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PROJECT REPORT

REPORT ON STUDY TOURS TO
NORTH AMERICA AND EUROPE 1981-1982

P.R. 19 1982

N.Z. LOGGING INDUSTRY RESEARCH ASSOCIATION (INC.)

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INTRODUCTION

During 1981-1982 LIRA's Director, Mr J.J.K. Spiers completed assignments in North America and Europe to update on research organisations involved in Research and Development in logging, and to attend relevant seminars and study tours whose major themes centred on logging. New developments in the field relevant to LIRA's programme and having implications for the logging industry in New Zealand were examined.

In the course of these investigations he visited the Eastern U.S., Scotland, Sweden, Norway, Austria, Bavaria, Switzerland, Germany, Denmark, Montreal, the BC Interior, Vancouver and the Pacific Northwest of the U.S.A.

The information presented herein results from very short term inspections, discussions and observations. Much of it is unsupported by data from independantly conducted tests or trials and thus must be treated as the opinion of the author. The report aims primarily to alert members to new developments and indicate sources for further information.

The assignment was dependent on the assistance and guidance of numerous people, most particularly from fellow logging research organisations, without whom the tour could not have been concluded successfully. Additionally, the author is particularly indebted to Ross Silversides of Canada, Dr Tom Walbridge of the Virginia Polytechnic Institute, Mike Lofthouse of the U.K. Forestry Commission, Professor Ivar Samset of the Norwegian Forest Research Institute, Dr Hans Loffler of Munich University, Kurt Vyplel of Franz Mayr-Melnhof Co., and Bob Rualt of Crestbrooke Industries, for their personal assistance.

The 1982 visit was financed by a travel grant from Munchen Messengelande, the organisers of INTERFORST 82, in Munich, West Germany.

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OBJECTIVES

The objectives of the assignments were :

1. To update on relevant research organisations, their administration and programmes.

2. To gain intelligence on new overseas developments that might have implications for the N.Z. logging industry.

3. To update on technology relevant to LIRA's current programme, particularly on steep terrain logging, and smallwood harvesting.

4. To attend and speak to the Forest Products Research Society Seminar on Smallwood Harvesting at Syracuse, New York; the Forestry & Harvesting Training Centre's Seminar on Research and Development in Timber Harvesting at Clemson, South Carolina; the combined FAO/ECE/ILO and IUFRO seminar on Planning and Technique of Transport and its relation to operational activities in forestry at Sandefjord, Norway; and INTERFORST 82's seminar on Forest Management Technology for multi-goal forestry in Munich, West Germany.

5. To attend Austrofoma, a field demonstration of logging equipment in Austria, and the Pacific Logging Congress in Vancouver.

6. To participate in the International Energy Agency's Forest Energy Planning Group Meetings covering smallwood harvesting, to investigate possibilities for international co-operation on projects relevant to N.Z.

7. To examine the implications of logging with long reach skylines for the combined Catchment Authorities who had given a grant for this purpose.

8. To establish and maintain the personal contacts that would facilitate future information exchange with management and personnel in relevant research and operational organisations overseas.

TOUR SUMMARY

(1) Logging Research Organisations

The research organisations visited are listed in Appendix I.

Exchange of publications was confirmed with all these, and personal relationships established with most senior staff. The visit enabled an examination of administrative procedures and systems of project control.

The most successful research organisations have a high proportion of direct contact with their industry, through courses, seminars, meetings, etc. The American Pulpwood Association are particularly well organised in this area. Skogsarbeten have a high involvement in training courses, and FERIC (Forest Engineering Research Institute of Canada) have held a successful presentation on machinery maintenance strategies. (These sessions were presented in N.Z. in 1982 as a result of the visit to FERIC).

The progression from research and development through demonstration to training is seen as most important, and the key to implementation of research results. A variety of approaches are taken to ensure effectiveness, e.g. the Austrian Training School do their own research which is incorporated in training programmes; Skogsarbeten sets up training courses and committees; the U.K. has a particularly good integrated system within the Forestry Commission between work study, research and development and training; the Norwegians have a very effective series of short training courses aimed primarily at small forest owners and contractors; the central Europeans have very good training systems based on early training of new entrants and certification, which is probably impractical to copy in N.Z. at present, but could serve as models for the future.

There are world-wide problems in conducting effective research in logging. Tree harvesting is, firstly, a tough engineering problem, and difficulties are compounded by requirements for complex heavy machinery with small potential markets. Problems are experienced in attracting professionally qualified engineers and foresters into logging, and it is difficult to duplicate field trials in different areas. It is considered that small research and development organisations should aim at providing information to aid the developers, particularly in the machinery sector. They should also act as a technology transfer bridge between manufacturer and industry user.

There is a requirement for greater involvement by the universities in management and engineering research in forestry, but with few exceptions this is not being done in the English speaking countries. A list of U.S. universities and their involvement is tabulated in Appendix II. A number of European universities are also involved in research relevant to logging, but publication is not in English and the results of research are not readily available.

(2) New Developments in Tree Harvesting

A number of new developments will eventually have application to logging in New Zealand. Many of these are in the initial development or prototype testing stage. The author considers that the appropriate technology for N.Z. should be centred on proven series machines and those that are still undergoing prototype modifications in their own country should be avoided. Nevertheless, it is important to have early information on these developments so that those with potential for use in this country can be monitored or selected for trials.

Among those that have future potential, and are commented on in the text of this report, are :

- Small cable haulers with potential for thinning, woodlot harvesting, or small clearfellings.
- Cable haulers with hydrostatic transmission and with interlock between operating drums.
- Machines and systems with potential for mechanised felling, bunching or delimbing on steep terrain.
- Delimbing processors which can be mounted on commonly available prime-movers and can be used in combination with cable systems.
- Chunkwood chippers with potential for harvesting wood residues from cutovers.
- A wide range of accessory units for farm tractors with potential application in farm forestry woodlots.
- A range of skyline carriages with abilities to lock onto the skyline and thereby improve speed and control in the break-out phase.
- Wide track, low pressure tyres for soils of low bearing capacity.

Those with lesser immediate potential include :

- More extensive whole tree systems, including field bagging of chips, and whole tree transportation for processing at the mill site.
- Short rotation wood harvesters.
- Long reach feller bunchers, processors, and loaders, aimed at mechanising thinning, particularly on easy terrain.
- Harvesting systems for, and improved utilisation of, industrial and domestic fuelwood.

(3) Technology

Technology is only briefly described in this report. Further information is available to members who want follow-up on specific items.

It is particularly important to understand the background which influences the adoption of techniques and machinery overseas, when trying to assess their application to the N.Z. scene. Topography and forest stand factors are relevant, but these are usually described in the literature and understood. Some other factors, however, which are well known in the country of origin, may not be described. Some of these are :

(a) The relative availability and costs of machines and labour, and the influence of such things as taxation and incentives on costs. The differences here mean that it is almost impossible to compare costs across borders. Productivity figures are more helpful, but there are difficulties understanding hourly or daily productivity recordings by different organisations in various countries.

(b) Land ownership patterns, particularly the importance of small owners in the forestry economy, have very important influences on the methods used. National legislation limiting forest management practices may also have important influences on the systems permitted or used.

(c) The high population density in Western Europe, where an affluent population seeking recreational space forces environmental objectives to take precedence over wood production in forest management.

(d) Published material on harvesting methods may describe limited application trials rather than normal practice.

For example, it is important to understand that, even in many of the mountain areas, the percentage of cable logging is low, e.g. less than 1% in the Interior of British Columbia or Norway; that something like 60% of the logging in Montane Central Europe (Austria, Switzerland, and Bavaria) is done by agricultural tractors; that a major problem in these areas is getting full utilisation of farm tractors otherwise used for less than 30% of their availability; and that the degree of mechanisation has been influenced by rigorous working climates, very high wage rates, and urban drift.

Felling is not just to get trees on the ground, but is of vital importance as an integral part of the logging system. In many areas and operations seen, considerable attention is paid to directional felling. Where felling is by chainsaw, systems are developed by research and trials, then demonstrated and incorporated in the training systems. This was most successful in the U.K., where considerable thought had been put into adapting Swedish systems to fit the U.K. environment. In the mechanised systems, felling is most successful where it is considered an integral part of the operation, and feller-bunchers are used to achieve great gains in the extraction stage. A good example was seen in the Interior of B.C., where a Drott feller-buncher worked to grapple skidders or clam-bunk skidders. For the future, modification of units such as the Menzi-Muck climbing hoe offer possibilities to increase effectiveness of cable systems on even steeper terrain.

Extraction on steep terrain is considered a problem everywhere, particularly where the major volumes of unexploited forest are on such terrain. Universally, tractor and skidder systems have proved cheaper than cable alternatives, and the drive is to push these systems into even steeper terrain. Surprisingly, the main extraction unit in Central Europe and Norway, is the farm tractor. Adaptations by counterweighting, using chains, and fitting double-drum winches, have enabled them to be used in a wide range of operations on very steep slopes. In the Interior of B.C., skidders are commonly used on slopes up to 30°, but more recently there has been a trend towards small tractors to cut down track width and reduce potential for slope failure. The FMC type track system has its place on such steep slopes, but the ability of the tracks to withstand the punishment is still suspect. There is work being done on the use of wide-track terra tyres, but these are very expensive and in the main limited to soft soils of very poor bearing capacity.

A wide range of short (under 2,000 ft) cable systems exist, from those mounted on and driven by farm tractors, to large swing boom interlock running skylines with costs around $500,000. N.Z. requires an analysis of the potential for the options, and this is being done by LIRA in the case of the small equipment. Of the wide range of machines seen, those that appear to have some potential for small-scale operations in N.Z. are the simple Austrian two-drum machines designed solely for uphill pulling with a gravity return system. The Smith Timbermaster and the Igland telescoping spars were very effective small timber machines (with well trained crews). Various loading crane conversions for short distance two-drum systems to work uphill to contour roads are common and work effectively in the Pacific Northwest of North America. The Austrians have developed a range of larger truck mounted mobile spars which work effectively, particularly when operating to narrow contour roads, rather than large landings. New development, particularly in Norway and the U.S.A., has concentrated on hydraulically operated haulers. These hydrostatic transmissions are easier controlled, enable smoother operation with less shock loading, better control of the rope tension and in some cases, interlock between drums.

A range of locking carriages which enable thinning, selection logging, or wide swath clearfelling, are available. The Koller is one of the most widely used in Europe. Both

Steyr and Wyssen also have good carriages and the Christy carriage is still one of the better and simplest of the U.S. carriages. N.Z. should give more attention to exploiting opportunities to use the better carriages.

Long reach cable systems have fallen into disfavour, primarily because of difficulties in rigging, in difficulties in getting the men on the ground to work them, and the need for roads for future forest management. The only exception to this is Switzerland, where by regulation there is no clearfelling and there is a need to log unhealthy mature stands on particularly steep and rocky terrain. There is virtually no alternative, and log prices are apparently sufficient to balance the high costs. Rigging of such systems usually involves ten or more days and about half that time to take it down.

Helicopter logging in mountain country has been used in Norway, Switzerland, and Western North America, as well as occasionally in other areas. But, it is invariably expensive and thus only applicable where log value can offset high costs, or where alternative access is unaccepted or more costly. Other aerial systems are under development but are expected to have restricted application.

To solve problems on very steep terrain, concerted efforts are being made to improve planning of road and logging systems, and road construction techniques, so that the more readily applicable and better understood techniques and machines can be used to log such steep terrain.

Mechanical processing, primarily delimbing, has not appeared to have progressed much. With the exception of chain delimbing, virtually no practical multiple stem delimbing systems have been developed for the bush. Problems with rubbish and breakage have been experienced in multiple stem delimbing at the mills. Thus, development has centred on improving single stem delimbers. In Europe, in particular, the small stem size processed on a single stem basis means low volume productivity and high costs. Although there has been some work on continuous systems, particularly in North America, few less costly alternatives to manual delimbing for the N.Z. economic environment exist. The only practical options open at present are chains or rough 'knock-em-off' procedures, which result in a poorly presented final product.

It is notable, however, that processors such as the Logma are being used at the felling site on steep terrain, and that roadside processors fitted on prime movers, such as skidders, excavators, and trucks, are being used on such terrain in association with cable systems, and such systems would have considerable potential for future N.Z. operations in thinning or second crop stands. Mechanisation appears to have gone too far in some regions. The light units for small wood are not robust enough and some of the bigger more complex machines are too sophisticated to be easily maintained in the field.

(4) Research Seminars

F.R.P.S. Seminar, Syracuse, N.Y., U.S.A.

"Harvesting Small Timber - Waste Not, Want Not" was an excellent, all embracing programme covering smallwood harvesting throughout the northern hemisphere. Much was relevant to LIRA's work in smallwood. Luckily a very loose interpretation of the category "smallwood" existed, ranging from the West Coast of North America's version to the mini species of Maine or Finland.

The seminar enabled a very good oversight of new developments worldwide in harvesting small trees, and gave an insight into prospective work planned. (The Proceedings are available in the LIRA library.)

R & D in Timber Harvesting - Clemson, S.C., U.S.A.

Reviews were given on current harvesting research, particularly around the U.S.A. and Canada, but developments in Scandinavia, South Africa and Australasia were also overviewed and future directions for research in harvesting discussed. The sessions on R&D with regard to logging machinery gave a valuable overview of costs and hazards in development of machines for the logging industry.

The main benefit to LIRA was the assessment of current developments that might have relevance to N.Z.

FAO/ILO/ECE Seminar and Study Tour - Norway

These sessions on the theme "Planning and Technique of Transport and its relationship to operational activities in Forestry" presented some excellent material on roading, planning and cable logging in mountainous forests. The field tour was particularly well organised and enabled demonstration of many new developments in haulers, carriages and cable systems. (The Proceedings of these sessions are available in the LIRA library.)

INTERFORST - IUFRO Seminar and Study Tour - Bavaria

The INTERFORST topic "Forest Management Technology for Multi Goal Forestry" covered harvesting as part of multiple use of forests and the IUFRO Division III concentrated on operations in mountainous forests, with particular attention to roading, harvesting and environmental risk. A session on centralised wood processing was also presented. The field tour in the mountainous areas of Austria and Bavaria presented excellent demonstrations of roading techniques in difficult conditions and systems for mechanical harvesting on very steep terrain.

All these seminars enabled the Director to meet key people from the logging industry, forest engineering facilities of the universities, the engineering and operational research divisions of the respective Forest Services, other logging research organisations, and the machinery industry. The contacts made will enable improved exchange of information and participation by some of those contacted in future LIRA seminars, as well as some project co-operation.

(5) Demonstrations/Exhibitions

A number of field and static demonstrations of relevance to LIRA's programme and extension were attended: Skogsodling, a field demonstration of establishment machinery, at Avesta, Sweden; Austrofoma, a two-day demonstration of machinery and systems on steep terrain, at Leobon, Austria; INTERFORST, a very comprehensive machinery exhibition of forest machinery in Munich, West Germany; the Pacific Logging Congress in Vancouver, Canada, where a mini display by manufacturers served as a model for a poster session in the 1982 LIRA machinery seminar.

Austrofoma was notable in being a field demonstration of a very wide range of European logging machinery, conducted on very steep terrain. Although the main attendees were Austrian, about 85%, and the operating language German, these field demonstrations were particularly well organised and worthwhile attending. The next one will be in 1983, centred on woodlot harvesting in easier terrain.

(6) Forest Energy Planning Group Meetings

Two meetings, convened by the planning group dealing with smallwood harvesting, were attended; the first at Syracuse, N.Z., U.S.A.; the second in Vienna. As a result of this, LIRA is participating as the N.Z. agent in an international co-operative investigation aimed at developing methods and machinery for harvesting smallwood from thinnings. The N.Z. involvement will be jointly financed by the Liquid Fuels Trust Board, F.R.I., and LIRA. The project is being co-ordinated by the Danish Institute of Forest Technology.

(7) International Co-operation

N.Z. is very dependent on overseas technology, particularly specialised machinery for logging. It is, therefore, necessary to establish and maintain good communications with research groups, manufacturers, and producers, overseas to be able to gain knowledge of new technology and to assess its potential and application for N.Z.

This visit enabled a collection of a wide range of reports, trial data, machinery specifications, and photographic coverage, which is now contained in LIRA's library and is freely available to members. A continuous exchange of such information, particularly with the relevant research and development groups, has been confirmed.

1 COUNTRIES VISITED

The following notes briefly describe some of the conditions affecting logging in the countries visited :

1.1 UNITED KINGDOM

Total production is 5.1 million m^3. Operations are in a generally depressed situation. Three U.K. pulpmills have closed down and they are currently exporting 300,000 m^3 of pulpwood to Sweden.

Major forest areas have been established since World War II and as in New Zealand are mostly on ground farmers do not want, sensitive soils of low bearing capacity in the border region, and steeplands in the highlands. They have developed a good terrain classification which enables them to decide on systems to suit the terrain.

The plantations are characterised by over-stocked, small dimensioned wood, but there has been a progressive approach towards adopting and modifying imported logging systems, particularly Scandinavian, for the U.K. conditions. Within the U.K. Forestry Commission there has been an impressive progression from research and development on these systems and equipment, to demonstration of them, through to setting up training schemes based on the new system.

Currently, 65% of operations are skidder, 20% forwarder, and 15% hauler. Haulers are considered too costly and their use is being minimised. Skidder operations are decreasing as forwarders take over. The latter are considered weather independent over the whole spectrum of tree size on a wide range of soil types, and are being applied on much steeper terrain than previously thought possible.

1.2 NORWAY

Production is 12.0 million m^3. A very high proportion of the forests are small farm forests with about 4,000 farmers involved. There is a progressive farm forestry association which does the logging for smaller farmers, employing contractors and its own crews. It also conducts a wide range of training courses, primarily aimed at farmers.

About 50% of the logging is done by farm tractor and some of this is on extremely steep country. These tractors are fitted with double-drum winches and may be used for hauling as well as skidding. Skidders do about 30% and forwarders and delimbers in combination do 10-20% - this is increasing. Cable systems, strangely, are less than 1% and this is on very steep terrain up to 50° slope. Historically, the skidding systems have creamed the easier parts of the steep country, thus the use of cable systems is expected to have to increase significantly to maintain production. Norway is short of wood and must utilise the steep terrain for wood to keep their industry going, thus all forestry work on steep country, including roading, is subsidised (at least 40% of cost) to promote work in these areas.

Initially, long reach cable systems were used for hauling, but the need for roads for management and access by logging crews have changed the emphasis to mobile haulers operating shorter distances, even though road construction in the glaciated granite terrain is both difficult and expensive.

1.3 SWEDEN

Currently production is 60 million m^3, but productivity in logging has come down since 1976 when labour went on to monthly salaries.

Thinnings are 25% of the volume but 50% of the cost. The State pays an incentive for thinning as part of the forest management policy.

The Swedes need to import 14 million m^3 per annum to keep their over expanded industry going and they pay twice as much for this wood as domestic wood.

Logging development is still oriented towards a high degree of mechanisation aimed towards harvesters which combine all functions on one chassis. It is considered easier to plan and manage operations for multi function harvesters, than for single function machines. In the case of thinnings, long reach booms on the basic forwarder-type chassis are designed to get trees from the stump to the track with a minimum of manual involvement. Some moves towards whole-tree, tree-section harvesting where the wood will be delimbed at the mill, are being made. Investigations into how best to extract, load and transport these unprocessed whole tree sections are underway.

1.4 AUSTRIA

Production 12.7 million m^3. 50% of the forests are in small ownership which produce 7 million m^3 of the total. The small ownerships and the legal requirements to restrict clearfelling to less than two hectare, has resulted in a strict pattern of narrow strip clearfelling on steep terrain, and sets a restrictive pattern for logging systems.

Currently, 60% of production is from skidder and tractor, 10% by cable, 26% by hand methods, and 4% by animal. 6% of the systems are highly mechanised, using roadside processors, and this is increasing. The strip felling pattern usually means cable systems which can be set up once in the strip and pull slack to each side of it, are preferred.

Currently 300,000 agricultural tractors are part-time involved and 250 skidders full time. The farm tractors are mainly under-utilised. Thus, the owners are seeking further logging work and are willing to operate on terrain up to 25° slope.

1.5 GERMANY

Production 30 million m^3 out of a 60 million requirement, thus is a major importer. There are many poorly managed over-stocked stands being thinned, and although mechanisation is being promoted there is considerable difficulty in manoeuvring machines in such stands.

There is an extensive road network throughout Germany, and this has been subsidised up to 60% to ensure farmers good road access. In the main, this is high standard roading capable of handling heavy axle loadings.

Each State operates an independent forest service. Bavaria, for example, which has most of the steepland, produces 7 million m^3. In this State there are restrictions on clear-cut size due to avalanche danger, and extreme environmental/conservation pressures. Again, most of the production is by farm tractor.

The very steep lands have been traditionally logged by long reach cable systems, but worker resistance to this type of operation, and the need for roads for management, is restricting their use. The shorter reach more mobile haulers are now more common.

1.6 SWITZERLAND

Production 4 million m^3, all from small forests. There is a wood shortage and thus a need to produce from all forests, even on extremely steep terrain. There is a strong commitment to forest management principles and all forests are selectively logged. No clearfelling systems are allowed. Final cuts are less than one hectare, 60% of the production comes from thinning.

Most of the forests are on sensitive soft soils and/or very steep terrain. In the alps some logging is on incredible steep terrain where large over mature trees are being affected by bark beetle. In these areas the long reach cables do up to 30% of the logging. There are about 400 of them in Switzerland, and there is probably no other possible way of logging such terrain with ground based systems. Helicopter logging is also carried out on a restricted basis, and helicopters may be used to set cable crane winches in position.

1.7 DENMARK

Production 2 million m^3, but 5-7 thousand people involved in producing it from mainly very small farm woodlots.

The conifer forests are characterised by dense over-stocked stands of smallwood on flat ground. Systems for mechanising smallwood production are being introduced, but it is very difficult to work in such stands with low productivity potential. The late thinnings being practised will probably leave stands vulnerable to windthrow.

The Danes are developing machines for their situation, and for export. The decentralisation of their manufacturing base is considered to give better productivity and lower costs and they can under-sell similar Scandinavian machines in the region.

1.8 NORTH AMERICA

There is a very wide range of forest and logging environments on this continent, and it is not proposed to describe them. The main crop logging conditions in the Pacific Northwest and the south are reasonably well known in New Zealand.

There are extensive smallwood resources in the south and east of the U.S., but 60-70% of these resources are held by small private owners who have little intention of cutting, as they do not see timber production as a primary objective. In the northeast particularly, there are important developments of fuelwood options and this is becoming more important than pulpwood in some areas, and has the advantage of being a cash crop. Much development centres on logging and processing of fuelwood through chunk chipping, bailing, compression, or chip harvesting into bags.

Some companies in the Northeast have converted the whole of their kraftmill input to whole-tree chips. The success of this system depends on heavy screening through several stages. It has enabled the whole-woods operations to be fully mechanised.

Lowest costs in Canada are achieved in the BC Interior with a combination of feller-bunchers, grapple skidders and chain delimbers at the landing. The south of the U.S. consider they have the world's lowest wood costs from traditional logging contractors with simple equipment and average $30.00 US per chord delivered at the mill.

2 LOGGING RESEARCH AND DEVELOPMENT - NEW TECHNOLOGY

The logging R&D organisations visited clearly aim to be a service and benefit to their industries. There is general consensus on the principle that there is no point in doing R&D unless the results are applied in the field. There are two main problems to be solved. The first is to identify the problems and be able to organise the work to solve these problems, and the second is extension, or the transfer of new technology from the research development to field practice. The R&D procedure follows a natural progression; problem identification - equipment and methods development - field testing and evaluation - demonstration - through to incorporation in the training systems so that the new technology is applied in the field.

To solve the problem of what work, and how to do it, the following approaches might be valid in the New Zealand situation.

Periodic Reviews - The Swedish Logging Research Foundation have a rationalisation conference every two years, to examine past progress, and define directions for the future. As a result of this their current research concentrates on felling patterns for mechanised thinning, harvesting of whole trees in sections, harvester development, improved bucking practice, and recovery of logging residues.

Concentration on major problems - The Norwegian Forest Research Institute identified steep terrain as a major problem and instituted a five-year programme to concentrate work in that area. This programme is nearly concluding, and considerable progress has been made in the development of haulers and in roading and trucking practices.

Group action on special projects - The Forest Industry Research Association of Canada in combination with member companies, and the Forest Service, formed a steep slope committee to work on the problems of harvesting steep terrain in the interior of British Columbia. As a result of this work they have been able to carry out trials and assess the productivity and effects of a wide range of different types of machinery and methods.

Two approaches to extension, which have been particularly successful, and might point the way for future work in New Zealand, are :

The U.K. Forestry Commission has instituted a development programme whereby they have introduced, adapted and implemented most aspects of desirable overseas systems (particularly Scandinavian), in their operations. They have developed a very good progression of testing equipment, trials of methods, demonstration, and incorporation in the training systems. Of particular interest is their development in the felling area, to fit felling methods to specific systems.

The intensity of the training programmes for log harvesting, in countries that have logging industries similar in volume production to New Zealand, e.g. the U.K., Norway, and Austria, is notable. They recognise that to utilise machinery effectively, and operate economically, they must have well trained people in operations where the influence of the individual (or team) on productivity and maintenance, is greater than any other factor. High levels of training are common in Europe. The Austrian training school at Ossiach, for example, has both the function of testing tools and machines, and the development of ways of using these. The new technology develped is then transferred to operators by way of training courses.

2.1 FELLING

Felling is seen as the key first step in the whole logging operation. Not just to put logs on the ground, but to place them in a situation that makes the next phase easier, and to minimise loss through breakage.

The U.K. has developed very effective manual felling systems to meet the requirements of the distinct extraction systems used. Separate systems have been developed for skidders, forwarders, and cable yarders. A key to applying these systems effectively are the fallers' training courses, developed by the U.K. Commission. The detail of much of these is described in the earlier LIRA report by Gaskin (Ref.1). In most cases, manual felling systems are still cheaper, and more effective, than mechanical falling.

Feller-bunchers are used in certain situations, particularly where these units can improve the effectiveness of the subsequent extraction system. Among the interesting developments were :

1. A Drott LC40 feller-buncher, seen working to bunch wood for an FMC grapple skidder in British Columbia operating on cross slopes up to 40%. The operator is able to level his cab position as he traverses the slope. This facilitates boom swing and control of tree placement. The skidder in this case fitted with a bunk grapple is able to handle three times normal skidder loads, on slopes up to 50%.

2. A new concept under trial is the Swiss Menzi Muck climbing hoe, which has been used experimentally as a feller-buncher for smallwood on steep terrain (Ref.2). The experimental work indicates future possibilities for combining feller-bunching and cable hauling, and also indicates that such a machine could be used for other functions on steep terrain.

3. The Makeri, a Finnish feller-buncher designed for smallwood and has potential for small thinnings, is about 50% the cost of other machines. But, it is said that the operator experiences considerable vibration, and the screwing of the machines track laying system may damage tree roots in thinnings.

4. The alternative concept in Sweden is directed towards machines with long booms that will operate off access tracks in thinnings. These are still in the development stage. Possibly the only proven production machine is the Huldens GP322. There are apparently problems in operator visibility due to parallax errors with this type of long boom, which makes accurate control difficult.

Felling heads for feller-bunchers have progressed from the hydraulic shears originally used, and common to the current N.Z. machines. Chainsaw heads are commonest in most current Scandinavian machines, and more recently new disc saw felling heads, with higher productivity than chainsaws, have been developed in Canada. This type of saw is a circular saw with larger teeth, which severs the tree and carries the cut stem onto the basic central cover of the saw where stems can be accumulated. Koehring are one Canadian developer of this fast cutting saw, and Denis have a twin saw felling head. All these heads allow faster cutting without butt damage, which is particularly important if the butt log is to be used as sawlog or peeler.

Feller-forwarders for small trees are becomming more widely used in North America, to forward whole trees to the roadside for processing. The Timberjack 30 is a smaller machine based on the Australian Windsor harvester. A principle which is enjoying some success in the southern part of the U.S. for whole tree logging (Ref.3).

Swathing is a relatively new development being pursued in eastern Canada for harvesting of very small trees for energy wood. A large circular saw on the front of the machine allows a continuous harvesting principle to be adopted, but as N.Z. is

SYSTEMATIC FELLING

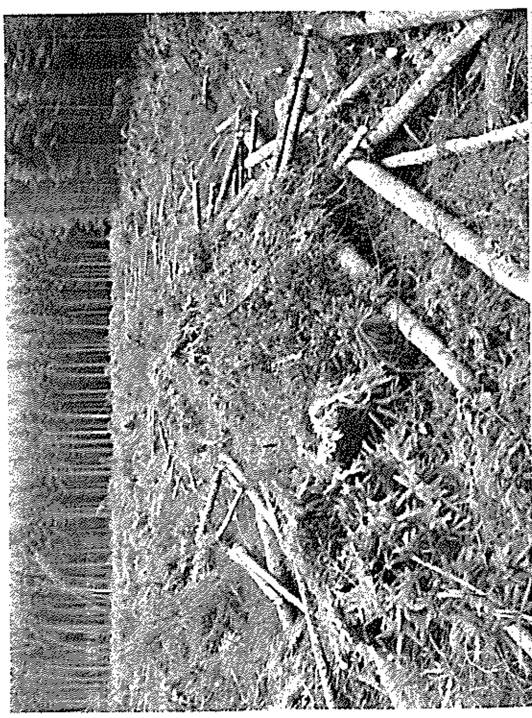
FIG. 1

Trees stacked by feller-buncher for mechanical processing and forwarding

FIG. 2

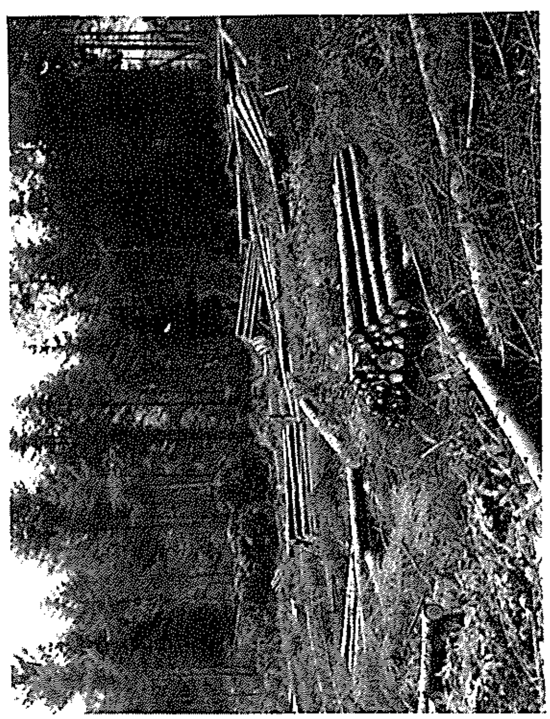
Uphill cross-slope felling of larger trees enables effective downhill skidding by small units.

FIG. 3



Scoot system for skidders. The breaking out track is kept clear for easy choking and the skidder moves on the assembled slash.

FIG. 4



Pulpwood stacked according to optimum load sizes for Timbermaster skyline. The sawlogs are hauled separately.

unlikely to get into energy cropping, and most forests are on steep terrain, it has little application here in the foreseeable future.

2.2 EXTRACTION

The common principle being adopted is to push the simpler systems onto the steeper and more difficult terrain, wherever possible. Skidding and forwarding systems, where terrain and soil type will allow, are preferred to cable systems, and everywhere investigations are being carried out to extend the range of these mobile extraction units into even steeper and more difficult terrain.

2.2.1 Skidding

A wide range of skidders are in use, most of them well known in New Zealand. One new unit with possible potential is the Logmaster hydrostatic skidder now on the market in the U.K. It features individual hydrostatic motors at each wheel. A low centre of gravity on the arch reduces tipping moment and allows it to negotiate terrain up to 45% of slope. It features radio controlled double drum winches, which can be operated by a small transmitter carried by the operator who does his own breaking-out. In the conditions seen it allowed excellent control by the operator to breakout numerous small logs, using polypropylene strops. The electric control system of the hydrostatic skidder is easily adapted to radio control, which can be fitted at a cost of less than $2,000. The portable transmitter has a 6-button control system, which allows separate forward or reverse movement of each winch and immediate stopping with the safety buttons located on top of the transmitter pack.

On all of the European skidders seen, double drum winches were standard and these increased the productivity on smaller trees. This productivity was related to the number of logs, their distribution on the ground, and how far the operator had to go to breakout. Thus, the felling system to improve presentation was vital. It was usual to pull the pin from the terminal of the mainrope and use two sets of chokers. In the case of the Logmaster skidder, with its double drum winches, and very small trees, 80-90 polypropylene chokers were used. The cost of these, at about $4 each, meant the few breakages were unimportant and they did not lose many because of the eye-catching colour.

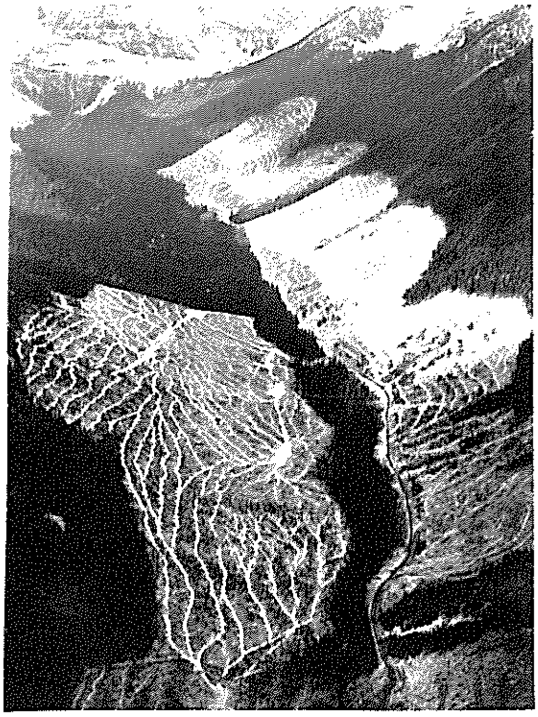
Commonly, in Central Europe, particularly Austria, Germany and Norway, agricultural tractors are used for logging as a very high proportion of the total timber cut comes from small ownership forests. In the mountain countries they were used in steep conditions, and were normally fitted with tyre chains. The Russian Belarus, and the Austrian Steyr, were the two commonly considered most suitable for logging. A Steyr FT120, with Huber front-mounted double drum winches, was seen performing very effectively on slopes of 25%, pulling uphill, and out-performing a Czech LKT80 skidder working alongside. The front mounted winches gave the unit better balance and applied more weight over the front axle so that the four-wheel drive could be utilised effectively. In the Norwegian case, agricultural tractors might be used directly for skidding on most of the terrain and fitted with a portable spar unit, such as the Igland, to handle the more difficult, very steep, sectors. In planning operations it was considered that logging units should be able to cover the whole of the terrain in any one area, and not just cream the easier parts which has been the tendency with some tractor operations. For farm tractors consistently used for logging, integrally mounted winches were preferred. But where the use was inconsistent, winches with stabilising legs mounted on the three point linkage of the tractor, were commonly used. Of these winches, the Finnish Farmi was considered among the best. The Danish Fransguard are similar, and said to be cheaper. All these winches are simple to operate and repair by any blacksmith, and require

SKIDDING AND FORWARDING

FIG.5

Logmaster skidder winches are radio controlled by operator who does his own breaking out.

FIG. 6



Skidder tracks on steep terrain in British Columbia indicate how most countries are trying to use ground based systems to the limit.

FIG. 7

Small tractors have displaced skidders in the more sensitive and steeper areas of British Columbia.

FIG. 8

Mini Brunett forwarder operating on slash to load out logs prepared with "bench" felling system.

AGRICULTURAL TRACTORS

FIG. 9

Loft hydraulically operated skidding tongs are designed so that the pull force is below axle level which improves stability, safety and traction.

FIG. 10

Steyr FT80 equipped with tyre chains, double drum winches, twin fairleads and skidding butt pan.

FIG.11

Simple single drum skidding winch can be easily fitted to tractor PTO and three point linkage.

FIG.12

Tongs can also be used for pulpwood forwarding with minimum loss of stability.

no special services. They have simple mechanical clutches which can be operated by nylon rope, and can handle loads up to about 4 tonne. Many of the Danish agricultural tractors have skidding tongs that are hydraulically operated from the three point linkage. There are separate types of tongs for log skidding or pulpwood forwarding. In the case of the Loft tongs, the two types can be exchanged easily in less than 4 minutes. Considerable attention has been given to designing these tongs to achieve greater traction and more stability through a low pull on the tractor itself.

In the southern interior of British Columbia, on the steep and sensitive terrain of the Rocky Mountain area, small tractors are currently being used with tracking systems. Being narrower and more stable they do not do as much damage as skidder systems and are considerably cheaper than cables. Currently, the requirement is to restrict the cut bank of tracks to a maximum of one metre, and these are put in by smaller tractors pushing tracks uphill or side hill, herringbone pushing the trees away from the tracks so that they can be butt pulled in extraction. The tracks are 25-45 metres apart, depending on tree size. For skidding, tractors such as the John Deere 550 are considered ideal because of speed, availability of service, and ability to do both tracking and skidding.

FMC skidders are used where large loads can be assembled for fast skidding. Their high horsepower to weight ratio enables big loads to be carried at speed, and they work effectively with feller-buncher systems. Where the FMC bunk grapple skidder (BG series) is used, it produces more than the choker arch (CA series), but because of a natural tendency to overload, there are more maintenance problems. The track systems have been improved and life is said to be currently from 2,700 to 3,100 hours, given a rebuild about 15,000 hours. Current costs of a new set of tracks is about $23,000, and although cheaper military tracks have been used as replacements, they are considered unsuitable as they do not stand up to the logging work and cause excessive downtime.

2.2.2 Tyres

The Swiss and Canadians have been doing studies on the bearing capacity of tractors on less stable soils. Special tyres have been developed for skidding on moist clay soils, and investigations are being carried out to find the type of tyres that suit specific soil types, as well as the most desirable type of machine for these. Terra (soft terrain) tyres have been tried on agricultural tractors, but these are very expensive and some problems have developed with punctures. FERIC is currently testing the very low pressure Rollogon tyre on a test track, testing traction, ground pressure, fuel consumption, etc. Advances in technology with such tyres has been possible because of new materials such as Kevlar. The advantage of the soft tyres is that they do not break through the roof mat and bigger loads can be carried, particularly on swampy soils. A problem is that they have to transfer torque through a small bead and a flexible sidewall so that there has been a problem in tyre life of these tyres. Lug size must be reduced because of the traction that can be applied through such tyres. They have no problems in negotiating hills up to 40%. To date the state of the art means that the current tyres are too expensive for the normal logging situation, but development is continuing.

The American Pulpwood Association has commenced a skidder tyre project as a result of a furore caused by an argument on whether off-highway tyres can be retreated. This investigation is underway at the present time.

Tyre chains are virtually always used on skidders and agricultural tractors in Europe to improve traction, except where they may damage roads. Initially they cost about half that of the tyres, but virtually last the life of the machine with some welding and repairs. Basically, they are considered essential on steep or frozen soils or hard surfaces, but on soils of low bearing capacity they may do considerable harm. There is some argument as to whether they should be worn loose or tight. Most manufacturers recommend the latter, but some operators consider they should be worn loose, to clean themselves of mud.

With regard to skidding tracks, lime has been used in trials on such tracks and has worked well as the skidder mixes lime into the soil and the lime in turn effects some water removal. Work has also been done on tracks to reduce sedimentation at temporary stream crossings, by constructing a "dam bridge", built from waste belting. It would have direct application in some New Zealand situations (Ref.4).

2.2.3 Forwarders

Forwarders, the most common method of extraction in Sweden and Finland, have been fundamentally designed for moderate terrain and rough ground conditions with shortwood systems. It is therefore interesting to observe that in the U.K. currently 20% of extraction is by forwarders, and this percentage is being increased as they extend forwarder operations onto difficult country, both in steeplands and poor soils. Forwarders are considered weather independent over the whole spectrum of tree size, and this is important in the 90"+ rainfall areas. There is less congestion of wood at the roadside and a higher level of stocks can be located, either parallel to, or at right angles to the road. The advantage here being that you do not need a stacking machine at the roadside, nor are landings required.

Currently, one of the most successful forwarders in the U.K. is the mini-Brunett, and the U.K. Commission is tending to standardise its operations on it. It is characterised by double bogey wheels and frame steering articulated in the centre, which makes it probably the most manoeuvrable forwarder. It can handle slopes up to 25° on good ground conditions, and 17° in any condition. It is considered particularly effective because of its terrain capability, hydrostatic drive, and torque convertor. When seen it was handling two and three metre pulp, and sawlogs which averaged 4.5 metres. Maximum length for this machine would be 5.5 metres, but more recently a bigger unit, the Maxi Brunett, has been produced which features the same principles.

Forwarder systems are commonly accepted in Europe as the most effective system of extraction. They allow the felling and extraction work to be de-phased, which increased the productivity in each phase. However, they are normally tied to shortwood systems, and there is a need for a high degree of training in forwarder operations, as this is considered one of the more difficult logging machines to operate.

2.2.4 Chutes

In mountain central Europe, wooden chutes or flumes, have been a traditional way of extraction of all sizes of logs. More recently, easily portable chutes, such as the Leykam logline, have become common for small logs. The systems for moving, joining and braking logs in these chutes would be applicable to the New Zealand situation.

2.2.5 Cable Haulers

Cable systems are clearly recognised as being more expensive and more difficult to manage. However, they are inevitable in many situations. In Europe there is general disillusionment with the traditional long reach cable crane systems because of the unwillingness of labour to work with these systems, the high requirements for skill, and the excessive level of unproductive time in rigging the systems. It is now recognised that for proper management of the forests, more roads are required, and that short reach systems working to these roads produce wood to the roadside at half the price of the old long reach cable cranes.

Separate workers in Europe and North America have identified common principles in their approach to the problems of designing better cable systems and equipment. Among these principles are :

- To simplify the machine controls and maintain better control of the log load;
- To use hydraulic and hydrostatic transmission systems;
- To simplify and smoothen the control of tensioning and deflection of cables;
- To use running skylines;
- To attempt to make more effective use of horsepower through interlocking main and tail rope drums;
- To keep the log butts in the air at all times, which results in less horsepower, less breakage and delays, smaller rope sizes, and easier calculation of critical loads;
- To avoid pulling logs into the ground by using intermediate supports and tail spars where required;
- To use better planning of layout to optimise deflection and clearance.

If we look at the haulers available, the following are the commonly used units, and some interesting new developments :

There are a number of light simple machines suitable for woodlots and small scale operations, particularly thinnings. Commonly used in Europe are small Austrian two drum machines that may be truck, trailer, tractor or skidder mounted, and driven by power take-off systems, from the carrier or by independent motors. A very popular machine is the Koller 300, but both the Andritz MM2000 and the Mini Urus, are effective machines in the same category. However, these units are generally restricted to uphill hauling with a gravity return skyline system to contour roads or small landings. An alternative in the U.S.A. is the Appalachian thinner, a tractor-mounted swing-boom machine with a single hydraulically operated drum on the spar. It is, in effect, only a short distance bunching machine.

Some small capacity machines with greater flexibility are operated by agricultural tractors. The Smith Timbermaster is the most effective of the U.K. machines. It has very fast cycle times and uses light rigging. It is exploited particularly successfully in the U.K. because of the high degree of training given the operators, who are able to stack logs at roadside in a position for fast loadout. The most versatile of the small machines is probably the Norwegian Igland telescoping spar, which is constructed primarily with the small forest owner in mind. The spar rests on a single pivot point, and is held in position by the guys. It is chain driven from the tractor PTO, and this can be easily disconnected from the spar and double drum unit, which may be left in position fully rigged. The hydraulically controlled mechanical clutch and brakes are mounted on an outrigger. The Igland unit is very flexible in that with a running skyline system, and a carriage that locks to control the amount of slack, it can be used uphill, downhill, or over intermediate supports.

The Norwegian Vario winch is a hydrostatically driven hauler fitted on the standard Variotrac 912 hydrostatic tractor. This wheeled tractor with flexible tracks, has variable displacement hydraulic pumps which separately drive two wheel motors, with one lever control to each. The drive can be switched to the hauler mode with a lever, and then two hand controls control each winch. A separate slack pulling line for running skyline operation can also be fitted. It is

SMALL HAULERS

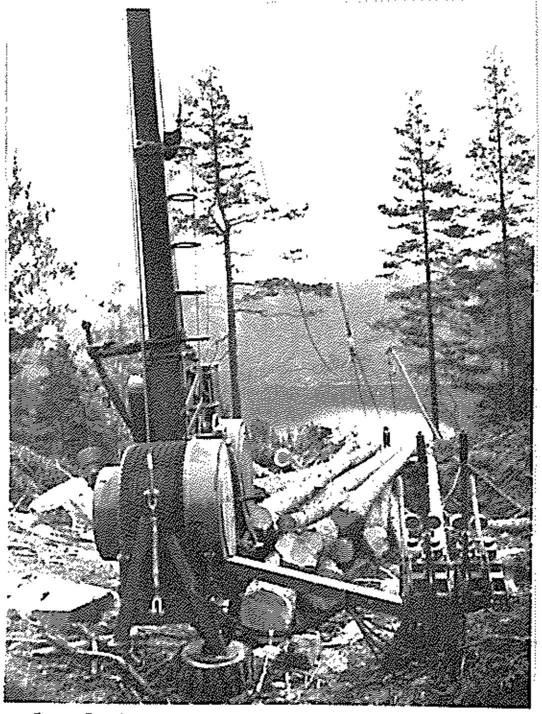
FIG. 13

Tractor operated Koller 300 two drum is used for uphill hauling to contour roads.

FIG. 14

Andritz two drum hauler is skidder mounted. This gravity return system is rigged to allow logs to be dropped on the road for load-out.

FIG. 15



Igland double drum telescoping spar for running skyline system can be removed from tractor PTO without de-rigging.

FIG. 16

Tractor operated Timbermaster hauler extracts and stacks pulpwood at roadside. Skyline carriage goes over intermediate supports.

simple to erect and move. The 5.5 metre spar folds over the top of the machine for transport and is raised hydraulically to give a fairlead height of 7.3 metres above ground.

The Clearwater yarder is a mobile truck mounted skyline hauler with a hydrostatic transmission, designed by the U.S. Forest Service for smallwood operations. It has been used in Eastern U.S.A. with a modified Christy carriage which allows both gravity skyline and slack pulling capability.

The Micro-master is a new skidder-mounted Canadian cable machine for smallwood harvesting. It has been used in both thinnings and clearfellings and is apparently a very fast and rugged machine with a simple 8.8 metre tower, mounted on a 404 130 horsepower Timberjack skidder. It has been recorded at averaging between 215-245 pieces of .6 m^3 per day. The operator unhooks at landing and a grapple skidder skids the logs away as well as doing some separate skidding.

Among the more effective high production machines is the Norwegian Moxi-winch. The U.S. designed Peewee-Lantec interlock drum set has been mounted on a forwarder dump chassis by the Norwegians, to give a very effective and fast running skyline interlock machine. Although an expensive machine ($220,000 NZ in 1981), its very fast speed (about 11 m per sec.) enables a high rate of productivity on steep terrain, both up and down hill. The 200 horsepower machine carries 700 metres of 14 mm mainline, and 1,400 metres of haul-back. Power output is 152 kW and the spar, which is both telescopic and tiltable, has a total height of 15 metres in the extended position.

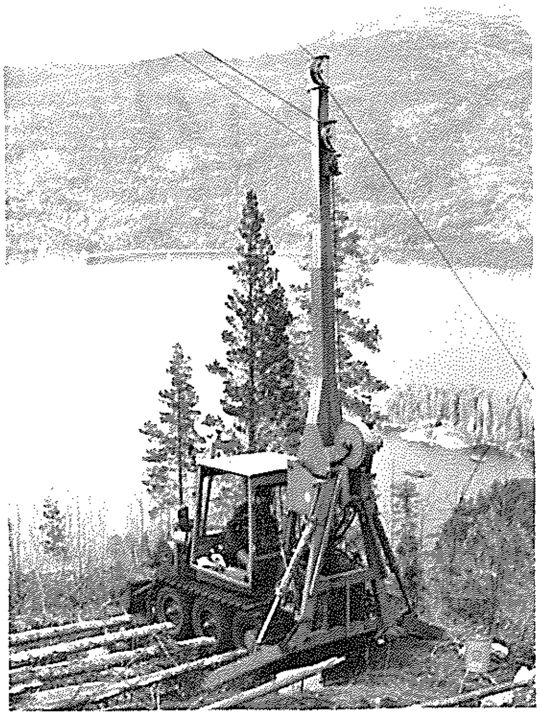
The Andritz hydrokran 80 skyline hauler, one of the larger Austrian units, has some unique design features. The separate twin grooved pulleys drive both the main and tail ropes and each rope has a storage drum with a hydraulic motor wherein only enough oil is allowed through the motor to keep the rope spooling onto the storage drum reasonably tightly. Control of the rope spooling onto this drum is achieved through a sheave on a swinging arm. The twin pulley system, with equal diameters, on each of the haul-back and mainrope drums enables an effective interlock and tension control without power being dissipated in a braking system. The skyline drum on this machine is mounted sideways, and the skyline is tightened by a hydraulic cylinder on the spar. The cab is self-raising into a position where the operator can see all drums. In the operations seen, a simple effective carriage was used for slack pulling.

Steyr, another Austrian firm, produce a series of KSK haulers, similar to the Madill 071. The KSK 16 has a 16 metre spar, and the KSK 20 a 20 metre spar. Steyr have produced 80 of these haulers, mainly for use in Eastern Europe. Set-up time is apparently fast and can be done in 3½ hours with an experienced three-man crew. The cabin folds up from its road position to its operating position. The skyline has two brakes, a disc and a band brake, the latter being set when the machine is not being used. In operation, the disc brake will slip on overload. Haul-back pressure can be automatically adjusted. In the field, a KSK 16 was seen effectively working on a contour road in combination with a grapple skidder and an Osa processor. It was notable that the gravity return system was used and the machine was rigged so that logs were landed in front of the machine with butts across the road (FERIC has produced an evaluation of this machine in Canadian conditions, Ref.5).

In western Canada and U.S.A., various loading cranes have been converted to haulers for gravity return systems. They use locking carriages such as the Christy or Maki. In these loader conversions, the main requirement is to build up the drum flanges to take the greater lengths of rope required, and the fitting of guyline to the top of the machines. Very few problems with the loaders swing gear have been encountered and these loader conversions allow

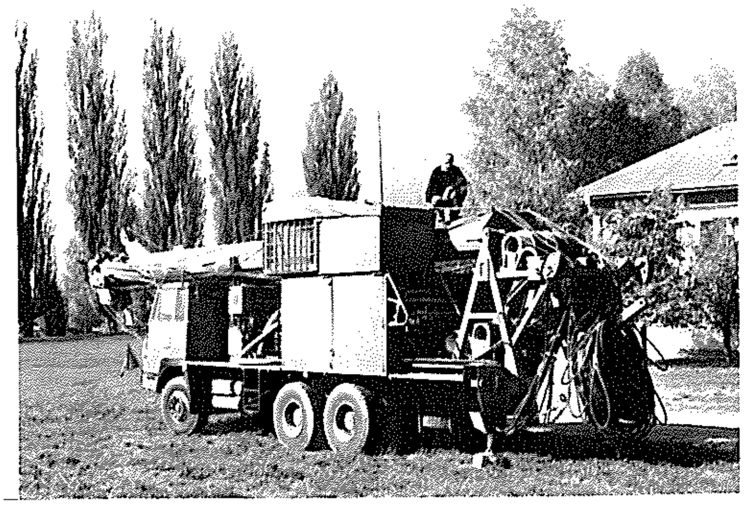
ADVANCED HAULER CONCEPTS

FIG. 17



Vario-trac hydrostatic hauler can be used with running skyline system over intermediate supports. Is particularly easy to move and reposition.

FIG. 18

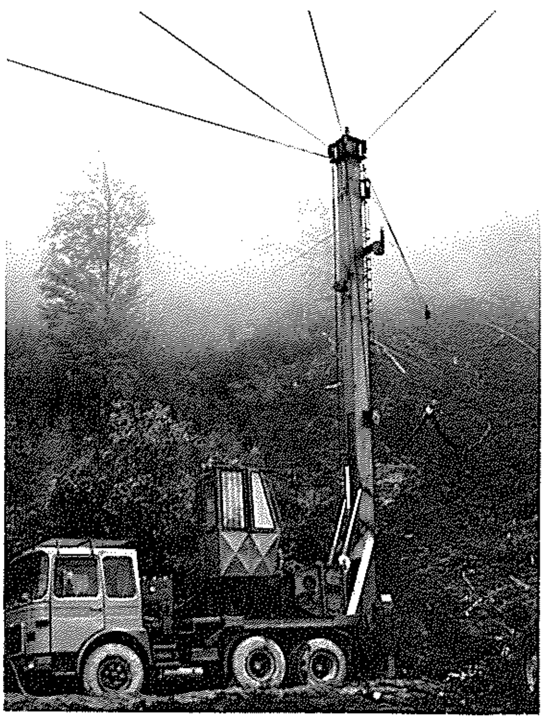


Steyr KSK 16 truck-mounted mobile hauler with cab and spar folded for travel.

FIG. 19

American conversion from loader to gravity return hauler. Swing ability enables hauler at road edge to land logs on road.

FIG. 20

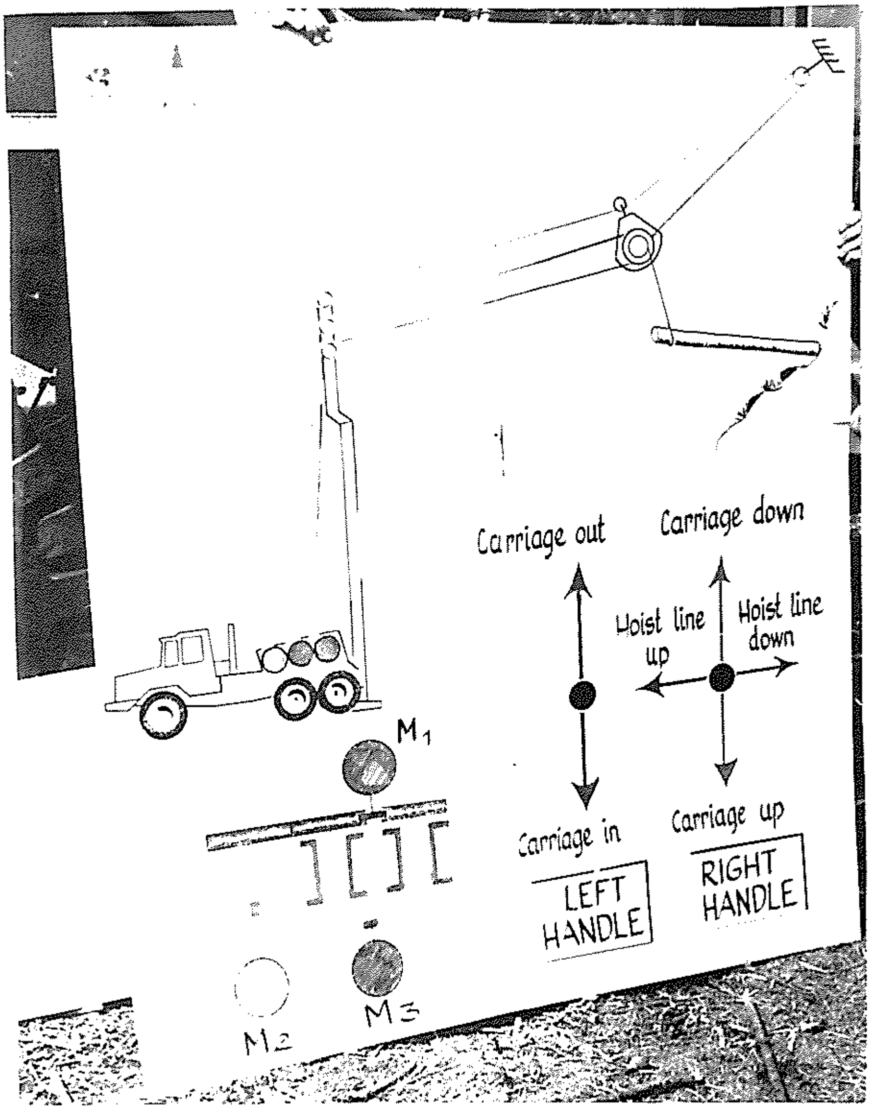


Mayr-Melnhof interlock hauler. A series of grooved pulley drums feed rope onto storage drums whose speed alters as rope lays build up.

HYDRAULIC INTERLOCK

THE MOXY - A 3 drum planetary interlock winch for running skylines

FIG. 21

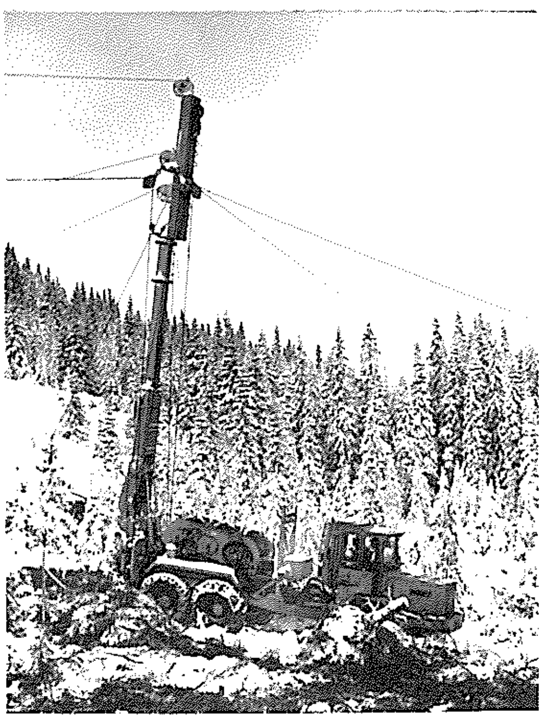


(Top) Rigging for running skyline system using a carriage which pays out slack.

(Right) Indicates simplicity of control system with two levers.

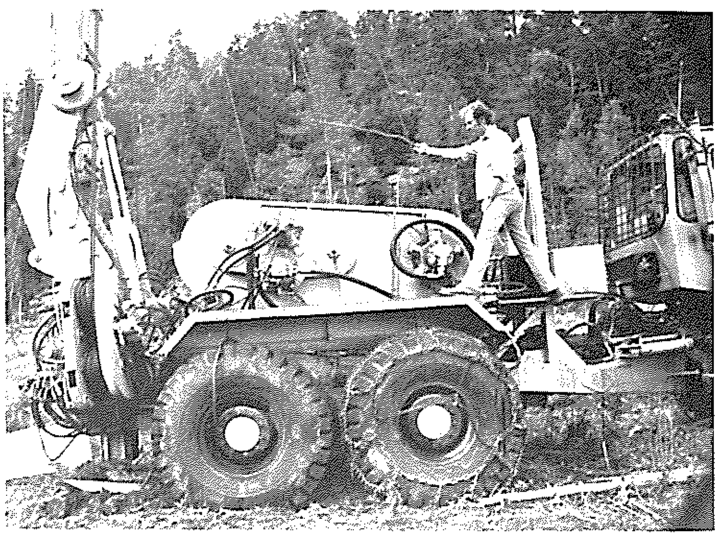
(Bottom left) Indicates how interlock operates using a planetary system to synchronize drum rope speeds.

FIG. 23



Moxy winch with spar erected

FIG. 22



Shows hydraulic motors for main winch drums, spar tilt arms and guy drums.

logging from steep contour roads, with easy landing of logs on the road. They also fit well to gravity return systems which require less length of rope to be carried on the drums.

2.2.6 Carriages

A wide range of skyline carriages is available, and it is notable that many operations, particularly in North America, use more than one carriage, and will change carriages in one setting, dependant on the topographical conditions in that part of the setting. Carriages which might be suitable to extend the range and flexibility of future New Zealand operations, could have one or more of the following features :

- suitable for gravity return systems
- able to lock on the skyline
- able to operate over intermediate supports
- ability to pay out slack, particularly in thinnings.

The following carriages have some of these features.

The Christy carriage, currently restricted in New Zealand to uphill operation with gravity return, has been modified to take a tailrope for crosshill or downhill operation. When a long dropline is used it is desirable to use a shay swivel to attach the tailrope and thus minimise the possibility of tailrope and dropline platting.

The Koller carriage is widely used in Austria and Bavaria. It was even being used by rival manufacturers demonstrating their haulers at Austrofoma. It is a gravity return system with a unique hydraulic accumulator incorporated in the carriage to allow clamping to the skyline. The clamp is activated mechanically by reversing the direction of the carriage and is released when the fall block returns to the carriage.

The Steyr slack pulling carriage operates with a running skyline system. The chain which drives the dropline drum, holds the rope on the drum from slipping, thus the running skyline carriage can be held in the air when slack is being played out, and remains in position on the skyline when hauling in. The dropline length, combined with the topography affecting clearance, limits the width of the strip that can be pulled.

The carriage used with the Moxi winch was also designed for a running skyline system and could pay out slack from the centre drum of three drums on the one axle. It worked very effectively in demonstration and could be modified to go over an intermediate support.

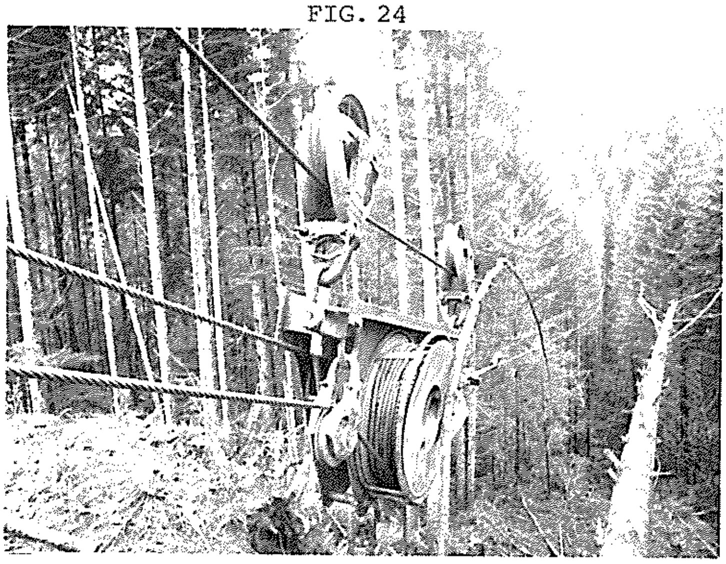
Generally, in rigging systems for these more effective and versatile carriages, it was accepted that clearance over obstacles would be maintained and the carriage not dragged into, or along the ground, as is commonly the case in New Zealand. Certainly, some of the carriages would not stand this treatment. Obviously then, to gain the benefits of their application, more attention would have to be paid to layout for clearance which might mean, in some cases, rigging back spars, or shortening haul distances with more roads and landings but benefits would be gained not only in higher productivity but reduced necessity for unduly large equipment.

2.2.7 Auxiliary Equipment and Rigging

Polyester web belting was widely used for attaching guys to standing trees in

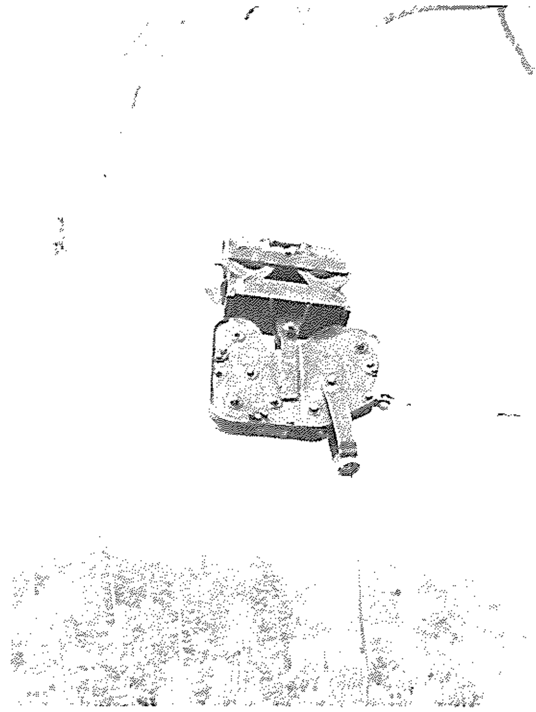
CARRIAGES

FIG. 24



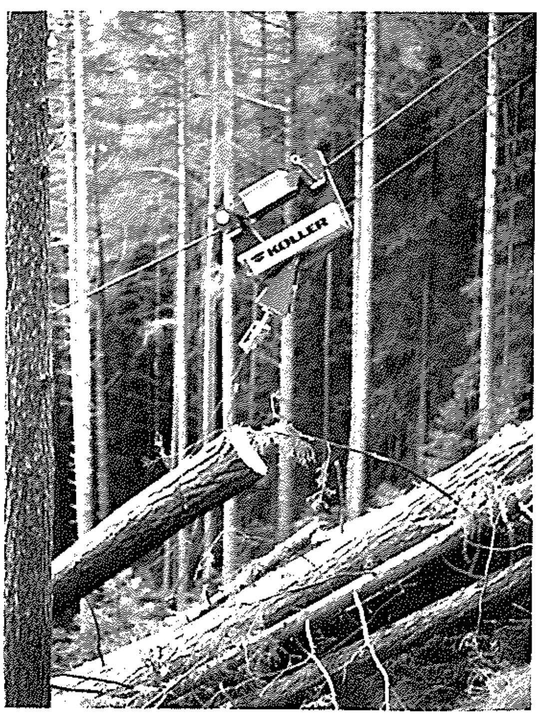
Steyr slack pulling carriage modified for North American conditions. A chain drive within the carriage controls the action of the drop line

FIG. 25



Simple Norwegian locking carriage designed to pass over intermediate supports. Used with the Igland telescoping spar in a running skyline mode.

FIG. 26



Koller gravity return locking carriage is the most popular in Central Europe. Locking is achieved by reversing the direction of the carriage.

FIG. 27

Three drum slack pulling carriage used with running skyline system. The centre drum holds a drop rope.

RIGGING

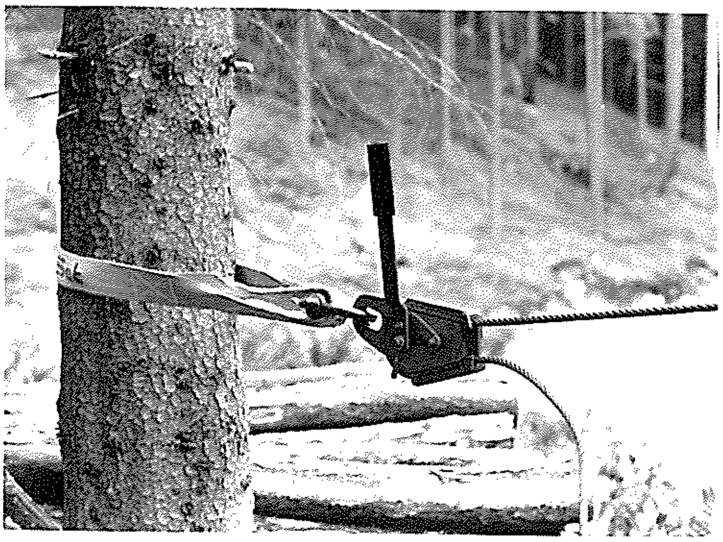
FIG. 28

Chain and toggle fitting transfers turn from hauler to skidding unit at the roadside. Two sets of chokers are used.

FIG. 29

Power saw operated winch for rigging, laying out lines or pre-hauling.

FIG. 30



Polyester web guy tie-back prevents tree damage in thinning. Rope is clamped by the action of the lever.

FIG. 31

Polyester sling chokers. Note, ring and bar slider which allows the choker to be threaded through the ring and retained in place by the bar.

thinning and smallwood systems. This prevented damage to residual crop trees.

Polyester sling chokers were also widely used. These chokers were constructed of loosely woven, continuous strands of polyester, covered by a sheath of polyester fabric. These are normally colour coded according to strength ratings and are ordered according to length and rating. They are light and very easy to handle, and would have application in N.Z. for smallwood operations.

In virtually all the larger operations in Europe, chain chokers are invariably used. The European companies, particularly Pewag, Rudd and Erlau, produce a wide range of choker hooks and other attachments for chain rigging. This rigging outlasts wire rope and is much easier to handle.

Intermediate supports for skylines are commonly rigged. The speed of the rigging is improved by ensuring that they are only rigged high enough to give adequate clearance to the log passing over the support, and by using aluminium ladders for rigging. Commonly, polyester straps were used to anchor the support line to the tree and a simple hand winch used to tighten it. Rigging time varied from 15-40 minutes, depending on the particular situation. American studies have shown that the tension set up in rigging intermediate supports were very low and this has been taken into account in the latest revision of the Oregon Safety Code.

In almost every instance of skyline hauling to a steep contour road in Austria, the logs were removed from in front of the hauler by some type of skidding unit to a processing situation further along the road, where delimbing and crosscutting took place. Use of simple chain rigging systems allowed a quick transfer of drags of logs from the hauler to the skidder.

Polypropylene rope is widely used for chokers in the U.K., usually simple slings of 14 mm rope. Strawlines are also often polypropylene of small diameter. Kevlar, a very strong synthetic material, has also been used for rope, but is difficult to splice or set fittings on and has a high rate of internal wear, thus is not generally considered suitable for logging.

2.3 LOGGING SYSTEMS ON STEEP TERRAIN

The integration of felling, extraction, processing, stacking and loading out, is very important in achieving a highly productive, low cost system, on steep terrain. In most New Zealand operations to date we have been able to achieve large landings on which processing is carried out, either under the spar or with logs being removed by loader to a less restricted position. Such large landings restrict clearance of cables over the lip of the landing and nearly always demand a high spar. In North America and Europe, operation of haulers off contour roads with little or no landing is the rule. In North America the system is generally based on logs cut to length in the bush, but in Europe whole trees are extracted as the delimbing and crosscutting work on the steep terrain is considered too arduous and time consuming (Ref.6). At the felling face, directional felling is mandatory to maximise production from the hauler.

These no-landing situations require immediate or near immediate removal of each drag or turn to a separate processing point, usually by skidder or, with smaller wood, by agricultural tractor. There are problems in matching the two phases of the system, but a compensatory advantage is that mechanised delimbing and length cutting is possible. Usually, two or three drags can be accumulated at the roadside without logs slipping back. This appears to be dependent on either short logs cut to length or full trees with branches on, and absence of logs or obstructions crosswise to the haul path where they are dropped. Options to such a roadside exchange system are either to rig a spar on the topside of the road so that logs may be landed on the road, or to use a swing boom yarder (common in the Pacific Northwest, but expensive), or to use a knuckle boom loader on the hauler.

MECHANISATION ON STEEP TERRAIN

FIG. 32

Menzi Muck climbing hoe on very steep terrain. The outriggers are used as legs to push the machine up and down slope.

FIG. 33

Kockums Logma operates without real difficulty on the terrain itself and steep slopes in Norway.

FIG. 34

Osa processor slewed on contour road delimbs and cuts to length logs hauled by cable machine.

FIG. 35

Levelling ability of Drott feller-bunchers enables these tracked machines to work cross slope on steep terrain.

2.4 DELIMBING, PROCESSING AND HARVESTING

There has been no real improvements in the development of multiple stem delimbing. The use of chain flails has fallen off, even in the northern interior of British Columbia, where they have been most successful on brittle limbed small logs in winter conditions. Elsewhere a rough standard of delimbing, and problems with dirt, have restricted their use.

Landing situated multiple stem delimbers based on the screw system, such as the Scruven, experience problems in loading, unloading, breaking, and removal of slash, which make them generally unacceptable. The mill based systems have the most possibilities, but there are problems with transportation being more costly, and waste disposal systems. However, drum delimber debarkers, as long as 60 ft, are now coming into use in Sweden and are expected to improve this situation.

Single stem reciprocating delimbers that grab the log and push or pull it through wraparound knives, are the most commonly used. Of these, the Kockums Logma has an excellent record for reliability and, where required, can work on slopes up to 30%. It operates from the top end of the log and it needs to be a large stable machine to do this. There are simpler, less expensive, Canadian options, modelled on the same principles as the Logma. Hurricana, Roget and Denis are proving very successful on common excavator carriers. Of the lighter machines, the Kockums 822 mounted on a skidder carrier is a most popular unit in Europe for thinning and smallwood. These stroke delimbers are considered to give better quality delimbing, and work well where the operation can be de-phased. It is possible for such delimbers to do up to 150-200 stems per hour at the roadside and in some cases, on smaller trees, 2 or 3 stems can be done at one time, if they are not too limby, but this does not apply to larger trees over .3 m^3.

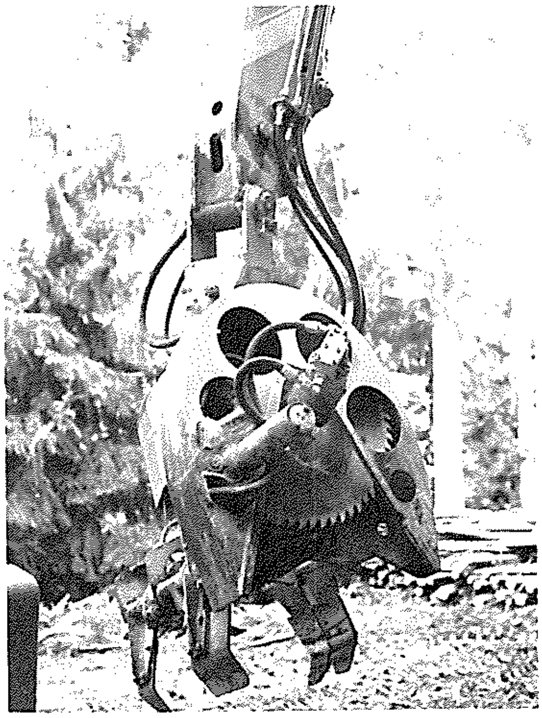
Roadside processing, on steep terrain, in conjunction with cable operations, is now receiving considerable attention in Austria, where a number of processors that may be mounted on a variety of standard prime movers have been developed. These contrast with the Scandinavian machines which are normally on modified forwarders, or specially designed chassis. Although many of the Scandinavian purpose designed machines are high producers, they are very expensive and could become orphans in a situation such as New Zealand. The Austrian machines, on the other hand, fit the earlier requirements for delimbers, identified by Gordon (Ref.7). Most of them are continuous delimbers employing a log drive system based on chains, rather than studded drums or tyres, and this system gives more positive drive with less damage to logs. Most of the units have some type of wraparound or angled knives and incorporate crosscutting devices, often circular saws, which enable better precision cutting, at speed, than chains. Steyr, Andritz and the Austrian Federal Forest Service, all produce such machines. Many of these are still in the prototype stage, and were seen working mainly on smaller limbed species, but they indicate considerable potential for future operations in New Zealand if productivity can be maintained at a level to effect cost savings.

The principle for application of processors on steep terrain is to reduce the amount of work done at the stump, and process at the roadside to get the optimum use of labour and machinery. There are problems in matching capacities of hauler and processor in such hot logging situations, and normally some type of skidding or forwarding unit is required to transfer logs from in front of the hauler at roadside to the processor location.

Harvesters that fell, delimb and crosscut, are common in Scandinavia. The aim has been to carry out all logging functions on one machine and one chassis. To apply such units is considered to need less organisation and planning, and investment per cubic metre logged. Experience indicates that there is slightly more downtime with such machines. The first generation of harvesters in Sweden gave approximately 62% availability, but this percentage was not considered important in Swedish logging

PROCESSORS ON STANDARD PRIME MOVERS

FIG.36



Austrian processing head which can be fitted to knuckle boom crane on skidder, truck or excavator.

FIG.37

Truck-mounted processor, note chain drive, which pulls logs through wraparound knives.

FIG. 38

Skidder mounted knuckle boom crane places logs in processing head fitted to the back of the skidder.

FIG. 39

Truck-mounted hauler dumps logs at roadside to be delimbed and cut to length by processing unit.

because there is a large buffer of wood supply in the field, and at the roadside. There is a feeling, however, that the Swedes may have overdone the high degree of mechanisation on one chassis and in some areas they are reverting to de-phased operations with separate feller-bunching and processing machines.

2.5 TRANSPORTATION

2.5.1 Roading

In the countries visited there was considerable emphasis on road spacing, but this appears to be more related to regularity of the terrain and the greater altitude from the valley floor to the exploitable tree line, comparative to the New Zealand situation. The fact that cable operations, normally operated from the roads rather than prepared landings, also influenced spacing aimed at optimising hauler production.

Road standards are closely controlled because of the high costs of roading, which are escalating faster than logging costs. Roads in the steep and difficult Rocky Mountain system of British Columbia are mostly single lane, as are the roads in the steep areas of Norway and Austria. It is noted, however, that to ensure safety most vehicles have radio and use it. The single lane roads not only cheapen construction costs in rock, but reduce the batter and spill. The main erosion problems are generally considered to be caused by roads, and this is a further factor which influences reduced road widths. The minimum standard is considered to be that which is necessary to carry the heaviest load safely. In most cases this might be the transporter necessary to take a hauler or loader to the logging site, rather than the logging truck itself.

The Norwegians have done a number of studies on the effect of road design standards (Ref.8). These indicate that N.Z. should look more closely at the criteria for its logging road standards in many of the steeper and more sensitive terrain in the new plantations to ensure that the standards are sufficient for safe operation without contributing unduly to overall costs.

Road construction by excavator is common in steep and difficult terrain. Normally, dozer's are still used in the easier conditions where the shovel is much more expensive, but on rocky or sensitive areas the excavator can breakout and place rock without wastage on a narrow bench much more effectively than a dozer. The Europeans pay close attention to blasting procedures to ensure that no more than the necessary rock is removed in road construction. Horizontal drilling with hydraulically operated skidder or rubber-tyred loader mounted drills is proving effective in Austria, in combination with excavators.

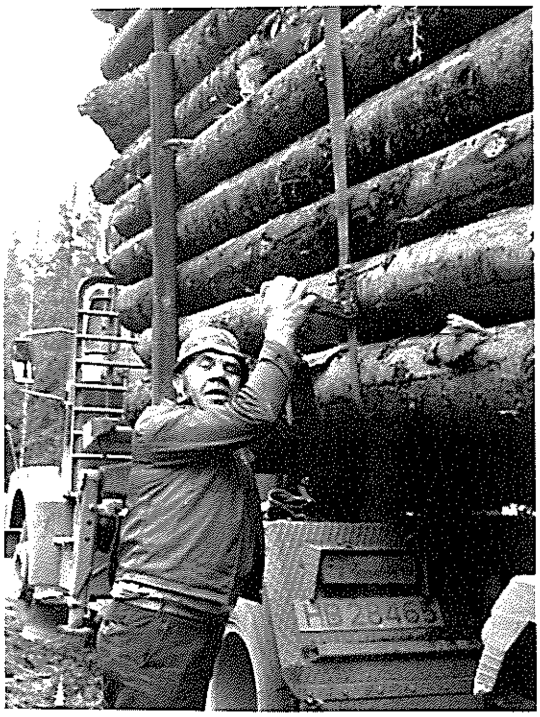
Fabrics for forest roads have been examined, particularly in Canada. They are only economic for short distances that breakdown at critical times, or where there has been inadequate time for proper consolidation. In some cases, they have uses on landings and in places where traditional materials are not readily at hand. Apparently used fabrics from paper machines have been used in some cases. There are different types of felts of woven or non-woven textiles. The woven generally have higher strength, less elasticity, but are not so good at filtration. They are laid between the base course and the top metal and the main objectives of their use are :

1. To allow the free flow of water, but not of fines. The fabric stops the fines moving up into the high quality gravel surface.

2. To stop trucks pounding the gravel down into soft materials, such as clays.

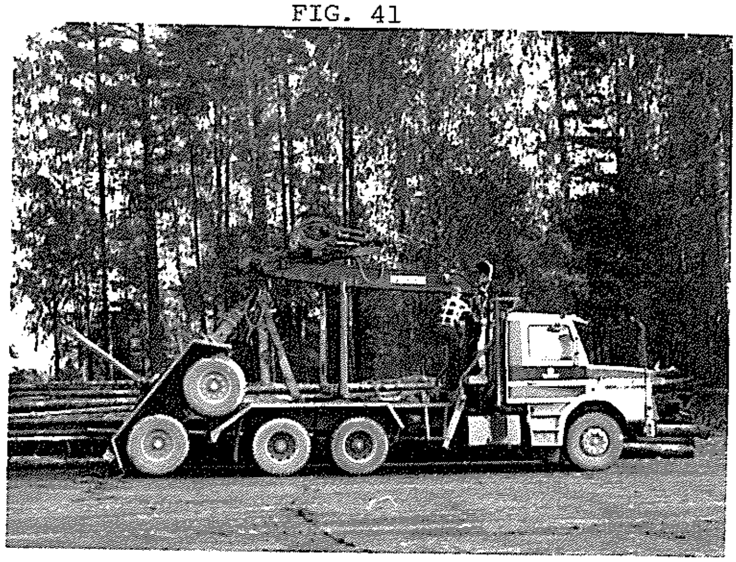
ROADS AND TRUCKS

FIG. 40



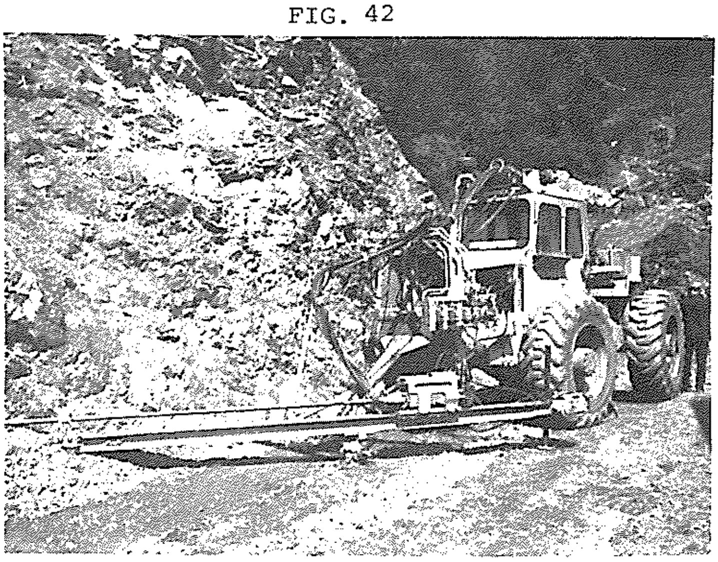
Ratchet tightening of web belly strap, commonly used in Norway.

FIG. 41



Knuckle boom loader on truck self loads trailer with folding reach pole easily.

FIG. 42



Skidder mounted hydraulically operated horizontal drill driving holes for controlled road blasting.

FIG. 43

Road construction in Austria with carefully controlled blasting and placement of rock by excavator.

3. A reinforcing function. (Less important).

As the material costs about $15.00 per square metre (1981 in Canada), it is used primarily for problem solving, rather than standard practice.

2.5.2 Trucking

FERIC, Canada, have reactivated their transportation research, the basic objective being to help industry choose components for transport machines, taking into account such things as least energy use. A computer programme is being developed to help this selection of componentry, e.g. engines, gearboxes or axle configurations, depending on road characteristics to be encountered. Long distance highway studies have also been carried out on five and six axle trailers, and what are known as 'B' trains (seven axle (3-3-2)). Basic to these studies is a road recorder truck that traverses a road automatically recording grade and curvature from which a computer printout is obtained. In the highway situation they can key in speed limits, bridges, turnoffs, etc, to assess the effect of particular road routes. The study figures are being integrated with a vehicle mission simulation package designed by Cummins Engine Co., which aims at checking truck performance.

Transportation of whole trees is receiving attention in Eastern North America, Scandinavia, and Germany. A primary problem is on the low bulk density of this material which tends to restrict payloads to 75% of normal on-truck volumes. New designs are being considered that will restrict the top and branch material within cross sectional limits and various systems for compaction are being investigated. In the case of very small material for energy or fuel wood, bailers have been developed in the U.S.A.

Self-loading trucks and trailers are most common in the areas of Europe where steep terrain and lack of landings limits the use of separate loading machines. Nearly all of the long log units can reload their own trailers, and can operate from roadside stockpiles. In the very steep terrain, short log truck and trailer units are common because of their ability to negotiate the tighter curved narrow roads.

In Norway, synthetic webbing material is commonly used as a tie down for truck loads. The material can be easily thrown over loads, is stored on a spring-loaded spool when not in use, and has a ratchet system for tightening, which is very simple.

In British Columbia, one ounce of glycol antifreeze in the tyres is considered to act very well as a tyre coolant in tubeless tyres. Tube tyres are not used, as it is considered there are too many moving parts, tube, tyre, boot, etc, which cause overheating. In the tubeless tyres the bonding surfaces between rim and tyre have been improved and they expect to get two recaps out of tubeless tyres.

2.6 WASTE WOOD RECOVERY - ENERGY HARVESTING

In the northern hemisphere, particularly Eastern U.S.A. and Canada, and the Scandinavian countries, there is considerable interest in development in the recovery of fuelwood and energy harvesting. Some of the new developments have implications for waste wood recovery or smallwood harvesting in New Zealand.

In the north eastern area of U.S.A. some companies have converted the whole of their kraft mill input to whole tree chips. The success of this system has depended on heavy screening through several stages at the mill, but it has enabled the whole woods operation to be successfully fully mechanised. Bark chip separation continues to be a problem, although the U.S.D.A. laboratory at Houghton, Michigan, is having success with separation by air flotation and compression debarking.

The Houghton laboratory has also developed spiral head and disc shear chippers, to produce chunkwood chips, 7 cm in length. The disc cutters accomplish fast speed shearing of the wood at a quarter to half the energy requirements of conventional chipping devices, and this type of chipping allows recovery of debris previously wasted. Field trials are currently being conducted.

One company, Westvaco, in Virginia, U.S.A., have cable logging operations in mixed hardwoods where wood is taken directly from the cable hauler to a whole tree chipper on the landing. These operations produce approximately 220 tonne of chips per day, as well as some sawlogs.

Field drying of logging residues and bailing of tops and limbs has been developed at the Virginia Polytechnic Institute. The objective is to transform woods waste into sizes for easier handling. Compaction crushing of the bigger pieces has enabled higher density bales.

In Sweden, a tree section harvesting system is under development, whereby early thinnings with limbs on are extracted whole and cut in sections, without delimbing, for transporting to the mill and processing there in large drum debarker/delimbers. This system is still at the prototype stage but the indications are that costs will be better than shortwood thinning, or field chipping. However, there are still some unsolved problems in reduced efficiency in transportation of the material and reduced debarking productivity.

The Canadian RECUFOR concept is a rotary pick-up system for recovering and processing ground logging residues, like tops, branches and chunkwood. The experimental prototype is undergoing field tests this year.

3 SUMMARY OF RECOMMENDATIONS

On Management of Research and Development Effort

1. That a high proportion of the R&D effort continue to be concentrated on applied research, particularly evaluation of potential of machines and system, and development of methods to make the best use of machines procured.

2. That a high proportion of LIRA's resources be allocated to extension, i.e. technology transfer to ensure that the results of relevant R&D and appropriate new developments are applied in the field.

3. That every effort be made to increase the intensity of training at all levels and that now, in a downturn, is the time to do it to prepare for the 1990's expansion and that the training systems be increasingly oriented to implement the latest technology through courses, etc.

On Operations

1. Systematic felling needs to be introduced to get the most productive logging without loss of wood. Appropriate methods of directional felling, trimming and crosscutting must be developed for each distinctive extraction and/or processing system. The developed methods then need to be incorporated in training programmes.

2. Mechanised felling and processing on steep terrain is a future possibility in New Zealand but only when the relationship of man and machine cost and availability changes. Given currently relatively cheap labour rates and unemployment, it would be both uneconomic and immoral to attempt to introduce highly mechanised systems. In the meantime, there is considerable development taking place which is worth monitoring. The Austrian roadside processing units, in particular, could have future application.

3. That the productivity and costs of hauler operations could be improved by better planning combined with the use of systems aimed at reducing power and capital requirements by ensuring clearance is maintained throughout the hauling process. To achieve this :

   (a) Running skylines, gravity return systems, and more versatile carriages, should be more widely applied.

   (b) That development should continue, aimed at perfecting simply controlled hydraulic haulers with the capacity for interlock and running skyline systems.

   (c) That the possibilities for lessening downtime and improving rigging and rope handling, by using polyester slings, climbing ladders, strawline packs, chain chokers, rigging winches, etc, be fully explored.

4. That in woodlot logging and the smaller operations, particularly thinnings, there is some scope for the application of agricultural tractors fitted with some of the accessories developed in Europe for logging with these units, such as double drum and front-mounted winches, skidding tongs, and mobile hauler applications.

5. The use of small agricultural tractor operated haulers is feasible for woodlot logging where log size is under 2 metres and/or in thinnings on steep terrain, but successful use will depend on adequate training of users to use systems and rigging suitable to these machines.

6. That the use of polyester web strapping be fully investigated for application in securing truck loads and the lighter cables, such as guys in thinnings hauler operations, and that the sheathed polyester choker slings be investigated for smallwood harvesting with both skidders, agricultural tractors and haulers.

7. That the current road standards in steeper terrain be examined to ensure that development finance is not being wasted in an unnecessary high standard of road construction and that in connection with this that there be a wider application of excavators in road construction, particularly in the steeper, rockier, or more soil sensitive areas.

APPENDIX I

OVERSEAS RESEARCH ORGANISATIONS VISITED

American Pulpwood Association,
1619 Massachusetts Ave.,
Washington D.C., 20036,
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Mr K. Rolston, Exec. Vic President

Austrian Training School,
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Austria.
Dr T. Trzesniowski, Director

FERIC (Forest Engineering Research Institute of Canada),
143 Place Frontenac,
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Quebec, H9R 4Z7
M.S.M. Hamilton, President.
G.P. Chinn, Manager, Eastern Div.
Ph: (514) 694-1140 Telex 05-822652

FERIC,
Suite 201-2112 West Broadway,
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Mr G.V. Wellburn, Manager - Western Division.
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Forest Engineering Department,
School of Forestry,
Oregon State University,
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Dr G. Brown, Dean.
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Forestry and Harvesting Training Centre,
Gulf Park Campus, Long Beach,
Miss. 39560, U.S.A.
Mr J. Mann, Director.
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Kuratorium Fur Walderbeit und Forst Technick, (K.W.F.)
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Dr Dummel, Director.
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Dr P.L. Cottell, Director Harvesting Research.
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Munich University,
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Mr P.T. Brenoe, Director.
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Mr B. Abegg - Division of Forest Techniques and Organisation.

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Mr G. Taylor, Director Harvesting and Marketing Division.
Ph: 031 334 0303

U.S.D.A. Forest Service,
Pacific Northwest Forest and Range Experimental Station,
Forest Engineering Research,
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U.S.A.
Mr C.N. Mann, Project Leader.
Ph:

Weyerhaeuser Company,
Tacoma,
Washington, 98401, U.S.A.
Mr D. Davidson, Director Raw Materials Research and Development.
Ph: (206) 924-6494.

APPENDIX II

U.S.A. UNIVERSITIES HARVESTING RESEARCH

School	Type of R&D	Specific Research
Univ. of Cal. & Davis (Ag. Eng.)	Analysis and Equipment Development	Simulation Pre-bunching machines Cable systems Modifications to Conv. Mach.
Univ. of Idaho (Ind. Eng.)	Analysis and Equipment Modification	Modification of small industrial backhoe to skidder for small wood Prod. testing of Koehler 300
Purdue (Ag. Eng.)	Analytical	Thinning Hardwood control in plantations Short rotation of hardwoods Potential of wood combine
Mich. Tech.	Analysis and Equipment Testing	Field studies of equipment Whole tree chipping Thinning Utilisation of tops
N.C. State	Analysis	Testing of F-B on steep slopes Kochums - 800 - 60% Menzi-Muck - up Nordfor flying saw - bunching
O.S.U.	Analysis and Equipment Development	Impact of harv on soil and H_2O Fuel consumption Research design Small yarders
Univ. of Wash.	Analysis and Equipment Development	Damage to logs from yarding Compaction of Wood Residues Analysis of Harv. Costs.
Auburn	Analysis	Machine and timber relationships Thinning machines and systems

School	Type of R&D	Specific Research
Univ. of Maine	Field Studies and Analysis	Small equipment for woodlots Kubota and Farmi winches Scandinavian machines Bunching
M.S.U.	Analytical	Fuel consumption Instrumentation for fuel cons. Thinning in U.C. Plains Simulation Modelling of R.T. feller-bunchers
V.P.I.	Analyticl and Equipment Development	Baling of logging residues Design of short rotation felling heads Economic analysis by simulation
L.S.U.	Analytical	Helicopter logging in Cypress Makeri feller-buncher
Colo. State		Scale model yarding on specific saw Evaluation of Highlead (from evaluation of history)
Univ. of Geo.		Record keeping with mini computers

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6. VIK, Tore. Cutting of tree-lengths and full-trees in very steep terrain. Performance and workload. In Norwegian Forest Research Institute. Report on forest operations research No.18 (1980) : 17-39.

7. GORDON, R.D. Delimbing studies. Rotorua : New Zealand Logging Industry Research Association, 1976. 44p. (Project report, New Zealand Logging Industry Research Association, No.4).

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