FIRST THINNING OPTIONS
ROW THINNING *V* SELECTION THINNING

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ABSTRACT

This paper compares the relative merits of performing a first commercial thinning operation in radiata pine plantations on the basis of either row thinning or selection thinning from below. These two approaches are compared on the basis of silvicultural considerations (growth, quality and stability of the retained stems) economic and financial considerations (to both the grower and the harvester) and wood flow considerations.

Row thinning is cheaper and easier than selection thinning, provides more scope for mechanisation of harvesting, and reduces tree marking and supervision costs. On the debit side, it reduces the options for selecting crop trees for retention and reduces the yield of sawlogs in second thinning.

It is concluded that third row outrow thinning is a practical and acceptable thinning technique for radiata pine, except for stands containing large numbers of defective trees, and possibly for stands particularly prone to wind or snow damage.

INTRODUCTION

Management prescriptions for State-owned radiata pine plantations in Victoria, with only one exception, specify production thinnings. Difficulties are currently being experienced in many plantations in carrying out thinnings as specified in management prescriptions. This situation applies particularly to first thinnings.

Current prescriptions for first thinning involve a selection thinning from below with a minimum outrow spacing of 1 in 6. The main problems relate to the difficulty and cost of extraction of wood of small piece size, involving high costs of harvesting and inadequate returns from the harvesting operation. The problem is compounded by steep slopes and the presence of hardwood debris on broadcast burnt areas. The result is that thinnings are not being carried out on schedule, but only partially carried out, postponed or abandoned. If this situation continues, it could have important repercussions on wood flows, stand stability, plantation economics and management strategy in general.

Row thinning has been suggested as a means of alleviating some of the problems currently being encountered with this method of first thinning. The purpose of this report is to collate relevant information that will enable an objective evaluation of the relative merits of row thinning and conventional selection thinning.

Aspects considered include:

(i) Silvicultural considerations — the health, vigour and stability of the stand following thinning.

N.Z. J. For. Sci. 6(2): 308-17 (1976).

(ii) Economic and financial considerations — the economics of the plantation investment and the financial viability of the actual harvesting operation.

(iii) Wood flow considerations — the dependence on thinnings for the supply of wood commitments.

In this report the validity of a silvicultural regime involving production thinning is not questioned, and it is assumed that production thinnings will be carried out. "No-thinning" or non-commercial thinning silvicultural options are not evaluated.

SILVICULTURAL ASPECTS OF ROW AND SELECTION THINNING

The current prescription for first thinning in Victorian radiata pine stands entails reducing the basal area to about 20 m^2/ha at about top height 17-20 metres. This is equivalent to a residual stocking of 600-750 stems/ha at age 11 to 15 years, depending on site quality.

This thinning is based on selection from below with a minimum outrow spacing of 1 in 6. A thinning to this intensity at this stage of the stand's growth has been found by several workers (e.g. Cromer 1961, Lewis 1963) to provide the best compromise between the various constraints applicable to thinning, viz.—

— maintenance of near maximum volume growth, i.e. full use of site capacity,
— high growth rate of retained stems,
— stability to wind,
— a requirement that the thinning produces an economic yield,
— quality constraints on products produced.

A thinning as outlined above normally removes about 40% of the standing basal area, and is therefore of similar intensity to a 1 in 3 row thinning which removes 33% of the standing basal area. However, since row thinning removes trees in equal proportion from all size classes, rather than predominantly from smaller size classes, it changes somewhat the structure of the stand following thinning and could have considerably different effects on the growth, quality and stability of the stand following thinning.

Growth of retained stand

Two aspects of the growth of the stand following thinning are relevant; total volume production and the growth of individual trees.

Preliminary indications from Australian studies (Hall, 1970, Cremer and Meredith) are that differences in total volume production between 3rd row thinning and selection thinning are not important. Hall's results indicate no difference in growth rate during the first 2 to 4 years after thinning, while the Canberra results indicate a growth loss of about 14% after 6 years. However, comparison of the growth of the 250 largest trees per hectare in the Canberra trial indicates that most of this growth loss can be ascribed to growth of the smaller trees, most of which will be removed in subsequent thinnings. Growth of the largest trees, i.e. the trees which will form the final crop, is similar in row thinning and selection thinning.

Stands that have been row thinned contain more trees than stands selectively thinned to the same density. A row thinned stand contains a proportion of trees with poor dominance; trees that would have been removed in a selection thinning. Accelerated growth on these trees is likely to be minimal, despite the release associated with thinning. This has been demonstrated by Cremer and Meredith, and also in other studies on the growth of individual trees (e.g. Opie 1968) which indicate that tree growth is dependent primarily on tree size and residual density, rather than spatial arrangement.

It therefore appears that row thinning results in little or no loss in subsequent stand growth or growth of crop trees when compared with selection thinning of a similar intensity.

Quality of retained stand

The retention after thinning of an adequate number of trees of acceptable form and vigour is a prime requirement of any thinning operation, particularly where the major management objective is the production of sawlogs, as is the case in Victorian State plantations.

Row thinning limits the opportunity to favour final crop trees, as crop trees in outrows are removed along with suppressed and defective trees. This is not important where tree form is generally good and there is an adequate number of crop trees available, but it can be a most important factor where tree form is poor, as is often the case on more productive sites.

Published information on the relationship between the type of thinning and tree form is scant, the only data for radiata pine being that of the Canberra trial referred to above. Results indicate, not unexpectedly, that the number of trees of good vigour and form retained after thinning decreases proportionately as the frequency of outrows increases, there being only about two thirds of the number of crop trees in third row thinned stands as in selectively thinned stands.

This aspect has also been examined in Victorian plantations where row thinning has been carried out on a trial basis. Results are summarised in Table 1.

Indications from these surveys are as follows:

(i) All stands examined had at least 200 acceptable crop trees per hectare remaining after thinning and most stands had more than 300/ha. A realistic lower limit for an adequate number of acceptable crop trees is 250/ha. Only 2 of the 10 stands examined failed to provide this number of crop trees after 3rd row thinning.

(ii) The number of acceptable trees was generally lower on more productive sites.

(iii) As expected, the number of crop trees decreased as the intensity of row thinning increased. Likewise where row thinning incorporated selection thinning in intervening rows, the number of retained unmerchantable trees was considerably reduced.

(iv) There was no evidence that the uneven exposure of the crown after row thinning had any adverse effect on crown development or tree form.

It is concluded that, although row thinning reduces the number of acceptable crop trees, this reduction is comparatively minor when comparing 3rd row thinning with a practical alternative. For example, 3rd row thinning will result in a reduction of about 16% when compared with 6th row plus selection thinning. It is further concluded that the availability of an adequate number of acceptable crop trees should not preclude the use of row thinning techniques except on sites where tree form is particularly poor. Such sites are the exception rather than the rule, and could be readily identified prior to thinning. Thinning procedure for such sites requires special consideration.

TABLE 1—Tree form following row thinning and selection thinning (first thinning at age about 12 years)

Location	Site Quality	Type of Thinning†	Stems/hectare Potential* Crop Trees	Thinnings**	Unmerchant-able***	Total
Myrtleford	High	Unthinned	505	810	222	1537
		OR6 + Selection	371	308	12	691
		OR3	336	559	146	1041
Rennick	Medium	OR6 + Selection	507	153	0	660
		OR4 + Selection	462	138	17	618
		OR3	497	205	35	737
Beechworth	High	OR3	220	320	0	540
	High	OR3	600	200	20	820
	Medium	OR3	300	240	180	720
Bright	High	OR3	400	360	0	760
	High	OR3	240	520	60	820
	High	OR3	300	460	60	820
Mansfield	Medium	OR3	320	480	80	880
	Medium	OR3	480	380	120	980

* Potential Crop Trees — Vigorous trees, dominant or co-dominant, acceptable form — no forks, moderate deviations from straightness, branch size not excessive.

** Thinnings — Poor vigour or form, including forked or excessively branched or crooked trees. Contains merchantable wood.

*** Unmerchantable — Suppressed or very poor form. Contains no merchantable wood.

† OR6 — Sixth row outrow, etc.

Stand stability

Little quantified data has been published on the effect of thinning on stand stability although general opinion and experience indicates that unthinned stands are less liable to windthrow or bowing than thinned stands. However, this situation applies only where the canopy is maintained intact throughout the rotation. Any gaps which develop in an unthinned stand, e.g. by roading or due to isolated snow, wind or lightning damage, can provide a focal point for subsequent wind damage. This has been clearly demonstrated in a number of stands in the Ovens Valley in north eastern Victoria.

It appears that, over the whole rotation, the most stable stand is produced when the initial thinning is carried out before the stand reaches a certain critical stage, which for *P. radiata* appears to be a stand height of about 18-21 metres. This conclusion is based on general observations in stands throughout Victoria, results of early thinning trials in a number of different localities, and opinions expressed at the New Zealand Symposium on Thinning and Pruning (e.g. Bunn, 1970; Chevasse, 1970).

No evidence has been found comparing the effects of type of thinning (row or selection) on stand stability under similar stand and site conditions. However, the fact that this aspect has not been commented on in various published studies suggests that no obvious differences existed. The influence of stand height, rather than type of thinning, on stand stability is illustrated by the following data from stands in north-eastern Victoria recently thinned on a 3rd row basis:

Top height at time of thinning	Number of leaning trees per ha 6-12 months after thinning	Locality
17.2 m	0	Mansfield
18.4	0	Mansfield
19.1	0	Bright
19.8	0	Myrtleford
20.7	0	Beechworth
21.4	20	Myrtleford
21.9	80	Beechworth
22.9	60	Beechworth
23.0	520	Bright
23.5	200	Bright

This evidence indicates that on most sites row thinning can be successfully carried out without impairing the stability of the residual stand, provided the thinning is carried out prior to stand top height about 20 metres. A possible exception to this general conclusion is in stands particularly prone to wind or snow damage. High elevation stands on steep slopes with shallow skeletal soils in north-eastern Victoria have shown particular susceptibility to such damage and it is felt that row thinning might accentuate this susceptibility.

Damage to retained stems

No quantitative information is available on the relative amounts of damage to retained stems in row thinning and selection thinning in *P. radiata.* However, observations in a number of row thinned stands showed no damage due to felling and minimal damage due to snigging. The damage that was caused in snigging was caused to the trees at the end of each outrow, and was caused as the tractor turned onto the roadside.

Damage due to snigging is considerably greater in selectively thinned stands, the problem being accentuated on steep slopes and with long length logging.

Fire protection

Quantitative data on fire behaviour related to type of thinning is not available, although studies of this aspect are being initiated in Victoria. Local experience and opinion indicates:

(i) The tendency for logging slash to be heaped along rows in row thinning represents a greater fire control problem than the dispersed slash resulting from selection thinning.

(ii) This increased hazard is probably offset to a large extent by the increased access available.

(iii) In the overall context of the fire control problems in plantations the effect of row thinning versus selection thinning is minor.

Stand hygiene

Selection thinning from below removes unthrifty or defective trees. With row thinning the residual stand will contain many such trees unless a selection thinning of retained rows is also carried out. Removal of unthrifty trees may be necessary from the viewpoint of stand hygiene; e.g. to minimize susceptibility to sirex attack. This should not cause any problem since such trees contribute little to the thinning volume, or if retained, contribute little to the growth of the stand.

Inter-relationships with other silvicultural practices

Thinning is only one of a number of inter-related silvicultural operations. As such the evaluation of row thinning must include an evaluation of its effect on other silvicultural operations, particularly initial spacing and pruning.

With respect to initial spacing, rectangular spacing has been proposed as an alternative to square spacing. Row thinning of stands spaced rectangularly (say 3.6 m between rows × 1.8 m between trees in row instead of 2.4 m × 2.4 m) could result in an unacceptably wide gap in the stand. With respect to pruning, which to be effective in improving log quality must be carried out early in the rotation (i.e. before first thinning), row thinning will remove a proportion of pruned trees, resulting in a partial waste of the expenditure incurred in pruning. Thus, if row thinning is proposed, stands should preferably be square spaced and unpruned. Virtually all existing stands in Victoria are square spaced, and only a small proportion is low pruned.

ECONOMIC AND FINANCIAL ASPECTS OF ROW AND SELECTION THINNING

Row thinning may have economic and financial implications for the grower on the one hand, and the harvester, and through him the buyer, on the other.

Plantation economics

As mentioned earlier, the main problems with current selection thinning concern the difficulty and cost of harvesting, a direct problem of the logger rather than the grower. However, as additional costs of harvesting are ultimately reflected in the residual stumpage value of the wood, any silvicultural procedure which affects the cost of delivered wood will influence plantation economics, and must be carefully evaluated by the grower.

In addition to this indirect effect, row thinning may have direct economic relevance in plantation management in the following situations:

(i) Earlier thinning: Row thinning may allow thinning to be carried out at an earlier age than would be possible in a selection thinning, because of the larger average log size resulting from removal of some of the dominant trees. For example, with the introduction of row thinning at A.P.M. in 1967, the age of first thinning was reduced by about 2 years. This earlier thinning can very greatly influence the growth of the retained crop trees (Fenton and Sutton 1968) with the possibility of a reduced rotation length and markedly improved profitability.

(ii) Log size: The production of larger logs from a row may, if quality considerations permit, allow the sale of sawlogs from first thinning in situations where selection thinning from below would produce only pulpwood. This would increase the financial yield from the thinning. Conversely the average log size and the yield of sawlogs from second and possibly subsequent thinnings is likely to be reduced, thus reducing the financial yield. The overall effect on present nett worth is not known precisely, but preliminary indications from a simulation study by Hall (1974), are that the reductions in log size and therefore in sawlog yield from second thinning and subsequent fellings are likely to have the greater effect, thus tending to reduce plantation profitability. The differences, however, are not great.

Marking costs

Selection thinning involves the cost of marking trees, unless a system of cutter selection is adopted (a dubious procedure). It also involves the provision of skilled labour to mark trees. Row thinning largely eliminates the need for tree marking, thus reducing costs and labour requirements, both of which may be considerable. A recent study indicated that an experienced overseer can mark trees for first thinning at a rate of about 2.2 ha/day. This is equivalent to a direct cost of about \$14/ha or 30 cents/m^3. When all overheads are included, marking costs may be up to 70 cents/m^3.

Logging productivity and costs

The major problem with the current selection thinning is the high cost and difficulty of harvesting. Current contract rates for felling, trimming and snigging of log length wood in Victorian plantations vary from just over \$2 per m^3 for clear felling to over \$8 for first thinnings. These figures relate to relatively flat sites. Loadings are generally added for steep slopes or heavy ground debris. It is obvious that wood from first thinnings is expensive wood, and that any improvement in productivity or reduction in costs of first thinning will have an important influence on the cost of wood production.

Quantitative data for radiata pine on the effects of row thinning on logging productivity and costs are meagre, although overseas studies with other species indicate definite increases in productivity and significant cost advantages. A preliminary trial carried out in a 12 year old stand at Myrtleford produced the following comparisons:

	3rd row outrow	Selection thinning (excluding extraction row)	6th row outrow plus selection (estimated)
Average tree size (m^3)	.147	.072	.100
Daily production			
(3 man crew) (m^3)	20.0	11.5	14.9
— (trees)	136	160	150
Daily costs (\$)	160	160	160
Volume cost (\$/m^3)	8.0	13.9	10.7
Contract rate (\$/m^3)	8.86	8.86	8.86

This trial compared 3rd row thinning with selection thinning in which the extraction outrows were not considered. The values for the 6th row plus selection thinning were computed from those of the other two treatments.

This study indicated that the 3rd row thinning was marginally profitable to the contractor, while the selection and 6th row plus selection thinnings were unprofitable at current contract rates. The differences in profitability were due to a lower production rate in the selection thinning, associated with the lower average volume per tree, since a similar number of trees per day were felled in each case. The time taken to fell, trim and snig a tree increased only slightly with increasing tree size, indicating that tree size has a most important effect on the logging costs per unit of volume. Many logging studies, both in Australia and overseas, substantiate this conclusion.

Experience with row thinning in South Australia supports the above contention that row thinning is cheaper than selection thinning. Preliminary results from production trials of row (1 in 3) and selection thinning (1 in 6 plus selection) indicate a gain in productivity of at least 10% using current methods, involving hand loading of billets at the stump.* The gain in productivity using mechanical harvesting methods is expected to be much greater.

Steep topography and the presence of hardwood debris greatly influence the difficulty and costs of harvesting, particularly in thinning. Whether row or selection thinning is the best thinning method for steep country is open to question but, in the writer's opinion, row thinning is the better alternative in virtually every case, except possibly where rows run along the contour or across the slope. In such cases extraction rows may have to be cut up and down the slope, irrespective of planting rows, and selection thinning between these extraction rows may be the most practical method.

Where hardwood debris is present, an outrow system can still be worked. However the system must be flexible so that outrows can be offset to avoid very heavy concentrations of debris. In stands with hardwood debris on slopes above, say, 15° thinning is unlikely to be practical and such stands may be best left unthinned.

This aspect of thinning in stands with hardwood debris underlines the dependence of utilisation operations on the method of stand establishment. A decision on whether to broadcast burn or to heap and plough should be made with due recognition given to its subsequent effect on utilisation operations.

Mechanisation

There is a general trend towards increased mechanisation of logging operations, and a general consensus that this trend will continue because of the increasing difficulty of obtaining bush labour and the very rapid escalation of labour costs.

Row thinning offers far greater opportunities for mechanisation than does selection thinning because it is possible to get a machine to the stump of each tree in the stand. This greatly facilitates the mechanisation, not only of snigging, but also of falling and delimbing, and, if required, full tree processing. In particular the mechanisation of delimbing, a major cost factor, offers considerable scope for reduction of costs.

The advantage of row thinning with respect to mechanisation relate not only to the first thinning, but also to second and subsequent thinnings, because all trees in the stand are directly accessible to mechanised equipment in subsequent utilisation operations.

WOOD SUPPLY ASPECTS OF ROW AND SELECTION THINNING

Row thinning is usually applied only to first thinnings. However its effect on yield and product mix extends to later fellings as well. Hall (1970) has shown that row and selection thinnings of similar intensity produce similar yields of pulpwood, if pulpwood only is produced. However, row thinning, because it removes some of the dominant

* A. Cole, Woods & Forests Department, South Australia; pers. comm. 1974.

trees, may enable the sale of sawlogs from first thinnings in situations where selection thinning produces only pulpwood. Row thinning may also affect the product mix in later thinnings, by reducing the average log size and thus the proportion of sawlogs. This effect is most pronounced in the second thinning but should be greatly diminished, and probably negligible at rotation age. Quantitative data on this aspect is not currently available, but should be forthcoming when current work on the development of stand growth models (Opie 1975) reaches fruition.

This reduction in the yield of sawlogs from second thinnings is unlikely to be important (in terms of wood supply) in plantation areas where the bulk of the sawlog volume is planned to come from the clear felling of older stands, or in areas where the resource is not fully committed. However, it is a very relevant consideration in new plantations where row thinning could delay the availability of substantial quantities of sawlogs until the third thinning. This could delay the establishment of a sawmilling industry based on these plantations by several years.

CONCLUSIONS

It is convenient to summarize conclusions in terms of the advantages and disadvantages of row thinning compared with selection thinning. Aspects in which there is little or no difference between the two procedures are also listed.

Advantages of row thinning

(i) Logging productivity is higher and costs are lower, due to an increase in average tree size, and to easier felling and snigging. Improvements in productivity are least with manual harvesting methods, but increase as the levels of mechanisation increases.

(ii) It offers far greater opportunity for mechanisation than does selection thinning, both for the row thinning itself and for subsequent thinnings.

(iii) It is likely to be more successful on steep slopes and on debris-covered areas than selection thinning.

(iv) It eliminates the need for tree marking.

(v) Damage due to snigging is considerably less.

Disadvantages of row thinning

(i) It reduces the number of acceptable crop trees. However this reduction is comparatively minor when comparing 3rd row thinning with a practical alternative (e.g. 6th row plus selection).

(ii) It may result in a slight loss of total volume growth in a stand in the years immediately following thinning, compared with selection thinning. However, the growth of crop trees is similar in both cases.

(iii) It results in reduced availability of sawlogs from the second thinning, and possibly also from later fellings.

(iv) It is not compatible with rectangular spacing, and expenditure on pruning may be lost if a pruned stand is subsequently row thinned. It should therefore be confined to square spaced and unpruned stands.

Other aspects

(i) Apart possibly from stands particularly prone to wind or snow damage, row thinning can be carried out without impairing the stability of the residual stand provided the thinning is carried out prior to stand top height about 20 metres.

(ii) In the overall context of the fire control problem in plantations, the effect of row thinning versus selection thinning is minor.

(iii) The availability of an adequate number of crop trees should not preclude the use of row thinning except on sites where tree form is particularly poor. Such sites are the exception rather than the rule. They can be readily identified prior to thinning and thinned under separate prescription if necessary.

(iv) The effect of row thinning on plantation profitability is uncertain, and requires further study. On the one hand, it should, by reducing logging costs, increase residual stumpage values. It may also improve plantation profitability by allowing earlier thinning and thus earlier amortisation of debt. This earlier thinning may also result in better growth of crop trees and therefore a shorter rotation. These effects must be balanced against reduced sawlog volume, and therefore lower returns, from second thinning.

(v) Row thinning appears to be a practical, cheap and satisfactory thinning technique for radiata pine on most sites. It is not an acceptable technique for stands containing a large number of defective trees, and may result in stability problems in stands particularly prone to wind or snow damage.

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