RECENT THINNING TRIALS WITH CABLE LOGGING SYSTEMS IN NEW ZEALAND

G. MURPHY

Forest Research Institute, New Zealand Forest Service,
Private Bag, Rotorua, New Zealand

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ABSTRACT

Nine thinning trials involving four types of hauler have been carried out on steep country to date. The data from these trials indicate likely production levels for a range of piece volumes, extraction distances, and methods. Changing the crop layout, and introducing more suitable haulers along with appropriate working techniques, are seen as two avenues for significantly increasing production and reducing unit volume costs.

INTRODUCTION

The total production of the eight small haulers currently extracting smallwood thinnings from exotic pine plantations on steep country represents less than 1% of New Zealand's annual exotic cut of 9 million m^3. Over the next 10 years steep-country smallwood thinnings may more than double but they would still account for only 1 to 2% of our annual cut (Wells 1980). Thinning steep country is about twice as expensive as thinning flat country and about four times more expensive than clearfelling 40- to 50-year-old unmanaged *Pinus radiata* D. Don stands (Murphy 1979a) and so, although it will remain a relatively minor aspect of logging production in New Zealand, it warrants some investigation.

Some of the more important factors affecting daily production and costs have been assessed with a view to pinpointing areas where unit costs could possibly be reduced.

MACHINE AND SYSTEM DESCRIPTIONS

Timbermaster Skyline

The Timbermaster Skyline as used in New Zealand has a set of three drums (excluding the strawline drum), an 8.8-m integral portable steel tower, and (occasionally) a hydraulic knuckleboom crane. It is powered by a separate 52-kW motor and is mounted on a truck chassis (Murphy 1979b). The Timbermaster Skyline has been studied under three operating systems – uphill and downhill extraction of tree-length logs, and uphill extraction of short pulpwood. The operating conditions are summarised in Table 1, and Figs 1 and 2 illustrate the work methods used.

TABLE 1—Operating conditions

	Timbermaster Skyline			Lotus Skyline			Lotus Interlock		Wilhaul
	Uphill tree-length	Downhill tree-length	Uphill short pulp	Uphill tree-length	Downhill tree-length	Downhill log-length	Uphill tree-length	Downhill tree-length	Downhill tree-length
Ground slope	23–25°	23°	20–24°	25–30°	20–30°	20–30°	—	—	7–30°
Maximum extraction distances (m)	180–210	70–160	100–120	100*	100*	100*	240	190	190–160
Stocking prior to thinning (stems/ha)	900	900	1800	765	1090	1090	—	—	670
Mean log volume removed (m^3)	0.34	0.17	0.05	0.21	0.40	0.27	0.22	0.27	0.27
Mean volume per cycle (m^3)	0.61	0.32	0.98	0.44	0.69	0.62	0.36	0.53	0.78
Crew size	5	4	10	5	4	4	5	4	6
Daily production (m^3)	32	23	56	26	49	42	24	35	40

* Standard distance used for calculations because of short nature of trial.

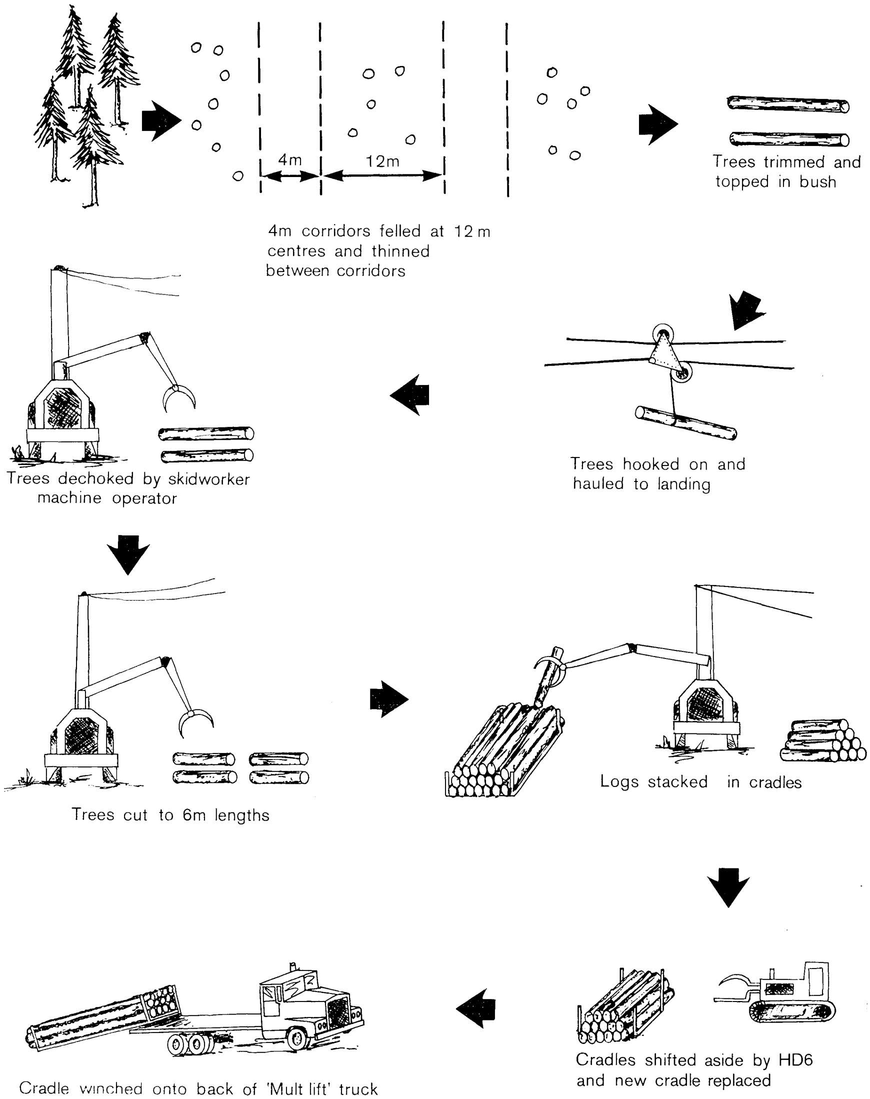

FIG. 1—Uphill and downhill tree-length extraction with the Timbermaster Skyline.

Lotus Skyline Hauler

In 1978 a group of engineers, loggers, logging managers, and researchers formed the Lotus Skyline Development Group, the aim of which was to test engineering concepts and develop a suitable hauler for steep country thinning under New Zealand conditions. One of the criteria was relatively low initial cost. The design arrived at was a three-drum machine, mounted on skids, and operated via semi-remote pneumatic controls. The drums were powered by a 60-kW motor, and tower height was approximately 9.7 m (LIRA 1979).

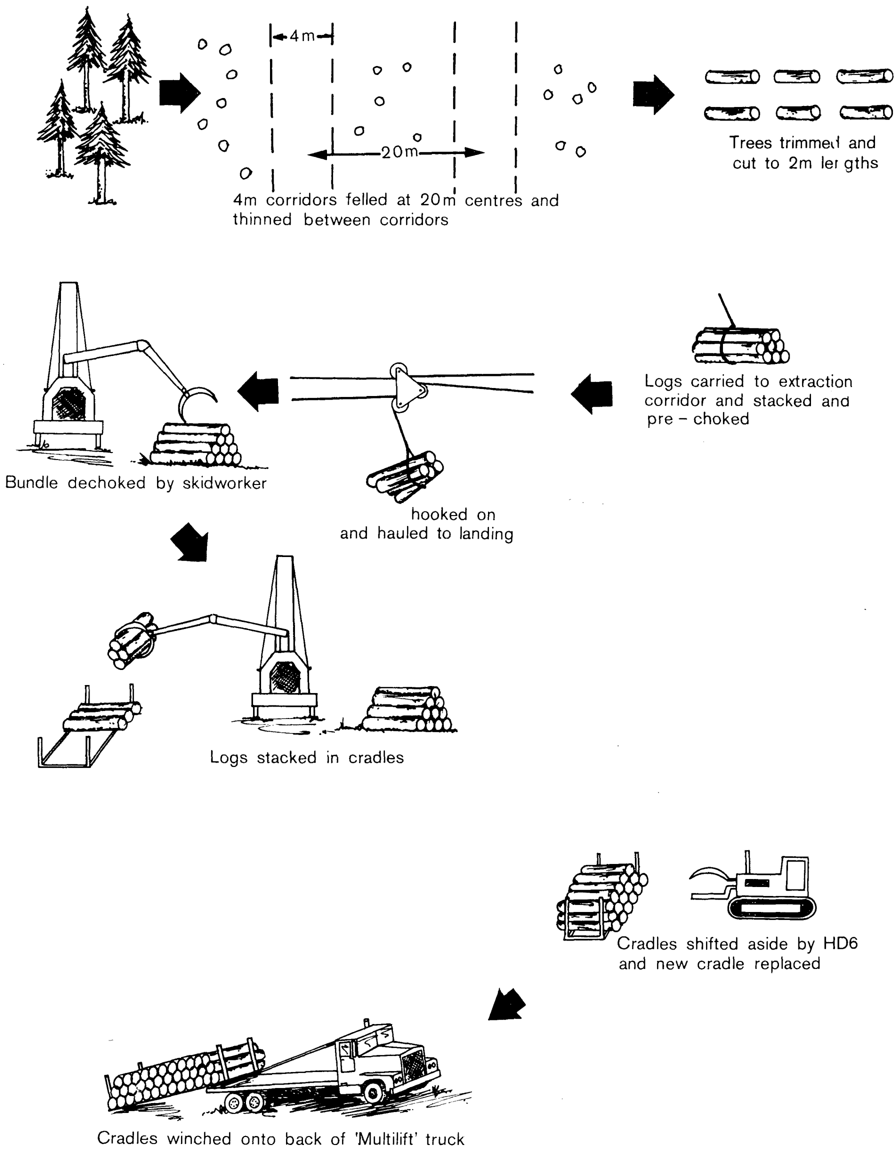

FIG. 2—Short pulpwood extraction with the Timbermaster Skyline.

The Lotus Skyline hauler was studied (McConchie 1979) in three operations – extracting tree-length logs uphill (Fig. 3) and downhill, and extracting log-length (up to 9.1 m) logs downhill (Fig. 4). The operating conditions are summarised in Table 1. It must be stressed that at the time of the trials the Lotus Skyline was a prototype machine still undergoing development.

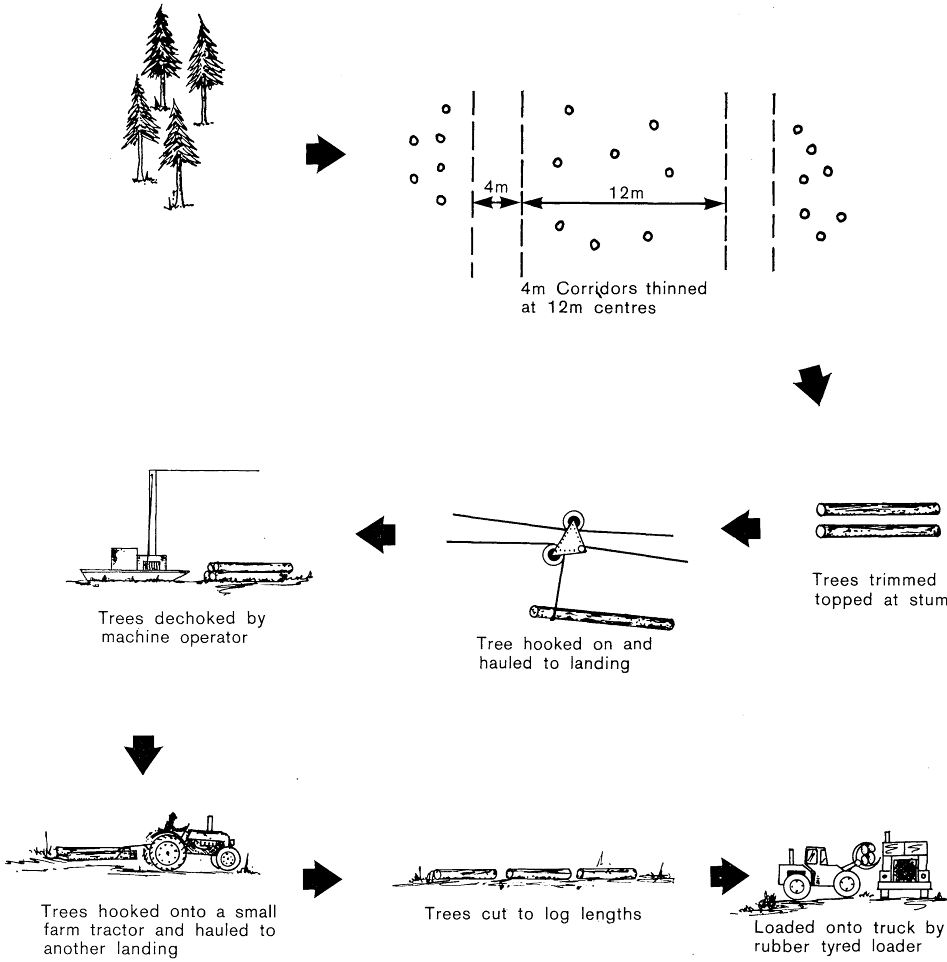

FIG. 3—Uphill tree-length extraction with the Lotus Skyline.

Lotus (Experimental) Interlock Hauler

The Lotus Skyline hauler was converted from a conventional three-drum hauler to a two-drum hydraulic interlock machine to test the interlock concept. Mechanical interlocking haulers have been used for decades in the north-western United States. Interlock systems can support and pull larger loads than conventional haulers with similar line sizes and power units (Carson & Jorgensen 1974).

The Lotus controls were converted from pneumatic to electric, also.

The Lotus Interlock hauler was used to extract tree-length 14-year-old *P. radiata* both uphill and downhill. The work methods used for the uphill extraction were similar to those shown in Fig. 3 except that a small skidder instead of an agricultural tractor was used to transfer the logs. For the downhill operation the work methods were as illustrated in Fig. 4. Operating conditions are summarised in Table 1.

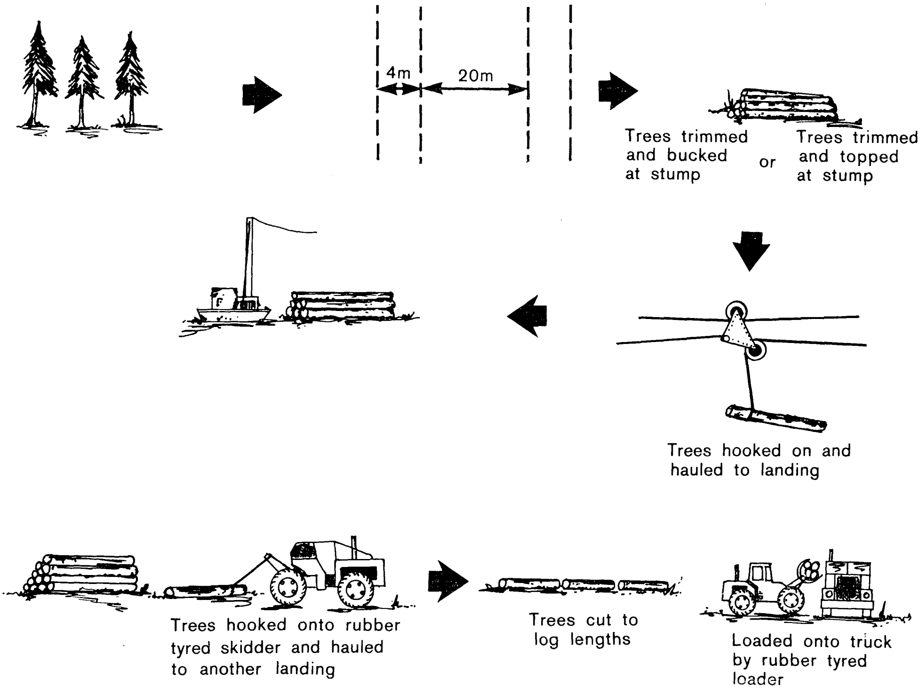

FIG. 4—Downhill extraction with the Lotus Skyline and the Lotus Interlock.

Wilhaul Skyline Hauler

The Wilhaul studied was a three-drum, 98-kW skyline hauler mounted on a Mercedes Benz truck chassis. Power was transmitted from the prime mover to the drumset via a transfer case, and a 9.1-m integral steel tower was attached to the hauler. A hydraulic knuckleboom loader mounted on the rear of the machine was not used during the study.

The unit was studied extracting 11-year-old *P. radiata* downhill (work methods *see* Fig. 5; operating conditions *see* Table 1).

The tree crop had been managed since planting to test the feasibility of organising the stand layout to improve harvesting productivity and allow for production thinning. The main criteria applied to the operation were that the presence of the production thinning element should not impede the growth of the pruned final-crop trees, that the cost of the operation should be largely covered by the sale of thinnings, and that physical damage to the final crop should be kept to a minimum (Terlesk & McConchie in prep.).

RESULTS

Factors Affecting Daily Production

Piece size

Undoubtedly the most important non-human factor affecting daily production of a hauler operation in thinning is piece size. Daily production increases linearly in pro-

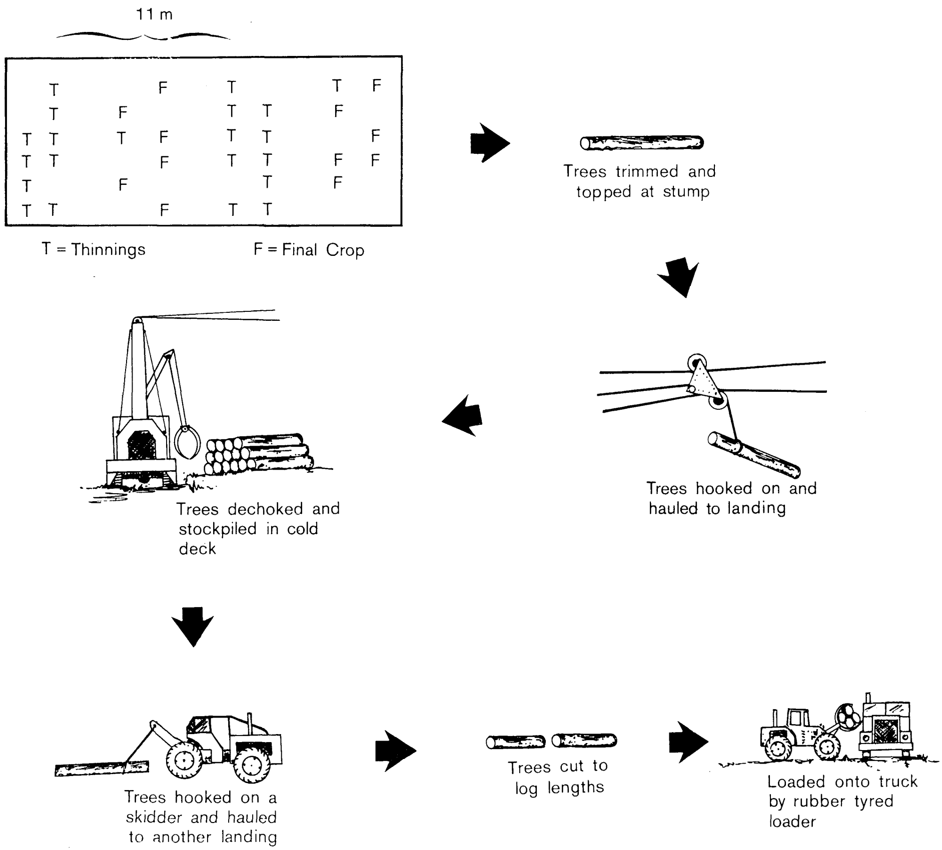

FIG. 5—Downhill tree-length extraction with the Wilhaul hauler.

portion to piece size until the point where the machine's capability is exceeded. Production can then be expected to drop rapidly. Figure 6 illustrates the effect of piece size on the daily production of the Lotus Skyline hauler extracting tree-length logs uphill. A similar pattern was found for the other systems studied.

The age at which a stand is extraction thinned determines the mean piece size. Because volume growth is exponential during the early years of a tree's life, a decision to thin a year earlier or later than originally planned can have considerable effects on mean piece size and thus on daily production and costs.

Small errors in assessment of piece size can also cause large errors in the estimation of production. For example, assessing the mean piece size of a stand to be 0.12 m^3 instead of 0.10 m^3 could result in a 20% over-estimation of daily production.

Pieces per cycle

Increasing the number of pieces hooked on per cycle will increase daily production if the machine has enough power and deflection to handle larger loads. The pattern illustrated in Fig. 6 for the Lotus Skyline hauler extracting tree-length logs downhill is

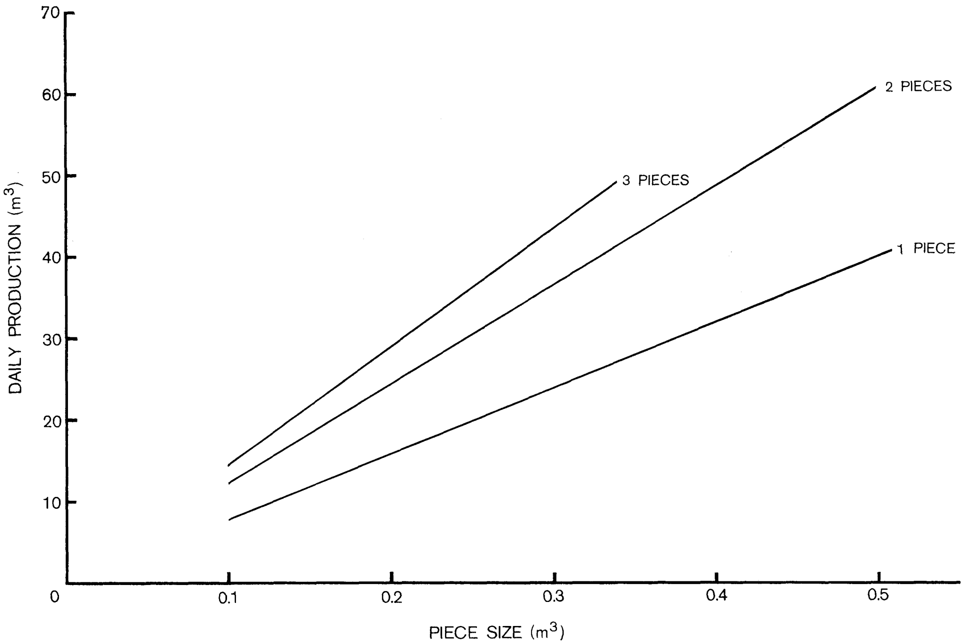

FIG. 6—Daily production **versus** piece size. (Assumptions: Lotus Skyline uphill; removal density 500 stems/ha; strip width 12 m; extraction distance 100 m).

also representative of the other systems. Although the number of cycles per day falls because of longer choking and dechoking times, the greater number of logs extracted per cycle more than compensates for this.

Extraction distance

For each system there is an optimum extraction distance at which daily production is maximised. Beyond this distance, hauling the logs to the landing and returning the carriage to the bush take up a relatively larger proportion of the cycle time, and daily production falls gradually.

At extraction distances less than the optimum, production falls rapidly because of the increasing frequency of skyline road changes which take between 30 and 90 min to carry out in a thinning operation. If intermediate supports have to be rigged, it can take even longer. In the time that it takes to change a skyline road (say 60 min) up to 10 hauls could have been extracted.

The optimum distance for each system will depend on such factors as strip width, removal density, number of logs extracted per cycle, machine line speeds, and the time needed to shift the skyline. For the systems studied the optimum corridor length (2 × optimum extraction distance) was found to be about 150 to 200 m. Because of the relationship described above, over-estimating the optimum distance is likely to have less effect on production than under-estimating it.

Removal density

Removal density has a minor effect on daily production. Increasing the number of trees removed per unit area makes building a load easier and reduces the frequency of skyline road changes. However, large changes in removal density cause only small changes in daily production. For example, increasing the removal density from 200 stems/ha to 700 stems/ha (250%) would increase the daily production of a Timbermaster Skyline extracting 0.2-m^3 trees by only about 30 to 50%.

Work Method Changes

Changing the decking system

Three types of decking were studied during the trials. Each had certain advantages (such as increased safety, lower costs, and reduced interference) and disadvantages under different situations.

A cold decking system was used when extracting logs downhill with the Lotus Interlock, Lotus Skyline, and Wilhaul haulers. Logs were left heaped under the skyline until all logs in the corridor were extracted and the hauler had been shifted to another corridor. The hauler operator had difficulty landing the logs and dechoking them when decks became too large and entangled.

A hot decking system was tried with the Lotus Interlock and Lotus Skyline haulers when extracting trees uphill. The trees were removed with a small skidder or agricultural tractor every two to three cycles to a separate processing area. Some interference usually occurred between the primary and secondary extraction phases.

"Warm" decking was used with the Timbermaster Skyline extracting trees both uphill and downhill. The trees were bucked into 6-m lengths by a skidworker under the ropes and then loaded into steel cradles by the hauler-mounted knuckleboom crane. The processing and loading activities usually interfered with the hauler extraction.

Figure 7 shows the effect of the three decking systems on daily production of a Lotus Skyline hauler extracting tree-length logs downhill. Although a warm decking system was not tested with the Lotus Skyline, its effect on daily production was calculated using pertinent elements and delays derived from studying the Timbermaster Skyline. The hot decking system was slightly more productive than the cold decking (2–3%) or warm decking systems (3–5%). Selection of a particular decking system is thus more likely to depend on landing, safety, or cost constraints than on hauler productivity.

Processing at the stump

In all trials trees were trimmed and topped at the stump but in two of the trials trees were also bucked. In the short pulpwood trial with the Timbermaster Skyline described in more detail previously (Murphy 1979b), productivity could be greater than in tree-length extraction systems for equivalent standing-tree sizes but only at the expense of a large labour input to manhandle heavy pieces of wood on steep country with no wage premium for the heavier work.

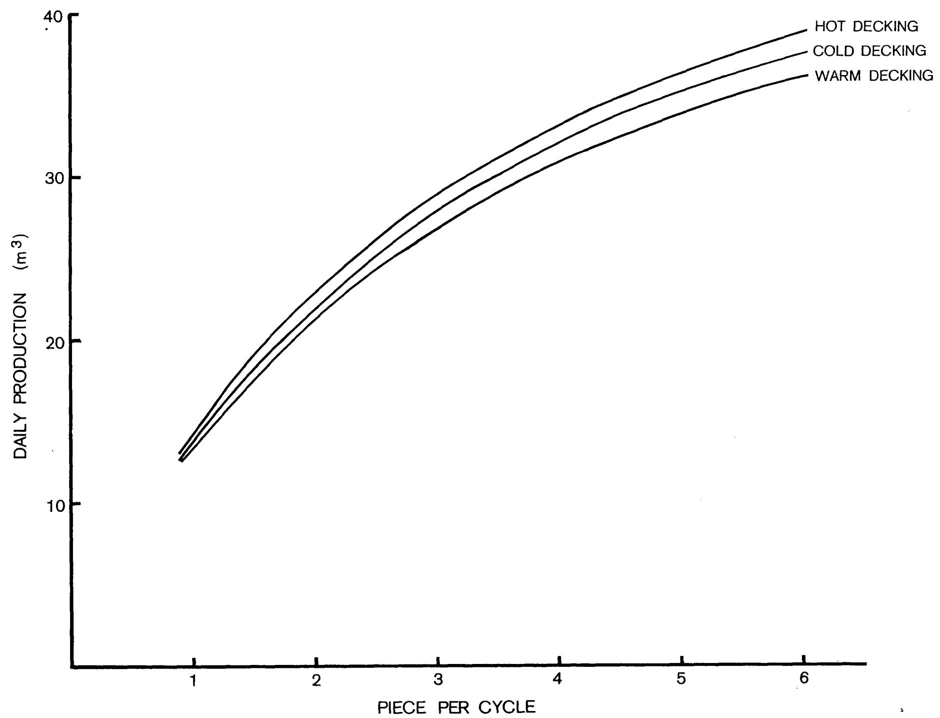

FIG. 7—Daily production **versus** decking systems.

In one trial with the Lotus Skyline hauler, trees were bucked into log lengths of up to 9.1 m to reduce damage to the residual stand during extraction. As a result the average piece size was reduced. Although the number of pieces extracted per cycle was greater (2.3) than for a comparable tree-length system (1.5), hooking on the additional pieces increased cycle times. Average haul volumes were also less than for a tree-length system despite the additional pieces choked. No gain in daily production could be expected from the manoeuvre.

Changing to a larger interlock running skyline

Interlock running skyline systems for equivalent line sizes and power units can handle larger loads than conventional skyline systems (Mann 1977). The Pee Wee yarder, developed in the United States for steep country smallwood harvesting, is an 82-kW hydraulic interlock running skyline (Table 2). The author has worked with this machine, and there is also more information available on its productive capability under a range of conditions (Pursell 1979; Mann 1979) than there is for the New Zealand-designed Lotus Interlock. It was examined as a means of increasing productivity and reducing costs.

TABLE 2—Machine characteristics

	Pee Wee yarder	Lotus Skyline hauler
Power (kW)	82	60
Line pull (kg)	2800	2000
Mainline speed at mid-drum diameter (m/min)	230	150
Line sizes (mm):		
Main	13	9
Haulback	13	9
Skyline	—	16
Slackline	13	—

Figure 8 shows expected daily production (average tree size 0.2 m^3) over a range of logs extracted per cycle. The shaded area indicates the levels of productivity for the New Zealand systems described, and the productivity curve for a Pee Wee yarder used in the same manner would lie about the centre of the shaded area. If some work methods were changed, however, greater advantage could be taken of the running skyline interlock system. Such changes could include prestropping logs, pre-rigging skyline road changes, hot decking, using a quick transfer system of chokers from the hauler to the skidder or agricultural tractor, wider spacing of corridors, and using a slack-pulling carriage. The solid line on Fig. 8 indicates the expected productivity of a Pee Wee yarder working under such a system. Some of these work methods are already used with New Zealand systems, with resulting greater productivity. The potential improvement is limited, however, by the difficult slack-pulling capability of the carriages used, the comparatively low hauler horsepower, and the narrow spacing of corridors associated with local hauler operations.

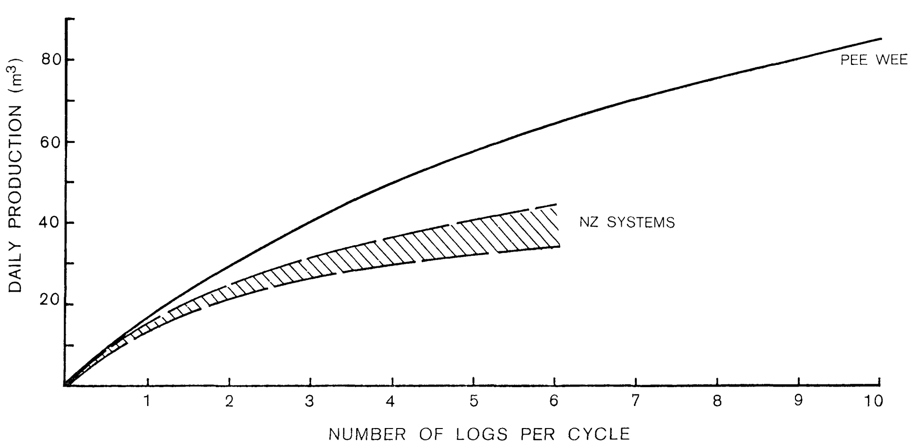

FIG. 8—Daily production and logs extracted per cycle.

Unit cost is generally considered to be the final criterion for comparison of systems. Any increase in daily production should result in lower unit costs if it is to be considered seriously. Although the Pee Wee yarder with improved methods could be more productive than other machines, unit costs would be higher unless four or more pieces were averaged per cycle (Fig. 9). This is about double the number of pieces normally extracted per cycle in New Zealand, although some operations in thinnings in the United States average over six pieces per cycle with this type of machine.

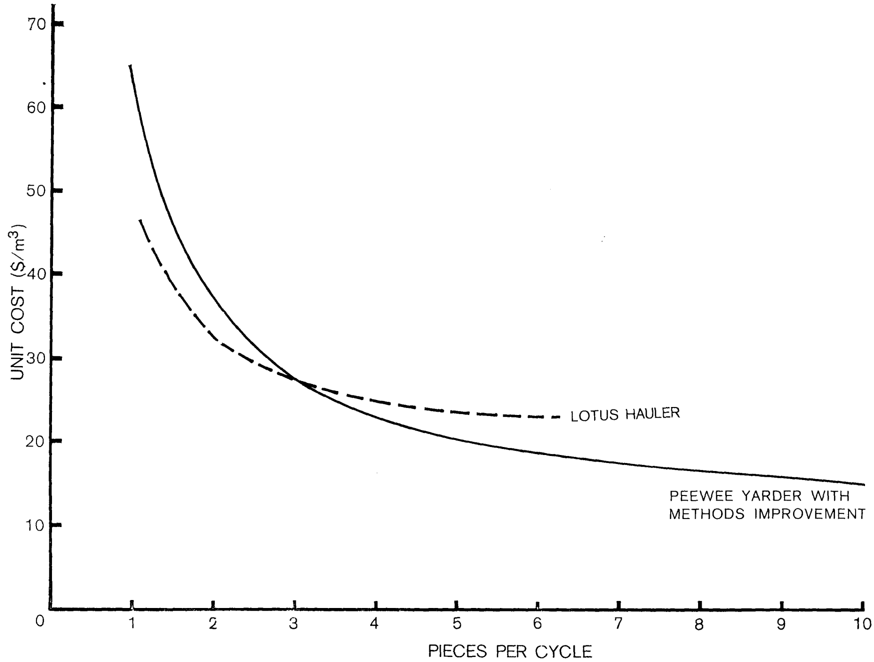

FIG. 9—Effect of improvement in methods on unit costs. (Assumptions: piece size 0.2 m^3; haul distance 100 m; removal density 500 stems/ha).

The cost of the Pee Wee yarder (about double that of the other machines) and the greater labour input required would result in higher daily costs. Thus larger hauls would be essential if unit costs were to be kept low.

Changing the Crop Layout

Re-organising the stand to improve thinning productivity by concentrating the thinning element in rows is another option for reducing smallwood harvesting costs (Terlesk & McConchie in prep.). The average number of pieces extracted per cycle in the Wilhaul trial in which the stand was laid out this way was 3.0. This is a 55% increase over the other systems which averaged only 1.9 pieces per cycle. The concentration of the thinning element made it easier to build a haul of reasonable size and resulted in greater daily production.

Planning, Supervision, and Motivation

Probably the most important factors determining daily production and unit costs are the planning of each setting and the supervision and motivation of the people doing the work.

When working with small haulers it is critical to set them up efficiently and in the best possible location if optimum use is to be made of their limited power, line sizes, and line pulls. Nor is there any margin for error in production estimates as there is with larger wood. At a rough estimate* the cost of planning and supervision of New Zealand hauler thinning operations is $1/m^3, or less than 5% of current "on-ride" costs.

The importance of motivation is well recognised, particularly for smallwood systems. Most, if not all, hauler thinning systems are owned by contractors with a vested interest in achieving high productivity and low costs. Many of their employees also work under a production target and incentive scheme.

CONCLUSIONS

Harvesting smallwood on steep country is a high-cost low-productivity operation, and so it is essential that planning and supervision are of a high standard to ensure that costs do not become exorbitant. Planning and supervision also have a small cost but are considered to be basic requirements for any smallwood harvesting system.

Piece size is one of the major factors affecting daily production. Reducing the piece size by lowering the age at which a stand is to be thinned, or by bucking at the stump, is likely to result in lower daily productivity and increased unit costs. The number of pieces extracted per cycle also affects daily production. Hooking on more pieces may increase cycle times but this is more than compensated for by greater daily production. It is essential that the greatest possible number of pieces, within the machine's power and safety capabilities, be extracted on each cycle. Reorganising the crop layout may make this easier to achieve. The optimum corridor length for New Zealand hauler thinning systems appears to be about 150–200 m, and it is essential that planning take this into consideration if production is to be maximised.

An interlock running skyline system such as the Lotus Interlock or the Pee Wee yarder should be able to reduce thinning costs provided suitable improvements in work methods are implemented so that the machines are used to their fullest capacity.

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REFERENCES

CARSON, W. W.; JORGENSEN, J. E. 1974: Understanding interlock yarders. **U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Research Note PNW-221.**

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* Based on a full-time supervisor with transport who supervises five gangs.

LIRA 1979: Lotus experimental skyline hauler (A progress report). **LIRA Report 4(7).**

McCONCHIE, M. 1979: Lotus experimental skyline hauler (Production summary). **LIRA Report 4(12).**

MANN, C. N. 1977: Running skyline systems for harvesting timber on steep terrain. Paper presented at Society of Automotive Engineers Earthmoving Industry Conference, Peoria, Illinois.

——— 1979: The Pee Wee yarder research program. **Proceedings of IUFRO Symposium on Mountain Logging, Seattle:** 207–12.

MURPHY, G. 1979a: The Forest Research Institute's work on cable logging: A review of its main findings. **New Zealand Journal of Forestry 24(1):** 76–84.

——— 1979b: Applications of the Timbermaster Skyline in Australia and New Zealand. **Proceedings of IUFRO Symposium on Mountain Logging, Seattle:** 98–106.

PURSELL, W. W. 1979: A production study of the Pee Wee yarder during a skyline thinning operation. M.Sc. Thesis, University of Washington.

TERLESK, C. J.; McCONCHIE, M.: Stand reorganisation: Another approach to the accumulation problem (in prep.).

WELLS, G. C. 1980: Industry smallwood harvesting intentions. **Smallwood Harvesting Proceedings, LIRA Project Report 13.**