ARTICLES

Impact of the full tree harvesting of thinnings on Canterbury Plains

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Abstract

Eleven-year-old Pinus radiata thinnings being harvested for fuel removed 175 kg ha-1 N when stems, branches and foliage were chipped. Harvesting eight-year-old thinnings reduced the N removed by 30% at the expense of 20% less harvested material and the chipping of 1000 instead of 400 trees. Stems contain 55-60% of the biomass (and energy) and only 25-30% of the N of the full tree. To reduce the impact of nutrient removal on these infertile sites, foliage and if possible branch material, should be left on the site. The use of fertilizers and legumes should be further investigated.

In 1986 Handifuel Fuel Systems of Christchurch started whole tree harvesting of thinnings in Eyrewell Forest on the Canterbury Plains. The thinnings are chipped on site and transported to Christchurch for use as industrial fuel.

This note considers the impact of this operation on the N economy of the site.

Eyrewell Forest

Eyrewell Forest is situated on the Canterbury Plains some 50 km N.W. of Christchurch. The soil, a Lismore very stony silt-loam, is derived from fluvio-glacial outwash sediments and thin loessal deposits. The fine fraction (<2 mm) of the topsoil is very low in total N (0.10%) - J. Adams, pers.comm.) and it is estimated that the total N content in the rooting zone is 2500 - 3000 kg ha^{-1}. Annual rainfall averages 870 mm but is highly variable; summer droughts are common. Site index is low, being 20-21 m at age 20 years for radiata pine. This slow growth rate results from the low nutrient status and droughty nature of the site. Fertilizer trials have shown good responses, particularly to N (Table 1).

Full Tree Harvesting

Handifuel Fuel Systems employ a Swedish designed machine to harvest thinnings after they have dried out on the forest floor (Fig. 1). The machine is a Bruks whole tree chipper (285 kW) mounted on an Osa forwarder (135 KW) with a 17 m^3 bin (see cover photo). Under Eyrewell conditions it harvests 50 m^3 hr^{-1}. Stems, branches and needles are able to be used as industrial fuel.

Methods

The estimates for the impact of this whole tree harvesting operation come from a detailed biomass and nutrient cycling study made in a thinning-fertilizer trial at Eyrewell forest (Mead *et al.* 1984; Grottker 1984; Mead and Madgwick in prep). The experiment involved measuring biomass and nutrient contents at ages 7, 8, 9 and 11 years; data from unfertilized plots at ages 8 and 11 were used. They should be considered gross values, as they do not take into account operational losses.

The impact of two thinning alternatives was considered. The first, which has been used until recently and is illustrated by Fig. 1, involves extraction of trees in a second thinning at age 11. Stocking is reduced from 650 to 250 stems ha^{-1} at top height 12m. The second alternative is a new prescription where the stands are thinned down from 1250 to 250 stems ha^{-1} at age 8 (7 to 8 m top height).

Madgwick *et al.* (1977) give calorific values for components of radiata pine and these were used along with the biomass data to estimate the energy in the harvested material. These values show gross heat of combustion and must be reduced to obtain usable heat values.

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Biomass, Nitrogen and Energy Removed

In the full tree chipping of thinnings over half of the biomass and energy was in the stems but the foliage contained the major share of the N (Figure 2). Total removal is greater when

Table 1 Responses in basal area (m^2 ha^{-1} yr^{-1}) of young radiata pine stands to fertilizers on the Canterbury plains.

Trial	Age at Fert (yrs)	Growth Period (yrs)	N applied (kg ha^{-1}) 100	200	300	400
Eyrewell[1]	7	4				1.11
Balmoral[2]	17	3		0.76		
Balmoral[3]	7	4	0.29	0.35	0.36	
Balmoral[3]	12	4	0.28	0.38	0.35	

1. From Mead, *et al.* (1984). P was applied to control and fertilized plots.
2. From Mead and Gadgil (1978). Response to 112 kg ha^{-1} P + 215 kg ha^{-1} N.
3. From Gordon and Graham (1986).

Table 2 Gross biomass, nitrogen and energy removed with the full tree extraction of 1000 stems ha^{-1} at age 8 or 400 stems ha^{-1} at age 11.

	Stems	Branches*	Foliage	Full tree
Age 8:				
tonnes ha^{-1}	13.3	5.6	5.0	23.9
GJ ha^{-1}	240	110	102	452
N (kg ha^{-1})	32.8	21.1	71.7	125.6
GJ/kg N	7.3	5.2	1.4	
Age 11:				
tonnes ha^{-1}	18.8	7.2	4.3	30.3
GJ ha^{-1}	367	137	88	592
N (kg ha^{-1})	54.5	43.5	79.5	177.5
GJ/kg N	6.7	3.1	1.1	

*Branch data includes cones.

Fig. 1

Full tree harvester chipping 11-year-old *P. radiata* thinnings at Eyrewell Forest (Photo, Neil Woods).

a second thinning is being harvested than for the very heavy thinning at age 8 (Table 2). Biomass, energy and N removed is up by 27, 31 and 41% respectively. This proportionally greater removal of N during the thinning of the older stand is reflected in energy per kg of N values and is a result of higher N concentrations recorded in all tree components in the older stand (Grottker, 1984).

Implications and Alternatives

Full tree harvesting, where 100 to 200 kg/ha N are removed, can be expected to reduce growth on these sites. The low initial N status, the negative impact of windrowing seen on these sites, and the responses obtained to N fertilizer applications support this contention. The amount of N being removed is of the same order of magnitude as a normal clearfelling operation (Madgwick and Webber, 1987).

To replace the N (and other nutrients) with the use of fertilizer is expensive. For example, current costs for applying 100 kg ha^{-1} N is about $200 and the energy involved is about 6.6 GJ. The use of a legume is a possible alternative, although it may increase moisture competition. Certainly the very low stockings proposed for the first thinning would suggest that this should be considered.

If foliage were removed prior to chipping this would halve the impact of the N removal. The reduction in energy removed would be a lot less; 15% in the older stand and 23% in the young stand. Similarly, leaving branches behind would also reduce the impact.

Handifuel Fuel Systems are currently investigating the removal of foliage prior to chipping. Their experience has shown that the foliage, while only a small proportion of the dry matter, makes up 30% by volume. Foliage therefore reduces the operational efficiency through increased haul costs per unit energy removed.

From the harvesting viewpoint, the older stand is to be preferred as the yield per hectare is higher and comes from fewer stems (Table 2). The loss of nutrients however is greater.

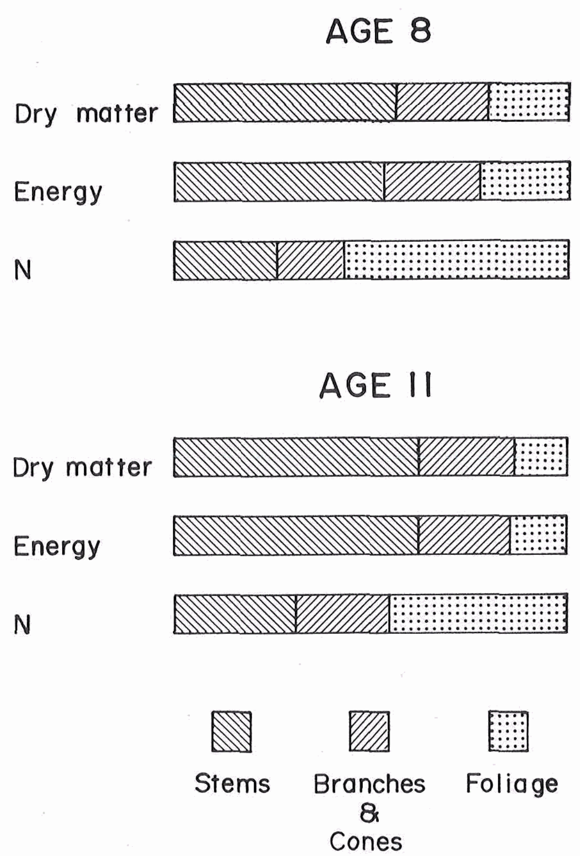

Fig. 2

Relative proportions of biomass, energy and nitrogen contained in the above-ground components of thinnings.

Conclusions

Forest managers need to be aware of the potential negative impacts of full tree harvesting of thinnings. Leaving foliage and preferably also branches behind should be encouraged.

Further investigations are needed to demonstrate the actual loss of productivity with whole tree harvesting. Options to overcome any reduction, including the use of fertilizers and legumes, also need further study.

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