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PROJECT REPORT

MECHANISED HARVESTING DEVELOPMENTS IN AUSTRALIA

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Project Report

P.R.37

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MECHANISED HARVESTING DEVELOPMENTS IN AUSTRALIA

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SUMMARY

This Report examines developments in mechanised harvesting in Australia since FIME '86 (April 1986). Over the last two years the Australian logging industry has reinforced its move to fully mechanised logging systems begun in the 1970's.

An even wider range of harvesting machines than was noted in 1986 is available and those in use two years ago have been replaced by newer and more sophisticated models.

The Australian logging industry has examples of all the worlds mechanised harvesting equipment sourced as widely as Scandinavia, Canada, the US, South Africa, New Zealand and locally in Australia.

The development of locally manufactured logging machines is a recent move, demonstrating that the Australian industry has developed the innovation and skills required to tailor machinery to its specific needs.

ACKNOWLEDGEMENTS

The assistance of A.P.M. Forests Pty.Ltd. of Morwell, Victoria, Australian Newsprint Mills Ltd. of Albury, N.S.W., Woods & Forests Department of Mt. Gambier, S.A., SAPFOR Timber Mills Pty. Ltd. of Tarpeena, S.A., and Softwood Holdings Ltd. of Mount Gambier, S.A., is gratefully acknowledged.

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INTRODUCTION

A tour of mechanised logging operations throughout the South-East of Australia was undertaken by LIRA researcher K Raymond during 24 April - 15 May 1988.

Three main regions were covered : A.P.M. operations in Gippsland, Victoria; A.N.M. operations in Victoria and New South Wales; and logging operations in South Australia (Woods and Forests Department, SAPFOR Timber Mills Ltd. and Softwoods Holdings Ltd.).

The objective of the trip was to update on mechanised harvesting developments in Australia since FIME '86. Of specific interest was the evaluation of new processors, and harvesters. This Report attempts to summarise the changes in Australian mechanisation over the last 2 years. Several logging contractors had recently updated their equipment, moving away from the original machine models (such as the Kockums Logma) into the single-grip and two-grip harvester type machines.

The inception of a fully mechanised shortwood logging system in New Zealand in 1987 demonstrates that it is timely for the New Zealand industry to look again at forwarders as a viable means of high productivity ground based extraction.

In all operations visited attempts were made to collect short term work study data as well as general production information and details of machine specifications.

In all cases costs quoted are in New Zealand dollars, for convenience. An exchange rate of NZ$1.00 = A$0.88 has been used, which was the average at the time of writing (May 1988). Machine prices are relevant to this time only, and will fluctuate with inflation and exchange rates.

Readers are invited to enquire at LIRA for further information on any machines of interest or details of logging industry contacts.

Figure 1 : Osa 250 Forwarder in Outrow thinning

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The A.P.M. forest estate covers approximately 42 000 ha in pine plantations and 6000 ha of eucalypts. Landholdings of more than 80 000 ha total include 12 000 ha leased from the Victorian Government. The annual input to Maryvale pulp mill from all sources is approximately 600 000 m^3 of pine and 570 000 m^3 of eucalypt pulpwood. Over 100 000 m^3 of sawlogs are also supplied to the Gippsland Woodmill annually. There are nine pine and 36 eucalypt logging contractors with fortnightly quotas in the range of 300 - 1800 m^3 in eucalypt, and 300 - 8000 m^3 in pine. Six pine contractors operate mechanised harvesting equipment.

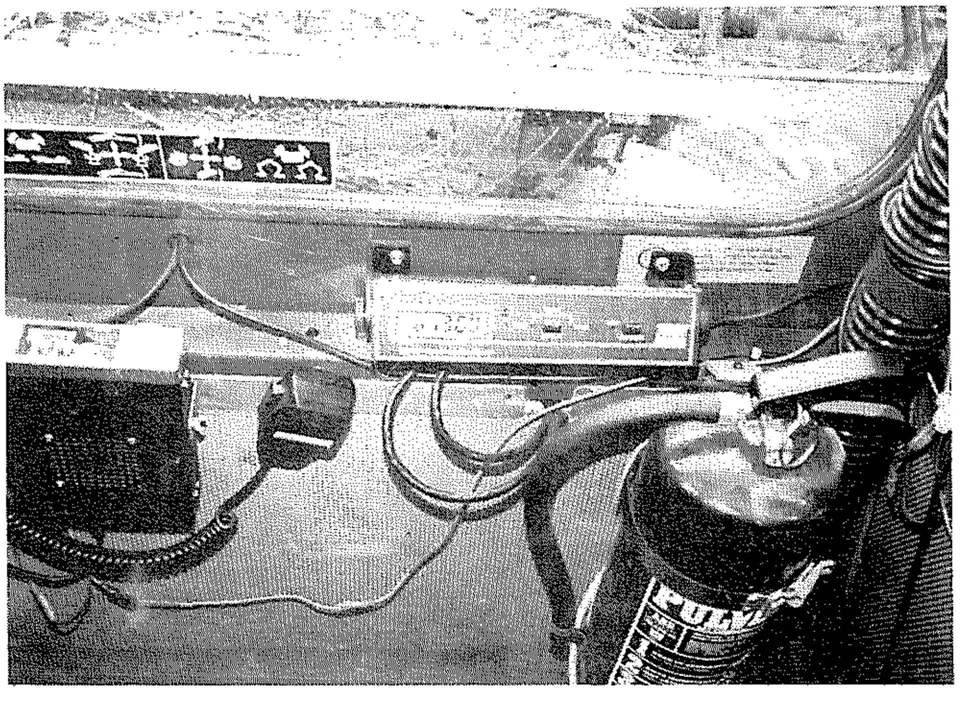

Figure 2 : Readout of Lodec Load Measuring Device

The contractors are responsible for the delivery of wood to Maryvale. They own and operate equipment for extraction and loading, and engage cartage contractors to transport the wood.

Venturoni Bros, A.P.M. Logging Contractors

The operation was a first production thinning (T1) in Stockdale Tree Farm, 103 km from Maryvale Mill. Machinery consisted of 2 Waratah DFB's, (one two years old, 2800 hours; the other three years old, 7500 hours); and 2 Osa 250 forwarders (one seven months old, the other 4000 hours old).

Current production per DFB was 65 tonne per day with a maximum of 100 tonne per day (0.23 m^3 piece size). Overall the system produced 1000 tonne/week of random length short pulpwood.

The Osa 250 is a small six-wheel drive forwarder rated at 10 tonne capacity. It has an Osa 362 boom, Indexator GV10 rotator and Hultdins grapple. The Osa 250 features articulated steering and hydraulic disc brakes. It is powered by a 119 hp Perkins diesel. Cost is $360,000.

The interesting feature of this operation was that the forwarder had Lodec on-board load scales mounted on the forwarder bunks to measure their payload (Figure 2). These load measuring devices were commonly found on truck trailers, and cost approx $11,500 per set to install.

The contractor was aiming to extract 13.0 tonnes per load. Accuracy of the load measuring device was ± 100 kgs. Using the load cell the contractor could not only optimise forwarder payload but also ensure maximum legal truck loading.

Wood cost with the mechanical system was 13.65/m^3 in comparison with manual cutting cost of \$16.79/m^3, a difference of over $3 per m^3.
Manual cutting rates in Victoria are:

$15.96	Basic rate
0.40	Payroll Tax
0.43	Work care

$16.79	per m^3

Work Care is a Government scheme introduced in 1986 for the subsidy of work-related accidents. It is calculated at 3.6% of 75% of the basic wage rate.

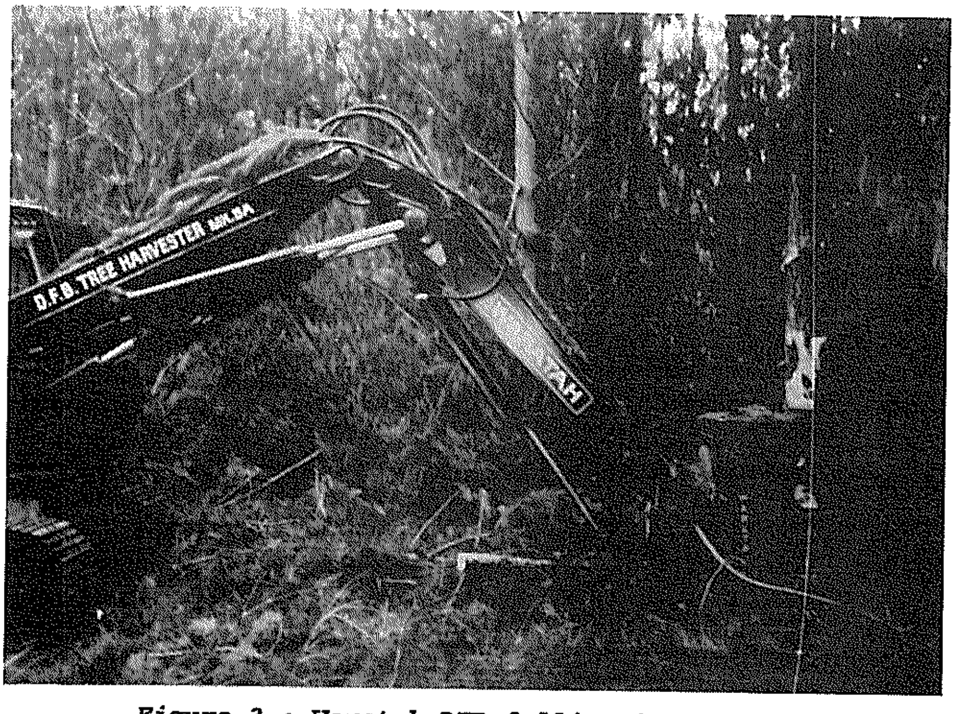

Figure 3 : Waratah DFB felling in outrow

Table 1 : Work Cycle of the Waratah Mk 5A DFB

ELEMENT	n	Mean per cycle (min)	± 95% Confidence limits
Position head	164	0.094	0.005
Delimb	164	0.588	0.027
Fell	164	0.070	0.003
Move (incl. move to bunch	64	0.044	0.007
Total Process	164	0.796	0.031
Clear slash	22	0.014	0.002
Total cycle (min)	164	0.810	±0.037

Given a total cycle time (net of mechanical & non-mechanical delays) of 0.81 mins, productivity = 74 trees per PMH

= 17.0 m^3 per PMH

The DFB's were mounted on the Kato 550SE model excavator. Capital cost in 1986 was $285,000. Current price for the boom and head alone was $156,860 plus $34,450 for fitting and modification to the base machine.

A short term study of the newer model Waratah Mk 5A DFB, was undertaken (Figure 3).

The stand was 14 year old Radiata pine. Average extracted tree size was 0.23 m^3, with an average diameter of 19 cm. Results are given in Table 1.

Cycle time was related to both tree diameter and tree volume over the range of tree sizes studied (Figures 4 and 5). Cycle time excluding clear slash time was predicted by linear regression :

CYCLE TIME = (0.0337 * DBH (cm)) + 0.150 (r^2 = 0.47)

CYCLE TIME = (1.190 * TREE VOLUME (m^3)) + 0.524 (r^2 = 0.45)

Garry Leeson, A.P.M. Logging Contractor

Clearfelling Radiata pine for A.P.M. in Longford Tree Farm, the operation consisted of a Koehring K620FB feller buncher, a Kockums 85-41 Logma delimber, a Koehring K620 DL delimber, and a Kockums 85-35 T Forwarder.

The productivity of the feller buncher was much higher than other machines in the system (70 - 80 m^3/PMH). The K620FB buncher could achieve the fortnightly quota in six working days. The capital cost was $375,000.

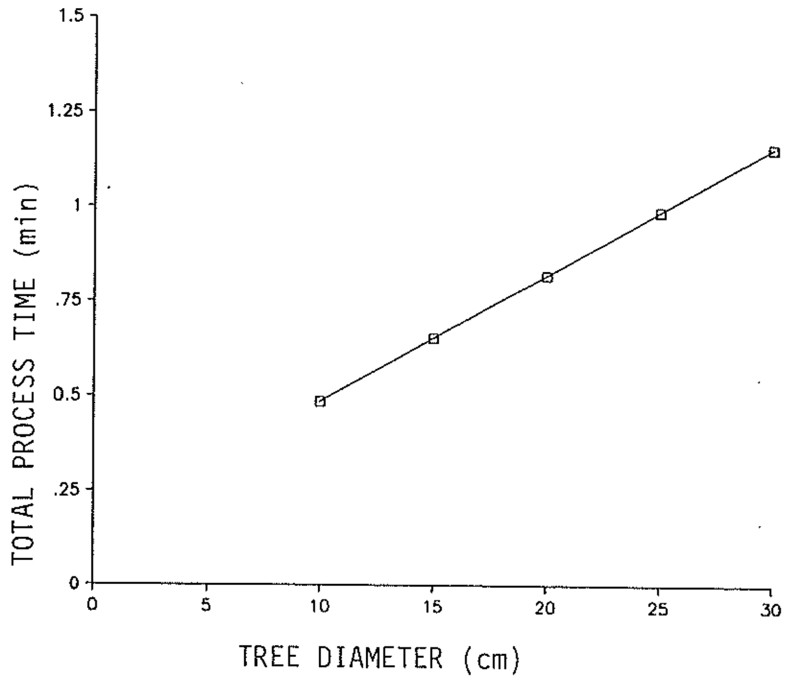

Figure 4: DFB Cycle Time vs. Tree Diameter

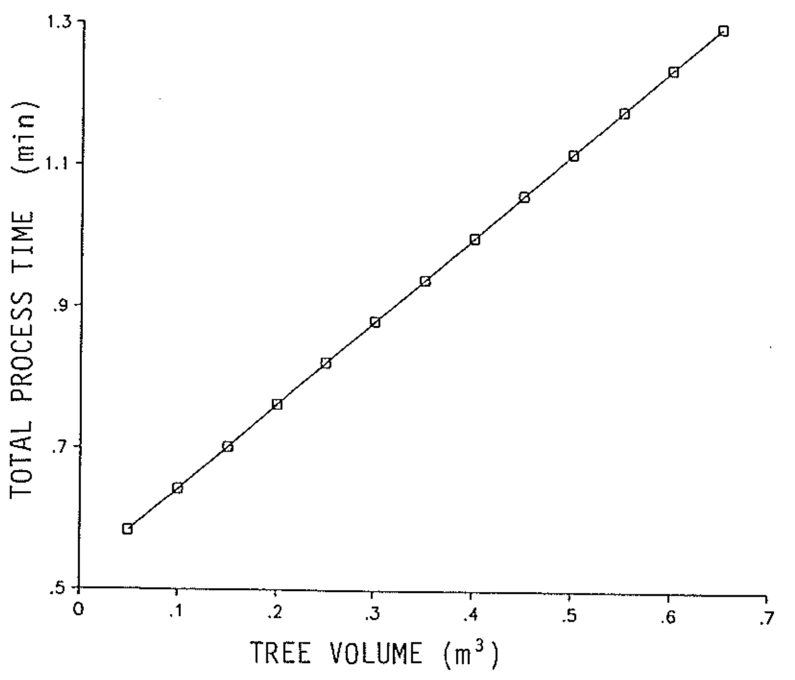

Figure 5: DFB Cycle Time vs. Tree Volume

Figure 6: Koehring K620FB Clearfelling Radiata Pine

Larger diameter trees (>56 cm) were felled, manually trimmed and (a 5 m butt) cut off to enable processing of the rest of the tree by the stroke delimbers.

Long term productivity of <u>34 m³ / PMH</u> in clearfell operations of approximately 2.0 m³ tree size, was quoted for the Koehring delimber.

Koehring K620DL Delimber

The Koehring stroke delimber has been in Australia for approximately three years and in terms of machine availability has proven to be a highly reliable machine. Garry Leeson's K620DL was purchased in April 1987.

Production rates quoted by contractors were very high and all owners spoke of having very few problems with the machine.

The K620DL has an improved Logma boom which has a faster speed and more power than the original Logma. The unit is powered by a 200 hp Cummins diesel and features Rexroth hydraulics system. An early production study by A.P.M. in Radiata clearfell (1.2 m³ piece size) showed the Koehring to be 22% more productive than the Logma depending on operator. Measured productivity of the two machines was 43.1 m³ per P.M.H. vs. 35.4 m³ per P.M.H. respectively. (O Raymond, pers comm).

The new model is the K618DL which is slightly smaller than the K620 DL. Capital cost was $522,000. The agent for Koehring is Summit Machinery and Equipment Limited of Sydney (also agents for Valmet, Denis and Sumitomo).

The Kockums 85-35T Forwarder

The Kockums 85-35 Turbo is rated at 15 tonne capacity. The unit is powered by a 178 hp Scania diesel turbo, and uses a Cranab 100 crane.

The machine studied was 18 months old and had been operating for 2200 hours.

A short term production study of the 85-35 T was undertaken (4 work cycles), where the forwarder was extracting just off the roadside.

Table 2: Work Cycle of the Kockums 85-35T Forwarder

Element	*Mean per cycle min)*
Travel Empty	*1.13*
Load	*19.82*
Move	*6.98*
Travel Loaded	*0.94*
Position	*1.13*
Unload	*7.46*
Total Cycle	*37.46*
Travel Empty Distance (m)	*100*
Travel Loaded Distance (m)	*52*
Number of pieces per load	*41*

In this block, the wood had been manually felled and crosscut into pulpwood and sawlogs.

The forwarder operator was extracting separate loads of sawlogs, peelers and pulp and loading directly to truck. Sorting sawlogs from pulp while loading appeared to slow up the operation due to double handling of pieces.

Due to the fact that the block was manually felled the forwarder worked a strip method to the back of the block. The operator preferred working behind the delimber since the wood presentation was much better.

Truck scheduling was such that there was always one and sometimes two trucks waiting to be loaded. Waiting times for trucks ranged from 15 - 30 minutes.

The work cycle of the forwarder is given in Table 2.

Operational delays consisted of waiting for the truck to position both prior to and during loading. This amounted to approximately one minute per cycle.

Figure 7: Extraction of Sawlogs Using Kockums 85-35T Forwarder

Forwarder loads for sawlogs (0.57 tonne per log) averaged 41 pieces. This equated to a payload of 23.3 tonnes (Figure 7).

Travel loaded speed averaged 0.95 m/s and travel empty speed averaged 1.37 m/s. At a cycle time of 37.46 minutes and average payload of 23.3 tonnes, forwarder productivity was calculated at 66 sawlogs per P.M.H. (37.7 tonnes per P.M.H.).

The Harvester/Forwarder System.

Working in second thinnings in A.P.M.'s Callignee forest in Gippsland, Gary Leeson also operated a grapple harvester/ forwarder system.

The harvesters were an Osa 762 mounted on a Kockums 880 base, (Figure 8) a Kockums GSA 62 (also on a Kockums 880) and an Osa 706/260 two-grip harvester (Figure 9).

Figure 8: Osa 762 on Kockums 880 Wheeled Base

Figure 9: Osa 706/260 Harvester in Thinnings

The forwarder was a Kockums 85-35 which extracted behind the three harvesters.

The Osa 762 harvester features two rubber wheels which are hydrostatically driven and a chainsaw with a capacity of 50 cm diameter. The head has one fixed and four movable delimbing knives, with length measuring by a separate measuring wheel. The rotator is an Indexator GV10 and the whole unit weighs 950 kg. Cost for the harvester head alone was $160,000.

The Osa 706/260 two-grip harvester is a high capital cost machine but is very impressive. It has the capability to process one tree through the processing head while felling the next tree. The felling equipment is an Osa 642 chainsaw felling head with a maximum diameter capacity of 56 cm. The unit incorporates a crosscutting saw and computer length measuring. During the period of observation the harvester was handling approximately 65-70 trees per hour.

The 260 Forwarder in its role as a carrier has the bunks removed and rear chassis shortened. The lighter model crane is replaced by the heavier Osa 395. The crane base is of heavy construction and is equipped with a 20° tilt facility which improves the slewing capacity on steep country. The boom extension gives the crane a maximum reach of 11.0 m.

The processor bed is mounted on a turntable to enable vertical movement and 122° slew in either direction. This enables processed wood to be sorted and stacked in any direction.

The delimbing knives closing on the tree indicate diameter and position is registered by proximity sensors. Minimum sawlog diameter and minimum pulp diameter are preset by the operator. A measuring wheel translates rotation to length via a pulse generator to the computer. Five lengths can be preprogrammed, and lengths are displayed on a digital readout in the cab. Crosscutting can be automatic or manually controlled. The 706/260 has been superseded by the 707/280 harvester which has a capital cost of $770,000.

Leeson was planning on bringing a shear feller buncher into operation felling in front of the Osa 706. This was an attempt to reduce R & M costs on the felling head, which had proven to be a high maintenance item.

The Waltanna Forwarder

The F6-18 is a new model six-wheel drive forwarder rated at 18 tonne capacity, and powered by a 200 hp Cummins turbocharged diesel (Figure 10). Specifications of the Waltanna forwarder are given in Appendix 2.

The unit is equivalent to the Osa 280 Master forwarder, and uses a Cranab 100 crane and grapple.

The cab is fully air conditioned and all gauges are mounted at the rear rather than the front or side as with the Scandinavian models. A warning system is fitted to indicate low water level, low oil and air pressure, high engine temperature and low hydraulic oil and filter maintenance. A fire extinguisher system is also fitted to the engine compartment.

Total length of the machine is approximately 11.0 m, and the forwarder bunk can handle logs up to 6.0 m length. The forwarder is 3.0 m wide at the front and 2.70 m wide at the rear. The bolsters on the forwarder bunk are being widened by 18 cm on each side to further increase payload.

Figure 10: Waltanna F6-18 Forwarder

Advantages of the Waltanna Forwarder

Three major advantages were quoted:

- increased capacity
- lower capital cost
- local servicing and parts

Although rated at 18 tonne capacity the maximum total permitted load is 33 tonne. To date the forwarder regularly extracts payloads of 21 tonne. The engine and transmission is specified to be robust enough for local logging conditions. The powershift transmission is larger than the rated engine output. Preliminary studies have shown productivity in Radiata clearfell of 0.8 m³ piece size of 29 m³/PMH. Fuel consumption has been measured at 10.2 l/PMH.

The cost of the forwarder was $352,000 which was almost $115,000 less than the equivalent size forwarder (OSA 280). Since the forwarder is manufactured locally from common componentry, servicing and spare parts are commonly available.

The cab, designed from the Waltanna Broad Acre tractor cab, features excellent all round visibility and simple joystick controls. In contrast to the Scandinavian forwarders there are no high tech electronics relating required engine power to hydraulic pump displacement.

Leeson's "ideal" systems for various Radiata operations are given below:

Radiata clearfell

- Large feller buncher (possibly Koehring K620FB)
- Koehring K620DL stroke delimber
- Waltanna forwarder

Large piece size thinnings (0.25-0.30 m³)

- Shear feller buncher
- Osa 706/260 two-grip harvester
- 14-16 tonne class forwarder (Osa 280 or Kockums 85-35)

Small piece size thinnings (< 0.20 m³)

- GSA62 or Osa 762 grapple harvester
- Small forwarder (Osa 250)

Leeson did not prefer the Waratah DFB as a felling and delimbing machine due to its poor ergonomic design and lack of length measuring capability.

Figure 11: Mechanised Radiata Clearfelling in Jeeralang Forest, Gippsland.

<u>Ivan & Robert Crawford, A.P.M. Logging Contractors</u>

As the largest logging contractor in the Gippsland region, Ivan Crawford and his son Robert, have played a major role in developing the highly mechanised systems currently being used. They have moved onto steeper country in both Radiata thinnings and clearfell.

The operation visited was a 28 year old Radiata clearfelling on easy terrain in Jeeralang Tree Farm, south of Morwell. Felling was by Kockums 880 shear feller buncher. Delimbing was achieved in the bush by a Harricana stroke delimber, mounted on a Cat 215 excavator base. Extraction was by Osa 280 forwarder (Figure 11).

The Harricana had been operating for approximately 10 000 hours and had the boom replaced at 5500 hours. Production of the Harricana was quoted at 10 loads per day, and the capital cost was approximately $280,000.

Total cycle time was estimated at 1.3 minutes. This gave indicative delimber productivity of 46 trees per productive machine hour. Tree size was estimated at 1.5 m^3, giving volume productivity of approximately 69 m^3/hour.
After FIME, Crawford purchased an Osa 280 Master forwarder in June 1986. The Osa 280 is in the large forwarder class, rated at 18 tonne capacity (Figure 12).

It is powered by a 209 hp Volvo turbo diesel and transmission is hydrostatic in combination with automatic computer controlled three-speed powershift and power control. Fuel consumption averaged 12.0 litres per hour (120 litres per day). The crane is an Osa 392 with tilt capability at the base, an Indexator GV10 rotator and Hultdins grapple. Capital cost of the Osa 280 forwarder was $470,000.

Forwarder productivity averaged 13 loads per day (310 tonne) with a maximum of 17 loads per day. Pulpwood log size averaged 0.27 tonne per piece. Sawlogs averaged 0.62 tonne per piece. Forwarder payloads averaged 34 pieces for sawlogs (21.3 tonnes).

The work cycle of the forwarder extracting sawlogs over an average haul distance of approximately 125 metres is given in Table 3.

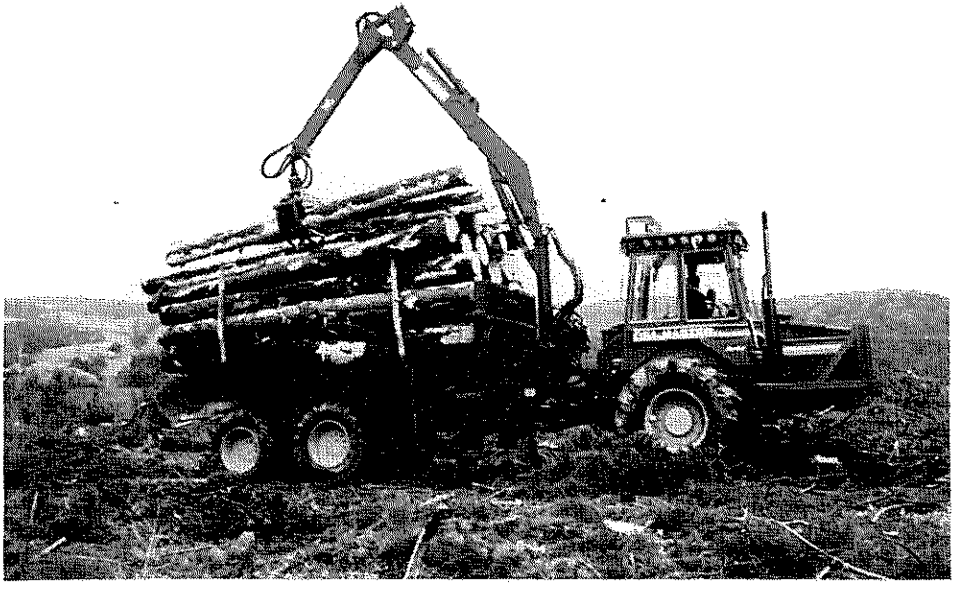

Figure 12: Osa 280 Master Forwarder Extracting Sawlogs

Table 3 : Work Cycle of the Osa 280 Forwarder (n = 7)

Element	*Mean per cycle (min)*
Travel Empty	*4.80*
Load	*7.66*
Move	*1.76*
Travel Loaded	*4.28*
Position	*0.98*
Unload	*5.79*
Total cycle (net of delays)	*25.27*
Travel Empty Dist (m)	*150*
Travel Loaded Dist (m)	*100*
Number of pieces	*34*

At a total cycle time (excluding delays) of 25.27 minutes, and an average payload of 21.3 tonnes forwarder productivity was calculated at 50.5 tonnes/PMH.

AUSTRALIAN NEWSPRINT MILLS LIMITED, ALBURY, NEW SOUTH WALES

A.N.M. obtains most of its pulpwood from first and second thinning operations in State forests in both N.S.W. and Victoria. Operating a shortwood system of 5.8-3.6 m in random lengths, input to the woodmill averages 1300 tonne per shift (8 - 10 000 tonne per week). Maximum diameter of wood into the mill is 45 cm.

Harvesting is done by 9 independent mechanised contractors who log to roadside. A separate contractor loads pulpwood using Prentice 210 knuckleboom cranes mounted on six-wheel prime movers.

Production is on a quota system, the crews being allowed to work for two days after the achievement of the fortnightly quota prior to shutdown. Rates are set based on the quota, with margins for slope, piece size and logging debris.

For A.N.M., forwarder extraction and loading of 5 m long sawlogs and pulp from thinnings has been found to be more efficient than skidders with manual crosscutting at the landing. This decision was based on :

- all wood coming from thinnings on land less than 20° slope;
- manual labour of adequate quality would not have been available;
- requirement for sawlog production in addition to pulpwood;
- the N.S.W. Forestry commission hydrological constraints on landing construction;
- the requirement for clean logs at the mill.

Subsequently, thinning is scheduled for all Radiata plantations on terrain of less than 20° slope and 6° sideslope. Major efforts are being undertaken to thin Sirex infected and wind damaged stands. This involves a move onto steeper country to thin these stands.

In A.N.M.'s view the only processor which satisfactorily delimbs Radiata pine to sawlog standard is the stroke delimber such as the Kockums Logma, Koehring 620DL, and the Denis delimber. On steeper country the wood is mechanically felled and bunched using the Timbco and extracted by skidder to easier country where it is processed by the stroke delimbers.

A.N.M. is currently looking at options for steep slope felling machines. One option is the large quad-track feller buncher developed in the Pacific Northwest. This unit (of which three or four have been manufactured) was designed originally by Washington Ironworks. Allied Systems (Wagner) have purchased the design from Washington. Its model designation is ATH-28, due to its ability to fell a 28 inch diameter tree at 28 foot reach (70 cm diameter tree at 8.5 m).

A.N.M. consider that a return to motor-manual systems is not an option. On steep country (> 28°) they are investigating cable operations, and have offered to clearfell Forestry Commission hauler areas in preference to thinning. This option may also involve some element of mechanisation. It will be worthwhile for the NZ industry to monitor their progress in this area.

A fleet of 20 trucks all using three-axle semi-trailers transport the pulpwood to the Albury mill. The average trucking distance is 150 km. As with A.P.M. in Gippsland, there is a move here towards the folding skeletal semi-trailer (Appendix 3).

Figure 13: Osa 706/250 Harvester in Second Thinnings

A.N.M. are currently instituting a new woodstocks inventory control system, which eventually will simplify the weighbridge system. Using Husky Hunter portable data loggers connected via radio link to the weighbridge, the forwarder operators will key in the location and description of wood produced at roadside. This will enable truck drivers to load out the oldest wood first and ensure a constant turnover of stocks (Appendix 4). Effectively the weighbridge will become mechanised, operating on a 24 hour basis with 2-shift trucking.

Alister Harvey, A.N.M. Logging Contractor

Logging operations were visited in Shelley Forest, 80 km east of Albury.

Alister Harvey operated a Kockums three-machine system in Radiata thinnings (Kockums 880 feller buncher, 85-41 Logma processor and 85-33 forwarder). Harvey had just purchased a new Kockums 85-35T Forwarder, and was logging to roadside.

A Cat 518 skidder with a Young grapple was also used to extract areas too difficult for forwarder extraction. Harvey's production was around 1200-1300 tonnes/week in 0.25 m^3 tree size, although the production quota was 710 tonne/week pulp and 150 tonne/week sawlogs (170 tonne per day total).

Dick Baucher, A.N.M. Logging Contractor

Dick Baucher started with the Kockums three-machine system in 1981. The original Kockums system had done 16 000 hours and he had started replacing units as required. Baucher has purchased an Osa 706/250 two-grip harvester and was addressing the problem of steep slope felling.

The Osa 706/250 is a smaller unit than the 706/260, using the same processing unit but mounted on a shortened Osa 250 carrier (Figure 13). It has a lighter boom, (the Osa 374) with a 9.5 m reach. Production of 34 tonne per hour in delayed first thinnings was quoted. Baucher was using the Kockums 880 to fell and bunch the trees at right angles to the outrow, and the 706/250 was being used as a processor only. The 706/250 has been superseded by the 707/250 harvester, which had a capital cost of $618,000.

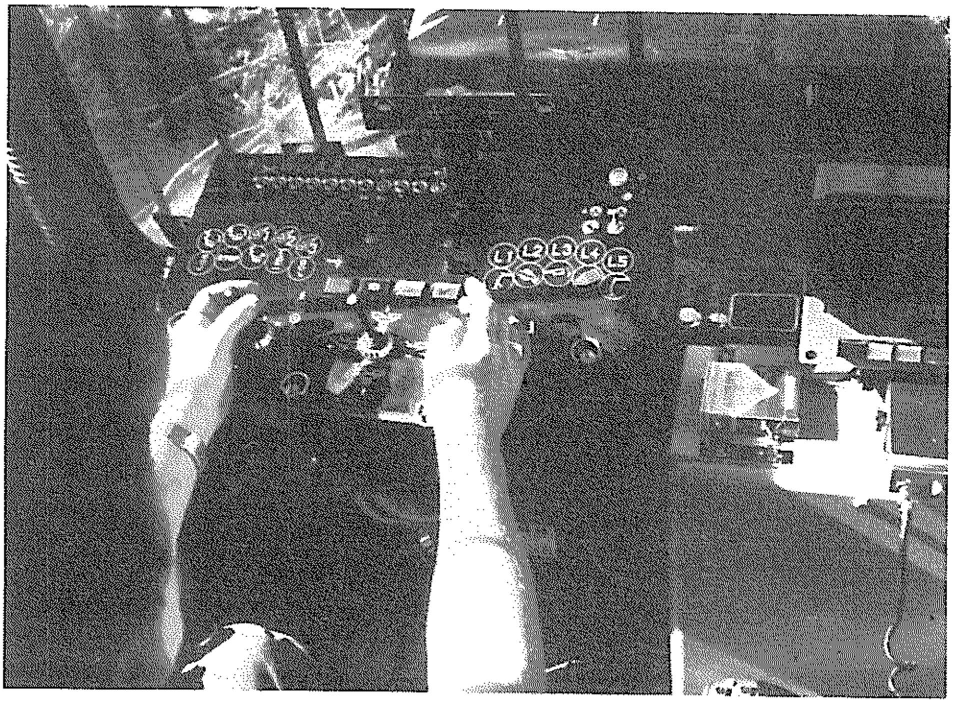

Figure 14: Control Console for Processor Unit

The functions of the harvester head are controlled by the loader control joysticks on either side of the operator's seat, each with a pad of pushbutton controls. The left-hand lever controls head tilt up and down, selection of pulpwood, shortwood and random lengths, offroad steering, head pressure for felling, and head float mode. The right-hand lever controls selection of five sawlog lengths, tilting of the crane base, the felling head clamp arm, felling saw, and automatic mode selection.

The operation of the processor is controlled by three joystick controls located on the lower section of a console facing the operator (Figure 14). The left-hand joystick has six positions, two controlling opening and closing of the feed rollers, two controlling the delimbing knives, and two positions giving combined control of both functions.

The centre joystick has four positions, two controlling tilting of the processor, and two controlling slew. The right-hand joystick has four positions, two controlling feed roller direction and two controlling the crosscutting saw.

To the right of this console is the microprocessor which controls length measurement and automatic processing and also records the number of sawlogs processed by length and the number of pulpwood lengths processed.

In Baucher's operation, forwarding was done using a Kockums 85-35 Turbo forwarder and a Clark 666c for difficult areas. Quota was 910 tonne pulp per week and 250 tonne per week sawlogs (230 tonne per day total).

Baucher attributed the success of his mechanised system to attention to maintenance, the use of mobile workshops, and quality operator training through joint courses between the N.S.W. College of Technical and Further Education, the machinery supplier (Kockums AB) and the company (A.N.M.).

Improvements in his operation were also attributable to :

- radio contact between all machines and the workshop
- on-board fire extinguisher systems reducing fire risk
- flexibility to work longer hours, extending shifts to increase production.

Figure 15: Valmet 902 Two-Grip Harvester

Greenfreight Harvesting Limited, A.N.M. Logging Contrac-tors

This mechanised operation in Shelley Forest, Victoria was the first opportunity to view the Valmet 902 two-grip harvester. This is one model of bed processor starting to appear in Australia (Figure 15).

The 902 is the next model up from the Valmet 901 single grip harvester on a purpose built six-wheel drive forwarder chassis. It is powered by a 170 hp Volvo diesel with turbo. Transmission is via Clark torque converter with full power-shift. It is similar in concept and size to the Osa 706/250, with a capital cost of $681,000.

The felling head can handle 58 cm diameter trees, and the processor delimbs up to 50 cm diameter. The processor feed is via two rubber wheels through one fixed and two moving knives. The processor bed is capable of 270° rotation, to segregate the various log types produced. The unit viewed was four months old (875 hours), and was processing behind a Kockums 880 shear feller buncher.

Productivity of 20 tonnes per hour in Radiata first thinnings was quoted. Problems with the unit had involved the operation of the crosscutting saw on the processor bed, and the brakes malfunctioning on steep country.

Jim Crozier, A.N.M. Logging Contractor, Tumbarumba, N.S.W.

Jim Crozier was working on moderate to steep country in Carabost Forest, Tumbarumba, 70 km south of Tumut, N.S.W.

The operation was delayed first thinning of Radiata pine. The stand was planted in 1963 (piece size 0.25 tonne). Crozier's system consisted of a Timbco feller buncher, one Kockums 85-41 Logma delimber, one Valmet 902 harvester and extraction by two Kockums forwarders (85-33 and 85-35). The production quota for this operation was 1520 tonne/week of pulpwood and sawlogs.

Crozier also operated a Kockums system (12 000 hours) and another Valmet 902 (4000 hours) in other species, producing sawlogs and posts.

The modification of a Kockums forwarder to a clambunk skidder reported in 1986 (Galbraith & Prebble, 1986), had not been an operational success. The concept had created problems of insufficient space on roadside and slash disposal problems.

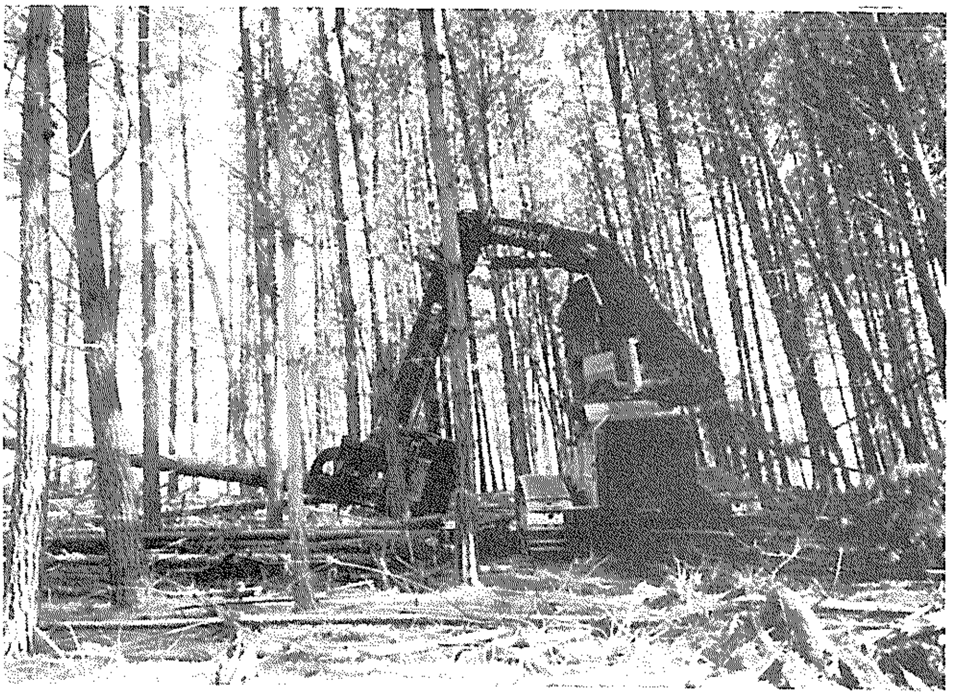

Figure 16: Timbco 2518 Feller Buncher on 8° Slope

The Timbco 2518 purpose built feller buncher has the engine and hydraulics system located between the machine tracks. The turntable which carries the boom and operator cab can be tilted so that slewing can be achieved in a horizontal axis on all slopes (Figure 16).

The Timbco is capable of felling on slopes of up to 27°. The safe working limit of the Kockums 880 feller buncher is around 20°. The felling head is a Tenco accumulating shear with 50 cm maximum capacity. Boom reach is 7.5 m horizontally and 11.0 m vertically. The Timbco was four years old (4000 hours) and had proved to be a high maintenance machine.

Problems had occurred with engine overheating (up to 350° F), failure of the tilt rams on the turntable, drive motors, idlers and top rollers on the track gear, and hydraulic pumps. However the contractor conceded that this was a function of the tree size and terrain on which the Timbco was required to operate. At over 30 tonne per hour the Timbco was much more productive than the other machines in the system. Crozier's overall view was that the Timbco was a great feller buncher and would fall just about any tree on any country despite the high maintenance. The current price of the Timbco was quoted as approximately $420,000.

The Valmet 902 viewed was 12 months old and had operated for 1700 hours (Figure 17). Crozier's other Valmet 902 was two years old (4000 hours).

Both machines had had some electronic problems, but the major maintenance item was the rubber drive wheels. The super-single tyres had not worn out but had been punctured beyond repair. The new 902 was on its second set of tyres, while the older 902 was on its third set. Life of the tyres was therefore estimated at 1600 hours. At $6,300 each, the cost of tyres added approximately $4 per hour to machine cost.

The forwarder studied in this operation was a three and a half year old Kockums 85-35 extracting from a fifth row outrow on moderate terrain (Figure 18). The outrows were cut directly up the slope, reducing the effect of sideslope. A short production study of the forwarder was undertaken. Ground conditions

Figure 17: Valmet 902 Harvester in Radiata Thinnings

Figure 18: Kockums 85-35 Forwarder Extracting Thinnings

were dry, the soil was hard packed loam and the slope ranged from 0-18°. The operator was highly skilled with approximately five years experience in forwarder operation. Results are given in Table 4.

Average extracted log size (5.4m length) was measured at 0.08 m^3. Forwarder payloads were calculated at 9.0 tonnes. Given a total cycle time of 26.68 minutes and an average payload of 9.0 tonnes, forwarder productivity over average haul distances of approx. 170 m was calculated at 20 tonnes per P.M.H.

Table 4: Work Cycle of the Kockums 85-35 Forwarder (n=10)

Element	*Mean per Cycle (min)*
Travel Empty	*3.18*
Load	*13.16*
Move	*1.36*
Travel Loaded	*2.54*
Position	*0.16*
Unload	*6.28*
Total Cycle (net of delays)	*26.68*
Empty Distance	*188*
Loaded Distance	*146*
No.of Pieces Loaded	*112*

Several points arose from observation of the forwarder work method:

- Where outrows did not extend to the roadside the operator reconnoitred the most effective route through the bush during the travel loaded phase of the cycle.

- No sorting was done during loading. The operator loaded pulp and sawlogs together then sorted into separate stacks at the roadside. The sawlogs were easily recognisable by diameter (25-28 cm), and quality.

- The average grab size of the forwarder was 8 pieces (0.6 tonne).

- Average time per move was 0.12-0.15 minutes (approx.8 seconds).

- Maximum slope the forwarder travelled was 19°. Travel empty speed (uphill) was 0.73 m/s. Travel loaded speed (downhill) was 0.84 m/s.

Geoff Groves, A.N.M. Logging Contractor

In Green Hills State Forest, near Tumut, N.S.W., Groves operated one mechanised crew which included a Koehring K620FB feller buncher and a K620DL delimber. His production was 1000 tonnes per week to A.N.M. in pulp and sawlogs and 2200 tonnes of sawlogs per week to ACI sawmill in Tumut (600-700 tonnes per day total).

His array of machinery was staggering:

3 Kockums 880 feller bunchers
1 Bell feller buncher
3 Kockums Logma delimbers
1 Denis delimber
7 Forwarders
4 Skidders
1 TJ520 clambunk skidder
1 D7 size tractor
2 Rubber tyred front end loaders
10 trucks and a mobile workshop!

These machines were divided into units and worked in different locations, all in Radiata thinnings. The labour force consisted of one operator per machine, with one machine operator being the boss for the unit (commonly the feller buncher operator).

Shift time was nine hours per day including a half hour maintenance (5.00 am - 2.30 pm). Groves stressed the importance of retaining good operators. He accepted that a 3-4 month training period was necessary for each new

Figure 19: Mechanised Clearfelling in Buccleuch Forest, Tumut

operator prior to any pressure for production. Take home pay rates averaged $680 per week, and many of his men had 12-13 years experience on machines.

Groves made the offer to assist any New Zealand logging contractors getting into mechanisation.

Ryam Pty Limited, A.N.M. Logging Contractors

Lex McLean and Dave Nuttall managed several large scale mechanised logging operations in Buccleuch Forest, Tumut, NSW.

Ryam Limited started operations in 1981 with a Kockums system. In 1982 they commenced an operation with two Link-Belt LS2600BJ excavators (88hp). One was fitted with a Waratah felling head and the other with a Valmet GP Skogsjan processor. A full description of their operation is given in LIRA Project Report 29 (Galbraith and Prebble 1986).

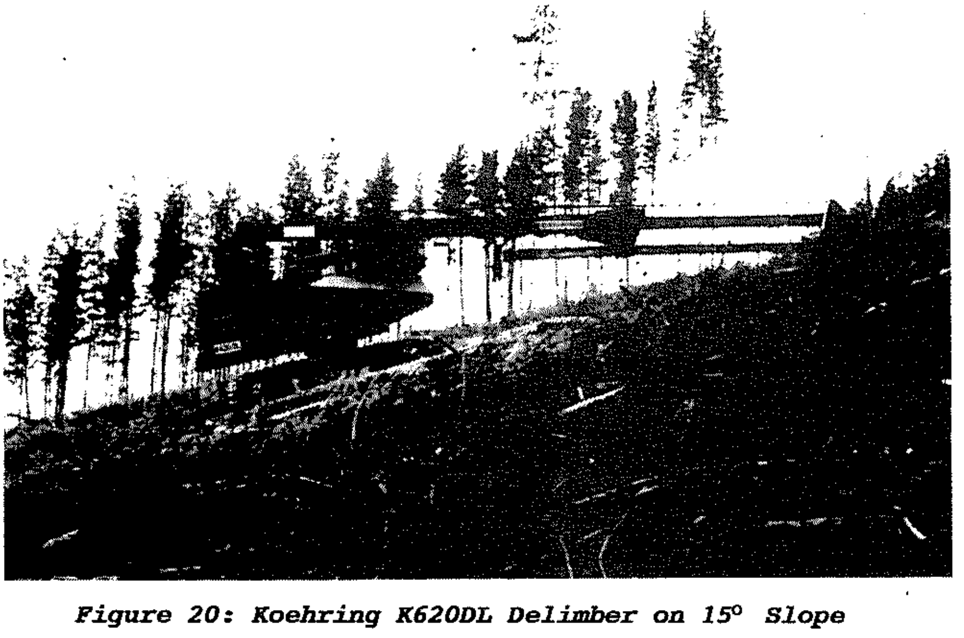

Figure 20: Koehring K620DL Delimber on 15° Slope

Table 5: Work Cycle of the Koehring K620 DL Delimber

Element	*n*	*Mean per Cycle (min)*
Pick up tree	*89*	*0.166*
Delimb & Cut	*89*	*0.547*
Clear Slash	*3*	*0.010*
Move	*8*	*0.080*
Total Process	*89*	*0.803*
Op.Delay	*6*	*0.043*
Total Cycle	*89*	*0.846*

Their operations have grown to the point where they now have 20 logging machines and 13 trucks, producing 220 000 tonne per year in all crop types to several mills.

The first operation visited was in a delayed first thinning stand (20 years old) using a Timbco 2520 feller buncher on easy country. The Timbco was 18 months old, and had a Tenco LDC-206 accumulating shear head.

A secondary felling machine used was a Kockums 880, which was seven years old (12 000 hours), one of their original machines. The operator usually worked on single shift (6.00 am - 3.00 pm) but if the feller bunchers got too far ahead, the forwarders would be double shifted. In this case shift hours would be 4.00 a.m. - Noon and Noon - 8.00 pm. The Timbco usually felled the steep country with the Kockums 880 used on more moderate slopes.

The second operation observed was in a moderate slope clearfell block. The stand was 1958 Radiata pine, with a tree size of 0.75 tonne. The block had been felled with the Kockums 880 wheeled feller buncher and was considered quite easy country for the stroke delimbers.

Two Koehring K620DL delimbers processed the felled wood into sawlogs and pulpwood for extraction by an 8-wheel drive Osa 280 forwarder (Figure 19). The Koehring delimber studied was two and a half years old (4000 hours) and was powered by a 200 hp Cat diesel engine (Figure 20).

The processing of 89 bunched trees was timed to determine indicative delimber productivity (Table 5).

A total cycle time of 0.85 min. per tree equates to 71 trees per hour, or 53 tonnes per P.M.H. (0.75 tonne tree size).

The second K620DL delimber was a larger unit, on a D7 size track frame (32 tonne). It was only nine months old and had operated for 1200 hours. The price was $635,000.

The delimbers were highly productive, working on slopes up to 28° behind the Timbco. Boom rope life however, was limited to six weeks (approximately 200 hours). Machine availability with the Koehring delimbers was quoted as 87%.

Another stroke delimber observed in this clearfell operation was a Denis stroke delimber on a new Cat 219 base (Figure 21). The unit was only 78 hours old and the

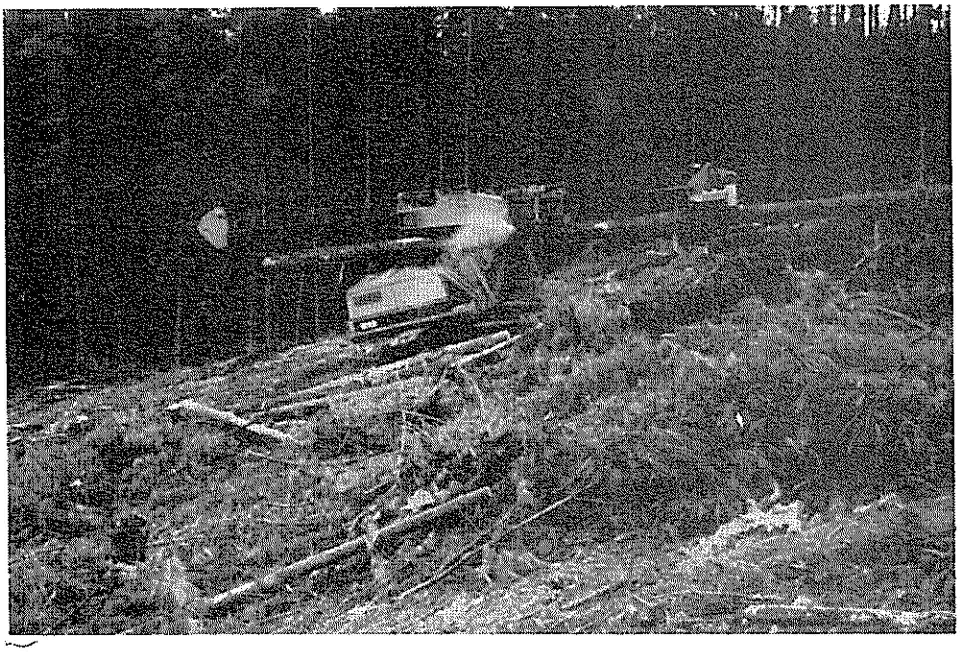

Figure 21: Denis Delimber Processing Large Diameter Sawlogs

operator was new, hence no studies were undertaken.

Another Ryam Ltd. thinning operation visited used a Caterpillar feller buncher, a Logma delimber and forwarder extraction. The feller buncher was a Caterpillar 215 BSA excavator with a Kockums 880 shear head (Figure 22). The Kockums 880 has probably been the most reliable and successful of the felling heads introduced to Australia. Its success is evidenced by the fact that it has been mounted on other base carriers. The maximum felling diameter is 42 cm. A set of shear blades usually lasts 12 months and costs $2,200.

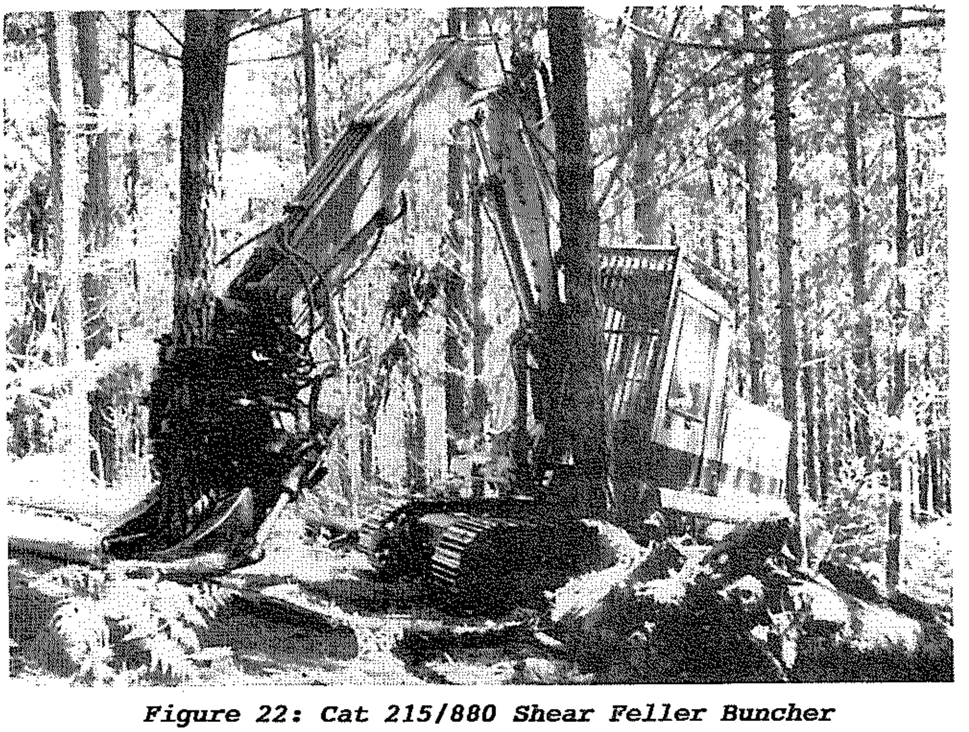

Figure 22: Cat 215/880 Shear Feller Buncher

Table 6: Work Cycle of the Cat 215/880 Feller Buncher

Element	*n*	*Mean per Cycle (min)*
Position head	*185*	*0.103*
Fell tree	*185*	*0.045*
Bunch	*185*	*0.197*
Move	*89*	*0.122*
Total process	*185*	*0.467*
Clear slash	*2*	*0.002*
Other Op.Delay	*6*	*0.007*
Total Cycle	*185*	*0.476*

A local contractor, Nino Rosen had redesigned the boom and mounted the 880 shear head on the Cat 215. The unit had been operating for 800 hours, and was 10 months old. A production study of this machine was undertaken in a delayed second thinning operation.

The stand was 24 year old Radiata pine with a mean tree size of 0.47 m^3. Mean tree height was approximately 26.6 m. Results are given in Table 6.

Bunch times included hangups during felling (3 observations). Operational delays consisted of rebunching trees and adjusting the bunch. The clear slash function consisted of moving old hardwood stumps out of the way.

Given a total cycle time of 0.48 min. productivity was 126 trees felled and bunched per productive machine hour. Given mean tree size of 0.47 m^3, productivity averaged 59 m^3/PMH. Scheduled work time was from 6 am - 3 pm (9.0 SMH per day). At 75% utilisation, daily productivity of the feller buncher would be approximately 400 tonne per day. However if the feller buncher got too far ahead the forwarders would be double shifted. Delivered wood cost to the board mill 28 km away was $19.30 per tonne.

<u>**Pine Harvesters Limited, A.N.M. Logging Contractors, Tumut**</u>

One of the most interesting machines viewed was the Grangarde 270 harvester, owned by Warren Phillips. The Grangarde is a Swedish stroke delimber that also has felling capability. It was originally designed from the Kockums Logma, and has delimbing power equal to the Koehring (Figure 23).

It is mounted on an Osa 270 chassis featuring a pivoting bogie giving the machine tilt capability for steep country operation. Tilt is controlled by two rams for side tilt and two rams for forward and reverse tilt (Figure 24).

The Grangarde 270 was two years old (3000 hours) and was working in second thinnings on easy country (0.5 tonne piece size). The operation was on a production quota of 710 tonne/week of pulpwood, plus sawlog production to ACI Sawmill in Tumut.

At a processing rate of 270 sawcuts per PMH (4-5 cuts/tree) productivity is estimated at approximately 30 tonne/PMH (27-34 tonne/PMH) or approximately 200 tonne per day. Machine availability was quoted as 65%. The felling head was a high maintenance item and hence in this operation, a Kockums 880 feller buncher was used for felling ahead of the delimber.

Figure 23: Grangarde 270 Harvester

Machine cost was approximately $550,000, the majority of the cost being the Osa harvester base. The Grangarde is sold and serviced by Scandinavian Logging Services, Melbourne.

The Grangarde harvester is also the basis for the design of the Denis feller delimber. A Denis telescoping boom delimber with a feller director head is currently being developed in Quebec, Canada. This is an interesting prospect for New Zealand for processing tree length at the stump for ground based extraction (either skidder or forwarder systems).

Figure 24: Side Tilt for Steep Country Operation

LOGGING INVESTIGATION AND TRAINING ASSOCIATION, MT GAMBIER, SOUTH AUSTRALIA.

Discussion with the Manager, Andy Cusack, centred around machine operator training.

LITA consists of three full-time training staff and one part-time administration staff, and is funded by equal levies on forest owners and mill owners.

The formal three-week Manual Faller Training Scheme run by LITA, combined with good selection procedures had been very successful in the past. Most failures in training had been attributed to incorrect selection rather than inadequate training.

Prior to the widespread mechanisation of logging operations (pre-1984), LITA was training 80 fallers per year, 35-45 of which were new to the industry. The balance of the training centred on improving the skills of experienced fallers. It is therefore recommended that a formal training programme be instituted in New Zealand.

Chainsaw suppliers such as Stihl are very supportive of LITA and the promotion of skills and development in general. Since 1985 there has been a Stihl study award to the value of $6,000 open to Australian applicants seeking to study any aspect of forestry relating to chainsaws or other powered tools. The successful applicant is expected to investigate and report on matters relating to :

- Productivity and work systems
- Environmental Issues
- Equipment evaluation
- Safety and training.

Those eligible to apply include logging contractors, supervisors, safety and training officers, work study researchers, and Government and Local Body employees who use chainsaws.

Although LITA does not currently do any manual faller training due to the reduction in manual operations, they will run courses on demand. They are currently concentrating on machine operator selection and training. One very useful tool is a computer

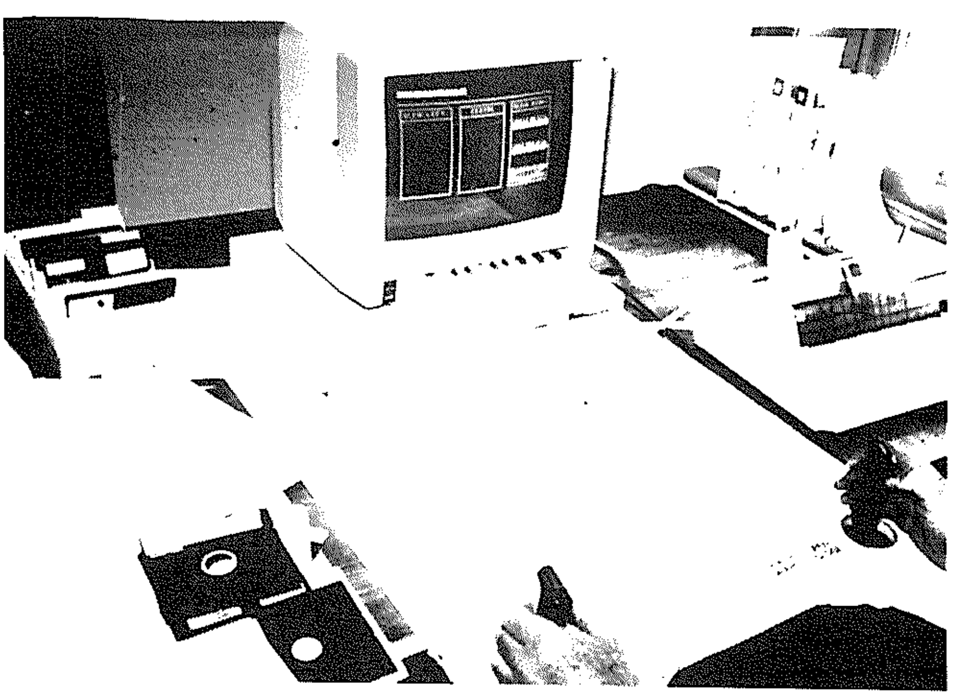

Figure 25: Forwarder Simulator Designed by LITA

generated forwarder simulation, consisting of personal computer, screen and two joystick controls. A sequence of 22 instructions are given to the candidate and he is timed as to his response (Figure 25).

The results of many runs through this sequence of commands are graphed to obtain a learning curve. Most operators times reduce to 12-14 seconds for the 22 instructions over a period of approximately two hours.

There are also two other routines that generate random instructions for forwarder operations for a period of two minutes and five minutes. The number of correct control movements undertaken during this set time period is recorded.

This forwarder simulator is used as another means of operator selection and is very effective in supplementing both normal interview techniques and in-bush forwarder training.

WOODS AND FORESTS DEPARTMENT, MT.GAMBIER, SOUTH AUSTRALIA

Eighty percent of South Australia's State Forest is in the south-east near Mount Gambier. The Woods & Forests Department controls 65 000 ha of pine plantations. The Department also operates sawmills at Mt Gambier, Mt Burr and Nangwarry. Harvesting volume totals 520 000 m^3 per year. There are 14 contract units, nine of which are mechanised.

All the logs stored both above ground, under water sprays and in Lake Bonney as a result of the 1983 fires, have been utilised. A major problem at present is tree death caused by the Sirex wood wasp. Although present in the region for seven years the Sirex problem has reached epidemic proportions. A large scale nematode inoculation program is underway and thinning of Sirex-infected stands is a major priority.

Colin Moreland, W&F Logging Contractor, Penola Forest

The operation studied consisted of a Valmet GP940 grapple harvester in first thinnings with extraction by Volvo 969 Forwarder. The Valmet GP940 is a later model to the old RK450 Skogsjan processor. Cost of the head alone was approximately $140,000. Mounted on a Sumitomo LS-2600EJ excavator the 940 head has three movable knives, delimbing up to a maximum 46 cm capacity (Figure 26). The crosscutting saw had been modified to enable tree felling. Posts were cut in two lengths (1.8 m and 2.1 m) plus pulp. Log length was measured by a sprocket wheel but measuring accuracy was reputed to be quite poor in comparison with other processors (eg. the Steyr KP40). Productivity was automatically recorded by the number of chainsaw cuts. Long term productivity in first thinnings averaged 15 tonne/PMH.

Overall, this first thinning operation produced 550 tonnes per week. The operator was highly skilled and had four years experience on the machine. Despite obvious operator skill and very fast processing, the delimbing quality was average to poor by New Zealand standards. The delimbing head was severely hampered by large branches (> 5 cm. diameter).

A short term study of the GP 940 was undertaken. The stand was 18 year old Radiata pine, and was being thinned from 1700 sph down to 700 sph.

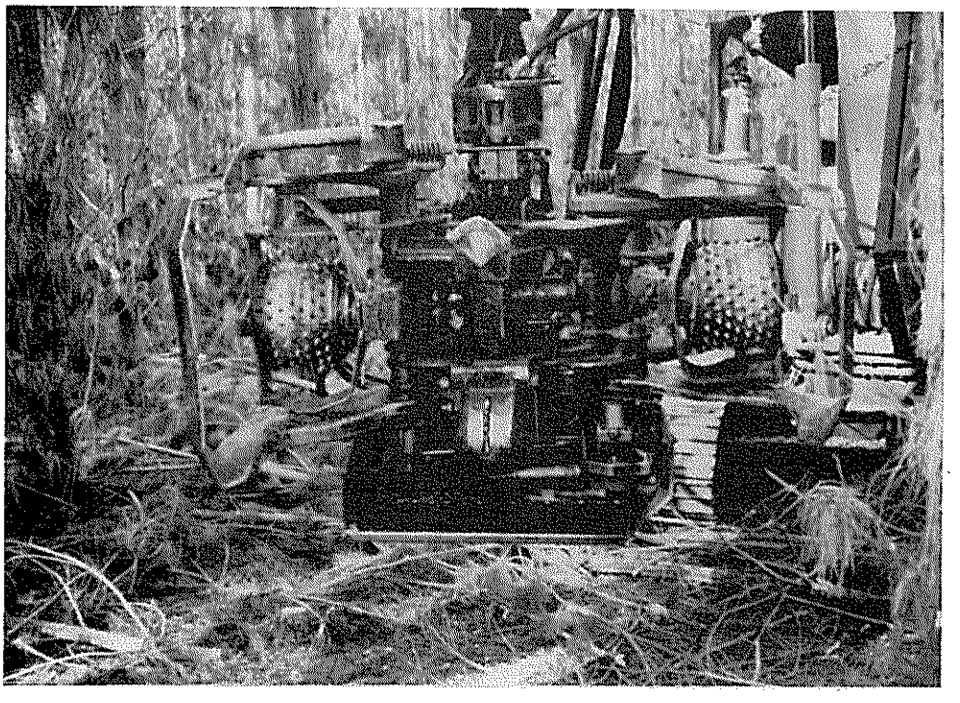

Figure 26: Close up of the Valmet GP940 Harvester

Table 7 : Work Cycle of the Valmet GP940 Processor

Element	*n*	*Mean per cycle (min)*
Position head	*193*	*0.083*
Fell tree	*193*	*0.077*
Delimb (incl cut)	*193*	*0.421*
Total Process	*193*	*0.581*
Move	*78*	*0.042*
Clear slash	*10*	*0.008*
Op delay	*3*	*0.003*
Total cycle	*193*	*0.634*
No of pieces	*681*	*3.53*

Net Productivity excluding delays = 95 trees/PMH
at 0.15 tonne per tree = 14 tonne/PMH
*Process time = 0.23 + (0.11 * number of pieces) (r^2 = 0.28)*

The trees were of small diameter (15-17 cm DBH), and merchantable length was approx. 7.5 m. Tree size was estimated at 0.15 m^3. Approximately 96% of the stand was of normal form. Double leaders comprised 4% of the stand.

During felling, hangups occurred approx.5% of the time. Results of the time study are given in Table 7. The work cycle consisted of positioning the harvester head on the tree, felling the tree, then activating the drive tracks to commence delimbing. On many trees, two passes over the stem were necessary to achieve the required delimbing standard.

Two mechanical delays occurred during the study period but were not included due to the short-term nature of the study. These delays involved sharpening the delimbing knives (approx.5 minutes, once or twice a day) and replacing a bolt on one of the drive wheels (15 minutes). Non-mechanical delay for operator lunch break, (28 minutes) also occurred during the study.

It was found that processing time (net of move or delay) could be approximated given the number of pieces cut from the tree. It was also found that tree form had a significant effect on processing time (net of move or delays). The difference in processing time between normal form trees and double leaders was significant at the 99% level (Table 8).

In 4% of cases, more than one tree was processed per cycle. The operator would fell two trees together then process them one after the other. Where this occurred, process time averaged 1.04 minutes (79% longer than standard time).

Kevin Boult, W & F Logging Contractor, Tantanoola Forest

Working in delayed first thinnings (planted 1957), the operation consisted of a Waratah feller buncher, a Steyr processor and a Moxy 5200 forwarder (Figure 27). The Moxy 5200 had been modified from a Moxy dump truck. The unit had only been operating for two

Table 8: Effect of Tree Form on Processing Time

Tree Description	*Mean Processing Time (min)*	*No. of Trees per P.M.H.*
Normal Form Trees	*0.530*	*113*
Double Leaders	*0.861*	*70*
All Trees	*0.581*	*103*

weeks and had cost $175,000. It was originally displayed at FIME '86 (Galbraith and Prebble 1986).

Overall crew production averaged 21 tonnes per hour (84,000 tonnes per year on extended single shift).

The Steyr KP40 Series I grapple processor was mounted on a Sumitomo LS-2600BJ excavator. The Steyr log feed is via one single drive track, and crosscutting is achieved by a circular saw which is very fast operating. The length measuring computer is programmable to 7 different lengths and the control has a repeat facility, or manual length selection.

The Steyr was three years old (6750 hours). Boult originally had a Valmet GP940 which had poor length measuring performance and low availability. He has been very pleased with the performance of the Steyr in comparison with the GP940.

Figure 27: Moxy 5200 Converted to a Forwarder

Table 9 : Work Cycle of the Steyr KP40 Processor: Delayed First Thinnings

Element	n	Mean per cycle (min)
Pickup	171	0.085
Delimb & Cut	171	0.411
Total Process	171	0.496
Move (inc. op delay)	32	0.046
Clear	4	0.004
Total Cycle	171	0.546
Product output		
4.95 m poles	113	2.3 per tree
2.15 m posts	114	3.4 per tree

Productivity = 110 trees per PMH (net of delays)
= 39 m^3 per PMH (0.35 m^3 tree size)

According to the contractor, the major advantage of the Steyr over the GP940 was its better mechanical availability. The delimbing quality was also improved, the Steyr producing acceptable quality wood in a single pass. There was very little evidence of damage to the wood from the teeth of the central drive track. Length measuring was very accurate (± 1-2cm over a 4.95m length), however the Steyr was apparently not as effective in handling trees with wobble or sweep.

Even in the larger size delayed thinnings wood, the Steyr showed good grappling ability, picking up tree lengths with no difficulty.

Wood presentation was excellent with different types of shortwood segregated for forwarder extraction (Figure 28). Product assortments were 2.15m posts (50-125mm SED), 4.95m sawlogs (150-200mm and > 200mm SED), 4.95m poles (125-150mm SED) and 4.95m pulpwood.

A short term production study of the Steyr processing 31 year old Radiata pine was undertaken.

The trees had been felled and bunched at right angles to the outrow in bunches of 6-7 trees. Tree size was estimated at 0.35 m^3 (average diameter approximately 25 cm). Merchantable tree length averaged 17.1 m. Results are given in Table 9.

Most trees (60%) were processed into a combination of 4.95 m and 2.15 m lengths. On average 2.3 long lengths and 3.4 shorts were cut from each tree. Processing time averaged 0.50 minutes. Where 4.95 m lengths only were cut, processing time averaged 0.53 minutes.

Short trees were processed into short lengths (2.15 m) only and process time averaged 0.41 minutes. For all trees, processing time was related to merchantable tree length:

Process Time (min) =
(0.032 * Length (m)) (r^2 = 0.61)

Although the stand was of predominantly good form, the effect of processing large diameter trees (>30cm) and double leaders was examined (Table 10).

Table 10: Effect of Tree Form on Processing Time

Tree Description	*% of stand*	*Mean Processing Time (min)*	*Increase from normal time (%)*
Normal	*94.8*	*0.47*	*-*
Large diameter	*2.3*	*1.13**	*140*
Double Leader	*2.9*	*0.81*	*71*
All trees (mean)	*100.0*	*0.50*	*6*

**Significant difference at 95% level*

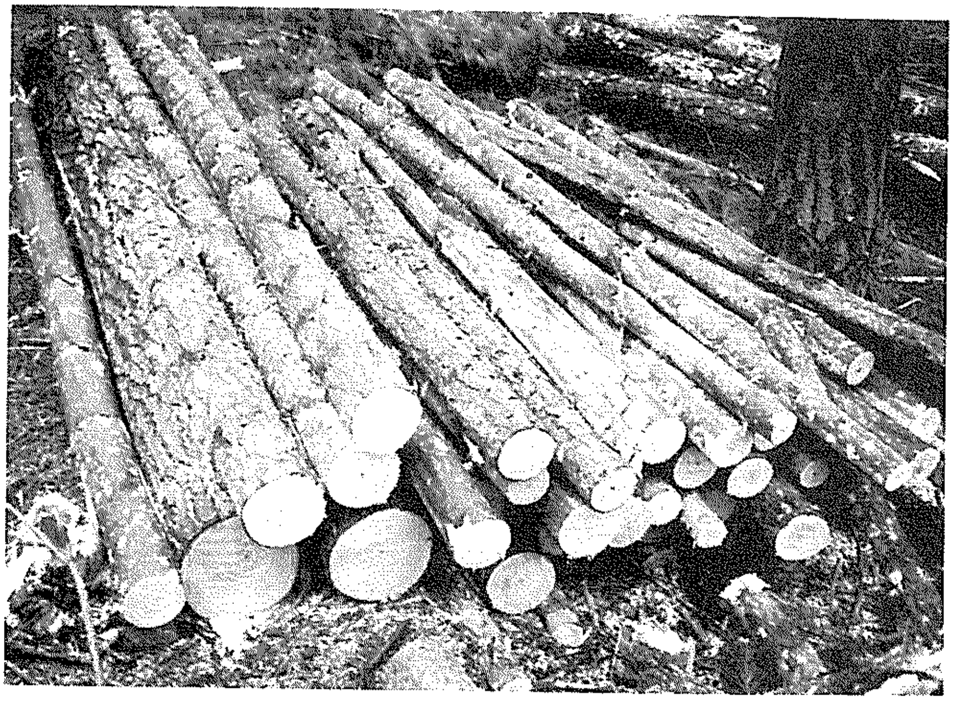

Figure 28: Wood Presentation from the Steyr KP40 Processor

A larger grapple processor is now being manufactured by Steyr Forestry Equipment in Austria. The Steyr KP60 is a processor head designed for larger diameter wood while still maintaining its precise cutting to length capability.

From an original design by Steyr, modified and developed by Weyerhaeuser in the US, the new KP60 is vastly improved from the original (Selby and Horsfield 1986). The maximum grab diameter has been increased from 76 to 86 cm, maximum delimbing diameter has been increased from 61 to 76 cm, and the maximum diameter for cutting to length is 58 cm. The minimum size of trees able to be handled has been reduced from 15 cm down to 12 cm diameter. Two log feed speeds are available depending on the size of the wood, (1.1 and 2.3 m/sec). Weight of the processor head is 3.4 tonne, requiring base power of 218 hp. There are also options for diameter measurement, a log counter and a topping chainsaw.

SAPFOR TIMBER MILLS PTY LTD, TARPEENA, SOUTH AUSTRALIA

SAPFOR Timber Mills Ltd draws wood from 25,000 ha of forest in both S.A. and Victoria to supply their sawmills and treatment plant.

Their logging operations are undertaken by two prime contractors, one with 3 mechanised systems and one with two mechanised systems and one manual crew.

Small sawlogs (15-25 cm SED) from the first and second Radiata thinnings operations go to the No. 2 stud mill at Tarpeena, which produces 200 m³ per shift (80,000 m³ per annum on a two-shift basis). Their No. 1 sawmill handles logs greater than 20cm SED, and produces 500 m³ per day. Pulpwood volume of 44,000 m³ per annum goes primarily to Kimberley Clarks APCEL Mill.

Total log input to Tarpeena is 207,000 m³ per year (194,000 m³ sawlog, 13,000 m³ treatment). SAPFOR also produce 27,000 m³ of treatment wood for other mills.

From a manual faller workforce of 64 four to five years ago, SAPFOR now have only seven manual fallers. Their move to mechanisation was due to a variety of reasons :

- High workers compensation payments;
- Lack of competitiveness among contractors;
- A requirement for log segregation in the forest;
- A move away from shortwood when the mill converted to random length (3.6 - 6.0m);
- Poor availability of labour;
- Technological developments in mechanisation in the late 1970's.

Ivan Dohnt, SAPFOR Logging contractor, Werrikoo Forest

Ivan Dohnt operated a Koehring system in 37 year old clearfell Radiata pine. The operation consisted of a Koehring K620FB feller buncher, a Koehring K620DL stroke delimber, and two Kockums 85-35 forwarders. All his logging equipment was less than two and a half years old. The Koehring 2-machine system cost $660,000 in 1985, however the new price is approximately $900,000 ($520,000 for the delimber alone).

In a SAPFOR trial in 1985, clearfelling 36 year old Radiata, producing short sawlogs only, the

Table 11: Koehring 620FB and 620DL: Summary of Thinning Trials

Operation	*Mean DBHOB (cm)*	*Mean Volume (m3)*	*Total Time (SMH)*	*Prod Time (PMH)*	*Utilisation (%)*	*Total Volume (m³)*	*Productivity (m³/PMH)*
DELAYED FIRST THINNING (DT1)	*21.0*	*0.34*					
Feller Buncher			*7.07*	*5.48*	*77.6*		*28.40*
Delimber			*11.05*	*9.29*	*84.1*	*155.60*	*16.74*
SECOND THINNING (T2)	*24.9*	*0.47*					
Feller Buncher			*10.73*	*8.80*	*82.0*		*40.14*
Delimber			*21.06*	*16.28*	*77.3*	*353.37*	*21.71*
THIRD THINNING (T3)	*27.7*	*0.61*					
Feller Buncher			*8.47*	*6.57*	*77.5*		*53.11*
Delimber			*15.80*	*11.91*	*75.4*	*348.97*	*29.31*

following productivity was measured (Kaethner, pers comm).

Merchantable Tree Size = 0.98 m^3
Average DBHOB = 34.2 cm

Koehring K620FB :
Productivity = 117 m^3/PMH
= 120 trees/PMH

Machine Utilisation = 89.7%

Koehring K620DL :
Productivity = 40.3 m^3/PMH
= 41 trees/PMH

Machine Utilisation = 82.0%

Results of SAPFOR trials in Radiata thinning operations are given in Table 11.

Production for Dohnt's Koehring system ranged between 300-360 m^3 per 10 hour shift (75,000 tonnes per year). In most clearfell blocks the feller buncher could fell enough wood in 10 hours to keep the delimber working for 26 hours. The delimber therefore worked on double shift, as did the forwarder. The operation also employed one manual faller for felling large edge trees, etc. The feller buncher worked a strip felling system, laying the wood on a slight angle to the strip, to enable the delimber operator to have a good view of the tree prior to processing.

The Koehring delimber was considered the most robust of the stroke delimber models, and although not as fast as the Valmet 902 harvester, was very reliable. Dohnt's comments on mechanisation in general were that it had extended logging into wetter country (possibly putting more pressure on roading), and had also enabled much higher productivity - 350 m^3/day vs 150 m^3/day with manual systems.

A second operation (in Radiata first thinnings) used a Valmet 902 Harvester, a Waratah felling head on a Sumitomo 2600EJ base, and a new Valmet 862 forwarder (10-tonne capacity). The Valmet 902 was 15 months old and was being used as a processor only since it was on double shift. A SAPFOR trial of the Valmet 902, felling and processing in first thinnings (tree size = 0.22 m^3) resulted in productivity of 16 m^3/PMH (72 trees per PMH). Over the two-day study downtime averaged 6.2%. In a second trial in similar conditions, productivity was measured at 19 m^3/PMH with downtime of 8%.

The third operation visited comprised a Steyr KP40 processor in first thinnings. Ivan Dohnt considered that the Steyr KP40 grapple processor was the most versatile machine for cutting various length products in thinnings. The log types were sorted according to diameter and length, e.g.:

4.9m : 17-25cm sed, and >25cm sed
5.4m : 17-25cm sed, and >25cm sed

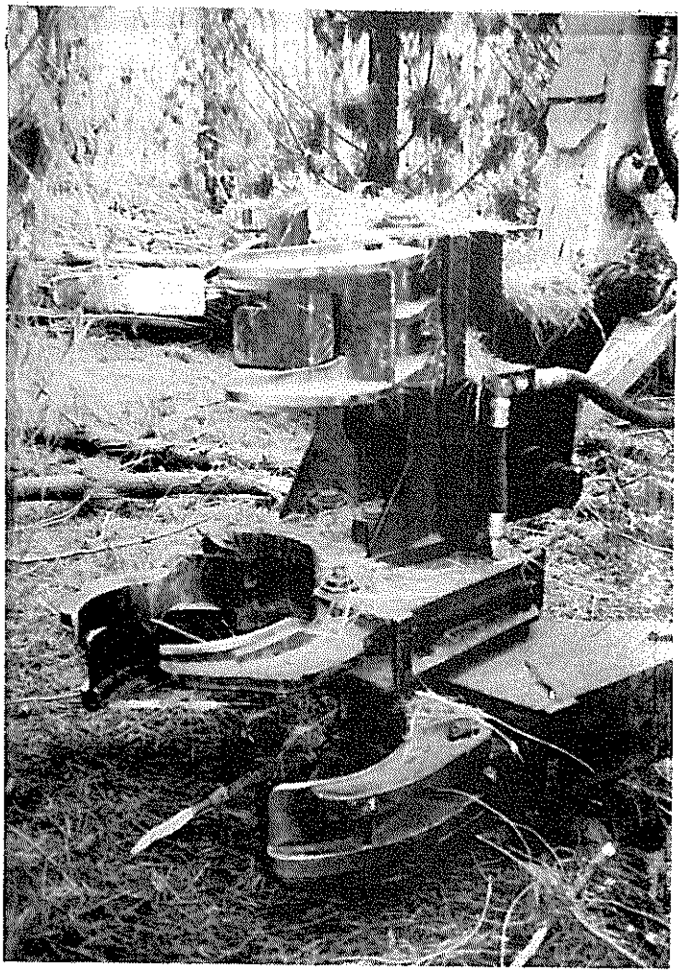

Figure 29: Attiwill Designed & Built Feller Buncher Head

Table 12: Work Cycle of the Steyr KP40 Processor in First Thinnings

Element	*n*	*Mean per Cycle (min)*
Pickup	*152*	*0.220*
Delimb & Cut	*152*	*0.448*
Total Process	*152*	*0.668*
Move	*15*	*0.044*
Clear	*9*	*0.013*
Total Cycle	*152*	*0.725*
Product Output		
4.9m Pulp (0.075 m^3)	*125*	*1.6*
2.4 m & 2.1 m Posts (0.025 m^3)	*95*	*3.1*

Productivity = 83 trees per PMH (net of delays)
= 17 m^3 per PMH (0.2 m^3 tree size)

Since there was no logsorting facility at the mill, it was essential that lengths were accurate.

The operation studied included a feller buncher designed and built by Ian Attiwill in Mount Gambier (Figure 29). The feller buncher was mounted on a Kato 450 excavator. Extraction was by Kockums 84-35 forwarder (12-tonne capacity).

The Steyr processor was the Series II KP40 model on a Kato 450 base (Figure 30). It had been in operation since August 1987 (1275 hours). Capital cost of a Steyr KP40 mounted on a Kato 550SE base was $272,000.

The feller buncher was more productive than the processor, felling enough wood in 7 hours to keep the processor working for 11 hours. Shift time was 5am - 2pm on the processor and 7am - 4pm on the feller buncher. When the processor operator's shift ends, the feller buncher operator works the processor for two hours to balance system productivity.

The stand was 1971 Radiata pine which was being first thinned from 1700 sph down to approx. 550 sph in a fifth row outrow system. Tree size was approximately 0.2 m^3. Tree form was very even with little evidence of tree wobble or sweep. Merchantable tree length averaged 14.5 m.

Log types produced were 4.9 m pulp, and 2.1 posts. Daily production was on a quota of 115 m^3 per day. Results of the short term production study are given in Table 12.

As with the previous Steyr operation studied, a combination of lengths were cut from each tree. On average each tree yielded 1.6 lengths of 4.9 m pulp and 3.1 lengths of post material.

Where trees were processed to posts only or pulp only, processing time averaged 0.63 minutes, however where a combination of log types were produced, processing time averaged 0.74 minutes.

A weak relationship between processing time per tree and merchantable tree length was evident.

Process time =
(0.027 x Length (m)) + 0.394
$(r^2 = 0.23)$

Generally the delimbing quality of the Steyr KP40 was very impressive with branches greater than 5 cm diameter easily delimbed.

Figure 30: Steyr KP40 Processor in first thinnings

SOFTWOOD HOLDINGS LTD, MOUNT GAMBIER, SOUTH AUSTRALIA

Softwood Holdings Ltd, a subsidiary of C.S.R Australia, were the only company logging operations visited. They manage approximately 30,000 ha of pine forest in the south-east of South Australia and Victoria.

Softwood Holdings are highly committed to mechanisation and have had the resources to enable them to support various machines not seen in contractor-owned operations.

Examples of this equipment are the LAKO harvester, the JD-762A harvester (JOSA), the Kockums 84-62 harvester, the Bobcat 1213 feller buncher, and the Morbark Chiparvestor.

The Company is also involved in an extensive programme of machinery evaluation and development.

The LAKO Harvester, Kentbruck Forest, Victoria

The LAKO harvester was mounted on a John Deere 743-A harvester base, via a John Deere boom that has been lengthened by 1.2 metres (Figure 31).

The JD743-A is a 152 hp rubber-tyred machine which, due to its narrow width (3.2 m) is ideally suited to outrow thinning operations. The base unit had done 9000 hours prior to modification.

The LAKO was the 3T model (three drive tracks), and was almost two years old (3,000 hours). Due to problems with the drive tracks breaking, Softwoods had replaced the two side tracks with steel rollers, and had also made substantial modifications to the hydraulics system.

Softwoods had had little satisfaction from the LAKO people in Finland (Metsatyo Oy) in setting up and adjusting the hydraulics for the head. Subsequently, modifications

Figure 31: LAKO Harvester on John Deere 743-A Base

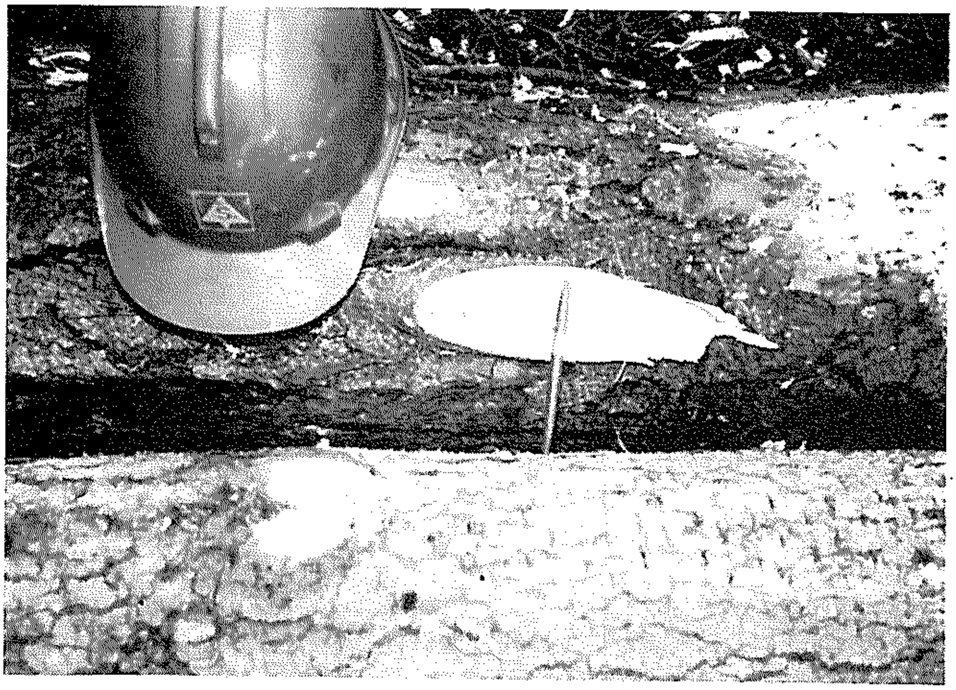

Figure 32: Large Diameter Branch Delimbed by the LAKO

were undertaken at their workshop in Mt Gambier (in conjunction with LAKO engineers.

A Linde BPR260 variable flow, pressure compensated hydraulic pump was mounted for the LAKO head, and geared to 900 RPM. A separate oil cooler and fan was installed for the Linde pump and a load sensing valve bank was also set up. Hydraulics were set at 210-230 l/min at 210 bar. A separate hydraulic pump for the John Deere operated the crane, steering, park brake and diff. lock.

The base and head had separate electrical circuits installed (12V for the John Deere, 24V for the LAKO).

Both grapple arm bogies had been replaced. Ros-tourge TRW hydraulic gearoller motors were mounted for the two drive rollers (model MAE-20). The hydraulic motor for the central drive chain was the standard MAE-14 model.

The cost of the LAKO head was approx. $115,000, however with the extra pump and modifications, the total cost was approx. $200,000.

Since the modifications the delimbing quality had been better than that of the Kockums GSA62, and length measurement was within 50mm ($\pm$ 25mm). The LAKO had sufficient feed speed to delimb branches greater than 6cm in diameter (Figure 32).

Softwoods personnel considered that the LAKO was their best model harvester and, under the same stand conditions, outproduced the Kockums GSA62 (84-62 harvester).

Working in 5th row outrow second thinnings (T2), on a single shift basis (5.30am - 2.00pm) productivity was around 630 m^3/week (125 m^3/day. Availability was calculated on a weekly basis and was averaging 75% over the long term.

<u>The JD762-A Harvester (JOSA)</u>

This machine was an Osa 762 grapple harvester mounted on a rebuilt John Deere 743-A harvester base (Figure 33).

The JD743-A first appeared in Australian pine forests in the mid-1970's. The harvester base was essentially a John Deere 740

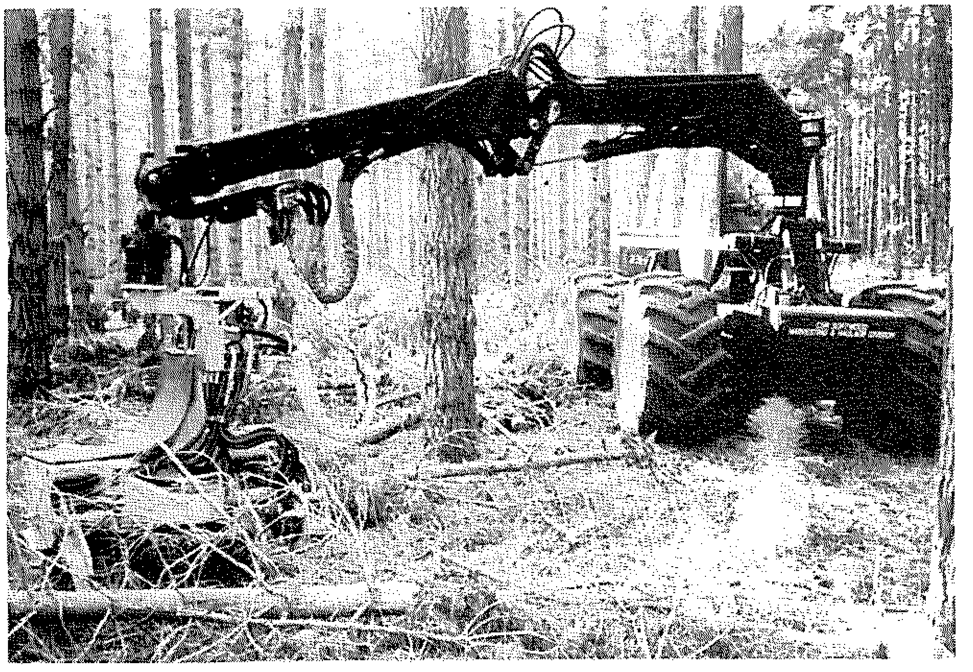

Figure 33: John Deere-Osa 762 Harvester (JOSA)

skidder chassis (152 hp) with a crane mounted forward of the operator cab. As with the John Deere-Lako modification, the original felling head and delimbing equipment was removed, reducing prime mover operating weight by approximately 6 tonnes. The operator cab was completely rebuilt, and repositioned at the front of the John Deere chassis.

The Osa 762 harvester head was mounted via an Osa 338 boom. The Osa 762 weighs 1000 kg including Indexator GV10 rotator. It works on hydrostatically powered rubber rollers giving a speed of up to 3.2m/s (Figure 34). Maximum felling diameter is 50 cm. Delimbing is achieved through four wraparound knives and one fixed knife, with a maximum delimbing diameter of 48 cm. Hydraulic

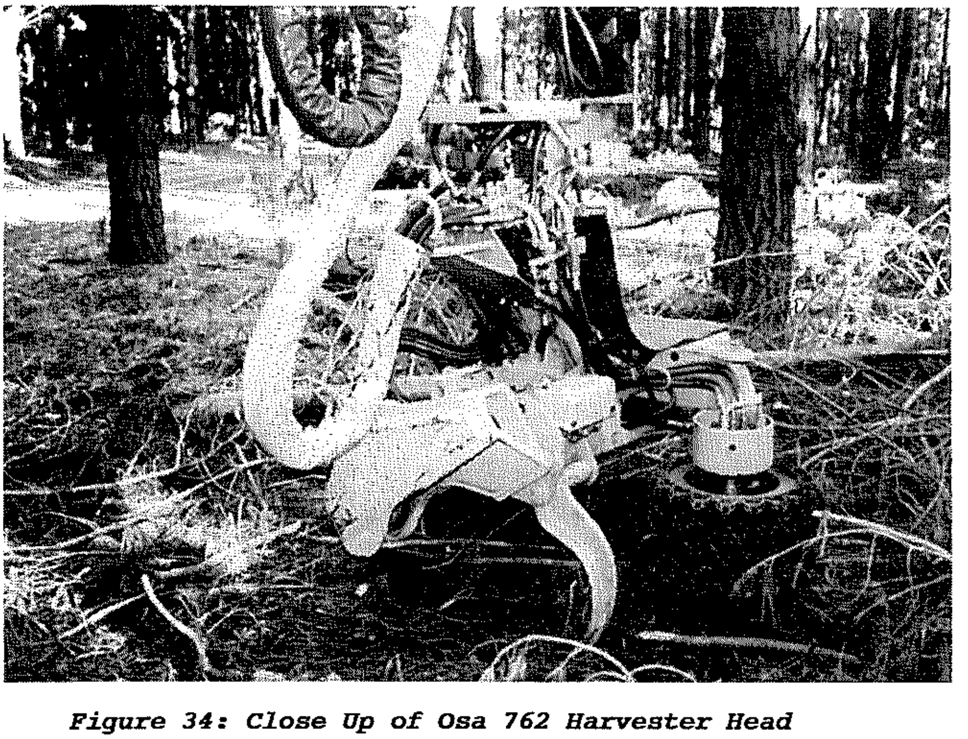

Figure 34: Close Up of Osa 762 Harvester Head

Figure 35: Kockums 84-62 Single-Grip Harvester

requirement is 180 l/min at 240 BAR. The microprocessor based measuring and control system is capable of being programmed to 10 different lengths and four diameter limits. Diameter measurement is achieved through a linear potentiometer on one of the grapple hydraulic rams. Cost of the Osa 762 head was $151,500 plus approximately $28,500 for fitting and guarding to base machine.

The JOSA had done 320 hours in Radiata pine third thinnings (400 sph down to 250 sph). According to Softwood Holdings, the machine has been an outstanding success, achieving average availability of 78%. Productivity of 23.5 m^3/PMH has been measured in thinnings of an average stem size of 0.4 m^3. Logsorts produced were 5.5 m sawlogs down to 200 mm SED, 4.9 m sawlogs from 80-200 mm, and short preservation material from 50-80 mm SED.

The Kockums 84-62 Harvester

In contrast to the two-grip harvesters such as the Osa 706/250 and the Valmet 902, the Kockums 84-62 is a single-grip harvester. It consists of a Kockums GSA62 harvester mounted on a Kockums 84-class forwarder chassis via a Cranab 100P crane (Figure 35).

The GSA62 grapple harvester has two 400mm diameter spiked steel rollers to drive the stem through the delimbing knives (Figure 36).

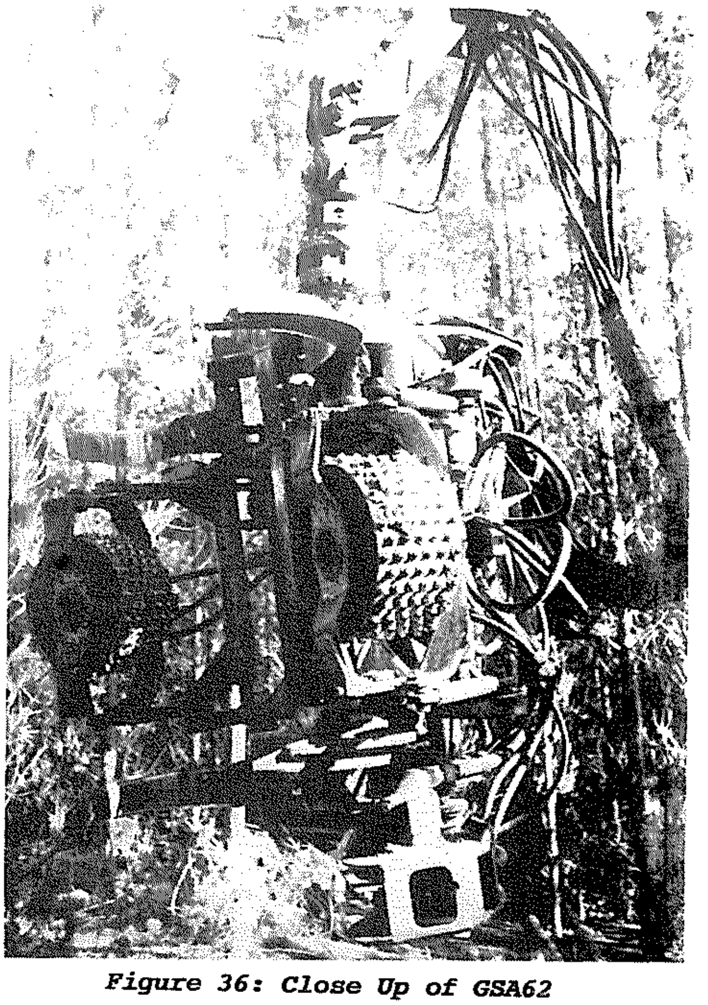

Figure 36: Close Up of GSA62 Harvester Head

Figure 37: Bobcat 1213 Feller Buncher

Like the two-grip harvesters, the GSA62 can operate automatically, and can be pre-programmed to cut 11 different lengths. The unit was 3 years old and had operated for 5500 hours. Cost was approximately $510,000.

The 84-62 harvester usually worked in second thinnings (800 sph down to 400 sph), on a double-shift basis, cutting 4.9m and 5.5m sawlogs. In this operation, Kockums 85-35 and 84-32 forwarders were used for extraction.

The stand was 21-year old Radiata pine (0.4 m^3 piece size). The harvester was cutting an average of 2 sawlogs per tree at a rate of 21.6 tonnes per PMH (100 sawlogs/PMH). Sawlogs averaged 0.22 tonne per piece.

It was felt that although the 84-62 had overall lower production than the LAKO, it had superior reach and was therefore very useful in second and third thinnings.

The Morbark Total Chiparvestor System

This whole tree chipping operation consisted of two Bobcat 1213 six-wheeled feller bunchers, three John Deere 540B grapple skidders and a Morbark whole-tree chipper.

The system produced whole-tree chips for either the particle board mill, or boiler fuel.

The Bobcat 1213 feller buncher was first introduced at FIME '86. This 6-wheeled rough terrain version of the Bobcat feller buncher was built around the Model 843 Bobcat loader. It uses a four-wheel front bogie system on an oscillating axle and a pair of oscillating single wheels at the rear (Figure 37).

The felling head is limited to a 33 cm diameter tree. In first thinnings productivity was approximately 150 trees felled and bunched per PMH. Availability of 90% was quoted. The system was third row Radiata pine first thinning in two stages: first the outrow was felled and extracted then the marked trees between outrows were extracted.

The Morbark RSL Chiparvestor is powered by a 600hp Cummins turbo diesel (Figure 38). Productivity averaged 50 m^3/PMH depending on the product (80,000 m^3 per year).

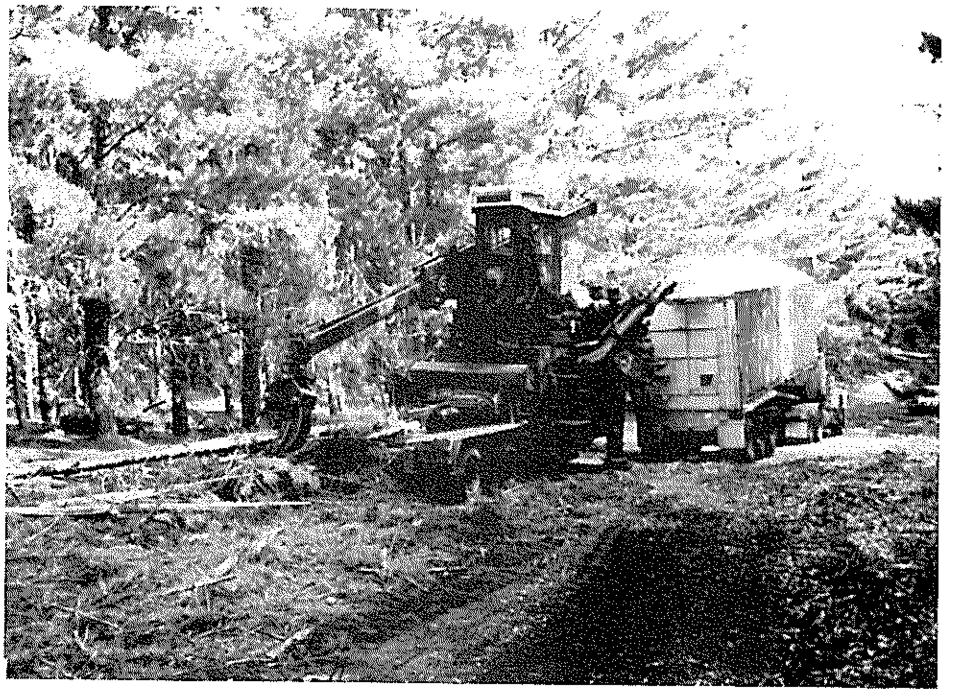

Figure 38: Morbark Whole Tree Chipper

The chip carriers transported 23 tonnes per load, and output averaged 15 loads per day (20-22 loads of boiler fuel per day maximum). The chipper was quoted to be a very reliable unit (95% availability).

A regular programme of preventative maintenance was a feature of all of Softwood Holdings mechanised operations. Another feature of these operations was the use of vibrograph recorders (Servis recorders) and daily operator log books to record downtime. This information was collected and summarised in weekly availability reports for each machine.

CONCLUSIONS

In Australia, mechanisation has almost completely eliminated the manual faller from Radiata pine thinning operations. Most logging companies visited were of the opinion that first and second thinning operations will continue to be mechanised, with some manual cutting in clearfell and steep country operations.

The major ground-based extraction machine is the forwarder, with skidders only used where wood is skidded tree length to a central processor, such as a stroke delimber, either on roadside or in a more accessible part of the cutover.

The proliferation of processors and harvesters seen between the time of FIME '80 and FIME '86 has continued with recent developments being the replacement, in some contract operations, of the old Kockums Logma delimber with Koehring, Denis and Harricana stroke delimbers or with the two-grip harvesters such as the Valmet 902 or Osa 706/250. These machines are predominant in second and subsequent thinning operations and also in clearfell.

Single-grip harvesters are still the preferred machine in first thinnings. Older models such as the Valmet GP940 are being replaced by the Kockums GSA62 and the Osa 762 harvesters.

Developments with single grip harvesters have concentrated on building experience with operating and maintaining these machines. Of the Scandinavian harvester models, the LAKO with drive rollers or the Osa 762 appeared to be the most suitable for New Zealand thinnings.

Grapple processors such as the Steyr KP40 have made inroads in some areas and the Waratah grapple processor has recently been introduced into South Australia. There are now 15 Steyrs in Australia, 11 in the Mount Gambier region. This model of grapple processor would be ideally suited to small piece size thinnings in New Zealand.

Another recent innovation has been the development of the Waratah hydraulic tree harvester which combines the features of the DFB (with its felling head and robust boom) with a grapple processor (having length measuring ability). One unit has been operating in the Coffs Harbour region of New South Wales, and a second unit is being commissioned in Tasmania. This unit looks to have great potential in larger Radiata thinnings (0.3 - 0.4 m^3, or small piece size clearfelling.

The pros and cons of fitting sophisticated harvesting equipment to excavator carriers have still not been resolved. In 1986 several contractors advocated the excavator base as the ideal carrier (McLean 1986). Reasons against the use of excavators include:

- Mechanical reliability (not being purpose built for logging).
- Slow travel speed.
- Lack of tractive ability on steeper slopes.
- Reduced operator comfort.

The choice of purpose built bases versus modified excavator bases will continue to be one of individual contractor preference.

The development of locally built machines such as the Waltanna forwarder, and modifications such as the Cat 215/880 feller buncher and the JOSA harvester, are examples of the industry identifying its specific machine requirements. The 6x6 Moxy forwarder seen at FIME '86 is now operating in a second thinning operation in South Australia. Although it is a one-off model, it is another demonstration of local engineering ability for half the cost of an equivalent Scandinavian forwarder.

Conclusions regarding the forwarders in operation in Australia are that despite their high capital cost their advantages are numerous:

(i) Ability to handle moderate slopes (20-25 degrees) without tracking as long as there is little sideslope.

(ii) Ability to extract timber on wet soil conditions - choice of 6 or 8 wheel drive.

(iii) Large payloads depending on model, up to 25 tonne (average for Osa 280 is 18-20 tonne).

(iv) Sorting can be done either in the bush during loading (hot deck) or at roadside (cold decking).

(v) Truck loading, especially with regular scheduling, eliminates the need for separate loaders.

vi) Load measuring devices on forwarders allow extraction of optimum payload each cycle.

(vii) Better quality log presentation at the mill. Logs are clean of dirt, etc for subsequent processing.

(viii) No landings are required.

Other general conclusions from the study tour include:

1. The assistance offered to New Zealanders in getting into mechanisation was widespread and sincere. Logging contractors in Australia have a high degree of experience with most types of logging equipment, and are willing to share with New Zealand loggers, the benefit of this experience.

2. The professionalism of the Australian logging workforce was evident. Mechanised operations hire keen young men including mechanics, fitters, welders, etc. and train them to a high standard as machine operators. Their pride in their machinery was obvious and resulted in good maintenance programming.

3. The emphasis continues to be placed on the "whole system" approach. Machinery is not bought piecemeal - for example, in steep country thinning operations, it is recognised there is no benefit in being able to fell the wood (eg using the Timbco) if the terrain is too steep for forwarders to be used for extraction. There is a realisation that cable systems may be required as operations are increasingly occurring on steeper country (>25°).

4. The major advantages for management are the high production rates and flexibility achievable with mechanised systems. Advantages to contractors are mainly in terms of the reduced dependence on manual labour and in vastly reduced accident rates.

RECOMMENDATIONS

1. That the New Zealand logging industry takes advantage of the opportunity to gain assistance in the establishment and further development of mechanised operations. This can be achieved through:

(a) organised visits to mechanical operations,
(b) attendance at demo's and machinery expositions,
(c) personal contact between contractors.

2. That companies currently using short log transport (5-6 m) pursue a programme of active encouragement both financially and in training input to contractors to convert to harvester/forwarder mechanised systems. Only through commitment by management and introduction of trial machine systems will the advantages of mechanisation be demonstrated to the New Zealand industry at large.

3. That LIRA continue a programme of trials with current logging systems used in Australia. Contractors and companies in the Australian logging industry have long-term records of production and machine availability for a wide range of machine types. They have also built up experience with machine repair and maintenance which will be invaluable to the New Zealand industry during the period it mechanises its operations.

4. The LIRA undertake a theoretical analysis whereby machines and methods presented in this Report are costed in a New Zealand situation. Several examples of operations observed during this study tour will also be reported in further detail.

5. That the New Zealand logging industry demonstrate a real commitment to operator training by establishing a logging training school for both chainsaw and machine operators. The lessons of both Scandinavia and Australia in the area of operator training (Gaskin, 1982) must be instituted in New Zealand.

If mechanisation is seen as a major method of harvesting in the next decade, a commitment to operator training must be made and highly skilled workers (such as fitters, engineers and mechanics) attracted into the logging industry. Reductions in logging accident rates in Australia with mechanisation have been well documented (Vine 1986, Crowe 1986, Cusack 1986). The same trend should occur in New Zealand as a consequence of converting to fully mechanised harvesting systems.

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APPENDICES

1. ITINERARY : MECHANISED HARVESTING STUDY TOUR

Sat 23 April	*5.15 pm*	*Rotorua - Auckland*
Sun 24 April	*1.45 pm*	*Auckland - Melbourne*
Mon 25 April		*Drive to Morwell, Vic.*
26-29 April		*Visit APM operations: Morwell - Gippsland (Mr O Raymond)* *1. Osa 250 Forwarder : Venturoni Bros* *2. Waratah DFB : Venturoni Bros* *3. Waltanna Forwarder : G Leeson* *4. Osa 280 Forwarder : R Crawford*
Sun 01 May	*2.05 pm*	*Melbourne - Albury, NSW*
02-06 May		*Visit ANM operations : Albury - Tumut (Mr T Beath)* *1. Dick Baucher and Alistair Harvey : Koetong, Victoria* *2. Jim Crozier, Tumbarumba, NSW : Timbco FB/Kockums Forwarders* *3. Ryam Ltd (Lex McLean & Dave Nuttall).* *4. Warren Phillips, Tumut, NSW : Grangarde 270 Harvester.*
Fri 06 May	*8.10 pm*	*Albury - Melbourne*
Sun 08 May	*6.45 pm*	*Melbourne - Mt Gambier, SA*
Mon 09 May		*Visit LITA (Mr A Cusack)* *Visit Woods & Forests Operations :*
Tue 10 May		*1. Waratah DFB/Skogsjan : C Moreland* *2. Steyr KP40 : K Boult*
11-12 May		*Visit SAPFOR operations : (Mr T Grguric)* *1. Koehring 620 FB/Koehring 620 DL : I Dohnt* *2. Steyr KP40 operation : I Dohnt*
Fri 13 May		*Visit Softwood Holdings operations : (Mr D Attiwill*
Sat 14 May	*10.20 am*	*Mt Gambier - Melbourne*
Sun 15 May	*4.55 pm*	*Melbourne - Auckland*
Mon 16 May	*8.05 am*	*Auckland - Rotorua*

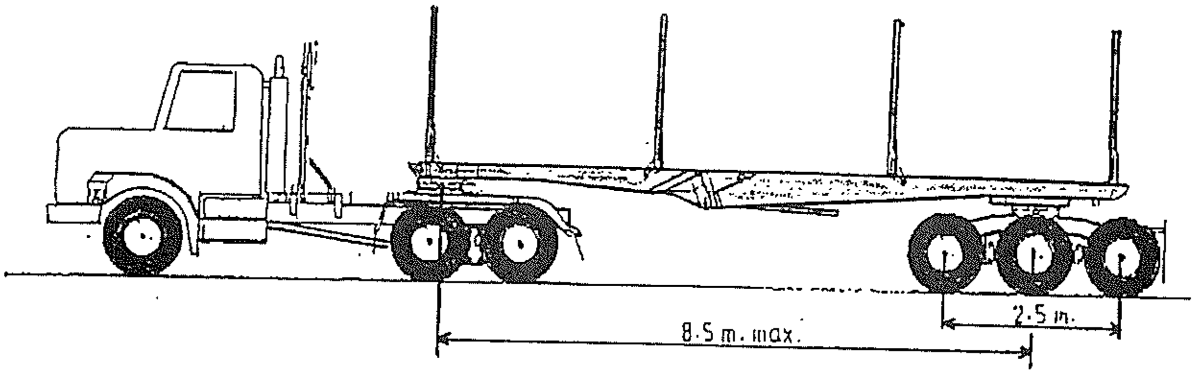
Appendix 2 : Specifications of Waltanna F6-18 Forwarder

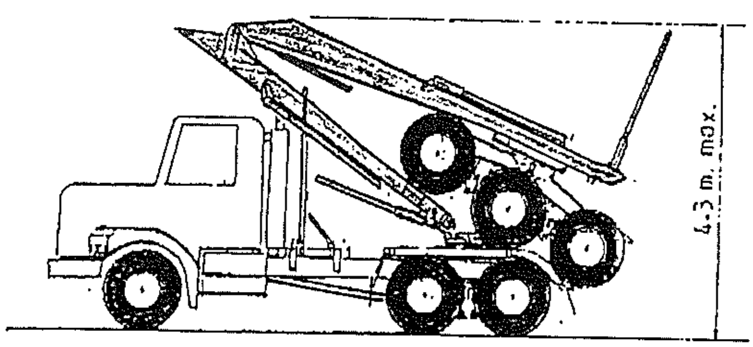
Engine	: *Cummins 6CT, six-cylinder turbo diesel*
Transmission	: *Caterpillar five-speed Powershift with Rexroth hydrostatic drive. Electrically operated front and rear differential lock*
Steering	: *Articulated frame giving a steering angle of 40°. Hydrostatic steering is separate open centre system*
Axles	: *Front - Raba (Hungary) double outboard planetary*
	: *Rear - Waltanna tandem bogies with Raba outboard planetaries.*
Hydraulics	: *Pressure compensated and load Densing.* *Max pump flow - 210 litres/min at 2000 RPM* *Reservoir - 220 litres maximum capacity* *Pressure - 175 BAR (2570 psi)* *Filtration - High pressure and return line filtration and continuous cooling* *Controls - electro/hydraulic operated by two electric joystick controllers*
Crane	: *Cranab 100 and Cranab grapple* *Maximum reach - 7.45 m (including extension)* *Lift capacity - 140 kNm* *Slewing torque- 22.8 kNm*
Electrics	: *24V, Two batteries, two 65A alternators*
Weight	: *Unladen operating -* *Front - 8400 kg* *Rear - 7000 kg* *Total - 15,400 kg*

ELPHINSTONE

FOLD A SKEL

LOG TRAILER





WIDTH 2.5 m. max.

DIAGRAM OF SYSTEM OPERATION

AUSTRALIAN NEWSPRINT MILLS LIMITED
ALBURY - WOOD PRODUCTION CONTROL SYSTEM