SESSION 4

Paper (a)

PRINCIPLES OF SELECTION AND DESIGN OF HARVESTING SYSTEMS

Matching machine to plan or plan to machine

V.F. Donovan

Research Officer
LIRA

INTRODUCTION

A logging system defined as an assemblage of logging machines arranged in a particular logical sequence is influenced by a wide variety of things which affect decisions made by the logging planner. Some of the key ones such as the terrain, the soil, the volume to be logged over a certain time span, and the tree size, are factors that cannot be changed by the planner although have a very real significance on the system selected. Decisions on the logging method and technique are open to the planner. He needs to be aware of these factors which can be influenced or modified to overcome logging constraints and to make the logging plan a workable and economic proposition.

This paper discusses the principles for the selection and design of systems when producing a plan. It is aimed at what could be termed critical site situations rather than the more common logging situation where the restrictions are not so dominant. The paper is in three sections, firstly the machine selection options, secondly the system selection options and thirdly the landing design options.

General Principles of Design for Critical Areas

Safety, production and environmental protection are compatible and trees can be logged without degrading other land values. However, three key points must be applied appropriately to prevent or defuse productive and environmental conflicts :

1. Communication,
2. Planning,
3. Co-operation.

Communication is probably the most easily dealt with yet is frequently overlooked. Planners must keep a generally poorly informed public abreast of developments in an area and also other agencies which can offer some input when compiling a plan. It is very easy for environmentalists to be destructive with their comments (and sometime in the past they have had good cause) but they are adept at slanting their presentations. Logging planners can and must counter much of this comment by letting people know what they are planning to do, why that course of action is being taken and why alternatives are not feasible.

Planning of critical sites must have a system and equipment designed to fit the site, not modify the site to fit the system. A range of options need to be available to the planner and he must be prepared to adopt a system that is less than conventional. In critical sites planners need to be receptive and innovative.

Co-operation between a whole range of people and agencies is essential when producing a logging plan. The forest manager, the sawmiller or buyer, the forester, the soil and water authorities, other off-site interests, the roading engineer, the logging supervisor and of course the logger and perhaps the unions. Roading has been discussed in previous sessions at the seminar as being a major problem for any logging operation. Roads and landings take on an awesome dimension when applied to critical or sensitive sites. They must be kept to a minimum to reduce damage. Given therefore that quality and quantity of roading and landing size are the key to overcoming site degrade, what system options are available to the planner.

SYSTEM OPTIONS

Highlead

Detail on the highlead system can be read in the paper "Planning for Tractor Skidder and Simple Cable Systems" tabled at this seminar. Highlead or ground hauling is not a good system for critical sites, particularly convex slopes, as the logs are mostly dragged along the ground with the only lift achieved close to the landing. The stationary highlead spars have disadvantages in that large landings are required to site the hauler back from the spar to get good fleet angles onto the hauler drums, and to site the spar back from the edge of the landing to land the last log on the butt rigging. Usually therefore a high spar is required to get some effective lift over the edge of the landing. Rigging up time is relatively slow therefore costly. No lateral hauling is possible unless long chokers are used and these subsequently reduce effective lift.

Highlead mobile integral steel spars overcome the requirement of fleet angles and the slow setting up and shifting time. The landing of logs and the spar height problem are not overcome. Mobile integral tower highlead machines or the smaller highlead mobile yarders have operating advantages which are discussed in the machine options on page 5, of this paper. The machines are usually big and relatively expensive. Planners must look at the ability to get them onto logging sites, given their overall length and weight.

Scab Skyline

This rigging technique is a type of running skyline which can be used with the newer highlead steel spar haulers. A riderblock is run on the tailrope with the butt rigging attached to the block. Lift to the rigging is achieved by tensioning the tailrope while at the same time bringing in the drag. Obstacles such as rock outcrops, intermediate ridges or logging downhill over bluffs, can be achieved because of the good log control but machines using this system need very high power and extremely efficient braking as one drum is being played off against the other (For further information see LIRA Report Vol.3 No.10, 1978). At N.Z.F.P. Kinleith forest the scab skyline system is being used on difficult terrain where traditional skyline systems would normally have been used.

Live Skyline with Gravity Return

A two drum hauler can be used for a gravity return skyline. The main rope becomes the skyline and must be free to be raised and lowered. The tailrope is used for inhaul. Provided a hauler has good free wheeling drums and reasonable brakes, and the lead blocks at the top of the tower can be changed so the mainrope is on the top, the gravity return is a very efficient system. Hauling distance is only limited by rope capacity of the skyline (mainrope drum) and a minimum 20% slope is required to get the carriage to return by gravity. Adequate clearance is needed all the way to the back of the setting. If a shotgun carriage is used, chokers are fixed directly to the carriage. No lateral pulling ability is available unless long chokers are used. The system is limited to uphill extraction and care must be taken not to overload the gear.

Gravity return with a lock-in carriage is an efficient technique because a two drum machine can be used as a skyline and lateral pulling can be achieved. It can be used in thinning and clear felling provided sufficient chord slope and deflection is available. The advantages of this type of carriage over the shotgun carriage are that the skyline doesn't need to be lowered to attach the logs. The load is locked into the carriage during inhaul thereby reducing the strain on the machine. (For further information on this hauler system see LIRA Report Vol.3 No.11, 1978.)

Standing Skylines (Single Span)

Unless a specifically designed three or four drum hauler is used (a slack-line yarder) with matching tower, these systems must operate with an independent spar and hauler and require relatively large landings.

North Bend is the most common rigging configuration used with standing skylines and is also discussed in the paper "Planning for Tractor Skidder and Simple Cable Systems". To re-emphasise the key points, the system requires a three drum hauler with big line capacity, power, and line speed to operate efficiently. Planning must be such to obtain good deflection over the total hauling distance. Bridling to the side is possible.

South Bend (also known as modified North Bend) differs from North Bend only by the rigging of the mainrope. Machine requirements are similar but a three sheave carriage is necessary. The South Bend is most suited to downhill or steep gully applications where lift is essential. Because of the extra purchase in the mainrope which achieves the lift, the system can be easily overloaded. Careful calculation of maximum allowable tensions and loadings on the skylines are needed.

Slackline

This option is a live skyline system but is included here because a three drum hauler is required with heavy rigging. The system is not commonly used in N.Z. because skyline haulers available do not have the skyline drum as a working drum so that the line can be raised and lowered readily. All lift is tensioned on the skyline and the forces imposed on the tower or spar are greater than the North Bend. There is limited ability to lateral haul from underneath the skyline.

Multi-Span Skyline

The multi-span is any skyline system which uses an intermediate support between the spar and back anchor to provide additional lift to the skyline. In N.Z. multi-spans have been used with the Wyssen hauler operated in the 1950-60's and are currently used with the small thinning haulers in radiata thinnings. Intermediate supports allow uniform or slightly convex country to be logged where deflection would otherwise not be available. Long convex slopes may require too many supports to be economical. Intermediate supports also allow the use of a short spar to achieve lift off the edge of the landing. The main disadvantages are the extra rigging time (although this depends on the complexity of the system) and the need for an open sided carriage. The lower the percent deflection the less difficulty the carriage has to pass the support. The change in the span of the chord slope at the support must be kept under 35%. Sensitive sites can be logged with intermediate supports and must be considered a strong option when logs would otherwise be dragged along the ground or deflection is not available. (For further information see LIRA Report Vol.4 No.4 1979.)

Running Skyline

The running skyline is where two or more suspended moving lines that, when properly tensioned will provide lift and travel to the carriage. Uphill and downhill logging is possible. The main system requirements are a specifically designed machine. A normal three drum slackline hauler is not suitable as the drums are not synchronized to wind in and out in the same direction and at the same speed. Good deflection is required throughout the haul line and distances up to 650 metres can be logged although maximums of 400 metres are more common.

Endless Line Systems

This option has limitations because of the high rigging time involved. The endless system is usually associated with a large number of intermediate supports to achieve lift. Rope wear is higher than other systems as ropes are in constant motion and tensioning the system can be difficult. The system requires a hauler with a Capstan drive and often two conventional drums.

MACHINE SELECTION OPTIONS

Mobile Spar Haulers

This type of equipment was developed as an improvement on the wooden spar hauler system. Mobile haulers have received wide acceptance due to their increased mobility and faster set up and derigging time. Recently small mobile haulers have been developed to log on steep country with tree sizes under 1 m^3.

Mobile haulers can be categorized into three groups, lightweight, medium and large, with each group having as variation of the main components, the tower, the winch and the carrier. Also there are certain differences between these three classifications as regards design and application of this equipment.

Small Mobile Haulers : Design Characteristics

Typical examples in N.Z., Timbermaster, Wilhaul, Lotus Skyline Series 1, Skagit SJ4.

The spar and hauler usually come as one unit.

The spar is laid down over the carrier for easy transport and sometimes hinged to shorten its length.

The spar is normally stabilised by two or three guylines. The hauler usually has three operating drums plus a strawline drum which is normally only used for laying out and changing operating lines.

When the carrier is a trailer, the power for the hauler may be included with the trailer unit or maybe provided by the machine which tows the unit, i.e. an agricultural tractor. When the carrier is a truck, the power for the hauler is sometimes provided by the truck.

Medium sized Mobile Haulers : Design Characteristics

Typical examples in N.Z., Skagit SJ7, Lotus Skyline Series 3, Madill 071, Ecologger.

The spar and hauler usually come as one unit.

The spar can be laid down over the carrier for easy transport.

The spar is normally stabilised with three to six guylines, depending on tower height, tower design and the forces exerted on the tower.

The hauler usually has two to four operating drums, plus a strawline drum. The strawline is normally only used for laying out and changing operating lines.
The self-propelled carrier can be a skidder, truck, crawler or tank unit.

The carrier and the hauler are usually powered by the same engine.

Large Mobile Haulers : Design Characteristics

Typical examples in N.Z., Madill 009, Washington 127T, Berger Portatower, Skagit Skyline Tower.

The three main components can be ordered individually so that the resulting combination best suits the users needs.

The steel spar can be telescopic or non-telescopic.

Spar is normally stabilised with three to eight guylines although some spars can use up to twelve guylines. The number of guylines is dependent on spar heights, spar design and the forces exerted upon them.

The hauler is available with two to four operating drums plus a strawline drum.

A carrier is available as a trailer unit or self-propelled rubber tyred or track unit.

The carrier and the hauler are powered by the same engine except in when the carrier is a trailer.

The small machines are designed for single or multi-span skyline use with the carriage often for lateral hauling. These systems are commonly used in thinnings with haul distances up to 400 metres. Small haulers are designed for temporary location with landings normally on road edges. In such situations the wood can be hauled and bunched for subsequent transportation to other roads by ground skidding equipment. In this way truck road transport can be reduced. The machines operate efficiently both uphill and downhill.

The medium sized haulers are basically designed for highlead or skyline use. In this country they are being used for gravity return systems. Their fast set up times and mobility allows them to be used in a similar manner as described for small mobile haulers.

Large mobile haulers being manufactured today are basically designed for clear felling of large timber in steep terrain. A variety of different cable configurations can be used which dictate the haul distance and operating conditions. Although these machines are designed for temporary location, they are in a somewhat fixed position and have no swing capabilities. The incoming logs are all placed in the same location on the landing therefore it is important to consider the difference in productivity between the hauler and the loading machine in order to keep operations as efficient as possible. The size of the machine and the need for an effective guyline set is one factor that restricts landing size and location.

Running Skyline Swing Yarders

This cable logging machine received rapid acceptance in North America since the late 1960's. The machines have the advantage of being mobile, have a swinging boom, and normally use a slack-pulling carriage with chokers. Running skyline swing yarders have the following design characteristics :

The three main components, tower, yarder and carrier come as a complete unit.

The leaning steel tower is normally of lattice construction.

The leaning steel tower is normally stabilised by two or three guylines. Walking guylines allow quicker shifts.

The yarder has three operating drums, two mainline drums (or a mainline and a slack pulling drum) and an interlocked tension haulback drum. In addition, the yarder has a strawline drum which is normally used for laying out and changing operating lines.

The yarder and leaning tower are mounted on a swinging assembly on the carrier and the entire unit is self-propelled.

The self-propelled carrier is either rubber-tyred or tracked.

The carrier and yarder are powered by the same engine.

To take advantage of the mobility of the running skyline machines, the harvesting operations can be planned so that the running skyline swing yarder can move along the road and stockpile the hauled logs on the road behind it. This eliminates the need for large landings. Also the loading machine can work independently compared with the mobile spar machines. Although a running skyline system need only consist of an interlocked mainline and haulback, in practice it consists of two mainlines (mainline and slack pulling line) and a haulback line. The haulback is tensioned to provide lift. By employing two mainlines it is possible to control the slack pulling operations from the yarder. The load is supported by the haul back and the mainlines. As this is equivalent to two lines these lines can be lighter to support a load. The best and more efficient means of maintaining the tension between the mainlines and the haulback is through the use of interlock. This tension device allows the deflection of the lines to increase with an increased load, rather than increasing the tension of the lines. As with all skyline systems, running skylines require good deflection. Haul distances of 600 metres are possible although common practice limits distance to about 400 metres.

Carriages

Cariages are available in many different designs but must be compatible with the harvesting situation and the logging system being used. It is possible to have a relatively simple hauler and a complicated carriage. Alternatively a simple carriage and a complicated hauler. Some important factors which determine type and application for a carriage are :

Whether or not the carriage can pass over intermediate skyline supports.

Whether the carriage is held in position on the skyline with a carriage stop, carriage clamp or by the operating lines.

Whether or not the carriage is dependent upon gravity to carry it in one direction along the skyline.

Whether or not the carrige has slack pulling capabilities.

The cable logging system with which the carriage can be used.

Since most carriages have a combination of operating features, the same carriage can often be used in different ways or modified for different applications. It is difficult to classify each carriage into a single category.

LANDING DESIGN OPTIONS

From the system options and the machine options already outlined, it should be obvious that these factors influence to a large degree the landing option. With critical sites the question must be asked, why have landings? Logging planners dealing with critical sites should address this question closely. If landings are to be constructed they should be part of the transport system and designed as such, not as an afterthought. Specifications that apply to roading should also apply to landings. If the locations are known in advance (as a result of good planning) they should be built as part of the road construction. Landing size should be pre-determined for each situation. Not a rigid standard for all landings. A survey and design should be made to determine the quantity of excavation required. The size of landings depends on many factors. Generally the larger the landing the more economical the log handling. However, this may well be in conflict with other forest management criteria. Landings must be located so logs can be handled with safety and efficiency. All weather landings are essential. It is little use having the best hauler or system available if logs cannot be loaded out because of landing conditions. Loader options must be looked into closely to see if hauler and loading work is compatible.

Excavations can be reduced by minimising the activity on the landing. Two stage landings can be used so logs can be processed at the second landing. In parts of Australia, the U.S.A. and Europe, logs are stockpiled parallel to the road by leaving high stumps below the road edge. Loading out is done with a swinging boom hydraulic or rope crane or a self-loading truck.

On steep side slopes between 20 and 30 degrees, split level or two tier landings require approximately half the excavation of a single level landing for the same effective width. On side slopes greater than 30 degrees access to the upper level becomes a problem. The amount of soil excavated for the access road may be more than the amount excavated if a single level landing is used.

Roads with steep gradients are not likely to limit hauler access provided the grades are not in excess of 11 degrees (20%). Most self propelled haulers can travel grades of this degree. Trailer mounted units are mostly pulled by a log truck and can negotiate grades similar to a loaded log truck (sometimes with a bit of help from a friend). A problem with steep grades is the difficulty of establishing landings on them. Large mobile spar haulers and swing haulers need to be level to operate. Swing loaders also need a near level surface to operate efficiently.

Most swing boom yarders are limited to boom height of 15 to 18 metres. A swinging boom will provide more deflection for uphill hauling than is available to a fixed tower of the same height if the fixed tower machine has to sit back on the landing to land logs in front of it. When proposing downhill hauling to narrow landings along a road it is essential to check the effect of the cut bank on deflection and the safety of the machine and the people on the landing.

CONCLUSIONS

Critical site logging is feasible and a range of options are available to the logging planner. It is essential that logging planners or forest engineers know in detail the various limitations of both equipment and systems. Critical areas to be logged must have machines and equipment to fit the site, not the design of the site to fit whatever is available. Logging planners in N.Z. have historically had planning and operational problems caused by limitations of equipment. They have had no choice in the way in which an area could be logged. Large landings have been necessary for example because of the wooden spar and independent haulers, whereas an integral spar machine with its mobility could possibly improve the situation. The economics of scale have also influenced decisions as to the type and size of equipment. The initial cost of machine should not be the sole criteria that should be used to decide if a hauler or not should be purchased and used.

Recent studies in North America looking at the theoretical cost comparison of highlead versus long reach alternatives (over 300 metres) found that although highlead had the cheapest hauling cost, the total cost picture indicated that better overall costs were possible for all the longer reach alternatives except balloon. Hauling costs represent the highest cost component of the systems investigated, and the average hauling cost for the long reach systems were all higher than highlead (this is probably the case in N.Z. at the moment where N.Z.F.P. are using Scab skylines where traditional skylines have been used).

The key to deciding the best environmentally acceptable plan with the best logging economics can only be solved by detailed costing of roads and landing construction and an understanding of production rates of the system based on sound planning by people with a full knowledge of all the requirements. The technology for achieving this is available as will be discussed in a later paper. The urgent need facing the industry is to train the people to use it so the decisions can be based on these results. Planning in critical site areas therefore needs sufficient lead time (three to five years) so that the design options available can be fully evaluated.