SOME CONSIDERATIONS IN PLANNING
A MOBILE LOGGING OPERATION

by

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B.Sc., University of Otago, 1949

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF FORESTRY

In the Faculty

of

Forestry

We accept this thesis as conforming to the
required standard

Members of the Faculty of Forestry

THE UNIVERSITY OF BRITISH COLUMBIA

December, 1956

ABSTRACT

The vast timber resource of the Pacific Northwest has been dwindling rapidly particularly in those areas of good accessibility close to the markets. This, together with the increased demand of a buoyant market and a rapidly expanding forest products industry, has made it necessary to recover the greatest possible amount of timber from the accessible forest acreages, and to utilize those areas previously considered inaccessible or uneconomic.

In order to accomplish this, the logging industry has changed from its former role as exploiter of a large natural resource and is approaching its future role of forest manager, in which it will stress conservation and increased utilization of the available timber previously considered unmarketable. During the last decade logging operators have had to modify the traditional logging methods designed to cope with large volumes on accessible timber tracts. This has been achieved by increasing the mobility of operations, in order to cope with scattered stands of lower timber volume growing on land that is more difficult to log. Also by introducing a variety of methods for handling smaller logs, a greater wood volume per acre is being recovered.

This thesis is a discussion of the planning of a modern mobile logging operation in order to take the maximum advantage of the new machines and methods of logging that have been developed. A comparison is made of the advantages and limitations of the machinery introduced recently to logging operations in order to outline the methods of operation whereby these machines may be used most effectively. The method of planning a layout is considered so that logging engineering, economics, and silvicultural considerations may be balanced in order to get the most effective utilization of the present forest crop, and to provide for the rapid regeneration and protection of the future crop.

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INTRODUCTION

The author was sent to British Columbia to study logging machinery and methods of operation. To accomplish this purpose he travelled extensively in British Columbia, Washington, Oregon and Idaho. The material which provides the basis of this thesis was collected during these travels.

A literature survey was compiled at the University, but most of the material presented is based on information gained during consultations with logging personnel throughout the Pacific Northwest. A large number of logging executives were consulted, and considerable attention was given to the viewpoints of equipment manufacturers, machine operators and individual logging contractors. In addition, valuable experience was gained by the author, who worked in various phases of the industry near Lake Cowichan and the Nanaimo Lakes on Vancouver Island.

Most of the information presented is based on the viewpoints of experienced workers who have little time to present their views on paper. The conflicting viewpoints sometimes expressed are in part due to widely differing operating conditions. In general the presentation of this thesis emphasizes those points of view which are supported by the most convincing corroborative evidence.

Unfortunately, production figures were not available in the form desired, or were confidential, therefore few tables are included in this thesis. Some graphs are included to show general trends rather than real values, which are too dependent on individual working conditions.

The writer wishes to acknowledge the extensive assistance given by many men in the logging industry of the Pacific Northwest. It is impossible to mention them all, but the following were particularly helpful;

Bill Chalmers	Comox Logging and Railway Co., Ladysmith
Jim Crickmay	British Columbia Forest Products Ltd., Vancouver
Tom Wright	Canadian Forest Products Ltd., Vancouver
Archie Byers	Alaska Pine and Cellulose Ltd., Port McNeill
Don McColl	Tahsis Co., Vancouver
Lloyd Edwards	Columbia Cellulose Co. Ltd., Terrace
Bud Penny) Chett Barr)	Skagit Iron and Steel Works, Sedro-Woolley, Washington
Marc Troyer	Berger Engineering Co., Seattle
Mac Billingsley	Pacific Truck and Trailer Ltd., Vancouver
Dick Nixon	Vancouver Laboratory, Forest Products Laboratories of Canada.

In preparing and presenting this thesis the assistance of the writer's graduate committee, Professors Knapp, Ker and Smith, was invaluable since the writer was not conversant with Canadian methods of presentation.

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Vancouver 8, B. C.
December 1956

INTRODUCTION

Close supervision is required to minimise logging costs, one of the largest and most variable items in the cost of producing timber products. Logging planning in advance is the most effective method of achieving the correct solution to the cheapest method of transportation from the stump to the mills. A good logging plan should consider the characteristics of a timber area as a whole in relation to possible extraction methods, transportation routes, and available equipment. The plan should indicate the most favourable methods of operation in an area and the sequence in which they are to be carried out. Essentially the necessity is for vision in management to take all aspects of forestry and logging into consideration. Low logging costs, expressed in dollars per thousand board feet, are no longer the only criteria of logging efficiency. In the past low logging costs have often meant excessive logging waste. Often areas of lower value were bypassed and these when logged as isolated units at a later date have proven uneconomic. The silvicultural and economic benefits to future operations must be considered along with current logging economics in any well prepared plan. The plan itself should be flexible enough to cope with fluctuating market conditions and to meet emergencies such as catastrophic wind and snow damage, or prolonged adverse climatic conditions. In addition advance planning must make provision for periodic revisions necessitated by new equipment and newly developed operating methods.

Over the past decade methods have changed considerably because loggers have been forced to move into rougher and more remote areas at higher elevations, and these stands contain lower volumes per acre than those previously experienced. In addition, the forest industry has changed appreciably from a predominantly lumber industry to one which uses small wood, previously wasted, as pulp, pressed boards, hogged fuel, etc. This change has two resultants which effect logging planning considerably: increased utilization of the available timber resource, and, a greater mobility of operation with less concentration on heavy equipment.

Faster, lighter, more mobile machines are a necessity to keep costs on a reasonable level, particularly when dealing with small logs.

The logging industry, having changed from exploitation of large logs to maximum utilization in the forest, is devoting more attention to achieving the maximum yield per acre not only in the present crop but also in the next rotation.

In this thesis the effects of increased utilization and greater mobility on planning are discussed. An outline of the traditional methods of logging is given and their advantages and limitations are compared with the newer methods of logging. The probable effects of present logging systems on the future crop are also considered.

In making this study the writer travelled extensively in the Douglas fir region of the Pacific Northwest and visited a wide variety of logging operations. It was hoped to present in this thesis a complete set of tables showing comparative costs and production figures from the logging systems studied. Unfortunately most companies do not record detailed cost and log recovery figures from small individual operations such as salvage and pre-logging. Therefore, a comparison of methods could not be prepared in tabular form and few cost figures can be presented in this thesis.

Much of the machinery discussed is still in the developemental stage and there is considerable controversy over the mechanical efficiency of certain units. Discussion on the mechanical side has been purposely eliminated in this study and only the principles of operation of the various units outlined.

The Necessity of Increased Utilization

The forest products industry in the Pacific Northwest is expanding rapidly to meet the demands of an increasing domestic market and a steady and possibly increasing overseas one. Much of this industry is based on the use of waste material from lumber manufacture and of small-wood from the forest. The latter traditionally has been considered unmarketable on the lumber market. Therefore, to meet the increased demand a much wider variety of forest products are being extracted. Logs of poor type and of species previously left behind are taken. Snags, windfalls and broken tops are salvaged. This is particularly important in areas close to the producing mills where everything possible is taken off each acre. Most of these forest products industries are equipped with expensive machines which must operate at a high capacity to be economical. Therefore, many companies with limited forest resources are now realizing that maximum wood production per acre is of paramount importance. This maximum wood production can be achieved in the present only by increased utilization of the forest resource and in the future by fullest use of the productive capacity of the available land as soon as possible.

The Necessity of Greater Mobility

In the early days of logging in the Pacific Northwest most of the areas harvested had heavy concentrations of readily accessible timber. This meant that the use of heavy, specialized, relatively immobile machines of high capital cost, like Lidgerwood Skidders, were feasible because they only required moving occasionally and large volumes of timber were yarded from one location. At the present time, however, there are few of these stands containing large volumes per acre left except in the more remote areas. Therefore, loggers are moving into stands of lower density and into more rugged country. In many areas operations are being carried out at elevations between 4,000 and 5,000 feet where logging is very difficult and where the timber is considerably smaller than on the lower slopes. Other areas, previously by-passed as scrub timber, are now being logged. In addition, increased effort is being made to take every available piece of timber off the ground. This is particularly the case in some areas of Washington and Oregon where certain companies are already becoming short of the timber needed to keep their pulp mills working at optimum capacity.

To harvest this smaller timber and to pick up the salvage, equipment that is lighter, less expensive,and more mobile is a necessity. Often the logging crew has to move from setting to setting several times in a month so that the amount of unproductive time between moves has to be kept to a minimum. Also, whereas it was relatively easy to run a logging operation at a profit where the volume of the average log handled exceeded 2,000 board feet, it is exceedingly costly to handle logs that may be averaging less than 200 board feet. As daily production is reduced considerably by the combined effects of logging small logs, stands of low density and difficult terrain, every effort must be made to keep unproductive time to a minimum and to make the maximum use of every man and machine. If machine operating costs are high, the timber is handled at a loss. In a mobile logging operation this machinery must be transported to the operation and moved from setting to setting rapidly if the operation is to pay.

Silvicultural considerations for the regeneration and protection of the next crop are affecting the methods of logging with the result that in most areas today some form of patch-logging or staggered-setting system is used. This means that current operations generally are spread over a much larger area of forest and increased mobility is required not only for the prime logging but also for logging salvage and right of way pickup.

Attaining Improved Utilization

Effective utilization is improving rapidly in the Northwest as small logs, broken pieces, long butts, snags and wind falls are removed before, during or after the major operation takes place. This small wood may be removed in three ways:

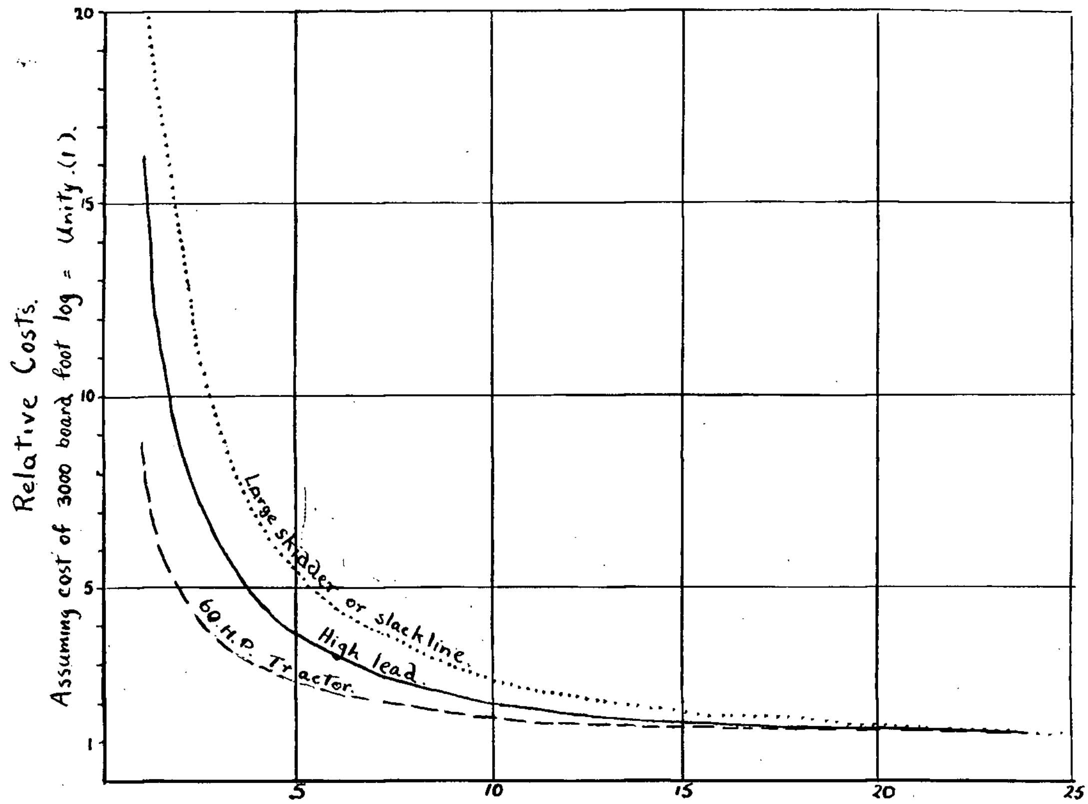
Salvage logging or re-logging
Pre-logging
Thinning

Salvage Logging

Salvage logging, the first method used in order to increase utilization, involves picking up the saplings, small ends, long butts, and broken tops, left after the main logging operation. This is usually expensive because very small pieces are handled and because adequate machinery for this type of operation has yet to be devised. Equipment that is most suitable for small pieces often is inadequate to handle occasional large logs. Brandstrom, (1933) showed that heavy machinery became very uneconomical when working on logs containing less than 200 board feet and was at its optimum working economy in logs near its maximum capacity (Graph I). The effect of log size on cost in the various phases of a 1955 Vancouver Island logging operation is shown in Table I. Hence, in many areas, smaller logs should be left for salvage or re-logging crews. Adopting this method results in much lower costs for the major logging operation but a larger quantity of the smaller logs are smashed in extracting the larger ones over them. Therefore, the overall economy of leaving a large amount of smaller logs on the ground is doubtful as the breakage increases and the percentage of the overall logging costs charged to salvage costs became considerably greater. All good logs that can be extracted at the break-even figure or above should be taken in the major logging operation and only the remainder left to salvage crews. The effect of the volume of pulpwood salvage extracted on overall logging costs is shown in Table II.

GRAPH I

Relation of Volume of Log to Yarding Costs



Volume of Log in hundreds of board feet

A summary of graph by Brandstrom

Pg. 61. Logging costs and
operating methods in the
Douglas fir region

TABLE I

Effect of Log Size on Costs in Various Phases

of a Logging Operation

Source - 1955 figures - a Vancouver Island operation

Log Average Board feet	Fell and Buck	Yard-Load	Trucking	Boom	Overheads General	Roads Maintenance and write off
50	7.50	22.80	4.90	4.00	4.50	3.00
100	6.50	15.30	4.50	3.75	4.50	3.00
150	5.50	12.00	4.40	3.25	4.25	3.00
200	4.50	10.25	4.30	2.75	4.00	3.00
250	3.60	7.75	4.20	2.50	3.75	2.80
300	3.25	6.45	4.00	2.35	3.50	2.80
350	3.15	5.25	3.75	2.10	3.50	2.80
400	3.05	5.00	3.25	1.90	3.25	2.80
450	2.95	4.80	3.25	1.60	3.00	2.60
500	2.85	4.60	3.00	1.40	3.00	2.60
550	2.80	4.30	3.00	1.20	2.75	2.60
600	2.75	4.00	3.00	1.00	2.75	2.60

TABLE II

The Effect of Percentage of Salvage Extracted on Total Logging Costs

Percentage Pulplogs by pieces	Total Logging Costs increased by	Increased Cost per cubic foot
10%	3.4%	$ 0.39
15	6.1	0.66
20	8.5	0.93
25	11.1	1.20
30	13.7	1.47
35	15.7	1.68
40	16.7	1.78

Source of data: 1955 production costs over a yearly output of 60,000 M board feet on a Vancouver Island operation.

Pulplog average	101 board feet (27.3 cubic feet)		
Sawlog average	360 board feet (69.5 cubic feet)		
Sawlogs minimum size	8 inch diameter	32 foot log	
	10 inch diameter	18 foot chunk	
Pulplog minimum size	6 inch diameter	32 foot log	
	10 inch diameter	12 foot chunk	

Nearly all of the larger companies on the coast are now engaged in salvage logging over most of their operations and good clean-up and a high degree of utilization is obtained. An example of the amount of wood on the ground before and after a salvage operation is shown in Figs. 1 and 2.

In Washington small contract loggers or "gyppos" are employed by the larger companies to do the salvage logging. On the job a company foreman can supervise about 20 "gyppo" sides by checking contracts, planning operations, and supervising clean-up. These small operators are usually hard-working and very cost-conscious and they make effective use of their equipment. Company policy usually seems to be to restrict them to one or two crews. These "gyppos", being mainly owner-operators, have lower machine maintenance costs and personnel problems are small. Sometimes they do not have machines best adapted for the job but they are ingenious and use the machines available to the best advantage. Usually the small operator is more efficient in getting more production per machine with less maintenance and loss of working time.

In British Columbia most companies do their own salvage logging with special crews. In this way use may be made of the machine best suited to the job. However, this advantage may be offset by the fact that day-wage labour is not as suitable to this type of operation where a considerable amount of very strenuous work is required.

The material to be removed in a salvage logging operation varies with the location of the operation and the end use. Most salvage operations are designed to provide chips for a pulp mill. In this case, burnt or charred logs are usually not salvagable, although the inside wood may be sound. On the other hand, logs with up to 50% rot are salvaged in some areas, notably in western Washington. This is particularly true if the rot is on the outside of the log as it will then be sloughed off in the log-barker. Species not suitable for pulping, such as cedar, are

Salvage Operations

Port McNeill, V.I.

Fig. 1. Before salvage.

Fig. 2. After salvage.

frequently left behind. Cedar can be utilized in sulphate pulp but the low price paid for it does not usually compensate for the additional logging cost. However, with general expansion of the wood-using industry and the possibility of utilization in the near future it probably would pay to salvage small cedar logs of good quality, particularly if there are adequate water storage facilities. The extra cost of yarding these logs, especially in a high-lead operation, is small because the more timber that is removed from an area the lower is the overhead cost per unit.

An important problem associated with the utilization of salvage logs is their handling at the mill. Very small pieces sometimes cause trouble in conveyors if they are not designed for small sizes. The percentage of salvage logs is an important consideration in mill costs because the handling, barking and chipping costs of small logs is high and the output is small in comparison to large logs.

The allowable percentage of rot and low value species, such as the hardwoods and cedar, in the log supply is a factor that has to be taken into consideration.

All fractured ends are usually bucked off because they pick up dirt, small stones, and other foreign bodies and tend to come through the chipper in long slivers. Also, as liquor penetration is from the end, these slivers do not cook properly.

Scaling of salvage logs is a problem. The general practice is to avoid scaling and to weigh the logs as truck loads instead. This can be done by installing a truck weigh-bridge or by attaching a hydraulic weighing device to the unloading A-frame at the log dump. A recent weighing device, in use in southern Oregon, is an electronic scale fitted on the truck and trailer bunks. The weight on the bunks registers on a dial fitted in the truck.

Salvage operations are being carried out up to five and more years after the normal logging operation. This usually means that there is a larger percentage of rot, especially sap rot. Salvage operations should take place about one or two years after normal logging. The advantages of this are:

(i) The volume of logging slash, particularly of tops and small branches is reduced.

(ii) The bark has had time to loosen and much will come off in logging. This reduces the heavy load that small logs put on the barking facilities.

(iii) Use of logging roads by salvage operators does not interfere with normal logging operations.

(iv) At this time the logging roads have not deteriorated, hence, road maintenance and repair is not expensive.

(v) Rot has not yet had time to affect the quantity or quality of the logs.

(vi) If salvage logging is long delayed, young seedlings will be damaged.

In some areas of the Pacific Northwest slash burning is compulsory within a year of logging. If this is the case, salvage operations must be carried out prior to burning as charred logs are unsuitable for pulp.

Yarding Systems

The methods used in yarding salvage logs are many and varied but the most effective seem to be the following:

High-lead yarding. In this method use is made of the same spar that was used in the original high-lead logging using lighter ropes, chokers, and a smaller yarding machine. This does not need any additional planning because the settings are the same as in the prime logging. The yarding machine is often light in weight and is often truck-mounted. A Skagit "B.U. 15" mounted on an old truck-chassis is shown in use at Forest Grove, Oregon (Fig. 3). Often with such light truck-mounted yarders, difficulty is experienced in anchoring them properly to prevent jumping out of lead. Large logs or stumps should be used for anchors. With a high-

Fig. 3. Truck-mounted Skagit B.U. 15. Used for yarding salvage with conventional spar.

lead system using an old spar, the chokers should be reduced to 3/4" wire rope. As a result, the operator of the yarder will have to treat the rigging more gently and will be less likely to break logs.

High-lead yarding using a mobile spar

Several different types of spar have been designed for this type of work. Most of them are homemade wooden spars about 60 to 80 feet high, mounted on wheels or tracks, with some type of A-frame device to aid in raising the spar. They can be pulled along by tractor or truck between settings. A spar of this type mounted on steel wheels is seen in Figure 4.

These spars are shorter than those used on the original high-lead operation, consequently their effective range is less (see Table III). This means that some revision of the planning is required to achieve more effective usage by eliminating any long corners. Usually three to six settings of the mobile spar along the road through the original setting are adequate (see Fig. 5).

High-lead yarding using truck-mounted spars

The units used in this system are light yarders and spars from 40 to 70 feet high mounted on trucks or trailers. The spar folds down over the transporting vehicle for easy moving and is raised or lowered by the yarding machine. These machines may incorporate some type of self-tightening guy device with guy drums mounted on and driven by the machine. A mobile spar of this type mounted with the yarder on an old solid-tired low-bed trailer is shown in Figure 6. This was being used on Vancouver Island and for short moves could be moved with the spar erect and held in place using the main rope and haulback.

Planning for this type of operation is similar to that in Figure 5, These units have an added advantage due to their increased mobility and quick set-up time in that they can make many small moves and windrow logs (Fig. 7). This means that

Fig. 4. Mobile wooden spar
Port McNeill

Spar has universal joint pivot and
A-frame is used to aid raising.

TABLE III

Range of Effective Lift of Various High-lead Spars

Range normally is effected by 3 factors:

(1) Height of spar

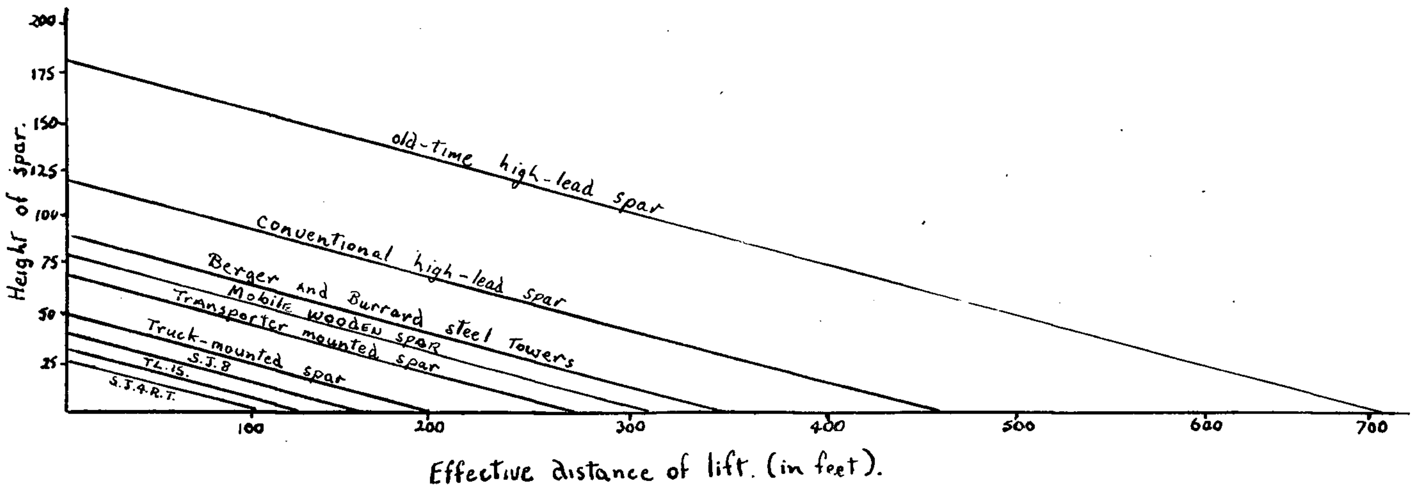
(2) Power and speed of yarder

(3) Slope and ground obstructions

Lift is considered to be effective out to 4 times the height of the spar, on level ground. From there on, conditions approximate ground yarding, with speed and power of the yarding machine being the controlling factors.

Effective range and lift of units referred to in this paper.

Unit	Height of spar	Maximum distance where lift is effective
Older type high-lead spar 1920's	180'	720'
Current conventional high-lead spar	120'	480'
Burrard steel tower	90'	360'
Berger porta-tower	90'	360'
Mobile wooden spar (Alaska Pine Co.)	80'	320'
Mobile transporter mounted spar (MacMillan and Bloedel)	70'	280'
Truck mounted spar (Comox Logging and Railway Co.)	50'	200'
Skagit S.J. 8. mobile yarder	40'	160'
Trackloader T.L.15	32'	128'
Skagit S.J. 4 RT. mobile logger	27'2"	109'



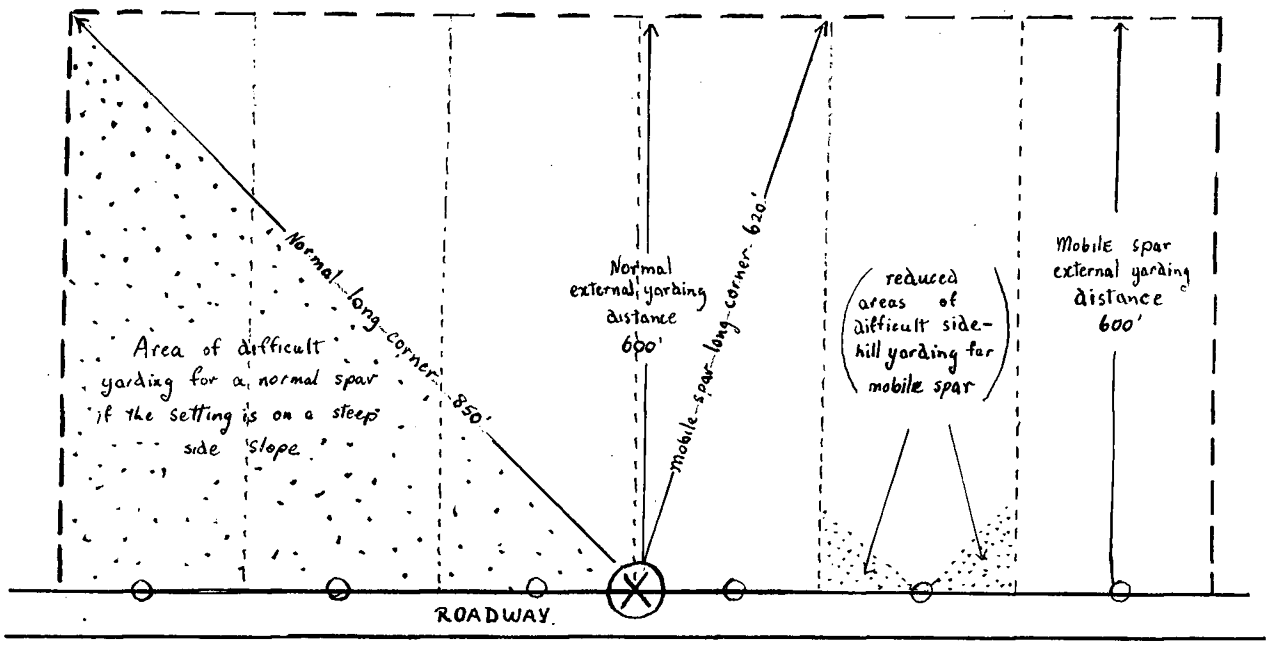


Fig. 5. Diagram to show original rectangular setting for conventional high-lead split up into 6 settings for a 70' mobile spar.

Legend: — — — Boundary of conventional high-lead setting.
Ⓧ Position of conventional high-lead spar.
- - - - - - Boundary of mobile spar settings.
O Position for mobile spar.

Fig. 6. 70' mobile spar and B.U.30 Skagit yarder mounted on disused transporter.

Fig. 7. Windrowed logs from mobile spar.

yarding can be well ahead of loading and the log pile does not become too high. High cold-decks difficult to load out are often a feature of a normal high-lead operation.

With this type of windrowing with an easily moved machine it is advantageous if the logs are yarded from the forward arc and not around to the right angle lead. This insures that the logs are at the best angle for the loading machine to facilitate rapid loading.

Use of mobile loggers

These are wheel or track-mounted self-propelled vehicles with a spar and boom that are used for both yarding (on the high lead principle) and loading. They are manufactured by machinery companies especially for logging. They are an expensive investment, but due to their rugged construction and extreme mobility they are prooving very useful in logging not only salvage but larger logs as well.

Moving from setting to setting is rapid due to the self-tightening guys incorporated in these machines. For fast rigging self-tightening guys are an essential. With a skilled crew the rigging time can be reduced from several hours to a matter of minutes. In some cases the machine can make short moves along a road for windrowing without any alteration of guy stumps and without the driver coming out of his cab.

Many of these machines are in use with "gyppo" operators in Western Washington, the Skagits, models S.J.4. and S.J.4.R.T., being particularly popular. This type of machine is very suitable for a contractor operation because:

(i) Yarding and loading investments are in one machine, which can be moved from setting to setting without additional towing expense.

(ii) The Machine can both yard and load. On high-production jobs it is versatile enough to yard out mainly during the daytime and can load out at night on a second shift from windrowed logs.

(iii) The machine is better suited to the higher paid, more skillful and careful operators usually employed by "gyppos". However, good operator-training is essential for this type of rig so that skill instead of power is used to avoid "hang-ups".

Some of these units have a swinging boom and often incorporate a wide "Tommy Moore" sheave on the boom tip through which the Butt-rigging can be pulled. This is a most useful aid in landing, stacking or loading logs on narrow roads on steep side slopes.

Photographs of this type of machine working in normal logging operations are shown in Figures 8 and 9.

Due to the shortness of the spar in these machines some revision in the planning of any operation is necessary. They are not suitable for yarding downhill because of the low clearance which causes many hangups, and their yarding distance on easy going should be restricted to about 400 feet. It is advantageous in increasing the effective yarding distance of these machines to have a fast line pull. This fast haul in speed, combined with an ability to change gears on the move, enables the turn to jump or bounce possible hangups. However, they do have a great advantage in yarding steep uphill sidings in that the boom projecting over the lip of the hill acutally may have greater clearance than a normal high spar (Fig. 10). In addition to this the Washington "Trakloaders" and the Skagit model S.J.4 R.T., can be moved close to the edge of the hill and because of their swing ability can land the logs at right angles to the line of yarding (Fig. 11).

These mobile loggers are most advantageouse when used over road layouts designed for their use. It is economic to build quite a more extensive road network if the fixed cost of yarding set up is very low. Most effective use of this type of machine is being demonstrated by crews of younger loggers rather than the "old timers". The older loggers often do not understand its application and require it to show the same performance characteristics as their conventional heavy machines.

Fig. 8. Washington trackloader yarding and stacking.

Note: Butt rigging has just gone through large sheave.

Fig. 9. Skagit S.J.4.R.T. yarding salvage.

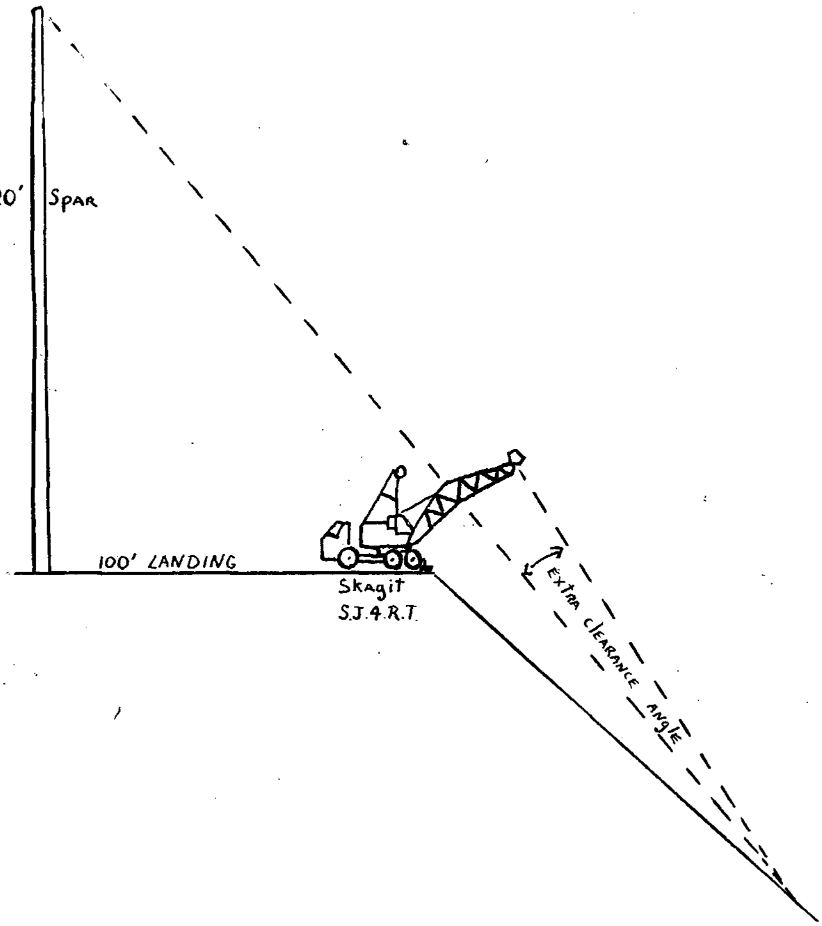


Fig. 10. Advantage in clearance when using a mobile logger to yard up a steep hillside to a roadway.

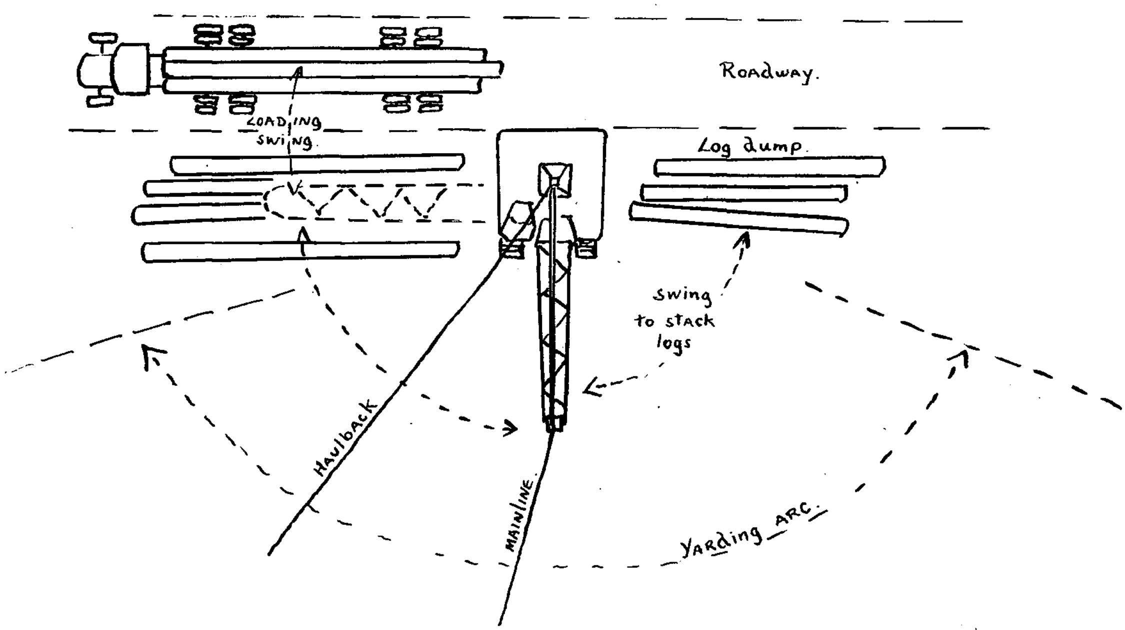


Fig. 11. Diagram to show advantage of mobile yarder in combined yarding, stocking, loading operation along a roadway.

The truck-mounted jammer is another type of mobile logger in use on salvage operations as well as on many cherry-picking and selective-logging jobs, particularly in the interior of British Columbia. A jammer is a truck-mounted yarder with a single wooden spar supported by an A-frame which can be folded down for travelling. The spar is free swinging and can be raised and lowered by a luffing device. Light guys, which can be hand tightened, are used and the machines can be moved from place to place in about five minutes. Old trucks are used for the most part and the machines can yard in an arc out to the square-lead. By changing from yarding rigging to end hooks it can be used for loading. This type of machine is good for yarding steep slopes uphill and for logging small but awkward settings. It is very mobile and so is useful in scattered timber but its production rate is not particularly high. It is designed for a small operation by a logger who does not want to invest in expensive equipment. A truck-mounted jammer loading small logs in the interior of British Columbia is shown in Figure 12.

Combination yarding - loading and trucking devices

These are machines designed for the small logger with a minimum of financial resource and a small crew. Their running costs are low, and production rate is usually not above fifteen cords per day for a 10 mile haul. Their use on wholesale salvage operations is limited as they must yard from a formed roadway and the maximum yarding distance is approximately 200 feet. Therefore, they are limited to small cherry-picking operations and cannot be used for a complete salvage job unless additional road is constructed. The "Easy-way logger" is a machine of this type at present being used in British Columbia. Figure 13 shows a crane truck suitable for yarding, loading and trucking.

Fig. 12. Truck-mounted mobile jammer.

Fig. 13. Crane truck for yarding, loading, transportation and unloading logs.

Salvage yarding by tractor

In many areas where the terrain is not too difficult salvage is being skidded out by tractor. A tractor on this type of operation has to be big enough to push its own way through the debris to the logs and have enough clearance to scramble over obstacles.

This usually means that a tractor of D.6 size has to be used to do the job and to enable it to get a reasonable payload, many chokers have to be used. Therefore, there is considerable machine delay time between turns while the turn is being choked. This occurs even when two sets of chokers are being used. A D.6 tractor and arch engaged in a salvage operation near Nanaimo is seen in Figure 14. It will be noted how small is the payload.

Planning for a tractor salvage operation should be confined wherever possible to areas where the prime logging has been by tractor and the access tracks already cleared. All yarding wherever possible should be downhill so that maximum payloads are carried.

Loading salvage logs

In loading salvage logs the conventional loading methods, such as a McLean type heel boom rigged to the spar tree or the adaption of a shovel crane to a heel boom, are not suitable. As these methods require a hooker to attach the tong and only one piece can be handled at a time, they are uneconomic for loading small logs. In the operations using mobile loggers or the Easyway logger described above, there is no necessity for a separate loading device. However, all other methods of salvage require a fast way of handling many small logs using as few men as possible.

Probably the most effective way to handle small salvage logs is by use of a converted shovel loader fitted with Berger air tongs. The closing and opening of these tongs is controlled from the loader cab and there is no need for a man on the ground. A big advantage is that the tongs can pick up

Fig. 14. D.6 tractor and arch logging salvage.

several logs at once. They provide fast loading with positive log control and a maximum of safety. One of these machines working on a Vancouver Island operation is shown in Figure 15. As production from individual salvage sides is fairly low, a truck mounted loader with air tongs is an excellent machine for two or three dispersed salvage sides in a patch logging operation.

In planning for the use of air tongs consideration must be given to a few factors that control their effectiveness. Primarily the main disadvantage with an air tong is that its flexibility is limited and most of them cannot reach further than a 33 foot radius. The height from which it can pick up or place a log is also limited by the construction of the dipper stick. Because of these limitations, certain principles should be followed in planning.

(i) Cold decks must not be allowed to get too high as the air tong cannot reach up to them. Therefore, if cold decking is being carried out, it is better if the logs are windrowed along the roadside at a height not exceeding about 15 feet from the ground. A mobile loading machine can move along the windrow easily.

(ii) As the air tong has restricted reach all logs must be close to the road. The machine can "cherry pick" but it is a difficult and expensive operation.

(iii) All unnecessary loading movement must be eliminated in order to load small logs economically. To accomplish this, yarded logs are windrowed at an acute angle to the road so the amount of swing in each movement of the loader is reduced to the minimum. (Fig. 16). The comparative arcs of the machine loading are indicated in Figure 17.

(iv) Consideration must be given to increasing the visibility of the loader operator. Most conventional methods have poor visibility and are often inaccurate and unsafe when placing the top logs on a big truck. Among the methods that have been tried are setting the loading machine on a ramp or excavating the truck

Fig. 15. Shovel with Berger air-tongs loading salvage logs.

Fig. 16. An example of windrowed logs.

Note: The acute angle of the logs on the right of the road. This gives the minimum loading swing.

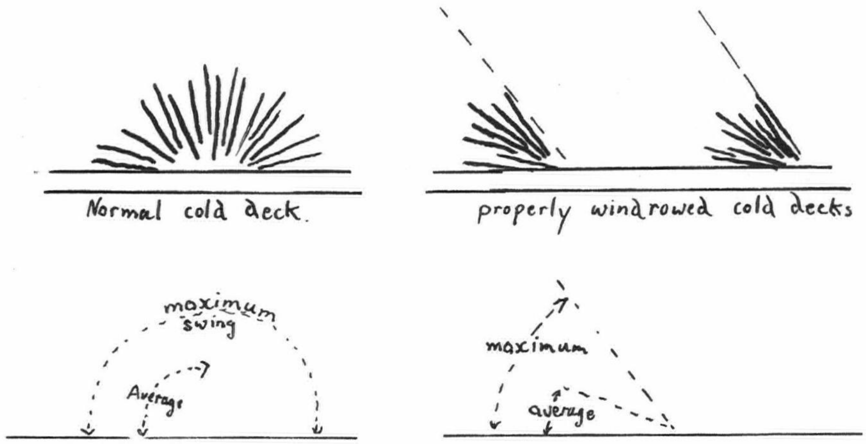


Fig. 17. Comparative loading arcs.

position slightly but both these tend to make the operation less mobile. Some companies have extended the cab height to increase visibility and this seems to be an excellent idea, giving increased safety to the operation (Fig. 18).

Methods that are commonly being used to load small logs would be applicable to salvage log loading. Bundling of logs in a prepared bin (as shown in Figs. 19 and 20), and loading them by bundles on to a truck, is practiced on a thinning operation at Sechelt tree farm. An adoption of this system could be used with almost any type of loading machine.

Bundling or package handling with the bundles being held in steel bands or wire rope straps is of great advantage, in that it can be carried through several stages of the log-handling facilities. In the water this system practically eliminates loss from sinkers. Packaging is particularly advantageous where loading and unloading devices are installed on a large operation to handle big logs, and where their cost in handling small logs as pieces would be completely uneconomical. Smaller "gyppo" operators are generally not so interested in handling their produce in bundles. Capital expenditure and depreciation charges per unit of time on heavy equipment required to handle bundles, would be high. The volume of salvage logs handled on a small operation may not be sufficient to make it economical. Package handling can be economical only when there is great volume production or where the packages can be set aside from a normal logging side and handled from then on as units as soon as they are completed.

The other method of loading salvage and small logs is the use of a log grapple used with a mobile type crane loader as shown in Figure 21. This machine is excellent for picking up several logs at a time out of windrows. It does not require a tong-man. Many of the smaller "gyppo" salvage loggers rig a gin pole to load out their logs. In this case the tractor used for yarding the logs is also used to power the loader operation.

Fig. 18. Osgood loader with cab extended for better visibility.

Fig. 19. Loading logs into a bundling bin. Sechelt tree farm.

Fig. 20. Prepared bundles being loaded onto a truck. Gin pole loader.

Fig. 21. Log grapple used with maxi-mounted northwest crane.

Trucking salvage logs

Handling of salvage logs has proved to be a major challenge in the area, and generally speaking the conventional logging truck is not suited to this type of operation. Several approaches are being tried to overcome the problem. Self loading trucks, such as the Easy-way logger are being used by some of the smaller operators. Other outfits plan their operations so that salvage is yarded at the same time as the major logs and, when a load of short logs accumulates on the landing, special "chunk" trucks designed to transport short logs are called for over the radio communication system.

One of the best methods is the use of specially designed short log salvage trailers. These trailers which are really big flat tops with several sets of stakes are designed to be pulled by the normal logging truck. As salvage takes considerable time to load, it is undesirable to tie a truck unit down to a loading time of 45 minutes or more. Therefore, these salvage loads should be preloaded. One version of these trailers, manufactured by Pacific Truck and Trailer Company, has hydraulically operated skids which take the weight off the load at the front end of the trailer, until it is picked up by the logging truck. These trucks have a hydraulic fifth wheel device which make the load easy to pick up. Truck turnaround time in this case is less than three minutes. These trailers can be used either with windrowed logs or conventional cold decks. Photos of these trailers are shown in Figures 22, 23, and 24.

Fig. 22. "Pacific" truck and salvage trailer.

Fig. 23. Maxi-mounted Northwest loading salvage onto salvage trailer.

Fig. 24. Fully loaded salvage trailer with skids down. Awaiting pickup.

Pre-Logging

Salvage logging is the attempt to pick up the rubbish and smashed logs left after a normal operation. This led to thoughts on the line of "Let us avoid the waste" and subsequently pre-logging was introduced. Pre-logging's major principle is to extract the small logs of high value, eg., cedar poles, before their value was considerably reduced by felling breakages. Along with these small logs it pays to extract snags and sound windfalls which may cause excessive breakage when sound logs are felled across them.

Pre-logging differs from thinning in that bark damage to the standing trees is of no particular importance as the main crop will be removed soon afterwards. Pre-logging operations are difficult as they are being carried out in the standing timber, often on rough terrain. Costs on this type of operation are high, but generally speaking, it is profitable logging because the type of produce extracted is often in a specialized category and may have high market value, e.g., piling and cedar poles. Even if pre-logged at a figure that gives only a small or even minus profit margin, it is usually more than offset by the markedly improved logging conditions of the main crop. In this case the major operation's increased profit could cancel any slight loss on pre-logging.

Most logging crews prefer to work in areas that have been pre-logged and it makes the main logging operation much easier and faster. In addition logging roads as well as some landings and skid trails are already formed in advance of the main logging operation. In the cases where it may be necessary to leave a pre-logged area for some time it enjoys some of the advantages of a thinned stand with the additional increment going onto the best stems. Slash in pre-logging is mostly from the thin-crowned sub-dominants and most of this is broken up by the yarding operation. Thus, a large volume of slash accumulation is avoided and the clearness under the trees (illustrated in Fig. 25) is a big factor in efficient fire control and protection. When

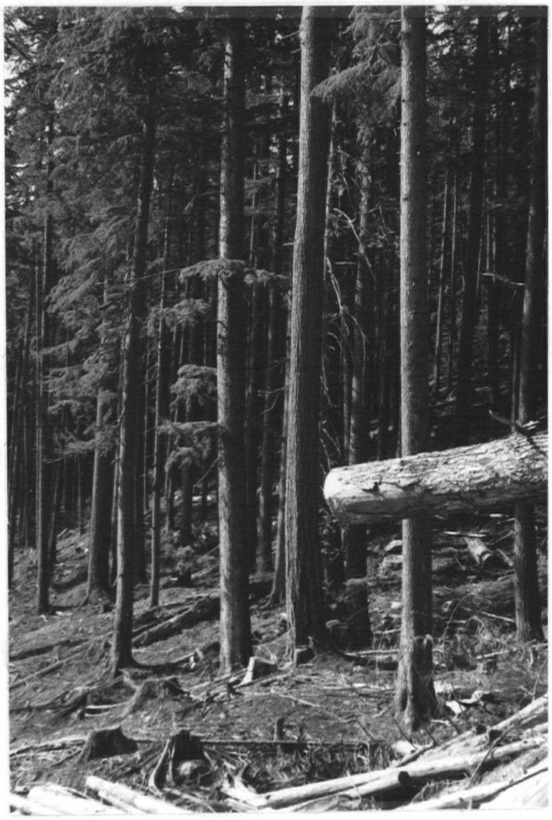


Fig. 25. Pre-logged area on a Vancouver Island operation.

Showing clean ground conditions for prime logging.

the fire hazard is high, pre-logging operations are much less dangerous than prime logging or salvage operations. Because of the shade factor, and the increased humidity and lower temperatures under the forest canopy, pre-logging can be continued when other operations are forced to cease work.

Small tractors are being used for most pre-logging operations on the easier terrain. The majority of these units are caterpillar D.4s or other makes comparable in size. On the rougher terrain, various types of partable high-lead machines, similar to those used for salvage logging are used. Yarders do not need to be very powerful as most of the produce is small. However, as the turns are small and the distances long, they require fast yarding and return speeds. Because of the great difficulty with hangups and logs going behind standing trees, it is essential to have chokers that can be easily detached from the butt rigging. Use of this type of choker also assists in reducing total turn time by allowing the turns to be pre-choked. A truck mounted spar of the type used on a pre-logging operation on Vancouver Island is shown in Figure 26.

In planning the layout of any operation where pre-logging is envisaged the yarding length on the settings sometimes needs to be reduced. This is particularly true in a high-lead setting where lost time due to hangups increases with distance yarded. Generally the pre-logger sets up several times in a conventional high-lead setting and this reduces the distance to long corners. Even then, particularly where yarding is downhill, it often does not pay to yard the full distance of the high-lead setting. This is because the low spars (40 to 50 feet high) used in pre-logging do not have the lift compared to a normal high-lead spar of approximately 120 feet or to a mobile steel spar of 90 feet (see Table III, page 16).

A desirable layout for pre-logging steep country might look something like that shown in Figure 27. Those strips, outside the pre-logged area shown, in some cases might be bunched by tractor to within the yarded area. Usually, however, the high

Fig. 26. Truck mounted mobile spar used for salvage and pre-logging.

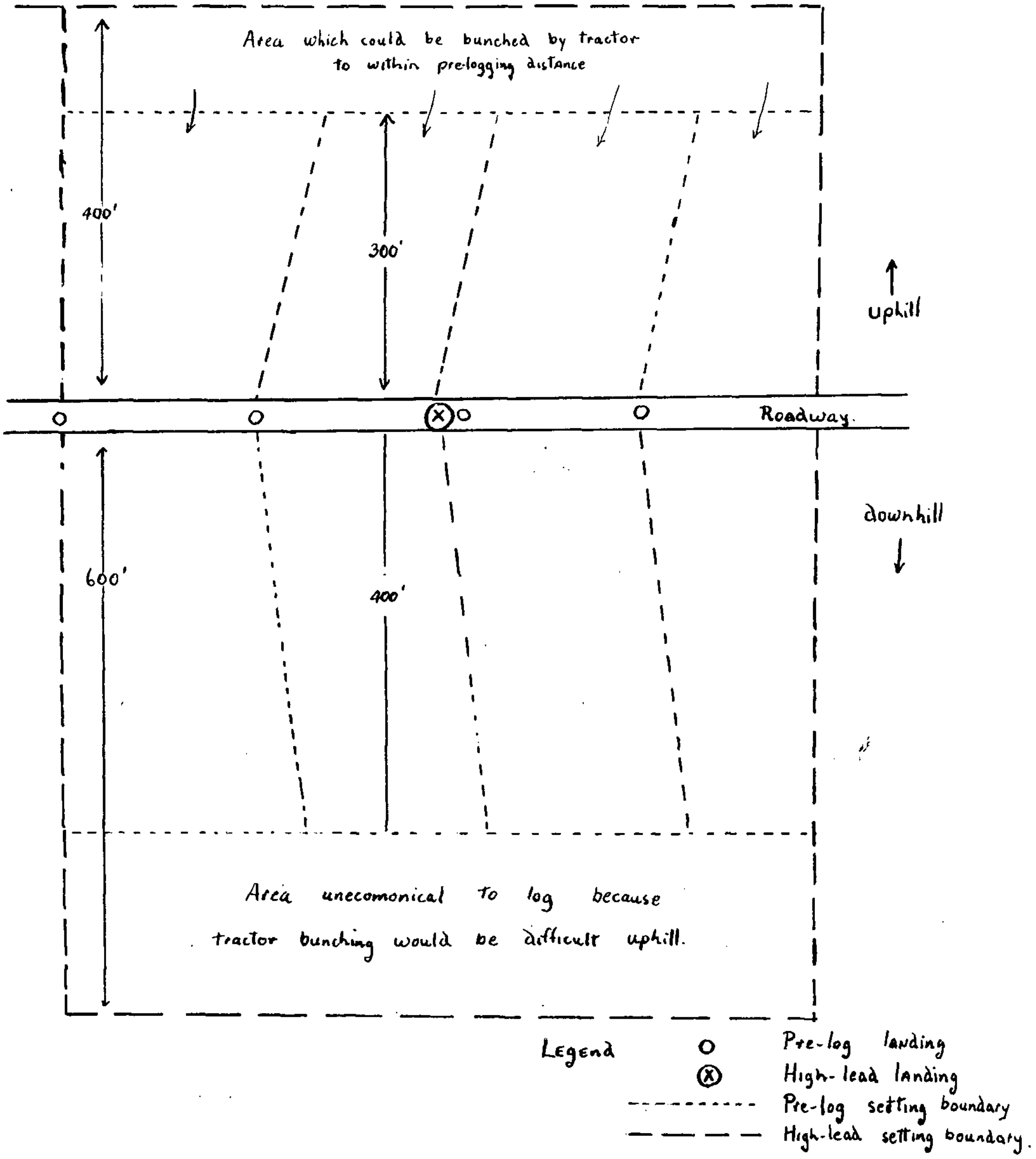


Fig. 27. Diagram to show typical pre-log layout in a high-lead setting in steep country.

Actual distances would depend on topography and machines used.

double-handling costs make them impractical to pre-log and they are left to be yarded in the major logging job in the conventional manner.

On steep country, if the yarding arc does not extend to the square lead there is less difficulty with logs sliding away from or onto landings on steep side hill settings. Hot logging, however, is almost a necessity on any of the steep hillsides where slopes are in excess of 40 percent (Fig. 28).

Ropes and rigging should be kept as light as possible in pre-logging because of the necessity of changing lines more often than usual. Smaller, less powerful machines are used so that the breakage due to using excessive power is reduced to a minimum. Then the pre-logger gets the maximum yield of whole logs from the acreage over which he is working.

Felling for pre-logging should be well supervised and stumps cut as low to the ground as possible. This is particularly helpful on a tractor job where ground clearance is important. In felling for pre-logging by high-lead, trees should be felled in a herring-bone design so that the number of hauling roads necessary is reduced. With this felling pattern logs do not have to be "siwashed" round standing trees any more than is necessary (see Fig. 29).

An area with cedar poles felled for pre-logging extraction by tractor is shown in Figure 30. An example of the good cleanup achieved and the optimum conditions then prevailing for the major operation has been shown in Figure 25, a photo taken near Nanaimo.

In planning for pre-logging operations access roads must be put in four to five years ahead of the prime logging operation to allow sufficient time for the pre-logging. Pre-logging should be far enough in advance of the prime logging operation to allow the slash (of which there is very little because pre-logged trees are mostly sub-dominants) to settle, but not that far ahead that barking damage to the main crop can cause defect and decay.

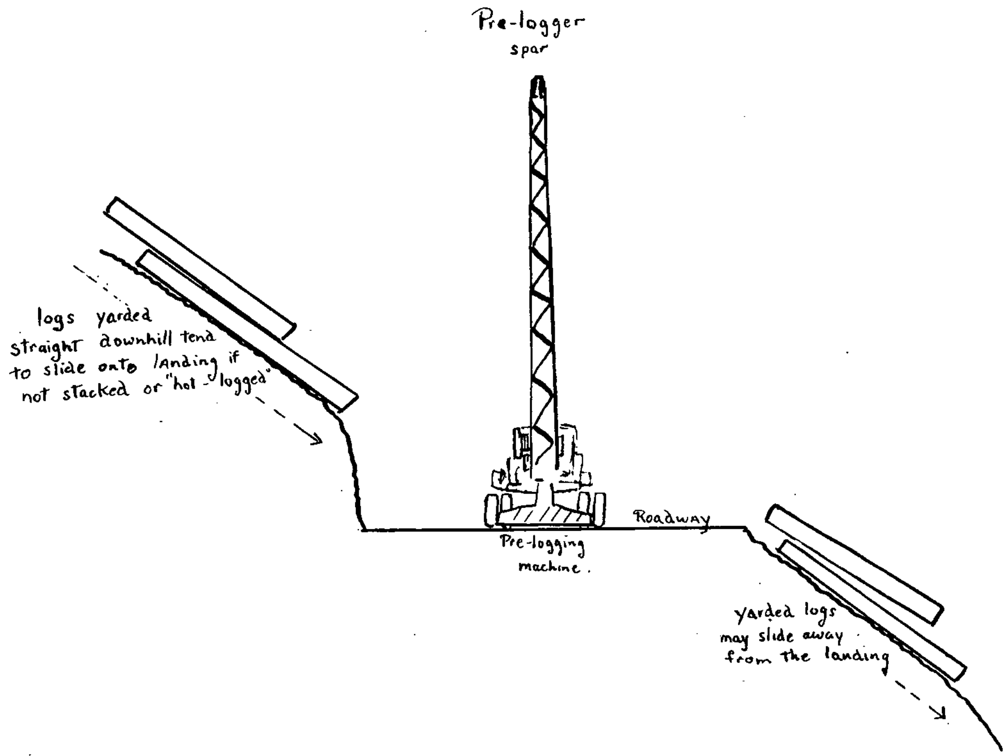


Fig. 28. Diagram to illustrate difficulty of square lead pre-logging on steep side faces.

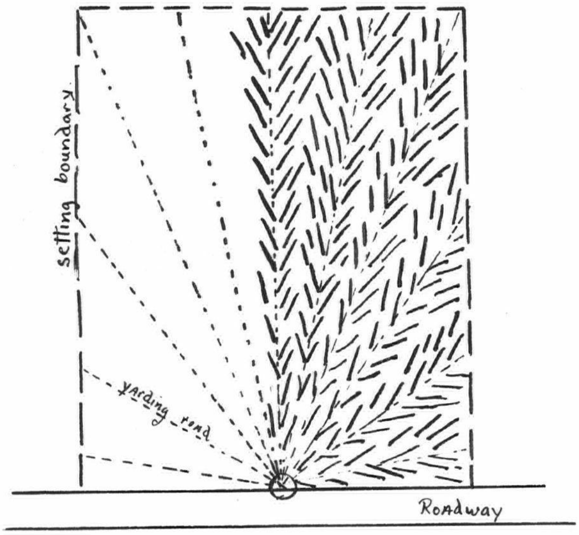


Fig. 29. "Herring-Bone" pattern of felling for a pre-logging operation.

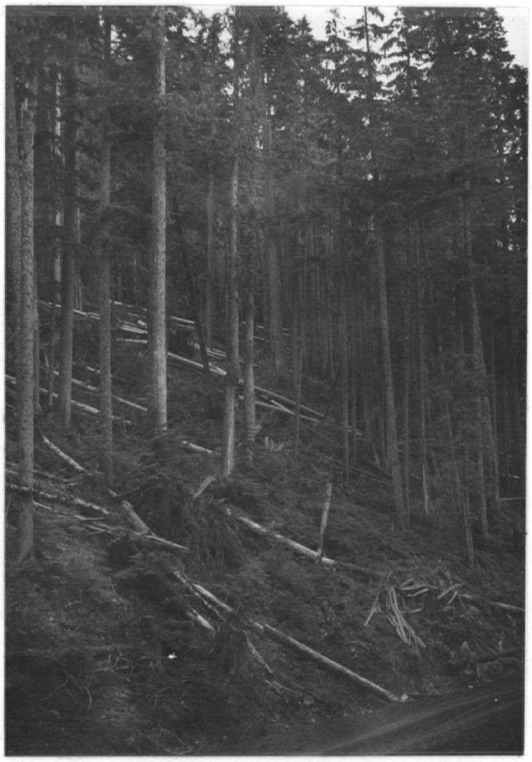


Fig. 30. Cedar poles felled in a pre-logging operation.

Thinning Operations

If the thinning operation is considered to be silvicultural felling, or extraction of trees from an area, with the major aim of improving the condition and value of the remaining crop, then there are few true thinning operations in the Pacific Northwest. However, if thinning is considered to be a profitable intermediate cutting of logs from an area without excessive damage to the remaining crop, then there are quite a number of operators practicing "thinning", "selective logging" or "thinning from the top". Removal of wolf trees and marketable snags are usually included in such thinnings.

The main difficulty in thinning compared to prelogging is to avoid damage to the remainder of the crop.

At present almost all thinning is being done by tractor. In planning such an operation, particularly in an immature, undeveloped stand, it may be unwise to establish an extensive road network because of unwarranted capital expenditure and increased taxation. Under these circumstance a rubber tired skidding machine which completes long swings of up to one mile, down prepared tracks to the landing is very efficient. This system is being successfully used in Sechelt Tree Farm where a Caterpillar D.4. bunches turns for a Westfall 100 (Fig. 31). These skidding tracks should be put in so that the bunching distance is limited to about 200 feet. For short distances the bunching tractor can dispense with the arch and manoeuvre easier within the standing trees. Skidding tracks should be designed so that the Westfall does not have to back up steep pitches. It is inefficient under these conditions because two-thirds of the unladen weight is over the front wheels. Production under this system is highest when bunched turns do not have to be rechoked. Therefore, a "hot logging" operation is most effective where output of bunching and skidding tractors are balanced to keep the skidding tractors just one turn ahead. This may mean when close to the landing, that two bunching tractors may be required to keep the rubber tired skidding tractor working at full capacity,

Fig. 31. Westfall "100" rubber tired tractor skidding thinnings.

whereas near the extremities one is sufficient. At this stage the other crawler tractor can be used to construct the next skidding track. A graph showing comparative operating costs of track and wheel type tractors is shown in Figure 32. As shown on the graph break even point for direct skidding is at 400 feet. A diagram of the ground layout for this type of operation is indicated in Figure 33.

In many areas that are due to come under management and to be thinned by using tractors, frequent light thinnings are considered to be most advantageous. Unsurfaced cat roads through the timber can only stand a certain amount of abuse before they breakdown, this is particularly the case under winter conditions. Also track-side trees have the ability to recover from slight bark damage but if this damage is heavy they may eventually die. Nature, then gets an opportunity to help in tree selection. Damaged trees and the less vigorous ones become obvious and can easily be removed periodically in a system of frequent light thinnings.

A thinning interval of about 5 years under these conditions allows complete utilization of windfalls and snow damaged trees. Timber loss from natural mortality can thus be more or less eliminated. With light thinnings it should be possible to selectively remove those trees producing little net increment or trees of poor quality. So far in the Pacific Northwest little is known about the effect of various thinning systems so a "get the feel of the stand" policy of frequent light thinnings is advantageous. Experimental areas of heavier thinning should be tried to test the effects of snow damage and possible heavy windthrow. With light thinnings it is possible to extend operations over a larger area and bring more forest under management.

From the psychological point of view it is desirable to start the contract logger off with the smallest profitable cut possible. If he commences with ideas of high production with large machinery it is then very much harder to reduce his

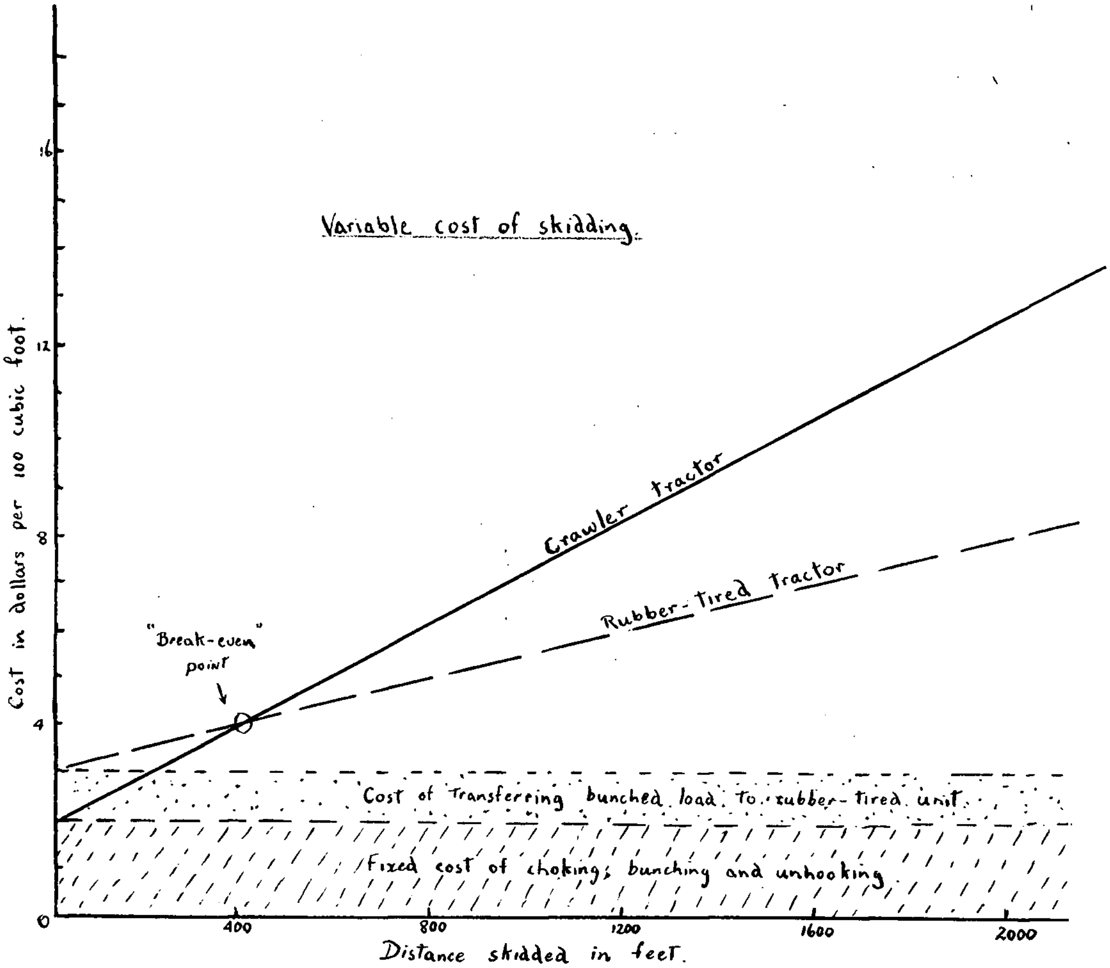
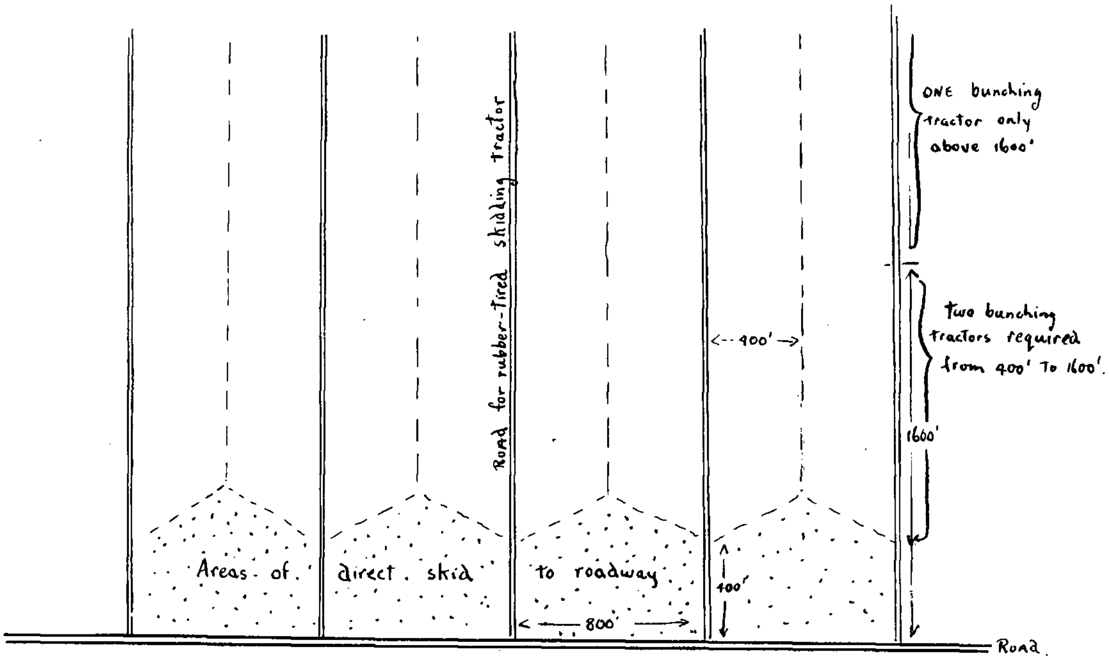


Fig. 32. Comparison of operating costs of tracklaying and rubber tired tractor.

A hypothetical example

(Assuming similar horsepower and conditions favourable to rubber tired skidding).

Inclination of this graph and the break-even point will vary with the different units being compared, but the pattern will be the same. A similar graph is shown in "Tractors for Logging". F.A.O. of U.N. 1956, p. 160.



Scale 1" = 800'.

Fig. 33. Layout for combined skidding operation.

cut per acre - whereas from small beginning it is relatively easy to increase it. With a small allowable output, strictly controlled, the logger takes more care to achieve maximum utilization and there is less loss through breakage.

In logging from a light thinning operation less landing space is required and lower cold decks minimize loading difficulties.

In more rugged country, where cable yarding-systems must be used, heavier thinning is required for an economical operation. The fixed costs of rigging is a large percentage of the yarding cost and the cost per M increases greatly as the allowable cut per acre is reduced.

On the steeper ground where tractors cannot be used, thinning is most difficult. The conventional methods of cable yarding used for clear logging steep ground do considerable damage to standing trees. Some use is made of horses in the British Columbia interior for selective logging and in Washington for thinning. However, in many other parts of the world, notably Great Britain, continental Europe, and New Zealand, horses are used almost exclusively for thinning operations on steep ground. This is probably the most effective and economical way of extracting small material as thinnings, with a minimum of damage to the standing crop. One of the main difficulties with horses is to get them back up the hill again. Therefore, their effective use on steep ground is limited to about 1000-foot hauls and an easy uphill return track must be provided. Stand density, amount of brush, and roughness of terrain have a considerable effect on the output of horses. In an area such as coastal regions of the Pacific Northwest two other problems in the use of horses are immediately evident: Firstly, there is a lack of suitable trained horses and teamsters, and secondly, the expense of looking after them and keeping them during week-ends and seasonal lay offs. To overcome this problem mechanical methods of yarding thinnings on steep ground are being developed.

One solution to the problem of thinning on steep ground is the use of skyline systems such as the Wyssen skyline crane, or the Naud skyline carriage. The Wyssen has been effectively used in many parts of the world and has great possibilities for steep areas of this country. In planning the use of the Wyssen system two limitations must be fully understood:

(i) The skyline has to be suspended above the ground with enough clearance for the logs to swing free of the ground for the whole distance on each yarding road. This involves the use of "intermediate hangers" to provide enough clearance. Rigging of these hangers involves considerable work.

(ii) The yarding machine is gravity powered so the skyline must be steep and tight enough, with little deflection, in order that the carriage does not have to run level or uphill any part of the way (Fig. 34).

Generally, in laying-out an area for extraction with the Wyssen system, a roading strip should be selected and felled. Logs can be yarded to this strip from up to 200 feet on each side of the skyline. In selecting this strip it is best to pick concave hill profiles wherever possible as less hangers will then be needed. This is important because the rigging expense involved with each hanger is considerable (Fig. 35).

Trees can be felled in herring-bone fashion for extraction direct to the skyline (Fig. 36) and from outside the 200 foot reach can be brought in by tractor or horse to a position within reach of the skyline.

For up-hill thinning on steep ground, various forms of single-drum logging-winches can be used. The clearance of these is aided greatly if some form of boom or A-frame is attached to the yarding unit. In planning their use, the timber should be felled to facilitate uphill yarding and, once again, an acute herring-bone pattern is probably the best. Also the skid-roads should be located straight up-hill, about 50 feet apart, or wherever there is a natural corridor through the standing timber.

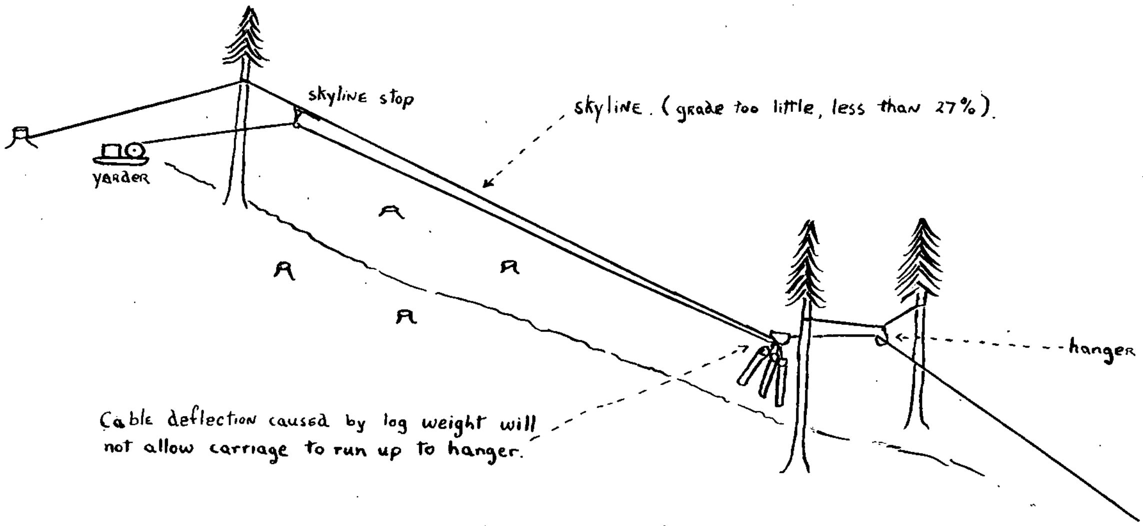


Fig. 34. Diagram to show Wyssen skyline rigged in unsuitable situation.

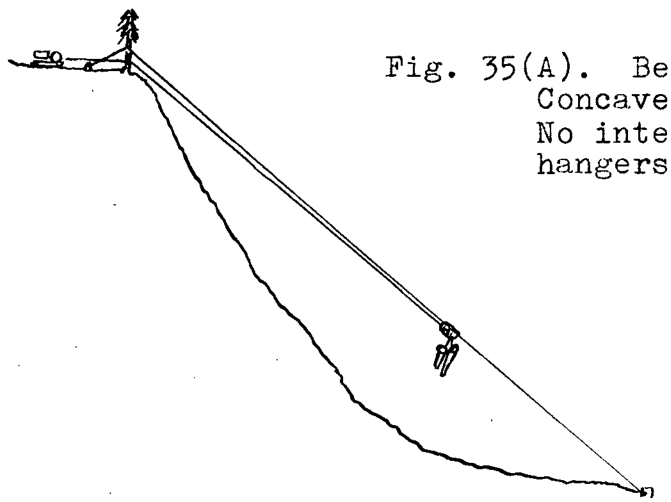


Fig. 35(A). Best situation Concave topography. No intermediate hangers required.

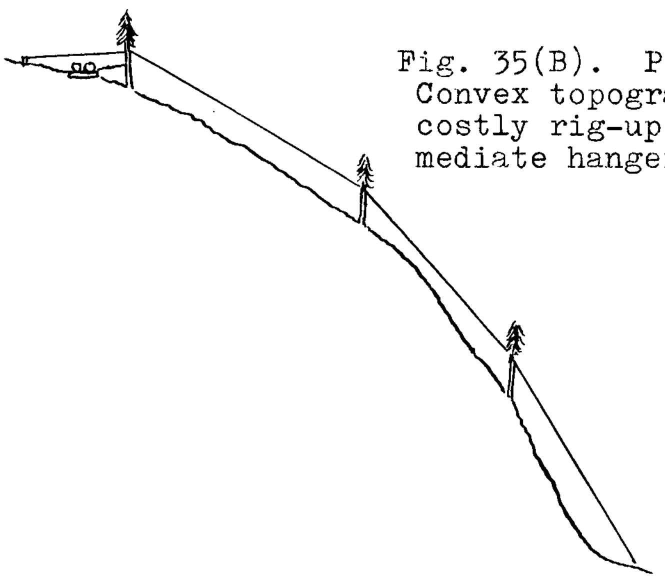


Fig. 35(B). Poor situation Convex topography, requires costly rig-up of intermediate hangers.

Fig. 35. Diagram to show rigging required for varying topography.

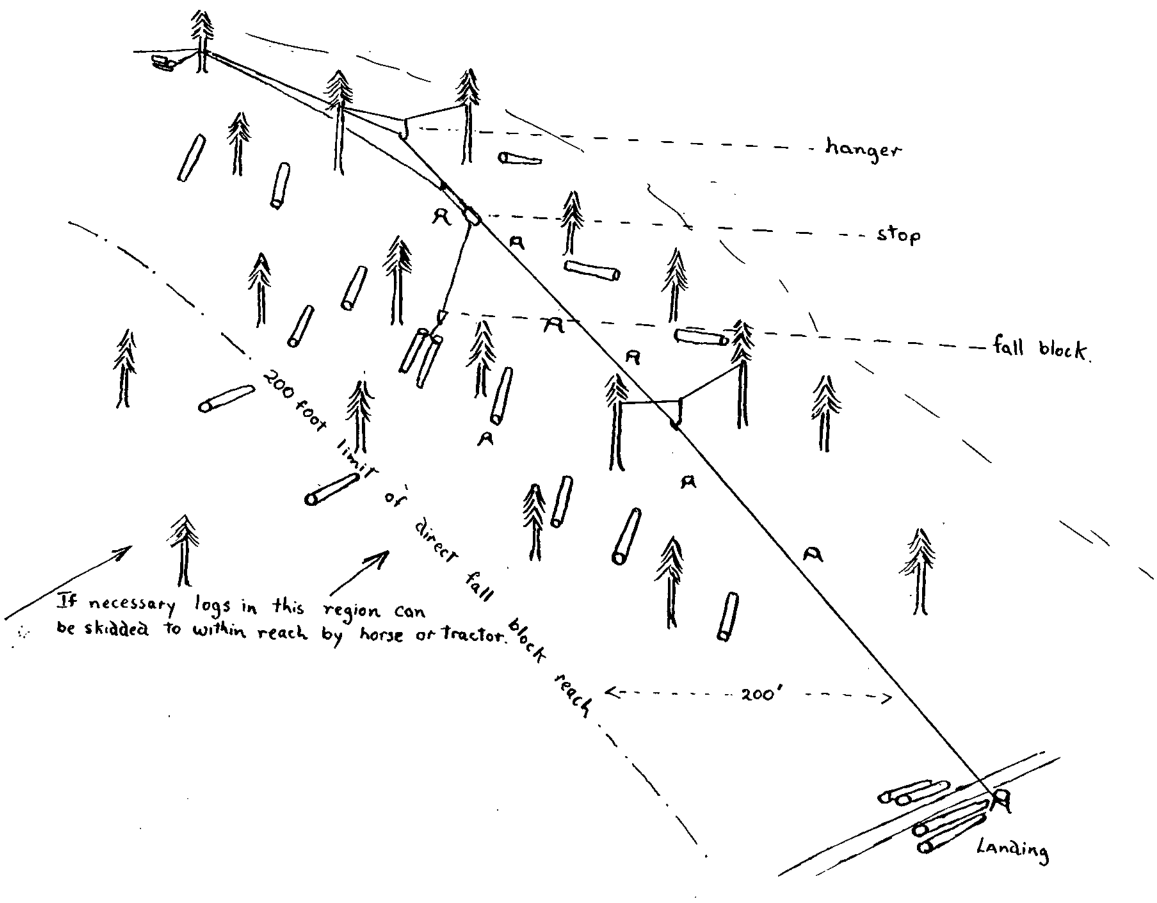


Fig. 36. Felling layout for use with Wyssen skyline.

Herring-bone pattern with logs skidded uphill to cause least damage to standing trees.

In this type of operation it is impractical to use the haulback system common to conventional yarders, as there would be excessive time lost in road changing. To overcome the haulback difficulty, chokers are returned to the bush, either manually, with a chokerman dragging downhill the half-inch main-line used, or, by using a drum attachment on a power saw. This latter carries about 200 feet of 3/16th line and is taken out to the extremity of the yarding road and operated by one of the chokermen. Wherever blocks have to be attached to trees for siwashing logs onto the main skid rows cord rubber belting is used to protect the tree from the block strap.

In the spring and early summer trees are very vulnerable to excessive bark damage because of increased sap flow, and the generally loose condition of the bark. Therefore, thinning operations may have to be reduced or stopped altogether.

Developments Affecting the Mobility of the Logging Operation

The traditional logging method of the Northwest is high lead yarding with some type of skyline swing where necessary and fixed heel boom loading from the spar tree. This system is gradually giving way to more mobile methods of operation because of the reasons stated perviously (page 3). The more important of these mobile methods in the major clear felling operations are:

(i) The use of portable spar trees with self tightening guys that can be set up and rigged in an hour or two. These spars should incorporate the use of a good fairlead block for both main and haulback enabling it to yard in all directions without the necessity of having to shift the block around the tree. A spar of this description is shown in Figure 37.

(ii) The divorcing of the yarding and loading procedure.

(iii) The use of fast rubber-tired skidding tractors for long swings over steep grades.

To make the most effective use of these new methods it is not sufficient that they just replace the older methods over the originally planned settings. The whole logging area must be planned specifically to take advantage of these methods.

Use of Mobile Spars

In the past big powerful machines, heavy rigging, and chokers, and large tall spars were the rule. High-powered yarders were considered essential in order to pull turn out of hangups. With this demand for more power, running lines, butt rigging, and chokers had to be strong enough to withstand the shock loads. This meant that there was little broken rigging, but there was plenty of log breakage and sometimes all the logs of a turn had pieces smashed off them on the haul in. Also with heavy chokers of 1" or more in diameter, choking time was slow, and two chokermen had to be used to handle them.

Fig. 37. Burrard 70' portable sled-mounted steel tower.

Yarder a Cat. D.8 with Carco winch.

It is not sufficient merely to use the newer mobile spars under the same conditions as the old high-lead system, as generally speaking, they are not so rugged as their predecessors. Steel spars are preferable to wooden ones because of their better strength to weight ratio. Lighter machines and rigging are advantageous, as this reduces choking time, a major factor in total turn time (see Fig. 38) and will probably result in lower costs due to reduction in the number of chokermen. To work with this lighter equipment two important deviations from the older practices must be made. The setting must be planned so that yarding distances are shorter and long corners are avoided wherever possible because these mobile spars are usually 30 to 40 feet shorter than the standing wooden spars.

Stumps must be cut lower. The major cause of "hangups" and "siwashes", with the resultant broken rigging and smashed logs, are the high stumps evident almost everywhere in the Northwest. Traditionally, stumps were cut high because the trees were felled by hand-saws. For safety, and in order to reduce the strenous amount of hand sawing the fallers cut high. In some cases they used spring boards to get up to 15 feet or more above any butt swell or heart rot. With the present use of power-saws, particularly on the smaller trees, there is no difficulty in getting down to near ground level on the high side of the stump. All timber, except that which may be dangerous to cut low, should be cut at this level. On steep ground it is an additional advantage to use the "Humbolt" undercut. In addition to the lessening of obstruction to yarding, low stumps reduce breakage both in the tree being felled and in others which may fall across the stump. Also, now that timber utilization is paramount, the volume of the additional timber that may be harvested is considerable. This adds greatly to the value of the largest and often the most valuable log in the tree. In some areas at least another 10,000 board feet per acre could have been removed from the high stumps.

The main advantage of mobile spars lies in their mobility and quick set-up time. Therefore, in comparison to the

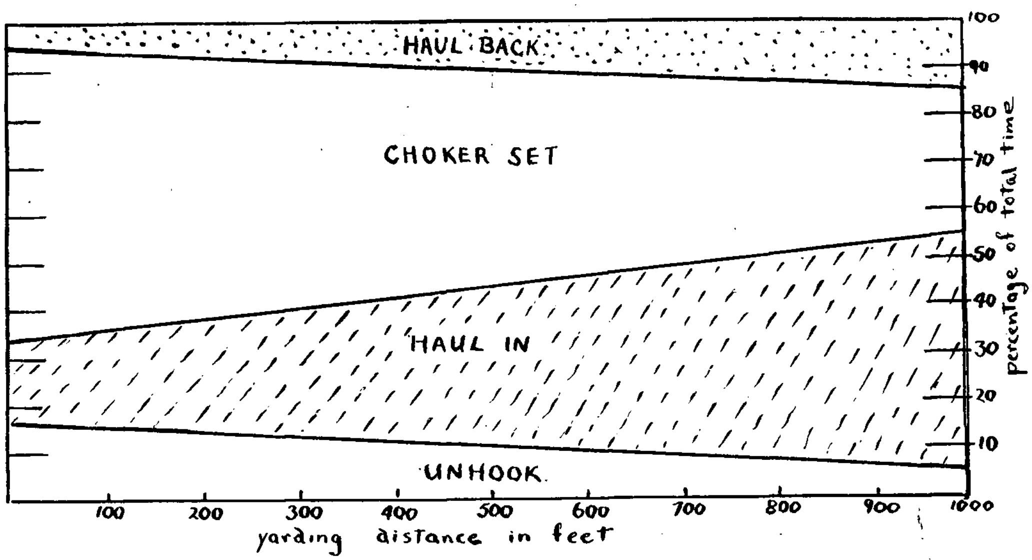


Fig. 38. Diagram to show relative distribution of element times for various haul in distances in a typical high-lead operation.

(Assume constant slope and turn volume)

Graph formed from figures given for a high-lead operation described in "Analysis of production and costs in high-lead yarding" by Tennas, Ruth, and Bernsten, 1956, p. 19.

Choker set time could be considerably decreased by use of lighter chokers.

normal high-lead setting the fixed cost of raising them is very low. It takes two hours to set up a Berger Portable tower in comparison with about 3 to 4 days for a normal high-lead spar, with many more men and machines involved. This advantage then must be used to reduce the variable cost of yarding by eliminating wherever possible the "long" corners of normal setting where yarding costs are high (Fig. 39). To make a mobile spar pay, the saving achieved through lower yarding costs and cheaper set up should be greater than any increased roading cost or high spar rental cost. In planning layout, more favourable hauling lines and lower cold decks should be the aim.

It is advantageous to have many more small settings along a road and to windrow logs to the road. If in this way the yarding is confined to the most effective arc, it results in quicker yarding, no swing of blocks on the spar, and reduced strain and wear on ropes and blocks. Also, there is the added advantage of good directional placement of logs for quick loading out. Because of lower yarding costs, it may be possible to construct a closer road network and further to reduce hauling distances (Matthews, 1942, Chapter V).

Separation of Yarding and Loading Operations

Most effective yarding and loading is accomplished when they are divorced, so that both the yarding and loading crew can work without interfering with each other and consequent loss of time. This eliminates the "feast or famine" system associated with some systems of yarding on certain topography. Congestion on the landing is reduced and yarded turns do not have to be delayed at the edge of the landing whilst the loading crew gets clear. However, as most of the more mobile loading equipment has limited reach, care must be taken in yarding to see that all logs are accessible to the loader and that cold-decks do not become too high. Any cold-deck or windrow pile should not exceed fifteen feet in height and logs should not be more than twenty feet from the roadway where a loader fitted with air-tongs is to be used.

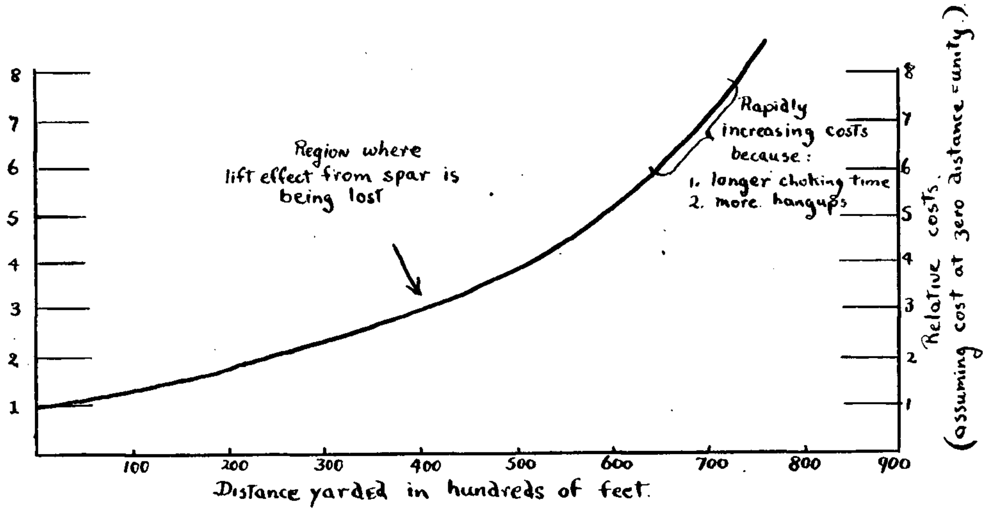


Fig. 39. Relationship of distance to yarding costs High-lead yarding.

(Graph summarizes Brandstrom, 1933)

In most of these high-production operations, machines especially designed for either yarding or loading are much more effective than combination yarding-loading machines which may be excellently suited for smaller outputs with limited crew and finance.

Use of Large Rubber-Tired Skidding Machines

In the Northwest, large rubber-tired tractors are achieving increasing prominence as a unit for swinging large turns distances of up to three miles. They are simpler in design than a tractor, but any new unit must be used correctly and its maintenance must be understood. These units do not replace entirely the track type tractor nor can they eliminate either the logging truck or the skyline swing, but they do have their place in providing a large-capacity machine that can swing large loads over fairly steep grades on roughly prepared roads. Probably their most successful application has been in those areas on the islands and inlets of British Columbia where logs have to be transported from 800 yards to three miles to the water. Their use in such an area eliminates the need for expensive truck roads and a loading and unloading device. Due to the slowness of turn time and excessive wear on tracks and roller assemblies, a normal tracklaying tractor would be impractical.

In planning to use these machines, it must be realised that they are expensive units with high fixed costs. Therefore, they must be used at maximum capacity during their entire operating time. Full-capacity loads are particularly important in skidding long distances. The great advantage over the crawler-tractor is in speed, and if this speed can not be utilized, they should not be used. Often they can do some of their own bunching but they are not nearly as effective as a crawler-tractor and are more limited by ground conditions. They will work well enough in mud if they can get down to a hard surface underneath. Therefore, it is always advantageous to have crawler-tractors bunching for them so that the rubber-tired machines may be used exclusively for high-speed swing. A crawler is usually necessary to make the roads for them.

Among the machines more commonly used in the Pacific Northwest at present is the Westfall Performer, (a diesel-engined machine with rigid frame and conventional transmission, Fig. 40), the Wagner loggermobile, (a diesel-engined machine with hydraulically-controlled kingpin steering, Fig. 41), and the Le Tourneau Westinghouse Tournaskidder, (a skid-steer vehicle with electrically powered winch and blade, Fig. 42).

Probably the most promising of the machines now operational is the Le Tourneau Electric Arch (Fig. 43). These machines are having some maintenance difficulties at present but, these should be overcome when logging operators become more conversant with electrical equipment. Their principle of using independently operated electric wheel drives and large rubber-tires with high flotation properties should be the most effective, particularly as speed and power are completely variable from 0 to 11 m.p.h. with no gear changing necessary in the varying tractive conditions they are likely to encounter. Grades up to 35 percent are negotiated easily in muddy conditions or broken rock, 65 percent grades are the maximum they can negotiate under optimum tractive conditions.

In planning the layout, the roads for the rubber-tired rigs should be laid out to provide favourable grades where-ever possible, as any adverse grade means a reduction not only in speed but in load capacity. Often turns cannot be of full capacity because of the difficulty in assembly of full turns. This is particularly true where the smaller log sizes are being handled. To keep the rubber-tired unit operating at full capacity the work of the bunching tractor should be organised so that its time to bunch a full turn equals the round trip time of the rubber-tired rig to the dumping ground. These machines are designed for large-load capacity, primarily by placement of the arch so that the load is on the driving wheels, thus increasing their tractive effort.

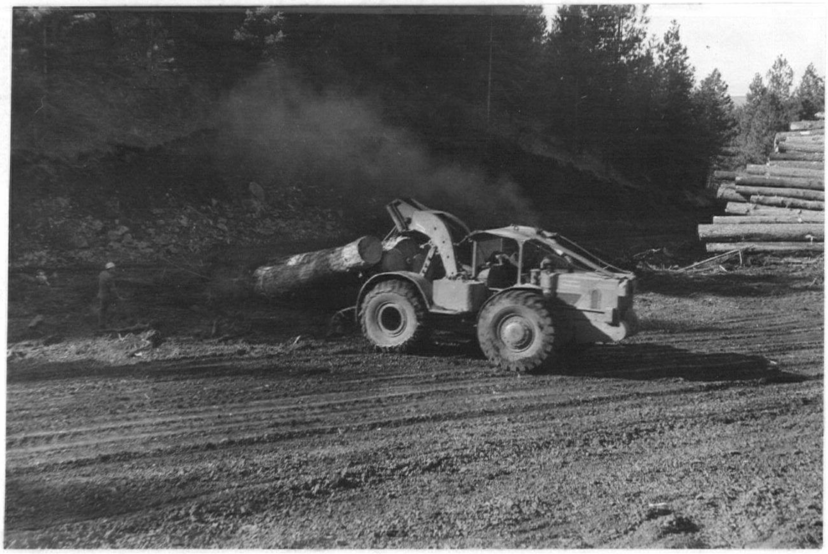


Fig. 40. Westfall Performer skidding pine logs.

Fig. 41. Wagner TRD 14. Loggermobile.
Skidding tree length logs.

Fig. 42. Le Tourneau Westinghouse
Tournaskidder

Fig. 43. Le Tourneau Electric Arch

A rubber-tired skidding device that is very popular in the interior of British Columbia, particularly for skidding on snow and ice roads under winter conditions, is the truck-arch (Fig. 44). These are heavy logging trucks fitted with an arch over the rear axles and a protective plate to prevent logs from damaging the rear-end and tires. A counter-weight is fitted in front and the whole chassis and springs are strengthened in order to take the increased load. In planning to use these truck-arches, logs should be skidded to the road-side and bunched by tractor. The logs should be short-choked as the arch does not extend back from the chassis as far as on a normal tractor-drawn arch. If this arch were extended, the truck's front wheels would tend to leave the ground

These rigs are ideal for skidding 16 to 20 tree-length logs up to five miles down 10 to 15 percent grades on packed snow or ice. Under these conditions it is possible to handle nearly twice the load that would be possible to truck normally.

In planning the use of these units, the logging area should be laid out and divided into summer and winter areas. The areas of rough topography with steep access-roads should be worked during the summer months using normal logging-truck transportation. (These trucks may have arch, protection plate, and counter-weight removed and may work as a normal logging truck during this period.) Other areas need to be reserved for winter operations; access roads to these areas should not have a grade in excess of 15 percent as trucks would be difficult to control under frozen conditions. Adverse grades should be avoided wherever possible as the load-capacity is considerably decreased if the trucks must cope with adverse grades.

In skidding on snow or ice there is little damage or abrasion to the logs but under dry conditions this type of hauling is inadvisable because, in addition to more skidding resistance, the logs are abraded considerably and small stones

Fig. 44. Pacific 4x4 truck-arch.
British Columbia interior.

which may seriously damage saws or other sawmilling equipment are embedded in them.

There are many advantages that accrue from tree-length skidding of logs on snow and ice as practiced with this system. These include the following:

(i) Cost of supplies is lower, e.g., fewer chokers are required.

(ii) Cost of manpower in bucking, bunching, and skidding is decreased.

(iii) More capacity under the arch is possible with each turn, particularly when logs are choked at the small end.

(iv) Long logs are easier to locate in heavy snow.

(v) Damage to the ground is reduced.

(vi) There is less grit in the ends of the logs.

(vii) With logs choked at the small end, the little abrasion that might occur at the butt does not matter as this is usually removed in the slab at the sawmill.

Truck Transfer Systems

In many areas of the Pacific Northwest the introduction of a pre-loading device, coupled with a log-load relay system, has become a necessity for the following reasons:

With much smaller logs and consequently longer loading times, non-productive delay time at the landing has increased. Because of the high fixed-costs of modern heavy trucks with large capacity trailers, it is essential that the time at the landing has to be reduced to a minimum.

Heavy-duty trucks of rugged construction are essential for hauling large loads over adverse grades and roads of poor standard, whereas lighter tractor units are more economical in hauling these same loads over good roads. This is particularly true where the added weight of the larger unit may cause the gross weight of truck and load to exceed highway limits.

The delay time associated with loading and hauling over a comparatively short section of rough road would reduce the number of trips possible per day. With a transfer unit however, a reduced number of highway trucks can operate on shift, working 24 hours a day. Forest Products laboratory in their equipment survey notes (D 1367-52, 1952) state:

"For example one California Company with a woods haul of 3 to 6 miles and highway haul of 57 miles had ten trucks doing two trips per day for a total of 120M per day. On introduction of a transfer system and using two heavy woods-to-highway units and three highway-units doing five trips the company put out 90M per day with half the number of trucks."

Most of these units are equipped with hydraulic cylinders to raise the front bunk until it can be supported by a fixed stand. In the Pacific trucks these hydraulic cylinders are incorporated in the truck design but, where highway hauling is the rule, the truck has to be kept to a minimum weight and the hydraulic cylinder is operated by a separate motor, such as in the transfer system shown in Figures 45 and 46, or from a yarding or loading machine at the preload point at the landing as shown in Figure 47. To gain more flexibility in transportation and increased safety, the introduction of any such transfer system requires effective dispatching. An efficient radio-communication system between all sides, the dispatcher, and the transfer points are an essential.

For companies operating vehicles over their own roads, on which it is not necessary to transfer all loads, such an installation would be primarily to increase the flexibility of operations. The transportation system therefore, would be independent of loading speeds and of landing shut-downs.

Transfer points should be located at the base of the access road to all landings, where there is room for at least 10 to 12 stanchions[1] on level ground. The road from the transfer point to the mill or dump should be a high-class road that can be operated over at high speed with safety both day and night.

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[1] Stanchions: These are the uprights on the ground which support the load bunks. They may be fixed in a concrete base or, for the more mobile operations they are fixed on a steel sled.

Fig. 45. Truck-Trailer transfer point at Clackamas Tree Farm

Fig. 46. Close up of transfer point at Columbia Tree Farm to show hydraulic cylinders at base of stanchion.

Fig. 47. Hydraulically operated pre-load device. Power from loader on right.

Wheel-Mountings for Mobility

Almost everywhere in the Northwest operators are attempting to reduce the amount of time lost in shifting from setting to setting, even in the more conventional operations. Everything, from the heaviest yarders to the lighter machines, including loaders, water tanks, guy-rope drums and servicing machinery, is being mounted on wheels wherever possible. Some manufacturers such as Skagit Steel and Iron Works are devising special chassis with solid steel wheels (Fig. 48), while some logging companies are making their heavy machinery mobile by using cast-off railway wheels with the flanges cut off (Fig. 49). In the lighter units an old truck, a discarded truck-chassis, or a trailer are used (Figs. 50, 51, 52).

Many loading cranes are now either maxi-mounted[2], for use in heavy timber, or truck-mounted for use in lighter timber, to give increased mobility. This often enables them to load from two or three different settings in one day. The maxi-mounts (Fig. 53) have a maximum speed of about 6 miles per hour, but the chain-drives can be disconnected for towing and the hydraulic system coupled to that of the truck for braking. This type of mount has an advantage over the truck-mounted version in that the operator does not have to get out of his cab when moving along a windrow or when logging a right-of-way. Usually the maxi-mounts are 11 to 12 feet wide, which increases stability and, if out-riggers[3] are used, very heavy logs can be handled.

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[2]Maxi-mounted: This is a method of wheel mounting heavy machinery such as loaders and shovels. There are usually 3 axles, with one of these being steerable and the wheels are chain driven from a power-takeoff. The entire unit is controlled from the loader cab.

[3]Out-riggers: These are adjustable fittings used to widen the base of a machine in the stationary position giving more stability. In many cases out-riggers also serve to take weight off the springs and axles.

Fig. 48. Solid steel wheel chassis for large Skagit yarder. Moved by D.8.

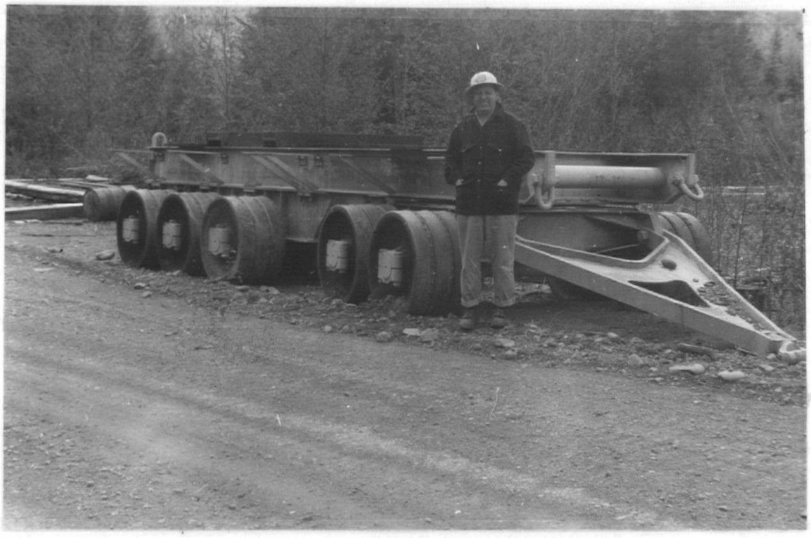

Fig. 49. Yarder chassis on discarded railway wheels with cut flanges.

Fig. 50. B.U.15 Skagit loader mounted on disused truck-chassis.

Fig. 51. 600 gallon water tank on old logging-trailer.

Fig. 52. Guyline pick-up drum and rig-up goat on out of date truck.

Fig. 53. Maxi-mounted Osgood loading crane.

The truck-mounted units (Fig. 54) are the least stable and so definitely need out-riggers. They cannot lift as much to the side as they can over the ends, so generally they are not suitable for handling large logs. Also, because of the truck cab, they usually do not have a full swing. However, they are often the cheapest and certainly the fastest where mobility to pick up scattered heaps of big logs is required.

The Necessity of Effective Planning

With the timber resource becoming smaller and much more difficult to handle the margin for profit is being reduced. It is becoming increasingly important that operations be planned to utilize all available equipment and methods that give maximum production per acre at the optimum profit margin.

Not only must operations be planned to give the best profit figure for current operations but due attention must be paid to re-forestation of each logged area. Gone are the days when the cost per M for logs delivered to the landing was the only guide as to whether the logging operation was a success or not. The present day logging manager must balance three factors; the profit to be made on the logging operation from stump to the mill; the necessity to recover the maximum volume per acre; and the need to bring a logged area into full production as soon as possible. The latter two factors are most important where the timber resource available to a particular company is limited.

Economic Control

A properly organized time study is one of the chief tools that can be used to provide owners and managers with a basis for intelligent decision on management problems by collecting, analyzing, interpreting, and evaluating all significant facts.

Diversification of silvicultural cutting practices, along with the development of a wide variety of logging machinery and methods of harvesting, have made it essential that the economical application of any of these techniques be thoroughly studied. The limitations and advantages of any particular system must be known as all management problems have to be studied eventually

Fig. 54. Truck mounted Bohemian Boom Loading Crane. Note supporting guys.

from an economic point of view, embracing both the present and the future. In the past many studies of logging have shown costs in units did not assist logging management in pinpointing sources of inefficiency. A well orientated time study should have one or more of the following objectives in view:

It may be used to locate the uneconomic phases or "bottlenecks" of any particular operation. The objective of this "trouble-shooting" type of study is to eliminate unnecessary work, reduce bottlenecks if possible, and limit the operation to the range of conditions within which it is most economical. A time study may be used to compare the efficiency of different methods or machinery over varied operating conditions. This type of study is a sound basis on which to design an overall logging plan. By using it, application of various machines and methods can be limited to those areas in which they can operate at their maximum production. Time studies can be used as a basis for setting up a form of incentive payments. From these studies, management can initiate incentive plans which increase production, reduce costs, and give the worker a just reward for more effective labour. Time studies considering a large number of operations can be used to form tables covering cost of operation for any particular machine or method under varying conditions. These tables can then be used as a basis for cost estimates on undeveloped or future operations.

An evaluation must be made of all the variables affecting a particular operation, and this must be considered in estimating the efficiency of a particular machine or method. The chief variables affecting a woods operation are:

(i) The timber crop, which may vary from a few, to several hundred logs per acre. Tree or log size may vary from setting to setting or even within a setting. The distribution and percentages of the various size classes are most important. The general condition of the trees as regards defect and tree form also play a part in evaluation of the influence of the timber crop on costs. A summary of the effect of average log size on all phases of logging costs was given in Table I, page 7.

(ii) Land topography and ground conditions, which may vary greatly within one small area, often control the selection of the method to be used.

(iii) The labour force is one of the most variable factors in the productivity of woods work, and one of the most difficult to assess. The abilities of groups of workers do not vary greatly in themselves but productivity is sensitive to such outside influence as labour-management relations, and the organizing efficiency of management.

(iv) Machine performance, due to age and mechanical condition, varys considerably. The skill, or inefficiency, of the operator often disguises this factor making it very difficult to evaluate.

In setting up a time study a clear definition of the objective is essential. A detailed study must be made of the elements involved in the operation to be timed. It is particularly important to distinguish the various elements in three different categories: operating time, subsidary time[4], and delay time. If the study is to have any value it must be carried out accurately with full attention to detail. A covering report should contain a full description of all factors affecting the operation timed. The results should be analyzed and presented in readily readable form such as graphs or tables. Any graph that can show the minimum and optimum levels of economical operation is very advantageous (see Fig. 55).

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[4] Subsidary time: This is the time factor that is not directly productive but is necessary to the completion of a yarding operation. It includes time for changing yarding roads, changing circuit blocks, swinging spar tree blocks, tightening guylines, and moving yarding or loading machines. (Tennas, Ruth and Berntsen, 1956).

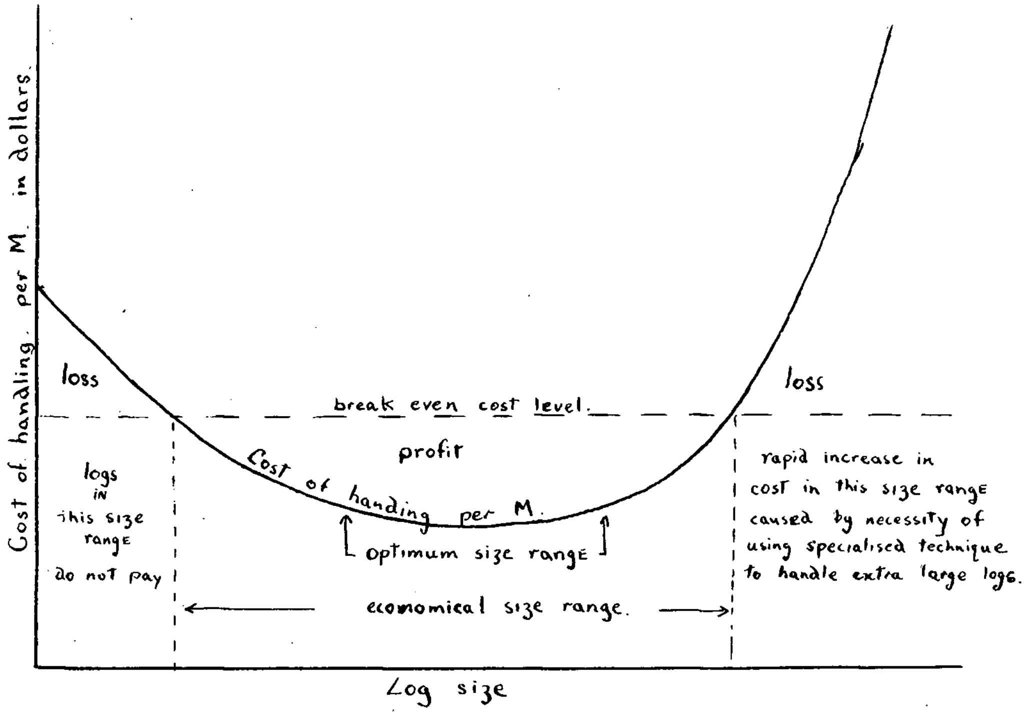

Fig. 55. Hypothetical curve to show range of cost variability due to size of log to be handled with any specific machine.

The Facilitation of More Effective Planning by the Use of Aerial Photography

A topographic map is an essential for advance planning of large scale logging operations. A well prepared map can greatly reduce the amount of time spent on ground reconnaissance and helps to integrate the various phases of logging in a particular area. Stand condition influences the felling sequence in any area. Since over-mature and decandent areas should be removed first, the location and extent of these areas has to be known. In the past decade aerial photographs have come into general usage. They have proved an invaluable aid, particularly when used in stereoscopic pairs, and when used with a topographic map.

Most topographic maps used at present have a 20 or 25 feet contour interval and a scale of from 400 to 500 feet to the inch. These are prepared in conjuction with the timber cruise and are essentially traverses with contour lines interpolated between. These maps although a great aid to logging operations have several disadvantages. Although usually accurate on the grid line considerable error can occur between the lines because of the limited view during surveying in dense stands or broken country. Preparation of these maps is time consuming and costly. A large pool of skilled labour is required for field surveying and office draughting.

In some areas topographic maps plotted from aerial photographs are being used extensively in planning ground operations. Not only can these photographic methods be used for topographic mapping but with recent advances timber types can be easily deliniated and using photo-volume tables the composition and volume of the stands can be estimated. This is advantageous in remote areas where ground reconnaissance would be both expensive and time consuming. Some difficulty in the measurement of stands from the air is still being experienced but this is expected to be overcome in the near future. So far, the most accurate mapping of this type has been done in the sparser timbered areas,or where there are many breaks in the canopy to allow the photogrammeter to distinguish ground level clearly. Where interpretation is difficult, a map based on aerial photographs presents a good picture of the relative relationships of topographic features which are often of more importance than the actual height of these features.

The dense, tall, coniferous forest of the coastal region of the Pacific Northwest provide difficult problems for the photogrammetrist due to obscuring of ground features by a heavy canopy and, the great difficulty in judging the height of the trees. This factor is exceedingly important because accuracy is dependent on an estimate of the height of the crown cover. The height used is not clearly defined but is close to average stand height. Top height is not used because tree tips would be too difficult to pick out on the photographs. This height is liable to vary due to different sites and aspects. The plotter can only check his height when he comes to a gap in the crown closure. Because of these factors even-aged stands are much more easily contoured than stands of mixed age classes.

Essentially, the topographic maps must present a picture of the ground, from which the logging planner can work. By highlighting the more difficult places these maps eliminate considerable aimless reconnaissance. Problem areas should be investigated thoroughly by ground methods.

In practice, trial road lines can be drawn out in the office and planned to give a balance of cut and fill. Their location is facilitated by the map, which indicates the most direct route to the main areas of timber, the best possible alignment of roads, and the relationship of routes to any control points which might effect location or limit construction. By perusal of the topographic map the area can be roughly divided into ground suitable for the various logging methods. With cable yarding these maps are most useful for the following reasons: The maximum yarding distances can be seen immediately;

with allowances for deflection, spar height, and sag, the setting can be allocated to machines of the required line capacity; clearance over obstacles can be calculated in doubtful cases, and profile traverses can be taken of the critical yarding roads; acreages and volumes per setting can be calculated easily.

In using maps based on aerial photography it must be realized that these are at present far from perfect because of the inability of the mapper to see below the forest canopy. Therefore, although these maps greatly minimize the amount of field work necessary they do not do away with it entirely and ground checks of all roadlines, landings and setting boundaries are necessary.

PATCH LOGGING

Patch logging is the limiting of clear cut areas to small units of less than one hundred acres (Fig. 56).

In the past the majority of operations in the Douglas fir region were continuous clear cuts. In some areas there was a type of patch logging due mainly to the practice of selecting only the best patches of timber for logging and leaving the rest. It was noted that the green timber areas left acted as a very efficient fire guard, and that restocking was most successful near the timber edge.

It is only recently however, that patch logging, or the staggered setting system, has been used systematically as an accepted system of silviculture and management. Like all methods it has its advantages and disadvantages and there is considerable controversy over its value to the industry as a whole. In all cases the individual circumstances must be taken into consideration.

The Effects on Fire Protection

Patch logging is effective in breaking up the whole logging area into small isolated areas with adequate green timber fire breaks in between. The monetary value of this type of insurance is impossible to determine but it adds considerably to the safety of the whole area.

The slash areas thus left are easily handled by controlled burning and risk of loss is reduced. Most large clear felled areas have a bad fire history.

For maximum fire protection the areas to be left should be selected so that there are no long uphill settings because fire travels rapidly uphill.

In these areas left as fire breaks no pre-logging should be carried out until the regrowth on the logged area is past the hazardous stage. Otherwise, pre-logging slash on the ground could make the firebreak dangerous in the case of a fire spreading from the logged over area.

Fig. 56. A forest near Mt. Rainier
showing patch logging.

The additional road network necessary for patch logging is itself useful in fire control as an efficient firebreak and provides rapid access for firefighting.

Usually, it is necessary to put a fire line round the edge of the slash to protect the standing trees when slash burning takes place, otherwise considerable damage could occur in the increased perimeter of standing trees given by patch logging. One disadvantage in patch logging is that the hazardous areas in the forest are more numerous and widely dispersed. But this is compensated by the actual hazard in any one area being reduced.

<u>The Effect on Regeneration</u>

In the Pacific Northwest one of the big advantages of patch logging is its value in restocking a logged area. This is particularly important since good seed years are irregular and an adequate seed source must be close to the logged area for several years to increase the changes of adequate restocking. Successful regeneration depends on the location and condition of the seed source, ground conditions, and the presence or absence of such seed destroyers as cone borers and rodents. One disadvantage lies in the fact that it is virtually impossible to control the composition of the new stand. For example cedar and hemlock seem to be more prolific seeders than Douglas fir and the dispersal distance is considerable greater. This may mean that while Douglas fir may hold its own in the mixture near the seed face it may hardly be represented at distances of over 1000 feet from the seed sources (Millar 1956). In most areas, particularly where the timber is being used for sawmilling, it is considered desirable to keep the stocking of Douglas fir as high as possible. Therefore, in some situations seed trees of this species may be left in the logged setting.

On unburned cutover areas with plenty of shade, cedar and hemlock germinate and grow well . Douglas fir does better after a moderate slash burn with a little shade remaining to protect the seed from excessive ground temperatures.

For the initial cut-over there is not much difficulty in selecting the areas to be left as a seed source, providing the settings are not too large. Reserved settings should be in good positions for seed dissemination. Those in depressions or downwind of the prevailing wind currents are of little use. In succeeding cuts, seed sources have to be left and these usually take the form of patches or isolated seed trees. With this method problems may arise, because it is difficult to avoid damaging these trees when carrying out a slash burn. After the areas become adequately restocked, harvesting of these isolated patches or individual trees may be uneconomical. Because of this, many companies tend to leave behind cull trees that are not worth harvesting. It is essential that seed be from the better trees. An attempt must be made to locate final seeding patches or individual trees in the postions there they facilitate maximum seed spread and in positions where they can be harvested fairly easily, after they have accomplished their purpose. Often it is difficult to reserve trees in favourable situations that are not subject to blowdown. When reserved seed patches are finally removed, the remaining area usually has to be planted. In some cases, when logging is carried out at the right time in a good seed year, sufficient seed is distributed by the felled trees.

One school of thought believes that in many areas, particularly where good seed years are infrequent and the seed source poor, that it pays to go to the added expense of planting. This means that the new area may be adequately stocked the first year, instead of taking five years or more. In this case it is argued that the additional volume increment obtained over the first five years more than pays for the cost of planting and maximum use is being made of the lands. In some areas however, planting has been unsuccessful. The use of school boys during vacation for planting has been a feature in one United States operation. Some others have tried reseeding from the air.

An Aid to Flexible Logging

A patch logging system opens up a wide area of timber and many more timber types are tapped in the early stages of developement. This enables a company to take the best advantages of fluctuating market conditions and to extract timber best suited to the prevailing optimum markets. For example, with high prices offered for large Douglas fir "peeler" logs an area containing a higher than normal percentage of these logs can be logged almost immediately. With a slump in this particular market, operations could then be transferred to some other area containing large percentages of the then most profitable logs.

With an extensive area developed, the planner is able to reserve areas on the lower levels close to the camps or booming grounds. These areas can be retained for winter logging or emergency operations. Also, with the whole logging area developed, salvage of areas damaged by fire, wind, insects or disease is possible.

A Barrier to the Spread of Pathological Disease

Patch logging in some cases proves a barrier to the spread of some insect and fungal damage. It may be particularly effective against those that occur at only one stage in the life cycle. Some insects in particular, may only attack young seedlings, for example, *Hylobius* pales (Pale's weevil).

Burning of slash helps to keep down infestations by *Dendroctonus* and *Ips* spp. which breed in logging slash.

A Silvicultural Viewpoint

In certain areas, settings for logging can be confined to certain forest types or site classes. If the setting boundaries concur with those of the forest types differential silvicultural treatment, thinning, or selective logging could be carried out.

Some Disadvantages

There appear to be two major disadvantages at present associated with patch logging practice. The increased capital outlay required to develop a staggered setting system and, the losses caused by blowdown around the increased forest perimeter. Both of these points are debatable and there is conflicting evidence on certain factors in blowdown (Worthington, 1953, Gratkowski, 1956).

Costs

Higher costs are the most immediate objection to patch logging and this system has to be balanced between good forest practice and sound economics. Often there is a higher capital investment in roads and in timber. If the logging company does not own sufficient land, a much larger timber inventory has to be acquired. The additional capital required for this is not earning as if it were invested for the company. A small company logging timber leases or licenses usually cannot afford to aquire enough land to put patch logging into practice.

At present in British Columbia and Washington, taxation is increased as the land is improved and many companies will not acquire land in advance or effect improvements, such as extensive road networks, because of this increased taxation. Therefore, they do not begin to develop an area until they are about to move into it. Roads, being classfied as an improvement, are taxable until they are finally written off. This does not give the operator any incentive to patch log. Patch logging can be encouraged on timber sale areas and in public working circles by reducing the stumpage on the more remote "take" patches so that the logger has more money available to construct his road. Subsequent stumpages for timber alongside an established road can be increased. There are increased road maintenance costs due to the larger road network. In addition logging costs are higher because of higher transportation, set-up, and supervision costs due to the more dispersed operations. With the increased perimeter of recently felled areas there is increased costs in constructing fire breaks around each setting before it is burnt off.

<u>Windthrow</u>

A prominent problem resulting from the greatly increased forest perimeter of small settings is windthrow at the tree edge (Fig. 57). Included with this windthrow are a large number of trees pushed over by the falling windthrown trees. In what were high lead or skyline settings, windthrown trees are difficult to salvage and the cost of logging is high. Logging equipment often has to be moved long distances to salvage these small amoumts of timber. Tractors are used on this type of salvage but are unsuitable in the very steep country. With the development of more mobile portable spars however, stand edges may be open to salvage at a more reasonable cost. In the case of a blowdown it is not considered good practice to cut down the remaining edge trees to straighten out the setting edge because these survivors are probably the most windfirm. In some cases where the yarding equipment is sufficiently mobile, some cold decking can be done.

Settings should be designed so that the reserve areas have maximum protection from the prevailing winds. In planning there are certain types of areas very vulnerable to windthrow and these should be avoided as a standing tree edge. Trees growing on swampy ground or soils with very little depth to the hardpan usually have a shallow root system that make them susceptible to windthrow. Areas where root rots, such as <u>Polyporus</u> <u>schweinitzii</u> or <u>Poria</u> <u>Weirii</u> effect root strength if exposed, may be subjected to heavy windthrow. Unfortunately these areas are difficult to detect.

Areas with a large percentage of overmature trees with heavy crowns can be extensively damaged.

Very narrow strip settings which force the wind to blow through them at a much increased velocity may cause in some cases severe windthrow. This can be disastrous if such a wind flow is funneled into a vulnerable area. A lot of this type of damage can be avoided if local wind behaviour is studied thoroughly before selecting reserve settings.

Fig. 57. Windthrow round the perimeter of a logged patch.

Planning Patch Logging Layout

Probably the best size for a logging patch is the smallest area that can be handled economically, however, it should wherever possible be kept to under a 100 acres. Full settings should be adhered to for the conventional type cable yarders because to return to the same setting later means double rig-up costs, which in most cases are considerable. In the case of cold deck settings, it must be remembered that the home tree setting must be selected for cutting at the same time as the cold deck setting.

Wherever possible the most distant part of the area to be logged should not be more than one thousand feet from the seed source, except where the logged setting lies under favourable distribution conditions, downwind of the seed source.

Usually the worst blowdown occurs on faces parallel to the wind stream where the wind has a funnelling effect in a steep gully or where the wind has a long unbroken approach into a large "face" of trees. Therefore, it usually is advantageous to have the strips across a gully. In considering the areas to be left as firebreaks consideration must be given to increasing the width of the firebreak on steep hillsides. A fire travels very rapidly uphill and the slash on a well drained hillside becomes very dry in the summer months, making this type of area extremely hazardous.

Roads and streams usually form good boundaries. Although ridges are not the best from a fire protection point of view they are often obligatory as edges, due to the logging method to be used.

For efficient fire protection each reserved area should be at least as wide as the "take" area. Each patch left should be the size of a setting normally logged, so that when the time comes to log it, it is profitable. Impractically sized "leave areas" with unsuitable topographic boundaries for future logging would mean increased future logging costs, with the resultant reduced returns. It is sometimes advantageous to reserve the "leave areas" on ground suitable for tractor salvage logging round the edges.

Planning of the layout requires compromise of all the factors involved. Rarely will the setting most suitable as a fire protection unit be ideal from the seed dispersal point of view and still fit in with overall logging planning considerations. The conditions effectings each different area must be balanced to arrive at the best answer. The design of the layout should be a compromise between practical logging engineering and efficient forestry.

Economics of Patch Logging

The extent that patch logging can be put into practice is determined by balancing good silviculture, present logging economy and future monetary benefits. It is difficult to forsee the future, but any method that protects the present forest crop, and aids in rapidly establishing the future one, must not be discarded because of present financial considerations alone. All factors must be weighed before the decision is reached.

Due to fluctuating economic conditions, any attempt to assess future market conditions of a forest crop is difficult. However, considering the present buoyant conditions of the timber industry, timberland developed now is insurance for any future setbacks. Therefore, with very competitive future prices, the necessity of spending money on establishing roads would not be present.

Rates on felled and bucked timber, and forest areas, are decreased by most insurance companies where there is the additional safety of a patch logging system.

PLANNING A LOGGING OPERATION

Intensive advance planning is required before moving into an undeveloped area. The objective should be to cut on a staggered setting system, concentrating on achieving the maximum return per acre by increased utilization at the best possible profit. Any logging plan must be reasonably flexible, and if it is to cover a long period of time, must make provisions for periodic revisions due to new equipment and methods of working.

Road development must be designed to serve not only the areas to be cut immediately, but also the leave settings and emergency units. Therefore, the whole area should be planned as a unit. Then the settings for immediate cutting should be selected, making adequate provisions for winter and summer working, and wherever possible reserving an area of good timber and easy access as an emergency area.

The major aims should be to balance the road spacing and yarding distances to get the minumum logging cost per M. This spacing can be easily worked out on level ground or even slopes (Matthews, Chapters V and VIII), but with the rough topography being worked at present in the Northwest, location is often dictated by topographical features. Setting boundaries, landings, and roads, must therefore be planned as composite units. Consideration must be given to such obligatory points of location as suitable stream crossings, natural landings, easy switchbacks, and favourable saddles. Rock outcrops, swamps, steep ridges, ravines, and unfavourable grades must be avoided.

The logging plan is essentially a compromise between engineering, economic, and forestry features. Therefore, to adequately plan an area, the Forestry Engineer must have available the following basic tools:

For engineering, adequate topographic maps showing contour lines and all information relevant to logging such as existing access, streams, ridges, rock outcrops and clearings are an essential. In addition, good aerial photographic coverage is necessary.

For forestry, the cruise report and a forest type map should be made up from cruise data and the aerial photographs. In addition to the normal cruise figures, it is advantageous if as well as volume per acre, the average log size and maximum log size expected are shown.

For economic control, a thorough knowledge of the capabilities, limitations and optimum and maximum working ranges on the equipment to be used is essential. To do this it is necessary to have available time studies and the statistical and graphic information prepared from them.

PLANNING A ROAD SYSTEM

Proper spacing of roads can be calculated by balancing road haulage and construction costs with yarding costs.. Road standards may vary with the amount of timber to be hauled over them. Naturally the main arterial roads should be constructed to a higher standard than those short life roads designed to serve only one or two settings.

In general, roads in easy sloping or undulating country, where tractor yarding is envisaged, should be planned to run below the country to be logged. Roads should not be so close to the drainage as to block streams, or be in danger of flood damage.

For cable yarding systems, the road wherever possible should be above the area to be yarded. On steeper country it is better to attempt to keep the road system in a series of levels so that the majority of the roads have little grade and result in economical hauling costs with least road maintenance. Such a system is most important in any windrowing system using mobile spars. The amount of steep maximum grade road joining these levels should be kept to a minimum. Steep joining roads intensify the amount of road per 100 acres but are of little use for landings and are ineffective mileage as a working road.

Attention given to engineering of a road is repaid many-fold in cheaper logging costs. Good road alignment is essential because it usually means the shortest route, easier adequate drainage, better visibility, and consequently increased safety, less gravel is required and maintenance costs are minimized.

PLANNING SETTINGS

The area is subdivided into separate settings according to the suitability of the topography to each type of yarding. For correct allocation of settings a knowledge of limitations and optimum working ranges of the various types of equipment is an essential. A great variety of yarding methods have been used in the past, but those used at present can be divided into two main methods: tractor-skidding and high-lead yarding. The tractor is more mobile, better suited to cleaning out small isolated areas and it can prepare its own landings and spur roads. Yarder operation needs a more experienced crew and has higher set up costs, but it is not limited by topography or ground conditions.

Tractor yarding is most economical when used on medium or easy downhill slopes. Uphill skidding is expensive and should be avoided if possible. The tractor is eminently suited to skidding logs out of a divaricating system of shallow gullies from below. Yarding distance varies with topography and ground conditions but usually the maximum economical distances lie between 500 feet and 1400 feet. On terminal stands of spur roads, skidding a longer distance than normal is economical because of the reduced road construction cost. The additional saving by not penetrating by road to within normal skidding distance from the edge of the setting more than balances the extra yarding cost. The major advantages of using a tractor for yarding are:

(i) It is mobile and can move itself from setting to setting.

(ii) It can do all its own "bull cooking"[5] for setting.

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[5] "Bull cooking". These are the servicing jobs performed around a landing, such as clearing the landing of slash, moving heavy equipment and rigging work.

(iii) It can be used on road construction and earth work as well as yarding operations.

(iv) It is well adapted to salvage and isolated jobs covering only a small area.

Its disadvantages are that it has a high operating cost and a fairly short working life. Also a tractor cannot work over rock areas without damaging tracks and its effective operation is hindered greatly by adverse ground conditions such as deep mud or swampy ground.

One disadvantage of a tractor setting on fairly steep downhill yarding area is that it tends to accelerate erosion problems by concentrating the water flow. Each tractor road spills its flow out into the landing area.

Cable hauling systems have several distinct advantages over the tractor operation. They can operate over steep country easily and are not affected by ground conditions such as rock, mud or snow. They are the most practical methods for uphill yarding. Usually yarding units have much lower operating costs than tractors of comparable horsepower. Yarding operations are not affected by weather conditions.

In planning for high-lead or skyline operations with a fixed spar, selection of a well situated landing is vital. A little time spent in choosing the best site is samply repaid by continued log production with a minimum of delay time. A suitable landing should have the following features:

(i) <u>Adequate landing space</u> - The landing must have adequate room to land logs safely and to operate a loader with all yarding roads. A good egress for trucks with a flat or slightly downhill start is desirable.

(ii) <u>Clearance</u> - Clearance is the determining factor as to whether certain roads can by yarded or not. Clearance enables the mainline to be lifted high enough to give "lift" or "bounce" to the turn being yarded so that butts do not drag into the ground or "hang up" on stumps.

"Bind"[6] of rope on obstruction and ground features should be avoided.

(iii) Coverage - This is the arc over which a yarder sitting on the one setting can gain clearance. The larger the coverage the less settings are required but coverage should never be increased at the expense of clearance.

Special consideration must be given to road location in planning layout for mobile high-lead operations where windrowing is to be the system of cold decking logs. The roads should be as nearly level as possible, so that yarding and loading machines are working on the level and their swing balance is not upset. This particularly applies to some loading cranes. The length of the setting from the roadside varies with topography and the height of the spar. Usually distance for the uphill yarding is at least twice that of the downhill or sidehill yarding. Uphill yarding is also better from the erosion aspect as the water runoff is spread instead of concentrated. Figure 56 shows a typical downhill yarding pattern and indicates how water runoff may be concentrated to give accelerated erosion.

SELECTING THE SETTING BOUNDARIES

Consideration should be given to location of the setting boundaries so that, as well as being a natural yarding boundary, the edge of the setting shall be in a good position as a fire-break with the standing timber in a windfirm area. The following features generally make good setting boundaries:

Spurs and ridges are natural topographic features that provide a definite yarding boundary. Timber in these places is relatively exposed normally and therefore, quite windfirm. However, with the adjacent trees removed there may be some wind damage. Seed dispersal from such a vantage point is good and a

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[6] "Bind". This occurs where running rigging is being pulled round or over an obstruction causing excessive rope wear and sometimes fire hazard.

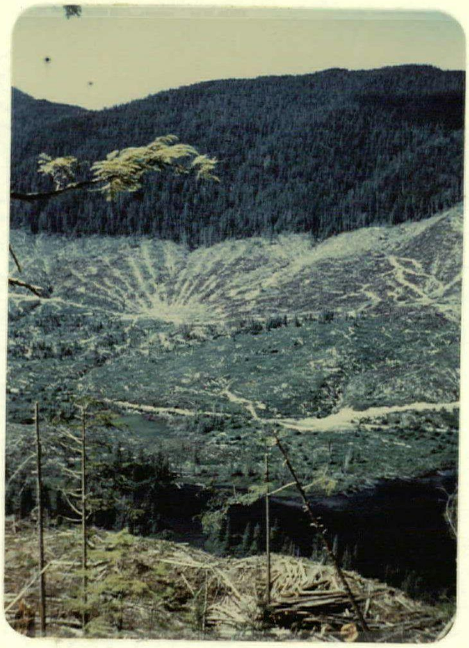

Fig. 58. A clear felled area showing the typical pattern of downhill yarding.

ridge is a natural boundary to a spreading fire.

Roads provide good boundaries. In the older, more static operations roads were not desirable as boundaries because rig-up costs were high for conventional high-lead settings. Therefore, in order to reduce rig-up costs both sides of the road were yarded to the one spar. With the very slight fixed per-acre cost of set-up in a mobile operation, the mobile unit can return to take a "leave" area on one side of the road with very little additional cost. Roads are excellent fire-breaks and provide access to the boundary of a setting for fire-fighting or salvage operations.

Streams are natural yarding boundaries both to tractor and yarder and provide a good fire-break. Also there is little interference with stream flow or wildlife facilities, and accelerated erosion is minimized if logs are not yarded across a stream.

Benches and gentle slopes make much better boundaries from the fire-control point of view than steep slopes where an advancing fire has considerable velocity. Fire-fighting access into such benches is considerably easier.

Timber type-lines are often good boundaries, particularly if there is great age or size difference between the stands in each type. A young stand, for instance, often makes a good fire-break. In addition, specialized equipment and different logging methods might be introduced in selected timber stands. For example, thinning might be introduced in an immature stand of good type in which lighter equipment would be used. If it is not possible to select setting boundaries on any of these features, it is much more desirable to have a boundary running at right-angles to the contours than along it. Fire control is easier under these conditions as a fire tends to run uphill and, therefore, fire-fighting can be concentrated on a narrower front if setting boundaries running parallel to the contour are minimized.

THE STEPS IN PLANNING AN OPERATION

A first requirement is a field reconnaissance, designed to give the forest engineer both orientation and some knowledge of ground conditions. A preliminary plan should then be made. This is made from a topographic map in the office with the aid of aerial photographs. Time-study data is used to determine economic road-spacing and yarding distances. This is essentially a preliminary plan and, as such, is subject to such modifications as later may prove advisable in the field. Usually, in easier country, the map location may be relatively easy to follow. In more difficult topography it may be necessary to fix the obligatory points of location first in the field, then to link them using the best possible alignment.

The second step is to complete field locations of all the road and settings. During this stage, full attention must be paid to local features affecting both road construction, and yarding methods and distances. Alternative locations are planned where necessary, and the relationship of these local alterations on the overall plan must be considered. An important alteration in one specific spot may necessitate re-location throughout the surrounding area. In this field investigation, controlling features must be given the most attention. Considerable engineering work is justified at points of large culvert installations, bridge sites, and where extensive rock work is encountered. Landing locations must be checked for space, clearance and coverage, and obstacles to yarding avoided where possible by re-location of landings. In steep country, switch-back positions are often controlling points of road location and have to be discovered. Usually, field locations are marked by using a stapling hammer to tack various-coloured cards or aluminum tags to the trees. When alternatives have been considered, final locations are pegged out in the field and estimates of road construction and logging costs are prepared.

Preparation of the Logging Plan

This is the final stage where logging plan, forest working plan, and production requirements are amalgamated to give a forestry logging plan. The plan must be flexible enough to cope with changing market or economic conditions, and progressive enough to be able to make use of new methods of logging and forest management. Ideally, the plan presents a planned method and a sequence of working the whole forest area.

For first cutting, areas should be selected in accordance with silvicultural considerations. Overmature stands and damaged areas should be cut first so that the maximum salvageable material is recovered. However, to make an economic operation there must be a balance of high and low-value settings. This balancing of types will vary with fluctuating markets. Where patch logging is being practiced, it is best to attempt to extract the more rugged settings first. There is sure to be some wind damage in the reserved setting. Salvage of this windthrow can be more easily accomplished in a setting of less difficult topography.

Provision must be made for summer and winter working areas and if possible an easily-accessible high-volume stand, close to egress from the area, should be set aside for emergency operation.

Finally a complete schedule of silvicultural, developement, and logging operations should be drawn up to act as a basis and time-table for the over-all operations.

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