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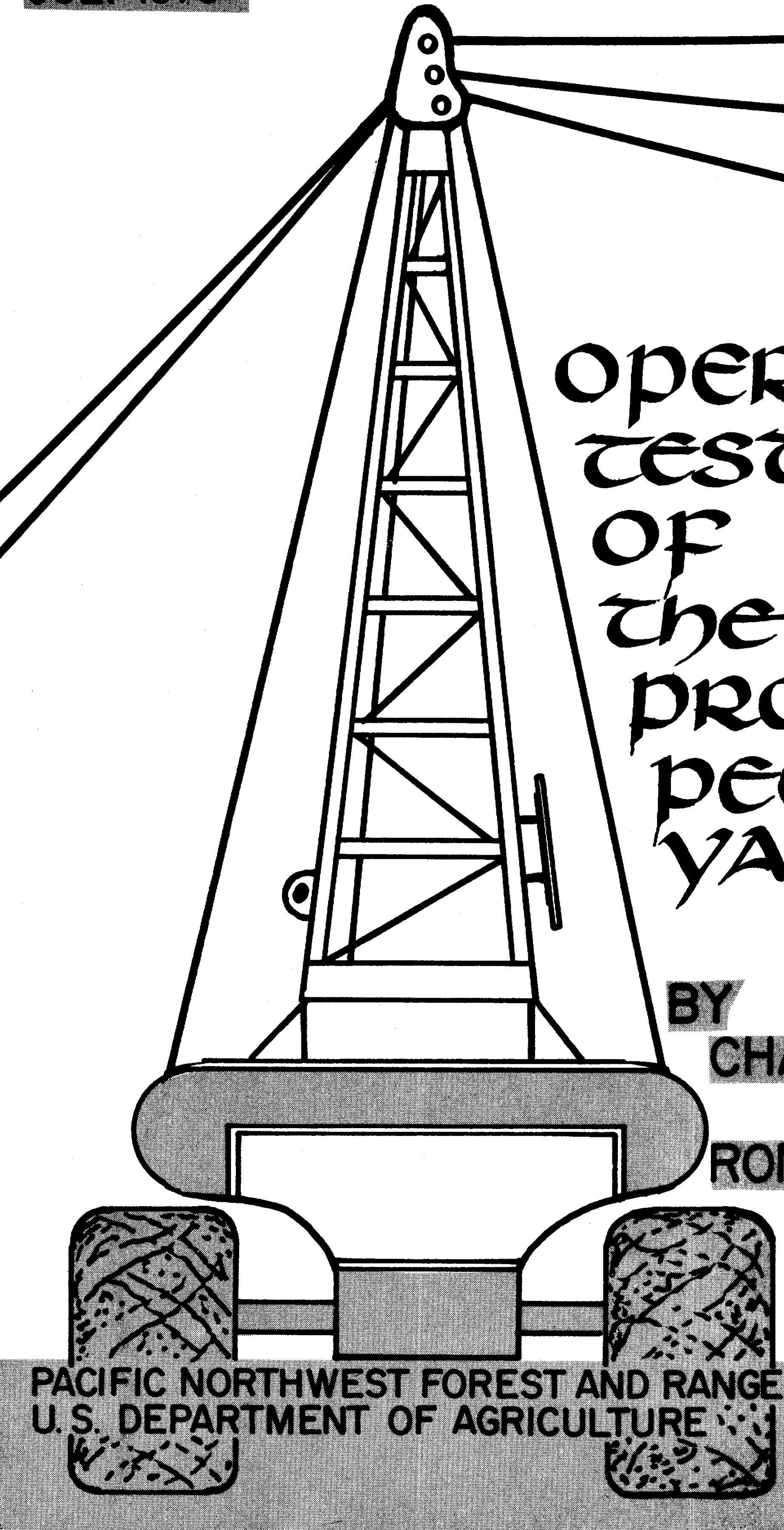

OPERATIONAL TEST OF THE PROTOTYPE PEEWEE YARDER

BY
CHARLES N. MANN
AND
RONALD W. MIFFLIN

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE   FOREST SERVICE

ABSTRACT

An operational test of a small, prototype running skyline yarder was conducted early in 1978. Test results indicate that this yarder concept promises a low cost, high performance system for harvesting small logs where skyline methods are indicated. Timber harvest by thinning took place on 12 uphill and 2 downhill skyline roads, and clearcut harvesting was performed on 4 uphill skyline roads. Skyline roads were spaced about 46 meters (150 feet) apart and were up to 335 meters (1,100 feet) long. Delays caused by the yarder were insignificant. Production as high as 343 logs per day was achieved.

KEYWORDS: Logging equipment engineering, production studies(-forest operations, logging operations analysis/design, logging economics.

Contents

Introduction

An operational test of the prototype peewee yarder was performed as part of a program to develop a system for harvesting small logs in areas where cable logging methods are required. The test was conducted at the University of Washington's experimental forest near Eatonville, Washington, by the Applied Physics Laboratory, a division of the University, on behalf of the Forest Engineering Unit of the Pacific Northwest Forest and Range Experiment Station. The objective of the test was to monitor the productivity of the system in a logging operation.

A thinning harvest was performed on 12 uphill and 2 downhill skyline roads over a 6-week period which began on February 22, 1978; and another week was spent in a clearcut area on 4 uphill skyline roads.

The need for commercial thinnings and the magnitude of the task were described by Lysons (1975). He also listed the systems criteria and technical requirements for suitable cable logging thinning equipment. Consideration of these criteria and requirements established the design of the peewee yarder.

Yarding System

The peewee yarder operates a running skyline system as shown in figure 1.

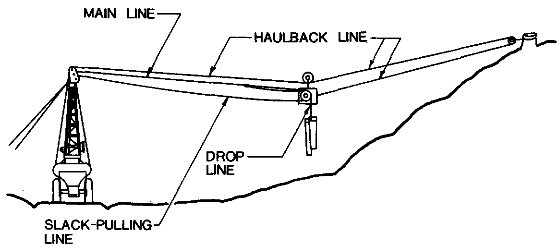

Figure 1.--Running skyline system.

The running skyline system was chosen because it provides a combination of features which are not available with other cable logging systems. These include: high mobility due to minimum rigging and small, light lines; versatility due to the ability to log uphill and downhill; and lateral yarding capability for partial cut operations which is provided by the slack-pulling carriage. General specifications for the yarder and yarding system are listed in table 1.

The prototype yarder (fig. 2) is mounted on a rubber-tired John Deere JD 640[1] cable skidder. Modifications to the skidder include removal of the winch and arch and installation of an oil cooler. The drum set is fastened to the skidder frame where the arch is normally located. A tower, with straw line and guyline drums, is mounted to the top of the drum set and can be lowered by hydraulic cylinders (fig. 3).

The drum set contains the main, slack-pulling, and haulback drums and the mechanism for interlocking the drums together. While details of interlocking drums are beyond the subject of this report, the peewee drum set is an advancement in interlock technology which

[1]Mention of products or trade names does not imply endorsement by the U.S. Department of Agriculture.

Table 1--General specifications of peewee yarder prototype mounted on John Deere JD 640 cable skidder

Engine power	82 kilowatts (110 horsepower)
Span capability	366 meters (1,200 feet)
Lateral yarding capability	46 meters (150 feet)
Line speed:[1]	
Inhaul/outhaul	3.8 meters/second (750 feet/minute)
Lateral yarding	0.76 meters/second (150 feet/minute)
Line pull:[1]	
Main	27 000 newtons (6,000 pounds)
Slack-pulling	20 000 newtons (4,500 pounds)
Haulback (interlock tension)	40 000 newtons (9,000 pounds)
Drop line	40 000 newtons (9,000 pounds)
Overall dimensions:	
Height (tower erected)	11.3 meters (37 feet, 0 inches)
Height (tower lowered)	3.7 meters (12 feet, 2 inches)
Length (tower erected)	6.5 meters (21 feet, 4 inches)
Length (tower lowered)	9.4 meters (30 feet, 8 inches)
Width	3.06 meters (10 feet, 1/2 inch)
Weight	19 958 kilograms (44,000 pounds)

[1] At mid-drum diameter on 366-meter (1,200-foot) span.

Figure 2.--Prototype peewee yarder.

Figure 3.--Prototype peewee yarder with tower lowered.

simplifies control and reduces cost. For basic information on interlocked drum sets, refer to Mann (1977).

The yarder is driven hydraulically which eliminates the need for clutches and brakes. The three yarder control functions are operated by two levers. Speed and longitudinal direction of the carriage is controlled by one lever. The other lever is bidirectional and is used to raise and lower the carriage and control the drop line. All three control functions can be operated at the same time.

The operator's control station, enclosed by a protective screen, is located at the rear of the skidder. It is designed to allow the operator to unhook the turns, eliminating the need for a chaser. Additional levers at the control station operate the hydraulically driven guyline and strawline drums, hydraulic lift cylinders, and engine speed. An instrument box allows the operator to monitor skidder and yarder systems. A gage indicates interlock pressure which is a direct measure of haulback tension.

Two carriages were used during the test. The first was a conventional mechanical slack-pulling carriage modified for 1/2-inch lines. It housed side-by-side sheaves for the drop line and the slack-pulling line. A problem was encountered as the slack-pulling line and drop line tended to twist or wrap around each other as they entered the carriage. Manual untwisting of the lines was often required to allow enough drop line to pass through the carriage to continue yarding. The twisting also resulted in kinked drop lines which had to be replaced.

Line twisting problems accounted for more delay time than any other problems encountered during the test. In an effort to reduce this problem, a second carriage (fig. 4) was designed by the Forest Engineering Research Unit. The primary features of this carriage are:

1. The sheaves are aligned in a plane, one below the other. This increases separation of the lines which reduces twisting and line wear.

Figure 4.--Slack-pulling carriage designed by the Forest Engineering Research Unit.

2. The lower carriage frame is hinged to allow the drop line sheave to separate from the pressure roller when a load is placed on the drop line. This prevents the drop line from twisting as it travels across the sheave.

Twisting problems were practically eliminated following the introduction of this carriage. Continuing design effort is expected to improve carriage operation and reduce carriage weight.

Test Site

Testing of the peewee yarder was conducted at the University of Washington's Pack Forest which is managed as an experimental forest.

Yarding tests took place in a 50-year-old stand of mixed Douglas-fir and red alder. The test site was on predominantly Site III land with very irregular terrain and stand density. All merchantable alder was removed wherever practical. The Douglas-fir thinning and salvage removed intermediate, overtopped, and damaged trees. In areas where Douglas-fir was predominant, approximately 120 cubic meters per hectare (17 cunits per acre) were removed from an estimated stand volume of 420 cubic meters per hectare (60 cunits per acre).

Logging Layout

The thinning operation was conducted in an area of about 14 hectares (35 acres). The yarder was set up on 12 uphill and 2 downhill skyline roads which extended approximately at right angles to an existing haul road. Skyline roads were spaced about 46 meters (150 feet) apart. Span lengths varied from 113 meters (370 feet) to 338 meters (1,108 feet), the average being 243 meters (797 feet). Average slope of the spans ranged from 31 percent downhill to 24 percent uphill.

Yarding corridors were initially flagged from selected tailholds. Narrow corridors were cleared to allow passage of the carriage and log loads. Trees to be removed were felled in a herringbone pattern which allowed logs to be pulled directly into the corridor.

The final test phase was a clearcut harvest of about 1.6 hectares (4 acres) of predominantly alder. Yarding took place on four uphill skyline roads which were about 150 meters (500 feet) long.

Logging Operation

The yarder was positioned in the haul road and maneuvered to align the fixed headblock with each skyline corridor. Two winch-powered guylines were attached to anchor trees opposite the direction of yarding. An additional fixed-length safety guy, attached to the top of the tower, was usually rigged to a third anchor. Tailblocks were hung in guyed trees although this was not necessary on all roads. Tail trees were rigged on weekends when the schedule allowed.

The crew consisted of a yarder operator and two choker setters. A loader with operator was needed to keep the small landings clear and to load log trucks. Some landings were steep enough to require the loader to hold the logs while they were unhooked to prevent them from sliding down the slope.

Test Description

The operational test consisted of monitoring production and productive and non-productive times during the logging operation. Records were kept of cycle times, pieces per turn, and estimated log diameters throughout the test. Log lengths, cycle element times, and yarding distances were recorded during limited periods.

The original test plan specified obtaining timber volume removed by measuring the log truck loads. Difficulties with this approach took place during the test. At the end of the test, a large portion of the logs remained decked at the site due to unavailability of trucks and scheduling difficulties. An estimate of the number of truck loads left at the site was made, but adding these estimates with the loads removed did not account for the total number of pieces yarded.

A partial explanation for the volume discrepancy may be found in the fluctuations in the alder market. Before the test began, there was a market for the alder pulp logs. By the time logging started, alder was no longer in demand. During the test, the alder market was intermittent and the minimum acceptable log size kept changing. For this reason, there were many alder logs yarded which were later considered to be unmerchantable and were not trucked out or included in estimates of remaining loads. Also, due to the small log diameters, many were broken by the loader at the landing.

Test Results

An estimate of the volume production rate was made by determining an average log size from test data and multiplying it by the piece rate. The average log volume for the thinning operation was found to contain 0.38 cubic meters (13.5 cubic feet). This gives a production rate of 14 cubic meters (4.9 cunits) per hour of yarding time and 9.9 cubic meters (3.5 cunits) per hour of total time. In the clearcut, the average log contained 0.48 cubic meters (17 cubic feet). The resulting production rate is 20 cubic meters (7.1 cunits) per hour of yarding time and 14 cubic meters (5.0 cunits) per hour of total time.

The piece rate is more significant than the volume production rate for estimating the yarder's production capability in timber of a different log size. Log size has long been recognized as the most significant variable affecting yarding cost and production (Mifflin and Lysons 1978). A maximum of 4 chokers were used in this test which resulted in an average of 3.5 pieces per turn. Average loads were estimated to be less than half the capacity of the yarder. Therefore, in similar yarding situations, the piece rate could be expected to remain fairly constant until the average log size approximately doubled with a similar increase in the volume production rate. From that point on, the number of pieces per turn would have to decrease.

Table 2 lists the time spent in various activities during the peewee test period. The time categories listed are defined as follows:

Actual yarding.--The time during which logs were being yarded. Short delays of 10 minutes or less are included.

Road change.--The time spent rigging tail trees, moving the yarder, and stringing lines between the last turn on one logging road and the first turn on the next one.

Scheduled maintenance.--The time prior to the start of actual yarding in the morning and after lunch for fueling, yarder warm-up, and checking levels of hydraulic fluids and lubricants.

Unscheduled maintenance (yarder).--The time spent correcting a yarder malfunction which caused a delay of more than 10 minutes.

Unscheduled maintenance (lines, etc.).--The time due to delays longer than 10 minutes caused by some part of the yarding system other than the yarder.

Miscellaneous delays.--The time due to interruptions in yarding of over 10 minutes caused by problems not related to the logging system.

Table 3 lists the daily yarding hours and the number of turns and pieces yarded during the test. The average number of turns per hour and pieces per hour for the thinning and clearcut are also shown.

Cycle element times and yarding distance measurements from two uphill skyline roads in the thinning operation were used to produce the plots shown in figures 5 and 6. Cycle time was divided into: (1) outhaul, which began when the carriage started moving away from the landing and ended when it reached the chokersetters; (2) hook, including lateral yarding; (3) inhaul, which began when the carriage started toward

Table 3--Daily production

Date	Hours yarded	Turns yarded	Pieces yarded	Turns per hour	Pieces per hour
			-Thinning-		
2/21	7.37	80	248	10.9	33.7
2/22	3.35	45	140	13.4	41.8
2/23	7.48	92	320	12.3	42.8
2/24	4.37	42	132	9.6	30.2
2/27	7.33	92	300	12.6	40.9
2/28	2.03	25	66	12.3	32.5
3/1	7.15	72	245	10.1	34.3
3/2	6.35	55	195	8.7	30.7
3/3	5.48	55	182	10.0	33.2
3/6	4.78	65	187	13.6	39.1
3/7	6.90	56	202	8.1	29.3
3/8	3.40	50	161	14.7	47.4
3/9	5.62	63	201	11.2	35.8
3/10	4.70	60	190	12.8	40.4
3/13	7.40	63	228	8.5	30.8
3/14	6.05	65	226	10.7	37.4
3/15	7.68	78	284	10.2	37.0
3/16	6.12	57	208	9.3	34.0
3/17	6.75	80	278	11.9	41.2
3/20	5.77	81	287	14.0	49.7
3/21	1.33	16	58	12.0	43.6
3/22	5.52	43	147	7.8	26.6
3/23	7.58	93	343	12.3	45.3
3/24	3.17	29	105	9.1	33.1
3/27	6.83	83	300	12.2	43.9
3/28	7.17	50	170	7.0	23.7
3/29	4.42	56	197	12.7	44.6
3/30	7.33	66	257	9.0	35.1
3/31	4.50	43	156	9.6	34.7
			Average - thinning	10.7	36.5
			-Clearcut-		
4/3	6.00	67	245	11.2	40.8
4/4	5.25	56	216	10.7	41.1
4/5	6.67	81	312	12.1	46.8
4/6	4.42	47	176	10.6	39.8
			Average - clearcut	11.1	42.0
			Average - combined	10.7	37.2

Table 2--Time summary

Activity	Thinning		Clearcut	
	Hours	Percent	Hours	Percent
Actual yarding	163.9	71.3	22.3	70.6
Road change[1/]	37.0	16.1	4.9	15.5
Scheduled maintenance	11.1	4.8	0.5	1.6
Unscheduled maintenance (yarder)	.7	.3	0	0
Unscheduled maintenance (lines, etc.)	6.9	3.0	2.8	8.9
Miscellaneous delays	10.3	4.5	1.1	3.5

[1/]An additional 98 man-hours were spent on rigging outside of normal working hours.

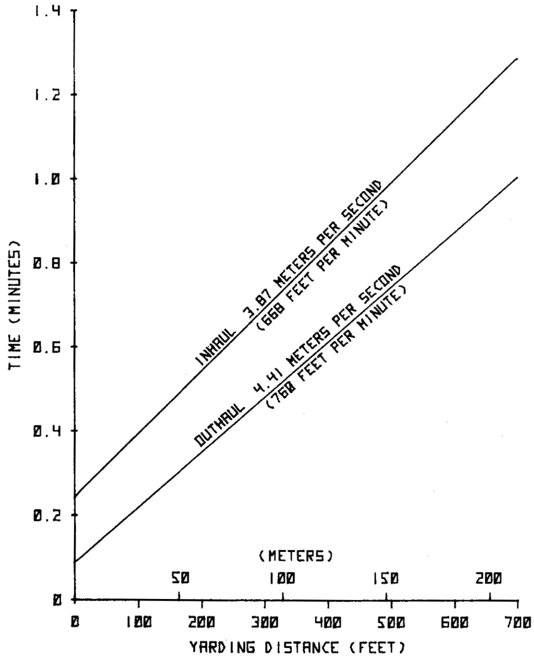

Figure 5.--Inhaul and outhaul times vs. distance.

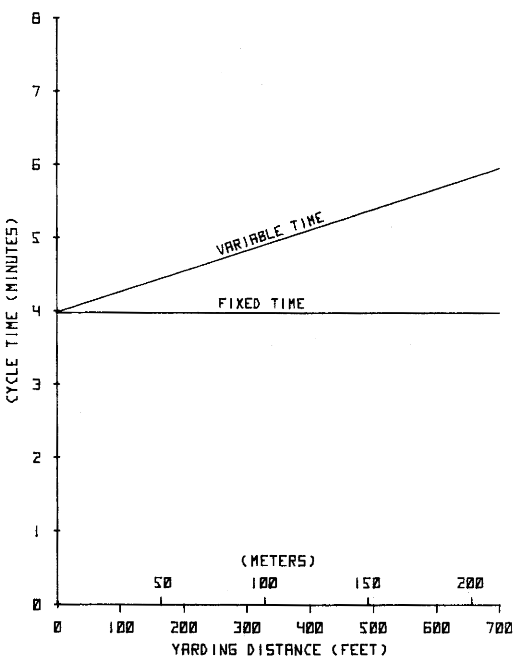

Figure 6.--Cycle time vs. yarding distance.

the landing and ended when the chokers went slack with the logs on the ground; and (4) unhook, which was the time between inhaul and outhaul.

Figure 5 shows the inhaul and outhaul time as a function of yarding distance. A linear regression analysis of the data resulted in the following equations:

$$\text{Inhaul:}\quad Y = .242 + .0049X$$
$$r = .910$$
$$\text{Outhaul:}\quad Y = .088 + .0043X$$
$$r = .969$$

where,
Y is time in minutes,
X is distance in meters, and
r is the coefficient of correlation.

The slopes represent an inhaul speed of 3.87 meters per second (668 feet per minute) and an outhaul speed of 4.41 meters per second (760 feet per minute).

Figure 6 presents a plot of cycle time versus yarding distance and was constructed according to procedures developed by Mifflin and Lysons (1978). The procedures were developed to provide cost prediction models for evaluating advanced logging systems. Cycle time is separated into fixed and variable times which can then be used to predict cycle times in different logging situations.

In figure 5, the inhaul and outhaul plots have a positive time value at zero yarding distance which indicates that some fixed time was included in these measurements. Therefore, total fixed time equals the inhaul and outhaul intercepts (time values at zero yarding distance) plus the average hook and unhook times.

$$\begin{aligned}\text{Fixed time} &= \text{intercepts} + \text{hook} + \text{unhook}\\ &= (.242 + .088) + 3.00 + .65 = 3.98 \text{ minutes}\end{aligned}$$

The variable time was obtained by summing the slopes of the inhaul and outhaul plots of figure 5.

Summary

The high production rate and lack of yarder-related delays clearly demonstrate the merits of a small running skyline yarding system for thinning where cable logging is desired. Crew size is reduced because the operator can act as the chaser, unhooking turns at the landing. Simplified controls reduce the training time required for an operator to become proficient. Location of the small yarder directly in the access road can result in minimal landing rerquirements.

The test also demonstrates the concept of a direct hydraulic drive, interlocked running skyline drum set. Problems with a prototype machine are the general rule in equipment development. The peewee yarder was an exception during the test. Problems with proven equipment such as the carriage and the radio signal system were the only significant causes of lost production time.

Production as high as 343 pieces per day were achieved during the test. Average loads were estimated to be less than half the capability of the yarder. This indicates that the production volume could have doubled given larger diameter logs and similar ground conditions.

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Mailing address: Pacific Northwest Forest and Range Experiment Station
809 N.E. 6th Ave.
Portland, Oregon 97232