THINNING PINUS RADIATA WITH THE KOCKUMS SYSTEM

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ABSTRACT

The Kockums system, incorporating a feller-buncher, two limber buckers, and two forwarders, was used in a fifth thinning of **Pinus radiata** D. Don. This system is a satisfactory form of mechanisation in **P. radiata** thinning when the merchantable volume of the trees being removed is greater than 0.25 m^3.

THE SYSTEM

The Kockums system as described in this paper is the one operated by contractors working for A.P.M. Forests Pty Ltd in Gippsland, Victoria. It consists of:

(a) A Kockums 880 Feller-Buncher;

(b) Two Kockums Logma limber buckers, one model T310 (bought 1977) and one model 85-41 (bought 1980);

(c) Two forwarders, one a Volvo SM969 and one a Kockums 875.

In this operation the feller-buncher working a single shift fells sufficient trees to keep the two Logmas working on a double shift. The Logmas delimb the trees and buck the stems into sawlogs and pulpwood. The two forwarders operating on extended single shift can extract and load the wood produced by the two Logmas on double shift.

The main operation described in this paper was a fifth thinning, from above, in a 26-year-old stand of *P. radiata* belonging to A.P.M. Forests in Gippsland. It was carried out during March-April-May 1981. This is an unusual operation, particularly to foresters unused to the silvicultural flexibility of *P. radiata* in Australian conditions, and was brought about by a violent hail storm in late 1979 which caused the death of about 91 000 m^3 of small trees in one of A.P.M. Forests' Gippsland Tree Farms. Deaths appeared to be due to infection by *Diplodia pinea* Desm. Kickx after the bark had been damaged by hailstones. In order to salvage the pulpwood from these trees before the wood quality deteriorated to such an extent that they would have been unacceptable to our pulpmakers, all other pulpwood cutting operations on Company property were stopped and moved to the hail-affected area.

However, as well as supplying a pulpmill, A.P.M. Forests' pine plantations produce sawlogs for an A.P.M. Wood Products pine gangsaw mill. As it was not possible to stop sawlog cutting (which generates pulpwood from the tops of sawlog trees) a thinning from above was instituted in our oldest stands in order to:

(a) Minimise pulpwood production per cubic metre of sawlog produced from undamaged stands while the hail-killed stands were being clearfelled for pulpwood, i.e., maximise hail salvage;

(b) Remove the largest trees from the stands being thinned and so allow the rotation to be lengthened, without producing timber which was too large for our sawmill or pulpmill chipper. This extended rotation was necessary to cover the gap in age classes caused by the hail storm;

(c) Minimise areas being clearfelled prior to a major expansion of pulping capacity in Gippsland, and not have oversized trees developing in our stands.

Most of the wood from this operation was produced by the Kockums system. Characteristics of a typical compartment thinned by this operation are given in Table 1. During thinning 20% of the stems were removed (aim was 25%) and 34.6% of the volume was removed (aim was 33%). Average tree size removed was 1.08 m^3 merchantable volume. Soil type was a sandy loam over clay and topography was gently undulating with a maximum slope of 12°. Rainfall during the time of the operation was March 76 mm, April 41 mm, and May 34 mm.

TABLE 1—Details of stand of 26-year-old **P. radiata** (Site Index 18.3 m at 15 years) thinned by Kockums system

	Before thinning	After thinning
Stocking	441 stems/ha	353 stems/ha
Volume	274 m^3/ha	179 m^3/ha
	(0.62 m^3/tree)	(0.51 m^3/tree)
Predominant height	26 m	24.7 m
Basal area	31 m^2/ha	21.4 m^2/ha

The production rates (Table 2) were affected by factors often found in such operations. One new operator was trained on the T310 Logma during the period, and one of the operators on the 85-41 Logma had only about 2 months' experience at the start of the operation. A new operator was trained on the feller-buncher during the period. Trees were processed into sawlogs down to a 20-cm small-end diameter under bark (s.e.d.u.b.), with the rest of the stem going into 1.8-m pulp billets down to a nominal 8-cm s.e.d.u.b.

TABLE 2—Machine Productivity

Machine*	Machine hours	Sawlog production (m^3)	1.8-m pulp billet production (m^3)	Total production (m^3)	Average production per machine hour (m^3)
Kockums 880					
Feller-Buncher	307	11 547	3981	15 528	50.6
Logma T310	386	4 620	1860	6 480	16.8
Logma 85-41	530	6 927	2121	9 048	17.1

* No measurement was made of the Forwarder's productivity

Thinning From Below

We have had very little production experience with the Kockums system working in conventional thinning-from-below with smaller tree sizes, as our initial production trials indicated that the system is most economic when harvesting large trees (Raymond 1979). However, we have studied one very light thinning-from-below with this system, in which the feller-buncher travelled distances up to 50 m to accumulate bunches for the Logma. All operators were trained, and all the production was 1.8-m-long billets to a maximum diameter under bark of 30 cm.

For the compartment thinned in this way mean merchantable volume of trees removed was 0.35 m^3, volume removed was 40.5 m^3/ha, production per machine hour for the Logma T310 was 10.05 m^3, production per machine hour for the feller-buncher was 14.97 m^3. It should be emphasised that we do not consider that this was a typical thinning-from-below. Logma production was depressed because the delimbed stems had to be bucked into 1.8-m billets.

Advantages of the System

Cheaper wood: We have found that, provided the average tree size is greater than about 0.25 m^3 merchantable volume, the Kockums system produces wood on truck more cheaply than motor-manual systems in our situation (Raymond 1979).
Safety: We have had only one injury resulting in one or more complete work days lost to the employer, in connection with wood produced by the Kockums system, since its introduction in 1977. That injury was a broken ankle incurred by a Logma operator stepping down off the bottom rung of the cab ladder on to the ground. In 1976 there were 82 lost-time injuries in our pine contractor force for approximately 214 000 m^3 delivered. In 1980 there were 12 lost-time injuries for approximately 225 000 m^3 delivered. About 102 000 m^3 of this wood was mechanically harvested by the Kockums system described and by Windsor Harvesters. Not all the improvement in safety performance can be attributed to mechanisation, as training of cutters involved in motor-manual systems, necessitating expensive scrub-slashing operations using a small crawler introduced.

Quicker extraction and reduced truck loading times: Wood processed by the Logma is pre-bunched (Fig. 1), leading to quicker forwarder extraction and truck turn-around times than for wood prepared by motor-manual systems.

Ability to work in scrub: Undergrowth inhibits the movement of cutters in motor-manual systems, necessitating expensive scrub-slashing operations using a small crawler tractor with a heavy-duty rotary slasher mounted on the rear. This is unnecessary with mechanised harvesting. By scheduling scrubby stands to be mechanically harvested, a cost saving of the order of \$1/m^3 was achieved.

Slash disposal: The Logma delimbs the felled trees in front of itself. It then moves forward over the pile of limbs and tops, crushing them down. Often the forwarder then traverses the same outrow, further crushing the slash and aiding its decomposition. This results in a much less flammable fuel type than a motor-manual thinning which leaves tops and branches randomly distributed throughout the stand and not crushed down to ground level (Figs 2 and 3).

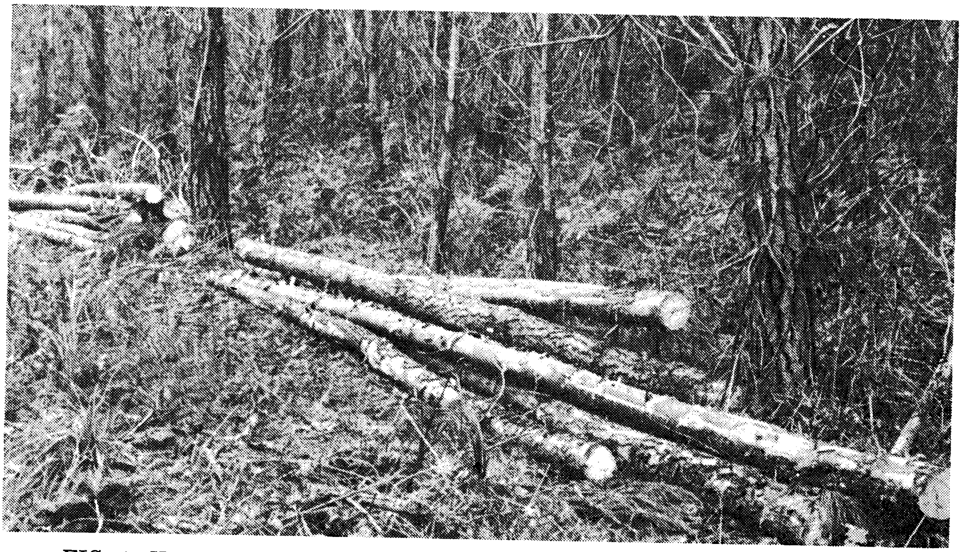

FIG. 1—Heaps of logs ready for extraction after processing by the Logma.

FIG. 2—Crushed slash in a stand thinned with the Kockums system.

FIG. 3—Slash left after motor-manual thinning.

Bark removal: The Logma removes some bark during the delimbing process. We estimate that this saves about 1–2% in cartage costs through a reduction in the volume of bark carted, and it leaves more nutrients on site for recycling to the remaining trees. The proportion of bark removed varies with the season of the year, but during the spring it appears to be as high as 25% removed.

Product upgrading: We have found that the Kockums system produces a higher proportion of sawlogs from a stand than a motor-manual system because of the ability of the Logma to virtually plane the logs. This makes logs produced by this system look more attractive to a sawmill than manually prepared wood.

Disadvantages of the System

Tree damage: Machines in forests always seem to cause some tree damage. The fault can often be traced to marking technique. If the stand is marked with the harvesting system in mind, and if operators are trained, damage can be kept down to about 4% of residual stems damaged. Marking principles for mechanical harvesting are simple.

- Keep outrows or gullets at right angles to the contour at all times;
- Make sure the outrows are wide enough for the machines (6 m for preference);
- Cut out trees which encroach into the outrow to ensure this;
- Make sure that the entrances and exits of the rows are wide enough to allow the machines access without barking the edge trees;
- Make sure that sufficient space is available for the processed wood alongside the outrow, as the wood falls off the Logma;
- Do not mark trees which cannot be reached by machines;
- Mark trees so that they can be seen by the operator of the feller-buncher.

Markers and machine operators should be made aware of each other's problems. If possible, get the markers to spend time in the cabins of the harvesting machines while the machines are working. This is the only way markers will realise the problems they can cause machine operators, problems which often lead to tree damage. However, not all the fault lies with the markers. The machine which causes the most damage is the forwarder extracting the wood, and so education and supervision of the operator of this machine could pay handsome dividends. In general, the immediate field supervisor of any pine thinning operation should spend some time observing the machine operators at work, talking to them, and, as well, marking trees with his markers. Our ideal is for the feller-buncher operator to be trained to do his own tree selection.

Portability: The system is cumbersome to move more than, say, 2 km. This means that planning should anticipate enough wood at each location to keep the system working for at least a month between moves of any distance.

Blue stain: While delimbing, Logmas remove much of the bark from the stem. This is particularly so in the spring and, when conditions are suitable, it causes more blue stain than wood prepared by motor-manual systems.

Feller-buncher head: There has been considerable trouble with the shear head of the Kockums 880 Feller-Buncher. Ten of this machine's dished shear blades have had to be replaced in its first 1500 machine hours, and these blades cost A$750 each. Also, numerous cracks have appeared in the head. The cause of the trouble could be the operator attempting to shear trees greater than 45 cm diameter at stump height, thus placing excessive strain on the head. It is not possible to accurately judge tree diameter from the operator's seat, and some trees with a stump diameter greater than 45 cm have been cut. However, the shears do not open sufficiently wide to allow larger diameter trees to be cut. Another major contributing cause of the cracking could be the greater weight per cubic metre of green *P. radiata* compared to softwood species found in Europe. This problem was first noticed in Scandinavian forwarders, many of which broke in the chassis under Australian conditions. Scandinavian softwoods weigh about 670 kg/m^3 when freshly cut whereas *P. radiata* in Australia weighs about 1000 kg/m^3 freshly cut.

CONCLUSION

To A.P.M. Forests, the Kockums system is a satisfactory answer to mechanising the thinning of *P. radiata* plantations when the merchantable volume of the trees being removed is greater than about 0.25 m^3. Australia still has no really satisfactory economic answer to mechanically thinning stands of small *P. radiata* in which the merchantable volume of the trees being removed is around 0.10 m^3 to 0.12 m^3.

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REFERENCE

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