1978

Description of remote control cable yarding systems and an evaluation of the Forestral Remote Control Grapple Yarding System

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A DESCRIPTION OF REMOTE CONTROL CABLE YARDING SYSTEMS AND AN EVALUATION OF THE FORESTRAL REMOTE CONTROL GRAPPLE YARDING SYSTEM

By

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B.S., University of Montana, 1966

Presented in partial fulfillment

of the requirements for the degree of

Master of Forestry

UNIVERSITY OF MONTANA

1978

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June 12, 1978

Date

6-15-78

ACKNOWLEDGMENTS

I greatly appreciate the extra time, suggestions and material that Leo K. Cummins extended to me in the preparation of this paper. And, to my wife, Jan; without her patience and typing, this paper would not have been completed.

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CHAPTER I

INTRODUCTION

The forest industry is an important one to the western states. In 1973, 223,000 persons were employed in the lumber and wood products industry. The estimated wholesale value of the lumber they produced was $4,123,200,000. In the state of Montana, in 1973, 9,300 were employed in the forest industry and the estimated wholesale value of the lumber they produced was valued at $242,200,000 (Western Wood Products Association 1974).

Logging is the production of round logs from standing timber and their transportation to the mills (Pearce and Stenzel 1972). Logging consists of three primary steps: (1) conversion of trees to logs (felling and bucking), (2) transportation of the logs from the stump to a yard, landing or gathering place for further transportation by some other means (yarding) and (3) loading and transporting the logs from the woods to the mills. Methods of logging are usually classified by the manner in which the logs are transported from the stump to a gathering place.

Two major methods of transporting the logs to the landing are used; tractive skidding and cable yarding. Tractive skidding is the process of transporting logs by attaching them directly to an animal or machine (usually a

crawler tractor or rubber tired skidder) and dragging the logs along the ground to the landing (Pearce and Stenzel 1972). Cable yarding is the movement of logs from the stump to a landing by a machine equipped with multiple drums or winches which operates from a stationary position (Pearce and Stenzel 1972). Cable-yarding systems have been divided into five categories: (1) ground lead, (2) live skyline, (3) standing skyline, (4) running skyline and (5) balloon (Binkley and Studier 1974). (Illustrations of selected examples of the cable-yarding logging systems are included in the appendix.)

Background

The ground lead is a method of yarding logs in which the pull of the skidding line is parallel to the ground. The ground lead system is not commonly used today. It was used for logging in the late 1800's and early 1900's. A steampowered "donkey" engine with a single drum was the most common configuration.

Later, a vertical spar tree was used to obtain a vertical lift on the logs to make it easier to get the logs over obstacles. An additional drum was also added to provide a haulback line and later another drum was added to hold a strawline. A haulback is a wire rope used to pull the main line back to the timber. A strawline is a light wire rope that is used to pull the rigging lines, blocks

and haulback into the area to be logged (Pacific Northwest Forest and Range Experiment Station 1969). With the spar tree and additional drums, the system was called the highlead system.

A variation of the highlead is the jammer. The jammer is a semi-mobile small scale highlead that is common in the Inland Empire Region.

Other cable yarding systems are variations of the skyline system. A skyline is a cableway stretched tautly between a head spar tree and a tail spar or stump. The cableway is used as a track for log carriers called skyline carriages (Pacific Northwest Forest and Range Experiment Station 1969). All skylines have an operating drum yarder, two spars or towers, a mainline and a skyline; it may or may not have a haulback line. When the contour profile allows, a stump may be used for a tail block in place of a spar.

A live skyline is a skyline that can be raised and lowered during yarding to facilitate the attaching of the logs and yarding logs over obstacles. The skyline is spooled to a drum on the yarder and by letting out cable, the skyline can be lowered and raised by reeling-in the cable. A common live skyline is the shotgun or flyer system. A modification of the live skyline system that employs a haulback line in addition to the skyline and mainline is called a slackline system (Binkley and Studier

1974).

A standing skyline employs a fixed cable with a carriage riding on the cable. The mainline is threaded through a fall block and then attached to the carriage. The chokers are attached to the fall block which can be lowered to the ground to make attaching the logs easier. Two common standing skylines are the North-Bend system and the South-Bend system (Binkley and Studier 1974).

Another standing skyline system uses a carriage which is capable of pulling a cable or is capable of having a cable pulled through it. This type of carriage is known as a slack pulling carriage. Lateral skidding is possible with this type of system. Two common systems are the sky-flyer system and the European system (Binkley and Studier 1974).

A running skyline is a system of two or more suspended moving lines, generally referred to as main and haulback, that when properly tensioned will provide lift. The haulback line acts as a live skyline and also pulls the carriage back to the woods. The mainline pulls the carriage to the yard. The carriage may have a choker or a grapple attached. A grapple is raised or lowered by increasing or decreasing the tension on the mainline and the haulback (skyline) at the same time (Binkley and Studier 1974).

Balloon logging is a system in which the yarder has

two lines, a mainline and a haulback. A helium filled balloon is attached to the lines to provide lift. Tension on the mainline and haulback pulls the balloon and log carriage down. A yarder pulls the logs and the balloon to the landing. The balloon and carriage are returned to the logging area by releasing the mainline and pulling in the haulback.

Another system of logging is helicopter logging which is yarding the logs with a large helicopter. Both helicopter and balloon logging are very expensive and are used on a limited basis. Helicopter logging is more common than balloon logging.

The cable logging equipment (with the exception of the highlead, grapple and balloon equipment) can be used for partial cuts as well as clear cuts. The highlead, grapple and balloon cannot be used in a partial cut because they do not have a lateral yarding capacity. The jammer can be because of its mobility. The only logs that can be yarded are those directly in line with the cable system. The optimum yarding distances for a highlead is 1,000 feet, for a jammer is 450 feet and for a skyline, depending upon the configuration, is 500 to 4,000 feet (Binkley and Studier 1974). The optimum slope percent for the highlead is 30-70%, a jammer is 30-55% and a skyline is 30-90% (Binkley and Studier 1974).

The timber resources of the forests are becoming

more scarce as a result of competing demands on the forest. The relative scarcity of the timber resource will increase the cost of the timber (stumpage). Because of inflation and the rising cost of living, the woods workers are demanding higher wages. As a result of the increase in stumpage prices and the increase in the wages of woods workers, new logging techniques have been developed to increase the efficiency of the harvesting (logging) operation. One technique is the application of electronic remote control devices to logging equipment to increase the productivity of the equipment, the worker or both.

Remote control has been used in skyline yarding operations for years. The skyline yarding system was the first to use a remote control carriage. American made standing skyline cranes have been using radio controlled carriages since 1958 (Pearce and Stenzel 1972). As a result of pressures to protect the environment, it was recognized about 25 years ago that a method of yarding that would protect the soils and the residual stand was needed (Lysons 1973). The European system of logging, a skyline logging system (illustrated in the appendix), does protect the soils and residual stand, but the European systems are not popular in America because of their low production and relatively high manpower requirements (Binkley and Studier 1974). About 15 years ago, logging engineers incorporated the advantages of the European system in protecting the

environment with the production of the Pacific Northwest cable yarder. That combination led to the development of radio controlled carriages for use on existing skyline yarders. Recent developments in remote control are the radio controlled grapple of 1967 for use on a running skyline yarder (Wood 1967), the Forestral remote control unit for use on a running skyline yarder and the Ecologger, which is a low cost cable yarder that can be operated by remote control. The Ecologger can be used as a highlead yarder or a live skyline yarder.

Purpose

The purpose of this paper is to analyze some of the reasons that caused the development of remote control logging systems, to describe the systems and to evaluate one type of system. The system that is here evaluated is a remote control unit manufactured by Forestral Incorporated of Canada. The purpose of the evaluation is to determine if the remote control unit does increase machine productivity and thus reduce the logging costs. A production and statistical analysis of the Forestral remote control system is made. A statistical analysis is used to obtain values which will not change with fluctuations in the economy.

CHAPTER II

FACTORS LEADING TO THE DEVELOPMENT OF REMOTE CONTROL YARDING SYSTEMS

There are several factors that have spurred the development of remote control logging systems. They are the lack of interest in logging jobs, an increase in stumpage prices and an increase in labor costs. In 1972, it was reported that "firms in the logging industry in Washington and Oregon have been concerned about the lack of interest in logging jobs for at least a decade" (Flora 1972). This trend has continued despite high unemployment in the Puget Sound Area in Washington and in some counties in Oregon. This trend in the decrease of interest in logging jobs has induced labor saving innovations in the logging industry such as the increasing use of skidding grapples to eliminate the choker setter (Flora 1972).

Smith and Gedney (1965) reported that employment in the logging industry in Oregon and Washington decreased from approximately 29,000 persons in 1950 to 24,000 persons in 1963, an 18% decrease, while the volume of logs harvested increased 14% (Figure 1). Manpower use per unit of wood input[1] decreased 26% in the logging industry from

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[1]Manpower use per unit of wood imput was expressed as number of employees per MM board feet of wood produced using the International 1/4 rule scale.

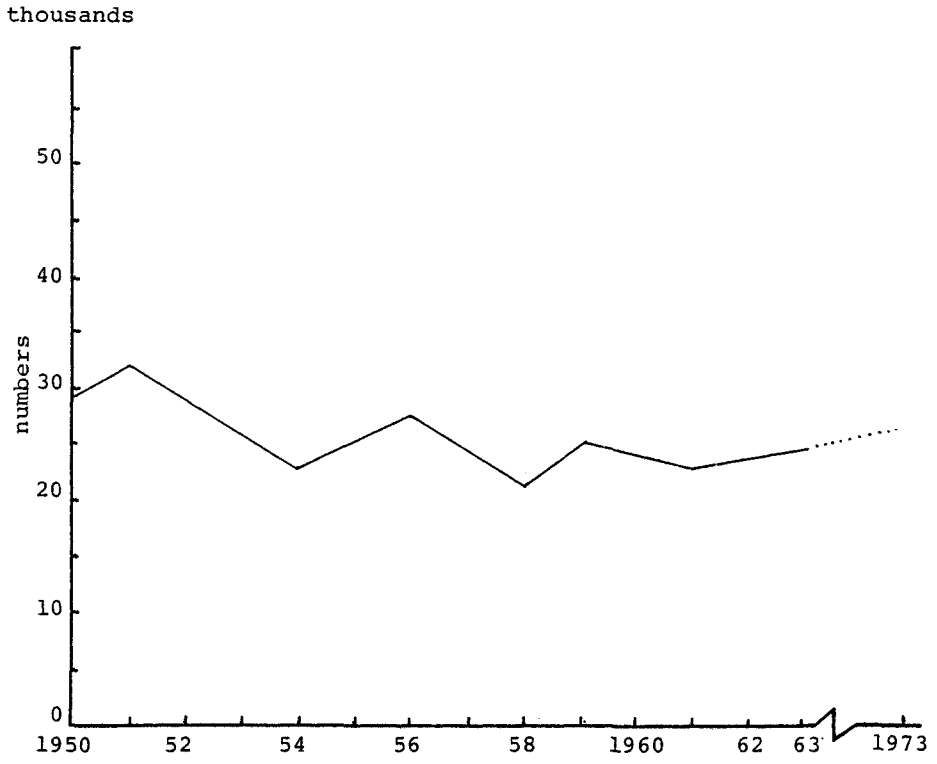


Fig. 1. Employment in the logging industry in Oregon and Washington, 1950-1963

Source: Gedney, 1965; and Ruderman, 1975.

1950 to 1963 (Adams 1974). The reductions in manpower use were attributed to mechanization in the handling of materials, increased worker skills and the use of more efficient machinery of greater capacity.

The average price increase of logs has not kept pace with the increase in the average prices paid for stumpage. During the period from 1963 to 1973, the price of logs increased 195% while the price of stumpage increased 392%. During the same period, the average hourly wage for woods workers increased 69%. Figure 2 illustrates a comparison of the log prices, wages for woods workers and stumpage prices. Log prices are a composite of prices from a large number of actual transactions in the Pacific Northwest. Stumpage prices are the average for sawtimber sold in Region 6, United States Forest Service.

As a result of the wage-price imbalance, the logging industry has found it necessary to reduce its costs. One way of reducing its costs has been to reduce the number of personnel and to increase production by increasing the amount of mechanization by using grapple yarding and remote control yarding.

The average hourly wage of woods workers has risen steadily over the past two decades. The average hourly wage of woods workers in Western Washington and Western Oregon increased from $2.71 per hour in 1955 to $3.13 per hour in 1963, and to $5.29 per hour in 1973 (Gedney 1965

TABLE 1

TABLE OF RELATIVE INDEX OF LOG PRICES,
STUMPAGE AND WOODS WORKERS WAGES
(1963 used as base year)

	Unit	1963		1973	
		Price in Dollars	Relative Price	Price in Dollars	Relative Price
Log Price	*MBM	58.50	100%	172.30	295%
Stumpage	*MBM	28.00	100%	137.70	492%
Woods Workers Wages	Hour	3.13	100%	5.29	169%

*Thousand Board Feet Log Scale

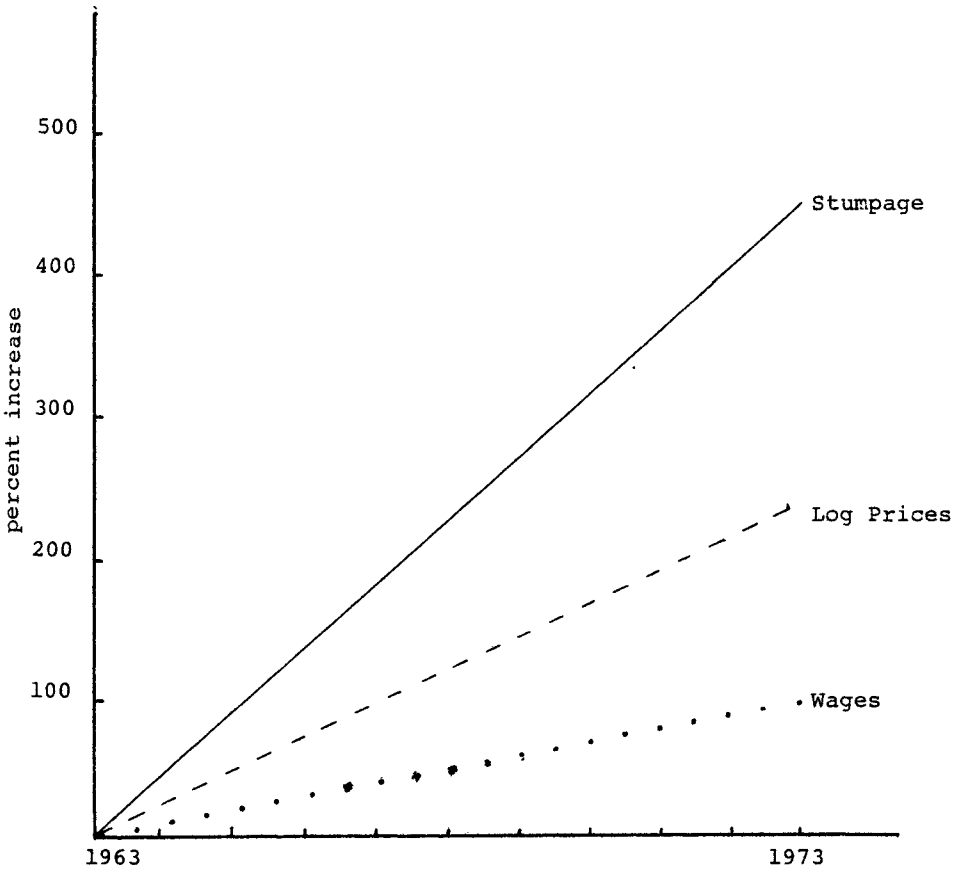


Fig. 2. A comparison of the increase in stumpage price, log price and woods-workers wages from 1963 to 1973

Source: Adams, 1974; Ruderman, 1975, and Western Wood Products Association, 1975.

and Western Wood Products Association 1975). See Figure 3.

The average stumpage prices paid for Douglas-Fir sawlogs on the west side of the United States Forest Service's Region 6 (Washington and Oregon) has risen from $28.00 per thousand board feet in 1963 to $137.70 per thousand board feet in 1973 (Ruderman 1975). See Figure 4. The average stumpage prices for all the important timber species on United States Forest Service's Region 6 has risen steadily from 1964 to 1974 with the exception of a downturn from 1970 to 1971.

Log prices for all species of timber sold in Western Washington and Northwestern Oregon also rose steadily between 1963 and 1972, and rose sharply in 1973. The average price of Douglas-Fir sawmill logs rose from $58.50 per thousand board feet log scale in 1963 to $172.30 per thousand board feet in 1973. Figure 5 provides a breakdown of log prices by log species (Adams 1974).

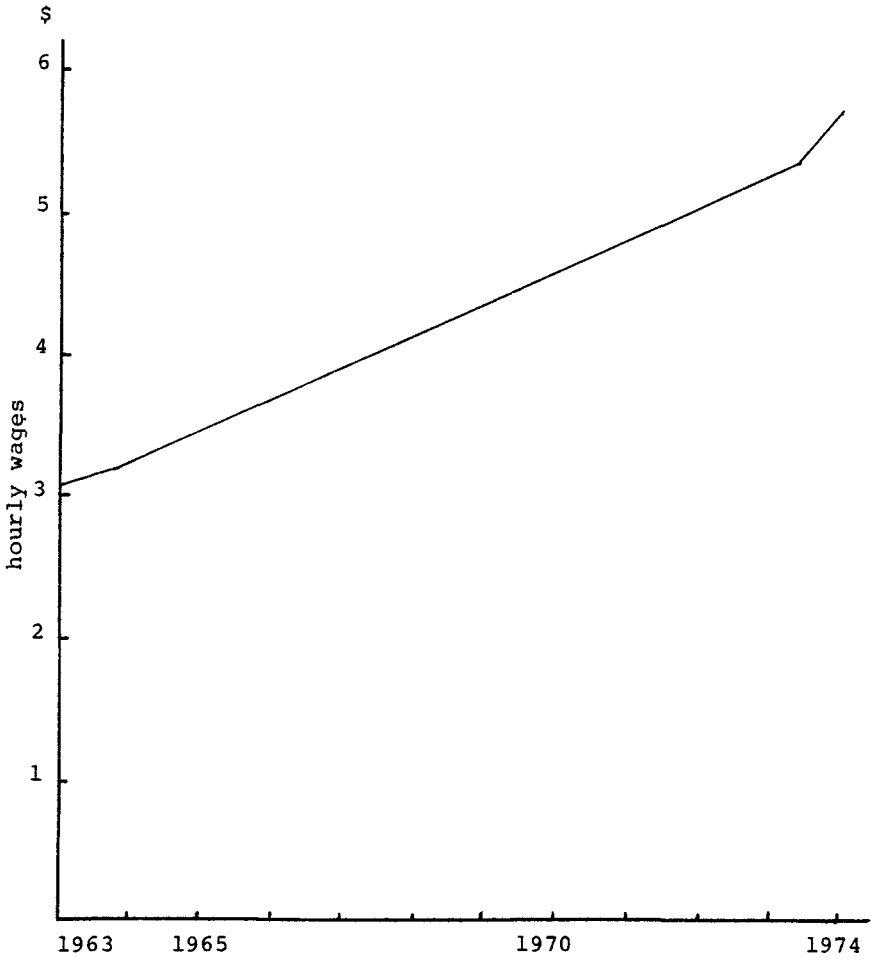


Fig. 3. Hourly wages for woods-workers in Western Oregon and Western Washington, 1963-1973

Source: Gedney, 1965; and Western Wood Products Association, 1975.

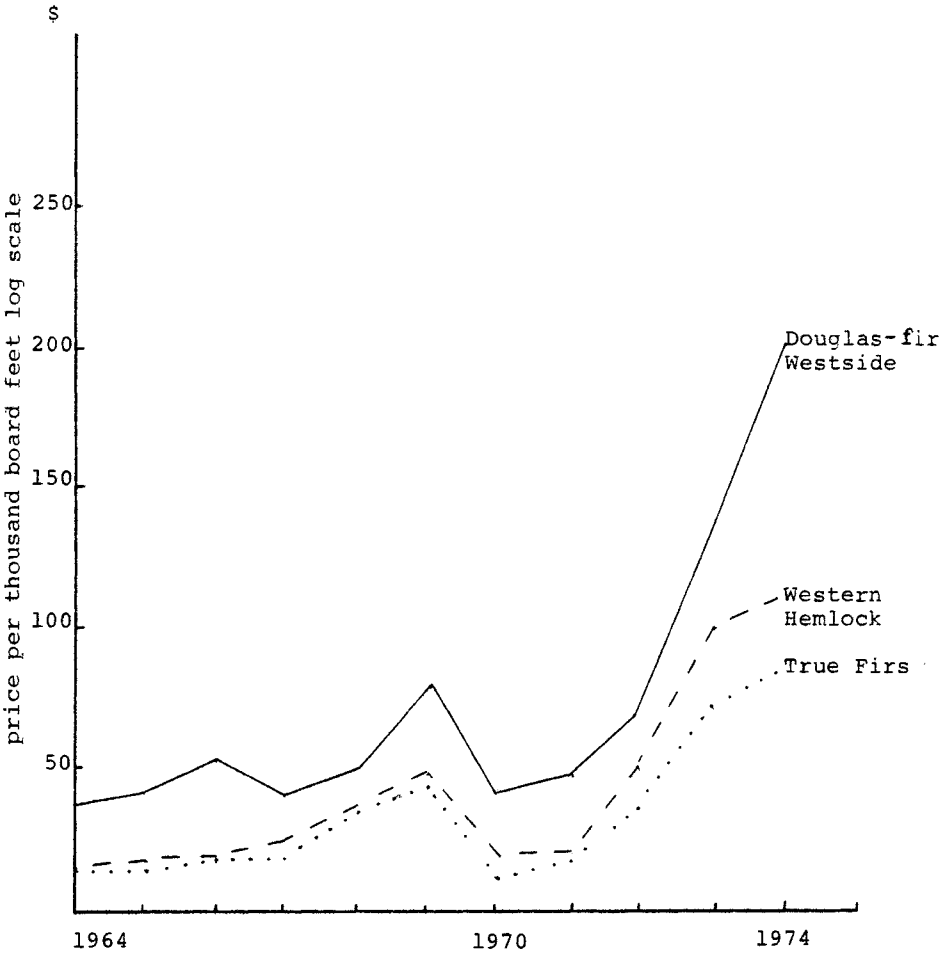


Fig. 4. Average stumpage price for selected species in Oregon and Washington, 1964-1974

Source: Ruderman, 1975.

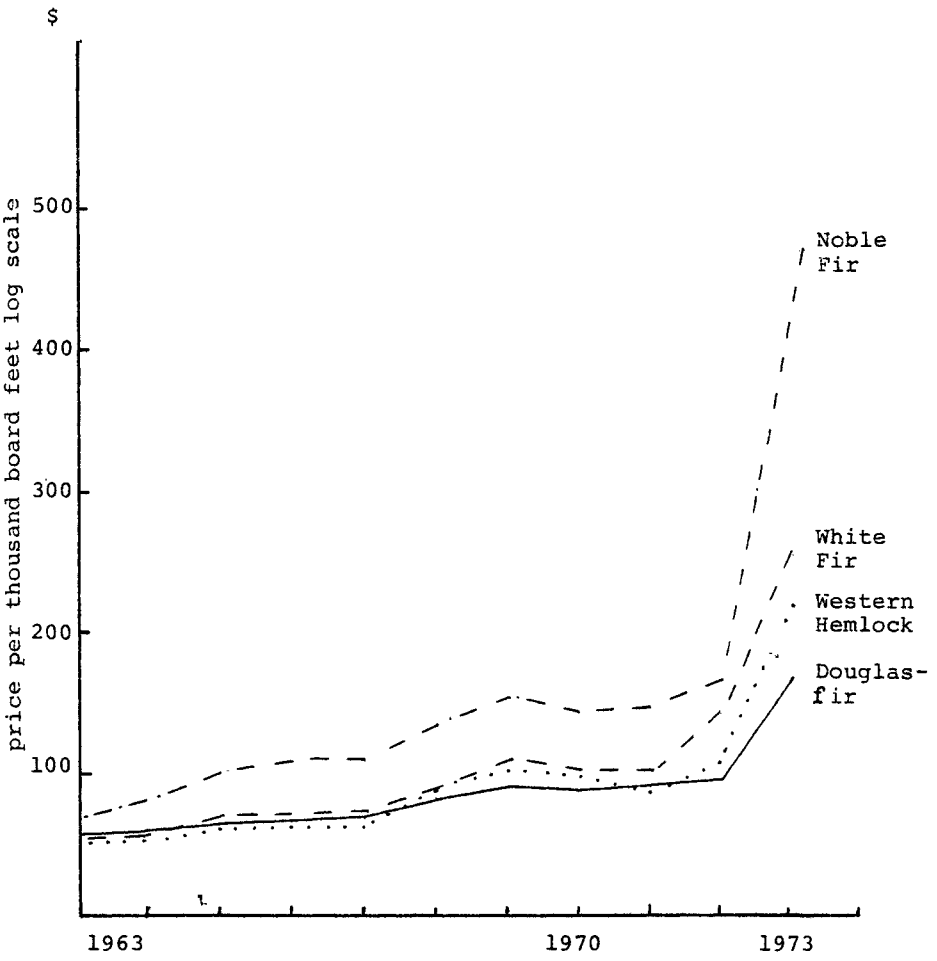


Fig. 5. Average log prices for selected species for Western Washington and Northwestern Oregon, 1963-1973

Source: Adams, 1974.

CHAPTER III

A DESCRIPTION OF REMOTE CONTROL YARDING SYSTEMS

Three major remote controlled yarding systems have been developed to date. The earliest was the remote controlled radio controlled skyline carriage. Later, when the running skyline became popular, a remote controlled grapple was developed for use with the running skyline. The latest development is the completely remote controlled system which has been adapted for use on the running skyline system. It also can be used on a small portable tower that can either be a skyline or highlead configuration. All of the systems are illustrated in the appendix.

The Radio-controlled Carriages

The oldest system is the radio-controlled carriage used on a standing skyline. The standing skyline is rigged to spar trees or portable towers. This system usually employs a yarder with one drum to store the mainline, another drum to store, move and tighten the skyline, and a third drum to store the strawline. This system can yard up to a distance of 5,000 feet with lateral yarding for distances of 75 to 250 feet (Binkley and Studier 1974). It can yard either uphill or downhill. Its biggest advantage is that it minimizes soil disturbance and eliminates many

secondary and spur roads (Binkley 1965). It is an effective way of moving logs on steep slopes with shallow soils. Its lateral skidding capabilities make it very effective for thinning and overstory removal operations. However, it requires a large capital investment and high rigging costs.

There are two basic types of carriages used on a standing skyline; the mechanically operated slackpulling carriages and the radio controlled carriages. The radio controlled carriages are of the Skycar type (RCC-15) or Bullet type (RCC-13) (Pearce and Stenzel 1972).

The skycar type contains a 95 horsepower diesel engine, a fuel tank, a winch for the tong line and radio equipment. Its load capacity is approximately 35,000 pounds (Pearce and Stenzel 1972). The skycar rides on a skyline and when it is hauled up the skyline to a desired spot, the rigging slinger sends a radio signal to the yarder operator to stop the snubbing line and set the brake. When uphill yarding with the system, the mainline becomes the snubbing line and when downhill yarding, the haulback becomes the snubbing line. At the same time, a signal is sent to the carriage which causes the carriage engine to lower the tong line. When the turn of logs is hooked to the tong line, another signal is sent to the carriage and the tong line is pulled in and another signal sets the drum brake. On the next signal, the snubbing line is released and the carriage is rolled by gravity to the landing.

The Bullet type contains a 24 horsepower butane engine, a fuel tank, radio controls and an airtank and compressor to operate the slackpulling sheave brake and skyline clamp. Its load capacity is approximately 25,000 pounds (Pearce and Stenzel 1972).

The Bullet carriage rides on the skyline and the mainline runs through the carriage around slackpulling sheaves and out the bottom. The carriage is pulled on out the skyline to the desired spot where the rigging slinger signals to the engineer to stop the carriage. At the same time, a signal is sent to the carriage to set the skyline clamp. A second signal accelerates the engine which pulls the mainline out. When the turn is hooked to the load line, a signal is sent to the yarder engineer to reel the line in. Other signals are sent to the carriage which sets the mainline sheave brake on the carriage and releases the skyline clamp.

The Skycar type is designed to carry the log turn downslope on single-span or multi-span systems. The tong line (skidding line) is stored on a drum in the carriage. The smaller RCC-15 can also be used for upslope single-span yarding. The Bullet type is designed to carry the log turn upslope and is a self powered slack pulling carriage.

A radio receiver and loud speaker are installed on the carriage and yarder. The controls for both carriages are operated by solenoid valves that are actuated by the

radio signals. The rigging slinger and chaser carry portable transmitters and another transmitter is installed on the yarder.

A Skagit Skycar's (RCC-15) selling price in 1975 was $70,000 and a Bullet's (RCC-13) was $55,000 (Ross Equipment 1975). An Eltro Bug 150 transmitter's selling price was $3,000. The RCC-15 and the RCC-13 are the only two currently available. A crew of six men is normally required for their operation.

The yarder commonly used with the radio controlled carriages has three drums which are a mainline drum with a capacity of over 4,000 feet of 1" or larger cable, a haulback drum with over 5,000 feet of 3/4" cable and a strawline drum with 5,000 feet of 7/16" cable. The yarder is powered by a diesel engine of over 300 horsepower and is used in conjunction with a steel tube tower of 100 feet in height. A yarder and tower combination of that configuration was priced at over $400,000 in 1975 (Ross Equipment 1975).

The Remote Controlled Grapple

A later remote control innovation was the remote controlled grapple. The remote controlled grapple unit was designed to be used with a running skyline system. The grapple skyline system was developed as a result of higher priced labor and manpower shortages during the 1960's (Lysons 1973). The grapple system achieved a marked

increase in production per man by allowing a reduction of the crew from five men to two men. The grapple can only be used when clearcutting is the prescribed cut because it has no lateral skidding capability. It can be used only on a live or running skyline.

When in operation, the carriage is moved out by pulling in the haulback and then is lowered to the log by releasing the mainline or lowering the skyline. The spotter radios the yarder engineer when to stop and lower the carriage. The spotter then sends a signal to the carriage to open the grapple and then to close it. The grapple is closed by an electric motor and opened by springs mounted in the carriage. When the log is grappled, the mainline pulls the carriage and log onto the log deck. The carriage is raised by creating tension on the mainline and haulback line simultaneously and lowered by slacking of tension on the mainline and haulback line simultaneously. A crew of two is required for its operation.

The typical crane yarder used with most grapples has four drums. The mainline drum would have a capacity of 1,700 feet of 5/8" cable, a haulback drum with a capacity of 2,400 feet of 3/4" cable, a strawline drum with a capacity of 3,200 feet of 3/8" cable and a guyline drum with 100 feet of 1" cable. They are usually self-propelled and are powered by diesel engines of over 250 horsepower. They are attached to a steel lattice leaning boom of

approximately 50 feet in length. The selling price of a typical grapple yarder in 1975 was over $240,000 (Halton Equipment 1975).

Completely Automated Yarding Systems

The most recent development in remote control yarding systems is the Forestral Equipment. Forestral Automation Ltd., a logging equipment manufacturer located in Vancouver, British Columbia, Canada, developed a remote control unit that can be adapted to a conventional skyline cable yarder to allow the yarder to be operated remotely from distances up to 3,000 feet (Forestral Brochure 1973). The system has been used on two different types of yarders in the United States. The first was used on a Skagit GT5 Skyline Yarder and the second was an Ecologger. The theoretical advantage of the remote control system is that the spotter, who also controls the yarder, can move about freely and place himself in a position where he can see exactly where to stop the carriage. He can then stop it precisely over the log and thus eliminate any time lost to repositioning the carriage if it is not stopped directly over the log.

Both the conventional system and the remote control system require two men for operation; a yarder operator and a spotter. When using a conventional system, the spotter has a portable radio and he radios directions to the

engineer positioned at the yarder. Since there is a time lag from the time of broadcast to the time the engineer stops the carriage, the carriage may have passed over the log and the spotter must give new directions to the engineer. When using the remote control system, the spotter has direct control of the yarder, can stop the carriage at any given moment and thus eliminate any time lost to repositioning.

The equipment consists of a portable transmitter, that the remote operator straps around his waist, and a receiving unit that is mounted on the yarder. The operator sends radio signals to the receiver which converts the radio signals to mechanical outputs that control the operation of the yarder.

The transmitter is actuated by two hand control sticks, each capable of moving in four different directions and each having a spring loaded button on its top end. The movement of the handles combined with the activation of the button provides ten functions for the receiver which corresponds to the ten motions normally required in the operation of a yarder (Forestral Brochure 1973). The power source for the receiver is a nickel-cadmium battery located in the transmitter.

The radio signals are transmitted on assigned frequencies to the receiver which converts the signals to electrical impulses. The electrical impulses activate a

pneumatic system that is interfaced to the controls of the yarder.

The system is activated by the engineer in the yarder who can select either a remote or manual mode. When the remote mode is selected, the air horn on the yarder sounds which signals the remote operator that he can take over control whenever he wishes. When the remote operator takes control, he depresses a command button that gives him control of the yarder. The remote operator returns control to the engineer by putting the left stick in the signal position. This sounds the air horn and turns on a light at the yarder which signals the engineer to return to the manual mode and take control of the yarder. This particular function provides a safety feature in that if the remote operator falls, the operation of the yarder is relinquished to the yarder engineer.

The Forestral Remote Control unit can be adapted to any mobile running skyline yarder. It has been adapted to a Skagit GT-5 yarder in the United States and to a Skagit SST and an American 7220 yarder in Canada. The remote control unit's selling price in 1974 was $12,500 (Forestral, Inc. 1974) and Skagit GT-3's, with large drums, had a selling price of $250,000 in 1975 (Ross Equipment 1975). The Skagit GT-5 is no longer being manufactured.

The Ecologger also used Forestral manufactured remote control components. The Ecologger is a small, low

cost mobile tower yarder. The Ecologger has two operating drums and a strawline drum coupled to a Tree Farmer rubber tired skidder which provides the power and mobility. The equipment was designed to be used in areas of small timber where low yields per acre prohibit the use of larger, more expensive cable yarders and where the small stumps will not support the guylines and tailholds on larger machines (Plummer 1974).

There are two sizes of Ecologgers. The Ecologger I has a 42 foot rectangular tube tower, 130 horsepower and 550 feet of 11/16" mainline. The Ecologger II has a 49 foot rectangular tube tower, 185-200 horsepower and 2,100 feet of 3/4" mainline. Each can be obtained with a remote control unit and hydraulic winches that are interlocked or with conventional belt and gear driven winches with air brakes. The remote control unit allows the engineer to operate the yarder from any position that provides the greatest visibility. The 42 foot model was in commercial use and had been used in Oregon. The first unit used in Oregon was not entirely successful as the operator had many mechanical problems with it. The unit was the hydraulic winch model and was being used on timber larger than the machine was designed to handle (Harvey 1975). A total of four Ecologgers with remote control units have been used in Oregon since their development. However, the Forestral remote control units were removed because of inadequate

service available for the units (Plummer 1977).

The 42 foot model's selling price in 1975 was $97,000 (Rosedale Machine Shop 1975) delivered to Portland, Oregon. The crew's size would depend upon the configuration used; i.e., when used as a running skyline with a grapple, a crew of two can be used, but three or more would be required when used as a high lead and it would not be completely automated.

CHAPTER IV

AN EVALUATION OF A REMOTE CONTROL GRAPPLE YARDING SYSTEM

The purpose of this chapter is to evaluate a remote control grapple yarding system. Two separate studies were made of the Forestral system. The first study was made for the Forestral Company in British Columbia, Canada, and the second study was made by Weyerhaeuser Company in Western Washington. The data obtained from the two studies is analyzed and compared. In both studies, greater productivity was noted when the remote control system was used. The productivity advantages in the Weyerhaeuser study, however, were offset by mechanical and logistical problems.

The advantage of the remote control grapple yarder over a conventional grapple yarder is illustrated by the flow process chart shown on Figure 6.

The Weyerhaeuser study disclosed that the average time to orient the grapple of a running skyline system was 0.4 minutes per occurrence; however, 12% of these occurrences took over 0.5 minutes (Christensen 1971). The study covered 750 cycles on slopes of 5% to 30% with a maximum yarding distance of 650 feet. The average operating cycle duration was 1.3 minutes. The author postulated that if a

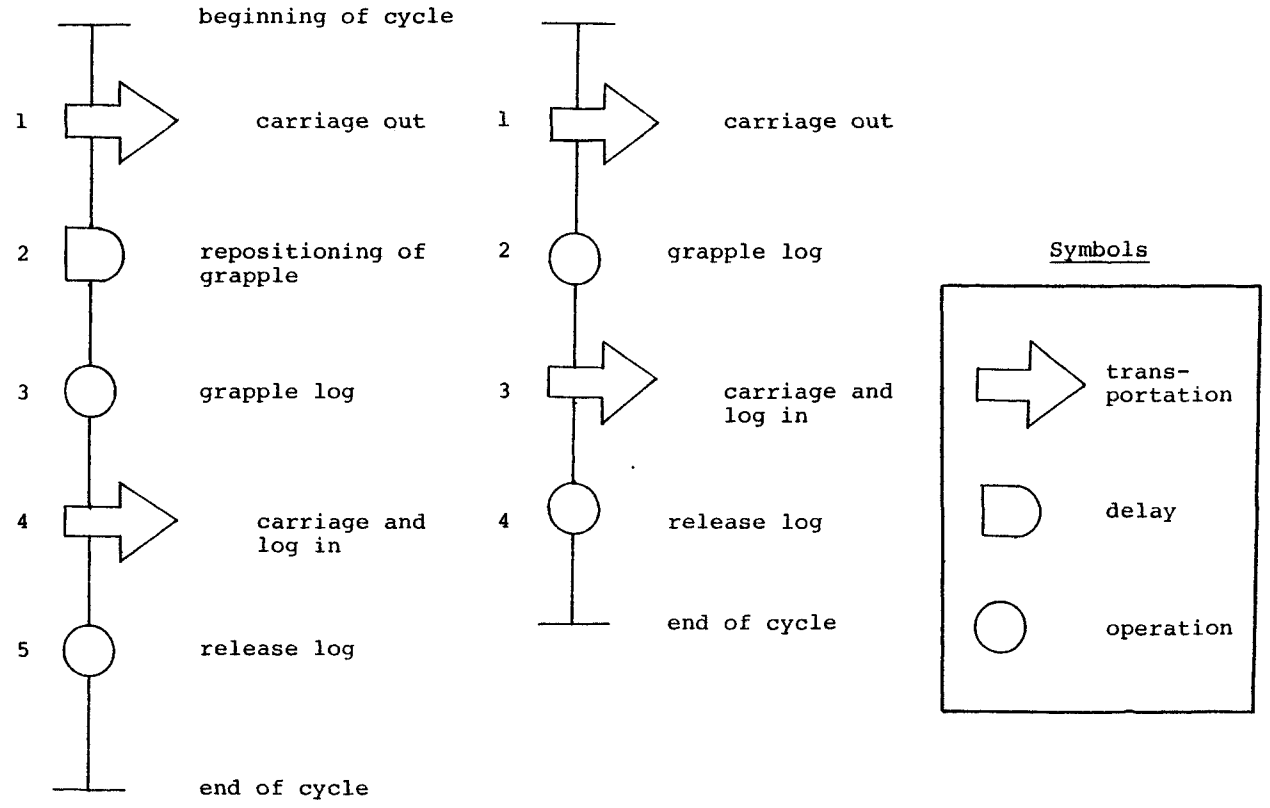


Fig. 6. Flow process chart comparing the operating cycle of the grapple yarder without remote control with a grapple yarder with remote control

mechanism could reduce the orientation time to 0.2 minutes, the savings would be $11.00 per shift, based on a $200.00 operating cost per shift.

Forestral made a time/motion study of their prototype machine. A time/motion study done by Weyerhaeuser of a conventional grapple system is presented for comparison. The studies are shown in Figures 7 and 8.

Statement of the Problem

Does the remote control operation increase production? If it does, is it enough to compensate for the added cost of the remote control system?

Purpose of the Evaluation

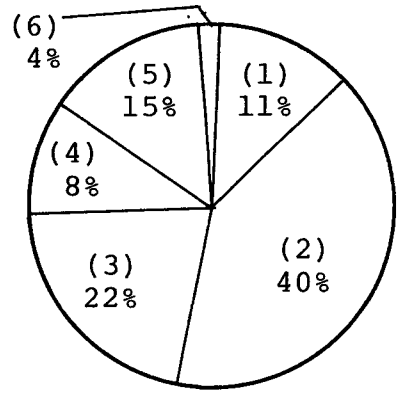
The purpose of the evaluation is to examine the operation of the Forestral Remote Control System to determine if it does increase production and if the increase in production compensates for the added cost of the remote control system.

Description of the Study

The production studies were done on the Forestral remote control grapple yarding system by two logging companies. The study made for Forestral Automation Inc. in Canada used the first machine to be produced, and the Weyerhaeuser Company in Washington used the second machine to be produced. A yarding cost analysis using machine rate was done by Forestral; however, they used cunits to express

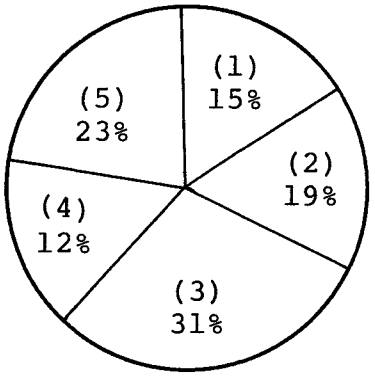
With Walkie-Talkie

Av. Cycle Time: 2 min. 30 sec.
Av. Cycles Per Day: 155



With Remote Control

Av. Cycle Time: 1 min. 40 sec.
Av. Cycles Per Day: 220



		Walkie Talkie Average Time	Remote Control Average Time
1.	Send grapple to woods	20 secs.	20 secs.
2.	Secure turn	1 min. 15 secs.	25 secs.
3.	Yard logs to landing	40 secs.	40 secs.
4.	Land and deck logs	15 secs.	15 secs.
5.	Move and rig	1.2 hrs. per day	1.8 hrs. per day*
6.	Idle time	.3 hrs. per day	nil**

The yarder with remote control yarded logs an average of 20.8 minutes per day less than the yarder without remote control due to the greater move and rig time for the remote controlled yarder. This would make the productivity figures for the remote controlled yarder conservative.

*High move and rig time was due to terrain being unsuitable for portable backspar.

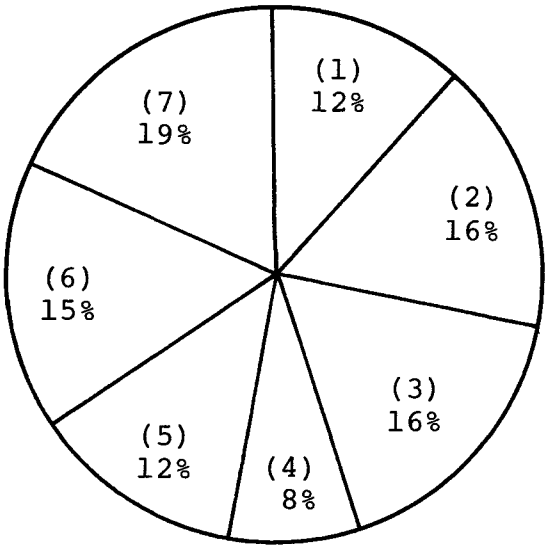
**No idle time was noted in study.

Fig. 7. Time/motion study on prototype remote control grapple yarding system using a crane yarder

Source: Forestral Automation Ltd., 1973.

Average Cycle Time: 1.6 min.

Average Cycles Per Day: 200



1.	Send grapple out	18 sec.
2.	Secure turn	24 sec.**
3.	Yard logs to landing	24 sec.
4.	Land and deck logs	12 sec.
5.	Rehandle and miscellaneous*	18 sec.**
6.	Move and rig	1.25 hours per day
7.	Repair and maintenance (idle)	1.50 hours per day

*Rehandle and miscellaneous included such items as recovering the turn that slips from the grapple, rearranging and preparing the landing and general communication and movement.

**A combination of items (2) and (5) would be comparable to item (2) of the Forestral time/motion study.

Fig. 8. Time/motion study of a conventional crane grapple yarding system

Source: Christensen, 1971.

production, so their analysis has been modified to use pieces per day since the data obtained from Weyerhaeuser was in pieces per day. A yarding cost analysis also was performed using data obtained from Weyerhaeuser.

The Forestral Study

The Forestral study was done using a track-mounted Skagit SST Grapple Yarder near Terrace, British Columbia. The terrain was steep, snow covered and the maximum yarding distance was 1,050 feet. The machine was operated for one week with a walkie-talkie and the following week with the remote control unit. Production with the walkie-talkie was 30 to 40 cunits per day, while production with the remote control unit was increased to 120 to 140 cunits per day (Cumming 1972). During a later study under better weather and terrain conditions, the production figures shown on Table 2 were obtained (Cumming 1972). These production figures were based on performances of identical Skagit SST's operated side by side. One was remote controlled and the other was controlled by walkie-talkie. The study took place over a three week period. The timber size and the cause of the idle time were not stated, and no statements were made concerning the operator efficiency.

The Weyerhaeuser Study

The Weyerhaeuser study was conducted near Longview, Washington, using a Skagit GT-5. It was operated on two

TABLE 2

FORESTRAL PRODUCTION FIGURES

	Without Remote Control	With Remote Control
Average cycle time	2 min. 30 sec.	1 min. 40 sec.
Average turns per day	155	220
Idle time per day	.3 hr.	nil
% increase in production		42%
Decrease in average cycle time		50 sec.

different settings both during the day and night. One setting, called the upper setting, was a flat setting with small timber (average diameter - 14") and the other setting, called the lower setting, was downhill (slope 25%) with timber to 70" in diameter and an average diameter of 24".

The machine was operated from 10/18/71 through 11/4/71 on the upper setting without the remote control unit and from 11/5/71 through 11/11/71 on the upper setting with the remote control unit. It was operated from 9/27/71 to 10/15/71 on the lower setting without the remote control unit and from 11/15/71 through 11/23/71 on the lower setting with the remote control unit. It was operated for two

eight-hour shifts per day on both settings; with and without the remote control unit.

Table 3 presents a summary of the data obtained from the Weyerhaeuser study (Weyerhaeuser 1971).

The average daily production of a running skyline with a mechanical grapple is 150 to 160 pieces per day (Studier and Binkley 1974). An average hourly production figure would be 18 to 20 pieces per hour.

The student's t-test was used to test the significance of the difference between the production of a yarder with and without the remote control unit. A two-sample t-test was performed to test the null hypothesis:

H_o: The mean productivity of a yarder with remote control equals the mean productivity of a yarder without remote control.

H_1: The alternative is that the mean productivity is greater using remote control.

(A 5% significance level was used)

Formulae*

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{S^2/n_1 + S^2/n_2}}$$

$$S^2 = \frac{(n - 1)s_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$

*Source: Statistics, Donald I. Koosis, John Wiley and Sons, New York, New York, 1972.

n = number of days equipment was used

$\bar{x}$ = mean production (average pieces per hour)

S = estimate of deviation for each sample

S^2 = a pooled estimate of the population variance

If we reject the null hypothesis (at the 5% level), we conclude that the mean production of a yarder with remote control is significantly greater than the mean production of a yarder without the remote control.

Upper Setting Day Time

REMOTE CONTROL	WITHOUT REMOTE CONTROL
$n_1 = 5$	$n_2 = 13$
$\bar{x}_1 = 32.3$	$\bar{x}_2 = 29.1$
$S_1 = 2.43$	$S_2 = 2.56$

degrees of freedom = 16

$\bar{x}_1 - \bar{x}_2 = +3.2$

$$t = \frac{3.2}{\sqrt{\frac{6.39}{5} + \frac{6.39}{13}}} = 2.404$$

At 16 degrees of freedom, a t value of 2.404 indicates that there is less than a 3% probability that the difference between the means was caused by chance or sampling error. Reject the null hypothesis.

TABLE 3

WEYERHAEUSER PRODUCTION FIGURES

Setting	Daytime	Nighttime
Upper without remote control (Walkie-Talkie)	29.1 pieces per hour	20.8 pieces per hour
Upper with remote control	32.3 pieces per hour	30.1 pieces per hour
Difference	+3.2 pieces per hour	+9.3 pieces per hour
% increase	11%	45%
Lower without remote control (Walkie-Talkie)	20.8 pieces per hour	20.6 pieces per hour
Lower with remote control	19.5 pieces per hour	17.1 pieces per hour
Difference	-1.3 pieces per hour	-3.2 pieces per hour
% decrease	6%	15%

Upper Setting Night Time

REMOTE CONTROL	WITHOUT REMOTE CONTROL
$n_1 = 5$	$n_2 = 11$
$\bar{x}_1 = 30.1$	$\bar{x}_2 = 20.8$
$S_1 = 2.16$	$S_2 = 4.88$

degrees of freedom = 14

$\bar{x}_1 - \bar{x}_2 = +9.3$

$$t = \frac{9.3}{\sqrt{\frac{18.34}{5} + \frac{18.34}{11}}} = 4.025$$

At 14 degrees of freedom, a t value of 4.025 indicates that there is less than a 1% probability that the difference between the means was caused by chance or sampling error. Reject the null hypothesis.

Lower Setting Day Time

REMOTE CONTROL	WITHOUT REMOTE CONTROL
$n_1 = 7$	$n_2 = 15$
$\bar{x}_1 = 19.5$	$\bar{x}_2 = 20.8$
$S_1 = 1.50$	$S_2 = 4.82$

degrees of freedom = 20

$\bar{x}_1 - \bar{x}_2 = -1.3$

$$t = \frac{1.3}{\sqrt{\frac{17.01}{7} + \frac{17.01}{15}}} = .687$$

At 20 degrees of freedom, a t value of .687 indicates that there is a 50% probability that the

difference between the means was caused by chance or sampling error. Accept the null hypothesis.

Lower Setting Night Time

REMOTE CONTROL	WITHOUT REMOTE CONTROL
$n_1 = 7$	$n_2 = 15$
$\bar{x}_1 = 17.1$	$\bar{x}_2 = 20.6$
$S_1 = 3.86$	$S_2 = 6.12$

degrees of freedom = 20

$\bar{x} - \bar{x}_2 = -32$

$$t = \frac{3.2}{\sqrt{\frac{30.685}{7} + \frac{30.685}{15}}} = 1.262$$

At 20 degrees of freedom, a t value of 1.262 indicates that there is a 20% probability that the difference was caused by chance or sampling error. Accept the null hypothesis.

Yarding Cost Analysis

Forestral Automation Ltd. also made a yarding cost analysis of the yarding operation using the prototype machine. It is presented below:

	WITH WALKIE TALKIE	WITH REMOTE CONTROL
Basic yarder cost	$200,000.00	$200,000.00
Radio/remote cost	3,500.00	12,500.00
Total capital cost*	$203,500.00	$212,500.00

*The salvage value for the equipment in the cost calculation was assumed to be zero.

	WITH WALKIE TALKIE (cont.)	WITH REMOTE CONTROL (cont.)
Cost per day (5 year pay out) (240 days per year)	$169.50	$177.00
Operating costs (labor, supplies, maintenance, etc.)	150.00	150.00
Total cost per day	$319.50	$327.00
Production (cunits)	80	115
Yarding cost per cunit	$ 4.00	$ 2.84
Yarding cost % decrease		29%
Yarding distance	800-1100 feet	

Since the Weyerhaeuser data was in pieces per hour, the yarding cost for the Forestral analysis was recalculated using pieces per day. It was assumed that each turn represented one piece.

	WITH WALKIE TALKIE	WITH REMOTE CONTROL
Total cost per day	$319.50	$327.00
Production - piece per day	155	220
Yarding cost per piece	$ 2.06	$ 1.46
Yarding cost % decrease	29%	

Using the same cost analysis and the same capital and operating costs as applied to the Weyerhaeuser production data, the following cost analysis was derived.

Upper Setting Day Time

	WITH WALKIE TALKIE	WITH REMOTE CONTROL
Total cost per day	$319.50	$327.00
*Production - piece per day	233	259
Yarding cost per piece	$ 1.37	$ 1.26
Yarding cost % decrease	8%	

Upper Setting Night Time

	WITH WALKIE TALKIE	WITH REMOTE CONTROL
Total cost per day	$319.50	$327.00
*Production - pieces per day	166	240
Yarding cost per piece	$ 1.92	$ 1.36
Yarding cost % decrease	29%	

Lower Setting Day Time

	WITH WALKIE TALKIE	WITH REMOTE CONTROL
Total cost per day	$319.50	$327.00
*Production - pieces per day	166	156
Yarding cost per piece	$1.92	$ 2.10
Yarding cost % increase	9%	

*Based on an eight hour shift

Lower Setting Night Time

	WITH WALKIE TALKIE	WITH REMOTE CONTROL
Total cost per day	$319.50	$327.00
*Production - pieces per day	165	136
Yarding cost per piece	$ 1.94	$ 2.40
Yarding cost % increase	24%	

Summary

The table below summarizes the increase or decrease in production and the reduction or increase in yarding costs as a result of using the remote control unit.

TABLE 4

YARDING COST AND PRODUCTION SUMMARY

Study Area	Cost	Pro-duction
Terrace, British Columbia	-29%	+42%
Upper setting, Longview, Wash. (day)	- 8%	+11%
Upper setting, Longview, Wash. (night)	-29%	+45%
Lower setting, Longview, Wash. (day)	+ 9%	- 6%
Lower setting, Longview, Wash. (night)	+24%	-15%

*Based on an eight hour shift

Greater reliability should be placed on the Weyerhaeuser study since the daily production figures were available and could be analyzed statistically. The only data available for the Forestral study was in final form and could not be statistically analyzed.

CHAPTER V

CONCLUSIONS AND DISCUSSION

Conclusions

The use of the Forestral remote control unit significantly increased production and reduced the yarding cost per unit in the Forestral study. The same was true in the Weyerhaeuser study when used at the upper setting which consisted of small timber (average DBH 14"). However, when used on the lower setting in larger timber (average DBH 24"), there was a decrease in production and a resultant increase in yarding cost. The increased production and decreased yarding cost per unit resulted from a marked decrease in cycle time.

Since no machine operating cost figures were available from Weyerhaeuser, the reduction in the yarding costs in the Weyerhaeuser analysis are hypothetical to the degree that the operating costs are figures that were obtained from the Forestral study and substituted into the Weyerhaeuser calculation. The increases in production are real figures.

However, mechanical problems in the Weyerhaeuser study were great enough, in conjunction with people problems, to discourage Weyerhaeuser from further use of the system.

Amual Knutz, Logging Manager for Weyerhaeuser Company, summarized their experience with the Remote Control Unit as follows:

> Many mechanical problems were encountered on both units used. (NOTE: Weyerhaeuser Company purchased one unit and another unit was on loan to us for use.) Electrical problems did not appear to be major.
>
> There appears to be no advantage with this system when used where yarding does not exceed 400 feet with good line of sight. The system may have application where very poor line of sight occurs or when weather impairs sight.
>
> Most GT logging shows will not and should not exceed 600 feet yarding distances.
>
> The economics of operating every day, all day, were marginal (i.e., low availability because of mechanical problems, some people problems, i.e., people using the system did not like it).
>
> Each time work had to be performed on unit by distributor, the unit had to go through Customs, causing delay to and from.

Weyerhaeuser is not presently using their remote control unit because of their problems with it (Knutz 1974).

Forestral advertises that with the use of the remote control unit, when chokers are used in the yarding, the engineer can also be the chaser and thus eliminate one man from the operation. The chaser is the individual who disconnects the choker from the logs when they reach the yard. However, the operation of the unit in that manner is prohibited by law in some states. According to Knutz (1974), Weyerhaeuser found that any attempt to use the engineer as the chaser had been unsuccessful.

In the future, if the cost of labor continues to increase and the number of people willing to work in the woods continues to decrease, it would be safe to say that remote control yarding systems will be further developed and used in logging operations. Forestral also manufactures a unit that permits the tractor skidder operator to operate the winch control and the engine speed remotely from the ground. This unit is presently being used in several places in the Pacific Northwest and Canada. Weyerhaeuser has used the unit with success.

In conclusion, the Forestral system, when used on small timber, can significantly increase production and the increase in production is enough to offset the added cost of the remote control unit. It can also increase production in situations where the visibility is poor and where the yarding distances are longer than normal.

Discussion

Several factors not related to the yarder and remote control unit could have had an effect on the production figures that resulted from the studies. Oakley (1976) stated that yarding cranes operate more effectively when a relatively short yarding distance (less than 500 feet) is used, when the log size is large and when there is adequate deflection. The reasons for short yarding distances are: (1) one log per cycle, (2) deflection can

be lost at long distances, (3) difficulty in placing the grapple on the log, (4) greater line pull at long distances and (5) yarding cranes are often slower than a conventional yarder (Oakley 1976). Item (3) would not be a factor when using a remote control unit. Large log size would cause an increase in production if production is measured in volume; however, if production is measured in numbers of pieces, log size would have the opposite effect. The large logs create an extra load on the yarder and an increase in inhaul time. Deflection is the sag in the skyline and the greater the deflection, the greater the payload.

Other factors would be operator proficiency and landing geometry. The landing geometry--angle of slope, spar height and angle and landing dimension--may greatly affect the capability of the yarding system (Cummins 1977).

Most of the above factors were eliminated by the designs of the studies. The one exception being operator proficiency. More than one operator was used in both studies. During the Forestral study, two yarders were operated side-by-side and during the Weyerhaeuser study the same machine was used throughout the study two shifts per day. In both studies, the machines were all subject to the same outside influences. They were either operated side-by-side at the same site or the same machine was operated sequentially--without remote control and then with remote control--at the same site at two different settings.

Another reference to the remote control yarder appeared in an article in the British Columbia Lumberman. The Forestral remote control system was successfully used on a logging show in Western British Columbia, Canada (Young 1975).

The Gawdawful Logging Company of British Columbia was using a Washington Model 78 yarder with a grapple, a Forestral remote control system and a Cat D8 as a tail-spar. The company was successfully logging small logs up to distances of 1,100 feet with the yarder and remote control system. According to the article, the practical yarding distance was approximately one-half the maximum yarding distance. The system produced a maximum 250 pieces per shift for one shift, but averaged 177 pieces per shift. The company tried using the system with only one operator but found that it worked better with two operators. The article did not explain why the system worked better with two operators instead of one operator. The average tree diameter and the slope gradient were not stated. According to the author, the logging company was completely satisfied with the operation and productivity of the machine.

No references to other studies or articles about the remote control system could be located. Attempts to contact Forestral Company in late 1977 were unsuccessful; the company had either moved and left no forwarding address

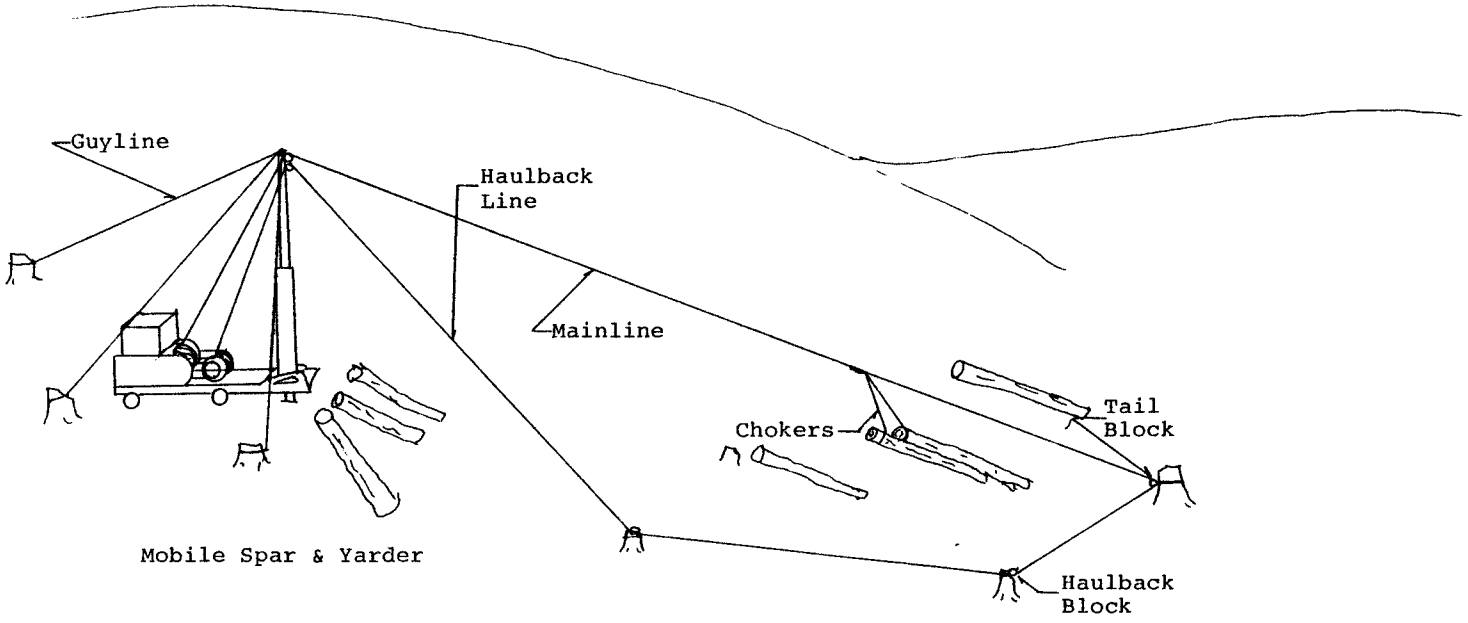
or had gone out of business.

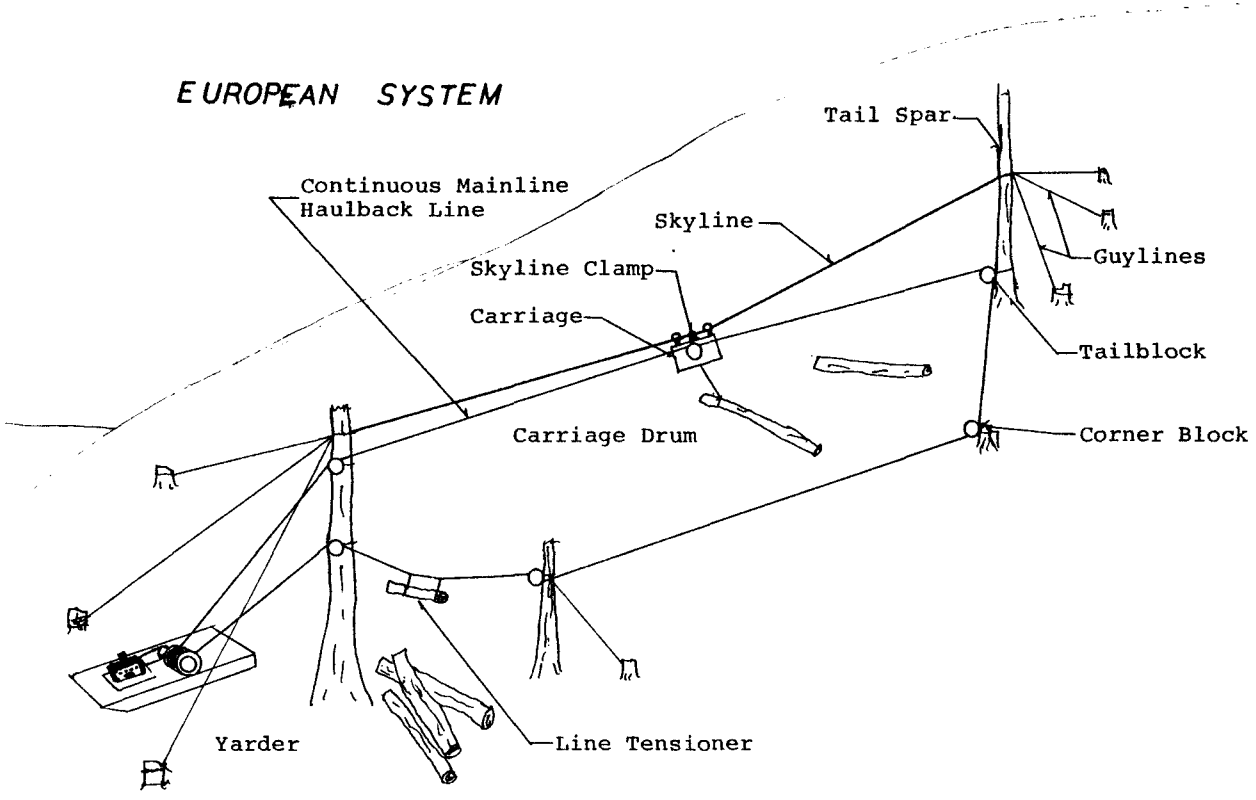
Why has the Forestral remote control unit, which can increase production resulting in reduced logging costs and possibly reducing manpower, failed to win consumer acceptance? There are several reasons. There was resistance by the workers to accept the device. Secondly, although the remote control unit makes it possible to eliminate a crew member when using the unit in conjunction with a grapple, the reduction in manpower has been denied by law. Some states' safety codes require two men for the operation of a yarder even if only one is needed to operate the machine. Thirdly, because of the distance between the Weyerhaeuser study location and the Forestral factory, obtaining parts and repairs was difficult. Perhaps the most overriding reason, however, was a marketing problem. Forestral Company, being a small firm with limited capital, did not have the resources to promote the device so as to obtain consumer acceptance of it. Forestral, also being a new company, did not have any established goodwill, sales expertise or marketing channels.

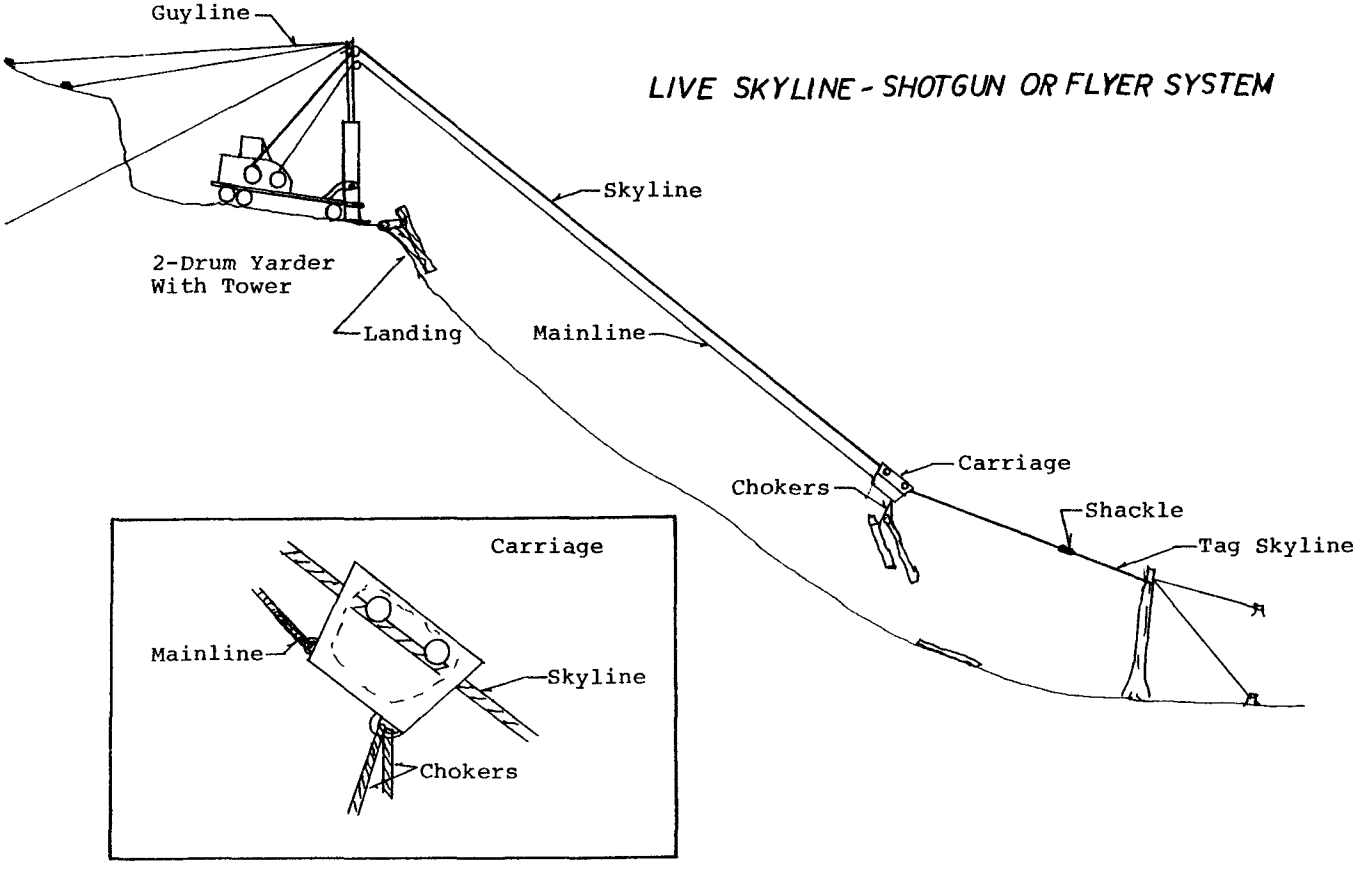
APPENDIX

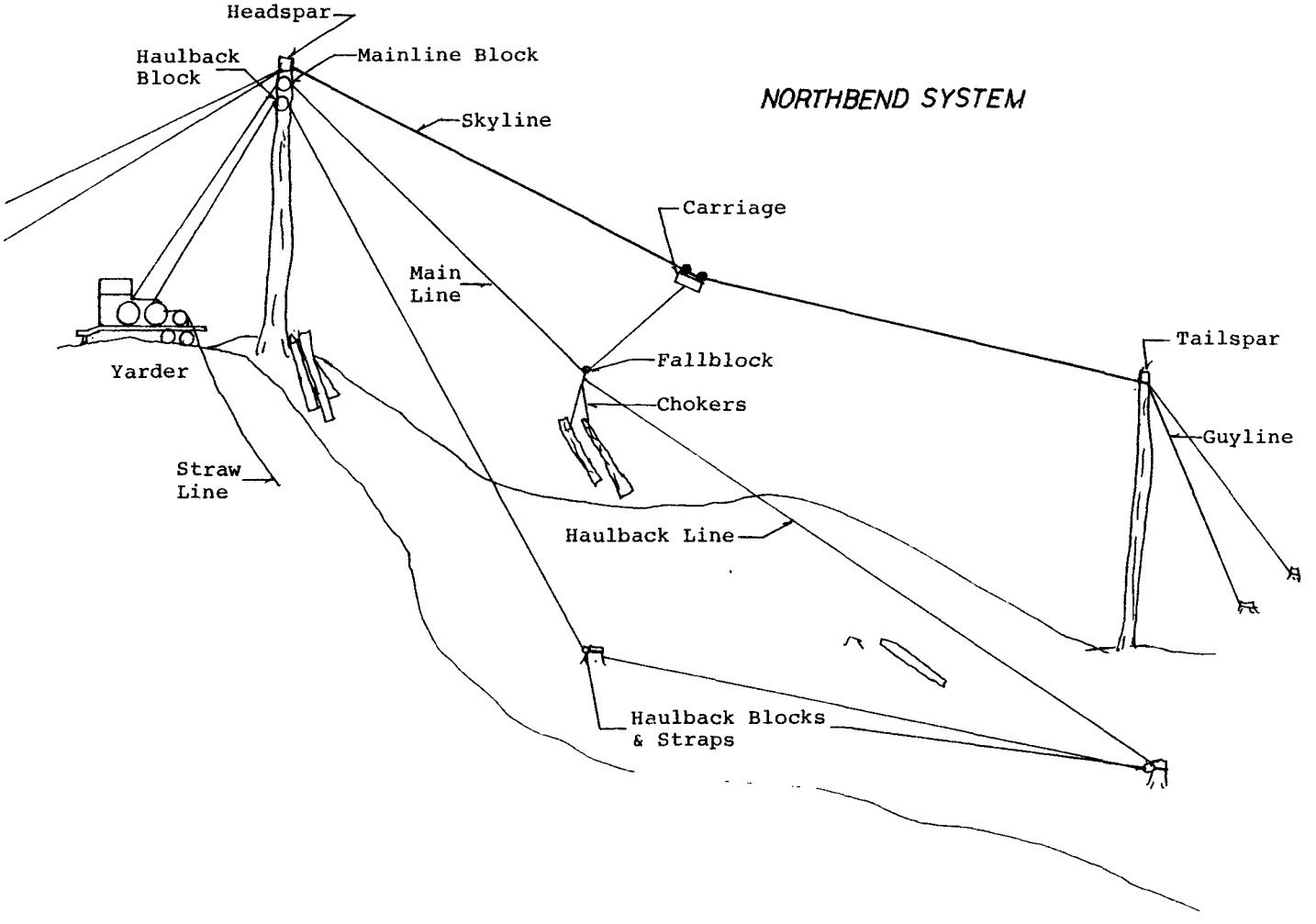
On the following pages are presented sketches of the more common types of yarding systems mentioned in this paper.

HIGHLEAD

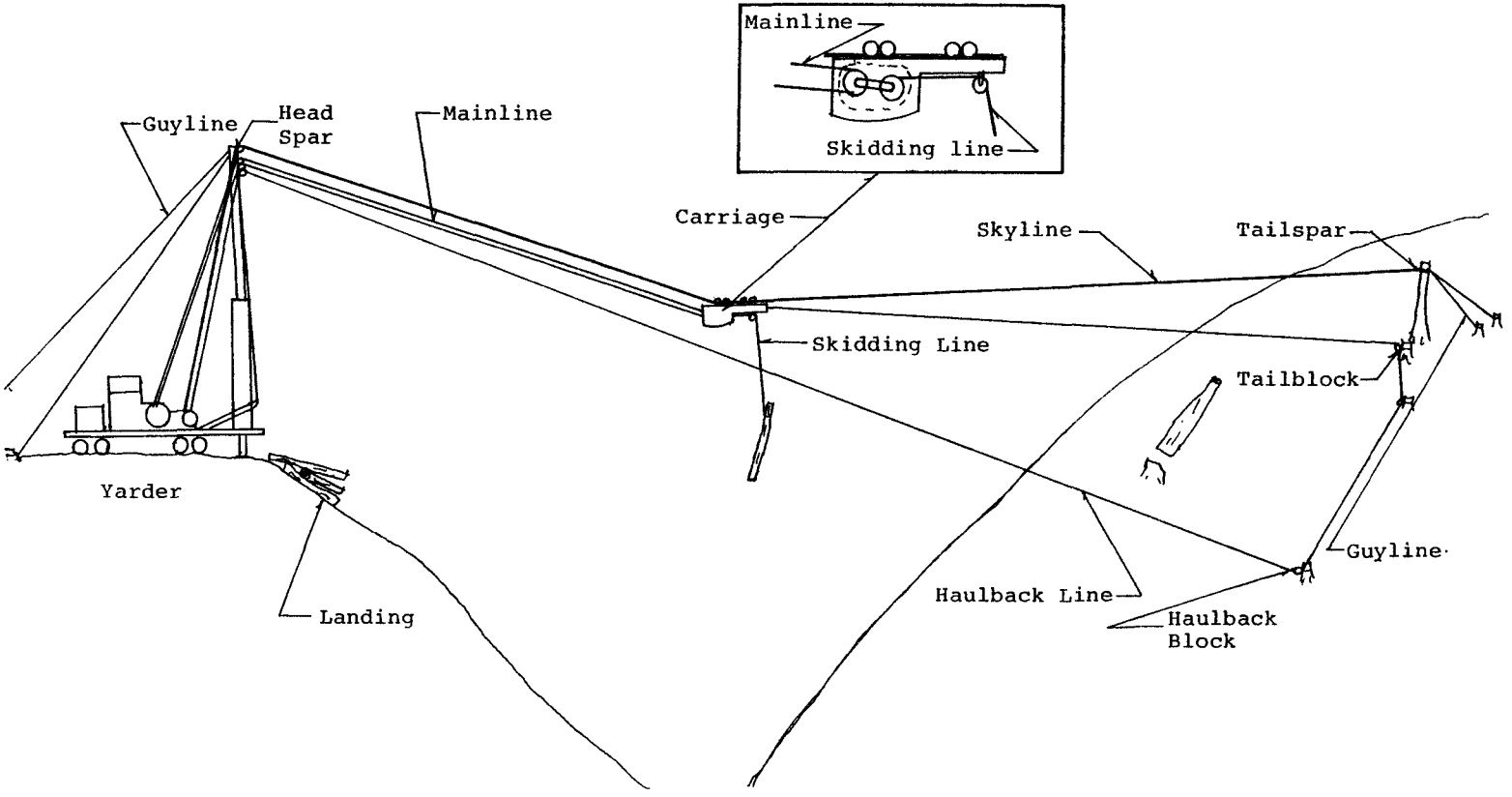

Guyline
Haulback Line
Mainline
Chokers
Tail Block
Haulback Block
Mobile Spar & Yarder


EUROPEAN SYSTEM
Tail Spar
Continuous Mainline
Haulback Line
Skyline
Skyline Clamp
Guylines
Carriage
Tailblock
Carriage Drum
Corner Block
Yarder
Line Tensioner

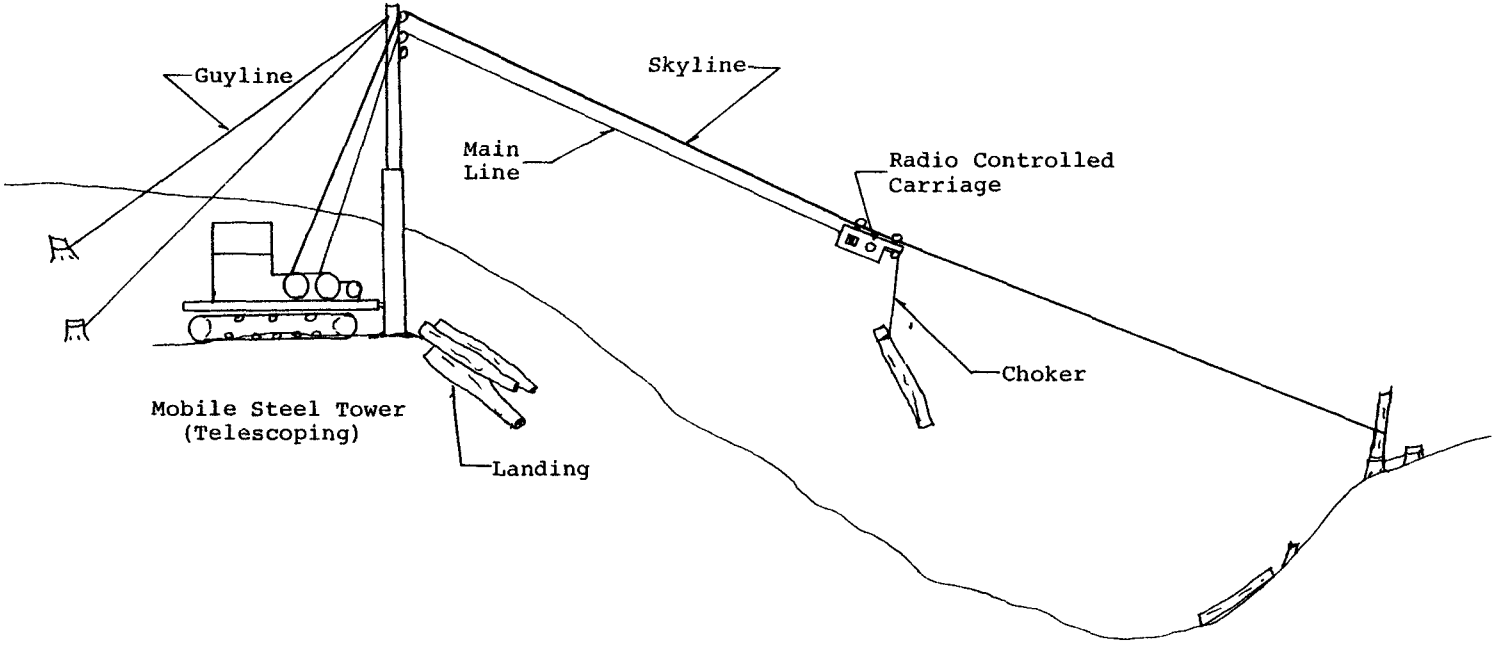

LIVE SKYLINE - SHOTGUN OR FLYER SYSTEM
Guyline
Skyline
2-Drum Yarder
With Tower
Landing
Mainline
Carriage
Chokers
Shackle
Tag Skyline
Carriage
Mainline
Skyline
Chokers


Headspar
Haulback Block
Mainline Block
Skyline
NORTHBEND SYSTEM
Carriage
Main Line
Tailspar
Fallblock
Yarder
Chokers
Guyline
Straw Line
Haulback Line
Haulback Blocks & Straps

SKYFLYER SYSTEM



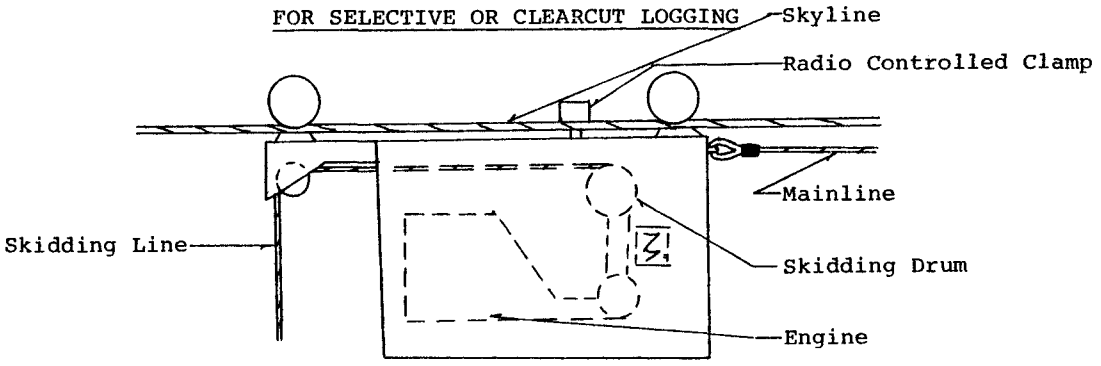
SKYLINE - RADIO CONTROLLED CARRIAGE



RADIO CONTROLLED CARRIAGES

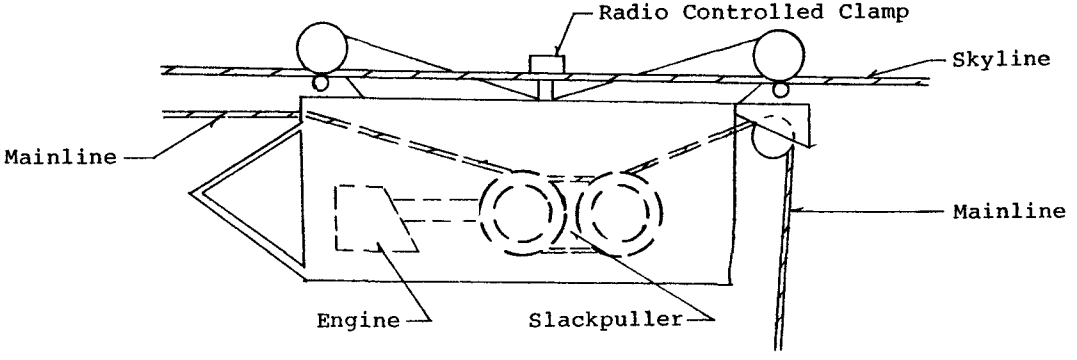
RCC-15

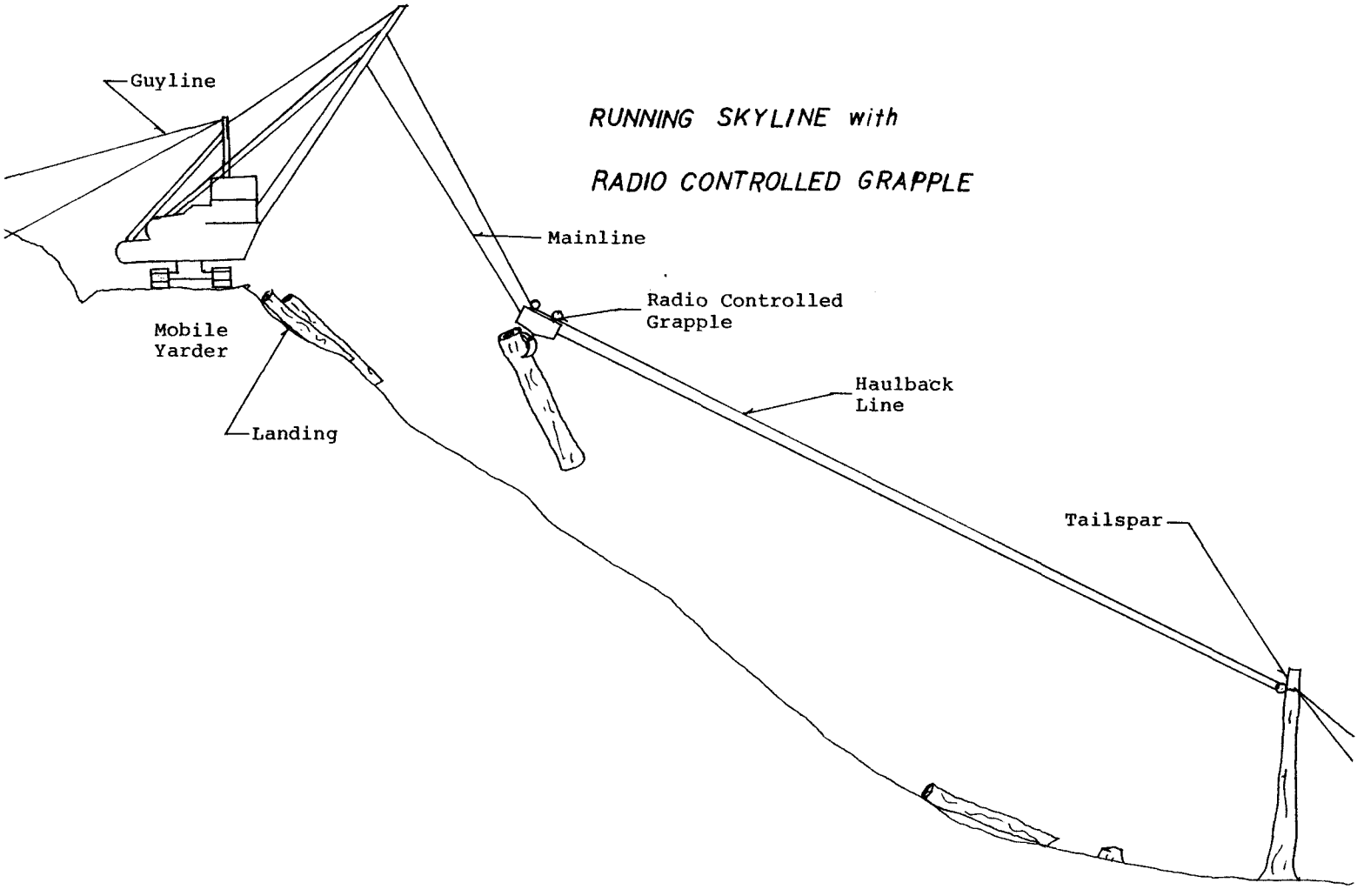
FOR SELECTIVE OR CLEARCUT LOGGING



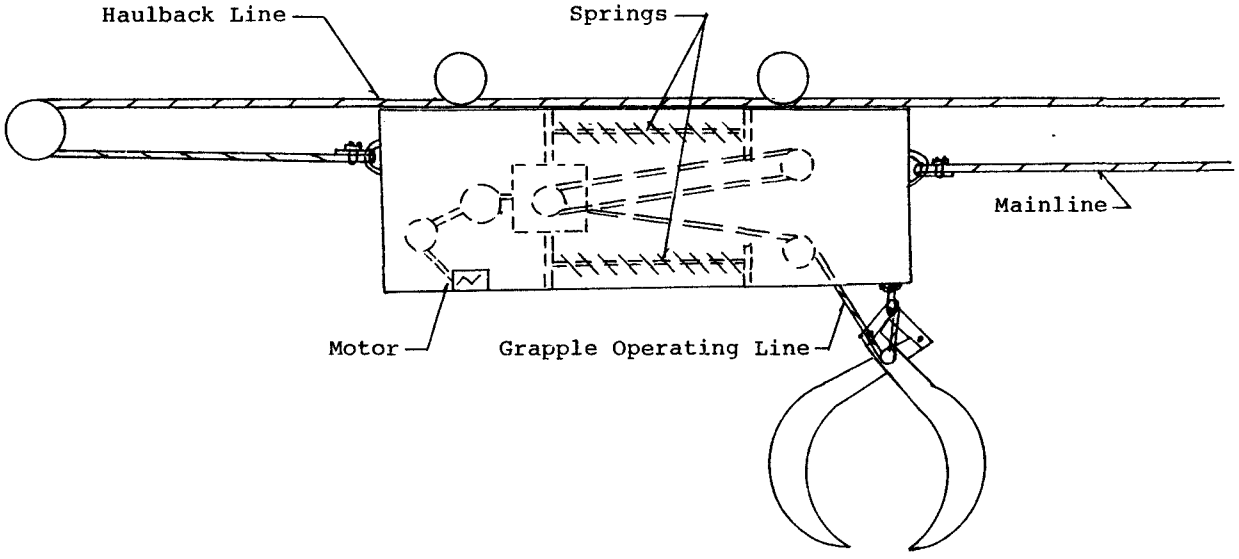
RCC-13

A THINNING CARRIAGE

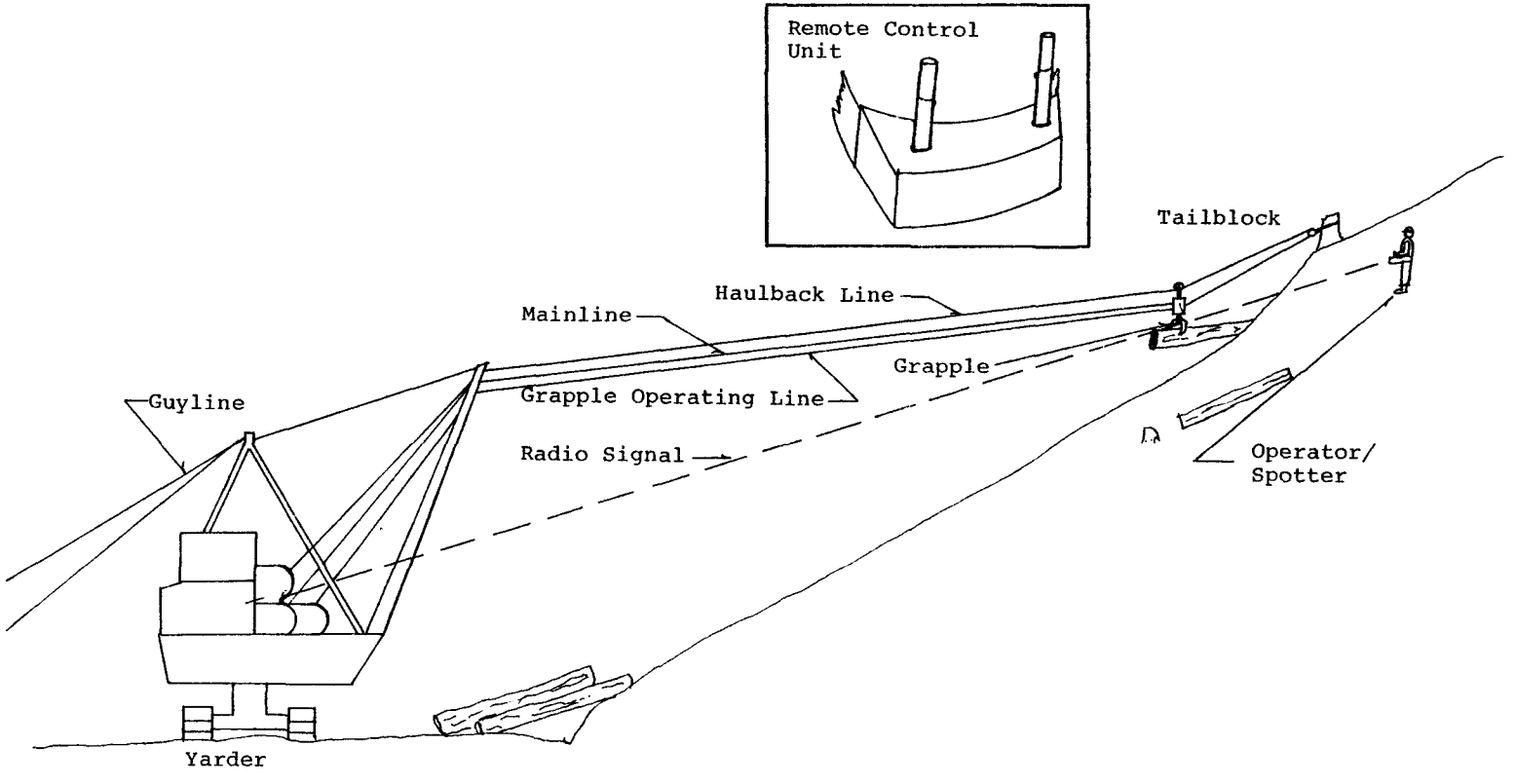



Guyline
RUNNING SKYLINE with
RADIO CONTROLLED GRAPPLE
Mainline
Radio Controlled
Grapple
Mobile
Yarder
Haulback
Line
Landing
Tailspar

RADIO CONTROLLED GRAPPLE



REMOTE CONTROL YARDING SYSTEM



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