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The Combination of Trees, Pasture and Grazing by Animals

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Summary

Lack of nutrients and lack of moisture are important factors that can limit the growth of pine. I present local and New Zealand evidence showing that these problems can be overcome on difficult sites by growing pine at wide-spacing in combination with pasture and grazing by animals. The higher fertility of pastured and grazed land compared with most native soils in Western Australia improves the growth of pine. Lack of moisture is alleviated by growing pine at wide-spacing. Widely-spaced stands produce less volume of timber per hectare than dense plantations but higher value per hectare.

Nutrition

1. Background

Most soils in Western Australia are too infertile in their natural state for growth of pine. For example the soils of the Donnybrook Sunkland contain levels of phosphorus and nitrogen that are respectively 1/10 and ½ of the levels considered necessary to grow Pinus radiata successfully (Chevis, 1983). Levels of copper and zinc are also inadequate. Chevis suggests that to grow pine satisfactorily there needs to be a permanent improvement in the fertility of the site . In other words the site should contain adequate levels of phosphorus, nitrogen, copper and zinc throughout the rotation. By what method can a permanent improvement in site fertility be made?

2. Effect of pastured land

There is evidence that pine grows better on pastured land than on unpastured land. Data from an agroforestry trial east of Mundaring are presented in Table 1. Density of trees range from 35 to 120 stems per hectare and the age was 19 - 21 years. Fertilizer used was superphosphate.

Table 1. Diameter increments of P. radiata grown under different regimes in the Wellbucket Agroforestry Trial.

Treatment	Diam. Incr. ('81-'83) (cm)
Nil	4.46 | *
Fertilizer	5.08 |
Fertilizer and clover	6.01 |

*Vertical lines signify not significantly different

Data show that six years after clover had been established under 16 year old trees, the trees with 'fertilizer and clover' are growing significantly faster than trees without clover. This recent finding is important as it is the first time that clover has been shown to produce an improvement in growth of trees, at similar rates of application of fertilizer. Earlier trials did not separate the effects of fertilizer (superphosphate) and clover.

Studies in New Zealand have shown that pines on farm sites grow faster than pines on forest sites. The data published by West et al. (1982) shows a 37% increase in basal area increment for pines on farm sites compared with pines on forest sites (Table 2).

Table 2. New Zealand data showing the difference in basal area increments for forest and farm sites (West et al., 1982).

Site type	Basal area increment m2/ha/yr
forest site	3.2
farm site	5.1

3. Nitrogen and phosphorus

What is the explanation for improved growth of pine on pastured land? Work on the Sunkland with inorganic nitrogen/phosphorus fertilizers has shown that nitrogen is quickly leached from the site and that it would be necessary to apply more every two years. This would be very expensive at the current rates of application[a].

Footnote: [a]Current cost of fertilizers

(i) Superphosphate-$91.10/tonne
(ii) Agras No. 1 (N.P. fertilizer)-$201.60/tonne

The work has also shown that the small amount of phosphorus applied under the nitrogen/phosphorus fertilizer regime[a] would contribute little to the level of phosphorus in the soil (Chevis, 1983). It was realized that levels of nitrogen and phosphorus in the soil must be raised significantly.

Regimes involving clover and superphosphate, involve much more superphosphate[b] and rely on clover for supplying nitrogen. Such regimes have been more successful in raising the levels of nitrogen and phosphorus in the soil.

Table 3 presents data showing the increase in levels of nitrogen and phosphorus in the soil for 'super and clover' regimes and for nitrogen/phosphorus fertilizer regime.

Table 3. Levels of nitrogen and phosphorus in the soil for different regimes, five years after establishing pine on newly cleared land (data from Chevis, 1983).

Type of regime	P. level after 5 years (ppm total)	N. level after 5 years (%)
N.P. fertilizer regime	16	0.039
'super & clover' regime	67	0.060

Footnote: [a] Nitrogen/phosphorus fertilizer regime

- (i) 100 g/tree Agras No. 1 at planting
- (ii) Foliar spray of copper & zinc at 6 and 30 months
- (iii) 400 kg/ha Agras No. 1 broadcast in years 2, 4 & 6.

[b] 'Super and clover' regime

- (i) 500 kg/ha Super Cu Zn Mo No.2 broadcast to establish clover
- (ii) 150 g Super Cu Zn B next to pine at planting
- (iii) 400 kg/ha Super broadcast in year 1
- (iv) 200 kg/ha Super broadcast in years 3 and 5.

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These data show that the level of nitrogen is about 70% higher on the clovered site compared with the unclovered site. Hatch (1981) used these data to estimate that clover had produced more than 400kg of nitrogen per hectare in 5 years. The level of phosphorus in the soil is 400% higher in the clovered site compared with the unclovered site.

4. Minor elements

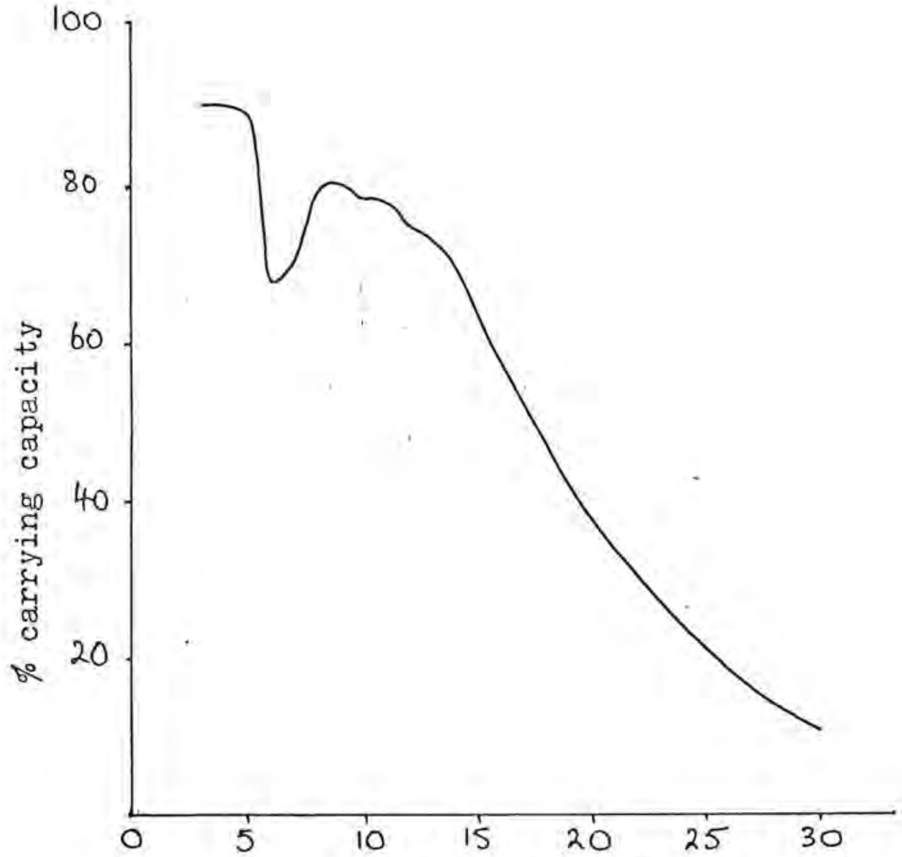
Few symptoms of deficiencies of zinc and copper have been observed in stands on the Sunkland involving the 'super and clover' regime (Chevis, 1983). Deficiencies were common with earlier regimes without clover and involving spot applications of either Superphosphate or a nitrogen/phosphate fertilizer. Under the 'super and clover' regime, foliar spraying of copper and zinc is unnecessary. However, neither the role of clover in supplying minor elements nor the respective roles of broadcast and spot applications of fertilizer are completely understood.

5. Grazing by animals

There is little information about the effect of livestock on growth of trees. West et al. (1982), in explaining the larger basal area increment for trees on farm sites compared with on forest sites, suggest that animals improve soil fertility by helping the turn-over of nutrients.

Grazing of livestock is necessary for maintaining the quality of clover pasture (Department of Agriculture, pers. comm.). A high quality clover pasture produces more nitrogen than an ungrazed pasture and improves soil fertility.

Grazing livestock under widely-spaced trees provide significant financial returns. Percival and Knowles (1983) have published data on livestock carrying capacity under P. radiata in New Zealand (Figure 1).



Source: adapted from Percival and Knowles (1983)

Figure 1. Livestock carrying capacity under P. radiata at a density of 100 stems per hectare over a 30 year rotation.

Figure 1 shows that over a 30 year rotation the carrying capacity is high (>80%) for most of the first 10 years, declines steadily during the second 10 years and is low (<40%) during the last 10 years. These levels of grazing are significant and improve the profitability of growing timber in widely-spaced stands (Knowles and Percival, 1983).

Silviculture

Lack of moisture can cause poor growth and even death of pine. For example, prior to the Forests Department changing thinning schedules there were many drought deaths in the Blackwood Valley in unthinned stands of P. radiata on north facing slopes.

Where moisture is limiting, wide-spacing of trees will improve growth. In the open conditions trees are able to establish larger root systems and tap more water. Data from Jarrahwood Thinning Trial (W.P. 21/78), presented in Figure 2, confirm that diameter increments of individual crop trees increase with decreasing density of trees.

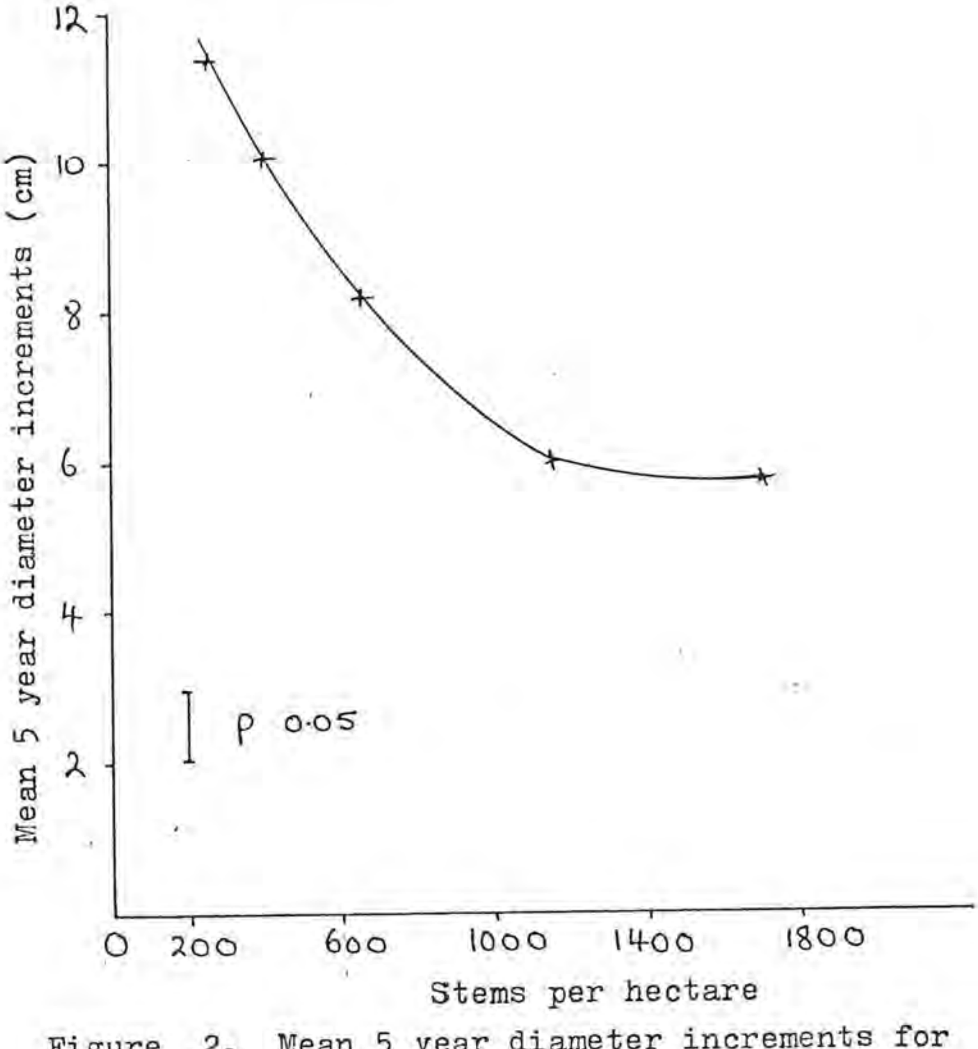
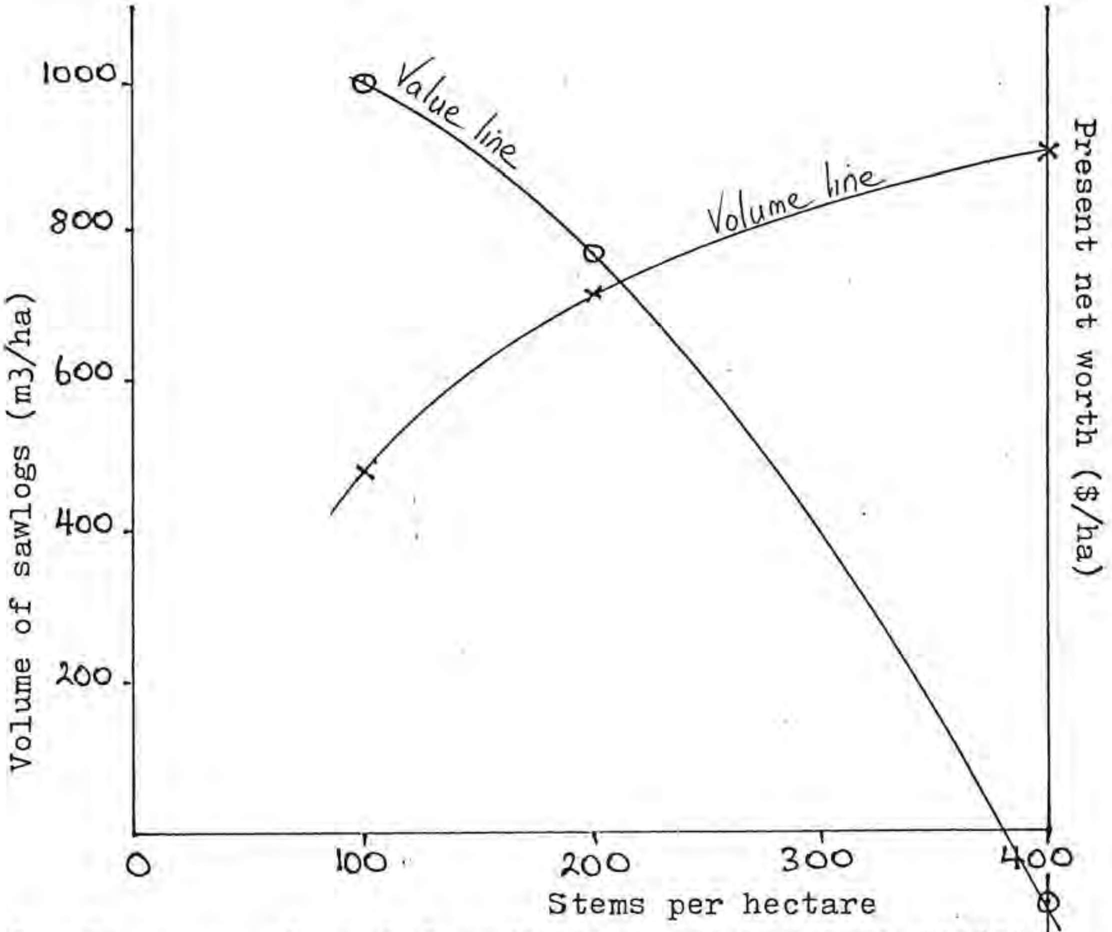


Figure 2. Mean 5 year diameter increments for P. radiata crop trees in stands of different stockings on the Donnybrook Sunkland.

The concern of many foresters, in thinning stands heavily to avoid drought deaths, is that production of timber is sacrificed. The findings of the New Zealand Radiata Pine Task Force provide relevant and perhaps surprising results on this aspect. The Task Force's findings come after 22 man years of work to incorporate into a computer model the variables that influence the profitability of growing radiata pine. There are about 90 variables, including spacing, pruning and rotation length as well as site quality, distance from mill and cutting patterns. One of the main findings is that widely-spaced stands (eg. 100 stems per hectare) produce less volume per hectare than denser stands (eg. 200 - 400 stems per hectare), but the value per hectare is higher (Knowles, 1983). Figure 3 shows the effect of final crop density on volume of timber produced per hectare and profitability per hectare as found by the New Zealand Task Force.



Source: adapted from Knowles and Percival (1983)

Figure 3. New Zealand Radiata Pine Task Force findings on the effect of final crop density on volume of sawlogs per hectare and value per hectare for a 30 year rotation.

The greater profitability of growing trees at wide spacing is dependent, to some extent, on premium prices for size and quality of logs. (Growers in New Zealand are paid more for large logs). However there are many other ways in which growing trees in widely-spaced stands improves profitability. Tending costs per hectare are reduced with fewer trees per hectare. The costs of harvesting, transport and especially the cost of sawmilling are also reduced with large logs.

Conclusion

Conditions for growing pine in Western Australia are often harsh. The summer drought is long and soils are generally infertile. For these reasons I consider that the benefits of growing pine in widely-spaced stands on pasture with grazing by animals are likely to be even more pronounced in Western Australia than they are in New Zealand.

Our research has shown that pines are healthier and grow faster on pastured land. We have also demonstrated that drought deaths are prevented by growing trees in widely-spaced stands and that open grown crop trees grow much faster than crop trees in dense stands. Widely-spaced stands enable grazing to be carried out for much of the rotation. Grazing improves soil fertility by maintaining clover pasture in high quality and improves profitability by providing annual financial returns.

The next phase of our research will be to use data on yields of timber and levels of grazing to determine the profitability of agroforestry in Western Australia compared with traditional methods of growing pine.

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