Fire Management Branch
Department of Conservation & Environment

LOW INTENSITY PRESCRIBED BURNING IN THREE PINUS RADIATA STAND TYPES

RESEARCH REPORT NO. 2
D S THOMSON
FEBRUARY 1978

Originally printed as Fire Research Branch Report No. 2, Forests Commission, Victoria
Ackowledgements: The assistance of Mr D Williams and Mr H Caldwell, District Forester, Myrtleford, is gratefully acknowledged.

FOREWORD

This report is based upon work by D S Thomson presented in a thesis submitted for the Diploma of Forestry, Victoria.

The results are being distributed to field staff as an indication of the conditions under which low intensity prescribed burning in *Pinus radiata* plantations has been successfully carried out.

It should be noted that the prescriptions contained in this report are specific to the areas studied, and that they have not yet been tested operationally on a broad acre basis.

However, the importance of fuel management in softwood plantations needs to be recognised, if more effective protection is to be achieved, and District Foresters should carefully consider whether the prescriptions may be applicable in plantation areas under their control.

At this stage, broad area fuel reduction burning within plantations is not to be undertaken. Where it is desired to use the technique to create fuel reduced strips and increase the effectiveness of existing roads and firebreaks in controlling wildfire, the District Forester is to consult with the Fire Research Officer before burning commences.

V P CLEARY
Chief Division of Forest Protection

INTRODUCTION

This report presents the results of experimental low intensity prescribed burning in three *Pinus radiata* stand types at Myrtleford.

Based upon this work, operational aspects of fuel reduction burning in *P radiata* are considered.

The aims of the study were:

1 To develop prescriptions for the use of low intensity fire for fuel reduction in the three stand types examined.

2 To define any short term damage sustained as a result of prescribed burning.

Experimental burning was conducted from September to November 1976.

STUDY AREAS

The location of each stand is shown in Figure 1.

1 Stand Description

(a) Carrolls Road
1960 second rotation planting on gently sloping ground, unthinned and pruned to three metres two years before burning, with a small quantity of residual hardwood.

(b) Rinaldis
1965 first rotation planting on gently sloping ground, unthinned and recently pruned to three metres, with residual hardwood in windrows.

(c) Walkers Spur
1950 planting on steep ground, selectively pruned to three metres at an early age. The stand has had at least two thinnings with the last, in 1972, being sixth row outrow, with selection thinning in retained rows. A large quantity of residual hardwood is present on the site.

Table 1 gives the stand characteristics for each area.

SUMMARY

A study of low intensity fire behaviour was undertaken in three *Pinus radiata* stand types at Myrtleford. Stand ages were 11, 16 and 26 years.

Prescriptions for the conduct of low intensity fuel reduction burning were formulated for each stand.

An assessment three months after burning indicated that damage caused by the experimental fires was very slight.

The application of the prescriptions to operational fuel reduction burning within *P. radiata* plantations is discussed.

TABLE 1 - STAND CHARACTERISTICS

Location	Age	Site* Index	Top Ht. (m)	Basal Area (m^2/ha)	Stem No. /ha	Volume** (m^3/ha)
Carrolls Road	16	24.0	20.5	36.4	1131	214.5
Rinaldis	11	25.8	16.0	30.8	1633	141.3
Walkers Spur	26	30.8	36.3	35.9	396	390.7

* Projected stand height (m) at age 20

** Assessed volume to 10 cm small end diameter

2 Stand Fuel Properties

Estimated fuel quantities for each stand type are given in Table 2.

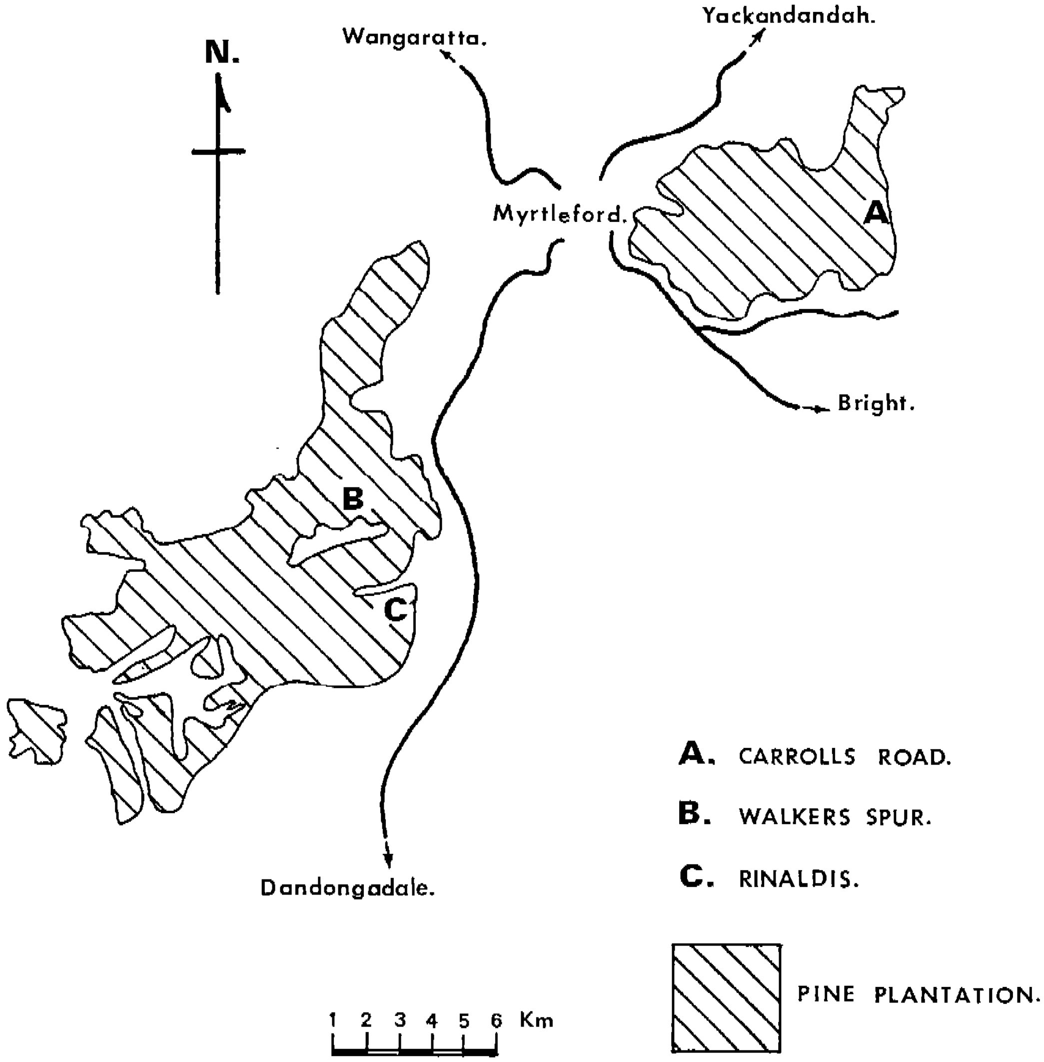
TABLE 2 - FUEL QUANTITIES (TONNE/HA - OVEN DRIED WEIGHT)

Location	Fine fuels	Medium fuels	Coarse fuels		Duff
			Hardwood	Softwood	
Carrolls road	6.85	1.98	18.41	0.35	7.24
Rinaldis	6.90	2.04	109.77	0.32	2.74
Walkers spur	5.71	4.49	93.85	9.09	2.80

The definition of fuel types is as follows:

- Fine fuels - <6 mm diameter
- Medium fuels - 6-23 mm diameter
- Coarse fuels - >24 mm diameter
- Duff - the layer of decomposing litter and slash between surface fuels and mineral soil

FIGURE 1 : LOCATION OF STUDY AREAS



METHOD

1 Experimental Burning

Initial trials were conducted on 30 m x 30 m and 15 m x 15 m plots. Under the mild burning conditions prescribed, the smaller plot size was found to be sufficient for the fire to reach a steady rate of spread, and was used for most of the 96 fires on which data were collected.

All fires were lit and allowed to develop from a single ignition point.

The following data were collected during each fire:

- Fine fuel moisture content (as a percent of oven dry weight) was measured at thirty minute intervals throughout each burning period, using a Speedy moisture meter.
- Temperature and relative humidity were recorded at the same intervals.
- Successive one minute records of wind speed were taken throughout each burning period. A sensitive cup anemometer was located 0.7 metres above ground level, outside the influence of wind movement created by the fire.
- The perimeter of each fire was marked at given intervals, and the spread for each period calculated.
- Maximum flame heights were estimated for each spread period.
- Maximum slope was recorded for each plot.
- The Fine Fuel Flammability Index (F.F.F.I.), described by Williams and Dexter (1976) was calculated for each burning day.
- After each fire an assessment was made of the fuel quantity

removed. This was used, together with the maximum rate of spread, to calculate the maximum fire intensity using Byram's (1959) equation.

The recent pruning at Rinaldis resulted in much of the fine fuel being elevated and well aerated. The fuel moisture records taken were for this elevated fuel. In the other two areas, moisture records were taken for the surface fine fuels.

2 Damage Assessment

An assessment of damage in each stand was carried out at least three months after burning.

Plots burnt with a range of intensities were selected on which to examine damage to crop trees.

The following data were collected on 470 trees. Observations were taken at four points around each tree : the uphill side, downhill side and both flanks.

- Cambial damage was assessed at a height of 30 cm above ground level. On each side of the stem, wads of bark and cambium were removed and the cambium assessed as living or dead.

- The height of bark scorch or charring was recorded for each tree.

- The height of crown scorch above pruned level, or above the first green limbs, was estimated for each side of each tree.

- The height of any fire scar was recorded.

- Any abnormal resin exudation judged to be fire induced was noted.

RESULTS

1 Fire Behaviour

Data for the period of maximum rate of spread of headfire and backfire are listed in Table 3.

TABLE 3 - EXPERIMENTAL FIRE DATA FOR THE PERIOD OF MAXIMUM RATE OF SPREAD FOR HEADFIRES AND BACKFIRES.

Variable	Carrolls Road		Rinaldis		Walkers Spur	
	Headfire Av./Range	Backfire Av./Range	Headfire Av./Range	Backfire Av./range	Headfire Av./Range	Backfire Av./Range
No. of experimental fires	27	23	26	37	11	16
Rate of spread (m/min)	0.56 0.26-1.00	0.21 0.12-0.42	0.72 0.32-1.72	0.31 0.16-0.62	0.75 0.27-1.4	0.25 0.14-0.52
Wind speed (m/sec)	0.63 0.0-1.41	0.57 0.0-1.41	0.82 0.0-1.65	0.85 0.0-1.89	0.77 0.0-1.44	0.80 0.05-1.65
Slope (degrees)	5 5-6	5 5-6	6 4-10	6 4-10	17 14-20	17 12-20
Ground surface fine fuel moisture content (% O.D.wt.)	14.5 11.9-18.9	14.8 11.9-18.9	NA NA	NA NA	17.3 15.8-18.6	15.9 12.2-18.5
Elevated fine fuel moisture content (% O.D.wt.)	NA NA	NA NA	16.8 13.2-21.8	15.3 11.0-22.2	NA NA	NA NA
Relative humidity	40 25-72	40 25-72	59 39-83	55 39-83	39 30-52	36 29-55
Temperature (^{o}C)	19 14-22	19 14-22	16 11-24	18 13-24	18 17-21	19 16-22
Quantity of fine fuel consumed (t/ha)	5.50 4.37-6.30	5.60 4.27-6.30	5.45 4.45-6.33	5.81 4.45-6.49	4.74 4.03-5.35	4.96 4.03-5.61
Fire intensity (kW/m)	97 42-195	37 18-75	121 51-272	56 28-109	111 39-232	39 20-75
Drought Index	47 10-97	47 10-97	35 16-53	35 16-53	22 11-39	22 11-39
Fine fuel flammability index	6.8 5.5-9.4	6.8 5.5-9.4	8.9 4.3-11.5	8.9 4.3-11.5	15.1 8.0-19.0	15.1 8.0-19.0

Table 4 gives the fuel reduction burning prescriptions formulated from data presented in Table 3. The prescriptions are more conservative than required by a strict analysis of the data.

TABLE 4 - BURNING PRESCRIPTIONS FOR THE THREE STAND TYPES

Locality	F.F.F.I.*	D.I.**	Fine fuel moisture content (% O.D.wt)	Wind speed (m/sec)	Slope	Comments
Carrolls Road	>6	<100	Ground surface fine fuels >14% for head fires >12% for backfires above 20% sustained burning is difficult.	1 m/sec. - maximum sustained wind speed. Up to 2 m/sec. allowable for a few seconds. No wind at low fine fuel moisture contents when using headfire. Some wind usually required at high fine fuel moisture contents.	Little influence but generally controls the head fire direction.	Headfire rate of spread should generally not exceed 1 m/min. Fire intensity under the prescribed burning conditions will usually not exceed 200 kW/m. Duff should be noticeably damp.
Rinaldis	>6	<50	Elevated and aerated fine fuels >15% for headfires >12% for backfires above 22% sustained burning is difficult.	As for Carrolls Road.	As for Carrolls Road.	As for Carrolls Road.
Walkers Spur	>10	<30	Ground surface fine fuels >16% for headfires >12% for backfires above 20% sustained burning is difficult.	Not to exceed 1 m/sec.	Headfire run not to exceed 6 m.	As for Carrolls Road.

* F.F.F.I. - Fine fuel flammability index

** D.I. - Drought index

2 Short Term Damage

Three months after burning, detectable physiological damage that could be associated with bark scorch or charring was minimal.

Of the 470 trees assessed, cambial death was recorded on one side of two trees, and on two sides of one tree.

Abnormal resin exudation was detected on two of the trees assessed.

All assessed crown scorch was at Rinaldis, the youngest stand in which burning was conducted. Scorch was evident on ten trees to two metres above the first green limb, and on one tree to four metres above the first green limb.

There were no fire scars found on any of the assessed trees, although there were rare instances of scars, on trees not included in the survey, at Walkers Spur. These scars were associated with the ignition of larger fuels near the bases of trees.

It was apparent from an examination of the stand at Walkers Spur, that low intensity prescribed fire can extend butt damage caused during logging operations.

DISCUSSION OF RESULTS

The prescriptions developed for each stand are more conservative than a strict analysis of the data shown in Table 3 would allow. This approach is justifiable in terms of increased control over fire behaviour and therefore fire caused damage in a sensitive species. The conditions prescribed will still allow satisfactory reduction of fine fuels.

All fires were conducted with a significant moisture differential between the surface fine fuels and the duff layer. At moisture contents greater than 28% the duff layer should not ignite (Dexter and Collier, 1975). The duff moisture content was in most instances greater than 40%, and at times so high that gentle squeezing of the duff would release water. Although the Speedy moisture meter in general field use is calibrated to estimate the moisture content of less than one year old needle fuel, it can still be used if there is some doubt as to the moisture status of the duff layer. Fires lit under conditions where the duff layer will burn are likely to cause control problems and increased stem damage.

The drought index developed by Byram and Keetch (1968) is used in Victoria to provide an indication of seasonal dryness and therefore, to some extent, the relative moisture levels of the larger fuel sizes. It is desirable that the medium and coarse fuels do not ignite during fuel reduction. As with fires allowed to burn in the duff layer, unacceptable control and damage problems are likely to occur if the larger fuels ignite and continue to burn. On only one day , at Walkers Spur, did substantial quantities of medium and coarse fuels ignite. The drought index was 39, and the reason for ignition may have been the very weathered condition of the fuels.

The importance of wind speed in the prescription should not be underestimated. Although wind speeds within the three stands did on occasions exceed 1 m/sec. when burning, the increased speed could not be tolerated for more than a few seconds without a marked and unacceptable increase in fire intensity.

Slope has not been included as a separate variable in the prescriptions. Its effect is reflected in the prescription for Walkers Spur where a higher fuel moisture content is prescribed for surface fuels, and limitations are placed on the length of head fire run.

The prescriptions are based on the development of spot fires lit from a single ignition point. It is well recognised that at the junction zone of two fires an increase in fire intensity occurs. Any lighting technique used operationally should take account of this fact, and the increased stand damage likely to result if intensities are too high. Similar alterations to fire intensity may occur if lines of fire are used to ignite an area.

Nicholls and Cheney (1974) concluded that a prescription for burning *P radiata* would need to specify a fire intensity less than 200 kW/m if stand damage was to be avoided. Some experimental fires at Walkers Spur and Rinaldis exceeded 200 kW/m but not 300 kW/m. The short term damage to the stands was very slight. Long term increment and growth study plots have been established to prove the validity of the results apparent in the short term.

THE APPLICATION OF FUEL REDUCTION BURNING IN SOFTWOOD PLANTATIONS

Plantation extension programs have resulted in large continuous areas, with protection relying largely on fuel reduction within surrounding eucalypt forest, and the construction and maintenance of good internal access.

Fuel management using low intensity prescribed fire is accepted as a necessary protection measure in eucalypt forests. The principle of fuel management applies equally to softwood plantations. The results described above indicate that low intensity prescribed fire can be used to manage fuel properties in *P radiata* plantations.

The fine control of fire behaviour required makes it undesirable, at this stage of our knowledge, to attempt to fuel reduce broad areas, or fuel reduce in young stands that have not been low pruned. Rather, fuel reduction of narrow strips along strategically located access routes and boundaries, to which the greatest hazard is likely to occur, should form the basis of burning plans. Low pruning will form part of the planning if the stands envisaged for burning are young and still maintain a continuous vertical distribution of fuel. Ideally, pruning of such areas would be carried out in autumn, with fuel reduction the following spring.

The moisture content of fine fuels changes very rapidly in response to changes in atmospheric temperature and relative humidity. The vital role of fuel moisture in determining fire behaviour makes it essential that moisture content is determined frequently during the burning period. The Speedy moisture meter can quickly and accurately monitor fuel moisture and must be used at all times.

Wind speed has been shown to be of major importance in determining whether acceptable fire intensities are achieved. Continuous monitoring of wind speed within the stand should also be conducted during the burning period.

The area alight at any given time should be of a size that can be readily extinguished in the event of a sudden deterioration in burning conditions.

CONCLUSION

Studies at Myrtleford have shown fuel reduction burning under young *P radiata* plantations is possible under carefully prescribed conditions, particularly of fuel moisture and wind speed.

Although not tested operationally, it is considered the prescriptions form a sound basis on which operations can be formulated.

* * * * * * * * *

ACKNOWLEDGEMENTS

The assistance of Mr D Williams and Mr H Caldwell, District Forester, Myrtleford, is gratefully acknowledged.

BIBLIOGRAPHY

BYRAM G.M. 1959 Combustion of Forest Fuels. In Forest Fire : Control and Use K.P. Davis, McGraw Hill, N.Y. Chapter 3.

BYRAM G.M. and KEETCH J.J. 1968 - A Drought Index for Forest Fire Control U.S. For. Serv. Res. Pap. SE-38.

NICHOLLS J.W.P. and CHENEY N.P. 1974 - Effect of Experimental and Wildfires in Pine Plantations on Wood Characteristics. Aust. For. 36(3) : 164-177

WILLIAMS D.F. and DEXTER B.D. 1976 - An Index for Fine Fuel Flammability Forests Commission Victoria. For. Tech. Pap. No 24.