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WHOLE TREE THINNING OF RADIATA PINE - EARLY EFFECTS ON GROWTH

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EXECUTIVE SUMMARY

ABSTRACT

Three trials comparing whole tree thinning of radiata pine with waste and production thinning were established across a range of sites with contrasting nitrogen availability. The thinning treatments were interacted with N fertiliser. In the first year after trial establishment N fertiliser increased foliar N concentrations at all three sites and increased growth at two of the three sites. Whole tree thinning removed between 105 and 240 kg/ha of N, depending on site. At the poorest N site, on a recent wind blown sand, this loss represented a high percentage of the total N on site and a significant interruption in N cycling on a site, which had demonstrated by its responsiveness to N fertiliser, that it was limited by low N availability. Despite these losses of N there was no immediate effect of thinning treatment on growth of the residual crop, at any of the three sites.

INTRODUCTION

Radiata pine is the main plantation species in New Zealand. It is grown to clearfelling size (48 cm diameter at breast height) in less than 30 years. It is planted at densities between 800 and 1500 stems per hectare. It is generally thinned at least once down to a final density of between 200 and 500 s/ha. Some stands are live-branch-pruned to 4 or 6 m height.

There is a strong preference to thin the stand to final density before age 15 and in some regimes densities are reduced as low as 200 s/ha by age 10. The choice of timing of thinning seems to depend on whether or not there is a market for the produce. If there is no market then the thinnings are done as early as possible because that is the cheapest strategy. The trees are simply cut down and left - a process termed "waste" thinning in New Zealand. In these regimes one or two thinnings are used to reduce the stand to final spacement by about age 10. If there is a market for the produce then the stands tend to be left at higher densities for longer. Such stands may be production thinned from 1500 s/ha to 500 s/ha at age 10 or receive one waste thinning to under 1000 s/ha at about age 5 and then a final production thinning between ages 11 and 15. In almost all such production thinnings the trees are currently felled by a chainsaw and delimbed close to the stump by the same means. This process of delimbing accounts for 65-70% of the total labour cost of processing one tree and causes most of the chainsaw accidents (K. Raymond, LIRA, pers. comm.). In Scandinavia the same operation would be done by a feller processor with reduced costs, greater throughput, less labour turnover and fewer accidents than the motor manual method. New Zealand has been much slower than Australia to adopt mechanised thinning. Some of the reasons given include : the very steep land afforested recently; radiata pine branches are thicker and tougher than those of the species for which the machinery was developed; and the high capital cost of the machinery. However a range of machines have now been imported on a trial basis and if they prove to be cost effective may be adopted.

Depending on the type of machine used there may be a more or less severe redistribution of branch material over the site. The Scandinavian feller-processors tend to leave the branches distributed similarly to manual methods of delimbing but some of the grapple skidder and flail or gate delimbing systems concentrate the branches at a central point well away from the stump. Thus "whole tree" harvesting may occur even when there is no intention to utilise the branch material.

The branches and foliage contain a large (generally greater than 50%) proportion of the total nutrients in the above ground biomass (Madgwick 1977). Many of New Zealand's exotic afforestation sites are marginal or low in one or more nutrients (Will 1985). Thus removal of branches and foliages would interrupt nutrient cycling, reduce the site nutrient capital and might impact on growth. In Norway Tveite (1983) had shown that a growth reduction of between 7-10% occurred in the residual trees following whole tree thinning.

Thus, in consultation and co-operation with the Forest managers of three New Zealand companies, three trials deliberately sited so as to span a range of nitrogen sufficiency, were established to compare whole tree and production and waste thinning. The sites were deliberately selected to by low, medium and high in soil N and well supplied with all other nutrients.

The main objectives of the trial series were :

- to determine whether the growth of the residual crop trees was affected by different intensities of material removal in thinning;
- to determine, by the application of nitrogen fertiliser, whether nitrogen availability was a major factor in limiting growth, and, indirectly, a major component of any growth effects caused by intensity of thinning.

METHODS

Site Selection

The experimental series is represented at three sites in the North Island of New Zealand.

1. **Woodhill Forest :** which lies 70 kms north of Auckland on recently reclaimed coastal sand dunes within 3 kms of the sea. The stand had been planted in 1976 and was standing, unthinned, at 1600 stems/ha in 1986 when the trial was laid out.

2. **Crohane Forest :** which lies halfway between Napier and Taupo on deep Taupo pumice (2000 years before present) overlying mudstone. The stand had been planted in 1975 and waste thinned in 1980 from 1500 to 800 s/ha. Pruning to 6 m had been carried out on 300 s/ha. The trial was laid out in 1987.

3. **Tarawera Forest** : which lies 50 km south east of Rotorua. The soil is derived from a shallow mantle of Tarawera scoria (gravelly pumice - 100 years b.p.) over Taupo pumice (2000 years b.p.). The stand had been waste thinned from 1800 to 800 s/ha in 1982 and was unpruned. The trial was laid out in 1987.

TRIAL LAYOUT

At Tarawera and Woodhill three intensities by thinning (waste, production and whole tree) were compared while at Crohane only two intensities (production and whole tree) were imposed. At Woodhill the residual crop stocking was 800 s/ha; at Tarawera, 400 s/ha and at Crohane 500 s/ha. Each treatment was replicated three times at each site and applied to rectangular plots approximately 0.05 ha in area with a similarly treated surround. The different intensities of thinning were imposed mainly manually with some machine assistance. Considerable forethought was given to providing trackways through the trial for machinery so as not to disturb any of the treated plots.

Nitrogen, at the rate of 200 kg/ha, was applied by hand as urea, shortly after thinning, in a factorial arrangement.

Subsidiary treatments were included at each site in the form of unthinned controls, plots where slash was dumped, and legume sowing as an alternative to fertiliser. They are not discussed further in this paper.

All trees were measured for breast height diameter and a sample were measured for height at the time of trial establishment and a year later. Tree volume per plot was calculated from logarithmic tree volume tables.

SITE CHARACTERISTICS

Soil samples were taken from the top 10 cm and analysed for total nitrogen. Forty-eight randomly located 0.25 m squares were cut from the forest floor in unfertilised plots, dried, weighed, ground and analysed for N content. Foliage samples from five trees per plot were taken from first year needles on secondary branchlets high in the canopy in the autumn following fertilising, and analysed for N.

Ten trees per site were selected at random, felled and divided into components so that the amount of material and the amount of nitrogen displaced by the various thinning intensities could be calculated.

RESULTS

The amount of nitrogen present on each site is given in Table 1.

TABLE 1 : PERCENTAGE OF NITROGEN IN THE SOIL AND AMOUNT OF NITROGEN IN THE FOREST FLOOR AND TREES

Site	Soil N Total N%	Forest Floor N Kg N/ha	N in the trees
Woodhill	0.01	78	260
Tarawera	0.15	235	268
Crohane	0.63	240	392

The dry weight and nitrogen content before and after thinning are given in Table 2. In Table 3 the amount removed and left by each intensity of thinning is given and in Table 4 the gain in dry weight but increased loss in N resulting from whole tree thinning is expressed as a percentage of the value for production thinning.

TABLE 2 : DRY WEIGHT AND NITROGEN CONTENT OF THE STANDS (KG/HA)

	As Unthinned		After Thinning	
	Weight	Nitrogen Content	Weight	Nitrogen Content
Woodhill				
Foliage	9800	111	5391	61
Branches	32944	63	18118	34
Stem	97619	86	53690	47
	140363	**260**	**77199**	**142**
Tarawera				
Foliage	8860	118	5377	72
Branches	37111	60	14404	36
Stem	121335	90	73632	55
	167305	**268**	**93413**	**163**
Crohane				
Foliage	12120	168	4758	66
Branches	40247	89	15778	35
Stem	132828	135	52070	53
	185195	**392**	**72606**	**154**

TABLE 3 : AMOUNT OF MATERIAL AND AMOUNT OF NITROGEN REDISTRIBUTED BY EACH TREATMENT (KG/HA)

Site/Treatment	Added to Forest Floor		Removed from Site	
	Weight of Material	Amount of N	Weight of Material	Amount N
Woodhill				
Waste thinning	63164	118	0	0
Production thinning	21421	81	41732	37
Whole tree thinning	-	-	63164	118
Tarawera				
Waste thinning	73892	105	-	-
Production thinning	28574	62	45317	43
Whole tree thinning	-	-	73892	105
Crohane				
Production thinning	35868	160	76720	78
Whole tree thinning	-	-	112589	238

Note : The values for production thinning do not correspond exactly to Foliage + branches - stem from Table 2. This is because the top of the stem is left in the stand in production thinning. The weight and nitrogen content of the top account for the small percentage difference.

TABLE 4 : PERCENTAGE INCREASE IN AMOUNT OF MATERIAL HARVESTED AND NITROGEN REMOVED BY CHANGING FROM PRODUCTION TO WHOLE TREE THINNING

Site	Harvest Yield Increase	Nitrogen Removal Increase
Woodhill	51%	319%
Tarawera	63%	237%
Crohane	47%	305%

TABLE 5 : FOLIAR NITROGEN CONCENTRATIONS 6 MONTHS AFTER TRIAL ESTABLISHMENT (% DRY WEIGHT AND SIGNIFICANCE OF DIFFERENCE)

Site	Effect		
	Thinning	Fertilising	Interaction
Woodhill	?	*	*
Waste Thinning	0.96	1.53	
Production Thinning	0.92	1.49	
Whole Tree Thinning	0.98	1.27	
Tarawera	NS	*	NS
Waste Thinning	1.39	1.71	
Production Thinning	1.38	1.65	
Whole Tree Thinning	1.42	1.61	
Crohane	NS	?	NS
Production Thinning	1.54	1.67	
Whole Tree Thinning	1.56	1.64	

NS = Not Significant
? = Probability between 0.1 and 0.05
* = Probability less than 0.05

TABLE 6 : VOLUME (M^3/HA) ONE YEAR AFTER TRIAL ESTABLISHMENT (SIGNIFICANCE OF TREATMENT EFFECTS)

Site	Effect		
	Thinning	Fertilising	Interaction
Woodhill	NS	*	NS
Waste Thinning	129	134	
Production Thinning	126	132	
Whole Tree Thinning	127	131	
Tarawera	*	NS	NS
Waste Thinning	211	210	
Production Thinning	214	221	
Whole Tree Thinning	210	208	
Crohane	NS	?	NS
Production Thinning	167	171	
Whole Tree Thinning	166	176	

DISCUSSION

Woodhill has the lowest soil nitrogen concentration of the three sites. Small particles of organic material are distributed throughout the wind-piled sand, making it very difficult to get a reliable estimate of the total amount of nitrogen potentially available to the tree roots. Several authors have attempted to estimate the amount of N in the Woodhill soil (Gadgil 1976, Baker et al. 1986). The amount is almost certainly less than 1500 kg/ha, more than 500 kg and in the region of a thousand kilogrammes/ha. By contrast the Tarawera site would have a few thousand kilogrammes/ha N and the Crohane site, many thousands kg/ha N (in both these soils buried topsoils are possibly supplying significant amounts of N to the trees). Therefore at Woodhill a high percentage of the total system N is concentrated in the forest floor and trees; at Tarawera a smaller but still significant portion is to so concentrated, while at Crohane less than 10% of total N would be in trees and forest floor.

Whole tree thinning constitutes a major drain on total N at Woodhill. The site had insufficient nitrogen to support vigorous tree growth since nitrogen concentrations in the foliage of unfertilised plots were very low (Table 5) and the site responded strongly to nitrogen fertiliser. Fertilised plots grew 5 m^3/ha/yr or 24% faster than unfertilised plots. In the second year the gain to fertiliser widened to 23 m^3/ha and represented a 62% in increment since trial establishment. Thus N availability is a major factor limiting growth at this site. At first site it is surprising therefore that the major interruption in nitrogen recycling represented by whole tree thinning had no immediate effect on tree growth (Table 6). There has been no effect in the second years growth either.

However we know that the nitrogen release from silvicultural slash is slow for the first 12 months - only 16% of the total N being released from litter bags containing green needles (Baker et al. 1988). It seems probable therefore that the slash has little direct role on nitrogen cycling immediately following thinning. In a warm temperature climate like New Zealand it may well have an indirect role in mediating forest floor decomposition through shading and mulching. This aspect is being investigated through forest floor decomposition studies which are being conducted concurrently at the three sites.

At Tarawera, nitrogen fertilising had a significant effect on foliar N (Table 5), although the unfertilised plots were not strongly N deficient and the stand did not respond significantly to the applied fertiliser (Table 6). There was, apparently, a significant effect of thinning treatment - with production thinning giving the better growth. However this result only appears after a large covariate adjustment to the means of the waste and the production thinned treatments and appears to be due to the fact that some trees that should have been cut down in the waste thinning treatment were not (average stocking 434 s/ha), while some extra trees that should have been cut down in the waste thinning treatment were not (average stocking 375 s/ha).

At Crohane nitrogen fertiliser had a weakly significant (probability between .10 and .05) effect on both foliar N and growth, increasing growth by 7 m^3/ha/yr or 20%. There was no difference between the thinning treatments.

At Woodhill there was a significant interaction of thinning and fertilising on foliar N concentrations. Foliar N concentrations increased less in the whole tree thinned plots than in the other two treatments. A similar pattern is detectable in the other two trials although there is no significant interaction at these sites. Possibly the slash has a shadowing, mulching effect which reduces volatilisation of applied N and thereby marginally improves uptake.

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