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HINNING YOUNG TIMBER STANDS
I MOUNTAINOUS TERRAIN

D. KELLOGG

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ABSTRACT

The Forest Engineering Department, Oregon State University, has evaluated several systems for thinning young timber stands on steep terrain. Stands averaged 35 to 40 years old and 25.4 to 35.6 cm (10-14 in.) dbh. Approximately 40 percent of the stems per hectare were removed in the thinning operations. This paper discusses research findings from 1972 to 1979 on felling and bucking as well as yarding. Felling and bucking production increased with thinning intensity. Tractor yarding production decreased with increasing slope percent. Total skyline logging cost ranged from 1.5 to 1.67 times that of tractor logging on slopes up to 40 percent. Prebunching logs to the skyline corridor increased yarding production for the machine on the landing. Using intermediate supports has extended yarding distances on convex slopes for short towers such as the Igland-Jones Trailer Alp.

INTRODUCTION

Timber harvesting is moving from declining old growth to young growth in the Pacific Northwest region of the United States. Twenty-five percent of the commercial forest land in the Douglas-fir region of Oregon and Washington--over one million hectares--is young timber stands (Aulerich, 1975) less than 70 years old, with most trees less than 50.8 cm (20 in.) dbh (diameter at breast height, 1.3 m) or logs averaging less than 0.48 m^3 (17 ft^3). Many forest managers consider thinning an important silvicultural treatment in immature stands to stimulate growth of residual trees. Many of these stands are on steep mountainous terrain or on fragile soils requiring cable logging techniques. However, to be economically feasible, the harvesting cost must be compatible with the price for the small logs. Therefore, old growth logging equipment and techniques must be changed to better handle smallwood.

In 1972, the Forest Engineering Department at Oregon State University (OSU) began a research program aimed at improving harvesting operations in young timber stands growing on steep slopes. At that time, little information existed defining production or cost for young growth harvesting, particularly with cable systems, in the Pacific Northwest. We began our research by gathering production and cost data for several operations and

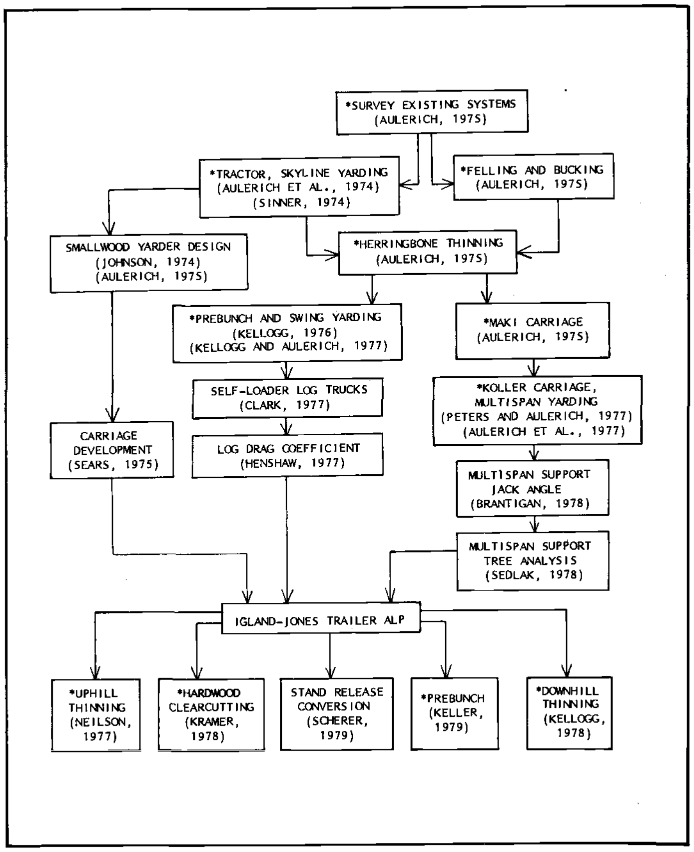

Figure 1.

Harvesting research projects at Oregon State University, 1972 to 1979. Asterisk (*) denotes studies discussed in this paper. Reference represents source of more detailed information in each area.

techniques and identifying variables influencing production. After an initial data base was developed and production variables identified, specific operational techniques to improve thinning were evaluated. The OSU smallwood harvesting program included 18 research projects from 1972 to 1979 (Fig. 1). These projects systematically addressed components of the felling, bucking, yarding, and loading activities to evaluate concepts, techniques, or methods of thinning new to the Pacific Northwest. Eleven of the studies have dealt most specifically with thinning techniques and harvesting production. In this paper, these 11 have been categorized into five areas--felling and bucking, tractor versus skyline, prebunch and swing yarding, multispan yarding, and the Igland-Jones Trailer Alp. Study conditions are presented and the findings summarized.

STAND DESCRIPTION AND STUDY PROCEDURE

Research studies were conducted on forest land owned and managed by the OSU School of Forestry. Stand characteristics are summarized in Table 1. Logging was done by contract loggers working on the School forest. Nearly uniform stand conditions and constant crew composition permitted researchers to focus on the harvesting systems studied without the variation encountered in industrial operations.

Detailed time studies were performed on all operations. Each activity in an operation was timed with a stop watch. One of two time-analysis techniques was used in each study: the multimoment method, in which a dot was recorded at regular intervals for the particular activity occurring, or the "flip back" method, in which times were recorded continuously for each activity by resetting the stop watch to zero when a new activity began. For either method, times were recorded to the nearest 1/10th or 1/100th of a minute. Variables influencing logging production such as yarding distance and pieces per turn were also measured as part of the time study.

A statistical analysis was done for each operation and predictive production equations were developed to aid us in comparing operations and for evaluating alternative harvesting techniques.

TABLE 1.

AVERAGE TIMBER STAND CHARACTERISTICS FOR HARVESTING RESEARCH PROJECTS AT OREGON STATE UNIVERSITY, 1972 TO 1979.

Characteristic	Measurement or item
Age	35 years
Species	Douglas-fir (*Pseudotsuga menziesii*)
	Western hemlock (*Tsuga heterophylla*)
dbh	25.4-35.6 cm (10-14 in.)
Log size	0.37 m^3 (13 ft^3)
Stems/hectare (acre)	544 (220)
Volume/hectare (acre)	33.90 m^3 (4,800 ft^3)
Stem removal, %	40
Slope, %	0-70

FELLING AND BUCKING

The major objectives were to define cutting production and cost for thinning operations over a range of conditions. Three random tree-selection patterns were studied: light thinning (37% stem removal), medium thinning (51% stem removal), and heavy thinning (62% stem removal). Additionally, herringbone thinning, a form of strip thinning, was evaluated (Fig. 2); this felling pattern requires 100 percent stem removal within the herringbone strips and no thinning outside. Skyline corridors and lateral strips averaged 6.1 m (20 ft) wide. The herringbone patterns averaged 35-percent removal of trees in the stand.

The fallers selected trees to be cut in the random thinning operations. The better dominant and codominant trees were left according to spacing guidelines requiring 7.6 m (25 ft) spacing in the heavy cut, 6.1 m (20 ft) in the medium cut, and 4.9 to 5.2 m (16-17 ft) in the light cut. Skyline corridors were flagged for clearcutting in all thinning patterns. Lateral strips in the herringbone patterns were located with a staff compass and flagged for clearcutting.

The time required for felling and bucking was segregated into 11 activities, themselves summarized into seven categories (Table 2). The most time-consuming

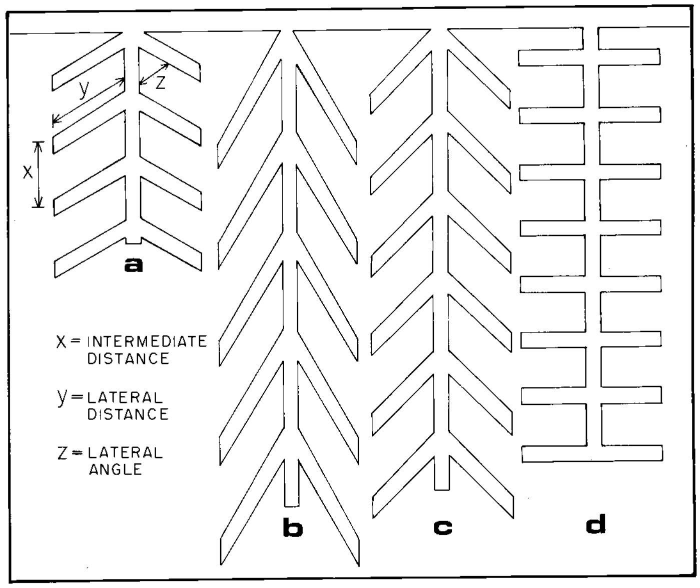

Figure 2.

Herringbone thinning patterns: (a) lateral distance = 35.7 m (117 ft), intermediate distance = 27.4 m (90 ft), and lateral angle = 60°; (b) lateral distance = 61.0 m (200 ft), intermediate distance = 43.0 m (141 ft), and lateral angle = 30°; (c) lateral distance = 43.4 m (142 ft), intermediate distance = 35.1 m (115 ft), and lateral angle = 45°; and (d) lateral distance = 30.5 m (100 ft), intermediate distance = 24.4 m (80 ft), and lateral angle = 90° (from Aulerich, 1975).

TABLE 2.

AVERAGE FELLING AND BUCKING TIME PER TREE BY ACTIVITY AND INTENSITY OF STEM REMOVAL (MINUTES PER TREE/PERCENT OF TOTAL TIME PER TREE) (AULERICH, 1975).

Intensity	Select tree	Fell tree	Correct hangup	Buck tree	Limb tree	Delay	Other*	Total/ tree
Light	0.79/11	0.97/14	0.56/8	1.00/20	0.24/3	1.31/18	1.79/25	6.66
Medium	0.89/12	1.24/16	0.54/7	1.75/23	0.82/11	0.79/11	1.49/20	7.52
Heavy	0.43/7	1.01/16	0.23/4	1.36/22	0.44/7	1.29/21	1.37/23	6.13
Herringbone	0.05/1	1.45/26	0.10/0	1.76/32	0.51/9	0.59/11	1.15/21	5.61

*Includes moving, site preparation, equipment collection, felling of nonmerchantable material, and helping another worker.

activity was either "buck tree" or "other," averaging 24.25 percent and 22.25 percent of total time, respectively. The average total felling and bucking times per tree generally decreased as thinning intensity increased, resulting in higher daily cutting production as a higher percentage of stems per hectare were removed. First, as thinning intensity increased, loggers spent more time cutting trees and less time considering which trees to cut (see "select tree" category). Second, hangups, which required additional work to get the tree on the ground, occurred more frequently as thinning intensity decreased (see "correct hangup" category). The OSU Forest Science Department is currently measuring residual tree growth in the herringbone thinnings for comparison to that in the random tree-selection thinnings.

TRACTOR VERSUS SKYLINE

After the felling and bucking study was completed, a series of detailed yarding studies was conducted to define yarding production and cost in a random felling pattern by comparing a crawler tractor to a skyline yarder over a range of conditions. Then skyline yarding production was measured in the herringbone units and in a random thinning pattern using a carriage designed for a two-drum yarder.

A random block design was applied. Two thinning intensities (35% and 55%) and two slope classes (20% and 40%) were selected. Average yarding distances were: skyline yarding 94.5 m (310 ft), skyline lateral yarding 14.9 m (49 ft), tractor yarding 120.7 m (346 ft), and tractor winching 9.4 m (31 ft).

The tractor operation used a John Deere 450 or an International TD 9B crawler tractor; the yarding crew included an operator and chokersetter. The skyline operation used a Schield-Bantam T350 yarder with 304.8 m of 1.90-cm (1,000 ft of 3/4-in.) skyline, 274.3 m of 1.59-cm (900 ft of 5/8-in.) mainline, and 457.2 m of 1.11-cm (1,500 ft of 7/16-in.) haulback. The yarding crew included a yarder engineer, two chokersetters, and a chaser who doubled as a skidder operator. A rubber-tired skidder swung the logs from the landing to the loading deck. In the first study with the Bantam yarder, a Ross carriage was used, and the haulback held the carriage in place during lateral yarding. Slack in the mainline was pulled manually.

In the skyline operation, hooking was the single most time-consuming activity, accounting for 19 percent of the total turn time. The lateral yarding sequence (pulling the end of the mainline from the corridor to the log and then yarding the log to the corridor) consumed 27 percent of the total turn time. In addition, resets to free turns from hangups and to lessen residual stand damage increased yarding time 10 percent. Time for the preceding activities (getting the log into the skyline corridor) represented 56 percent of the total turn time, and this time can be costly when the hourly cost to run a skyline operation is high. The cost per hour for the skyline operation was 2.5 times more expensive than the tractor operation. Much of our subsequent research was directed toward evaluating techniques for reducing time and cost in the lateral yarding sequence.

Yarding slope had a greater influence on the tractor operation than the skyline operation (Table 3). Tractor yarding production dropped more than 15 percent whereas skyline production fell less than 3 percent as slope increased from 20 to 40 percent. Thinning intensity had the

TABLE 3.

SKYLINE AND TRACTOR YARDING PRODUCTION FOR 7-HOUR DAY (AULERICH ET AL., 1974).

	Skyline				Tractor			
	Thinning Intensity, %							
	35		55		35		55	
	Slope, %							
Item	20	40	20	40	20	40	20	40
Logs	121	118	137	134	135	117	140	121
m^3	29.07	28.46	32.96	32.17	32.52	28.07	33.79	29.02
fbm	6,158	6,030	6,983	6,815	6,890	5,948	7,158	6,148
Cunits	10.26	10.05	11.64	11.36	11.48	9.91	11.93	10.25

greatest effect on skyline yarding (a 12-percent drop in production) as stem removal decreased from 55 to 35 percent. Average daily yarding production was similar for tractor and skyline operations.

Tractor yarding cost less than skyline yarding (Table 4). Skyline yarding costs ranged from 2.25 to 2.75 times those of tractor yarding, depending on slope and thinning intensities. Total skyline logging costs, including felling and bucking, yarding, loading, and hauling, ranged from 1.5 to 1.67 times those of tractor logging.

Logging costs incurred in any thinning operation should be offset by the value of the timber removed and the silvicultural improvement to the stand. Thinning can cause serious damage to residual trees and to the site. Differences initially were found between the two logging methods evaluated (Aulerich et al., 1974), indicating less harmful stem damage in the skyline than the tractor operation. Additionally, the tractor operation resulted in higher soil compaction. The OSU Forest Science Department is studying the long-term effects, as yet unknown, after logging.

Next, skyline yarding in stands thinned with the four herringbone patterns (Fig. 2) was evaluated. Slope and timber type were the same as those in the randomly thinned stands, and the same Schield-Bantam yarder and crew were used. Comparing these two skyline operations under similar conditions showed a 17-percent reduction in average turn time using herringbone thinning. Statistical analysis indicated (at the 90% confidence level) that the lateral angle of the clearcut strips off the main corridor was not a significant predictor of turn time.

In thinning operations, the carriage must remain fixed in one location during each lateral yarding cycle to reduce hangups and lessen residual stem damage. The haulback accomplished this in the skyline study using the Ross carriage, but the slackline system used required a three-drum yarder. A three-drum yarder is more expensive than a two-drum machine, and many operators adapting their equipment to thinning operations in the Pacific Northwest have two-drum machines. As an alternative, the Maki carriage, a unique carriage designed for thinning requiring only a two-drum yarder, was evaluated (Fig. 3). For each turn, the carriage was held to one location on the skyline with a stop device that clamped to the skyline. The carriage was released from the stop when a ferrule near the end of the mainline snapped into the lock in the carriage. The carriage stop was moved along the skyline by lowering the skyline and releasing the clamp. On the average, the stop was moved 10.7 m (35 ft) once every 5.5 turns in 1.86 minutes. Total turn time was reduced 22 percent using the Maki rather than the Ross carriage over comparable conditions in random thinning patterns at an average yarding distance of 70 m (200 ft).

TABLE 4.

TRACTOR AND SKYLINE LOGGING COST (YARDING ONLY/TOTAL COST) (AULERICH ET AL., 1974).

	Thinning intensity, %			
	35		55	
	Slope, %			
Item	20	40	20	40
		Skyline		
$/m^3	12.45/19.52	12.71/19.79	10.98/18.05	11.25/18.32
$/M fbm	58.76/92.14	60.01/93.39	51.82/85.20	53.09/86.47
$/cunit	35.26/55.28	36.00/56.03	31.09/51.12	31.85/51.88
		Tractor		
$/m^3	4.41/11.49	5.11/12.18	4.25/11.32	4.94/12.02
$/M fbm	20.83/54.21	24.13/57.51	20.05/53.43	23.34/56.72
$/cunit	12.50/32.53	14.48/34.51	12.03/32.06	14.00/34.03

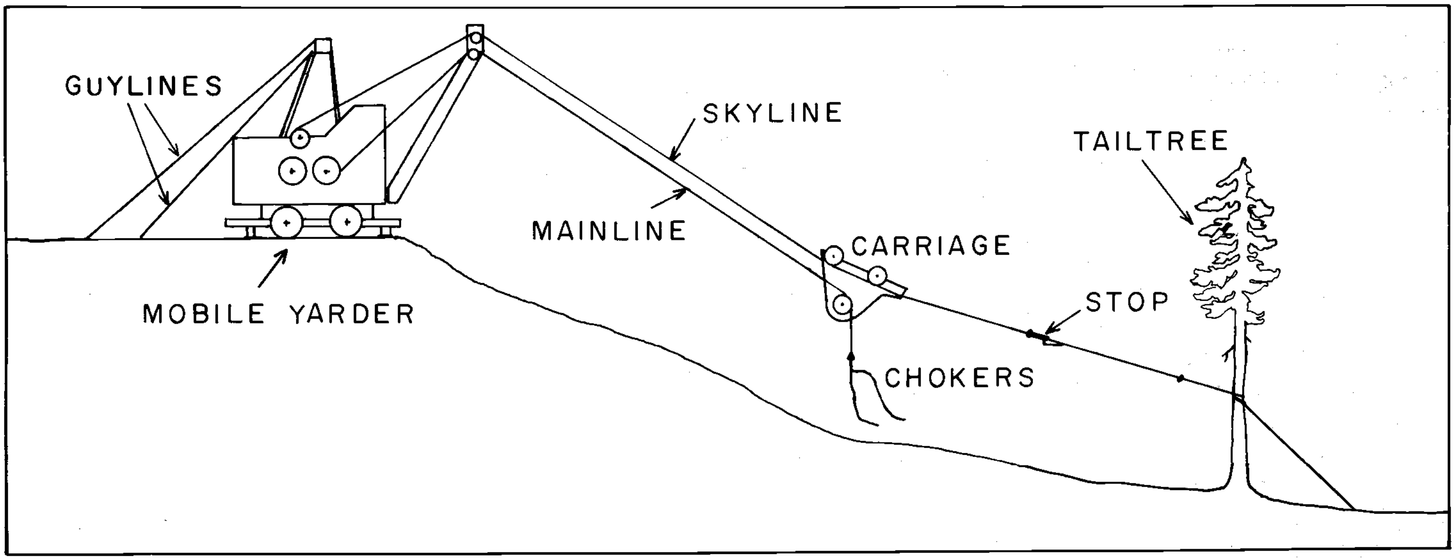

Figure 3.

Yarding layout using Maki carriage (from Kellogg, 1976).

PREBUNCH AND SWING YARDING

Our first studies in young growth thinning provided a good data base, suggesting many promising areas for improving production and lowering thinning cost. One such area was the lateral yarding sequence.

Several activities occur during lateral yarding. Pulling line manually to the logs is difficult work and often requires adding an extra person to the yarding crew. Hooking is the most time-consuming part of the operation, during which the yarder is idle. Finally, yarding logs into the corridor usually involves additional time fighting hangups. If the time-consuming lateral yarding sequence could be accomplished with a less expensive system than previously described, thinning cost might be reduced. A research project testing a two-step yarding procedure--prebunch and swing--was conducted to evaluate this hypothesis (Fig. 4).

Prebunching logs to the skyline corridor was accomplished with a small, portable, single-drum winch consisting of a 47-hp engine and a remote-controlled winch unit capable of spooling 96.3 m of 0.95-cm (316 ft of 3/8-in.) line. The unit was mounted on a metal sled, which together weighed 726 kg (1,600 lb). Yarding required only one person; however, in a production setting, an additional person would fell trees just prior to prebunching. The two could rotate positions.

The machine was winched along the skyline corridor into various settings. At each setting, a 12.7-cm (5-in.) block was hung in a tree along the corridor; often, more than one tree was used at the same machine location. A 1.8-m (6-ft) ladder was used to hang the block 3.0-3.6 m (10-12 ft) in the tree to gain lift when prebunching. Prebunch yarding brought the lead end of the logs into the skyline corridor. Average prebunch yarding distance was 23.2 m (76 ft). The total cost for the prebunching operation was $11.92 per hour.

In the second step of the operation, the same Schield-Bantam yarder used in earlier projects swung the prebunched logs to the landing. Lateral yarding was not required during the swinging operation, reducing the crew size by one. Total yarding cost per hour for swinging was $49.67.

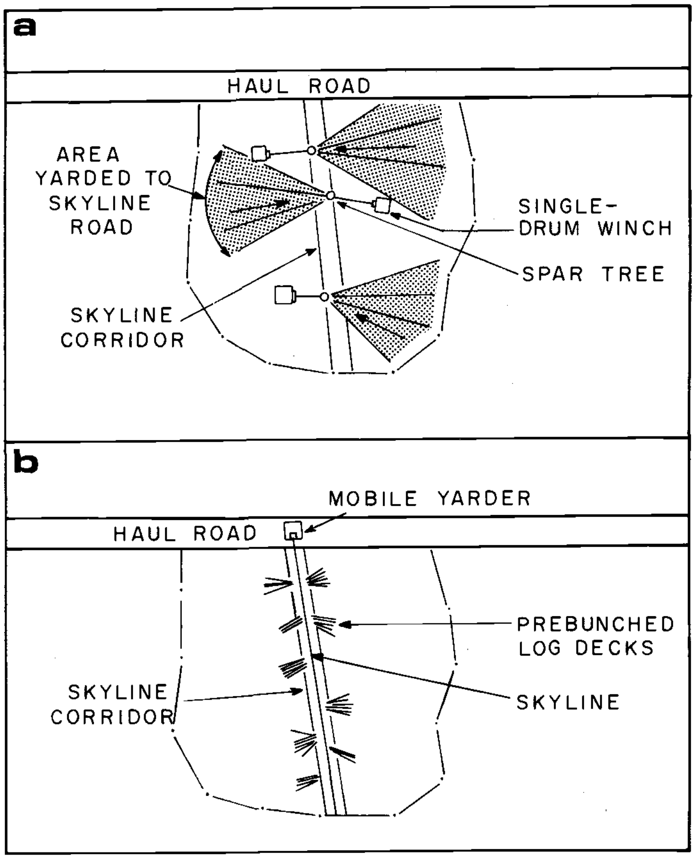

Figure 4.

Two-step thinning system: (a) prebunching with single-drum winch, then (b) swinging prebunched decks with mobile yarder (from Kellogg, 1976).

The prebunch and swing yarding strategy was compared to an earlier skyline thinning project with similar conditions except without prebunching (Table 5). The average skyline yarding distance was 54.3 m (178 ft); the average lateral yarding distance without prebunching was 23.1 m (76 ft). Daily production for the Schield-Bantam yarder more than doubled when lateral yarding was eliminated and logs were prebunched in the skyline corridor. Yarding cost was reduced 27 percent using the prebunch and swing yarding strategy.

Several factors contributed to the cost difference between the two systems. First, Schield-Bantam daily production was lower for skyline thinning without prebunching due to the time-consuming lateral yarding sequence. Additionally, the yarder brought in less volume per turn compared to the swing operation. Second, labor costs were reduced during the swing operation with only one chokersetter working in the skyline corridor compared to two chokersetters required for slackpulling. Third, lateral yarding was accomplished with a relatively low-investment machine, and the more costly skyline yarder was more fully utilized in the swing operation.

TABLE 5.

PRODUCTION AND YARDING COSTS WITH AND WITHOUT PREBUNCHING BASED ON 8-HOUR DAY (KELLOGG, 1976).

Item	Prebunch and swing: Single-drum winch	Prebunch and swing: Schield-Bantam	No prebunch: Schield-Bantam only
No. logs	105	396	182
m^3	46.24	168.00	77.39
Cunits	16.33	59.33	27.33
Cost/hour	\$11.92	\$49.67	\$58.90
Cost/unit			
\$/m^3	2.06	2.36	6.09
\$/cunit	5.84	6.70	17.24
Sum	\$4.42/m^3 \$12.54/cunit		\$6.09/m^3 \$17.24/cunit
Difference	\$1.67/m^3 \$4.70/cunit		

MULTISPAN YARDING

One of the first tasks completed in planning our harvesting research program was a survey to determine what equipment and techniques were currently being used for thinning. For the most part, yarders had short towers (6.1–15.2 m, or 20–50 ft) and were relatively mobile to keep rigging cost low (Aulerich, 1975). Short towers with single span skylines often restricted yarding distance on convex or broken slopes. Multispan yarding, tested prior to 1976 in several European countries and to a limited degree in the United States, had gained little acceptance in the Pacific Northwest primarily due to the long road changing time associated with intermediate supports (Peters and Kellogg, 1978). Yet intermediate supports seemed promising for yarding difficult terrain using short towers in the Pacific Northwest if road changing time could be reduced. As a result, several projects to evaluate multispan yarding in thinning operations were initiated.

In the first study, 16 skyline corridors were rigged with either one or two intermediate supports per corridor and yarded with the Schield-Bantam using a Koller carriage. The Koller SKA 2.5 is a self-clamping carriage rated for loads up to 2,500 kg (5,500 lb) and weighs 250 kg (550 lb, Fig. 5). In this study, outhaul was by gravity although a haulback could be used if needed. The carriage clamps to the skyline to facilitate lateral yarding. The clamping mechanism is part of the skyline carriage that is activated at the hook point by a directional change of the carriage.

All skyline corridors were flagged before cutting. Intermediate support trees, tailtrees, and tailholds were located and ground profiles run. Skyline road changes and logging proceeded more smoothly when each corridor was carefully planned using a combination of practical field layout and analysis techniques aided by a desk-top computer (Hewlett-Packard 98-30).

The key to rigging intermediate supports quickly is using light lines and blocks well matched to the loads they must carry and a minimum guying of support trees. Analysis of forces produced during yarding revealed that support lines of 1.90 cm (3/4 in.), initially used, could be reduced to 1.27-cm (1/2-in.) diameter (Peters and Aulerich, 1977). A double-tree

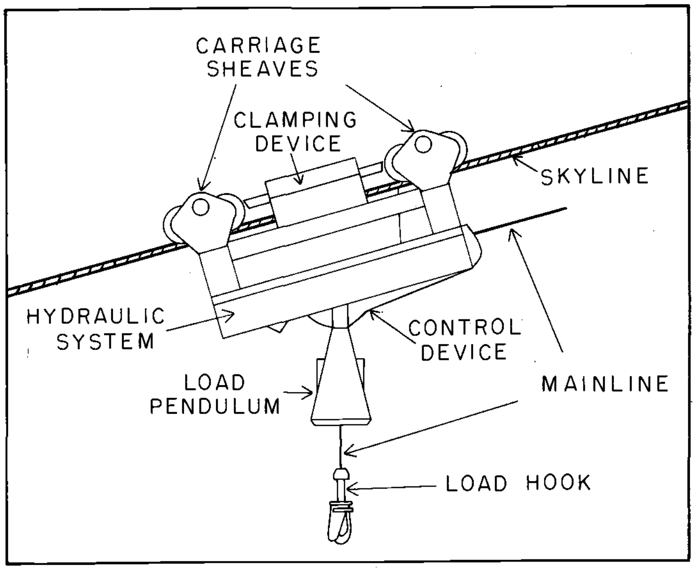

Figure 5.

Koller self-clamping carriage type SKA 2.5 gravity system (from operating instructions for the Koller Automatic Cable Crane, undated).

intermediate support system was adopted for our thinning operations (Fig. 6). No additional guylines were needed because the support line was rigged to also stabilize the support trees. Rigging the intermediate supports was normally accomplished before the skyline road change (prerigging) by one person in less than two hours. Rigging involved hanging a 10.16- to 15.24-cm (4- to 6-in.) block in each tree approximately 10.7 m (35 ft) from the ground. The intermediate support line was placed in each block and remained slack between the two trees. The intermediate support jack was then attached to the support line by placing the support line in a block above the jack. During the actual road change, the support line was pulled by two or three people to raise the jack and skyline in the air. Raising the support line usually took less than 10 minutes. Each end of the support line was finally tied off to nearby stumps.

Thinning with the Koller carriage yarding over intermediate supports averaged 145 logs per day at an average skyline yarding distance of 113.7 m (373 ft) and a lateral yarding distance of 11.4 m (39 ft). There was no drop in production in this study compared to earlier single span thinnings with the Schield-Bantam. In addition, yarding distance had been extended on convex slopes using intermediate supports.

The multispan system, successfully applied in thinning Pacific Northwest forests, offers another logging alternative. Road changing time was not significantly increased using intermediate supports, especially when the support system could be "pre-rigged" before changing skyline corridors.

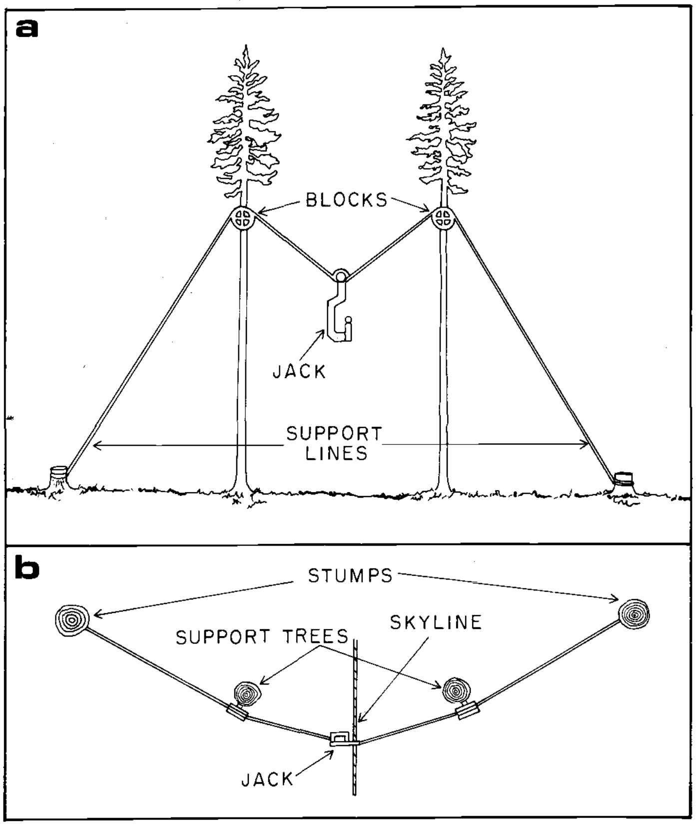

Figure 6.

Double-tree intermediate support system: (a) front view, (b) top view (from Peters and Aulerich, 1977).

IGLAND-JONES TRAILER ALP

Our 1972 survey indicated that "small" yarders (such as the Schield-Bantam or those in the Skagit SJ series) and medium-class yarders (such as the Skagit GT-3, Washington 78, and Madill 071) were predominately used for thinning in the Pacific Northwest (Aulerich, 1975). Additionally, there were many homemade configurations. At that time, no manufacturers produced or seemed interested in developing yarders specifically designed for smallwood.

Yarding costs can be lowered in two ways: by increasing production or by reducing equipment ownership and operating costs. The yarders previously mentioned can be expensive (up to $300,000) and were not designed for young growth thinning operations. In addition, a yarding crew of four to six people is usually required, resulting in high labor cost. Earlier work with the Schield-Bantam (Aulerich et al., 1974) showed us that, although skyline yarding production could equal tractor yarding production, the hourly ownership and operating costs were widely separated, resulting in higher logging cost with the more expensive equipment. Logically, then, less expensive yarders designed specifically for handling smallwood should be used.

Several European systems designed for smallwood had seen little application in Pacific Northwest thinning. One such machine is the Igland-Jones Trailer Alp. The Alp used small lines and rigging equipment and cost much less ($46,000) than most of the new yarders used at the time. The operator also served as the chaser. A cooperative research project between OSU and several timber companies was established to purchase the Alp and evaluate the concept of using a small, inexpensive yarder in Pacific Northwest applications.

The Igland-Jones Trailer Alp (Fig. 7), partly produced in Scotland and partly in Norway, is designed for yarding distances up to 609.6 m (2,000 ft). The skyline drum can store 914.4 m of 1.59-cm (3,000 ft of 5/8-in.) line, and the mainline and haulback drums can each hold 548.6 m of 0.95-cm (1,800 ft of 3/8-in.) line. The yarder has an additional utility drum and a strawline drum. Drum frictions and brakes are mechanical but hydraulically

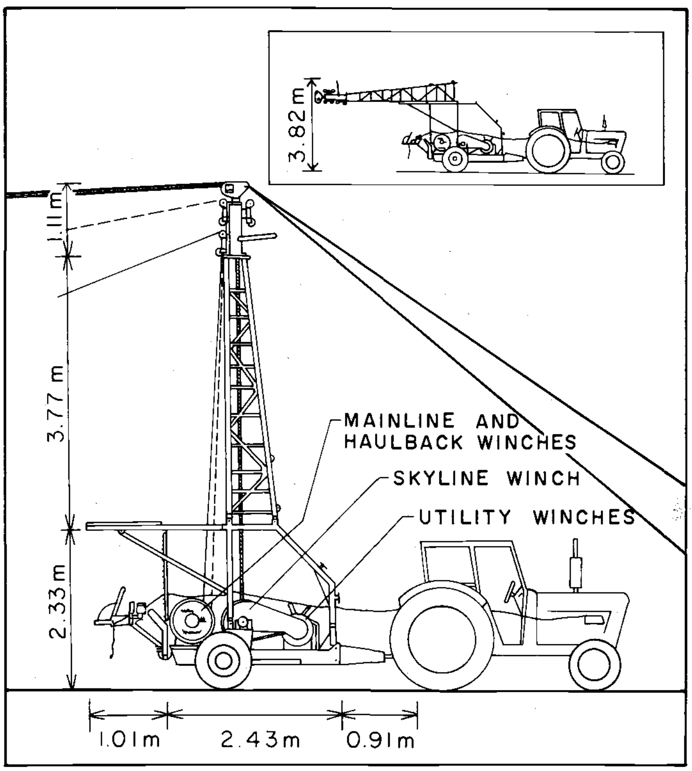

Figure 7.

Igland-Jones Trailer Alp.

controlled. The tower, 7.3 m (24 ft) tall, folds at the base for transport. The machine is stabilized with three guylines. A John Deere 2640 70-hp farm tractor was the power source for the winch units on the yarder and transported the machine between skyline roads.

Four different yarding studies were completed with the Alp; additionally, release-conversion of a hardwood stand was researched (Scherer, 1979). The first involved thinning uphill with intermediate supports on four corridors and without intermediate supports on three corridors (Neilson, 1977). The average skyline yarding distance was 45.7 to 91.4 m (150-300 ft), and the average lateral distance was 12.2 m (40 ft). Two different Igland-Jones carriages were used in this study: a simple carriage for single span yarding (Fig. 8b, inset) and a carriage designed to pass intermediate supports (Fig. 8a, inset). A standing skyline configuration was used, and slack was pulled manually to reach the logs off the skyline corridor (Figs. 8a and b). The haulback line held the carriage in place when logs were brought into the corridor.

In a second study, yarding uphill in a hardwood clearcut operation (Kramer, 1978), the average skyline yarding distance was 76.2 m (250 ft) and the average lateral yarding distance, 11.6 m (38 ft). The hardwood stand averaged 378 stems/ha (153/acre) with an average piece size of 0.45 m^3 (16 ft^3). A combination of single span and multispan yarding was also tested in this study. The two Igland-Jones carriages were used in yarding configurations similar to the uphill thinning study (Figs. 8a and b). In addition, a Christy carriage was used. The Christy, similar to the Maki carriage used in previous research projects, is stopped on the skyline and held stationary during lateral yarding with a mechanical stop that clamps to the skyline (Fig. 8c, inset).

A third project evaluated the Trailer-Alp yarding downhill in a thinning operation (Kellogg, 1978). All but one of the nine

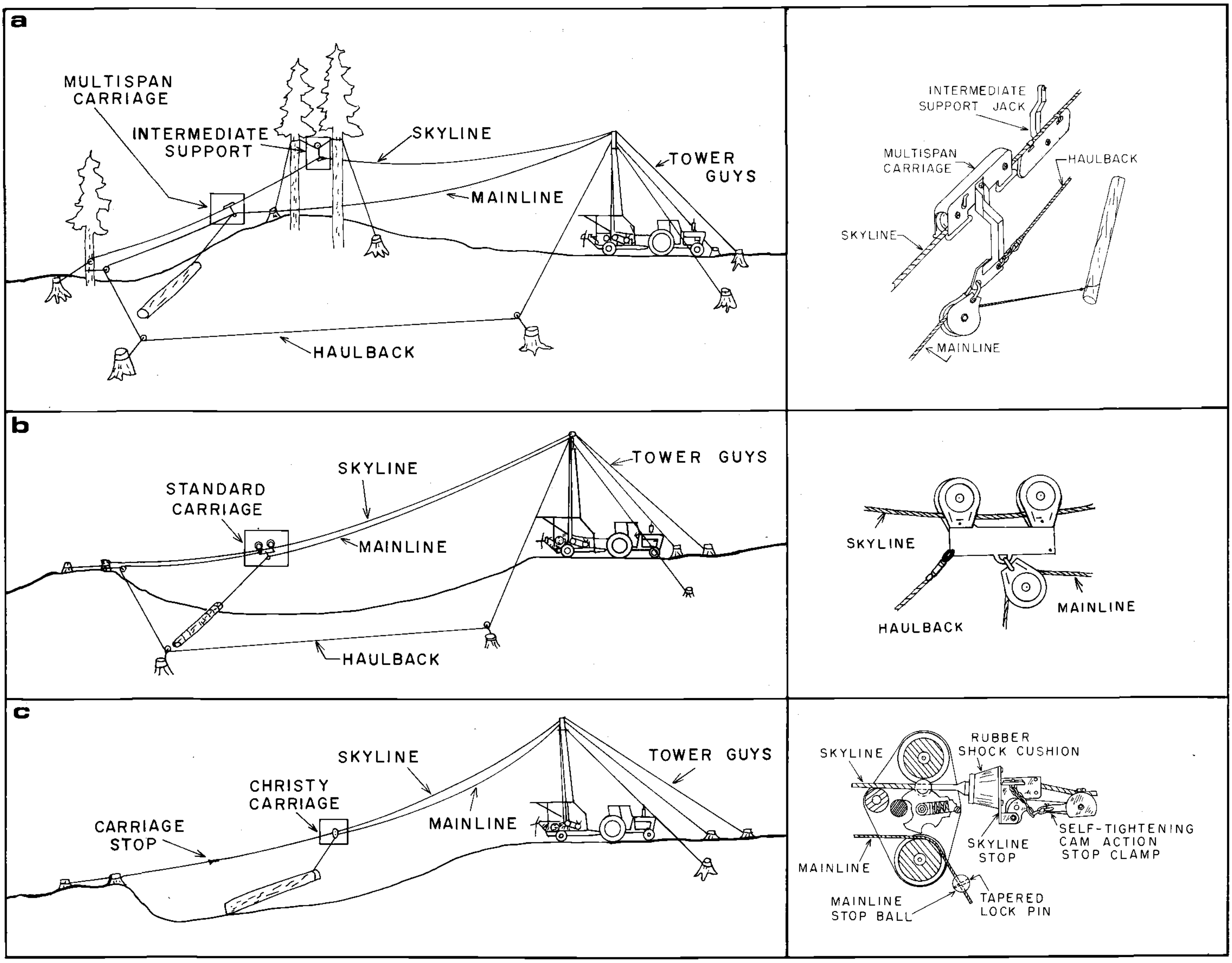

Figure 8.

Rigging layouts and carriages used with Igland-Jones Trailer Alp: (a) multispan standing skyline using Igland-Jones multispan carriage; (b) single-span standing skyline using Igland-Jones standard carriage; and (c) single-span live skyline using Christy carriage (from manuscript submitted for publication, P. A. Peters and L. D. Kellogg, 1979).

corridors logged required intermediate supports, and two intermediate supports were required on six corridors. The average skyline yarding distance was 143.3 m (470 ft) and the average lateral yarding distance was 8.5 m (28 ft). Tree-length material was yarded on five corridors, and bucked logs were yarded on four. A slack-pulling Igland-Jones Alp Cat carriage designed to pass intermediate supports was used. A three-part drum in the carriage spools on mainline, haulback, and a separate skidding line (approximately 38.1 m of 0.95-cm, or 125 ft of 3/8-in., line). A separate carriage stop clamps to the skyline, serving to release the drum brake in the carriage to allow for lateral yarding.

In the last study (Keller, 1979), the Trailer-Alp was used for prebunching. The earlier prebunching project showed that a single-drum winch prebunching logs to a skyline corridor reduced thinning cost. However, a winch unit dependent on pulling itself over the terrain could present difficulties in much of the steep, brushy terrain common to the Pacific Northwest. The first prebunching project showed that a low-investment machine with low operating cost was desirable for a prebunching operation, and the research group felt the Igland-Jones Trailer Alp represented such a machine. It also had the advantage of remaining on the landing during prebunching.

The Trailer Alp was used to prebunch logs to skyline corridors. The Igland-Jones Alp carriage and Christy carriage were used for both manual slackpulling and haulback-assisted slackpulling (Figs. 8a and c, insets, and 9). The prebunched skyline corridors required intermediate supports. Average prebunching yarding distance was 18.40 m (62 ft).

Swinging the prebunched logs was done with a West Coast yarder/Madill 071, a four-drum machine with a crawler tractor undercarriage and a 14.94-m (49-ft) tower. Drum capacities are 487.68 m of 2.86-cm (1,600 ft of 1 1/8-in.) skyline, 365.8 m of 1.40-cm (1,200 ft of 3/4-in.) mainline, 670.6 m of 1.43-cm (2,200 ft of 9/16-in.) haulback and 487.7 m of 1.11-cm (1,600 ft of 7/16-in.) guinea line. The drums have Wichita brakes. A Koller carriage was used during the swing operation because it could pass intermediate supports.

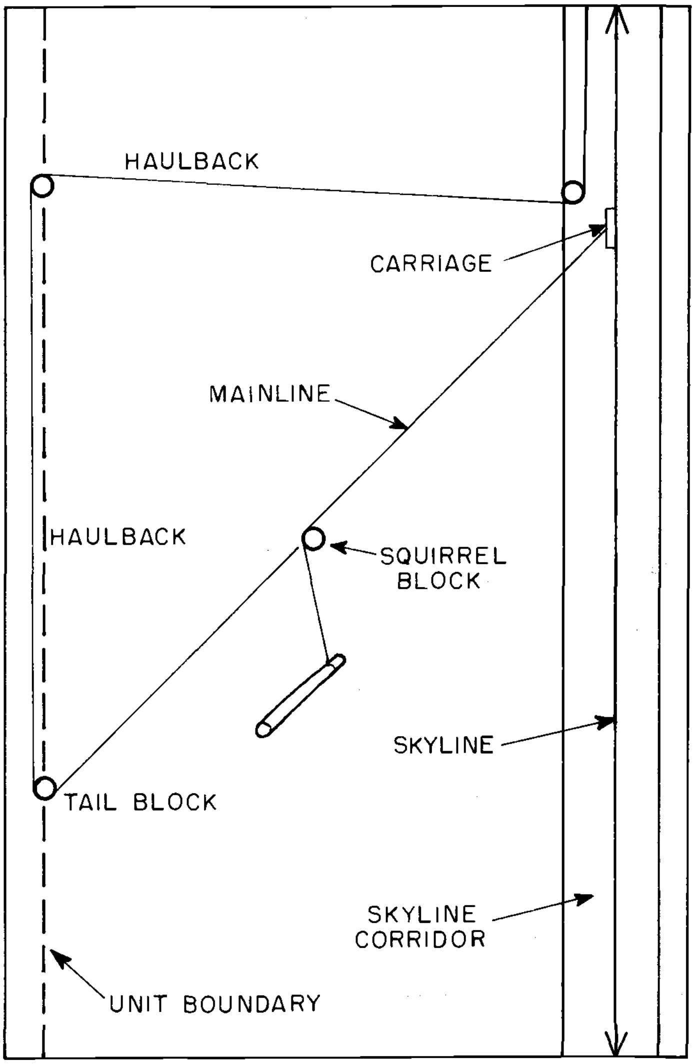

Figure 9.

Haulback-assisted slackpulling layout in prebunching operation using Trailer Alp (from Keller, 1976).

Production and cost in the prebunch and swing operation were compared to the West Coast yarding an adjacent area without prebunching. Stand characteristics and crew composition remained fixed. For the thinning operation without prebunching (full cycle thinning), a West Coast slackpulling carriage containing a three-part drum was used. The 61.0 m of 1.59-cm (200 ft of 5/8-in.) skidding line is controlled by the guinea line from the yarder to pull slack and by the mainline to take up slack. In both operations with the West Coast yarder, the average slope yarding distance was 141.4 m (464 ft), and the average lateral yarding distance was 18.3 m (60 ft).

In all the OSU studies using the Trailer Alp, the hourly operating cost ranged from $53.38 to $56.42, depending on yarding accessories and when costs were determined. Production and cost on the landing for the uphill thinning, clearcut studies, and downhill thinning are summarized in Table 6. Data are based on a three-man crew that rotated positions to become familiar with each task. The crew also felled and bucked the timber before yarding.

In the hardwood clearcut operation, the gravity outhaul system using the Christy carriage was estimated to be 35 percent more efficient than the system using the single span Alp carriage with a haulback (Kramer, 1978). This increased efficiency was attributed to the faster outhaul and rig-up times associated with the gravity system.

In the downhill yarding study, the average turn volume was 22 percent greater for tree length yarding than for yarding bucked logs. However, average turn time was 1.12 minutes longer when yarding tree length material than when yarding bucked logs. There was little difference in the daily production between tree length and bucked log yarding.

Average road changing time (hours) for Trailer-Alp operations were: uphill thinning without intermediate supports, 1.83; uphill thinning with intermediate supports, 2.17; uphill clearcutting without intermediate supports, 1.17; downhill thinning with intermediate supports, 7.07; and prebunch thinning with intermediate supports, 6.07. In all except downhill thinning, the haulback and mainline were laid out without using a strawline; the downhill operation required using a 0.32-cm (1/8-in.) strawline. The light line frequently broke during road changes, causing recurrent delays, indicating the need for bigger strawline in future applications. The road changing time for downhill yarding was excessively long because of crew inexperience and the intermittent work schedule required to complete the project. A road changing time of 4 hours was assumed for developing the downhill yarding production rates in Table 6.

The production and costs for both systems in the prebunch study are presented in Table 7. Production increased 22 percent for the West Coast yarder when logs were prebunched in the corridor and no lateral yarding was required. However, total yarding cost also increased $6.67 per

TABLE 6.

DAILY PRODUCTION AND LOGGING COSTS ($) ON THE LANDING FOR THE IGLAND-JONES TRAILER ALP BASED ON 8-HOUR DAY.

	Uphill thinning[1]		Clearcut, single span, Christy carriage[2]		Clearcut, multispan, Alp carriages[2]		Downhill thinning: Tree length		Downhill thinning: Bucked logs	
Item	Production	Cost/unit	Production	Cost/unit	Production	Cost/unit	Production	Cost/unit	Production	Cost/unit
No. pieces	90		192		134		73		89	
Cunits	11.58	35.30	31.68	13.64	21.20	20.25	12.53	36.02	11.37	39.70
M fbm	6.95	58.83	13.46	32.11	9.11	47.11	6.26	72.10	5.68	79.46
m^3	33.00	12.46	89.70	4.82	60.03	7.15	35.48	12.72	32.20	14.02

[1]Neilson 1977.
[2]Kramer 1978.

m^3 ($18.95 per cunit) using prebunch and swing compared to full cycle thinning with the West Coast yarder. The prebunching yarding cost was not offset by the increased production of the West Coast yarder swinging logs.

The key to prebunch and swing yarding is to prebunch logs to the skyline corridor with an inexpensive system, then to lower the cost of moving logs up the corridor by increasing production for the skyline yarder and eliminating the lateral yarding sequence. Inexpensive prebunching can be achieved with the right combination of low equipment cost, low labor cost, and high yarding production. Hourly costs using the two prebunching systems studied (Tables 5 and 7) were distinctly different; also, production more than doubled for the Schield-Bantam when swinging logs (Table 5) but only increased 22 percent for the West Coast yarder (Table 7). We are pursuing the findings from these two prebunch and swing yarding studies and continuing to research this concept.

TABLE 7.

PRODUCTION AND YARDING COSTS WITH AND WITHOUT PREBUNCHING BASED ON 8-HOUR DAY (KELLER, 1979).

	Prebunch and Swing		No prebunch
Item	Trailer-Alp*	West Coast Yarder	West Coast Yarder only
No. logs	163	357	290
m^3	54.90	121.42	99.33
Cunits	19.39	42.88	35.08
Cost/hour	$56.42	$79.74	$89.56
Cost/unit			
$/$m^3$	8.20	5.23	6.76
$/cunit	23.22	14.82	19.14
Sum	$13.43/$m^3$ $38.09/cunit		$6.76/$m^3$ $19.14/cunit
Difference		$6.67/$m^3$ $18.95/cunit	

*Prebunching layout: Alp multispan carriage, manual slackpulling.

APPLICATION

Harvesting operations in young timber stands in the Pacific Northwest can be difficult and challenging, especially when profit margins for selling smallwood are narrow. The OSU Forest Engineering Department evaluated a number of different techniques used in thinning operations. All the research projects complemented each other and aimed toward the same final goal--improving operations in young timber stands on mountainous terrain. We are continuing with further research in this area.

It was not the intent of these research projects to provide production rates and logging costs for purposes of timber harvesting appraisal. Use of the figures in this manner can yield inaccurate estimates. The results of these projects present options to be considered by persons involved in smallwood harvesting and show relative differences between systems within the conditions of the studies.

As the timber industry continues advancing into young forests with harvesting operations, there is a continual need for research and evaluation of alternative harvesting systems and techniques.

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BRITISH/METRIC CONVERSIONS

1 acre = 0.4047 hectare (ha)
1 inch (in.) = 2.54 centimeter (cm)
1 foot (ft) = 0.3048 meter (m)
1 mile = 1.6093 kilometer (km)
1 pound (lb) = 0.45359 kilograms (kg)

Kellogg, Loren D. 1980. THINNING YOUNG TIMBER STANDS IN MOUNTAINOUS TERRAIN. Forest Research Laboratory, Oregon State University, Corvallis. Research Bulletin 34. 19 p.

Several systems for thinning young timber stands (35-40 years old) on steep terrain are evaluated. Felling and bucking production increased with thinning intensity. Tractor yarding production decreased with increasing slope percent. Total skyline logging cost ranged from 1.5 to 1.67 times that of tractor logging on slopes up to 40 percent. Prebunching logs to the skyline corridor increased yarding production for the machine on the landing. Intermediate supports extend yarding distance on broken terrain for towers such as the Trailer Alp.

KEYWORDS: harvesting, thinning, skyline yarding, tractor yarding, prebunching, multispan, Trailer Alp.

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