitched to a skidder was used to move the Chiparvestor at Company B.

RESULTS AND DISCUSSION

Time studies at Company A covered 33 scheduled machine hours during 4 consecutive days in July 1976. Those at Company B were for 31.5 scheduled machine hours during 4 consecutive days in October 1976. Temperatures were about 25^{o}C during the study at Company A and 0 - 5^{o}C at Company B, but this difference appeared to have no significance.

In many respects the operations at Company A and Company B were similar. Both operations harvested trees of a similar size. Both operations had experienced crews; muddy ground conditions due to rain were common to both operations. In addition, both Chiparvestors required relatively few repairs during the studies resulting in similar levels of machine availability (75% at Company A; 77% at Company B).

Table 3. Production Data

Time Classification	Company A (% of SMH)		Company B (% of SMH)	
Productive Time (Chipping)	64.7		48.3	
Mechanical Delays	24.9		22.5	
Repairs, service & warm-up		12.2		8.6
Debris chute plugged *		4.9		0
Cleaning chip discharge spout		0		0.9
Change knives		7.8		8.5
Wait mechanic		0		4.5
Non-Mechanical Delays	10.4		29.2	
Wait for van		2.6		16.4
Wait for trees		2.9		1.0
Moving chipper		0		7.3
Trouble feeding large trees or limbs		0.9		2.3
Personnel		3.5		2.2
Other		0.5		0
Scheduled Time	100.0		100.0	
Availability **		75%		77%
Utilization **		65%		48%
Production				
Total green tons (tonnes) produced***	969.14	(879.44)	516.84	(469.00)
Green tons (tonnes) per PMH	45.41	(41.21)	34.00	(30.85)
Green tons (tonnes) per SMH	29.37	(26.65)	16.41	(14.89)
Average load per van (green tons (tonnes))	26.19	(23.76)	24.61	(22.33)
Number of vans loaded	37		21	
Time required per van (based on PMH)		0.58 hr		0.72 hr
Time required per van (based on SMH)		0.89 hr		1.50 hr

* During the development of the debris chute,Company A experienced some plugging, but have since solved this problem. The debris chute now available from Morbark is termed a "dirt separator" and is said to have no plugging problems.

** 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.

*** Conversion factors used at Company A:
1 green ton = .511 oven dry ton
1 cunit = (approximately) 6500 lb (green weight)

The production rates on the two operations were, however, quite different. The production rate (based on green tons/PMH) was 33% higher at Company A than at Company B. This, coupled with the higher chipper utilization at Company A (65% at Company A; 48% at Company B), resulted in a production rate 79% higher (based on SMH) for Company A, as compared to Company B.

Since the operations were quite similar, what accounted for the substantially higher productivity at Company A? The following section attempts to provide some answers to this question. (It should be noted that Company B has since shifted to a modified hot logging system with substantially increased productivity).

PRODUCTIVE TIME

The production rate for the Chiparvestor at Company A (based on green tons per PMH) was 33% higher than at Company B. If based on the number of vans loaded (a less accurate measure of production) the difference was 24%.

The difference in production per PMH can be largely attributed to the following factors: tree orientation, the type of supervision, wood hardness, and possible operator differences.

Tree Orientation

Perpendicular feeding is more time consuming than parallel feeding. At Company B, the trees were piled at roadside at right angles to the Chiparvestor; these trees were swung through an arc of 90^{o} before being dropped onto the feed conveyor.
Perpendicular feeding also places greater strains on the knuckle-boom loader. See Figures 2 and 4.

Supervision

At Company A the contractor-owners served as full-time supervisors and mechanics for the operation. Due to their efforts the operation functioned very smoothly and delays were minimized.

At Company B there was less direct supervision since one supervisor was responsible for two Morbark Chiparvestors. On both operations the employees were fully experienced and were paid on an hourly basis with no bonus provision.

Wood Hardness

The chipping of "hard" hardwoods (especially the large diameter trees) required more power and a slower infeed speed than for similar sized "soft" hardwoods. Since Company A had 23% "hard" hardwoods as compared to 51% for Company B, Company A had a production advantage in this respect (see Table 2).

NOTE: Previous studies have shown that chipper infeed speed does not vary appreciably with log size; van loading time is dependent on the size of the material chipped. Chipper output varies as the square of the diameter of the logs chipped, e.g. the output from 10 in (25 cm) logs ($10^2 = 100$) is four times that from 5 in (13 cm) diameter logs ($5^2 = 25$).*

MECHANICAL DELAYS

The amount of mechanical delay was similar for Company A (25% of SMH) and Company B (23%). Mechanical delays were classified into various categories and are discussed below:

Repairs, Service and Warm-up

Several minor repairs were required on both operations during the time studies. Differences in time spent in repairs, service and warm-up between Company A (12% of SMH) and Company B (9% of SMH) were not considered to be significant because of the relatively short period studied.

Debris Chute Plugged

Company A's Chiparvestor was equipped with a debris chute designed to remove some of the bark, twigs and other debris from the wood. Although this modification helped to produce cleaner chips it also was a cause of non-productive time when it became plugged. Note - design revisions to the debris chute since the study have overcome the plugging problem.

Change Knives

Knife changes on the chipper were closely related to wet weather and resulting muddy ground conditions. Muddy skid trails and soft ground often have a negligible effect on skidding production; the effect on chipping, however, can be very pronounced since many of the whole trees become caked with mud during the skidding phase. When such trees are chipped, the knives on the Chiparvestor soon become dull and frequent knife changes may be required.

At Company A, careful planning alleviated the mud problem. To get away from muddy landing conditions the Chiparvestor was moved 5 miles. At the new location mud was not as great a problem. During the study at Company A knife changes averaged 11 minutes each and were carried out every 2.5 van loads.

At Company B, knife changes were frequent, due to mud caked on roadside piles. Knife changes were carried out an average of once per van load, each change requiring 8 minutes (see Fig. 6, 7).

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* McIntosh, J.A., Johnson L.W. Chipping In the Woods. Can. For. Ind. Oct. 1975, Vol. 95 (10).

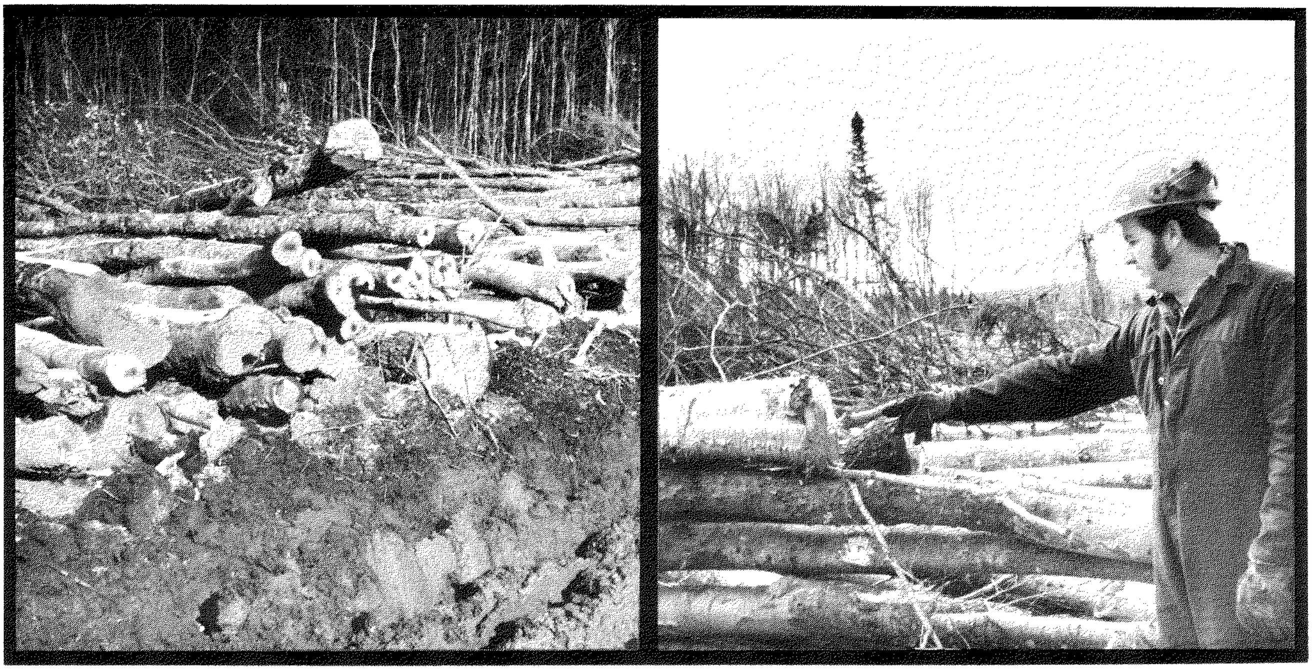

Fig. 6. Company B. Right - operator points to mud on logs resulting from skidding. Left - mud splashed on roadside piles by trucks.

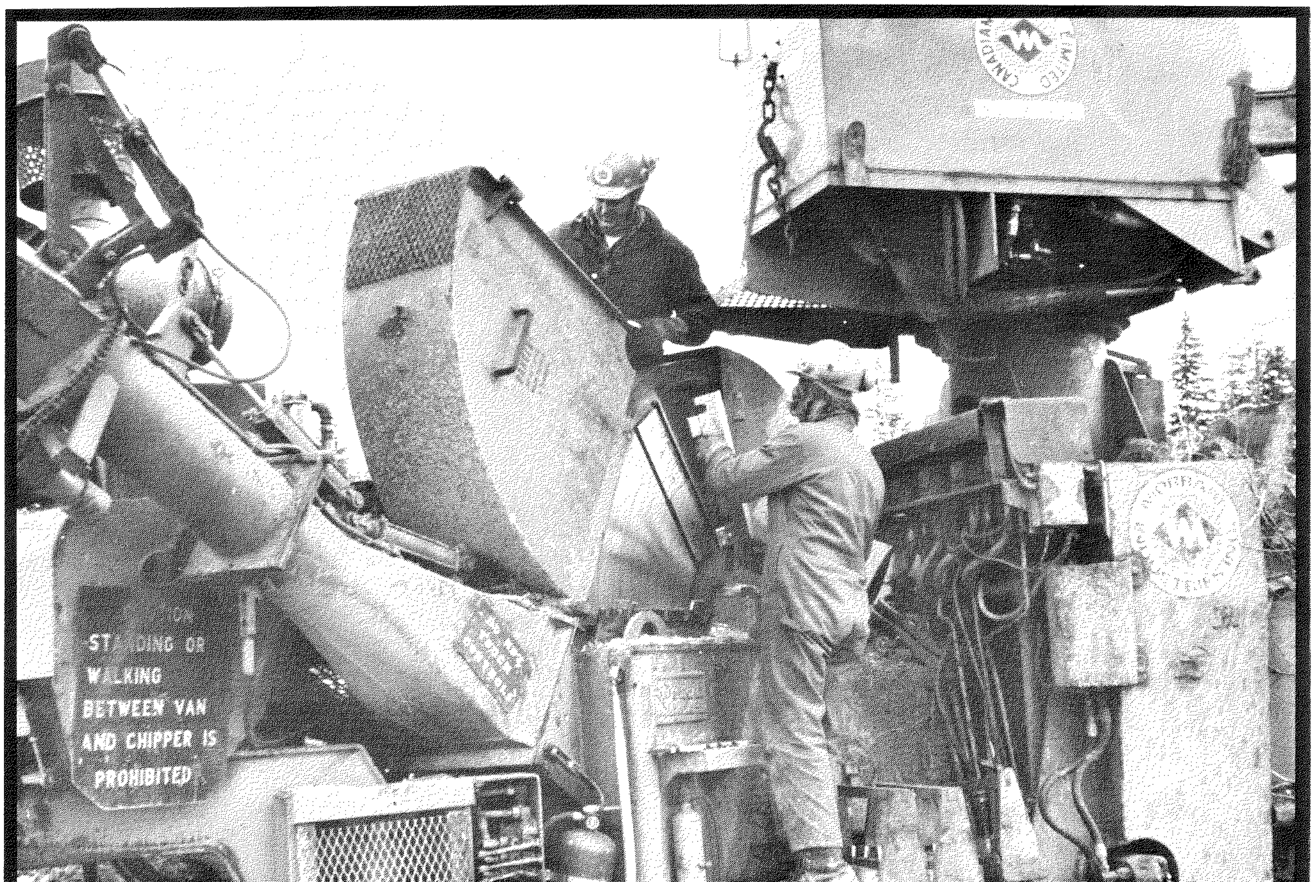

Fig. 7. Due to muddy conditions, knife changes were carried out an average of once per van load at Company B.

NON-MECHANICAL DELAYS

Non-mechanical delays were nearly three times as high at Company B as compared to Company A. At Company A non-mechanical delays comprised 10% of the scheduled time; at Company B, 29% (see Table 3). Some of the reasons for non-mechanical delays are discussed below.

Wait for Van

Waiting for trucks and vans often account for a large percentage of the non-productive time on Chiparvestor operations.

At Company A, trucks were well scheduled. Also, at Company A, spare vans were used as back-up units at the Chiparvestor, which reduced to a minimum the loss of chipping time during van changes. The delay time 'Wait for Van' (3% of SMH) was due to muddy conditions on the landing, which necessitated the use of skidders for towing and positioning the vans.

At Company B, 16% of SMH was spent in waiting for a van. These delays appeared to result from a less than ideal number of trucks to maximize chipper production on this operation. Also, Company B did not use a spare van as a back-up unit (see Fig. 1).

Wait for Trees and Moving Chipper

On the hot logging operation (Company A) there were very few delays due to the Chiparvestor waiting for trees. The delays amounted to only 3% of SMH, indicating a good balance of skidding capacity and skidding distances.

On cold logging operations there is usually no waiting for trees since the trees are already decked at roadside. However, at Company B some trees were skidded directly to the Chiparvestor, which accounted for the 1% of SMH attributed to 'Wait for Trees'.

The main disadvantage of the cold logging system used at Company B was the frequent moves required by the Chiparvestor. These averaged once per van (see Fig. 5) and required approximately 10 minutes each. The resulting delays comprised 7% of the SMH.

Note: 1. Moving time when cold logging can be reduced by using a tractor unit attached to the Chiparvestor. This method requires more road width than was available at Company B. Fig. 8 shows a 1977 Model 22 Chiparvestor in such a configuration. Using this method there is still some lost time due to re-positioning the van.

2. Company B has converted to a hot logging operation since the time studies were conducted.

Trouble Feeding Large Trees or Limbs

On both operations some delays were caused by large irregular-shaped trees and large-diameter branches. The deckman usually prevented such problems by partially cutting the tree or branch with a chainsaw, thereby facilitating chipper feeding.

Fig. 8. Model 22 Chiparvestor with tractor unit attached, shown loading a chip van. The machine is equipped with a sliding boom loader and a dirt separator (debris chute). Photo supplied by Canadian Morbark Ltd.

CONCLUSION

This study measures and explains the differences in productivity between two fundamentally different logging systems - cold and hot - in relatively similar stands of mixed hardwoods.

The results indicate that the productivity of the hot logging system was 79% higher (based on scheduled machine hours) than for the cold logging operation. Based on productive machine hours the difference was less striking, but still important.

The results clearly indicate that the hot logging system is inherently more productive than the cold logging system and should be used where possible. However, before the choice of logging system is made all local factors must be considered. Several variations of the above systems also exist, and should be duly considered as they may offer advantages not apparent from this report.

Regardless of the logging system, a considerable amount of planning is required if the full potential of the Chiparvestor is to be realized. Experience gained by machine owners can be very useful to other owners and to prospective buyers.