LOGGING INDUSTRY RESEARCH ASSOCIATION
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PROJECT REPORT

- LOG LOADERS -

Criteria for Machine Selection and Application

P.R.15 1981

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N.Z. Logging Industry Research Assoc. Inc.

Project Report No. 15
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Criteria for Machine Selection and Application

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- S U M M A R Y -

Selecting a log loader is a common decision that has to be made by logging personnel. The range of options available in both equipment and methods of use for log loaders is extensive, and this does not make the selection procedure easy. With log loading operations being the important link between log extraction and transport, and contributing approximately 10-25% towards the loaded-on-truck cost of logging, good selection and application of log loaders is very pertinent. This study thus set about to identify the factors to consider in machine selection and application for log loading.

To meet the objective, which is aimed at a wide range of operation types, the study analysed patterns of loader application and performance, rather than specifics.

Initially a survey of current N.Z. operations was carried out to establish patterns of application and variations in performance. This provided leads to important criteria for loader selection and application. Specifications and cost characteristics of machines commonly available for loading were then analysed to provide an indication of potential loader performance patterns, irrespective of what was achieved in practice. Finally, loader performance study data from a wide range of N.Z. sources was gathered and used to quantify the factors influencing loader performance. A comparison of these three sections of the study identified the more important factors influencing loader performance and it provided the basis for establishing guidelines for loader selection and application.

It was found that the main criteria to consider in loader selection are the operating condition characteristics of the overall system into which the loader must fit. The factors are identified, many of which are well known by industry. This study establishes a formalised approach to take (not generally used by industry) when selecting a loader. It also compiles data to help quantify the relative importance of the various factors. Three main steps are recommended in loader selection, comprising:

- identifying most suitable type of loader
- establishing size of loader necessary
- selecting brand of loader or specific machine

Where a loader is already on hand the important factors to consider for efficient loader application were also identified, however, the options available to manipulate the system in which loaders fit are not as great. It is thus doubly important to place added emphasis on loader selection. The considerations to make are detailed within this report.

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INTRODUCTION

The range of options available in both equipment and methods for loading logs onto a means of transport is extensive. The choice between options is also a common one that has to be made by logging personnel.

In New Zealand, independent mobile log loading machines such as cranes and front-end loaders are most commonly used to load log trucks or sort logs. This operation contributes approximately 10% to 25% towards the loaded on-truck cost of logging. Good selection and application of log-loaders is thus very pertinent to N.Z's logging efficiency.

Although there is a considerable range of general literature and reports on different loading machines and their performance, detailed guidelines on machine selection and application are not readily available. Two early writings found, that are relevant and worthy of note, are a 1966 paper (Ref.1) by Phillips (U.S.A.) and a 1975 report (Ref.2) by Wellburn (Canada). Both outline the various types of loaders commonly used in logging, and the operating conditions to which each is best suited. Phillips also discusses loader selection, noting that "loggers ought to take a more systematic approach in selecting their loading equipment". He concludes that "factors of each logging area must be considered in order to determine the most desirable loader".

The objective of this study was to identify the key factors that should be considered in the selection and application of log loaders in N.Z. Further, to formulate guidelines for effective machine selection and application.

Ref.1 - Paper titled "Loading Machines" by R.A. Phillips, pages 114-122 in "Proceedings of the First Annual Forest Engineering Symposium 1966"; West Virginia University Technical Bulletin No.82

Ref.2 - Section titled "Loaders" by G.V. Wellburn, pages 14-17 in "Alternative Methods for Logging Steep slopes in the Nelson Forest District of British Columbia"; Canadian Forest Service, Forest Management Institute Information Report FMR-X-76.

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CURRENT N.Z. LOADER APPLICATION PATTERNS

While current loader application patterns should not automatically be accepted as the most efficient, the patterns were considered important in indicating the conditions under which the logging machines have to work, as well as indicating the current range of operational performance achieved. The high and low extremes of performance were considered to provide leads as to important criteria for loader selection and application.

During November/December 1978, LIRA surveyed current operations to obtain an updated indication of the equipment in use, the operating conditions, the performance achieved and the main factors considered by owners in machine selection. This was basically a repeat of, and an extension to an earlier survey done in 1974 by F.R.I. (Ref.1). The quantification of machine types and brands is based on knowledge of 205 loaders out of an estimated 255 in the industry, (i.e. an approximate 80% coverage). All other factors covered in this Section 2 come from the results of a LIRA postal survey which covered detail on 68 loaders owned by 24 different owners, (i.e. an approximate 27% representation). The survey questionaire is outlined in Appendix I.

Ref.1 - "A Survey of the Logging Industry for the year ended 31 March, 1976" by T. Fraser, G. Murphy and C. Terlesk. An N.Z.F.S. Forest Research Institute Report (unpublished).

2.1 LOADING EQUIPMENT IN USE:

In 1978 the most common type of loader was the rubber-tyred front-end loader (61% of total), followed by crane-type loaders* (31% of total), and tracked front-end loaders (8% of total).

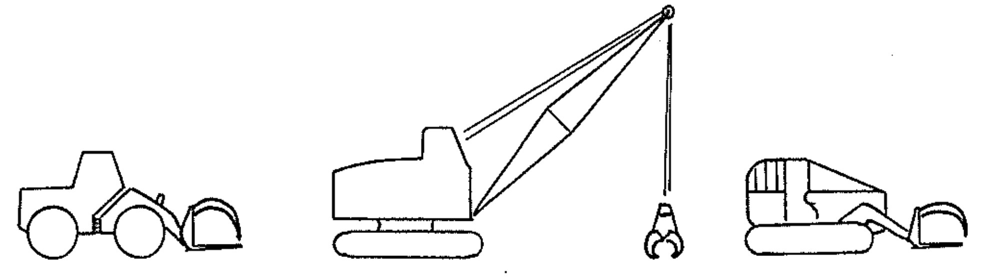


Figure 1 - Most Common Types of Loader Used

The most common brands of loading machine were as follows:

- Fiat Allis 22% of total
- Clark Michigan 19% of total
- International Hough 15% of total
- Bucyrus 15% of total

A comparison of these figures with a similar survey done in 1974 by F.R.I. (Ref.1) indicates a greater proportion of rubber-tyred front-end loaders are in use, however the number of crane-type loaders has remained constant.

A categorisation of the loader sizes by power rating indicates that the bulk of machines are in the 38-112 kW (51-150 h.p.) class as follows:

Power Class	Portion of all Machines
0 - 37 kW	1 %
38 - 75 kW	26 %
76 - 112 kW	59 %
113 - 150 kW	6 %
150 - Over kW	8 %

* This group of crane-type loaders includes a small number of hydraulic knuckle boom cranes. The majority were track mounted rope crane loaders.

Ref.1 - "A Survey of the Logging Industry for the year ended 31 March, 1974" by T. Fraser, G. Murphy, and C. Terlesk. An N.Z.F.S. Forest Research Institute Report (unpublished).

Average power for the different loader categories is as follows :

- Average rubber-tyred front-end loader power - 101 kW (range 55-194 kW)
- Average tracked front-end loader power - 40 kW (range 30-47 kW)
- Average crane-type loader power - 85 kW (range 62-93 kW)

For the loading equipment used in exotic forest operations (93% of all machines), the distribution of machine ages is shown in *figure 2*.

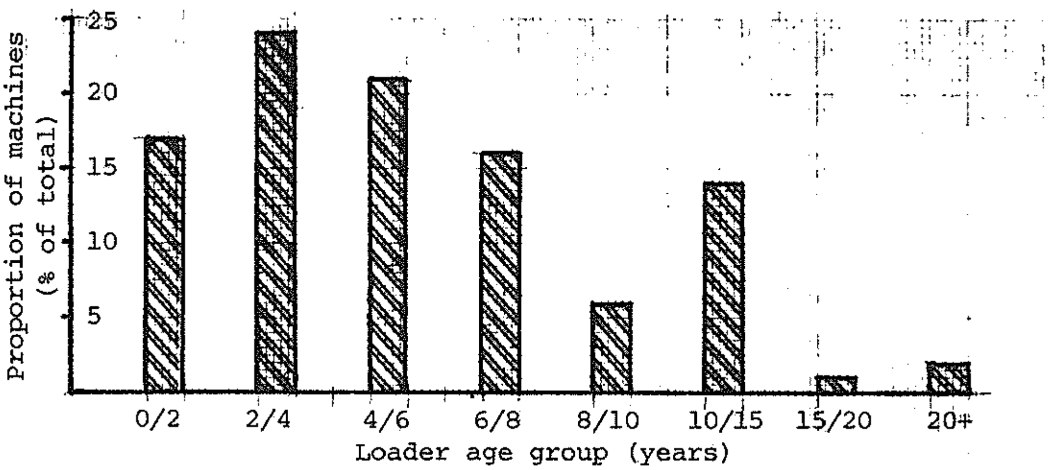


Figure 2 - Age Distribution: Loaders (Exotic Only)

Note the early peak at 3 to 4 years, a low at 9 years, and a second peak at 12 years, which drops quickly away. This is a similar pattern to that obtained in the F.R.I. 1974 survey. The current average age of loaders is 5.7 years for machines in exotic operations.

The most popular "preferred machine replacement ages" expressed were as follows :

64% of rubber-tyred front-end loader operators favour replacement at 3-6 years and 25% favour replacement at 8-10 years.

67% of tracked front-end loader operators favour replacement at 3-6 years.

81% of crane-type loader operators favour replacement at 10 years.

This indicates a strong tendency to replace front-end type loaders twice as fast as crane type loaders.

2.2 OPERATING CONDITIONS FOR MACHINES:

The survey indicated that the majority of all loaders in N.Z. are required to perform all the following functions:

Clear landed logs.
Sort and stack.
Load trucks.
Off-load trailers.

59% performed all four functions.

21% performed only three functions, comprising mainly sort and stack, load trucks, and off-load trailers.

13% performed only two functions, comprising mainly, load trucks, and off-load trailers.

7% performed only one function, comprising mainly, sort and stack (loading performed separately by another machine).

The only machines performing the single function of sorting and stacking were rubber-tyred front-end loaders with an average power rating of 78.7 kW (range 75-85 kW). This is a much lower power rating than the overall average for all rubber-tyred front-end loaders of 100.4 kW, and is indicative of the type and size of machine required for this operation.

The distribution of log sizes being handled by all the machines surveyed, is indicated as follows:

(a) Distribution of log diameters being handled

53% of machines were handling diameters less than 40 cms.

73% of machines were handling diameters in the 40 cm to 80 cm range.

15% of machines were handling diameters greater than 80 cms.

The major application of machines is thus in diameters up to 80 cms.

(b) Distribution of log lengths being handled

18% of machines were handling lengths less than 2.4 m

51% of machines were handling lengths in the 2.5 to 6.0 m range.

85% of machines were handling lengths greater than 6.0 m.

The major application of the machines is thus in handling lengths over 6.0 m.

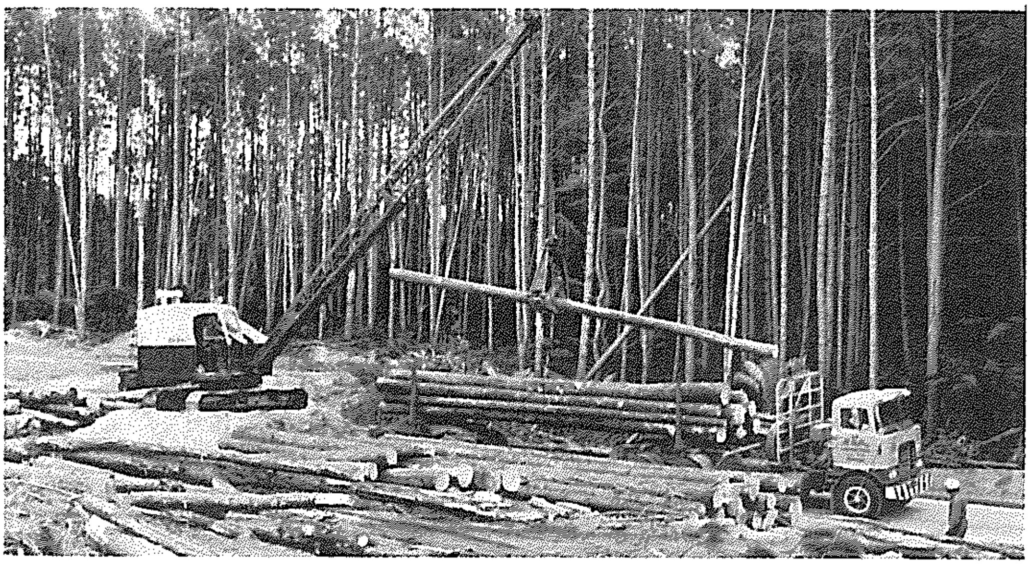


Figure 3 - Most common log sizes are diameters up to 80 cms and lengths over 6.0 m

No obvious patterns stand out indicating prefered machine types and sizes in relation to log sizes being handled. The following however should be noted:

Front-end loaders are most popularly used in the two log sizes as follows:

(a) Diameters up to 40 cms with lengths 2.5 m - 6.0 m and over 6.0 m.

(b) Diameters 40 cm - 80 cm with lengths over 6.0 m.

The average power rating of loaders in each of these log size groups was:

(a) 97 kW (130 h.p.)

(b) 104 kW (140 h.p.)

Crane type loaders are most popularly used in the log size of diameters in the 40 cm - 80 cm range and lengths over 6.0 m.

The classification of landing areas being worked by the different categories of machine is shown in the following table.

Machine Type	Landing Areas		Surface Preparation	
	Restricted	Ample	Nil	Strengthened
Rubber Tyred Front End Loader	59%	41%	39%	61%
Tracked Front End Loader	67%	33%	100%	0%
Crane Type Loader	29%	71%	19%	81%

Most surveyed users of front-end loader machines considered the landings being currently operated were restricted in area. By contrast, the majority of crane users considered they were operating on landings with ample area. This is taken as indicative of crane-type loaders operating more effectively on smaller landing areas than front-end type loaders.

For both rubber-tyred front-end loaders and crane loaders, the majority of operations surveyed were on landings with crushed rock surface preparation. This is probably a requirement for trucking rather than loading. In the North Island, surface preparation for rubber-tyred front-end loaders was evenly balanced between nil and strengthened. However, in the South Island, where generally soil conditions are poorer than in the North Island, 85% of rubber-tyred front-end loader operations were on landings with strengthened surfaces.

2.3 LOADER PERFORMANCE ACHIEVED

An indication of the volumes of logs loaded out per day by different loaders is shown below in *figure 4*.

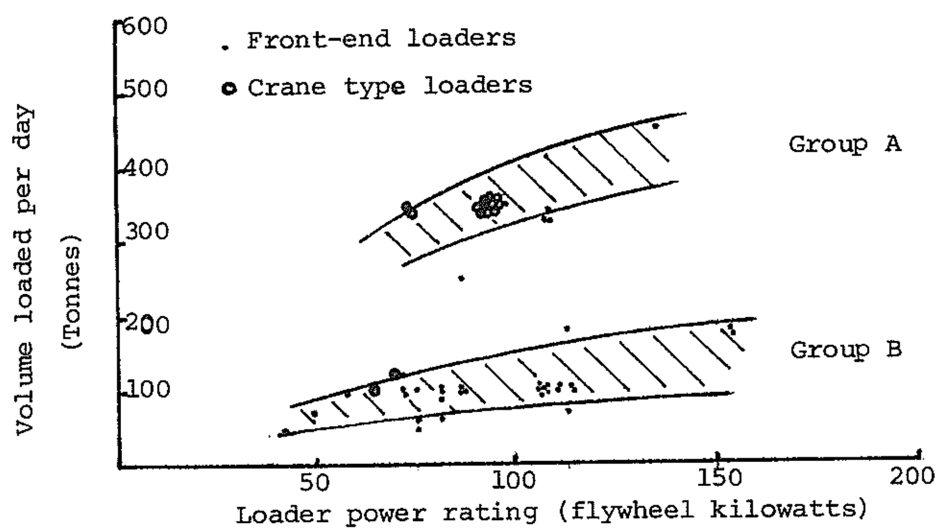


Figure 4. Loading Machine Performance

The patterns are not strong, however it would seem that for all loader types, larger machines where used, do achieve a slightly higher log handling rate. It should be noted however that for loaders in the 38-112 kW range, (where most lie), the difference in performance due to power rating is small.

Two groups of loaders are shown in *figure 4*. Group A are mainly loaders associated with company truck fleet operations, and which achieve a higher daily loading rate by either:

(1) Night-shift loading as well as day-shift stacking and loading.
(2) Loading out from a number of logging operations with no stacking.

Group B comprise loaders that tend to be tied to a single logging gang's production and are used on a single day-shift basis only. In the main they handle the volume of logs shown in the graph twice, as they first stack them and later load them out.

When comparing supplied loader operating cost data with machine power, a wide spread of results was obtained generally indicating that category and size of loader are not major factors in determining the cost of log handling operations. The cost of log handling by loader is probably influenced more by the machine operators care, the type of maintenance performed and the manner in which the machine's productive time is utilised.

The only reasonably strong operating cost patterns that do exist, indicate that the bulk (approximately 80%) of log handling costs - operator costs excluded - are as follows: (1978 N.Z. costs)

For front-end loaders, log handling costs per tonne are between $0.21 and $0.60.

Crane type loaders, log handling costs per tonne are between $0.21 and $0.40.

2.4 REASONS FOR MACHINE CHOICE

It was considered pertinent to reflect on what N.Z. loader owners consider important when choosing a machine. In the LIRA survey, 23 factors for machine choice as identified by a LIRA working group (comprised of selected industry representatives) were noted for loader owners to rate in terms of importance. These 23 factors and survey form are shown in appendix I. For the most common loader categories the results indicated the following:

Main Considerations by Machine Category

(a) For rubber-tyred front-end loaders, the most popular major factors considered in choosing a machine were:

- 'Ability to sort and segregate logs.'
- 'Service and parts availability.'
- 'Maintenance considerations.'

Following this group there was:

- 'Log sizes and types to handle.'
- 'Log handling rate.'
- 'Versatility of machine.'

The most notable factor not considered important was:

- 'Environmental considerations.'

(b) For tracked front-end loaders, the most popular major factors considered in choosing a machine were:

- 'Ability to sort and segregate logs.'
- 'Service and parts availability.'

These were followed in popularity by:

- 'Purchase cost.'
- 'Operating cost expected.'
- 'Versatility of machine.'
- 'Lift height ability.'
- 'Maintenance considerations.'

The most notable factor not considered important was:

- 'Mode of landing operations.'

(c) For crane-type loaders five factors stood out as being of major importance in selecting a machine, these being:

- 'Ability to sort and segregate logs.'
- 'Log handling rate.'
- 'Operating cost expected.'
- 'Log sizes and types to handle.'
- 'Purchase cost.'

These were followed by:

- 'Ground surface conditions.'
- 'Mode of landing operations.'
- 'Service and parts availability.'

The most notable factor not considered important was:

- 'Operator availability.'

In aiming to identify the specific factors that may determine a specific machine category, the surveyed choice factors with the most contrast in popularity were analysed. The results were as follows:

'Mode of Landing Operations'

No importance is placed on this factor in the choice of a tracked front-end loader and its importance increases for rubber-tyred front-end loaders and then again for crane-type loaders where it is reasonably important. This suggests that crane-type loaders are more suited to particular modes of landing operations than the other loaders.

'Availability at Time of Purchase'

Again for tracked front-end loaders, only minor importance is placed on this factor with the factors, importance increasing for rubber-tyred front-end loaders and increasing again to be reasonably important for crane-type loaders.

'Landing Size Restriction'

The importance of this factor is only minor where a front-end loader has been chosen, but increases where a crane-loader is chosen. This suggests that the landing size restriction is a basic reason for choosing crane-type loaders rather than a front-end type loader.

'Ground Surface Conditions'

Relatively low importance is placed on this in the choice of a rubber-tyred front-end loader. However the importance is higher in the choice of a tracked front-end loader and of significant importance where a crane-loader is chosen. This is an expected result.

'Log Handling Rate'

Medium importance is placed on this when choosing a tracked front-end loader. However it is a major factor considered when choosing either rubber-tyred front-end loaders or crane-type loaders.

'Versatility of Machine'

Medium importance is placed on this factor in the choice of a crane-type loader compared to it being a relatively important factor in the choice of rubber-tyred and tracked front-end loaders. This tends to suggest that operators consider the front-end loader machine more versatile than the crane-type loader.

2.5 COMMENTS ON CURRENT LOADER APPLICATION PATTERNS

The sections that look at current loader application patterns in N.Z. indicate the following:

(a) There is a trend away from use of the rope crane type loader to using the more mobile rubber-tyred front-end loader type machine. This is considered a result of changed operating requirements for loaders in N.Z., rather than a reflection of their respective capabilities or economics.

(b) Even though rubber-tyred front-end and crane type loaders are used to handle similar sized logs, and perform similar functions, a higher power rating is used with rubber-tyred front-end loaders than cranes. The reasons for this from the survey are unclear, however, it is considered to reflect the fact that front-end loaders are required to move themselves around also when handling logs.

(c) Owners consider crane-type loaders are worth holding onto for 2 to 3 times the length of time for front-end loaders. This seems to be a reflection of their respective capital costs, and that the major components on cranes don't wear out as quickly as those on front-end loaders.

(d) Where rubber-tyred front-end loaders are used for sorting and stacking only, a smaller sized machine is more commonly used than that used for loading operations. This is to be expected as sorting involves handling 1 or 2 pieces per grab compared to loading which ideally involves handling the maximum number of pieces per grab, if possible.

(e) On smaller landing areas crane loaders operate without restriction compared to front-end loaders which are considered restricted, obviously because of their need to move around in handling logs.

(f) Wood handling ability of front-end loaders and crane-type loaders in the commonly used sizes are considered comparable, although on the cost of handling logs, crane-type loaders would seem to do it at a slightly lower cost.

(g) Application experience indicates that front-end loaders are chosen over cranes mainly because of maintenance considerations (they are simpler to maintain), machine versatility (they are more versatile), and operator availability (they are easier to operate). Conversely, cranes are chosen over front-end loaders mainly because of landing size, ground surface conditions, and the mode of landing operation (cranes are not as restricted by landing characteristics as front-end loaders).

In terms of the main points for selection criteria, this section indicates both the common machine types used in N.Z. (rubber-tyred front-end loaders and cranes), have similar log handling abilities and costs, and that the main criteria for choosing one over the other is based on the operating conditions and situation into which the machine must fit.

- 3 -

EQUIPMENT OPTIONS AVAILABLE FOR LOADING IN N.Z.

Although it would be desirable to directly compare different machine types and sizes under exactly similar operating conditions, over a wide range of actual operations, this is impractical. The alternative was thus to compare machine specifications to indicate their potential capabilities. Then to consider this data along with a small sample of actual field trials, to indicate the important criteria for loader selection and application.

This section thus looks at equipment available and compares their potential characteristics as determined purely by specification.

3.1 LOADING SYSTEMS

Loading can be performed under the following broad categories:

Manual systems
Ramp loading systems
Guyline and spar systems
Mobile front-end loaders
Swing crane-type loaders
Self-loading truck systems.

The first three options are mainly historical in N.Z., although are still used in a small number of cases, particularly where either log sizes are very small, (e.g. post loading operations which handle 100-200 pieces per day at approximately 50 kg per piece), or the number of logs loaded per day is small, (e.g. some indigenous logging operations which handle 10-20 pieces per day at 5,000 kg - 15,000 kg per piece). They are well described along with the other methods above, in the range of good general reference books listed in appendix II and will not be detailed further. This study concentrates on the latter three categories, listed above of mobile front-end loaders, swing crane-type loaders, and truck crane options for self-loading trucks, all of which are basically used where a high rate of handling numbers of logs is required, (i.e. exotic logging operations handling from 100-1,500 pieces per day at 100 kg - 2,000 kg per piece).

3.2 COMMON CATEGORIES OF MACHINES

For mobile front-end and swing-crane type loaders, the following basic options exist in formulating a machine to perform the log loading operation.

Action type
Carrier type
Reach-arm type
Log holding device type.

Examples of each of these are shown in *figure 5*.

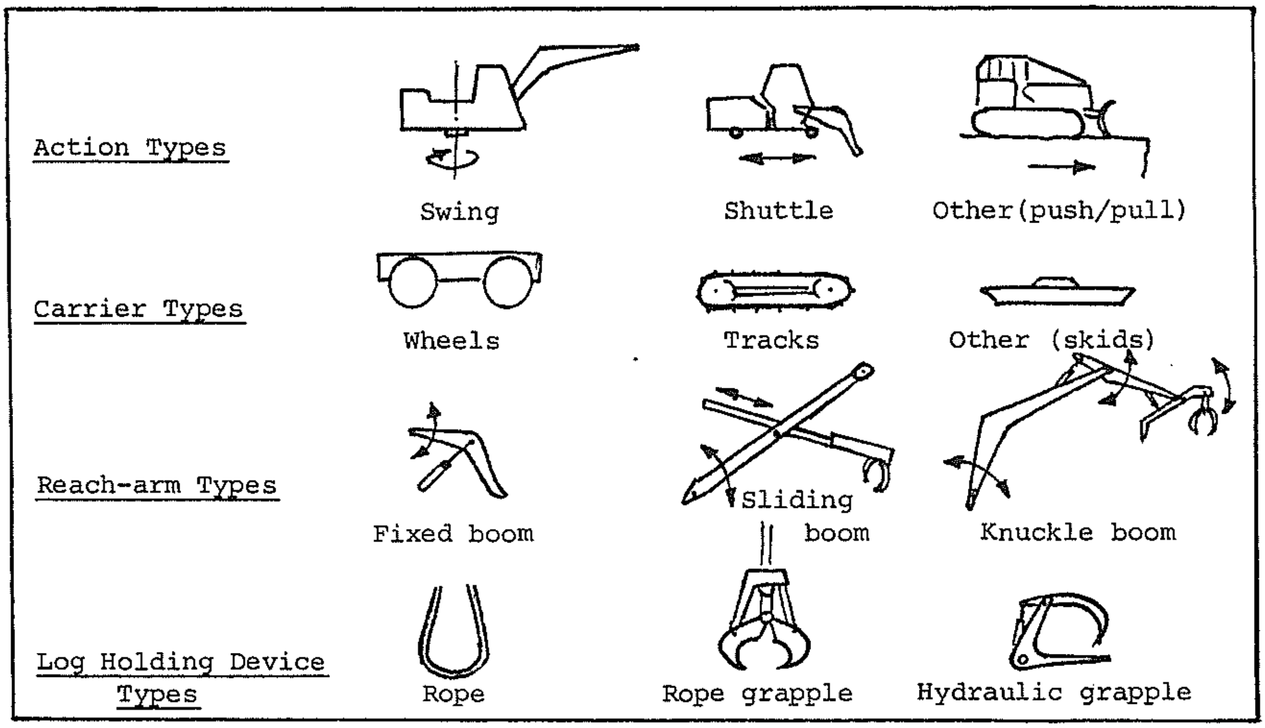


Figure 5 - Basic Options for Machine Layout

Although the above options can produce numerous different layouts, there is in practice only a small number of combinations commonly available and these 5 basic categories are illustrated in *figure 6*. The basic reason for this is that log loaders in general are adaptations of roading and construction machines.

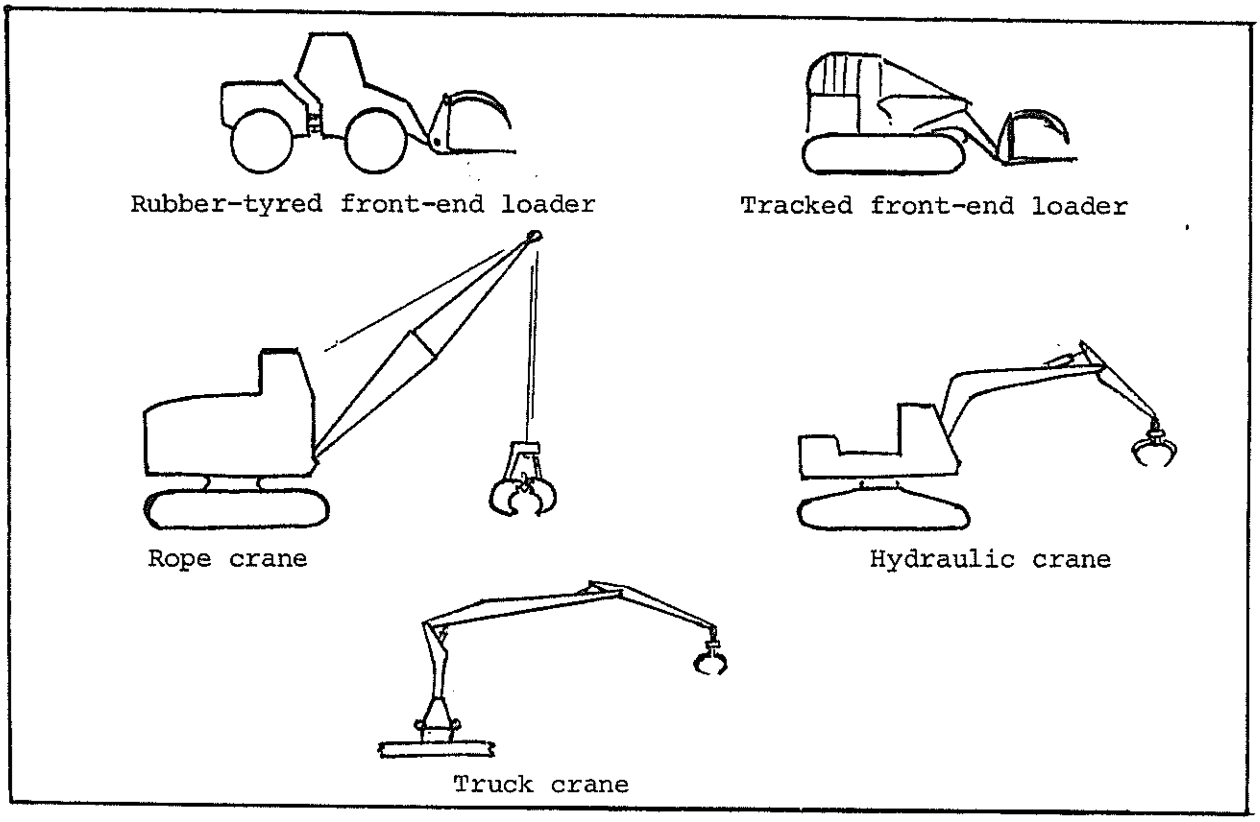


Figure 6 - Common N.Z. Log Loader Categories

Many machine brands are available in each of the categories shown, and some are listed in appendix III.

The range of machine sizes offered in each category by each manufacturer, can be extensive.

Within the different categories, there is also a wide range of grapples and lift-arm types available. Some of these are illustrated in *figure 7*.

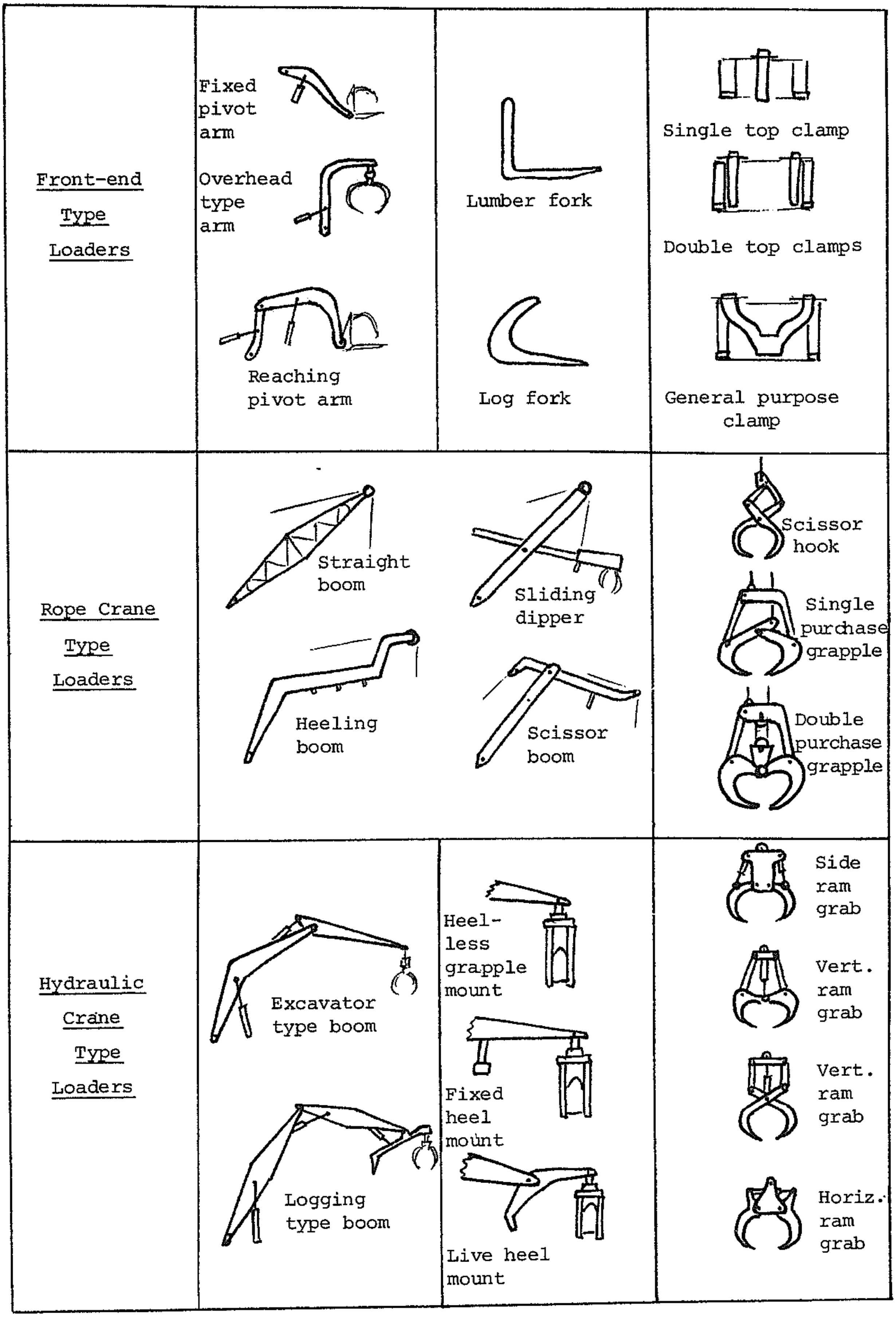


Figure 7 - Alternative Log Handling Devices

3.3 SPECIFICATIONS AND COSTS OF MACHINE CATEGORIES

The specification characteristics of the five common machine categories, determine to a certain extent, the types of operation in which the machines are best suited.

To compare performance characteristics of the machine categories, an extensive collection of equipment specifications (continually collected over the last three years by LIRA's library), have been referred to. These specification brochures were considered to reflect relatively up to date information on the majority of machines available throughout the world, and were used to compare the following specifications between categories of machine:

(a) Maximum load and reach abilities
(b) Load capacities
(c) Travel speeds
(d) Power ratings
(e) Machine costs

(a) Maximum Load and Reach Abilities

For loading work, of primary interest are either the maximum load capacity, or the reach ability, or a combination of both. The range of machines available in terms of load capacities and reach abilities is indicated in *figure 8*. This graph is made up by plotting the maximum load and maximum reach specifications for a wide range of machines. It is not the load/reach characteristic for any particular machine.

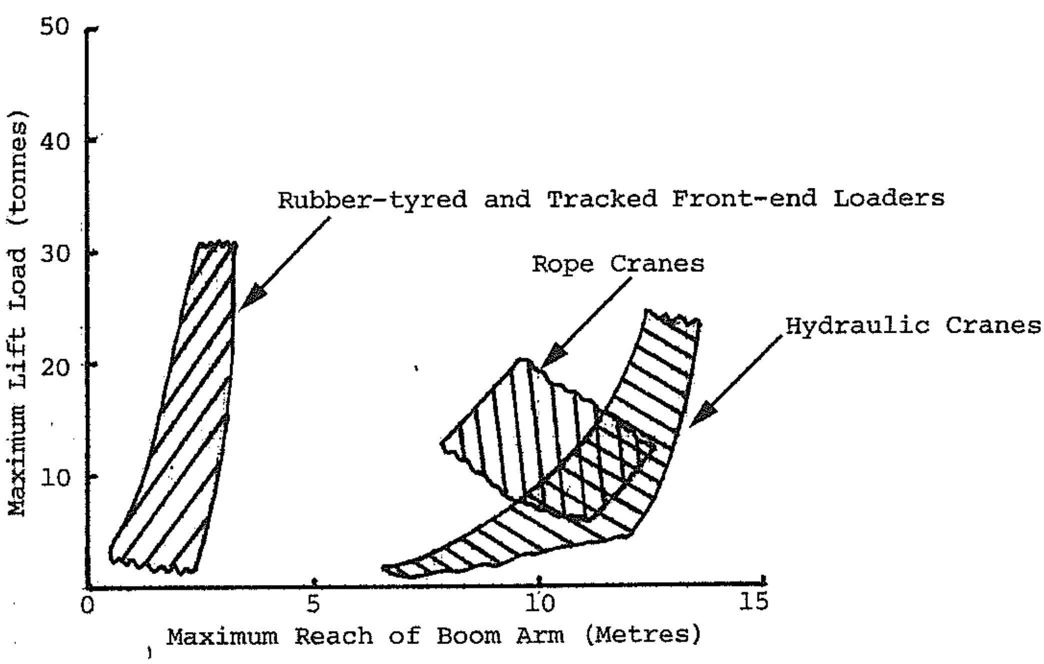


Figure 8 - Graph Indicating Range of Machine Sizes Commonly Available in Terms of Maximum Lift Load and Reach Ability

While many crane type and front-end type machines are available with lift capacities up to approximately 20 tonnes, the crane type machines by virtue of their layout, offer the ability to reach up to 5 or 6 times the distance of front-end loading machines. Rope cranes can extend their reach further by throwing the grapple.

Maximum lift ability or load however varies with the reach, thus a more accurate comparison of lifting abilities should take reach into account.

(b) Load Capacities

Load capacities (generally determined by tipping, but also by structural strength), are best compared in terms of the tipping moment, (i.e. maximum load times reach for this load). The tipping moment rating of a machine is determined to a large extent by the machine weight, as all machines use similar base spreads about which tipping occurs. The load capacity patterns for loaders available in the different categories is shown in *figure 9*.

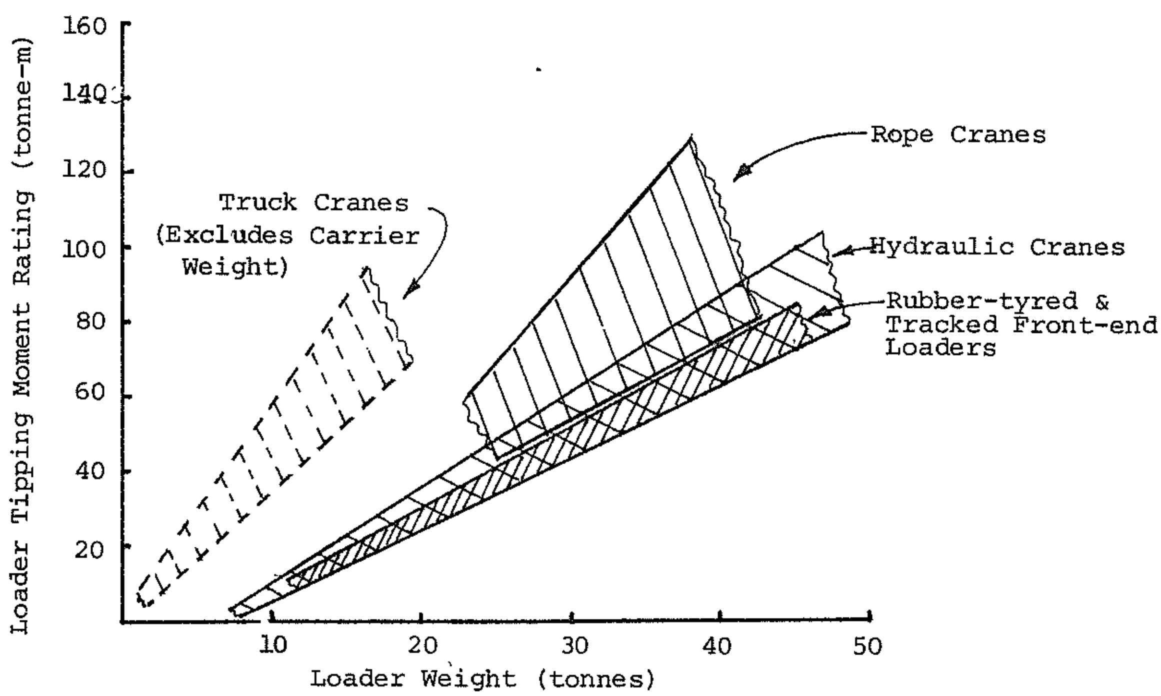


Figure 9 - Comparison of Tipping Moment Ratings

The patterns in *figure 9* indicate the following:

1. Rope crane loaders have the best tipping moment performance characteristic for equivalent machine weight. These loaders however are available in a smaller range of sizes than alternatives.

2. Hydraulic crane loaders and front-end loaders (both rubber-tyred and tracked), have similar tipping moment performance characteristics through the range of machine sizes.

3. Truck mounted cranes have a similar tipping moment performance characteristic to hydraulic crane loaders if you take into account the likely weight of a truck or carrier unit.

(c) Travel Speeds

In looking at travel speeds, the survey of specifications indicates that generally in a particular machine category, no noticeable difference occurs in the maximum travel speed with increasing loader size. Between categories however, there are differences as follows:

Rope operated cranes on tracks	up to 2 kph
Hydraulic operated cranes on tracks	up to 4 kph
Rope operated cranes on wheels	up to 40 kph
Hydraulic operated cranes on wheels	up to 40 kph
Front-end loaders on tracks ..	up to 12 kph
Front-end loaders on wheels ..	up to 45 kph
Truck cranes on truck unit ...	up to 80 kph

(d) Power Rating

The power rating of a loader reflects to a degree the initial cost and likely machine operating cost. It is also associated with loading performance. *Figure 10* shows, for available equipment, how power rating varies with machine size in the different categories. It indicates that front-end loaders, have a higher power requirement than crane type loaders. This is undoubtedly due to the fact that they travel with the load compared to cranes which in general don't.

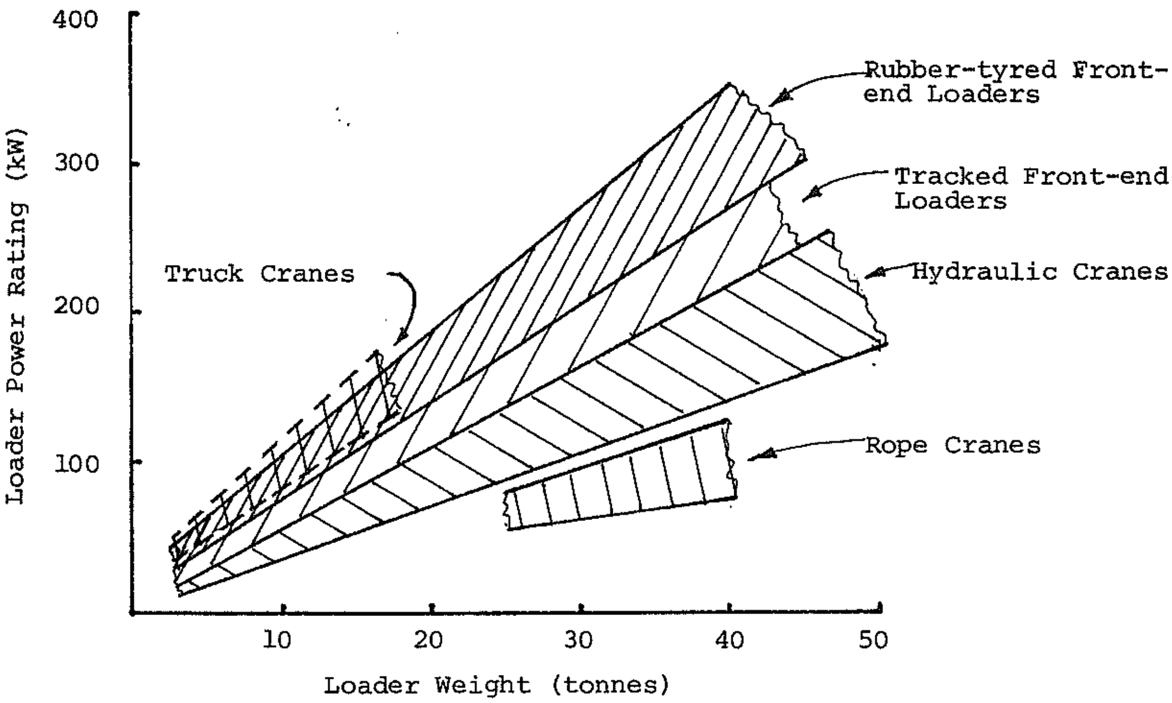


Figure 10 - Comparison of Power Requirements

Figure 10 also indicates that rope cranes have a lower power for size requirement, than hydraulic cranes. Also, tracked front-end loaders have a lower power for size requirement than rubber-tyred front-end loaders. If the likely carrier weight for truck cranes was added, their power for size requirement would resemble that for other crane categories.

(e) Machine Costs (from a survey of loader costs - Jan. 1979)

The costs of loading machines in the different categories is shown in *figure 11* and this indicates that all machine categories have a similar capital cost per unit weight. If anything, rope cranes are slightly cheaper than the rest, on a weight basis.

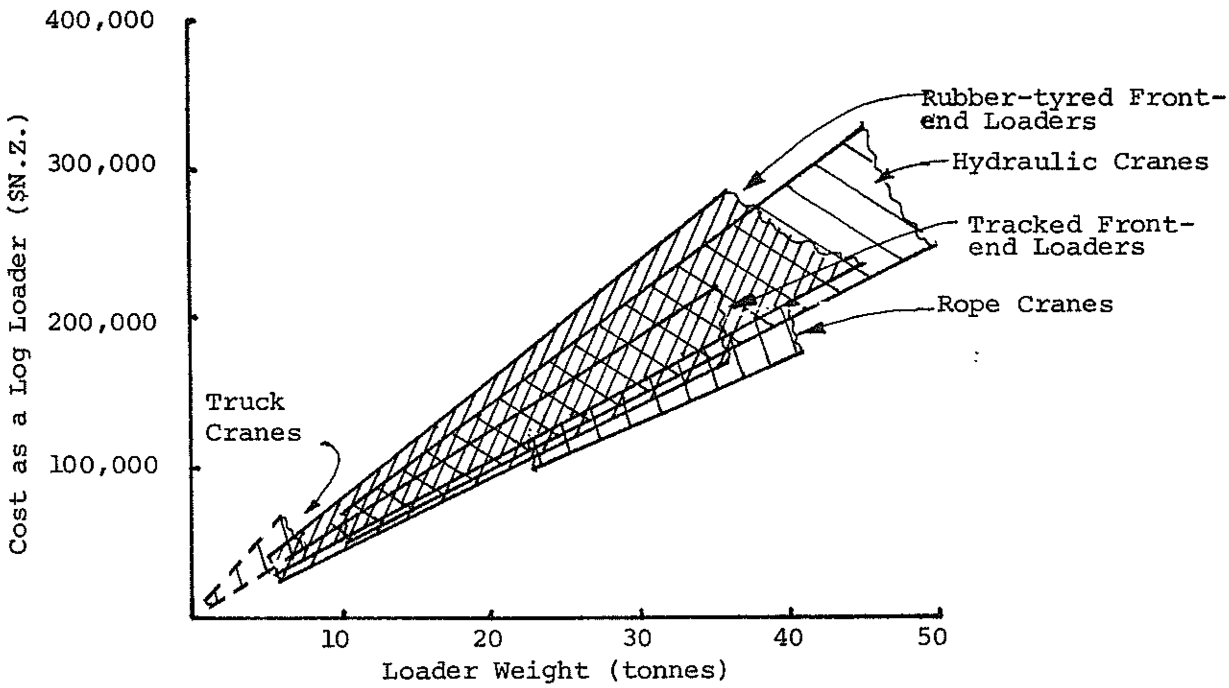


Figure 11 - Comparison of Log Loader Capital Costs (1979)

3.4 SUMMARY OF LOADING EQUIPMENT OPTIONS

Although there is potentially a large range of machine layout options that are feasible, in actuality only a small range of categories is commonly available in N.Z. They include:

Front-end loaders (rubber-tyred or tracked).
Rope-cranes (rubber-tyred or tracked, but commonly tracked).
Hydraulic cranes (rubber-tyred or tracked, but commonly tracked).
Truck cranes for self loading trucks.

Other possible layouts that are not readily available and which possibly have some desirable characteristics include the following:

Over-head front-end type loader
Swinging front-end type loader
Telescopic boom type cranes.

Little detail is known of such machines in log loading applications. Any opportunities to either develop or evaluate such machines should be taken as they arise.

In comparing the specification and cost characteristics of the readily available loader-types on a machine weight basis, rope cranes are slightly lower in cost than the rest. They also have a greater tipping moment rating, and a lower power requirement. This must make them very competitive to the appropriate operating conditions, compared to alternatives. It should be noted however, that they tend to be available only in a limited size range. They are not for instance readily available in small sizes suitable for loading out small log sizes as in thinnings operations. Between the other readily available machine categories (rubber-tyred front-end loaders, tracked front-end loaders, hydraulic cranes, and truck cranes), the differences in lifting capacity, power rating, and machine cost are not marked.

Best choice of machine thus tends to fall back on a consideration of operational characteristics.

- 4 -

PERFORMANCE OF VARIOUS LOADER TYPES

Ideally the primary function of any loading machine is:

to transfer logs onto truck.

In practice, however, there are other secondary functions that must also necessarily be carried out, depending on the operation in question. These are:

Clearing landed logs from extraction machine.
Sorting and stacking logs.
Off-loading log trailers.
Assisting other interfacing operations,
(skiddies, extraction machine, log trucks).
Keeping landing areas suitably clean.

All the above can be considered productive functions, and the proportion of time spent on any of these will vary considerably, depending on the logging operation in question. All can be necessary functions so the important factor is to ensure for any loading machine that its time is fully occupied on a combination of necessary productive functions.

Non-productive time normally cropping up in any loading machine applications can be due to:

Idle, waiting for work.
Re-fueling, servicing.
Repair and maintenance.
Operator rest.

In this section the report aims to identify for the various loader types their performance ability at the different productive functions. Analysis of the non-productive elements, which are essentially determined by the management and operators involved, is outside the scope of the study.

4.1 CLEARING LANDED LOGS - SORTING AND STACKING

In general, these two functions go hand in hand. Logs are removed from the landing and/or processing area, where they would otherwise interfere with the extraction and/or processing operation, and are then stacked into heaps of various log types. No matter what loader type is used, its clearing, sorting and stacking performance is affected by several variables which alter in importance according to the type of logging system utilised. (Ref. 1). These variables are:

1. The cycle time of the extraction unit. This sets the limit for the period of unrestricted access the loader has to the haul deposited in the landing/processing area.

2. The volume of wood arriving at the landing with each haul. This determines the amount of wood the loader must move within the period limited by the cycle time of the extraction machine.

3. The number of different log types into which the haul is cut, and the number of pieces in each (this factor is important if one or two particular sorts dominate the cutting pattern).

These three factors interact to determine the amount of time available for the loader to sort and stack each haul arriving on the landing and to some extent the pattern of cycles which must be undertaken to achieve this objective.

Figure 12 - Stacking Sorted Logs with a Rubber-Tyred Front-End Loader

Ref.1 - "Rubber-tyred front-end loader application - A Pilot Study" by A. Twaddle - Forest Research Institute. LIRA Report Vol. 4 No. 2, 1979

A comparison of the variables observed in two different Radiata old crop clear-felling operations (Ref.1) is outlined below.

	Hauler Operation	Tractor Operation
Average extraction-cycle time (estimated)	8 mins	17 mins
Average haul-volume (estimated)	5 m^3	13 m^3
No. different log types cut	10	5
Percentage of pieces cut in the predominating log types	27%	53%

The sorting and stacking phases of the two operations are quite different. The loader in the hauler operation had a smaller average haul volume to handle but less time to remove the logs from the processing area, a larger number of types to handle, and a greater spread of pieces within the different log types. This results in a different pattern of work for the operator, who has to carry out a greater variety of cycles to complete his sorting and stacking. In this detailed study of two separate logging operations (one a hauler operation with rubber-tyred front-end loader and the other a tractor operation with rubber-tyred front-end loader) ten different cycle types were identified in the sorting and stacking phase for the two front-end loaders observed. The proportions of the various cycles utilised by both loaders differed markedly. Further, the sorting and stacking pattern of the haulers loader was more complex.

The patterns of work will also be different depending on whether a front-end loader type machine (tracked or rubber-tyred), or swing-crane type machine (rope or hydraulic) is used.

Ref.1 - "Rubber-tyred front-end loader application - A Pilot Study" by A. Twaddle - Forest Research Institute. LIRA Report Vol. 4 No. 2, 1979

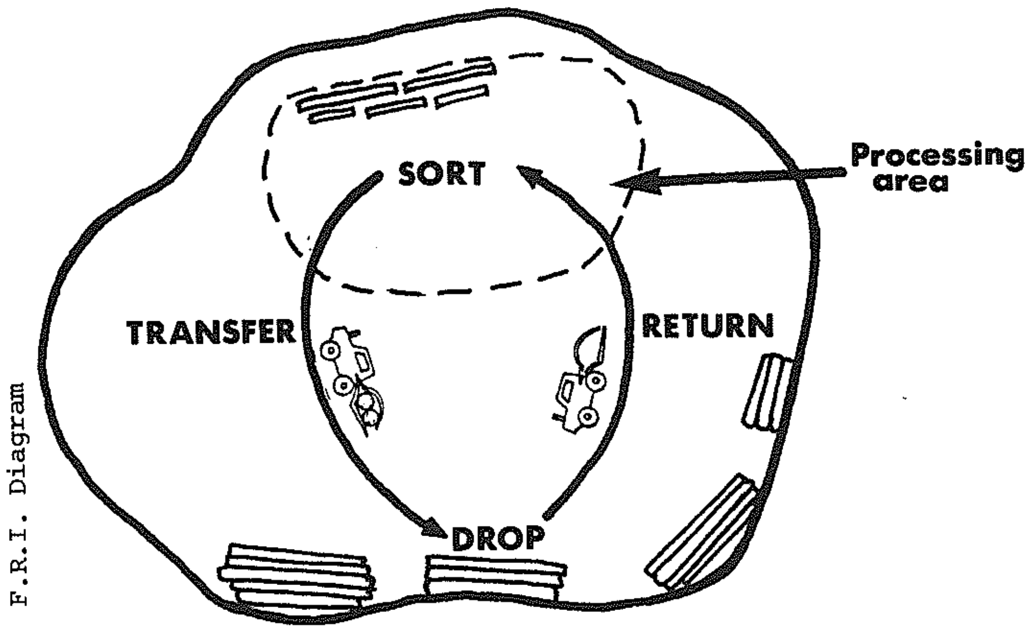


Figure 13 - Single Transfer Sorting Cycle with Rubber-Tyred Front-End Loader. The Most Common Pattern of Sorting. (Ref.1)

The preceeding section indicates that a large number of options are available on patterns of work in sorting and stacking, and that factors that influence the effectiveness of a work pattern include:

Loader type and size.
Extraction machine type and production characteristics.
Truck loading frequency and priority.
Number of log sorts and proportion of pieces in each.
Landing area available and shape.

The effectiveness of a work pattern will of course be based on:

Overall system performance rate and logging cost.
Safety to workers and equipment.

4.2 TRUCK LOADING

Just as the sorting and stacking phase is affected by the extraction unit so too is the loading phase (Ref.2). When loading a truck the loader can collect its logs from two main sources, either the heaps piled about the landing or the cut logs in the processing area but not yet moved.

Ref.1 - "A Pilot Study of Loading Operations" by A. Twaddle, F.R.I. Economics of Silviculture Report No.129 (unpublished)

Ref.2 - "Rubber-tyred front-end loader application - A Pilot Study" by A. Twaddle - Forest Research Institute. LIRA Report Vol. 4 No. 2, 1979

If long cycle times and large haul volumes are characteristic of the extraction operation (such as is often the case with a crawler tractor operation), then a loader in this system often has time to transfer logs directly from the processing area to a log truck, thus reducing the amount of double handling. This however requires a log truck or staked-out trailer to be available for loading and in some highly organised truck scheduling operations a continuous supply of trucks or trailers for loading can be achieved. The important factor if using this however is to ensure no truck queuing or waiting arises (such as due to another truck still being loaded or no logs being available to load out), as the cost of trucks waiting can be high.

Cable logging operations are generally not as suited as ground skidding operations to direct truck loading. Apart from the already noted factor of cycle time and haul volume of the extraction unit, added pressure is placed on the loader in a hauler system because the hauler cannot land extracted logs in any position other than directly under its ropes. Its loader therefore has to remove the logs from the processing area frequently or interference can occur to the hauler and more importantly the skid workers could be placed in danger. When the loader is loading trucks it often has to return to the processing area to clear wood away. This therefore increases loading time. Because a tractor unit can place its haul in any position on the skid site its loader can defer sorting while it is loading trucks without endangering the skid workers or interfering with the extraction phase.

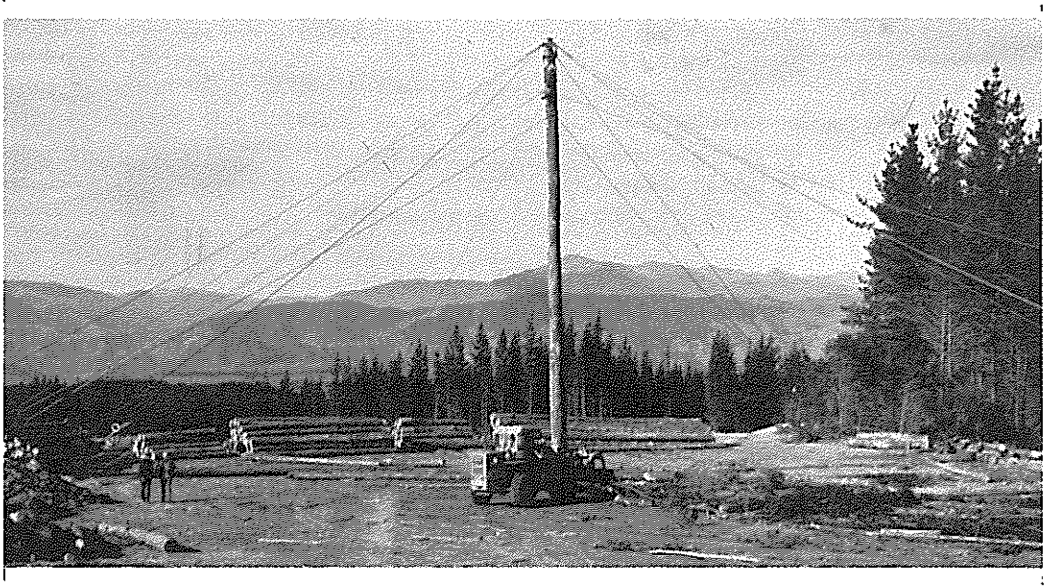


Figure 14 - Cable Logging Operations can Only Land Logs in One Position. This can Affect Loading Out Performance

The F.R.I. study (page 26) showed that a rubber-tyred front-end loader could direct-load in 55% of its loading cycles at a tractor operation, compared to only 18% of its loading cycles at a hauler operation.

In the job of handling logs onto trucks the following factors influence the rate at which any loader performs:

(a) The operator (his experience, technique used and motivation).
(b) The machine (machine size, and type or category).
(c) Operating conditions (material being handled and ground conditions working on).

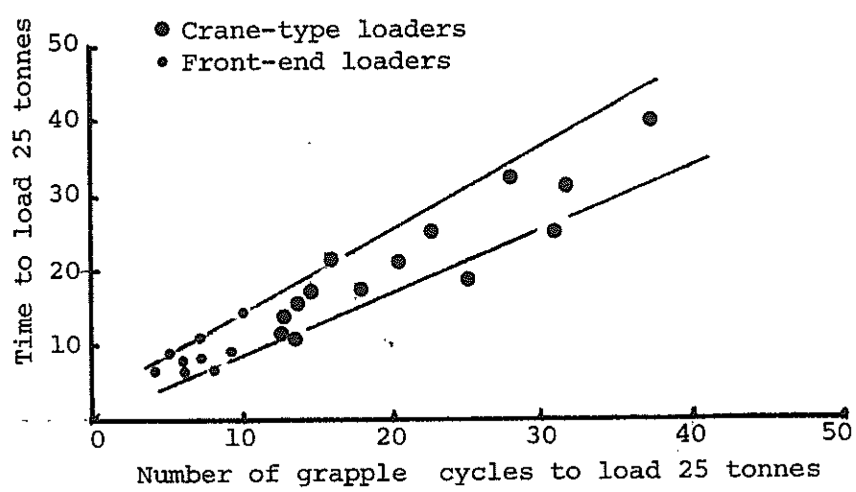
(a) <u>Influence of Operator Characteristics</u>

Loader log handling rates are influenced by the operators experience, the operators technique, and by operator motivation.

Although it is not within the scope of this project to quantify the influence of operator experience on loader log handling rates, it is pertinent to note that it takes approximately twice as long to train an operator to a competent level for a crane loader (particularly rope cranes), than for a front-end loader (Ref.1).

The technique used by the operator can also have a marked influence and important factors to note, no matter what type loader is in use, are:

(1) The importance of ensuring the grapple is filled completely so that a minimum number of grapple loads is used on each truck load.



<u>Figure 15 - Influence of Grapple Loads on Truck Loading Time</u>

Ref.1 - "Logging's Labour Force - A Pilot Study" LIRA Report Vol. 4 No. 6, 1979

(2) The importance of having good loader positioning relative to the truck and stockpile so that loader moving (either travel or swing) is minimised.

In the study of a hydraulic crane loader (Ref.1), any regular loader repositioning required during truck loading was found to increase loading time substantially, as was any increase in angle of crane slew. (See below)

Slew Angle during Loading Action	Ave.Time per Grapple Load No Loader Repositioning	Ave.Time per Grapple Load when having to Reposition
120°	0.68 minutes	1.01 minutes
290°	0.90 minutes	1.29 minutes

Where crane travel is necessary then hydraulic drive track machines are best, as mechanical chain-drive tracks are not easily controlled, and cranes on rubber-tyred carriers normally require stabilisers to be lifted to move. Swing time (both loaded and empty) depends on the angle of slew involved. In the study of a rope-crane loader (Ref.2) swing time formed from 50% to 80% of total loading time per grab cycle.

Similarly for front-end loaders the cycle time per grab is affected by the loader's travel speed and the distance the loader must travel while loading. For rubber-tyred front-end loaders, travel time (both loaded and empty), was found to form from 30% to 50% of total loading time. For tracked front-end loaders, which have a slower travel speed, travel time is even more significant.

Various means exist for motivating operators of equipment. They are not dealt with here, in the context of this study.

(b) <u>Influence of Machine Characteristics</u>

The log handling performance capabilities of different loading machines is influenced by size (or capacity) of machine, and by type of machine.

Ref.1 - "Cat 235 Hydraulic log loader" LIRA Machinery Evaluation Vol. 3 No. 4, 1978

Ref.2 - "Hitachi KH100 Log Loading Crane" LIRA Machinery Evaluation Vol. 4 No. 2, 1978

Large capacity loaders (whether crane or front-end type) can obviously move more volume per cycle than small capacity loaders, provided of course that their grapples are loaded to capacity.

Different machine types have different potential cycle times. This is due to their slew or travel speeds, and also their grapple characteristics. Grapple characteristics affect the time to select and grasp logs, or to hold logs during movements, or to place logs on truck. One cannot compare a crane slew time with a front-end loader travel time unless the landing layout detail is taken into account. Between tracked front-end loaders and rubber-tyred front-end loaders, however rubber-tyred machines have a faster travel speed as indicated in Section 3.3. Both hydraulic and rope cranes have similar slew speeds.

Any grapple configuration that cannot be positively and directly controlled (such as a rope operated crane grapple or a hydraulic crane grapple without controlled pivoting), slows down the loader cycle time due to slower selection and grasping of logs. This is most apparent on rope-crane loaders, and for such machines is significantly influenced by log form (Ref.1), as indicated in *figure 16* below.

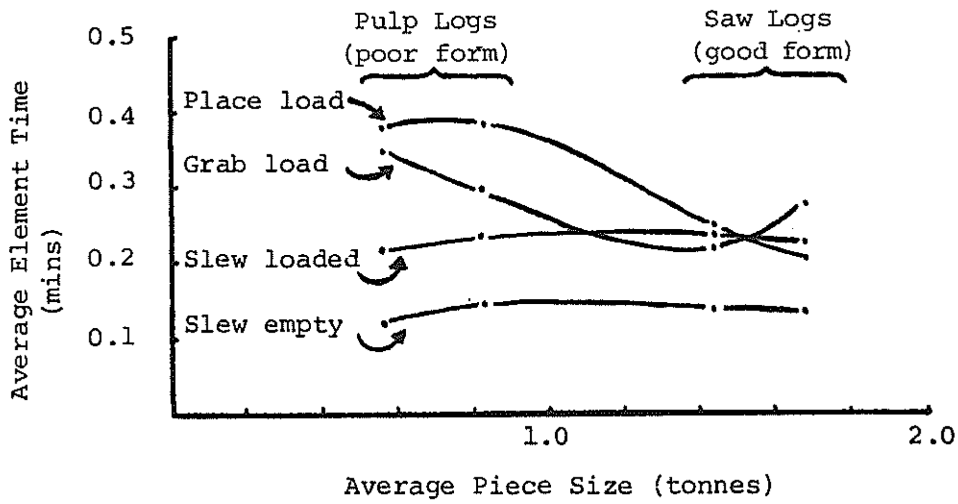


Figure 16 - Affect of Log Form on Grapple Handling Time for a Rope-Crane Loader

Similarly, the nature of the grapple jaws, or forks and tusks, influence the ability to hold the log or bundle of logs during handling so that no interference occurs while moving the logs. The appropriate grapple for an application depends on the log types and the numbers of logs being handled at any one time.

Ref.1 - "Hitachi KH100 Log Loading Crane" LIRA Machinery Evaluation Vol. 4 No. 2, 1978

Figure 17 - Grapple Design Should Be Matched to Log Types For Good Log Control

Generally, hydraulic crane type loaders are more effective where log placement on a truck load becomes important. This is due, in the main, to their better reach capabilities and positive log control.

(c) Influence of operating conditions

Operating conditions can have the greatest effect on log handling rate in loading, particularly the material being handled and the ground conditions, if they don't suit the loading machine type. A discussion of how these factors influence machine performance follows. The information comes from a wide range of general reports as detailed N.Z. studies of this subject are few.

(1) The material being handled:

Log diameters in N.Z. range from 10 cm to 80 cm. Within any specific operation however they are relatively uniform. Common grapples on front-end loaders and hydraulic cranes are suited to handling these log diameters in multiples, however on rope cranes some difficulty is experienced in grabbing multiples of small diameter logs. For operations though where the handling of single pieces occurs frequently, the rope crane grapple has few problems but some of the front-end loader grapples do have problems due to not closing far enough.

When considering log lengths front-end loaders in general have difficulty handling lengths over approximately 15 metres while it is this area that crane loaders have few problems.

The handling of large and heavy logs can impose significant dynamic stresses on loaders, particularly crane-type loaders. The N.Z. experience with crane operated grapples indicates that ropes tend to have a better capacity to absorb and to prevent shock loads from being transferred to the base machine than do hydraulic operated crane grapples. (Ref.1).

Figure 18 - Rope-Crane Type Loaders Easily Handle Large Sized Logs

(2) The ground conditions worked on:

Crane-type loaders can, with an appropriate landing layout readily load out from a limited number (approximately 4 or 5) of different stockpiles in a comparatively small area. It is important though to minimise crane travel required (as earlier noted) during operation as this reduces log handling rates. Ground surface conditions are not important if a minimum of crane travel is attained.

While front-end type loaders can effectively work a large number of stockpiles they require comparatively large landing areas as well as good surface conditions for effective performance. Due to their need to move around, both tracked and rubber-tyred front-end loaders tend to progressively churn up the operating

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Ref.1 - "Hydraulic Knuckle Boom Cranes for Log Handling" by I.S.MacDonald University of Canterbury Department of Mechanical Engineering Project Report No. 39, 1979.

surface if climatic and surface characteristics allow it.

Figure 19 - Tracked Front-End Loaders Can Operate in Poor Ground Conditions

From a large number of N.Z. loader performance time studies it was impossible to directly compare loading performance between the different machine types, due to the wide range of influences that the factors discussed in this section exert. Under typically experienced operating conditions all loader types in the sizes commonly used in the bush show up as having comparable log handling rates ranging from 0.5 to 1.5 mins/tonne.

Where frequent loader shifting between landing sites occurs then the mobility of a rubber-tyred loader is desirable whether the loader is a front-end loader or crane-type machine. Generally the rubber-tyred front-end loader is lighter and has lower axle loads than a crane on wheels, and this can be important where the machine must travel over a public highway. Their maximum travel speeds as shown in Section 3.3 are similar. If shifting is infrequent and over long distances where a transporter vehicle is used, then the heavier crane-type loaders tend to cause most difficulties, particularly the track mounted rope cranes.

4.3 OFF-LOADING LOG TRAILERS

Most log trucks in N.Z. carry their empty trailers and require the log loader to off-load the trailers. While both front-end and crane-type loaders can perform this function in a minimum of time (usually 2 to 3 minutes) it is often the heaviest load they are required to lift. Two-axle trailers weigh from 3 to 4 tonnes and three-axle trailers from 4 to 5 tonnes.

Crane-type loaders commonly in use, except truck mounted knuckle boom cranes, generally don't have any problems provided they have appropriate capacity.

Figure 20 - Off-Loading the Log Trailer - Often the Heaviest Load to Lift

It is noted from Section 2.2 that where rubber-tyred front-end loaders are used purely for sorting and stacking, machines in the 75-85 kW range are most common, compared to machines averaging 100 kW where all functions (including off-loading trailers) are performed. LIRA discussions with operators, and observations, indicate that for rubber-tyred front-end loaders, machines in the 75 kW class (e.g. Fiat Allis 605, Cat 930, Clark 55) can off load two-axle trailers but not three-axle trailers. These require a rubber-tyred front-end loader in the 100 kW class (e.g. Fiat Allis 645, Cat 950, Clark 75) although even this size loader can have some problems with heavier three-axle short-log trailers (Ref.1). With front-end loaders, when difficulties are experienced in off-loading trailers it is because of both lifting capacity and lifting height. Lift height is a problem mainly because of New Zealand's use of high and relatively heavy construction log-truck staunchion arms. Dropping these to off-load trailers is thus time consuming and manually difficult. Two commonly used techniques used with front-end loaders are either to lift with the loader forks under the turned bolster or to use a slipper-hook over a single fork or both forks as follows.

Ref.1 - "Log Truck Axle-Layouts" by R.D.Gordon, LIRA Project Report PR10, 1980.

The technique using the forks under the bolster is to do a straight vertical lift (forks near horizontal) as far as possible then to tilt the grapple back which tilts the trailer. This results in the inner trailer wheels moving to a position between the truck staunchion arms and the outer trailer wheels being raised to clear the far side staunchion arms as shown below.

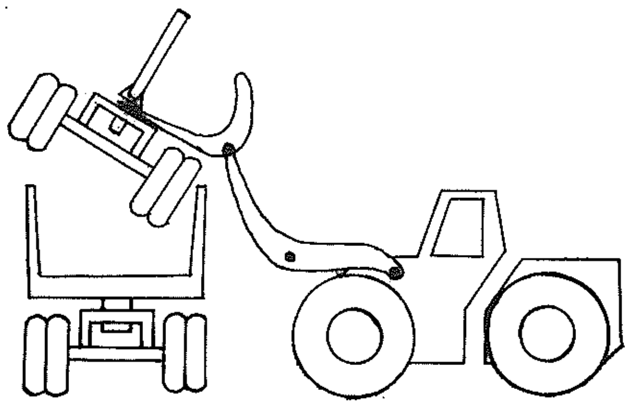

Figure 21 - Lifting a Trailer with Forks Under the Trailer Bolster

Care must be taken not to tilt the forks too far as if the trailer slips on the forks you end up in a tangle.

The technique using a slipper-hook over forks is to lift the trailer with its lifting strop, the strop being positioned so that the trailer rear is heavier. This results in the trailer front-axle being higher when lifted, thus allowing the truck to drive out without problems, as in *figure 22*.

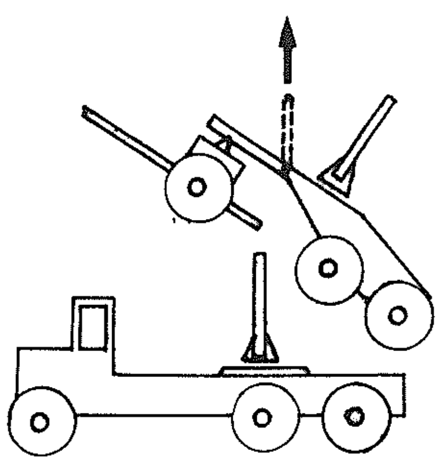

Figure 22 - Lifting a Trailer with its Lifting Strop

Although this is considered a little hard on a single loader-fork if used, it is easier than using a hook mounted on a lifting bar which is fitted over both forks. The problem with a double-fork lifting-bar is that the loader forks can become entangled or obstructed by the truck and trailer staunchion arms.

An important consideration in loader procurement and application is thus the job of off-loading log trailers, where it is required.

4.4 ASSISTING OTHER INTERFACING OPERATIONS

The interfacing operations most commonly requiring loader assistance are the skid worker, extraction machine and log-truck operations.

Skid workers occasionally require a log moved to assist their processing work. For example, to obtain access to logs for crosscutting if in a pile, or to gain access to branches for trimming, or to free a jammed chainsaw. All loader-types are equally capable of meeting this requirement.

Tractor and skidder extraction machinery do not normally require assistance from loaders unless it is to do with lifting needs during extraction machine repair and maintenance. Haulers on the other hand apart from occasionally requiring loader assistance on maintenance, can also require loader assistance during setting up rigging at a new landing, and to hold extracted logs or rigging while unstropping drags. For hauler assistance crane-type loaders tend to be slightly more useful then front-end type loaders, due to their better reach.

Log trucks occasionally call on loaders to get them moving if stuck or without traction. For this assistance front-end loaders are better than crane-loaders, with the tracked front-end loader capable of providing the best pushing power. On the other hand, rubber-tyred front-end loaders are faster if there is any distance involved in travelling to provide the log truck assistance.

4.5 KEEPING LANDING AREAS SUITABLY CLEAN

For typical operations this loader function generally only absorbs a small portion of loader time, from 1 - 2% for cranes and up to 5% for rubber-tyred front-end loaders.

Cleaning landings is not so easily done with cranes, particularly hydraulic knuckle boom cranes as they have difficulty throwing debris. Rope cranes with an effective operator can however throw debris. Cranes themselves don't particularly need a clean landing or even surface on which to operate effectively, so the cleaning is usually carried out for some other reason, such as to suit log truck movement. With front-end loaders cleaning landings of debris and providing a flat surface on which to operate can easily and effectively be done using a make-shift blade held in the log forks *(see figure 23)*.

Figure 23 - Cleaning the Landing with a Make-Shift Blade

Although log extraction operations using crawler-tractors or skidders could use the extraction machine to clear landings, this is not recommended as generally the operation's daily production is limited by the extraction machine and not the loader. It is thus more appropriate to use the loading machine which normally tends to have more time available.

4.6 SUMMARY OF FACTORS AFFECTING LOADER PERFORMANCE

Loaders can be used for a number of functions and different loader types are suited to these functions in different ways. For machine procurement then, it is thus important to consider the key functions and proportions of time the loader will be involved in these.

Performance in the function of clearing landed logs and sorting and stacking is to a large degree influenced by the chosen pattern of work involved. This in turn not only depends on the machine type but also characteristics of the overall operation, such as extraction operation characteristics, trucking operation characteristics, log segregation requirements and landing area characteristics.

The main differences here, that should be considered in machine selection are that rubber-tyred front-end loaders are more suited to operations with a large number of log sorts (greater than 4 or 5), and cranes are more suited to landings of restricted area.

In the truck loading function, performance is influenced by the operator, the machine, and the operating conditions, the major influence being the operating conditions. Operator technique, particularly with respect to maximising loads per grapple grab, and minimising loader travel or swing is important. It is also pertinent in some localities to consider the fact that it is much easier to train front-end loader operators than crane operators. Machine factors only significantly influence loader performance as a result of operating conditions unfavourable to the specific machine type. In particular, characteristics of the logs being handled and the landing on which the operation performs. Small diameter logs are best handled with front-end loaders, while long and large diameter logs are best handled with cranes. Where loading from a restricted landing area is involved, then crane-type loaders are best.

Off-loading trailers can be done by both crane and front-end loader machine types, provided appropriate lift capacity exists, although crane-type machines do have fewer lift height and interference problems.

For assisting other interfacing operations, the main difference occurs in hauler operations (cranes generally better for assistance), and in trucking operations (front-end loaders generally best for assistance).

The need to keep landing areas clean of debris is not a strong factor in need of consideration for machine procurement.

- 5 -

CONCLUSIONS ON LOADER SELECTION AND APPLICATION CRITERIA

From consideration of sections 2, 3, 4, of this report, it is obvious that the main criteria to consider in machine selection are those operating condition characteristics of the overall system into which the loader must fit. In appropriate operating conditions all loader types have comparable log handling rates and costs. However, these vary markedly if the loading machine is not appropriately matched to the operating conditions or characteristics.

Similarly for any particular loader type a consideration of sections 2, 3, 4, identifies the important factors to consider for efficient application of the machine. Where a specific loader is already on hand however, the options available in manipulating the system for improved efficiency are not great.

Separate guidelines for selecting a new loader, and efficiently applying a current loader, have been formulated from the above, and are presented in the following two sub-sections.

5.1 GUIDELINES FOR SELECTING A LOG LOADER

Selection of a log loader should be carried out in three stages, in order as follows :

(a) Identify most suitable type of loader;

(b) Establish size of loader necessary;

(c) Select brand of loader or specific machine.

Under each of these a number of factors need to be considered. Their relative importance to the selection decision involved will depend very much on the situation in question. Not only should the loader be chosen based on the operation it will immediately be applied in, but consideration needs to be given to future operations the machine may be used on, whether in logging or not.

In some cases type and size may already have been established, and specified by a contract. However reconsideration should not be overlooked.

(a) Identifying most suitable type of loader

The initial selection step should establish the category or type of loader most suited to the operation. The main options are :

1. A swing-crane type of loader or a mobile front-end type loader;

2. Whether the loader is mounted on a separate rubber-tyred carrier, mounted on a separate tracked carrier, or fixed as an addition to an extraction or transport machine.

The choice should be made by considering the following factors :

landing space and shape commonly available, any restrictions on loader operating area;

landing organisation and landing layout, as determined by the extraction, stockpiling and trucking operation characteristics;

ground surface conditions, firmness, roughness, and slope;

key functions the loader will perform and proportion of time at each, (clearing landed logs, sorting and stacking, loading trucks);

versatility requirement of loader for performing other functions such as assiting skid workers, assisting extraction machine, assiting log trucks and keeping landing suitably clean;

operator availability and level of skill required;

ability of machine to segregate and stockpile the required number of log sorts;

log sizes and types (lengths, diameters, form) that will be handled;

mobility between landings (frequency, length of shifts, transport availability).

The above are the major factors to consider in selecting machine type, however other factors as follows may also influence choice of category :

operator visibility requirements for the operation;

environmental considerations. Likelihood of loader unduly disturbing soil and water values or forest values where important;

standardisation of equipment types and components where adding to a fleet;

lift height and reach requirements in the operation;

purchase cost and finance availability limitations;

loader life expected;

expected loader resale value;

expected operating cost;

trailer off-loading requirements;

truck damage considerations when loading;

operator comforts required.

(b) Establishing size of loader necessary

Once the type of loader has been established it is then important to select the most appropriate size of machine for the operation. Machine sizes available vary widely, although in some types of machine (e.g. rope crane) the size range offered, or available, is limited.

The following factors are the most important ones to consider in choosing machine size:

required log handling rate (tonnes per hour) at key functions (clearing landed logs, sorting and stacking, loading trucks);

log sizes and types to handle (weight per piece and dimensions);

loader maintenance considerations and machine life expected;

lift height ability and reach requirements of the operation;

trailer off-loading requirements, trailer weights and types;

Some other factors that can also influence machine size selection but that are considered not as important as the above in most operations include:

truck damage considerations during loading logs or off-loading trailers;

loader purchase cost;

expected loader operating cost;

standardisation of equipment and components where adding to a fleet.

(c) <u>Selecting brand of loader or specific machine</u>

With the type of loader, and the best size established, the remaining decision is that of choosing the specific machine. Two main options existing are:

1. A new machine or a used machine;

2. The particular machine manufacturer or brand preferred.

The choice should be based on considering the following factors:

availability of machine, at time when wanting to purchase;

service back-up and parts availability for the loader in the locality in which it will be used;

maintenance considerations and machine life expected, (knowledge and past experience relating to the specific machine);

purchase cost of machine and overall deal offered by the seller, (trade-in allowance, warranty, finance charges etc.);

resale value expected when later selling this loader;

expected operating cost of loader, (knowledge and past experience);

equipment standardisation where adding to a fleet;

operator comforts available and required;

operator visibility requirements for the operation.

5.2 GUIDELINES FOR APPLYING A CURRENT LOG LOADER

The objective in any loader application is to get the required job done that results in minimum overall cost to the logging system.

Maximising efficiency of loader application depends on the ability within the operation to manipulate some of the operating condition factors. The ability to do this should be considered, in light of the machine in question (type, size and brand), for the following more readily manipulated factors:

Landing layout: are the relative positions of stockpiles, processing area, log landing and truck loading areas, the best for efficient loader cycles, while still meeting the overall operational requirements?

Functions performed by Loader: is the loader being used as much as practical on productive or necessary system functions? Are there some non-productive functions being performed that need not be done or which interfere with efficiency?

Operator Technique used: is the operator adequately trained and aware of the factors influencing operational performance (such as minimising travel and maximising volume handled per grab in each cycle), and cost performance (such as minimising unnecessary running, carrying out appropriate preventative maintenance and servicing etc.)?

Log sorts being handled: has the number of different log sorts been minimised as far as possible? Can different log sorts be stockpiled, loaded and transported together?

Loader lift capacity and reach: is the loader lift capacity maximised as far as desirable without over stressing the machine?, (hydro-inflated tyres or maximum of counterweights can be used, lift height for truck loading can be improved by stepped landings).

Log grapple suitability: is the log grapple suited to effectively handling the log sizes? Is it matched to the loader lift capacity.

Extraction machine operation: can this be altered in any way (drag size, cycle time), to assist loader efficiency without adversely affecting overall system performance?

Log Trucking operation: can this be altered in any way (arrival times, load type required) to assist loader efficiency without adversely affecting overall system performance.?

APPENDIX I - SURVEY FORM; CURRENT LOADER APPLICATION PATTERNS

The N.Z.Logging Industry Research Association (LIRA) is carrying out a study on Log Loaders in N.Z. The study is aimed at identifying the main factors that should be considered in the procurement and application of Log Loaders. Your completing this questionnaire, enclosing it in the envelope supplied, and posting (postage paid by LIRA), will help provide important data on current loading machine operations.

(PLEASE DO IT NOW WHILE YOU REMEMBER!)

OWNER.

Name or Firm:	
Postal Address:	

REASONS FOR MACHINE CHOICE (On your newest loader only).

LOADER NUMBER: *(Enter)*	*(Tick to describe importance)*		
FACTORS CONSIDERED IN CHOICE	MAJOR FACTOR	MINOR FACTOR	NOT CONSIDERED
Purchase cost			
Operating cost expected			
Resale value expected			
Log handling rate			
Mobility between landings			
Versatility of machine			
Ability to sort & segregate logs			
Ability to load multiple trailers			
Landing size restriction			
Ground surface conditions			
Environmental considerations			
Mode of landing operations			
Lift height ability			
Log sizes and types to handle			
Trailer unloading ability			
Truck damage considerations			
Equipment standardisation			
Operator availability			
Operator comforts			
Operator visibility			
Maintenance considerations			
Service & Parts availability			
Availability at time of purchase			

(PLEASE COMPLETE OTHER SIDE ALSO.)

CURRENT LOG-LOADING MACHINES (including truck-mounted knuckleboom units)

(Enter detail)				*(Tick columns below to describe loaders)*									
LOADER NUMBER	MACHINE		AGE (Years)	TYPE		UNDERCARRIAGE			GRAPPLE OPERATION			CAB	
	MAKE	MODEL		Crane	Front-End	Tracks	Wheels	Skids	Rope	Hydraulic	Other	Standard	Raised
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
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.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

CURRENT OPERATING CONDITIONS

(Tick columns below to describe current applications)												
LOADER NUMBER	FOREST TYPE		COMMON LOG DIAMETERS			COMMON LOG LENGTHS			LANDING AREAS		SURFACE PREPARATION	
	EXOTIC	INDIG.	Up to 15" (38 cm)	15"-30"	Over 30" (76 cm)	Up to 8' (2.4 m)	8'-20'	Over 20' (6.1 m)	Restricted	Ample	Nil	Special
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.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

CURRENT MACHINE PERFORMANCE (This information will remain confidential to LIRA.)

(Enter estimated detail)					*(Tick to describe*			
LOADER NUMBER	AVE.TONNES PER DAY		CURRENT OPERATING COST.EXCLUDE DRIVER *(Dollars/day)*	TOTAL AIMED LIFE TILL REPLACEMENT *(Years)*	FUNCTIONS COMMONLY PERFORMED			
	Stacked	Loaded			Clear Landed Logs	Sort & Stack	Load Trucks	Off-Load Trailers
.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
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COMPLETED BY:

Name *(Please Print)*:		Date:
Position in Firm:	Phone No.:	Exchange:

APPENDIX II

SOME GENERAL REFERENCE BOOKS WHICH OUTLINE LOADING METHODS

1. S. Conway 'Logging Practices - Principles of Timber Harvesting Systems'. 1976 A Miller Freeman Publication.

2. J.K. Pearce & G. Stenzel 'Logging and Pulpwood Production'. 1972 Published by the Ronald Press Company, New York.

3. 'Timber Transport & Handling from Forest to Sawmill'. 1964 Published by the Organisation for Economic Co-operation and Development.

4. W.S. Bromley 'Pulpwood Production'. 1976 Published by the Interstate Printers & Publishers Inc.

5. 'Planning Forest Roads & Harvesting Systems'. 1977 Published by the Food & Agricultural Organisation (FAO)

APPENDIX III - SOME MACHINE BRANDS AVAILABLE (WORLD WIDE)

Loader Categories	Rubber-tyred Front-end Loaders	Tracked Front-end Loaders	Rope Operated Cranes	Hydraulic Cranes	Truck Type Cranes
Some Brands Available	Bray	Case	American	American	Atlas
	Case	Caterpillar	Hitachi	Atlas	Barko
	Caterpillar	Fiat Allis	NCK-Koehring	Barko	Cranab
	Clark	International	Northwest	Bucyrus Erie	Dunham
	Fiat Allis	John Deere	Poclain	Caterpillar	Fiskars
	International	Massey Ferguson	Priestman	Dixie	Hiab
	John Deere	Komatsu	Ruston Bucyrus	Drott	HMF
	Patrick		Washington	FMC	Gafner
	Pettibone			Ford	Husky
	Rossi			Hitachi	Jonsered
	Terex			Hymac	OSA
	Timberjack			Ishiko	Palfinger
	Volvo			J.S.W.	Prentice
	Yale			Kato	S.A.P.
				NCK-Koehring	Savage
				Lokomo	United
				Lorain	
				Massey Ferguson	
				Nicholson	
				Nikko	
				Northwest	
				Poclain	
				Ruston Bucyrus	

Refer to the annual New Zealand Forest Industries Directory for the brands available in N.Z. & their agents.