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LOGGING INDUSTRY RESEARCH ASSOCIATION

NEW ZEALAND

PROJECT REPORT

AN INTERNATIONAL PROJECT INVESTIGATING THE FELLING AND BUNCHING OF SMALL TREES ON EASY TERRAIN

P.R. 22 1984

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

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N.Z. Logging Industry Research Association Inc.,
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AN INTERNATIONAL PROJECT INVESTIGATING THE FELLING AND BUNCHING OF SMALL TREES ON EASY TERRAIN

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INTRODUCTION

The International Energy Agency (IEA) has undertaken to co-ordinate a research programme in the field of utilising forest biomass and residues for energy intensive products. The programme operating under the Forest Energy (FE) Agreement is divided into three planning groups called co-operative projects (CP)s.

1. CPB covers growth and production, mainly involved with species selection, breeding and evaluation.

2. CPC works in the field of harvesting, storage, transport and primary processing of forest biomass.

3. CPD is concerned with the conversion of forest biomass by combustion and direct liquifaction.

A joint association between the Liquid Fuels Trust Board (LFTB), the Forest Research Institute (FRI) and the Logging Industry Research Association (LIRA) has become actively involved in the CPC planning group, which is divided into 12 different workshops. The workshop of particular interest to New Zealand is the CPC7 group, which is concerned with felling and bunching small trees from thinnings using small-scale equipment on gentle terrain. There are nine countries involved in this group, each controlling one or more of the eleven subprojects. A list of the subprojects and the countries controlling them is shown in Table 1.

TABLE 1

	Subproject	*Country in Charge*
1.	*Bunching (chokers and horses)*	*Belgium*
2.	*Feller-chipper*	*Canada*
3.	*Continuous feller buncher*	*Denmark*
4.	*Felling principles*	*Denmark*
5.	*Grapple bunching*	*Ireland*
6.	*Winch bunching*	*New Zealand*
7.	*Base machines*	*Sweden*
8.	*Crane mounted feller-buncher*	*Sweden*
9.	*Motor-manual felling and bunching*	*Norway*
10.	*Chassis mounted feller-buncher*	*U.S.A.*
11.	*Felling patterns*	*Norway*

The long-term objective of the project is to specify, design, and test a small number of prototype machines over a five year period. The four phases of development are :

Level A - Test and evaluation of existing methods and machinery, the research to be organised and carried out in comparable systems.

Level B - Description and development of a set of demands and criteria for development of relevant machinery and equipment. Silvicultural, technical and economic restrictions should be the basis for the results.

Level C - Final description of the machine system. This level should be joined by countries who are already working in this field.

Level D - Initiation and evaluation of new techniques and methods.

Each participating country pays a set amount ($1,829.56 in 1983) into the IEA FE CPC7 account annually to fund the project. This can be drawn upon to carry out research or cover the costs of attending meetings. Every year representatives from the countries meet in a selected country to present reports on the progress of their subprojects and to discuss future proposals.

In 1983 the meeting was held in Belgium and eight of the nine countries were represented. A list of the participants is shown in Appendix 1.

This report covers in detail the reports presented at the meeting, gives an account of the field excursions that were organised and discusses the prospects of continuing participation in this project.

All costs quoted in this report are in N.Z. dollars unless otherwise specified.

BACKGROUND

LIRA's involvement in this IEA FE CPC7 project began in 1982 when it was appointed New Zealand's managing agent for the project. For the first meeting, held in Denmark 1982, a National Status and Planning Report (Ref.1) was prepared by each country to begin the information exchange process. A member of LIRA's staff attended the 1982 meeting where it was decided to divide the project into eleven subprojects and responsibility for those subprojects were allocated to countries with a specific interest in that field. As a result of that meeting, New Zealand took control of the winch bunching subproject and agreed to be involved in :

1. Bunching (chokers and horses);

2. Grapple bunching, and

3. Motor-manual felling and bunching.

A questionnaire was prepared for collecting information about winch specifications and descriptions of the systems in which they were used. This questionnaire was distributed to countries participating in the subproject and to some New Zealand companies. The response, unfortunately, did not provide the information that was needed, so a search of relevant literature had to be made to supplement the winch bunching subproject presentation.

At a pre-meeting held in Brussels in 1983, prior to the main IEA FE CPC7 meeting, the proposed increase in contributions to $2,067.07 for 1984 was outlined. All countries accepted this increase. A joint Status and Planning Report (Ref.2) compiled from the National Reports, was tabled and discussed and countries were given until January 1984 to put forward any amendments.

The participants were reminded of the need for appropriate progress reports to be sent in on time for the overall PGC meeting which decides future direction and funding for the projects. As the FE agreement officially terminates at the end of 1984, the meeting was called on to decide whether a three-year extension to the project was necessary. The general feeling was that the CPC7 group should not just meet for the sake of meeting, but provided the project was developing along useful lines the avenues for extension should be kept open.

The next day, following this meeting, a field excursion to Soignes, Louvain la Neuve and Cedrogne was taken, ending up in Worriken Bütgenbach, where the main meeting was held.

SUBPROJECT REPORTS

A review of the progress of each subproject was presented by a representative of the controlling country at the meeting in Butgenbach. Although some countries had gone to considerable trouble to present their material in a well structured fashion, others had obviously put little effort into their presentation. The well prepared reviews took the form of a tabled paper supported by slides and overhead transparencies. At the end of each presentation the opportunity for questions and discussion was available. The meeting was of the opinion that the usefulness of this information exchange phase of the project could be improved by subproject leaders clearly identifing their objectives and circulating the appropriate questionnaires. A decision was made to extend the circulation of these subproject questionnaires to all countries in the CPC7 project, rather than just the countries participating in that subproject. The main reason for this was that countries outside the subproject area often had useful information relevant to the topic, but were not asked for it.

Each review has been summarised for this report and salient points of particular interest to New Zealand are covered in more depth.

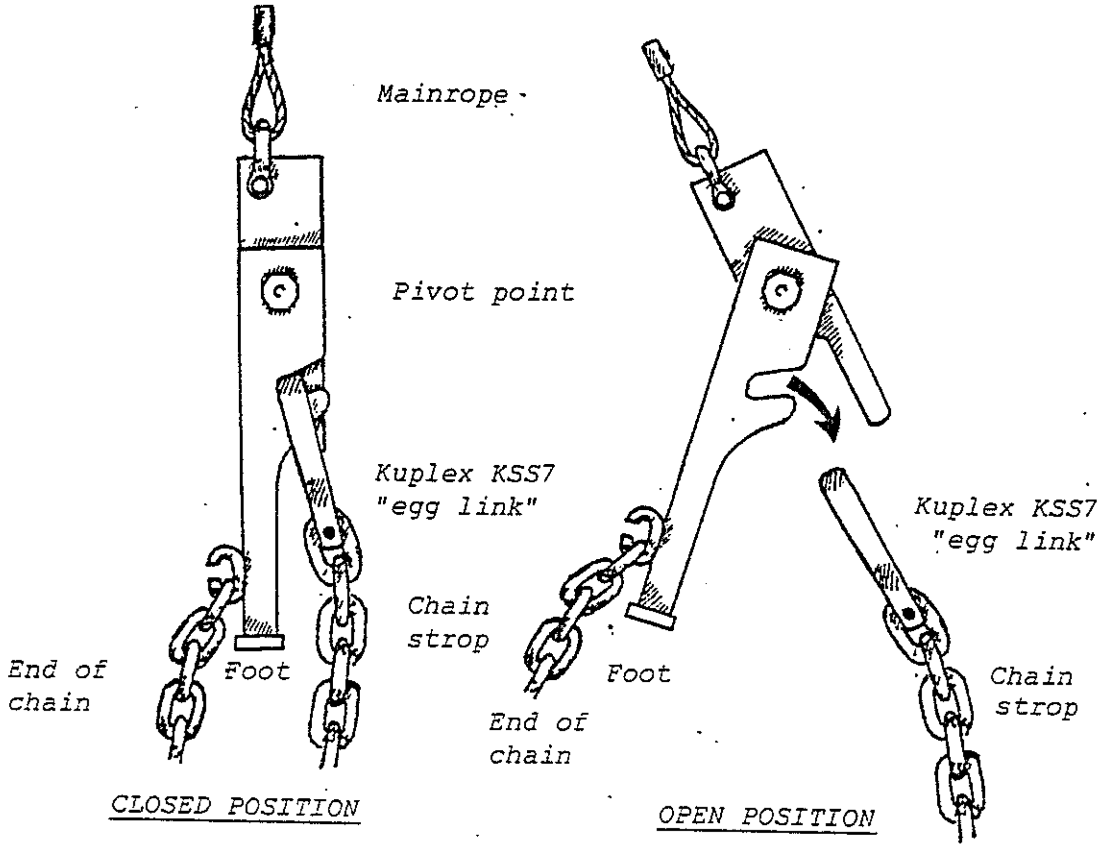
1. <u>Bunching with horses</u> (includes rigging options)

   Subproject leader - Belgium

   To ensure a mutual understanding of the various items described, a terminology of common rigging components had been prepared to introduce this subproject. No new or different innovations were included as far as New Zealand was concerned, although a quick release hook suitable for attachment to a hauler main rope, or skidder winch rope, was described by Ireland. This release mechanism was modelled on the original Timbermaster quick release hook but cost considerably less to fabricate (see Fig. 1).

   A comparison of the different ways the three contributing countries had used horses for logging was made, with most attention focussed on the harnessing equipment. Due to silvicultural and environmental constraints in Belgium, logging or bunching with horses relied mainly on a direct line of pull from the horses harness to the log or logs. This resulted in the spreader bar having to trail on the ground behind the stepping arc of the horses rear hooves and necessitated a short strop when attaching logs. Some spreader bars used in Belgium are triangular with strop attachment being to the apex of the triangle. Productivity with the horses varied anywhere between 15 and 40 m^3 per day, depending on tree size and extraction distances. Individual drag size ranged from between 1 and 1.5 m^3 and

Fig. 1 - A lightweight quick release hook



over short distances daily productivity as high as 80 m^3 had been recorded. A working day in Belgium, however, can be up to ten hours during the summer months.

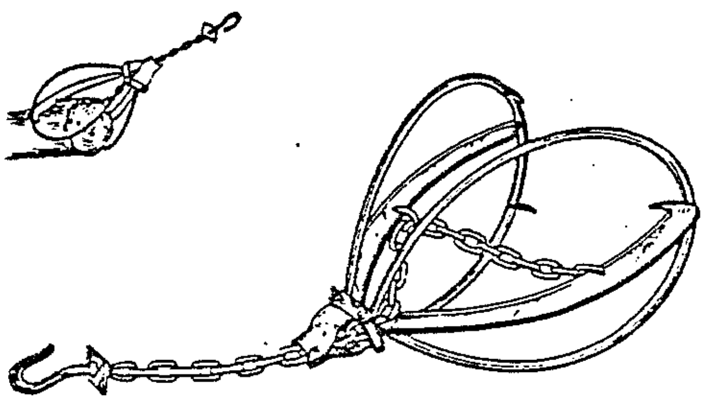
There were two harnessing methods used in New Zealand. The first being very similar to what was described for Belgium, the second, slightly more complex, was called a spider harness which employed webbing straps to elevate the spreader bar above the knee joint of the horses back legs. The log attachment method remained the same.

The data available from Sweden revealed a different approach to horse skidding in that country (Ref.3). Depending on the ground conditions and the size of assortments various skid and wheel mounted sulkies attached directly to the harnesses were used. These sulkies ranged from single skid mounted bar attachments for winter use, to sophisticated wheel trailers with hydraulic loading devices to be used in summer (Ref.4). Where extraction to a truck road was proposed, sleds or trailers that could carry the logs clear of the ground were used, while in a bunching to extraction strip operation the simple two skid sleds, sometimes used with a nose cone, were the main skidding methods. Payloads, when extracting to a truck road, could be in the region of 2 to 5 m^3 and when bunching, an average production of 7 m^3 per hour was quoted.

Generally, shoeing of horses was done on a two-monthly basis at a cost of round NZ$150.00 according to the information supplied. The average cost of outfitting a horse for logging in Belgium was estimated at $1,335.00, excluding the cost of the horse.

Sweden tabled a publication on tools and equipment for horse logging (Ref.3), including loading devices and skid pan designs. One item that could be of interest to New Zealand was the Domän tongs. (Refer fig. 2). The tongs weigh less than 10 kilograms and could be used on logs up to 60 cm.diam. They are sold by Nordforest in Sweden for around $95.00.

Fig. 2 - Domän Tongs



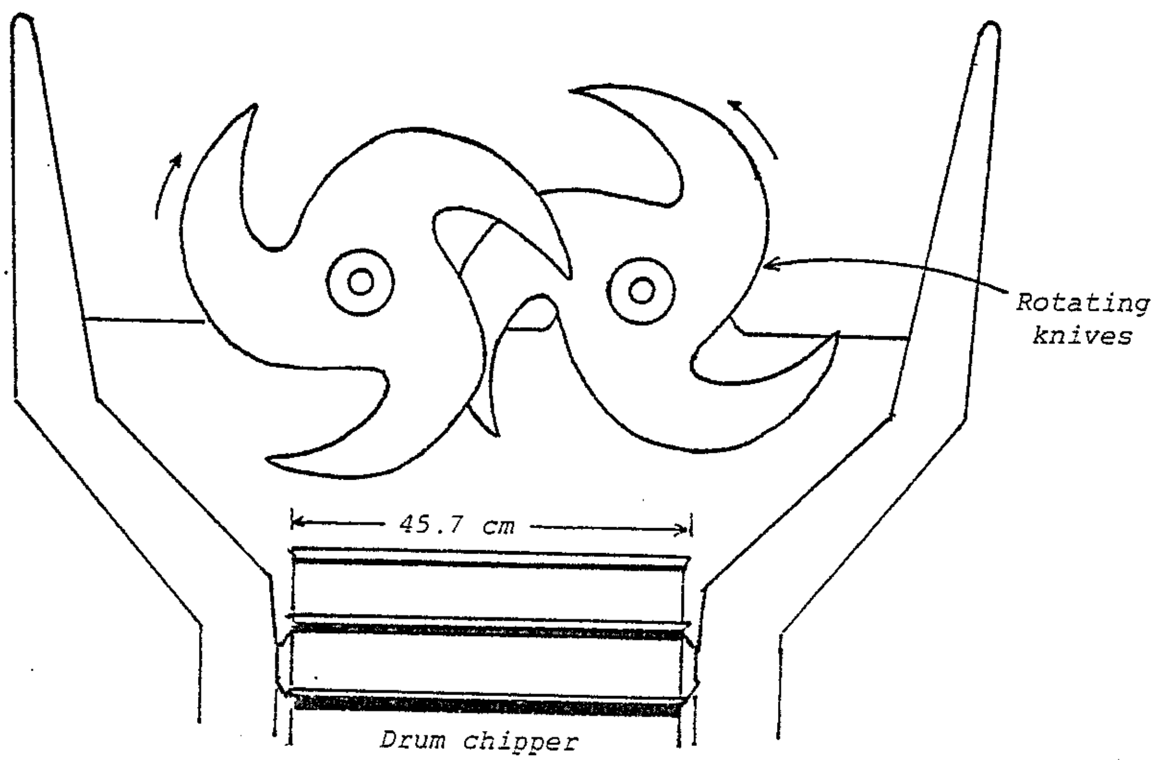
The information received on the use of horses in bunching and extraction would be of limited interest to the New Zealand logging industry as a whole, but the ideas of loading and sled skidding could provide some useful suggestions to the few loggers using horses here. The tongs and strop attachment concepts are worthy of follow up work as they can be applied to other areas of log skidding. The future work proposed in the horse bunching subproject was to look at the tractive efficiency of various breeds of horse and to try and establish why there are such vast differences in the food consumption levels, between countries. It is hoped that by the 1984 meeting, the productivity figures, costs and maintenance data of running horse operations will be available.

2. <u>Feller Chippers</u>

Subproject leader - Canada

An upsurge in interest has been shown in this feller chipper idea, particularly in Canada where demand for spruce and conifers to improve paper strength has been increasing. One particular example discussed was the Pelari harvester, which had been designed for row thinning where the cut stems were fed directly into a drum chipper.

Fig. 3 - Felling head of the Pelari Harvester



The average size of stem that could be handled with this machine was about 15 cm in diameter. Problems had arisen in the transfer of the stem from the knives to the drum. It was suggested that the possibility of vertical chipping should be investigated.

One of the major drawbacks to feller chipper development was the relatively low value of the chips produced. For example, chips produced from on-site chipping were selling for around $11.00/tonne while prices for green pulpwood chips were up as high as $76.00/tonne. One approach to overcome this particular problem in clear felling has been to offset cutover salvage costs against the cost of land preparation. The system tried had a mobile chipping unit feeding into bins. After clearfelling had been completed the slash had been raked into rows with a John Deere skidder fitted with a large modified blade. A Morbark chipper mounted on a Timberjack then chipped the rows into detachable chip vans. Once full these chip vans were extracted by the John Deere skidder and the chips transferred into a transport van by means of an agricultural blower, mounted on the back of a GMC jeep. The low quality chip produced was marketed as residential heating fuel. A report published by the National Research Council in Canada on "Mobile Roadside Chipping Feasibility and Design Concepts", by C.A. Short and J.E. Kipping, detailed production figures and costs of the aforementioned operation.

A French development called the Scorpion feller chipper was discussed, but apparently the availability of funding to complete this project had not been finalised.

One further item of interest was the Canadian experience using wood and foliage from aspen to produce winter feed for stock.

At this stage the feller chipper subproject required more work to be completed. The existing trends in the development of mechanisation in New Zealand suggests that even then, it will have limited application here. The design concepts and prototype development will still be of interest to research groups, in particular the FRI.

3. <u>Continuous Feller-Bunchers</u>

Subproject leader - Denmark

For this presentation the construction of a prototype continuous felling head designed to fit on an agriculture tractor was traced through the various development stages (Ref.5). Skovteknisk's objective was to establish design criteria and study the cost benefits of continuous felling and accumulation when thinning young stands of Norweigan spruce. The base machine used for the trials was a modified International Hydro 84. The hydrostatic transmission of this machine enabled it to easily change direction from forward to reverse, which helped with the bunching phase of the operation. The felling unit was three point linkage mounted and could support three to four cut trees in either side of the head (refer fig. 4). The tractor would simply reverse up the row while trees were being cut and stored in a vertical position in an accumulating frame. When a full load of trees was cut the tractor would extract them to the skid road and release the side arms of the frame to allow the trees to fall in a bunch.

Initially a shearing mechanism for severing the stems was considered but this was abandoned in favour of four flails mounted on a rotary disc. Provided the knives were kept sharp the idea worked well, but keeping the knives sharp was the problem. Similar problems with keeping cutting edges sharp also occurred when the milling technique was tried.

One further disadvantage found with using a rotary disc as a basis for the cutting knives was the limits on diameter that could be handled. For example, a disc with a minimum diameter of 25 cm is necessary to cut 12 cm stems, and that means a high power input is necessary to drive the disc. A possible solution to that problem arose from the meeting. This was based on the Boreal idea of twin horizontal discs powered from a common central driving mechanism (refer fig. 5). With this system, the two discs, one mounted above the other, would take out a narrow biscuit of wood between the stump and the stem, hence utilising the full diameter of the discs. The biscuit would have to be split somehow to enable it to pass either side of the drive mechanism.

Fig. 4 - The felling and bunching unit mounted on an agricultural tractor

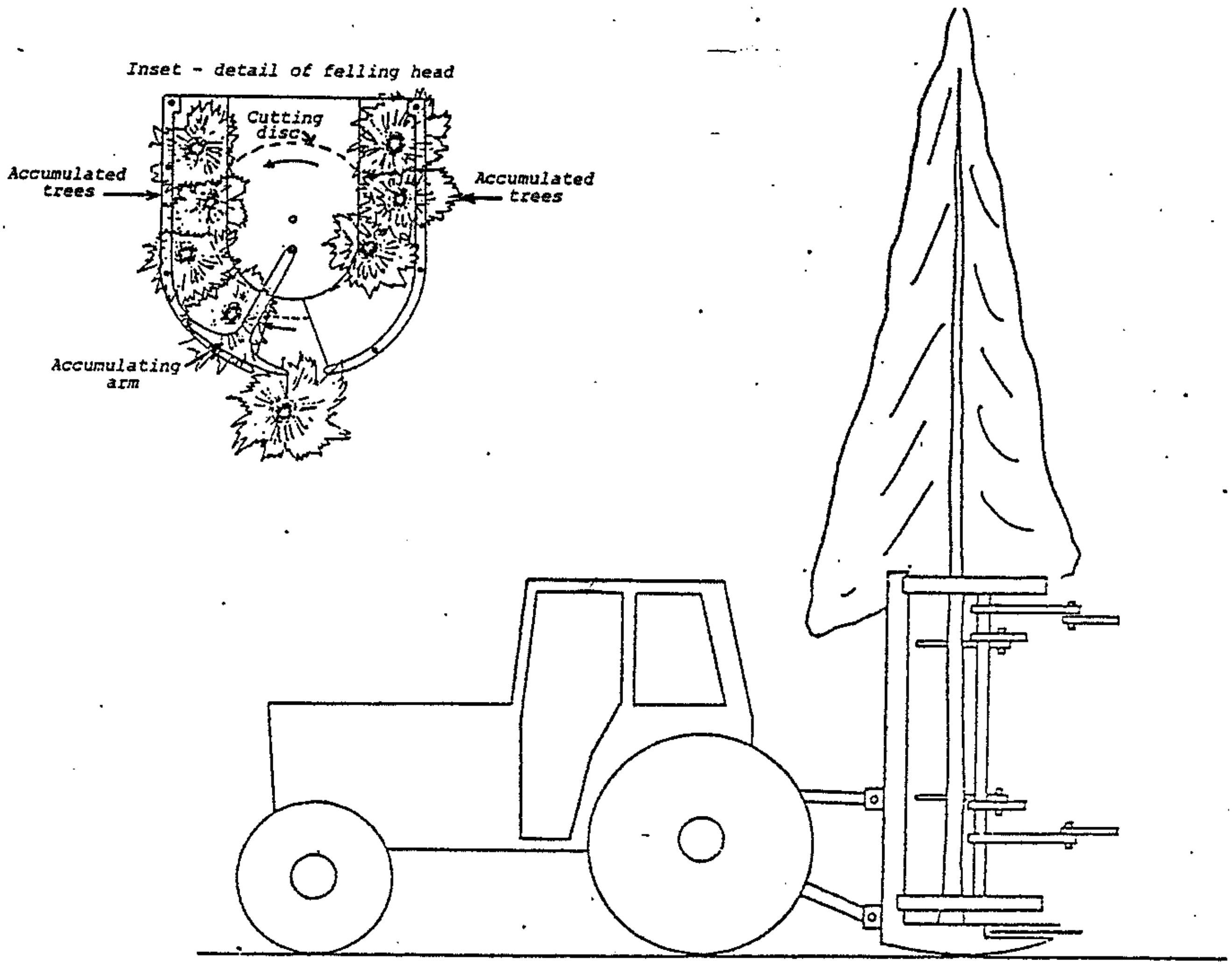
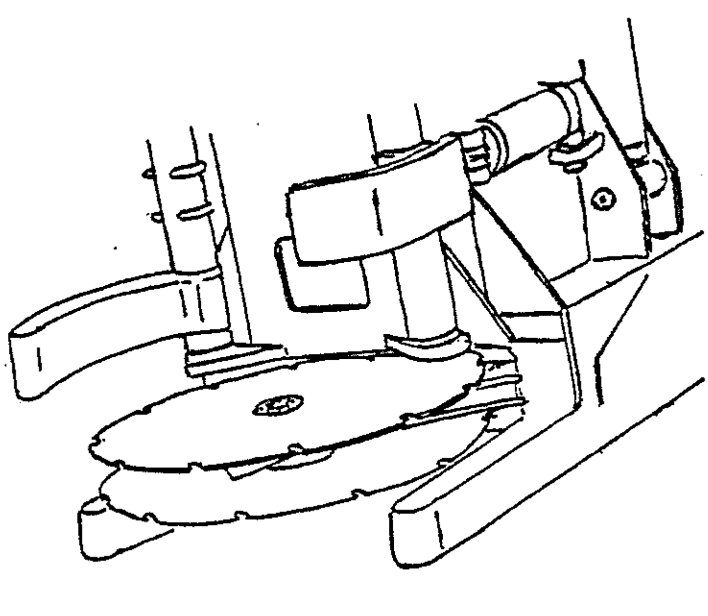


Fig. 5 - Twin disc Boreal concept for felling



Other problems that appeared during the trials were the difficulty in controlling the tractor when a full load of trees had been accumulated in the head. The tendency was for the crowns of the cut trees to catch in the residual stems causing a reduction in the machine's stability. These problems, however, have been partially overcome by redesigning the head to a smaller more compact unit to cut down on the amount of weight mounted on the three point linkage. Also by angling the top of the accumulating frame in towards the centre of the head, the crowns of the cut trees could be kept in the middle of the row.

To avoid cutting the rocks which made the knives blunt, a small sensor wheel could be added in front, but to one side of the infeed to the disc. Conceivably this would also improve the stability of the unit when fully loaded. Further discussions resulted in the suggestion that a machine with a conveyor type through feed system should be designed so that a cut tree could be moved in the vertical position to an accumulating frame at the back. In this way, the bunches could be dropped in the row without the machine stopping. The engine and driver's compartment could be offset to either side to enable this through feed system. It was pointed out, however, that the concept was getting away from the original idea of a low cost attachment for felling and bunching wood that has a relatively low market value. The unit cost of the prototype head would be in the region of $18,635.00 with an hourly running cost of $29.80. It would cost 58¢ per tree, working on the assumption that the machine could fell and bunch 51 trees per hour. Simulated production levels indicated that the number of trees per hour could be increased with closer outrow spacings and in clearfell, so costs per m^3 could be reduced.

Generally, the example shown in this continuous felling and bunching project had no application in New Zealand because it was designed for tree diameters 8-10cm. The ideas expressed, however, were certainly worth recording in case the principles could ever by applied on a large scale for row thinning here.

Plans for the future of this continuous felling subproject included investigating the possibilities of shearing again as opposed to rotary discs for felling. Suggestions for reducing the dimensions and the weight of the head were welcomed as were any ideas on using a different base machine, the aim being to improve stability. To avoid repeating any unknown mistakes for a second time, a closer analysis of the principles used in the system was to be made.

4. Felling Principles

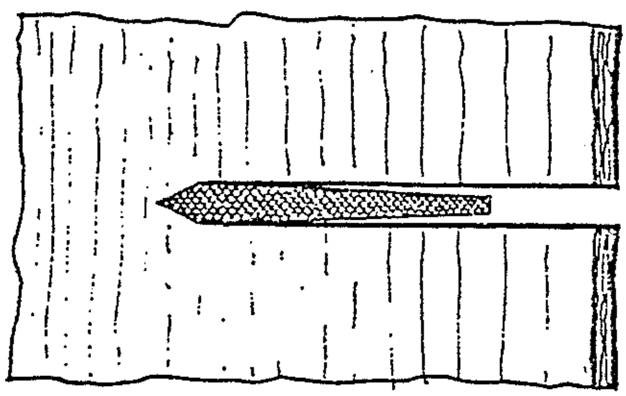
Subproject leader - Denmark

A detailed survey of mechanical felling methods had been undertaken to determine capacities and power requirements of each type, and to investigate their suitability of both continuous and intermittent felling operations. There was a

20% reduction in felling time with continuous felling systems. The advantages and disadvantages in terms of power requirements, size, maintenance, stem damage, etc., were described for different combinations of shear, chainsaw and rotary disc cutting methods (Ref.6).

The shear was described as a low maintenance cutting method which was limited to relatively small tree diameters because of the size and power required to handle larger stems. It was noted how the angle of the shear cut directly affected the shearing force necessary to cut the tree - this force being highest when cutting perpendicular to the grain. The angle of the cutting edge, as long as it was above 30° and below 60°, had little influence on the shearing force. However, if the shears were subjected to vibrations parallel to the cutting direction, shearing force could be reduced by 30 to 50%. A shear tapered towards the back behind the cutting face was found to be more efficient than a normal flat shear (refer fig. 6).

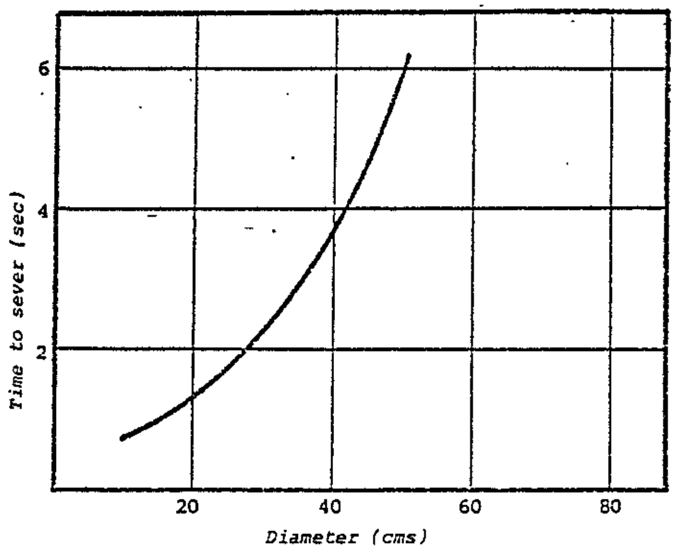
Fig. 6 - A shear, tapered towards the back for more efficient performance



Using a chainsaw to cut the trees was seen as a better option for larger trees and resulted in less damage to the stem. However, high maintenance costs and the increased susceptibility to damage from stones or jamming in the kerf offset these advantages. With chain speeds of between 25 and 45 m per second, and up to 50 kilowatt motors driving them, cutting rates could be high although operational problems of rocks and jamming in the kerf still existed. Felling time per stem increased significantly as the diameters got bigger (refer fig. 7).

Less power was required for the disc type cutting device which, if sharp, could have a very fast cutting rate. But keeping the knives or cutting teeth sharp was a problem. High maintenance costs have also been associated with disc felling methods. It had been found that two smaller discs had a lower weight and less power requirements than one large disc, however, both options were relatively inefficient as less than one third of the disc or discs could be used for cutting at any one time.

Fig. 7 - Time to cut stems as a function of diameter.



The auger, or milling cutting methods, had been tried in Canada and in Denmark with both peripheral and auger type millers. Field experience indicated that they were reliable but maintenance costs were high, particularly when frequent sharpening was necessary. Power requirements for the circular saw type were generally low (less than 7 kilowatts for 25 cm diameter Spruce). The auger type, or cylindrical miller, had certain advantages over the chainsaw cutting methods when used in larger diameter trees because it was not sensitive to the kerf closing (refer fig.8). This unit could handle trees up to 60 cm diameter at the base. Flails worked successfully in smaller diameter trees less than 12 cm, but power requirements were relatively high and maintenance and stem damage were also above other systems. Once again the knives were sensitive to damage and efficiency dropped rapidly if they became blunt.

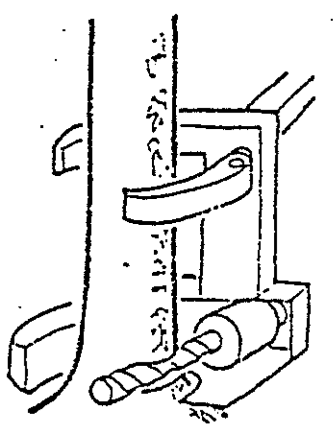
Other options such as anvil and shear combinations, scissor type shears that cross over, saw chain with no bar support, offloading band saws, etc., were discussed, but limited information on them was available.

Interest tended to centre on the horizontal circular saw type felling system as that appeared to have the most potential, particularly in the small tree harvesting situation.

Some of the cutting methods identified in the felling principles section could be of particular interest to certain factions in New Zealand's logging industry.

More information on the various techniques is likely to become available as further development takes place, although as yet no one has been able to fully overcome the inherent high costs of mechanised felling.

Fig. 8 - Auger-type felling head



No particular felling method was identified as the best option although all systems had advantages and disadvantages when compared with the others. Further investigations were needed and an update of this information should be presented at the next meeting. Continued development and refinement of the horizontal circular saw method was planned.

5. Grapple Bunching

Subproject leader - Ireland.

A review of the available literature on grapples was conducted to supplement this presentation (Ref.7). The objectives of the grapple bunching subproject were restated as follows :

1. To test and evaluate the range of forest logging grapples currently available.

2. Compare the performance of logging grapples with conventional choker systems - tractor-mounted winch and chokers.

Grapples were not in common use in Ireland because of the ground conditions (peat bog) which meant that planting ribbons had to be formed to establish trees. It was the size and extent of the ribbons, combined with the soft ground conditions, that made grapple operation difficult. Planned trials with a KAR grapple in pole and tree length operations were delayed by the late delivery of the grapple.

From what had been recorded on the use of grapples in thinning, the presentation of the timber was considered critical. Butt first presentation reduced breakage and log loss but, under some conditions, resulted in an increase in felling costs. This was particularly noticeable when comparing row thinning with the row plus chevron* system. The use of a grapple in shortwood operations had not reduced the amount of manual effort required on the part of the faller because manual stacking was still necessary to keep the grapple productive.

Because of the additional weight transferred to the rear of the skidders or tractors with a grapple, it tended to be less suited to soft ground conditions or slopes above 20%. Winch skidders were considered more versatile as they could drop their load and reposition with it still connected to the winch rope. The time taken to collect a drag was much quicker and less tiring for the operator of a grapple skidder but the importance of optimising every payload to capitalise on this advantage had to be remembered. The grapple also eliminated the need for the operator to get out of his cab in adverse weather conditions.

Three main types of grapple were identified - the basic type, the horizontal and vertically adjustable type, and the boom type grapple. The basic model, which had two jaws operated by one or two double acting hydraulic rams and a rotator, was considered more suitable for extraction than bunching because, generally, it had limited stacking ability and no horizontal movement. An example of this type of

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* Chevron - trees felled on a diagonal strip between two outrows (refer Fig.11).

grapple was the hydratongs (see fig.9). Grapples with more functions, such as horizontal and increased vertical movement, were often three-point linkage mounted and more suited to the bunching operation, particularly in heavily stocked stands. Usually, the grapple size and consequently the payload of this type of grapple was smaller.

Stacking height, even in the best conditions, seldom reached above 1.5 metres. Some of the more sophisticated grapples produced had a winch and fairlead arrangement incorporated in the three-point linkage frame, which enabled material to be winched to the grapple. An example of a grapple with horizontal and vertical movement was the Highland grapple (refer fig.10).

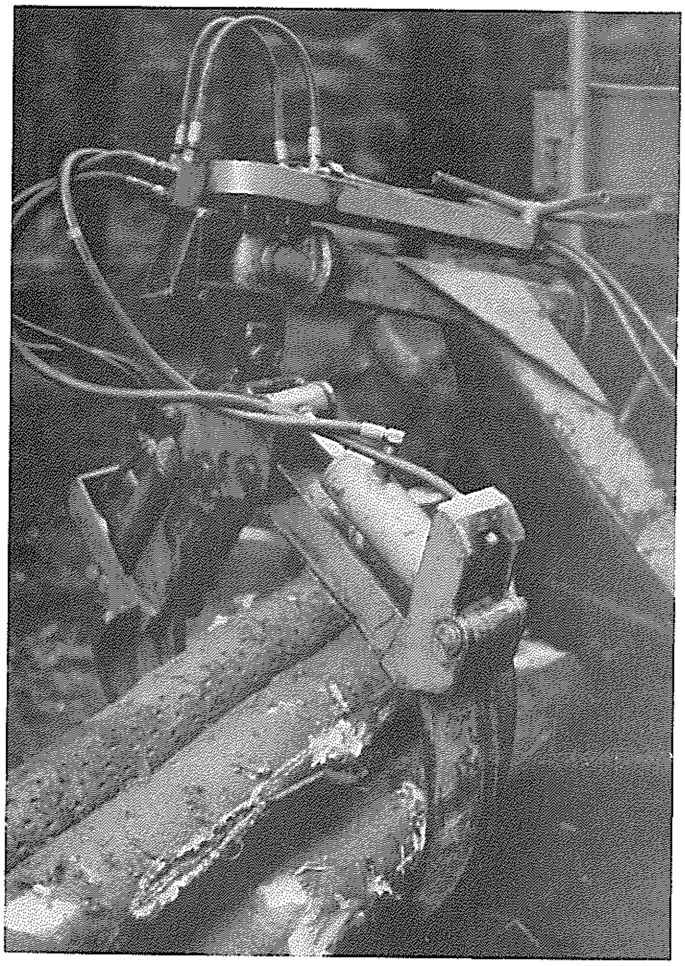
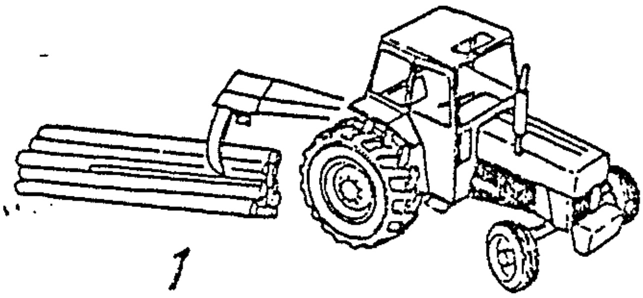


Fig. 9 - Hydratongs used for bunching

Boom grapples were normally unsuitable for attachment to small thinning machines because they created stability problems. Only on purpose-built clambunks and forwarders were grapples of this nature used successfully. The Bell Logger was considered an exception to this rule and although it was seen as a purpose-built machine, it had performed well with production levels in bunching ranging from 8.7 to 20.1 m^3 per machine hour. By comparison, the hydratongs on a Massey Ferguson tractor would produce between 6.8 and 10 m^3 per hour under similar conditions, but the unit cost of the hydratongs was much lower than the Bell.

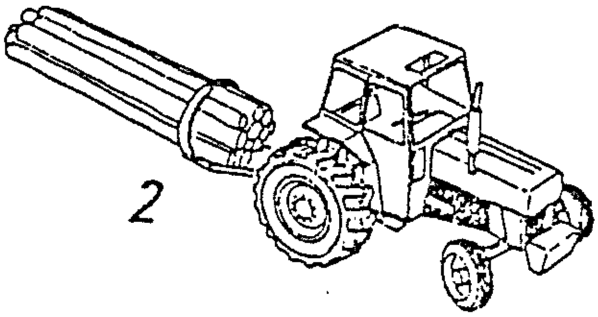
Specific examples were cited which showed the development of grapples from the hand operated Thetford tongs to the hydraulically controlled hydratongs. Diagrams of the systems using these tongs were shown and the pros and cons of row thinning discussed. The loss of quality, crown

Fig. 10 - The Highland Grapple

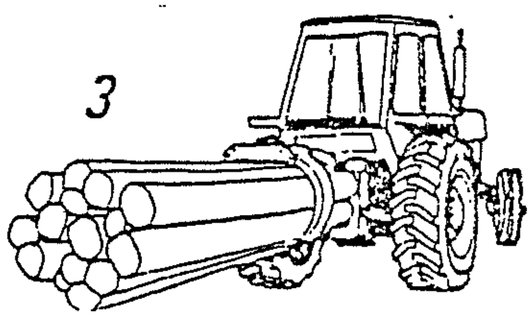


To use :

1. *Reverse the tractor towards the timber with the grapple lowered, the skidding pan can pivot - precision reversing is not necessary. Lower and grip.*



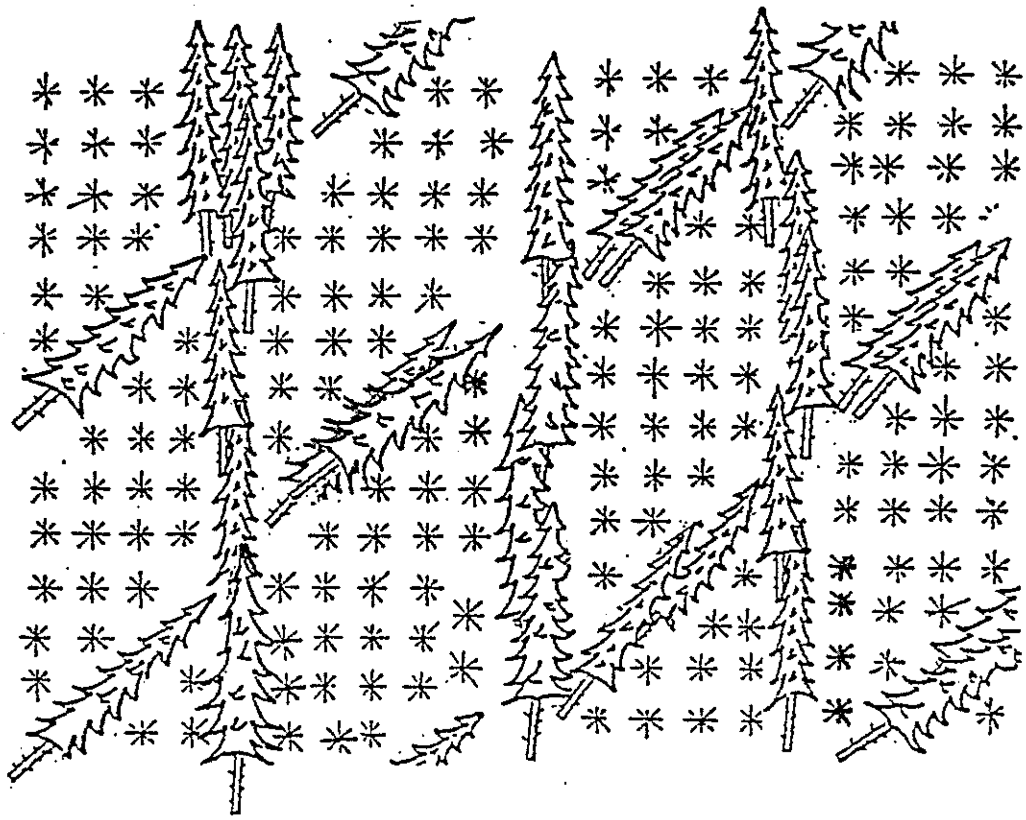
2. *Turn the grapple upwards. With the skidding pan towards the ground and the cylinders in the neutral position, the load can be skidde The skidding pan is slewed by the rotating cylinders to assist steering at difficult points.*



3. *Lift the skidding pan and rotate it half a turn. Ease the timber into the desired position. Lower and open the grab.*

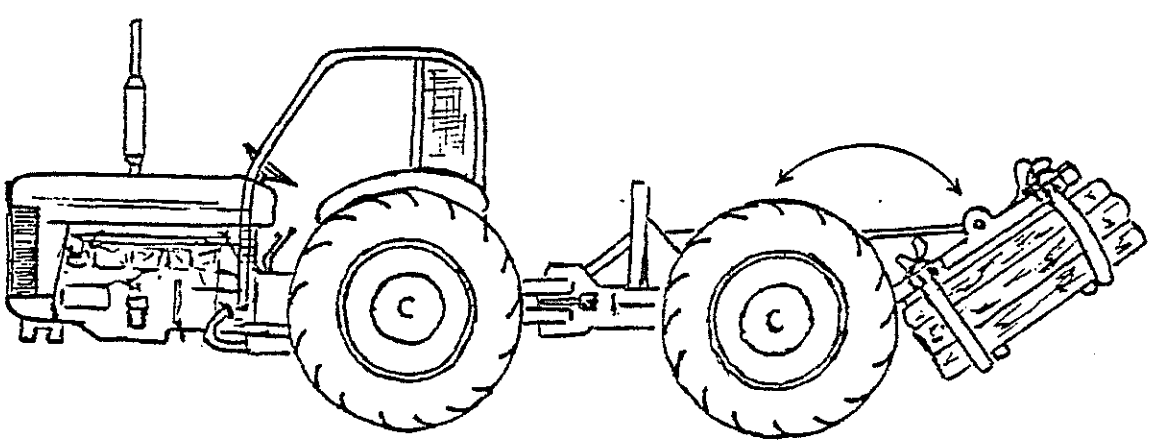
distribution and wind stability combined with lower volume production per hectare (about 18 m^3 per hectare less than selection thinning) made row thinning less attractive, particularly when considering a second thin operation. The chevron system (see diagram) was found to partially overcome wind stability problems but still restricted selection and resulted in lower production per hectare.

Fig. 11 - The Chevron thinning pattern



Mention was made of a grapple forwarder for shortwood, based on a Massey Ferguson 65 tractor. The designer, a New Zealander by the name of Smith, had developed and trialled a prototype but none had been sold. The whole bunk of the forwarder could be rotated hydraulically through a 180° arc to allow accumulating arms to pick up bunches (refer diagram).

Fig. 12 - The Smith shortwood grapple forwarder



Denmark had conducted studies of weight distribution of grapple skidders and found that the weight on the front wheels change from 50% to 7% between unloaded and loaded conditions.

Valuable research has been done on the use of grapples in both extraction and bunching. The future harvesting and handling of produce from small woodlots on easy terrain can undoubtedly benefit from this work as these grapples could have application in other areas such as agricultural work. Although the concept of grapple use has been reasonably well exploited, the system in which they are used could be developed further, specifically the optimum grab size and bunching distances for both machine and piece sizes. Attention could also be paid to the ergonomically bad position an operator has to work in to control three-point linkage mounted grapples.

This subproject was to be divided into two sections for further work to be carried out. They were :

(a) Bunching energy wood;

(b) Bunching under normal conditions.

An updated inventory of grapples was needed along with some cost figures on the various options so that a base figure for comparisons could be established. The most significant advances were expected to be made in the small accumulating tong field.

6. Winch Bunching

Subproject leader - New Zealand.

The main reason for New Zealand involvement in this subproject was stated as, "to investigate ways of maximising the payloads of extraction machinery with integrated bunch and extract methods". To cater for these interests the subproject was divided into two sections : (Ref.8)

1. Bunching as an integral part of the extraction cycle;

2. Bunching out of phase with independent winches.

For section 1, a comparison was made of studies done on agricultural tractors and skidders fitted with double drum winches and these were compared with a skidder with a single drum winch. Trials with the Iwafuji T20 and Holder A60 skidders highlighted the benefits of double drum winches by showing that with less than half the kilowatt power of a larger Clark 664 skidder fitted with a single drum winch, daily production in smaller .14 to .16 m^3 piece size was comparable. Although the figures were not substantiated by stocking levels or soil conditions, the advantages of optimising payloads was clearly demonstrated. As machine size and, consequently, payload size increased with double drum winches, problems arose with balancing the manpower requirements of the system. Indications were that with suitable, reliable, radio control of double drum winches, productivity of the extraction machine could be increased even further.

The conclusions drawn from the first section were :

1. Payload size was more important than travel speeds.

2. Efficiency of the breakout phase directly influenced the productivity capacity of a machine.

3. Double drum winches showed significant gains, particularly in smaller piece sizes.

4. The use of remote controls appeared to reduce the time spent accumulating an economic payload.

The recommendations for future work were to involve :

1. The trials on various outrow and selective thinning patterns to identify the most productive system.

2. Clearly establishing the effect of an improved felling presentation had on machine productivity.

3. Identifying the most economical balance between manpower and machine for the various options.

4. In conjunction with 3, investigating the most suitable rigging systems in terms of production efficiency and continuity of work.

For section 2, a literature search (Ref.9) was made to supplement the limited information received on bunching with independent winches. The winches used for out of phase bunching could be mounted on a mobile carrier, sled mounted, or be manually carried between work sites. Various innovations, such as automatically releasing blocks, elevated lead blocks and the use of fibreglass nose cones were found to be effective in certain applications, but no information had come to hand on the costs of these operations.

It was summarised that :

1. Remote control provided more flexibility than semi-remote or attached to controls.

2. Independent winches should have the facility to move themselves between work sites.

3. It was considered desirable to keep winching distances below 50 metres on flat terrain.

4. An elevated lead block improved the stacking ability of the winch.

5. When winching multiple stems a nose cone reduced the occurrence of hang-ups.

6. The bunching system should be designed so that one man could carry out the operation.

Recommendations for future work suggested the aims should be to :

1. Determine the upper limits of piece size that could be handled by various independent winches.

2. Identify the different slope classes that could be worked by winches of this nature.

3. Set guidelines for winching distances and the number of logs per occasion for a range of piece sizes.

4. Find out the optimum height to rig a lead block.

5. Decide when it was more productive to use the nose cone.

This presentation was based on limited information received from participating countries. For it to be of any real use to New Zealand loggers, additional cost and productivity data from trials and productive operations were necessary. The need for further investigation into small winches for bunching and pulling rope could well increase as New Zealand looks to extend the range of ground-based extraction machinery on steeper slopes. In such instances where pre-stropping with secondary hauling from the bunching machine is envisaged, then quick release hooks for terminal stops or possibly the use of tongs on the bunching machine could significantly improve the efficiency of the operation. With this in mind, it was decided to transfer the chokers and rigging sections from the horse bunching subproject to the winch bunching subproject.

A call was made for more involvement from all countries in each subproject. More information was needed on the radio control systems for both independent and machine mounted winches. It was felt that an indepth systems analysis could identify areas where new concepts in winch bunching could be developed.

7. Base Machines

Subproject leader - Sweden.

It had been found that agricultural tractors were not entirely suitable as base machines for tree harvesting equipment. The main reason for this was that tractors were primarily designed for pulling implements not carrying attachments or powering extra equipment. When fitted with auxiliary winches, cranes or felling heads, there were difficulties in maintaining the stability of tractors on uneven ground. Problems had also arisen with the structural design and strength of the tractors when they were subjected to stresses greater than what they were originally intended for.

The main requirements for base machines were listed as follows :

1. To provide a power supply for :
   (a) Mechanical drive (PTO)
   (b) Hydraulic systems
   (c) Pneumatic systems
   (d) Electrical systems.

2. To make available sufficient tractive effort to skid logs and, at the same time, provide transport for additional equipment necessary to carry out other parts of the operation.

3. To protect the operator from hazards such as falling logs or a machine roll over and to provide protection from the elements in adverse conditions.

Future research and development work was expected to depend largely on the economic situation and harvesting trends that developed in European countries.

It was claimed that the agricultural tractor was a poor base carrier for logging work because it was designed like the horse and a change in philosophy of the industry would be necessary to achieve any progress. It was suggested that what was necessary was a tractor that fitted equipment, not one that equipment had to be fitted to. The meeting was warned against recommending standards or designs to revolutionise tractors, but this was contended by the fact that in Europe most farms have at least two tractors and therefore one could be a carrier, which was adaptable to fit various attachments, and the other would remain the same as existing tractors, designed primarily for pulling.

This new tractor would need to be a 2-3 tonne machine developing around 100 hp. It would require higher power output from the hydraulic pump, be able to carry and operate various types of logging and agricultural equipment and have electric or pneumatic power outlets. It would be desirable to have a machine on which the operators seat and controls could be rotated 180° to allow comfortable operation in either direction.

The developments in this field of base machines is likely to be of particular interest to agro-forestry concerns in New Zealand as the harvesting of small woodlots increases. The availability of a multi-purpose machine capable of operating a grapple, winch, incorporator or plough, without modification, could make an important contribution to the economic management of small woodlots.

Students at the University of Louvain La Neuve in Belgium have been working on a project looking at farm tractor utilisation and design criteria so Belgium volunteered to take over the administration of this subproject. It was hoped that some machine design specifications would be prepared by the next meeting.

8. Crane-mounted Feller-bunchers

Subproject leader - Sweden.

This subproject was expanded slightly to include the crane-mounted felling heads on some harvesters as well (Ref.10). Two machines, the Kockums 81-11 and the Klippmyran, were used in Sweden as true crane-mounted feller-buncher machines. The Kockums unit was capable of felling in outrow and selection systems and relied on manoeuvrability up and down the felling strip to perform the bunching activity. The Klippmyran was a smaller machine which could also be used in an outrow and selection system, but because it was operated from the ground and had a relatively slow travel speed the cut stems were accumulated in a clam-bunk and dragged to the outrow once a full load had been gathered.

Other machines considered were the SP21, the Volvo BM Valmet 935 and the Kockums GSP62 which had the delimbing and crosscutting function incorporated in the grapple, and the Hultdins GP322 and the Rottnesnoken 810 which had the processor mounted on the chassis (refer Table 2 for productivity data).

A recent development in Sweden had been the wheel supported felling head for attachment to a long-reach crane. The idea relied on a wheel which was hydraulically raised or lowered to control the height of the felling head and provide support for it while bunching stems (refer Fig.13). Distances of up to 15.3 metres had been reached, but problems had arisen with the visibility of the head at that distance, and damage occurring to the residual stems.

Fig. 13 - A wheel supported felling head

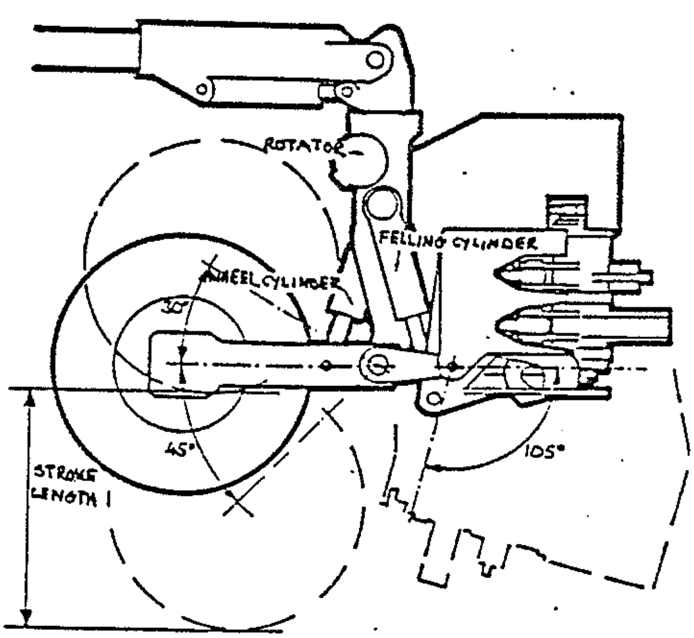


TABLE 2 : BRIEF SPECIFICATIONS AND PERFORMANCE DATA OF CRANE MOUNTED FELLER BUNCHERS

	BRIEF SPECIFICATIONS				PERFORMANCE		
Machine	Power Requirements	Maximum Reach	Maximum Diameter	Cutting Method	Trees per hour	m^3/hour	Cost per m^3
Klippmyran	18 kW	2.9 m	25 cm	Sh	50 - 70	3.0	$11.48
Kockums 81-11	52 kW	2.9 m	35 cm	Sh	120 - 180	5.0 - 6.5	$9.57-$7.66
Sp 21	52 kW	D.B.-1-	25 cm	Sh	60 - 80	3.5 - 4.5	$22.97-$17.23
Valmet 935	55 kW	11.0 m	25 cm	Cs	-	-	-
Kockums GSP62	90 kW	D.B.-1-	50 cm	Cs	-	-	-
Hultdins GP322	D.B.-1-	14.0 m	45 cm	Cs	90	9.0	-
Rottne Snoker 810	72 kW	10.0 m	60 cm	Cs	-	-	-
Gremo 802/TN25	60 kW	5.5 m	25 cm	Cs/Sh	50 - 60	2.2 - 3.2	$22.97
Mikro TH25	54 kW	2.5 m	25 cm	Cs/Sh	40	1.8	$22.01
Lako	105 kW	-	50 cm	-	75	7.5	-
Kubota KH 18L	-	-	35 cm	-	83 - 100	-	-
Sifer 725	50 kW	-	25 cm	Sh	-	-	-
Sifer 730-40	56 kW	-	40 cm	Cs	-	-	-
SFM 20	33 kW	-	-	Sh	33	1.3	-

* Sh = Shear, Cs = Chainsaw

-1- DB = Depends on base machine.

Developments in Denmark were centred around the Gremo SK35 and Gremo TH25 felling heads. Most attention had been paid to the TH25 unit mounted on either a Gremo 802 or a Mikro base carrier. Results from trials had shown that productivity of these heads was closely linked to piece size (refer Table 2 for indications of capabilities).

In Finland, the Lako crane-mounted processing head had been developed and indications from a Metsateho study were that it was performing well. Tests had been done in the U.S. with a Japanese Kubota KH18L excavator equipped with a Morbark 10 felling head. Further developments had been curtailed on this project because the machine wasn't suited to the working conditions.

The Sifer 725 and the Sifer 730-40 were mentioned but little information was available on them. East Germany had also been involved in crane-mounted feller-buncher trials with a SFM20 feller-buncher skidder. The machine could cut trees in a selection system then turn them through 180° (in the vertical position) inside the width of the machine and place them in a clam bunk at the rear.

Although not likely to be of direct use to the New Zealand industry at the moment, the information on crane-mounted feller-buncher machines could be of value to organisations looking at harvesting high quality smallwood such as posts and poles off relatively easy terrain.

Continuing work in this crane mounted feller-buncher subproject will be looking at a computerised cost evaluation of existing machinery and analysis of new concepts.

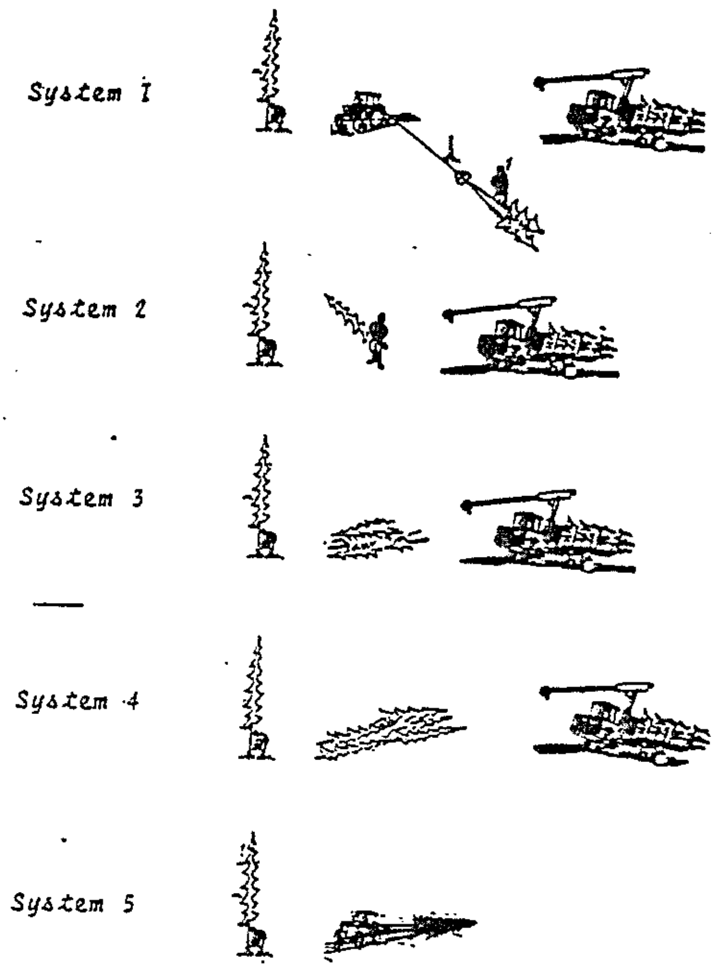
9. Motor-manual Felling and Bunching

Subproject leader - Norway.

The report for this subproject was prepared from studies of five thinning systems which compared mechanical and manual bunching methods (Ref.11). The field work was carried out in five different unthinned stands of spruce and spruce birch mixes where the trees were manually felled by chainsaw then bunched by either manual dragging, a small winch, or a crane and grapple system (refer Fig.14). The stands were stocked at 3,200-3,650 stems per hectare and were being thinned down to between 1,630 and 2,130 stems per hectare. The average piece size ranged from .025 m^3 to .056 m^3.

The results showed that manual dragging and winch bunching had a higher manual input per cubic metre and also incurred the highest costs (refer Table 3). However, if strip road spacing was extended to over 35 metres it was necessary to use winches for bunching. Systems based on a bunching operation by the felling pattern, and a crane on a forwarder, had the lowest manual input and costs. A widening of strip road spacing from 20 metres to 50 metres would result in a $4.10 increase in cost per cubic metre. A record of stand damage and strip road density after thinning was also kept and it appeared that damage was more dependent on strip road spacing than the bunching method.

Fig. 14 - Motor-manual felling and bunching systems



System no.	Felling	Bunching	Bucking	Transport-equipment
1	chainsaw	winch	chainsaw	forwarder
2	chainsaw	manual	chainsaw	forwarder
3	chainsaw	fellsys/crane	grapplesaw	forwarder
4	chainsaw	fellsys/crane	grapplesaw	forwarder
5	chainsaw	winch	chainsaw	small tractor

TABLE 3 : COMPARISON OF BUNCHING SYSTEMS

System No*	Production m^3/hr	Costs $\$/m^3$	Damage % frequency	Strip Road area % -1-
1	1.37	27.00	9	8
2	1.30	23.00	19	24
3	2.44	23.00	4	13
4	2.33	21.00	10	17
5	1.96	28.00	10	8

* Refer to Fig.14

-1- Expressed as a percentage of the total area of the stand.

From New Zealand's point of view, the results from these studies provide an interesting comparison between mechanical and manual bunching methods. Should the concept of machine bunching and extraction by forwarder be considered here, the information may be useful in deciding on the systems to be used. It must be remembered, however, that the piece size under consideration in Norway was less than .04 m^3 and that labour there is more expensive than in New Zealand.

At the meeting, New Zealand undertook to take over leadership of this subproject and tabled a work plan aimed at getting more information from contributing countries. Analysis of these questionnaires will help identify the most suitable felling and bunching techniques for various types of operation which can then be further developed to suit New Zealand's conditions.

10. Chassis Mounted Feller Buncher

Sub project leader - U.S.A.

Unfortunately the representative from the United States was unable to attend the Belgium meeting. However a paper covering the simulation analysis he had done was received by mail at a later date (Ref.12).

The analysis considered the use of chassis and boom mounted feller bunchers in a range of softwood stands based on representative stand data and basal area data. Assuming a basal area range of between 20 and 50 square metres per hectare the effects that outrow spacing and bay thinning patterns had on productivity were assessed. The results showed that there would be little difference between production rates for taking out two rows vs a single row in outrow thinning, and it was anticipated that single row outrow felling and bunching would have a slight advantage in this respect. This applied to both machine types. The double row situation was expected to produce larger bunches however, which would improve later extraction.

Both machine types would have suffered a decrease in productivity when thinning the bays in between outrows, according to the simulation, but the chassis mounted shear would show the greatest decrease (approximately 18%). The performance of the boom mounted shear would rely heavily on the boom reach and the speed at which it could be operated. Machine travel speeds were considered to be an important factor in the productivity of a chassis mounted shear. Not so significant with a boom mounted shear.

When simulating a 50% removal rate with a diagonnal thinning pattern one and two rows wide between outrows, it appeared that productivity would increase and bunch size would remain the same in contrast to outrow thinning where productivity was similar, but bunch size increased with the double rows removed. Overall efficiency should be greater with diagonnal pattern thinning because of the higher number of stems available for each pass of the machine.

TABLE 4 : PRODUCTIVITY OF BOOM AND CHASSIS MOUNTED FELLER BUNCHERS IN SINGLE AND DOUBLE ROW THINNING

	Chassis Mounted		Boom Mounted	
	Single Row	Double Row	Single Row	Double Row
Trees/hour	141	148	151	176
Tonnes/hour	3.6	3.8	3.8	4.5
Trees/bunch	22	28	27	24

In studying the effect that machine capabilities had on the various thinning options, a number of considerations were taken into account. These are summarised in Table 5.

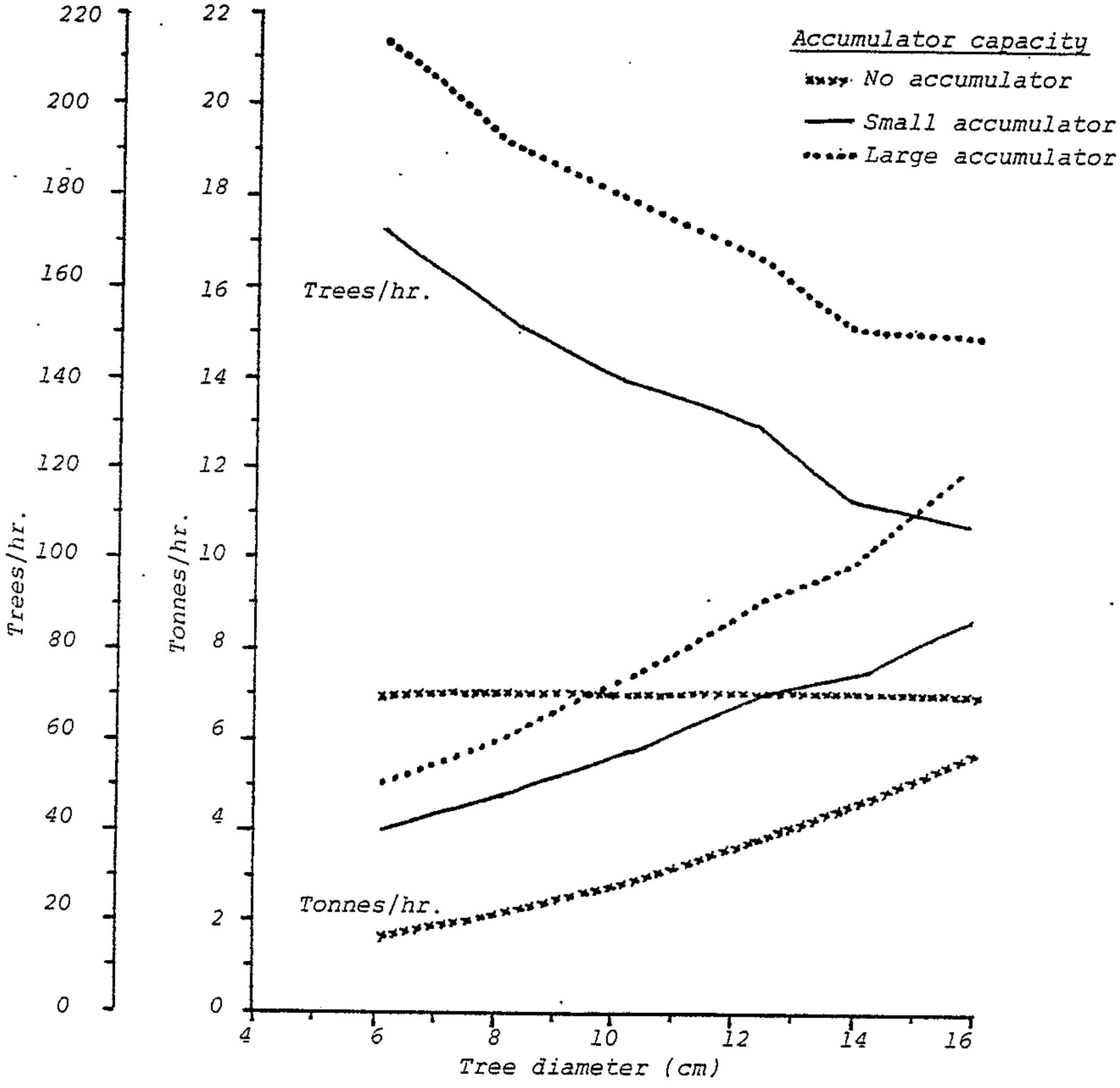
TABLE 5 : VARIABLES CONSIDERED WHEN ANALYSING POTENTIAL MACHINE PERFORMANCE

Variables	Range	Base Value
Sheer Accumulator Capacity - total diameter	No accumulator to 50 cm	25 cm
Average Travel Speeds		
- chassis mounted shear	2 - 8 kph	4 kph
- boom mounted shear	1 - 4 kph	2 kph
Average Shear Time (min/stem)	0.1 - 0.4	0.2
Average Drop Time (min/stem)	0.1 - 0.4	0.2
Boom Reach Speed (Boom mounted only)		
- Unloaded	0.5 - 2.0 m/sec	1 m/sec
- Loaded	+ 10% for each additional tree	
Boom reach		
- Minimum	2 - 3 m	2 m
- Maximum	5 - 15 m	10 m

The most significant findings were that shear rate had a major effect on both machine types. This could lead to a 30% increase in productivity if the average shear time was reduced from .2 to .1 of a minute per tree. The most important characteristic identified by the simulation was the machine's capability to bunch. Naturally enough, the capacity of an accumulating device directly affects the productivity advantage it offers (refer Fig.15).

In heavily stocked stands it appeared that a short boom reach was more productive than long reach booms, but this also resulted in smaller bunch sizes for the extraction machine which was not quite so desirable.

Fig. 15 - The effect an accumulating device has on productivity



There does not appear to be a lot of significance in these findings for the New Zealand logging industry, but once again the results could be useful in determining the elements of machine design and operation that warrants most attention. Indications are that other countries such as Denmark and Sweden are on the right track with simultaneous cutting and collecting concepts for multiple stems.

Further work is planned by Sweden, Canada and U.S.A. in developing prototypes of both chassis mounted and boom mounted felling and bunching heads.

11. Felling Patterns

Sub project leader - Norway.

The objective of this subproject was to evaluate the effect felling patterns had on a variety of subsequent harvesting techniques. The work that had been done at the time had considered felling in relation to processor conversion, looking at:

1. The effect that felling patterns had on output and costs for processing;
2. The influence outrow networks had on processing;
3. Actual studies done on the felling work.

Outrow spacing was considered to have a direct influence on productivity, and more of an influence than the pattern used for thinning the bays in between. The upper spacing limits for each type of operation were described as follows:

1. Felling with no winch bunching and being picked up, untrimmed, with a long reach crane - 24 m outrow spacings;
2. Felling without winch bunching and being picked up in a log length with a long reach crane - 35 m outrow spacing;
3. Felling with a winch bunching to outrows before delimbing - 35 m outrow spacing;
4. Felling with winch bunching of prepared logs to the outrows - up to 50 m between outrows.

The effect that stem layout had on machine productivity was also under investigation. Particularly the difference in time involved with parallel butt or tip first presentation, as opposed to combined tip and butt stem layout. The extra effort in parallel alignment was being assessed in relation to the other options, such as

(a) machines making a double pass, picking up one type of layout on the first run and the other type on the second run;
(b) the extent of the crane zones and whether it was feasible to pick up stems from the adjoining outrow by the tip;
(c) the influence that butt first or tip first patterns had on processing time;

Three different types of processor were considered in this felling pattern sub-project. They were:

1. The continuous feed processor, chassis mounted;

2. The step feed processor, usually boom mounted;
3. The crane mounted continuous feed processors.

The results from studies of the effect of felling pattern on step feed and continuous feed processors are shown in Table 6.

TABLE 6 : THE EFFECT OF THE FELLING PATTERN ON STEP FEED AND CONTINUOUS FEED PROCESSORS

Felling Pattern	*Conversion Productivity mins/m^3*	
	Processor Type	
	Step Feed	*Continuous Feed*
Outrow felling	*15*	-
Felling with winch bunching	-	*20*
Felling for both tip and butt extraction	*22*	*27*
Parallel felling	-	*24*

This analysis was done in a stand of spruce with an average diameter at base of 10-12 cms on easy (less than 20%) slopes. The reasons given for higher productivity with the step feeding processor was the lack of crane work required.

Interest in mechanised delimbing concepts has increased in New Zealand over the past few years, and the effects that felling patterns have on delimbing productivity are of relevance to this. The further work planned was:

1. Experiments with felling patterns for processing units mounted on small agricultural tractors;
2. Felling patterns for crane mounted processing units;
3. The influence of felling patterns on bunching with winches.

It is hoped that from the results of this work a model of principles for felling patterns can be produced, and that any advantages or otherwise with regard to the biological influences on the residual stand and its site will be identified, i.e. the effect of altering the deposition of slash from the forest to the outrow, or to the landing or roadside. Incorporated in this could also be an investigation into the effects that the number of machine passes has on ground compaction etc.

ADDITIONAL REPORTS

To supplement the information presented by sub-project group leaders, a number of reports on trials and studies of operations or machines relevant to the terms of reference of the CPC7 group were presented to the meeting. These reports were prepared by the countries conducting the particular trial or study. They are summarised as presented.

1. The Tree Turner

Country involved - Denmark

The tree turner was a machine developed to reduce stem damage during bunching, by lifting logs out of the thinned bays following manual felling and placing them into a clambunk. The boom had a 6½ m reach but logs at that distance from the machine had to be dragged in closer and re-grabbed for lifting into the clambunk. The boom could be rotated through a 180° arc with a chain driven mechanism. If used in sufficiently small whole tree thinning, the stems could be accumulated in a basket mounted on the rear of the machine. The Chevron system of felling was found to be most suited to this type of machine with felling strips at between 85 and 135° to the outrow. The herringbone pattern was found by the fallers to be more difficult to implement and less productive for the tree turner. The machine was designed for 14-15 cm diameter stems.

When compared with winch bunching, the tree turner was found to be approximately 40% more productive and resulted in less damage to the residual stems, i.e. 1% as opposed to 5-10%. The trial identified that the machine worked best in tree length logs. The main advantages of the tree turner were listed as follows:

1. Improved working conditions;
2. Higher production;
3. Lower damage to residual stems;
4. Relatively easy to learn to operate;

The unit cost of a tree turner was estimated at around $43,000 compared with a winch unit costed at $32,000.

2. Klippmyran

Country involved - Denmark

This report covers trials that the Danish Institute of Forest Technology has done with the Swedish built Klippmyran feller buncher skidder, commonly known as the feller ant (Ref.13). The Klippmyran was described as an articulated machine incorporating motor crane and controls on the front section with a clambunk mounted on the rear section. The operator controlled the machine from a standing position in front of the motor under a protective screen. The machine was powered by a two-cylinder 18 kilowatt motor and had a boom reach of 4.5 m. It was built specifically for felling and bunching small stems and cost approximately $50,900.

The study undertaken by Skovteknisk compared three different thinning methods in two separate areas. The methods used were:

1. Row thinning;
2. Row plus selective thinning;
3. Selective thinning from existing outrows.

In row thinning the Klippmyran reversed from the outrow into the stand at every 7th row interval, felling trees and laying them to one side of the strip. When it had felled sufficient trees for a full load (usually about 30 m in distance) it drove forward to the outrow picking up the felled stems on its way, and collecting them in the bunk. This system enabled a 60 m spacing between outrows, but meant that most stems had to be handled twice.

In the row plus selective thinning system a similar 7th row felling pattern was adopted but because three rows either side of each felled row were selectively thinned as well, a shorter distance (about 15 m) was covered. Only the stems on the felling strip had to be handled twice with this system, but extraction outrows had to be spaced at 30 m intervals.

The selective thinning was a second thinning operation working from existing outrows spaced at 60 m intervals. The machine would simply thin 30 m on one side of an outrow and reverse up and thin the other side over the same distance. The remaining 30 m of the outrow would be thinned from the next extraction track.

The results from these trials compared favourably with other studies done in Sweden, but still indicated that only selective thinning from existing outrows would be economically viable. In a tree size of 6-7 cm base diameter the machine was capable of row thinning 43 trees per hour at a cost of $7.95 per stere*. In outrow and selective thinning up to 60 trees per hour could be handled for about $5.88 per stere*. The straight selective thinning produced 67 trees per hour at a cost of $5.25 per stere* and this was expected to decrease to $4.77 in larger piece sizes. The damage to residual crop trees was kept to a minimum at 1%.

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* A Stere is a measure of green chips which would fill a box 1 m x 1 m x 1 m. One Stere equals roughly 0.33 m^3 and about 0.33 of a tonne. It takes approximately 7 stere for 1 tonne of dry weight.

3. <u>The Kockums 81-11 Feller Buncher</u>

Country involved - Denmark

This report presented the results of trials done in Denmark with the Swedish made Kockums 81-11 feller-buncher (Ref.14). The machine was an eight-wheeled articulated base carrier powered by a rear mouted 52 kilowatt motor. It had a parallelgram boom capable of extending from 2.2 to 2.9 m and was equipped with a special tilting cylinder to adjust the level of the felling head.

The maximum stem diameter the machine could cut was 35 cm at base and it did have the facility to accumulate stems if working in small tree sizes. The machine was designed for low maintenance requirements with fuel and lubricant capacity for up to 40 hours continuous operation. The cost of an 81-11 was $103,350 in October of 1983 and operating costs at that time were calculated to be $31.64 per hour without operator.

The machine was studied in row plus selective thinning and in straight selective thinning operations in two separate stands of Norwegian Spruce. Times and volumes produced could be kept separate for each bunch which meant it was possible to simulate productivity with a straight row thinning system as well. Both stands had extraction tracks spaced at between 50 and 60 m which meant that maximum travel distances were approximately 30 m. Bunching was achieved by reversing the machine out to the extraction track once a full load had been accumulated in the felling head. For convenience the row thinning was always done first. Productivity and cost data for the three methods are summarised in Table 7.

TABLE 7 : RECORDED COSTS AND PRODUCTIVITY OF THE KOCKUMS 81-11 IN THE THREE THINNING SYSTEMS

	Thinning Method		
	Row thinning	*Row + Selective*	*Selective*
Stem diameters	*6.5- 9.7 cm*	*5.5- 8.0 cm*	*5.0-12.0 cm*
Productivity recorded	*10.9-20.6 st**	*8.2-12.5 st**	*7.0-20.0 st**
*Costs/stere**	*$4.23-$2.27*	*$5.63-$3.69*	*$6.50-$2.27*

Given a target cost of $7.95 per stere* for green chips on ride, and a chipping cost of $3.38 per stere*, all three thinning systems could have been economically viable.

The damage to residual stems in the stand was recorded at

* Refer page 31.

1.4 - 1.8%, but this did not consider damage that could have occurred to the root systems. Under normal operating conditions the machine could make up to 15 passes over the outer regions of the outrow during bunching. When loaded, the front wheels on the rear bogey were prone to wheel slip which added to the soil disturbance.

Operator comfort was adequately catered for with a well equipped cab, but the larger window area on all sides created visibility problems through dust collection and sun reflection.

4. <u>Motor Manual Felling and Chipping with Hand Feed Tractor Mounted Chipper</u>

Country involved - Denmark

This study investigated the options of motor manual felling and manual feeding of a tractor mounted chipper, and compared them with 2 m short wood cutting methods (Ref.15).

Trials were done using three systems.

1. Row thinning.
2. Row thinning plus selective thinning.
3. Selective thinning.

All options were carried out in Norwegian Spruce stands. The thinning patterns are illustrated in Fig. 16.

Fig. 16 -Diagram of studied thinning methods

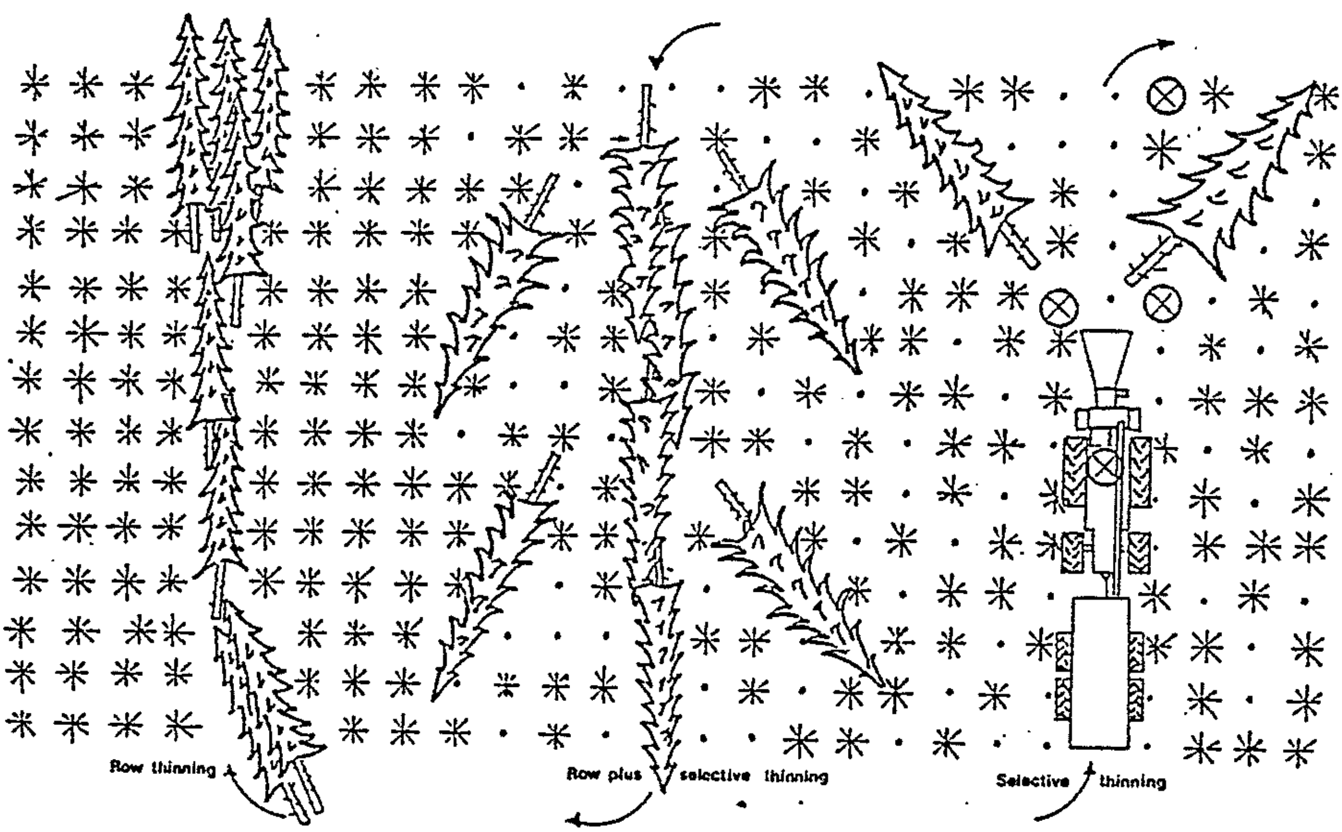

Diagram reproduced from Ref. 15

In row thinning every 9th row perpendicular to the extraction track was felled for butt first feeding into the chipper. The row plus selective system had a similar pattern to the straight row thinning and the thinned trees in the bay were felled into the stand to align the butts for feeding into the chipper. In both row and row plus selective thinning cases, the chipper moved in the opposite direction to the fallers. During straight selective thinning both butt and tip first alignment for the chipper was tried. The larger trees in the bays were cut from the stump but left standing to facilitate later handling.

The chipping equipment was a hydraulically driven TP950 disc chipper on a 79 kW JL1100 four-wheel drive tractor. Chips were collected in a tandem axled TIM high tip side tipping trailer with a maximum loading capacity of 11 m^3. Once the tipping trailer had been filled, it off-loaded into a TIM self-loading tandem axle trailer loacted on the extraction track. A 51 kW JL700 four-wheel drive tractor towed this trailer to the storage site for off-loading. The chainsaws used were 40-50 cc Husqvarna and Jonsereds. The chip crew consisted of four men who rotated jobs after every load.

The felling was found to be fast - up to 280 stems per hour - but very monotonous, and accordingly higher allowances had to be considered. As expected row thinning was the easiest from the fallers point of view, and the cheapest at 56-87 cents per stere*, compared to selective thinning at 83-110 cents per stere*. The optimum diameter settled on for motor manual felling and feeding tractor mounted chippers was 6.5 cm to 8.5 cm. Below this the trees were too small, and above it they became too big to handle.

A device called a fell frame was tried in one stand, and it resulted in a 12% increase in productivity with row thinning, and 25% increase with selective thinning. The fell frame was simply a mounting structure for a chainsaw which had handle bars that eliminated the need for the operator to stoop. It was found that a larger 60 cc saw was necessary with the fell frame because it cut at ground level and the chain was inclined to blunten quicker.

The costs of chipping varied considerably depending on the diameter, i.e. in row and row plus selective thinning the smallest trees were the most expensive, but in the straight selective thinning larger trees cost the most. Table 8 summarises these costs.

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* Refer page 31.

TABLE 8 : COSTS OF CHIPPING AGAINST DIAMETERS FOR THE THREE THINNING METHODS

	Thinning Method		
	Row Thinning	*Row + Selective*	*Selective*
Diameters	*4.8 - 8.0 cm*	*3.9 - 7.6 cm*	*10.7 - 4.8 cm*
*Costs/stere**	*$9.13 - $5.04*	*$12.04 - $5.98*	*$9.76 - $7.39*
Production, st/hr*	*9.1 - 16.5*	*6.9 - 13.9*	*8.5 - 11.2*

When compared with the costs and productivity of short wood operations, motor-manual felling and chipping was more tolerant of smaller stems and thus could be used to thin younger stands. The value of the chip produced, however, was not as high as stacked short wood, i.e. $8.75 per stere*, approximately $2.89/m^3, compared with $26.39/m^3 . However, even with this apparent high return, short wood systems were struggling to be viable in trees under 8 cm in diameter. These costs were drawn on the hourly rate for a chainsaw and operator at $12.72. The chip crew, including 4 men and machines, was estimated at $83.00 per hour. This study showed that motor manual felling and feeding a tractor mounted chipper could be a viable option for thinning young Norwegian Spruce stands, but it was found to be very hard work and it would most likely be difficult to sustain production levels.

5. <u>Motor Manual Felling and Chipping with a Crane Feed Tractor Mounted Chipper</u>

Country involved - Denmark

As a follow up to the eariler studies on hand feeding the chipper, a crane feed chipper was tried under similar conditions, i.e. row thinning, row plus selective thinning and straight selective thinning in young Norwegian Spruce stands (Ref.16).

An 83 kW Fendt Favorit 612 LSA 4 wheel drive tractor equipped with an ABC 7/45 drum chipper was used to chip trees into a 16 m^3 Alsidig high tip, back tipping trailer. The crane mounted on the tractor had a reach of 5.6 m. The tractor seat could be rotated 180° which was ergonomically much better for the operator.

Further studies were carried out with the previously mentioned fell frame and the results reflected the trends of earlier studies but had extended the findings to show a decrease in productivity - up to 31% - in large trees. Once again felling for selective thinning was found to be less productive than row thinning (refer Table 9).

* Refer page 31

TABLE 9 : FELLING PRODUCTIVITY AND COSTS FOR THE THREE THINNING METHODS

	Thinning Method		
	Row thinning	*Row + Selective*	*Selective*
Stem diameter	*4.8 - 9.7 cm*	*3.9 - 8.0 cm*	*5.0 - 10.1 cm*
Stere/hour*	*14.1 - 35.6*	*7.9 - 22.7*	*11.3 - 11.8*
*Cost/stere**	*$0.90-$0.36*	*$1.61-$0.56*	*$1.13-$1.08*

Results of the chipping studies show that in all cases the crane chipper was a cheaper option than hand feeding the chipper. The main reasons put forward being the capacity of handling larger load sizes and the lower manpower requirements. These advantages appeared to increase rapidly as tree size got bigger. The total costs per stere* for green chips indicated that all three thinning methods would have made a profit considering an on ride value of $11.13 per stere* and based on a 500 m extraction distance (refer Table 10).

TABLE 10 : CHIPPING COSTS AND TOTAL COSTS PER STERE OF THE THREE THINNING OPTIONS*

	Thinning Method		
	Row thinning	*Row + Selective*	*Selective*
Chipping costs	*$3.86-$7.36*	*$3.23-$7.27*	*$4.35-$5.09*
Total costs	*$4.65-$8.69*	*$4.23-$9.32*	*$5.87-$6.65*

Although it was felt that the dimensions of the trailer were not entirely suitable and that the opening mechanism could be improved, the concept of a crane fed chipper thinning smaller trees for energy wood was found to be economical.

6. <u>Summary Report - Felling Bunching and Chipping Small Trees from Norwegian Spruce Thinnings</u>

Country involved - Denmark

This report (Ref.17) simply reviewed all the studies done on felling, bunching and chipping in Denmark and concluded that row thinning was nearly always the cheapest method (refer Table 11).

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* Refer page 31.

TABLE 11 : SUMMARY OF COSTS PER STERE AT LANDING, OF GREEN CHIPS ACCORDING TO THINNING PATTERN, DBH AND METHOD*

DBH and System	Thinning Method		
	Row thinning	Row + Selection	Selective
5 cm			
handfed chipper	$8.90	$11.77	-
cranefed chipper	$8.90	$9.54	-
5 - 7 cm			
Handfed chipper	$5.72	$6.20	$7.16
Cranefed chipper	$5.25	$5.72	$7.16
Kockums 81-11	$7.47	$8.74	$9.70
Klippmyran	$11.61	$9.06	$8.43
7 - 10 cm			
Handfed chipper	$4.93	$6.36	$7.95
Cranefed chipper	$4.77	$4.45	$6.36
Kockums 81-11	$5.41	$6.84	$7.47
Klippmyran	-	-	$7.95
Tree turner	-	-	$8.43
10 - 12 cm			
Handfed chipper	-	-	$9.22
Cranefed chipper	-	-	$6.04
Kockums 81-11	-	-	$5.57
Tree turner	-	-	$7.47

The report also stated that crane fed chipping after motor manual felling was the most economical method tried, and the following comments were made on ergonomics.

1. Motor manual felling, followed by hand fed chipping, led to bad working conditions with monotonous heavy work.
2. In motor manual felling with crane fed chipping, the working conditions for the tractor driver were much improved but the monotonous and heavy felling work remained.
3. The conditions for the faller were improved by the use of a felling bunching machine.
4. With the Klippmyran the driver did not undergo whole body vibrations because he was standing on the ground, but on the other hand he was exposed to weather.
5. The Kockums 81-11 had a well designed comfort cab but exposed the operator to whole of body vibrations.
6. With the tree turner, the felling was done by chainsaw, and the chipping by a crane fed chipper. But improvements could have still been made to the work place.

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* Refer page 31.

In the final analysis it appeared that early row thinning and on-site processing into chips was a viable proposition for tending Norwegian Spruce stands in Denmark. The long term prospects were obviously sensitive to price fluctuations according to market demands. Several larger scale operations had been planned at the time of the meeting.

7. Stand Damages in Thinning

Country involved - Sweden

In order to find out more about the effects of thinning on the residual stems, Skogshögskolen had undertaken studies on both first and second thinning stands after the operation had been completed (Ref.18). The seven most common thinning systems used in Sweden had been selected for the study. They were:

1. Manual cutting and piling - fowarder;
2. Manual cutting and piling - farm tractor;
3. Manual cutting winch - farm tractor;
4. Manual felling winch processor - Rottne Snoken 780 forwarder;
5. Manual felling, long reach crane processor - Rottne Snoken 780 forwarder;
6. Manual felling processor - RK450 forwarder;
7. Manual felling, grapple saw, forwarder.

Diagrams of the systems are shown in Fig.17.

Approximately 35% of the thinnings were first thinnings and 65% second thinnings. The stands were stocked at between 1083-2130 stems per hectare, with diameters ranging from 12.2 cm to 19.8 cm. All stands had relatively good ground conditions with easy slopes. Table 12 summarises the % damage recorded with each system.

TABLE 12 : AVERAGE DAMAGE FREQUENCY FOR EACH SYSTEM

System	Damage frequency, %	95% conf. level
1. Manual cutting and piling, forwarder	8.0	± 1.9
2. Manual cutting and piling, farm tractor	3.5	± 1.9
3. Manual cutting, winch, farm tractor	5.9	± 5.0
4. Manual felling, winch, processor Rottne Snoken 780, forwarder	16.4	± 3.2
5. Manual felling, long reach crane, processor Rottne Snoken 780, forwarder	13.6	± 2.5
6. Manual felling, processor RK 450, forwarder	13.2	± 2.9
7. Manual felling, grapple saw, forwarder	10.3	± 2.8

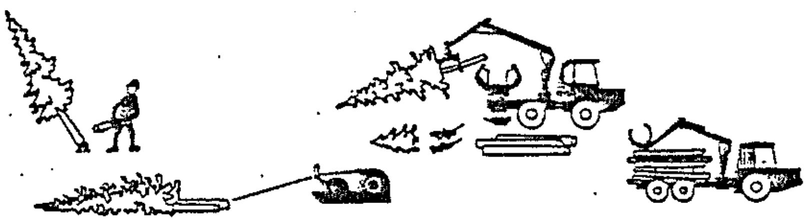
Fig. 17 - The seven thinning systems studied in Sweden

1. Manual cutting and piling, forwarder.

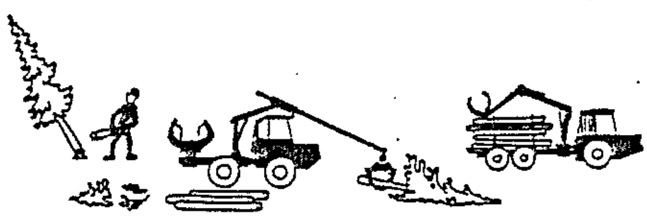
2. Manual cutting and piling, farm tractor.

3. Manual cutting, winch, farm tractor.

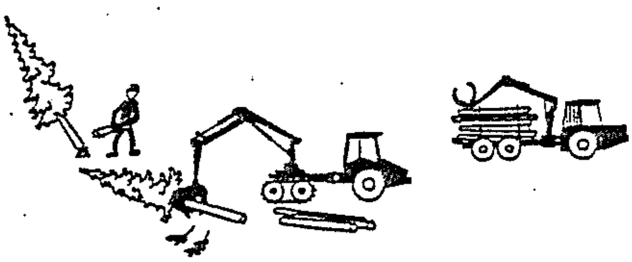
4. Manual felling, winch, processor Rottne Snoken 780, forwarder.



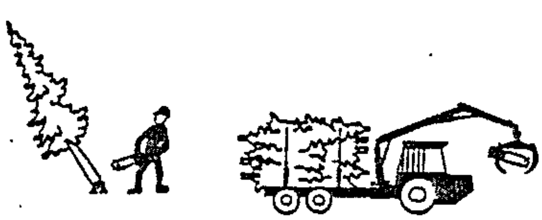
5. Manual felling, long reach crane, processor Rottne Snoken 780, forwarder.



6. Manual felling, processor RK 450, forwarder.



7. Manual felling, grapple saw, forwarder.



As was quite obvious by the table, the degree of damage occurring the stands was almost directly proportional to the amount of mechanisation. Although the results showed considerable variation between stands for each particular operation, it was felt that to a large extent the amount of damage was closely related to the capability of the machine operators. This in turn was dependent on the quality of the planning. Suggested remedies to the problem were:

1. Recruitment. Thoroughly test prospective machine operators to sort out those not suitable for the job.
2. Education. Make operators aware of the consequences of the damage, and intensify the training effort.
3. Salary. Reward operators who perform well and improve assessment methods to suit.

The recommendations had not been implemented at the time of the meeting.

8. Performance of Agricultural Tractors and Tyre Improvements

Country involved - Belgium

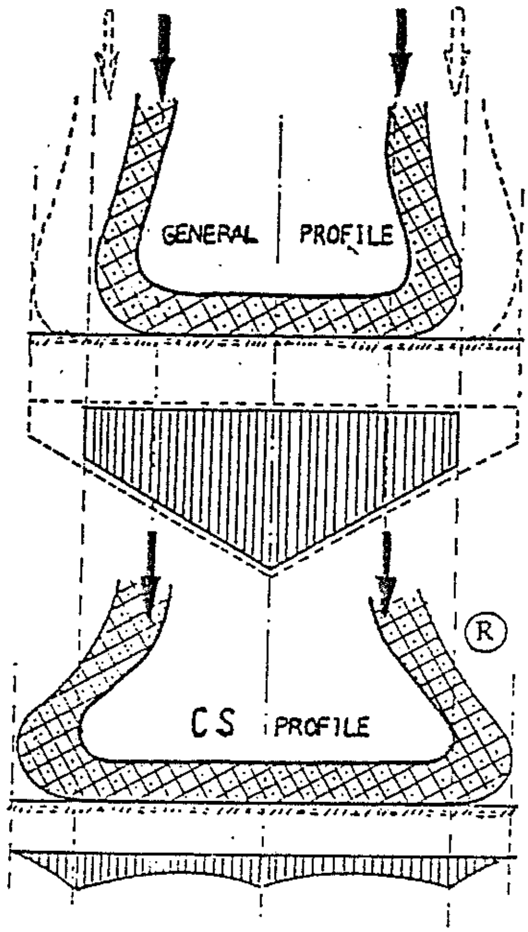
Incorporated in the first field trip was a stop at the University of Louvain La Neuve, where the faculty of Agronomical Sciences was visited. The Agronomical Sciences division had been investigating the tractive capability of various types of tyre under controlled conditions, and a paper of these findings was tabled at the meeting (Ref.19). A series of test rigs had been set up to determine:

1. The area of the contact zone between the tyre and soil;
2. The shape of the contact zone between the tyre and the soil;
3. The load distribution under a tyre's tread;
4. The torque transmitted by the tyres.

Test results from tests on these rigs were used to design a new tyre profile called the "Camelshoe" (patented) (refer Fig.18). This tyre had a reduced width between beads at the rim level for a given width of tread. After calculating profiles the thickness of sidewalls were derived in order to keep modulus of rigidity constant, which ensured the best load transfer on the tread.

From a trial in the field a farm implement normally requiring a 70 kW tractor to tow it, was easily towed by a 45 kW tractor equipped with Camelshoe tyres. Observations from a ploughing test in the same soil conditions with the same tractor had shown that the Camelshoe design had better traction than conventional tyres.

Fig. 18 - Camelshoe tyre profile compared with a normal tyre



FIELD TRIPS

Soignes Forest, Belgium

On Monday 24th October a field trip was taken from Brussels to Worriken Bütgenbach. The first stop was the 4,386 ha forest of Soignes located 20 kilometres from Brussels. The forest consisted of 3,500 ha of beech, 300 ha of oak and 300 ha of pine. A combination of mixed species of trees, 20 ha of farming and a racecourse occupied the remaining land, along with 169 kilometres of sealed road and 52 parking lots. Approximately 240 ha of the forest was over 200 years old and most of the trees were of high quality. In one 180 year old stand of beech the tree diameters were between 80 and 120 cm at breast height. The block was stocked at between 70 and 90 stems per hectare with an average volume of 476m^3 per hectare. The annual increment for the stand was estimated at 4.2 m^3 per hectare. Although the 10 ha block of trees was established in 1793, the Belgium Forest Service had only managed them since 1929.

The standard procedure for establishing and managing beech was to plant to a stocking of 4,600 stems per hectare and over a period of 180 years bring the stocking down to 17 stems per hectare with 20 thinnings. Establishment costs were quoted at \$556.00 per hectare to cultivate the soil, and \$1.94 per tree for planting. When logging a stand in Belgium, felling costs could be as high as \$4.20 m^3, delimbing up to \$3.50 m^3 and extraction over \$5.60 m^3, however good beech could be sold for between \$85.00 and \$110.00 m^3.

All of the wood in Soignes Forest was sold on a stumpage basis. Consequently the logging was done on contract with independant contractors carrying out each separate phase of the operation. The main skidding machines used were Timberjack and John Deere skidders with a capacity of about 8 tonnes. Production levels of up to 40 m^3 per hour had been reached. There appeared to be a major conflict of interests between the foresters and the loggers in the State controlled areas. The foresters were primarily concerned with growing and caring for trees and had no interest in harvesting. This meant that stem damage and soil disturbance and/or ground compaction in thinning created a rift in communication between the two parties. Loggers on the other hand, were only out to make money and objected to regulations governing load size, extraction track location etc. A further constraint on the logging operation was the fact that each phase was usually done by a separate contractor and therefore felling was done with little or no consideration for the extraction method.

University of Louvain La Neuve, Belgium

On the way to the southern forest area, the faculty of Agronomics Section of the University of Louvain La Neuve was visited. They had been doing considerable work on soil compaction measurements, looking at the various pressures that tyres exerted on surfaces.

A number of test rigs had been devised to determine the load on a tyre and the effect that the tread had on the ground with a given weight on it, so that they could measure the load either way and the deflection of the tyre from its central axis. From the results of these studies, the Agronomics Section had developed a tyre with very strong sidewalls and a lower profile. This tyre was called a Camelshoe tyre and it spread the load equally across the whole tread. This work resulted from calculating the modulus of elasticity for each tyre case which was tested, and it was believed that this elasticity in the walls was the main cause of slippage. By changing tyre configuration, the University had been able to halve the size of horsepower input necessary to do the same job.

The low profile with better strengthened side walls kept the weight of the tyres distributed equally over the whole width and the University considered itself in the position to recommend tyres for different soil conditions. Soil disturbances were found to be directly effected by cleat height, but this did not really effect traction to a great deal.

The Agronomics Section was also working on a dual wheeled tractor test rig which had the tail end of a second tractor attached to the three point linkage of the front tractor, without the front wheels. This pivoted behind the three point linkage almost the same as a skidder (refer Fig.19).

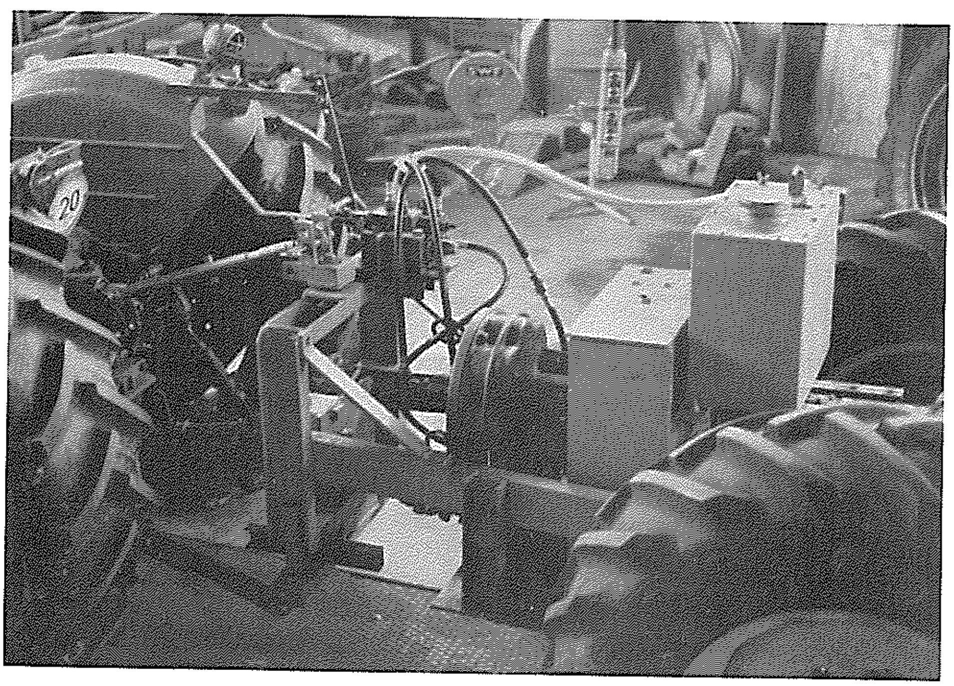


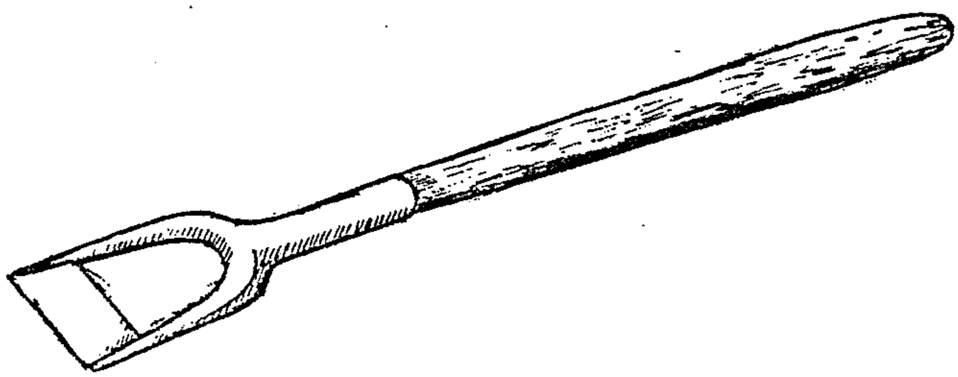
Fig. 19 - Dual wheeled tractor test rig

This rear bogey was driven from the PTO of the front tractor and the rear drive could either be mechanical or hydraulic, but the best results had been received with the mechanical drive. By transfer of torque, the test rig was found to have three times the tractive capacity of the original tractor before being modified.

The Cedrogne Forest District, Belgium

In the afternoon the field excursion called on a second thinning operation in Norwegian Spruce in the Cedrogne Forest District. In a stand stocked at roughly 2,600 sph, between 50 and 60 m^3 per hectare (600 stems) was being removed. The trees were felled with a chainsaw and delimbed by a manually operated delimbing knife (refer Fig.20).

Fig. 20 - Diagram of manually operated delimbing knife



Felling and delimbing was done on a selective basis by groups of two workers who received $6.40 total for each cubic metre produced. They worked 8-9 hour days, but only 7 of these were productive. A team of five horses then followed the fallers, bunching logs to outrows. Each horse was capable of bunching 20 m^3 per day over 60 to 70 m distances, but on occasions they were expected to bunch for distances up to 150 m. The horse operators were paid between $22 and $25 per day, which included the costs of transportation. They worked for up to 10 hours per day in the summer so that they did not have to work in adverse conditions during the winter. The horses used were especially breed for logging and cost between $2,780 and $3,350 to purchase.

A four-wheel drive Ford 754 fitted with Hydratongs was used to pick up bunches left by the horses, and extracted them 80 m along the outrow to drop them in larger bunches along the main extraction track. A John Deere 740 grapple skidder then picked up the large bunches and dragged them to the skid site. The John Deere had a 13 tonne capacity and was capable of extracting over 200 m^3 per day. Part of the shortfall between what the skidder could produce, and what the horses could bunch, was made up by a Sifer delimber which, when working behind manual felling, had a productive capacity of 40 m^3 per day at a cost of about $9.00/$m^3$. A small Holder tractor with a single drum winch was used to bunch logs behind the Sifer.

Later a brief stop was made at a one-man processing yard where horticultural post and fencing material, special use posts and poles and pulp wood were cut with an electrically powered circular saw. The logs were fed manually onto the bench, then either stacked, again manually, in the yard or delivered to the customer. The saw was a dangerous contraption operated by a bar pedal with no protective device on or around the blade. An inadvertent step on the bar at the wrong time would result in the circular saw springing into the cutting position, taking with it any limb or other part of the body that could be in the way.

By the time stumpage, logging and cartage costs had been paid, the operator's return of $25.00/m^3$ for pulp wood made it an uneconomical venture. The higher price of $50-55.00/m^3$ for specialised post and poles would have made a modest profit.

Monschau Forest, Germany

A second field excursion was made to the Monschau Forest District in West Germany on 26 October. The area of 10,000 ha had been planted immediately after the war with main species being Norwegian Spruce. A demonstration of bench felling was shown in a 32 year old stand being thinned to 20 m extraction tracks with chevrons being cut into the bays in between. Extraction was being done with Danish made Gremo forwarder.

A lot of attention was being focussed on the protective equipment and felling aids used, and the principle of building a bench with the trees being felled. Unfortunately, however, the demo was not well performed on account of the operator failing to observe appropriate safety measures and using incorrect techniques.

The second stop was in beech logging where a small 48 kW Deutz skidder was being used in a selective thinning operation. The removed volume was 50 m^3/ha which was extracted along tracks 60 m apart. The six year old Deutz skidder had three Riiter and Schone winches (two on the back and one on the front) all of which could be radio controlled. Each winch drum had 100 m of 10 mm wire rope on it but damage to the ropes was high because overspooling caused birds-nests which the operators could not see.

Production was relatively low due to the poor felling (resulting in frequent hangups) and the fact that the machine was uphill pulling unnecessarily.

Kronberg Forest District, Denmark

As an extension to the meeting in Belgium, an individual visit was made on the 4th November to the Kronberg Forest District in Denmark. The first operation seen was a windthrow salvage of 60 year old Norwegian Spruce. Logs were being cut into 3 m lengths by two chainsaw operators working ahead of the extraction machine. A 52 kW International Hydro 84 tractor fitted with loft tongs and towing a trailer was extracting the logs to the roadside (refer Fig.21). The machine grabbed the drawbar of the tow bar in the tongs to tow it around, and during loading and unloading simply left the drawbar resting on a stump. The trailer had a capacity of 1.5 m^3 and cost approximately $1,750.00 to purchase.

The tongs were three point linkage mounted and could rotate, pivot from side to side, open and close, and crowd backwards and forwards in the hydraulic arms. They also had a .75 m long sting used to align logs and which also doubled as a heel for loading and unloading. Priced at $3,975.00, they were ideally suited to the fully hydrostatic Hydro 84 tractor. The tractor had been modified to enable forward, neutral and reverse movement to be controlled by one pedal so that the hands were free to operate the mudguard mounted, grapple controls. The main disadvantage of the tractor was the ergonomically bad position the operator had to get into to operate the grapple. Depending on the size and length of timber, up to four or five logs could be picked up at once. With the crowding action of the grapple, logs could be stacked as high was 2 m at the roadside.

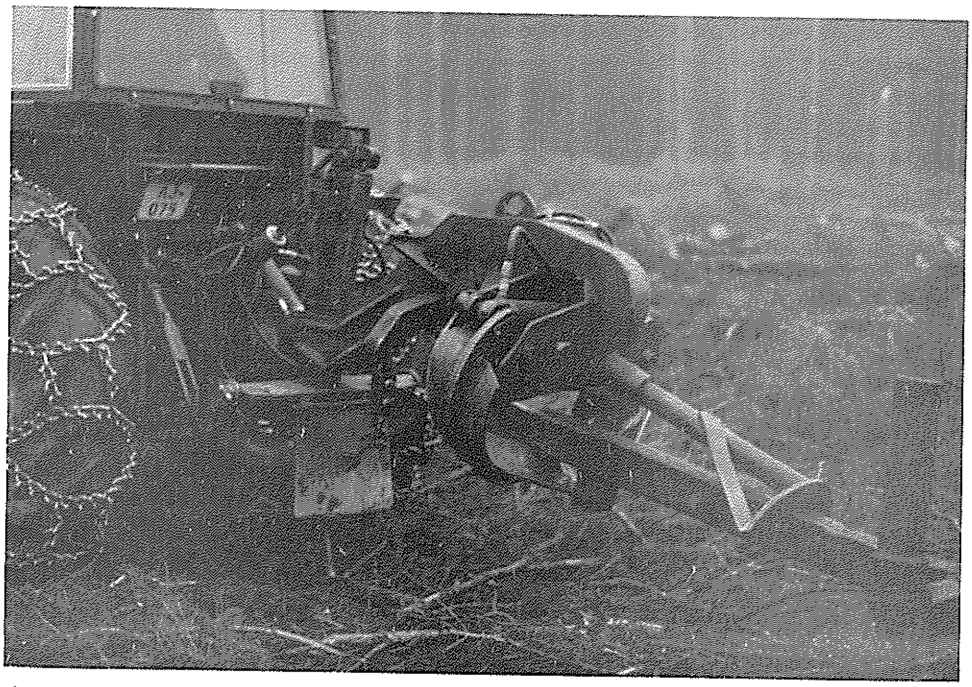


Fig. 21 - International Hydro 84 with Loft tongs and Trailer

The second stop was at a Gremo DT8H feller delimber buncher with a boom mounted Gremo TH25 felling head. It was working strip roads in a stand of 25 year old Norwegian Spruce stocked at between 5,000 and 6,000 sph. The machine had automatic log measurement and cut-to-length activiation, a ten tree memory and ability to sort into five different categories. The maximum sized tree it could handle was 25 cm at the butt and it had a delimbing speed of 2 m per second. It took approximately 1 minute to fell, delimb, cross cut and bunch a stem.

The saw chain used for felling was semi-chisel and it was mounted on a solid tipped bar with a protective shield around the end. The whole operation was considered as part of a silvicultural treatment programme by the forest owner, not a profit making operation.

During this visit the Huski time study computer was demonstrated. This hand held digital read out clock could store 650 observations consisting of a maximum of 10 time variables and 4 numeric values. Each time variable and numeric value had its own key on the keyboard and after every complete observation had been made, a key was punched which automatically entered the time for that element in the memory of the computer. Times were recorded directly in centi-minutes.

With a special programme, it was possible to calculate the mean value of the observations taken while out in the forest. A standard error of mean was also calculated at the same time. When the memory space on the computer became full, or, at the completion of a study, the contents of the memory were transmitted by telephone to a central computer.

FUTURE PLANS OF THE CPC7 PROJECT

While the FE agreement runs out in 1984, the meeting still considered it worthwhile to keep the CPC7 project going. The reasons behind this were that for the most part progress had not extended beyond level B - description of demands for relevant machinery and equipment. This meant that at least one, possibly two, further years were necessary to complete the project. To obtain this extension a documented plan for continuation is necessary before the next PGC meeting in October 1984.

In order to speed up the progress of the project and increase the value of the information exchanged, it was decided to distribute subproject questionnaires to all countries participating in the CPC7 project. Target dates were set for 1983, 1984, as follows :

December 1983 - Preparation and distribution of questionnaires and time schedules by the subproject leaders.

April 1984 - A progress report to project managing agent for report to executive committee.

May 1984 - Information assembled on individual subprojects.

June 1984 - National reports to be prepared.

July 1984 - Dispatch National Reports by airmail to subproject leaders and the Secretary.

August 1984 - Collection of the National Reports into a subproject report and distribution to all countries.

September 1984 - Presentation of subproject reports to the CPC7 meeting in Canada - U.S.A.

Plans for a new subproject, No.12, on felling and bunching of solid fuelwood was outlined and Austria allocated the responsibility to control it.

The next meeting was scheduled to be held in Canada and the U.S.A. in September of 1984. It was suggested that the dates be organised to coincide with the Wood Expo starting in September.

VALUE OF CPC7 INVOLVEMENT TO NEW ZEALAND

The benefits to New Zealand of involvement in this project have at this stage been mainly in the area of information exchange. Although harvesting trees specifically for energy purposes is not carried out in New Zealand, some of the information obtained is quite applicable to existing pulpwood thinning operations. Should New Zealand ever have to undertake specific energy wood operations, it would be most beneficial to have access to a broad base of knowledge on the viability of various systems that have been tried.

As the overall aim of the project incorporates machine design and construction, it will be important that the constraints affecting the harvest of New Zealand's tree crop are well known to those designing and building these new machines. The IEA project is one way of ensuring that design criteria takes these factors into consideration.

Production thinning in New Zealand is becoming recognised more as a silvicultural tool rather than a straight moneymaking venture. In the interests of thinning at an earlier age and still maintaining a viable return, the need for improved efficiency in the thinning operations is important. Continued involvement in projects such as the IEA FE CPC7 co-operation will help to identify better machines and techniques quicker. An example of this would be the radio control of winches, which could have a lot of potential in New Zealand. By knowing about the experiences of other countries that have used this idea, a lot of costly mistakes could be avoided.

To get the most of a project such as this, however, requires the full commitment of all the participating countries. To date this has not been the case, although after discussions at the 1983 meeting the response from other countries has improved.

The IEA FE CPC7 project is a low cost avenue for getting information on an exchange basis. Already, ideas received from other countries have been tried out in New Zealand conditions. For example, the quick release hook from Ireland. The future developments planned in felling and bunching with both manual and mechanised systems will be of definite interest to New Zealand and, therefore, continuing involvement in the project is recommended.

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APPENDIX I

LIST OF PARTICIPANTS AT THE 1983 MEETING

AUSTRIA	Eberhard Nossek
BELGIUM	Pierre Abeels (Host) Mr. Vanderpoorte (Delegate Ministry of Agriculture)
CANADA	Emil David
DENMARK	Per Tutein Brenøe (Chairman) Jan Clausen Pieter Kofman (Secretary) Per Rosendahl
IRELAND	Henry Phillips
NEW ZEALAND	Rob Prebble
NORWAY	Inge Krogstad
SWEDEN	Hans Knutell Lars Hedman