Fire Management Branch
Department of Conservation & Environment

FUEL MANAGEMENT IN RADIATA PINE FOLLOWING HEAVY FIRST THINNING

RESEARCH REPORT NO. 24
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MARCH 1985

Originally printed as Fire Protection Branch Research Report No. 24, Department of Conservation, Forests and Lands.

INTRODUCTION

Approximately 900 hectares of the Department's radiata pine (*Pinus radiata*) plantations in North-East Victoria are being thinned for the first time each year. About 75% of this area is thinned using mechanical techniques(1) to reduce stocking rates (stems/ha) by as much as 70%-80%. This very heavy thinning regime has been implemented because many areas are now well behind the normal thinning schedule.

The quantities of slash fuels left after the type of mechanical thinning operation used in the North-East are very high. The slash is also unevenly distributed and it constitutes a considerable additional fire hazard.

Low-intensity fire has been shown, in some circumstances, to be an option for managing plantation fuels (Billing, 1979, 1980; Woodman and Rawson, 1982), and the possibility of using fire in these heavily-thinned areas is discussed in this report. Mechanical methods can also be used to modify fuel properties and the results of a trial using a National Hydro-Ax are presented.

FUEL DESCRIPTION

Fuel properties were assessed in a 17 year old stand which had been thinned from 1500 stems/ha to 280 stems/ha. Three strata (1 = slash heaps, 2 = extraction rows, 3 = undisturbed bays) were defined and estimated to cover 30%, 40% and 30% respectively of the total area. The fuel loads within each stratum were assessed using the following techniques.

1 Fine Fuels (< 6 mm diameter).

   Five 0.5 sq.m plots spaced at 2 m intervals along a 10 m transect were located within each stratum. The fine fuels were collected from each plot and the weight determined after oven-drying at 105 C.

2 Heavy Fuels (≥ 6 mm diameter)

   The line intercept method (Van Wagner, 1965) was used, with fuels measured on 5 x 1 m transects located in each stratum.

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1 The mechanical thinning operation in North-East Victoria uses the Kockums system, comprising a feller-buncher, a tree processor and a forwarder. Stands are marked with extraction rows 12-15 m apart and intervening bays are thinned from below to approximately final crop spacing. A second operation is sometimes required within 12 months to salvage windthrown trees.

The fuel quantities estimated for each stratum are given in Table 1.

Table 1: Fuel quantities (t/ha) following machine thinning

	Fuel diameter (cm)							
Stratum	<0.6	0.6-0.9	1-1.9	2-2.9	3-4.9	5-6.9	7+	Total
1	29.4	11.6	12.7	36.6	13.7	14.0	87.7	205.7
2	21.0	5.8	6.6	6.1	0	0	0	39.5
3	11.8	5.5	0.4	0	0	0	0	17.7

The total quantity of fuel on the site was therefore 82.8 t/ha, comprising 20.8 t/ha of fine fuel and 62.0 t/ha of heavy fuel. These quantities are far greater than can be expected after more conventional first thinning operations. Williams (1978) found that after:

1 third row outrow, and
2 sixth row outrow with bay thinning

operations in 12 year old stands near Myrtleford, the total fuel quantities on the plantation floor were 45.8 t/ha and 48.2 t/ha respectively.

The very uneven distribution of the fuel resulting from machine thinning is indicated by the fact that 75% of the 82.8 t/ha was located on 30% of the area.

FUEL MANAGEMENT

Fuel-reduction burning

The feasibility of undertaking fuel-reduction burning in the high fuel quantities described above was tested at three sites. The sites were similar in all respects except for the time since thinning. Burning was conducted at Sites 1, 2 and 3 18 months, 13 months and 3 months after thinning respectively. At Site 3 50% of the needles on the slash were still green at the time of burning.

The range of conditions experienced at each Site during burning operations is summarised in Table 2. Full details are given in Appendix 1.

Table 2 Burning conditions

Site	DI*	Temp (°C)	RH (%)	Wind Speed (km/h)	Fuel moisture content (%) Elevated	Fuel moisture content (%) Surface
1	20	13-15	54-74	0.9-2.1	14-16	28-32
2	4	19-21	39-53	1.3	14	30
3	26	15-17	47-50	1.9	14**	19

* The Keetch-Byram Drought Index in points.
** The moisture content of fully cured needles only

Fires burnt readily within fuel heaps under the conditions experienced at all Sites, although on Sites 1 and 2 the surface fuel moisture contents were too high to allow ready spread between heaps. Billing (1979) achieved 100% removal of the elevated fine fuel from slash resulting from lighter on-schedule first thinning. However, the very high fuel quantities and relatively dense packing of fine fuel within the heaps made it difficult to achieve a similar result in the fuel type studied here. At Sites 1 and 2 it was estimated the fires removed 30% of the elevated fine fuel and insignificant amounts of the surface fuel. At Site 3 80% of the elevated fine fuel and 30% of the elevated coarse fuels were estimated to have been removed.

Flame heights averaged one metre and extended to three metres on occasions. In the 18 year old stands concerned the tree crowns were not scorched although some tree boles were damaged. Resin from scars caused by utilisation readily caught fire and as a consequence the damage was extended. The fuel distribution meant that some trees were subjected to flame heights of one metre or greater for periods in excess of four minutes. These trees have since exhibited splits in the bark and resin exudation from bark furrows, and at Site 3 a survey showed 10% of trees to be in this condition.

The conditions under which burning was conducted were generally in accord with those prescribed for burning slash from first-thinning operations (Woodman and Rawson, 1982). However, the results indicate that, in the fuel type created by the mechanical thinning technique used in North-East Victoria, it will be difficult to achieve significant reductions in fine fuel without causing damage to the retained high-value trees.

Mechanical treatment (Hydro-Ax)

The Hydro-Ax 400 Series uses an articulated four-wheel drive prime-mover and in this trial it was equipped with a front-mounted Rotary-Ax slasher (Figures 1 and 2). The blade angle of the slasher tends to shatter rather than cut material across a 2.3 m swathe. Similar units are used in the plantations of South-East South Australia and South-West Victoria in the control of natural regeneration and treatment of slash from clear felling.

The machine was trialled in a 17-year old site quality 1 stand which had been thinned from 1500 stems/ha to 300 stems/ha four months previously, with most wood down to 10 cm diameter being removed from the site. The ground slope was generally less than 10°.

Figure 1 The National Hydro-Ax

Figure 2 The Rotary-Ax Slasher

Dense heaps of slash and poor access into bays inhibited machine movement and it was quickly determined that the only way to operate within the thinned stand was to use the extraction row for main access and then drive into bays, lower the Rotary-Ax onto individual slash heaps, back out into the extraction row and continue to the next heap.

To evaluate the impact of the Hydro-Ax on fuel distribution the height, cover and density of fine fuels were assessed before and after treatment. This assessment was conducted after locating twelve 9 metre transects across the bays, parallel to extraction rows. At one metre intervals along each transect, the height and cover (as a % of 0.1 sq.m) of fine thinning slash fuel, were estimated. Twelve percent of these points were destructively sampled to determine relationships between height, cover and the bulk density of fine fuel before and after treatment, and the relationships used to estimate bulk density for the other points. Each point (except those previously sampled for bulk density) was remeasured following treatment with the Hydro-Ax.

Table 3 describes the changes in average height, cover percent and density of fine slash fuels after treatment with the Hydro-Ax.

Table 3 Effects of treatment with Hydro-Ax

	Average pre-treatment	Average post-treatment	Significance
Height (m)	0.26	0.06	**
Cover (%)	24.83	62.63	**
Bulk density (kg/m3)	2.00	3.17	

** significant at p=0.01 (Freese 1967)

The impact of the treatment on fuel properties is illustrated in Figures 3 and 4.

Burrows (1980) found that treatment of 7 month old first thinning slash with a Holt bladed scrub roller gave a 216% increase in slash bulk density and 210% decrease in slash height. Test fires conducted under mild conditions demonstrated a reduction in spread rate of 50% and flame height of 75% following rolling and concluded that this was due to reductions in height and increases in density of fine fuel. The changes in fuel properties brought about by the Hydro-Ax are likely to have a similar effect on the potential for fires to spread quickly. An additional benefit, as shown in Figure 4, is improved access for fire suppression operations.

Figure 3 Fuel distribution before slashing

Figure 4 Fuel distribution after slashing

Treatment of an area with the Hydro-Ax is slow and therefore costly. During this trial the machine output was 0.35 ha/h at an overall cost of $230/ha. Even allowing for improved efficiency with more operational experience, use of the Hydro-Ax does not appear to be a viable technique for managing the fuel problem created in heavily-thinned stands.

CONCLUSION

Neither treatment with the Hydro-Ax nor burning following the heavy thinning used in North-East Victoria appear to be suitable methods for dealing with the hazard that is created. The Hydro-Ax is slow and costly while burning is likely to cause unacceptable levels of stem damage in the high-value trees which remain.

Fuel-reduction burning in radiata pine plantations is a cheap and effective fire protection practice in many circumstances. In the North-East plantations utilisation methods may need to be modified in strategic areas to allow effective fuel management using fire to take place.

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Appendix 1 - Burning Conditions

Site 1 Burnt 13/9/84, 1230-1430 hours
18 year old P. radiata, thinned March 1983

Area: 50m x 100m

Weather: Drought Index = 20
1 day since 10.8 mm of rain

Time	T (°C)	RH (%)	Wind (km/h)	Fuel moisture (%) elevated	surface
1120	12.5	74	0.9	16.3	32
1220	13.0	59	0.6	15.8	28
1420	15.0	54	2.1	13.6	28

Fire behaviour: Flame height to 3 metres (average 1 m)
Fire residence time at selected trees: to 5 mins. (recent wound caught fire) average 3 mins.

Site 2 Burnt 5/10/84, 1130-1300 hours
18 year old P. radiata, thinned September 1983

Area: 100m x 100m

Weather: Drought Index = 4
2 days since 41.8 mm of rain

Time	T (°C)	RH (%)	Wind (km/h)	Fuel moisture (%) elevated	surface
1100	19	53	-		
1130	20	51	-		
1200	21	40	-	14	30
1230	20	39	1.3		

Fire behaviour: Flame height to 3 metres (average 1 m)
Fire residence time: to 3 mins. (average 1 min.).

Site 3 Burnt 11/10/84, 0900-1000 hours
19 year old P. radiata, thinned June 1984

Area: Three 20m x 20m plots

Weather: Drought Index = 26
1 day since 1.4 mm of rain

Time	T (°C)	RH (%)	Wind (km/h)	Fuel moisture (%) elevated	surface
0900	15	50	-		
0930	16	50	-	14	19
1000	17	47	1.9		

Fire behaviour: Flame height to 3 metres (average 1 m)
Fire residence time to 10 mins. (average 5 mins.).