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Effects of removing logging residue for Bioenergy on some potentially available cutover nutrients

Figure 1 - Logging residue on flat terrain - how would harvesting this material for bioenergy fuel affect cutover nutrient pools?

ABSTRACT

In a previous study, average residue volumes left on sites harvested by ground-based logging systems were found to range from 30 m³ per ha to 70 m³ per ha. Individual plot volumes ranged from 1 m³ per hectare to 180 m³ per hectare. Most of the residue volume was composed of unmerchantable stem wood and large branches.

The residue volume results by tree component were used to determine residue composition. The amount of some key nutrients (N, P, K, and Mg) contained in the different residue components were estimated. The amount of nutrients that would be removed if a proportion of the residue was harvested was estimated.

INTRODUCTION

Biomass and nutrients are taken off-site at harvest in the form of merchantable stems. Residues remain on site and at landings that could potentially be removed if required, for example, for use as fuel in bio-energy systems.

The distribution and volume of harvest residues will vary with harvesting system, extraction pattern and crop type (Hall, 1999). Residue accumulated at landings can be easily recovered. The volume and nature of this material has been reported elsewhere (Hall, 1994) but is not discussed in this report. On some sites, the volume of logging residue left at stump is so high (100+ m^3 per ha) that it requires treatment (windrowing for example) to facilitate re-establishment of the next crop.

On hauler cutovers (steep terrain) there is little opportunity to recover residue. Most of the residue is concentrated in the gullies or low points in hauler settings. Recovery of residues from hauler cutover would be very expensive and is therefore of low priority.

Cutover logging residue can be defined as that material which is left at or near the stump when forest harvesting occurs. This material is made up of needles, branches and small sections of stem wood (Figure 1). The stem wood left after harvest as cutover residue is that portion of the stem which is unmerchantable owing to its quality, or it is uneconomic to extract due to its small size. These residues are assumed to have long-term benefits for the nutrient status of the site as nutrients will be released and recycled during the decay process (Kukkola and Malkonen, 1997, Squire et al., 1990).

Residue from cutovers clearfelled by ground based logging systems could be recovered by a number of methods. In areas such as the central North Island where there are large areas of flat to rolling terrain, this residue could represent a significant volume of biomass for use as fuel in bioenergy systems. Removing some or all of this material would further reduce the amount of nutrients potentially available for the next rotation.

The objective of this study was to determine the amount of residue biomass and nutrients that are available for removal from cutovers harvested by ground-based logging systems. Data from previous studies (Hall, 1999) provided information on logging residue volumes and distribution. This data has been extrapolated to estimate the nutrients and biomass volumes that would be removed if a proportion of the residues were to be recovered.

METHODS

The amount of N, P, K and Mg contained in the residues on the cutover was estimated from residue volumes, components and nutrient concentrations.

Logging residue volume, distribution and component data were from a previous study. The proportions of N, P, K and Mg that would be removed if certain components of the total residue were removed during biomass harvesting were calculated.

The harvesting systems which had been used on the different sites were:

A. Conventional ground-based (motor manual fell and delimb at stump; skidder extraction to log processing landing)

B. Whole stem (mechanised fell and delimb at stump; skidder extraction to roadside; load stem lengths on to trucks)
C. Mechanised (mechanised fell and delimb at stump; skidder extraction to log processing landing)

At six cutover sites (two for each of three harvesting systems), the residue was classified into the following categories and measured (Hall, 1996):

- Merchantable stem (> 10 cm small end diameter (SED) and > 1 m length)
- Unmerchantable stem
- Large branches, >50 mm diameter
- Medium branches, 25 to 50 mm diameter
- Small branches, <25 mm diameter
- Needles (number in 1m sub-plot)
- Bark, estimated by variable percentage based on stem and branch components

Data on the nutrient concentrations (kg per m^3) of radiata pine needles, bark, branches and stem wood were derived from Webber and Madgwick (1983).

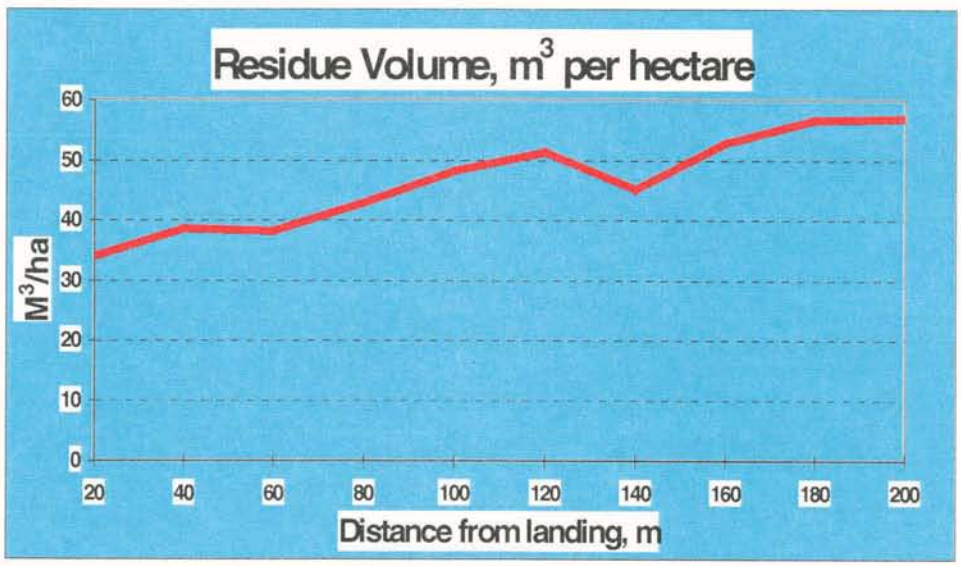
RESULTS

Residue volume and distribution

Total residue volumes varied from plot to plot, ranging from 1 m^3 to 180 m^3 per hectare. These figures do not include the woody residue piled in landing surrounds. Average volumes were:

- 49 m^3 per ha for conventional ground-based systems (A) (s = 15.5)
- 37 m^3 per ha whole stem systems (B) (s = 27.7)
- 67 m^3 per ha mechanised systems (C) (s = 30.1)

Variation in the amount of residue left on site was high. There was a trend for there to be more residue the further the plot was from the landing or road edge (Figure 2).



Residue volume by component

The bulk of the residue was in the unmerchantable stem and large branch classes (Table 1). A substantial proportion of the total residue on all sites was contained in very few pieces (Table 2).

Table 1 - Residue volume by component and harvest system (m^3 per ha)

	Conventional	Whole stem	Mechanised
Total	49.0	37.3	67.3
Merchantable stem	0.25	0.6	0.5
Unmerchantable stem	21.0	14.0	23.5
Large Branch	12.5	8.0	21.7
Medium Branch	7.0	6.5	11.5
Small branch	4.5	4.5	5.5
Needles	0.15	0.1	0.1
Bark	3.6	3.6	4.5

Table 2 - Percent of pieces and percent of volume contained in stem wood and large branches by harvest system

	Conventional	Whole stem	Mechanised
% of pieces	3.0	5.2	2.1
% of Volume	68.8	60.5	74.4

Based on the average volume of residue per hectare and the component nutrient concentrations (Appendix 1), the amount of macro-nutrients (N, P, K and Mg) per hectare in the residue, was estimated (Table 3).

Table 3 - Nutrient content of residue remaining on site following harvesting (kg / ha)

	Conventional	Whole Stem	Mechanised
N	63	47	109
P	10	7	17
K	74	53	126
Mg	17	13	29

If residue were to be recovered, a realistic recovery rate may be 80% of the stem wood and large branches along with 20% of the small branches and needles. In this case, approximately 60% of the total cutover residue volume would be removed. It was estimated from this that 40% to 50% of the N, P, K, and Mg content of the residue would remain on site (Table 4). On average, for all four elements, just over 70% of these nutrients estimated to be in the stand prior to harvest is removed in the harvest of merchantable logs.

Table 4 - Percent of nutrients in residues left on the cutover if; 80% of stem wood, large branches and bark, and 20% of small branches and needles were removed.

	Conventional	Whole Stem	Mechanised
N	42 %	45 %	40 %
P	43 %	48 %	40 %
K	41 %	42 %	39 %
Mg	41 %	45 %	40 %

DISCUSSION

For ground-based harvested sites collection of the cutover residue would be possible, although not all of the residue could or should be harvested. From a purely economic standpoint, residue harvesting should concentrate on the larger piece size material, as do conventional logging systems (McMahon et al., 1998; McMahon 1999).

CONCLUSIONS

The majority (60% to 70%) of the volume of residue was in the stem wood and large branches greater than 50 mm diameter. It is this component that should be the focus of any residue recovery operation.

If residue recovery occurred and focused on removing the larger material (80% of stem wood and large branches and 20% of small branches and needles), 40% to 50% of the N, P, K and Mg contained in the residue would be left on the site, in the small branches and needles.

Whether residue harvesting, as described above, will impact significantly on the growth of subsequent crops will depend on the soil fertility of individual sites.

REFERENCES

Hall P. (1994): Waste wood at logging landings. LIRO Report, Vol. 19, No. 15.

Hall P (1996): Cutover waste assessment - A Comparison of Sampling Techniques and Intensities. LIRO Project Report, P. R. - 60.

Hall P. (1999): Logging Residue Distribution. Liro Report, Vol. 24, No. 9.

Kukkola M., and Malkonen E. (1997): The role of logging residues in site productivity after first thinning of Scots pine and Norway spruce stands. In: Forest management for bioenergy. The Finnish Forest Research Institute. Research Papers 640. Vantaa 1997

McMahon S., Evanson T., Hall P., and Baillie B. (1998): Cable extraction of pulp: Effect of minimum extracted piece size on productivity. Liro Report, Vol. 23 No. 14.
McMahon S. (1999): Evaluation of pulp top piece extraction in ground based operations. Liro Report Vol. 24, No. 15.

Squire R. O., Finn D. W., and Campbell R. G. (1990): Silvicultural research for sustained wood production and biosphere conservation in the pine plantations and native eucalypt forests of southeastern Australia. In: Long term field trials to assess environmental impacts of harvesting. Proceedings, IEA/BE Workshop, Florida, Feb 1990. (Eds) W. J. Dyck and C. A. Mees. IEA/BE T6/A6 Report 5. Forest Research Institute, Rotorua New Zealand, FRI Bulletin 161, 1991, pp151-161.

Webber B. and Madgwick H. A. I. (1983): Biomass and nutrient content of a 29 year old Pinus Radiata stand. New Zealand Journal of Forestry Science. Vol. 13(2): pp 222-228

Appendix 1.

Component nutrient concentrations (kg of element per oven dry tonne of biomass)

	N	P	K	Mg
Foliage	14.2	2.0	9.9	1.3
Branches	2.04	0.33	2.3	0.55
Stemwood	0.44	0.07	0.58	0.15
Bark	2.1	0.23	2.8	0.45