An exploratory analysis of skidding in the Rocky Mountain area with emphasis on crawler tractor skidding
by LeRoy Conrad Stevens

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Industrial Engineering
Montana State University

Abstract:
When the first plans related to this thesis were laid out, a large Monte Carlo simulation program adapted to a computer was foreseen that would relate all of the variables affecting the skidding operation. After only a short period of time in the field it became obvious that, due to the time limit and limited funds, this approach was not feasible for a Master's thesis. This author estimates it would take at least five years of full-time work to accomplish the original objective.

Because the original objective was not feasible, a more practical approach was taken. This approach was to present the thesis in two sections.

The first section discusses some of the advantages and disadvantages of non-crawler tractor skidding machines in common use in the Rocky Mountain area. Information for this part of the thesis was attained primarily through personal interviews with logging contractors and operators.

The second and major section of this thesis is devoted to a parametric analysis of the principal variables affecting the economic skidding capabilities of some crawler tractors in the Rocky Mountain area.

The principal variables chosen were the following: 1. Tractor size 6. Operator efficiency
2. Soil 7. Number of men
3. Slope 8. Log type
4. Number of logs per turn 9. Size of logs
5. Distance 10. Altitude Data to be used for the parametric analysis were collected by utilizing continuous stop watch studies with some modification to fit the needs of the analysis.

Time was used as the dependent variable in determining the effect of the principal variables.

After basic times and factors were determined for the variables, they were related to the costs of running different crawler sizes. This was accomplished by determining cost curves for different combinations of variables.

The most important conclusion is that although large crawlers cost more per hour to operate than small or medium crawlers, they generally yield the lowest cost per thousand board feet for skidding logs. It is also shown in this thesis that as the number of men increases, skidding costs increase, and as the number of logs per turn decreases, skidding costs decrease.

AN EXPLORATORY ANALYSIS OF "SKIDDING" IN THE ROCKY MOUNTAIN AREA WITH EMPHASIS ON CRAWLER TRACTOR SKIDDING

by

LEROY CONRAD STEVENS

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

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Approved:

Head, Major Department

Chairman, Examining Committee

Graduate Dean

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To Mr. Gerald Seay and Mr. John Heaney go my sincerest thanks for helping in the data collection.

To my typists go my thanks.

Finally to my family goes my humblest appreciation for their gentle urging and assurance when progress faltered.

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ABSTRACT

When the first plans related to this thesis were laid out, a large Monte Carlo simulation program adapted to a computer was foreseen that would relate all of the variables affecting the skidding operation. After only a short period of time in the field it became obvious that, due to the time limit and limited funds, this approach was not feasible for a Master's thesis. This author estimates it would take at least five years of full-time work to accomplish the original objective.

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CHAPTER I

INTRODUCTION

HISTORICAL BACKGROUND OF THE PROBLEM

The forest products industry is one of the major industries in the Rocky Mountain area. In Montana the forest products industry is the third largest industry following mining and agriculture. (8, p. 3)

The forest products industry may be divided into two major activities:

1. Harvesting of the raw material and its transportation to the mills.
2. Manufacture of the raw material into finished products for the consumer.

The harvesting of the raw material and its transportation to the mills is known as the logging industry. The forest products industry is no different from any other industry in that it must produce a quality product at the lowest possible cost to be competitive. The cost of logging is so high in areas where steep slopes and small stems prevail that often times a less expensive, equally suited material can be found to substitute in place of wood. The Rocky Mountain States and western Montana in particular have many areas characterized by substantial volumes of small stemmed trees, such as lodgepole pine growing on steep slopes.

To help the logging industry a long range forest engineering program has been set up to develop systems to economically harvest the timber in areas characterized by steep slopes and small stems.

This long range program is designed to develop new logging methods and improve existing methods.

Before new logging methods can be developed and existing methods improved, a knowledge of the economic capabilities of the present methods must be obtained. After this knowledge is obtained it can be used to develop plans for future engineering research studies.

The skidding operation (i.e. movement of the logs from the stump to the landing) was selected as the area of the logging industry to study because:

1. Considerable work has been done on the logmaking operations. (9)
2. Skidding follows logmaking in the logging system.
3. Skidding represents one of the biggest costs in the logging industry.

STATEMENT OF PROBLEM

After spending some time observing skidding in the field it becomes obvious that there are nearly as many different variations of skidding methods as there are logging contractors. There is little agreement among these contractors concerning the best method. This should be expected because of the differences in soils, slopes, stand densities, personal preferences, and many other variables inherent in the logging industry.

In the Rocky Mountain area four basic skidding methods are in common use. The basic methods are:

1. Crawler tractors
2. Rubber-tired tractors
3. Jammer skidders
4. High lead skidders.

Each basic method has its own advantages and disadvantages.

There are two major objectives of this thesis. They are:

1. To present preliminary conclusions reached concerning non-crawler tractor skidding (i.e. rubber-tired tractors, jammer skidders, and high lead skidders),

2. To present an exploratory analysis of the effect of the principal variables affecting some crawler tractor skidding in the Rocky Mountain area.

Data collection was confined to eleven weeks during the summer of 1965. Due to the large number of variables inherent in the logging industry, it was impossible to gather enough data on all the basic skidding methods to make a thorough analysis comparing the basic methods. Therefore, it was decided to talk to the logging contractors to determine what the major limitations and advantages are of the basic non-crawler tractor skidding methods. Pictures, advantages, and limitations of these non-crawler tractor skidding machines will be presented.

The major part of this thesis will be devoted to a parametric analysis to determine the effect of the principal variables on the economic skidding capabilities of some crawler tractors in the Rocky Mountain area. A partial list of variables affecting crawler tractor skidding includes:

1. Tractor size
2. Soil (coefficient of traction)
3. Use of an arch
4. Tree-length versus log-length skidding

5. Size of logs
6. Number of logs per turn
7. Slope of terrain
8. Season of the year
9. Operator efficiency
10. Condition of equipment
11. Use of a choker setter
12. Altitude
13. Ownership of equipment
14. Log scale used
15. Stand density
16. Skidding distance
17. Type of chokers used
18. Type of landing
19. Felling practices
20. Branch road spacing
21. Brush density and height
22. Silvicultural requirements
23. Non-effective time
24. Resistances (grade, sliding, and rolling).

Time did not permit gathering enough data to compare all of the above variables. Therefore, those variables which contribute the most to the economic effectiveness of the crawler tractor skidding methods were considered. After considerable reading and discussions with individuals who understand the logging industry, it was decided that the following variables are the principal ones affecting crawler tractor skidding:

1. Tractor size
2. Soil (includes brush density, soil moisture content and rockiness of the soil)
3. Slope
4. Number of logs per turn
5. Distance
6. Operator efficiency
7. Number of men
8. Log type
9. Size of logs
10. Altitude.

The major objective of this thesis may then be said to determine the inter-relationships among the above principal independent variables and dependent variables (time and cost). This information will then be used to determine which crawler tractor yields the lowest skidding cost per thousand board feet for a given combination of variables.

CHAPTER II

LOGGING IN GENERAL

THE LOGGING SYSTEM

Logging in the Rocky Mountain area is done by both independent contractors and people who work directly for the mills.

An independent contractor is known as a "gyppo" in the logging industry. A gyppo owns his own equipment and agrees to deliver the logs to the mill for a stated amount. This amount is generally so much per thousand board feet (e.g. $28.00 per MBF). Having gyppo contractors deliver the logs to the mill is an advantage for the mill owners because they need not have so much money invested in equipment. The major disadvantage for the mill owners is that they do not have good control of the logging operations when they let gyppo contractors do the actual logging. In the Gallatin National Forest and much of southwestern Montana most of the logging is done by gyppo contractors. In northwestern Montana and other areas where larger trees prevail, the mills often buy their own equipment and do their own logging.

The logging system may be divided into four major interrelated processes. These processes are:

1. Logmaking
2. Skidding
3. Loading
4. Hauling.

Logmaking is the process of transforming the standing tree into log sizes that will meet the mill requirements. In the Rocky Mountain area most mills require 16, 25, and 32 foot log lengths.

The logmaking process includes three major operations which are felling, limbing, and bucking.

Felling is the operation of cutting down the standing tree. This operation is generally performed with a power chain saw.

Limbing is the operation of removing live limbs and large knots from the stem. Limbing nearly always follows the felling operation and is generally performed with the same implement. With the advent of smaller power chain saws some fellers now cut down the tree with a large saw and limb with a small saw. Dead limbs need not be removed because they will break off during the skidding operation.

Bucking is the operation of cutting the stem into acceptable log lengths (i.e. 16, 25, and 32 foot lengths) which the mills require. If the stem is not bucked until after it has been skidded, but before loading, this is called "hot logging" by many logging contractors. If the tree is not bucked at all before it reaches the mill, the logging industry refers to this as tree-length logging. Of the 13 logging operations visited during the data collection period only one contractor was engaged in tree-length logging. Whether or not a contractor engages in this type of logging depends primarily on the mill's ability to handle the longer stems.

The second process of the total logging system is skidding. This thesis deals with the skidding process so, at this time, skidding will merely be defined as the movement of the logs from the stump to the landing.

The third process of the total logging system is loading. Loading is the process of transferring the logs from the woods deck to a vehicle for transportation to the mill. In the Rocky Mountain area trucks are the most common vehicle used for transportation.

Three major pieces of equipment are in common use in the Rocky Mountain area for the loading process. They are:

1. Heel boom loader
2. Air tongs loader
3. Front end loader.

A heel boom loader is a small mobile crane that often has a boom attached to a manufactured cab and engine. This type of loader is rated by the manufacturer according to its stated capacity to excavate so many yards of earth with a certain size bucket. Common sizes in the Rocky Mountain area are 3/8, 1/2, and 5/8 yards. A heel boom loader utilizes a set of tongs which is set on the individual logs by a person known as a tong setter. The machine operator then butts the log against the boom for stability of the log, and then places the log on the truck. Often the tong setter or the truck driver has to get on top of the load to release the tongs. This can be dangerous as individuals on the load frequently will walk under a log still controlled by the machine operator. An advantage of a heel boom loader is that it can also be used as a jammer skidder. Jammer skidding is discussed in Chapter III.

An air tongs loader is also a small mobile crane rated in the same manner as a heel boom loader. An air tongs loader utilizes a set of

air operated tongs for loading. Only one man, the operator of the loader, is needed to load with this type machine. An air tongs loader is safer than a heel boom loader because it is not necessary to manually set and release the tongs. A major disadvantage of this type of loader is that it does not have the versatility of a heel boom loader because it cannot be used as a jammer skidder. Many of the small gyppo contractors in the Rocky Mountain area load only three or four loads a day requiring about two to three hours working time. The remaining time an air tongs loader is idle and therefore not fully utilized.

A front end loader used in the woods is generally mounted on a crawler tractor. This type of loader will load a truck faster than a heel boom or an air tongs loader because it can load several logs at a time. A higher initial investment is required for a front end loader than for a heel boom or an air tongs loader. A relatively large and level landing area is required for the operation of this type of loader. Among the larger logging contractors (i.e. those who load at least ten loads per day) this type of loader seems to be the most popular.

Hauling is the final process in the logging system. Hauling includes the transportation of the logs to the mill, unloading the logs, and returning to the logging area for another load. As previously stated, trucks are commonly used for the transportation of the logs. Unloading is a function of the mill and is most commonly done with a large rubber-tired front end loader.

The total logging system is portrayed with a flow process chart in Figure 1.

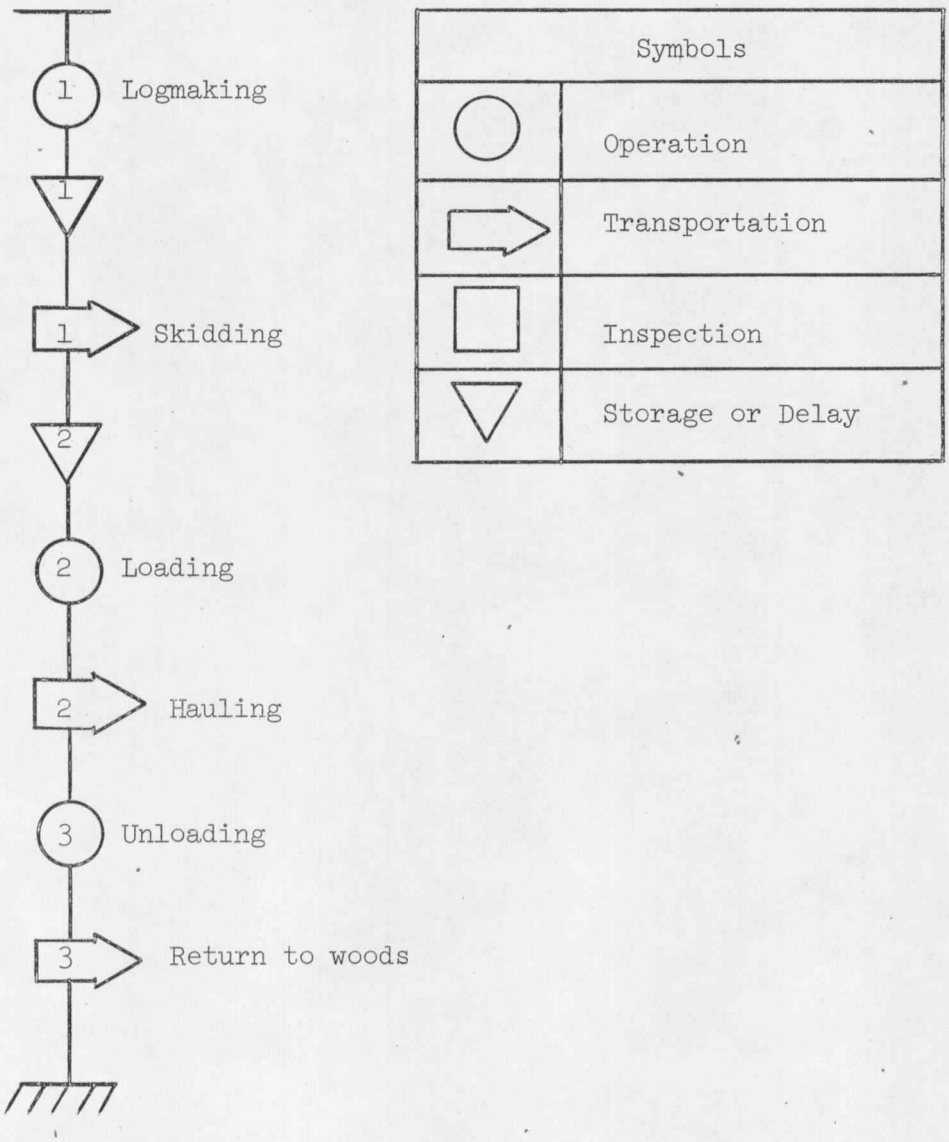

Figure 1. Flow process chart of logging operations.

SKIDDING PROCESSES NOT IN COMMON USE IN THE ROCKY MOUNTAIN AREA

Skidding has previously been broadly defined as the movement of the logs from the stump to the landing. Actually two terms are used to characterize the movement of the logs from the stump to the landing. These terms are skidding and yarding. Skidding is defined as "any method of moving logs from the stump to the landing wherein the logs are skidded along the ground." (4, p. 14) Yarding is defined as "any method of moving logs from the stump to the landing when the logs are in part or wholly lifted from the ground." (4, p. 14)

In this thesis only the term skidding will be used regardless whether the logs are skidded along the ground or are partly or wholly lifted from the ground during the movement from the stump to the landing. This is justified because most of the people in the logging industry use the two terms synonymously.

As previously stated there are four basic methods of skidding in the Rocky Mountain area which are:

1. Crawler tractors
2. Rubber-tired tractors
3. Jammer skidders
4. High lead skidders.

These basic methods are discussed in the next chapter. The remaining portion of this chapter is devoted to acquainting the reader with still other skidding methods in use or being developed in the logging industry.

Helicopters have been proposed for skidding logs from steep rugged terrain. (7, p. 1) A helicopter equipped to carry an external load of

4,000 pounds was tested in Canada in February, 1963. Test results are as follows:

(7, p. 9)

Assumptions:

1. Skidding distance = 3,000 feet
2. Wood weight = 12 pounds/board foot
3. Automatic release at landing takes .10 minutes
4. Hooking in woods takes .50 minutes
5. Aircraft cost = $350.00/hour

Representative cycle times:

Hooking time	= .50 minute
Unhooking time	= .10 minute
Inbound time	= 2.79 minutes
Outbound time	= 2.31 minutes
Total cycle time	= 5.70 minutes

Calculations:

Volume per turn = 4,000 lbs./12 lbs. per B.F.
= 333 board feet

$$\text{Number of turns per hour} = \frac{60 \text{ minutes/hour}}{5.70 \text{ minutes/turn}} = 10.5$$

Number of board feet per hour = 10.5 turns/hour
x 333 board feet/turn = 3,500

$$\text{Skidding cost per MBF} = \frac{\$350.00/\text{aircraft hour}}{3{,}500 \text{ board feet/hour}}$$
$$= \$.10/\text{board foot} = \$100.00$$

By comparison it costs approximately $10.00 per thousand board feet to skid using more conventional equipment such as crawler tractors. From the above helicopter trial it is obvious that this type of skidding is not practical for the present.

Balloons are being tested because of the high aircraft cost (i.e. $350.00/hour for a Sikorsky S58 helicopter) involved in helicopter logging.

If air-born logging (i.e. either helicopter or balloon logging) becomes economically possible, three very distinct advantages will be obtained. These are:

1. The ground will not be disturbed excessively during the skidding operation; thus, the soil will not be nearly so susceptible to erosion after the logging is completed.
2. Fewer roads will be required thus reducing the erosion problem.
3. There will be a method of skidding from areas not accessible by any means other than air.

Animals are still in use in some logging areas as a method of skidding. Horses or mules are used economically when either light timber stands or other factors make volume production impossible.

COMBINED PROCESSES

Machines are being developed to combine some of the processes in the logging system. As far as this author can ascertain, none of these machines are in common use in the Rocky Mountain area. Nevertheless, they should at least be presented to acquaint the reader with some of the newer developments in the logging industry since these machines or variations of them may be used in the Rocky Mountain area in the future.

A combine is now available that will fell, limb, buck, and bind the stems into cords. It is called the Busch Combine. A Busch Combine is essentially a four-wheel drive rubber-tired tractor fitted (13, p. 51) with hydraulic knives used for felling and bucking. Limbing and

measuring devices are also incorporated in a manner such that all phases of preparing the stick are done in one continuous manner. After a cord is harvested the combine binds the cord and drops it behind the machine to be picked up later. This combine would have limited use in the Rocky Mountain area as it is for areas with level ground and heavy stands of medium or large size trees. A Busch Combine costs approximately $37,000.00.

The Vit Feller Buncher was developed in 1957 and 1958 to fell the trees and skid them whole to the landing where another machine limbs and bucks them. The Vit Feller Buncher fells the trees with a hydraulically driven chain saw and collects them on an overhead rack for delivery to the landing. It is basically a crawler tractor that utilizes an overhead rack rather than chokers for skidding trees. Its cost is approximately $15,000.00. A Bombardier Processing Unit (BPU) is used in conjunction with the Vit Feller Buncher. The BPU is a lattice-like structure almost 100 feet long which performs the following functions: (13, p. 55)

1. The tree is pulled through a limbing device.
2. The tree proceeds by conveyer to a stop plate set for different log lengths.
3. A large circular saw bucks the tree after which the logs fall onto the ground.

Another new prototype machine is a Pope Harvester. A Pope Harvester is an attachment for the C-frame of a crawler tractor. The Harvester mounted on a large crawler tractor is a mobile machine (13, p. 58)

which severs the tree from the stump, carries it upright to the landing, limbs it, bucks it, and deposits the logs on the ground. Mounting a Harvester on a crawler tractor does not alter the basic tractor and can be removed at any time restoring the tractor to its original form. A Harvester is basically two jaws and a hydraulically operated chain saw used for felling and bucking. In operation the operator drives the machine up to a tree, grasping it with the main jaw, and severs the tree with the chain saw. The unit then moves to the landing and rotates the tree to a horizontal position. The second set of jaws moves along the tree removing the limbs. Next the tree is held by the limbing jaw and pushed through the main jaws removing the remaining limbs and positioning the tree for bucking. The chain saw rotates for the bucking cuts, makes the cuts, and the logs fall to the gound. It has been estimated that this Harvester could be manufactured on a production basis for about $10,000.00 per unit.

CHAPTER III

NON-CRAWLER SKIDDING MACHINES IN COMMON USE IN THE ROCKY MOUNTAIN AREA

The three major non-crawler type skidding machines in common use in the Rocky Mountain area will be discussed in this chapter. The presentation of any particular manufacturer's equipment does not constitute an endorsement, but is presented only as an illustration of the equipment commercially available.

RUBBER-TIRED SKIDDERS

Rubber-tired skidders are gaining an important place among skidding machines used in the Rocky Mountain area. These skidders, equiped with large pneumatic tires, offer good flotation making them better than crawlers for skidding in muddy or boggy areas and on level to moderate slopes with little slash. Crawler tractors generally have a great amount of difficulty operating in muddy or boggy areas because of their weight and poor flotation. Rubber-tired skidders have a top speed of about 21 miles per hour compared to about seven miles per hour for conventional crawler tractors.

Many of the larger logging companies that wish to reforest their land after logging are using rubber-tired skidders for skidding on level ground because these skidders do not disturb the soil as much as crawlers.

It was the opinion of most of the interviewed loggers that rubber-tired skidders yield higher production and lower maintenance costs than

conventional crawlers in areas of level to moderate slopes, little slash, and in muddy or boggy areas.

The limitations of rubber-tired skidders may be summarized by saying these skidders lack versatility. These skidders are generally limited to level to moderate slopes (i.e. up to 15%) and little slash. Rubber-tired skidders presently are not used to build roads in logging areas.

Photographs, specifications, and a summary of data collected for two rubber-tired skidders in use in the Rocky Mountain area are shown on pages 18 through 21. Because the sequence of operations for rubber-tired tractor skidding is the same as for crawler tractor skidding, the flow process chart for both methods will be presented later.

Figure 2. The Garrett Tree Farmer is a small rubber-tired skidder.

TABLE I

SPECIFICATIONS AND SUMMARY OF DATA COLLECTED
FOR A SMALL RUBBER-TIRED SKIDDER
(5, p. 1)

Manufacturer: Garrett Enumclaw Company, Enumclaw, Washington

Model: Tree Farmer-Model 15

Engine: Ford, 4 cylinder gasoline, horsepower = 68

Transmission: Warner-Ford, 4 speed

Speeds: .728 m.p.h. to 21.25 m.p.h.

Tires: 13.6 x 28

Clearance at center pin: 21 inches

Dimensions: Length - 193 inches
Width - 79 inches
Height - 98 inches

Drawbar horsepower: 58.3

Weight: 7,000 pounds (estimated)

Cost: Approximately $10,000.00

Hourly operating cost: $2.50 (estimated) - Does not include operator's wage.

Summary of data collected:

Number of turns studied	= 15
Slope	= -11% (skidding downhill)
Distance	= 300 to 450 feet
Soil condition	= Good
Time studied	= 3.2675 hours
Number of board feet skidded	= 7,685
Number of board feet per hour	= 2,350

Figure 3. A Mountain Logger is a medium sized rubber-tired skidder.

TABLE II

SPECIFICATIONS AND SUMMARY OF DATA COLLECTED
FOR A MEDIUM SIZED RUBBER-TIRED SKIDDER
(6, p. 1)

Manufacturer: Mountain Manufacturing Company, Kalispell, Montana

Model: Mountain Logger

Engine: General Motors, 4 valve diesel, 101 BHP at 3,000 RPM

Transmission: 4 speed

Speeds: .75 m.p.h. to 21.5 m.p.h.

Tires: 16.9 x 30

Clearance: 22 inches

Dimensions: Length - 189 inches
Width - Legal
Height - 110 inches

Drawbar horsepower: 65 (estimated)

Weight: 11,500 pounds

Cost: Approximately $16,000.00

Hourly operating cost: $3.90 (estimated) - Does not include operator's wage.

Summary of data collected:

Number of turns studied	= 23
Slope	= -5%
Distance	= 350 to 800 feet
Soil condition	= Fair
Time studied	= 4.7345 hours
Number of board feet skidded	= 12,320
Number of board feet per hour	= 2,600

JAMMER SKIDDERS

Jammer skidding, or shovel logging, is done with a small mobile crane similar to an air tongs or heel boom loader. Jammer skidders utilize a set of tongs at the end of a cable for skidding. These skidders have either a homemade wood or steel boom attached to a manufactured cab. Jammer skidders are rated the same as an air tongs or heel boom loader.

These skidders may be mounted on tracks and be self-propelled or mounted on a truck. If mounted on a truck, they are easier to move from one logging area to another logging area.

Jammer skidders are used by many of the gyppo contractors because most of these machines can be used for both loading and skidding. A smaller investment in equipment results if a small contractor uses jammer skidders. Also by using a jammer skidder for both loading and skidding, the equipment can be more fully utilized.

Besides the unique advantage of being able to both load and skid, a jammer skidder can also skid logs for short distances from ground that is too steep for crawler tractors or rubber-tired skidders.

Most loggers agree that jammer skidders are limited to skidding 50 feet downhill and 150 feet uphill. For short distances (i.e. 50 feet to 150 feet) jammer skidders generally yield high production at low operating cost.

Although skidding trails are not needed for jammer skidding, many more roads are required because of the short distances over which jammers can effectively skid. Roads are very expensive to build and maintain.

Besides being expensive, roads tear up the ground to such a degree that replanting is nearly impossible. This need for many roads is the major limitation of jammer skidding.

Jammer skidding utilizes two men, one for operating the equipment and one for setting tongs. This results in three disadvantages. The first is that during periods of downtime two men are idle. Another disadvantage is that the tong setter is often in some danger because an experienced operator maneuvers the skidder in such a way that the tongs are tossed to the tong setter. The tong setter could be hit and injured by the tongs. It is common practice among loggers to let dead trees and trees under a certain diameter stand during the logmaking process. When a log is being skidded to the deck, it may hit one of these trees, knocking it over subjecting the tong setter to additional danger.

Jackstrawed decks are usually made by jammer skidders. There are also more decks because of the small area that can be skidded with one set-up of the skidding machine. These jackstrawed and numerous small decks tend to increase the loading time.

A flow process chart of steps involved in one cycle of jammer skidding is shown in Figure 4.

Pictures of two typical jammer skidders used in the Rocky Mountain area are presented in Figures 5 and 6. Because most jammer skidders are converted back-hoes or small draglines, specifications are not too meaningful.

The Link Belt jammer skidder shown in Figure 5 costs about $30,000.00 new and the P & H jammer skidder presented in Figure 6 costs about

$12,000.00 used.

These skidders can skid about 50 logs per hour and load about 60 logs per hour. These estimates are from actual studies and discussions with the operators. Neither of these estimates include set-up times.

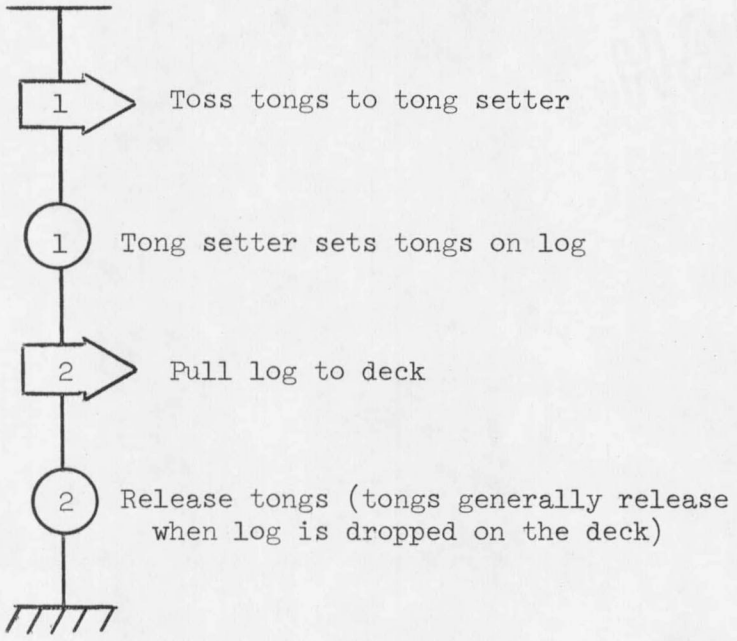

Figure 4. Flow process chart of steps involved in jammer skidding.

Figure 5. A 5/8 yard, steel boom jammer skidder mounted on tracks.

Figure 6. A combination 3/8 yard heel boom loader and jammer skidder mounted on a truck.

HIGH LEAD SKIDDERS

The two major components of high lead skidders are a tower and a "donkey" which contains the main power unit and the haulback and main drums. Figure 7 shows a simplified sketch of a high lead system.

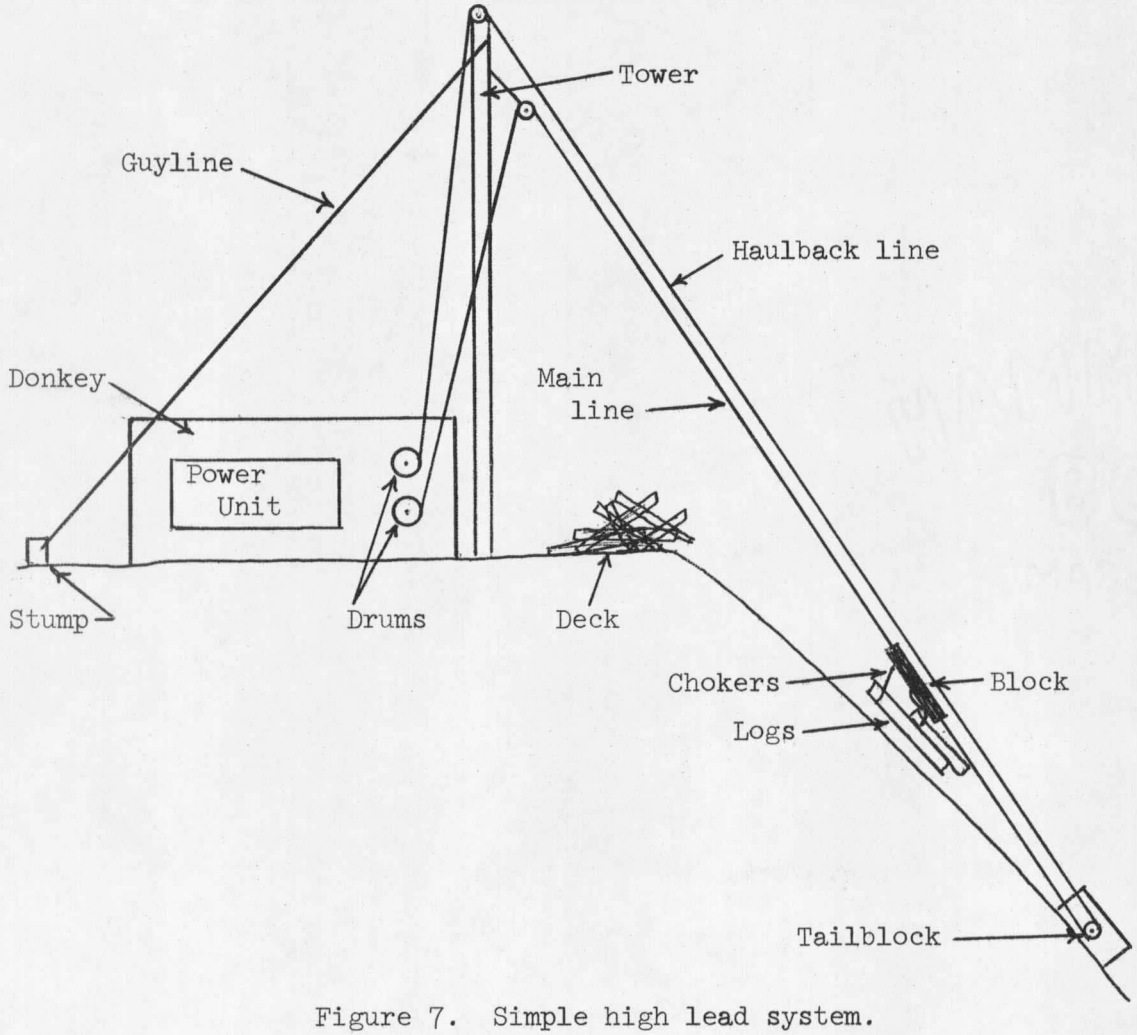

Figure 7. Simple high lead system.

In operation the operator sends the block with attached chokers to the choker setter in the woods. The choker setter sets the chokes and signals the operator to pull the logs up to the deck where someone releases the chokes from the logs.

High lead skidders yield high production in areas of dense stands. They are particularly advantageous in areas of very steep slope. These skidders work very well on slopes over 45% which are nearly impossible to negotiate with crawler tractors or rubber-tired skidders. These skidders work very well for distances over 1,000 feet which can not be skidded economically by other methods.

Skidding trails are not needed for this method of skidding. Few roads are needed with high lead skidders because a large area can be worked from one set-up of the machine. Because this method does not need skidding trails, requires fewer roads, and lifts the logs off the ground during the skidding process, the ground is left virtually undisturbed from the logging operations.

The major limitation of high lead skidders is their high initial cost. A gyppo contractor generally can not afford the initial investment for a manufactured system. For this reason there are very few high lead systems in areas logged primarily by small independent contractors. These systems are extensively used in the Pacific Northwest where large logging companies are working in dense stands of fir and other large diameter trees.

Homemade high lead skidders can be made to overcome the limitation of high initial cost. A picture of a homemade skidder is presented in

Figure 9. It is this author's opinion that these low cost homemade skidders have much potential and should be thoroughly investigated by the small logging contractor.

Another limitation is that at least two and often up to nine or ten men are needed to operate a high lead system. One man is used to operate the machine, one or more men run crawler tractors pushing the logs to an area where chokers can be hooked, one or two men release chokers at the deck, and the rest hook chokers in the woods.

A deck made by a high lead skidder is the most jackstrawed of any deck observed. Therefore, the loading time from a deck made by a high lead skidder is generally longer than from decks made by the other skidding machines.

Another limitation in some areas is that the stumps that are used to anchor the tower pull out during wet weather, therefore, making the system inoperable.

A picture of a manufactured high lead system is presented in Figure 8. The Skagit system costs approximately $80,000.00 new. The homemade system as shown in Figure 9, costs about $2,000.00. (1, p. 1) Two men skidded 42 logs over a distance of 150 feet with this homemade machine in 58 minutes.

Figure 8. A Skagit system used for high lead skidding.

Figure 9. A homemade high lead skidder.

SUMMARY

This chapter has been devoted to descriptions of non-crawler skidding machines in common use in the Rocky Mountain area.

After spending approximately three months in the field gathering data, this author has come to the following conclusions concerning non-crawler skidding machines:

1. None of the machines can be used without the aid of a crawler tractor for building roads.
2. Rubber-tired skidders should be investigated by loggers if they work primarily on level to moderate slopes.
3. Small contractors should investigate jammer skidders because of their versatility to be used as both a skidding and loading machine, thus lowering the initial investment in equipment and also utilizing the equipment more fully.
4. A lower priced high lead system is needed in areas where small loggers work so they can manage the initial investment.

CHAPTER IV

CRAWLER TRACTOR SKIDDING

Crawler tractors are the most versatile of all the skidding machines presently employed in the Rocky Mountain area. Because crawler tractors are so versatile, each logging contractor generally owns at least one crawler tractor even if he utilizes some other machine for skidding. Crawler tractors are commonly used for the following operations:

1. Skidding right-of-way for roads
2. Building roads
3. Skidding logs
4. Decking logs
5. Pulling trucks
6. Cleaning up the area after the logging operations are completed.

To minimize investment in equipment many small gyppo contractors own one or two crawlers to perform all of the above operations. Observations in the field indicated that crawler tractor skidding is the most popular method presently employed in the Rocky Mountain area. For this reason the remaining portion of this thesis will be devoted to crawler tractor skidding.

THE CRAWLER TRACTOR AND AUXILIARY EQUIPMENT

Crawler tractor skidding in the Rocky Mountain area is performed with all sizes of crawlers. In areas of small stems, such as lodgepole pine, small and medium size crawlers are most popular. Large crawlers are predominant in areas of larger stemmed trees, such as ponderosa pine and Douglas fir. A basic crawler tractor generally has a winch, dozer, and protective canopy mounted on it when used for skidding. Crawler tractors,

with their great weight and crawler tracks, offer a maximum traction effort for the various soil and terrain conditions that must be worked on.

Crawler tracks are designed in such a way that rutted surfaces and other ground irregularities can be driven over. Wide tracks reduce the ground loading per square inch thereby improving flotation. Greater flotation is needed on soft soil to keep the crawler from sinking in. After the logmaking operation there is considerable slash (i.e. branches, bark, tops, decayed logs, and broken or uprooted trees) lying on the ground which may cause track slippage. Because of the slash and soil condition, one generally finds crawlers with wide tracks in the forests. If an operator plans to be working in areas that are characterized by abrasive materials, such as rock and sand, he should be certain that the track shoes are heat treated. A special style track shoe is available for use in ice and snow.

Steering of crawler tractors is generally done by means of multiple disc clutches which stop the power to a track when disengaged. The tractor will turn in the direction of the stopped track. These steering clutches may be operated either mechanically or hydraulically, depending on the make and model of the tractor. A master clutch on a crawler tractor is used to connect the power from the engine to the transmission. All clutches are operated by hand levers instead of foot pedals. The speed of a crawler tractor is controlled with a throttle lever.

The winch is probably the most important piece of auxiliary equipment mounted on the crawler tractor. The winch allows the crawler to skid logs to the landing and also to retrieve logs from inaccessible spots.

Pulling trucks out of mud and removing stumps are two other jobs commonly performed by a winch. Fifty to one hundred feet of 3/4 or 7/8 inch diameter cable are attached to the winch. Chokers are attached to the end of the cable to be placed around the logs during the skidding process.

A canopy is required by law for crawler tractors used in the woods. A canopy is basically pipe, sheet steel, and heavy screen manufactured in such a way as to be mounted over the seat of a crawler to protect the operator from falling trees, limbs, and logs that get jackstrawed during skidding.

Most crawlers used for skidding have a dozer attached. Most dozers are hydraulically controlled although cable controlled dozers are available. An angle blade is preferred over a straight blade for the following reasons:

1. Sidecasting material while skidding road right-of-way
2. Decking logs with minimum damage to the logs.

A crawler tractor with auxiliary equipment used for skidding is shown in Figure 10.

Some crawlers are further equipped with an arch to lift the ends of the logs off the ground during the skidding process. An arch may be either mounted on the crawler or be pulled by the crawler as a separate unit. If mounted on the crawler it is known as an integral arch. An arch mounted on crawler tracks and pulled by the crawler is known merely as an arch. An arch mounted on steel or rubber wheels and pulled by the crawler is commonly called a sulky.

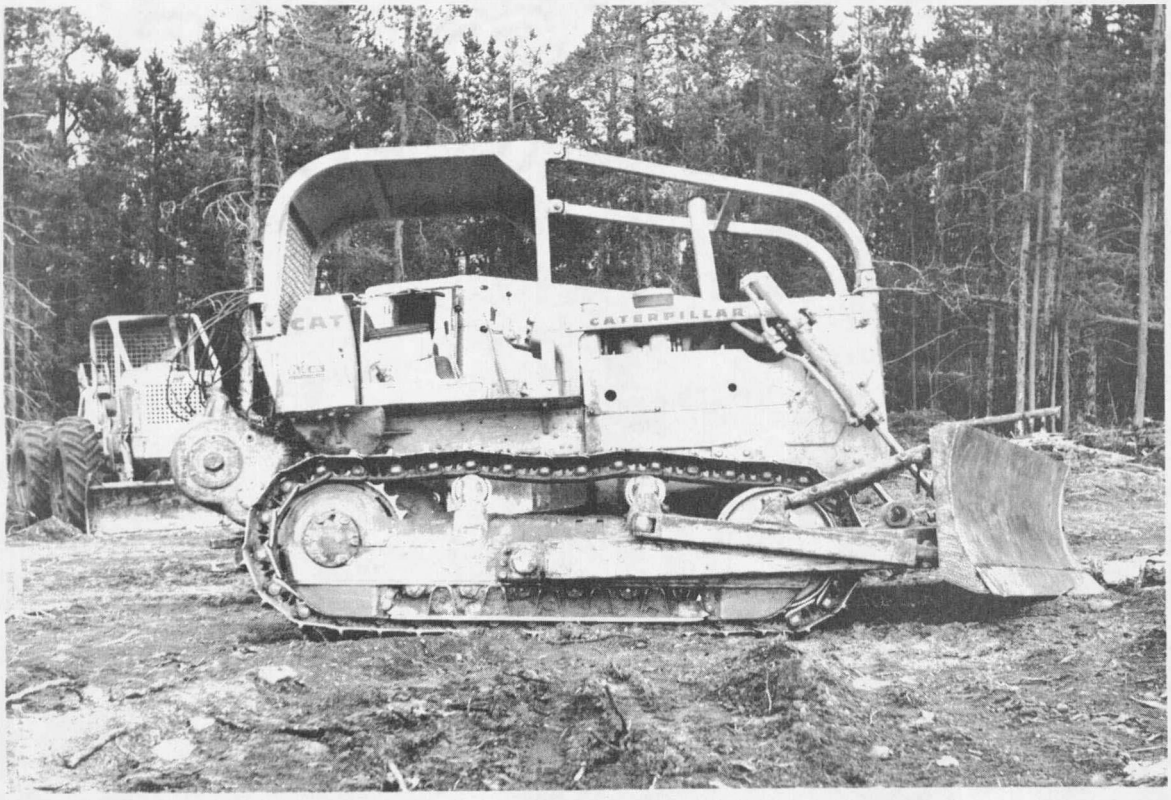

Figure 10. Crawler tractor with auxiliary equipment used for ground skidding.

The following list contains some of the advantages of an arch:

1. It keeps the ends of the logs off the ground, thereby increasing load capacity because of less log sliding resistance and eliminates the bulldozing effect of logs in the dirt.

2. Chokers are much easier to unhook at the landing because the logs have not been skidded on the ground packing the chokers full of dirt and foliage.

3. Maintenance cost and downtime at the sawmill are reduced because sand and rocks are not imbedded in the bark, as in the case of ground skidding, hence reducing saw sharpening at the sawmills.

Some of the disadvantages of an arch are:

1. Towed arches are slower to maneuver and require slightly longer to gather a load than regular ground skidding crawlers.

2. Integral arches put added weight on the back of the crawler and are said to cause excessive wear on the driving mechanisms, thereby increasing maintenance costs.

3. An arch costs about $1,200.00 installed.

Heavier loads and long skidding distances are particularly suited to skidding with a towed arch. Small crawlers can be used to bunch the logs in the woods for larger crawlers with towed arches which skid the logs to the landing. An integral arch mounted on a crawler is shown in Figure 11 and a picture of a rubber-tired arch (sulky) is shown in Figure 12.

Eleven turns studied on a small (about 31 drawbar horsepower) crawler with towed arch indicated that a small crawler with an arch skids approximately with the same number of board feet per turn as a medium size crawler (about 52 drawbar horsepower) without an arch. Studies showed that both crawlers skid about 450 board feet per turn.