Fire Management Branch
Department of Conservation & Environment

FUEL PROPERTIES BEFORE AND AFTER SECOND THINNING IN RADIATA PINE

RESEARCH REPORT NO. 17
M WOODMAN
OCTOBER 1982

Originally printed as Fire Research Branch Report No. 17, Forests Commission, Victoria

SUMMARY

Williams (1978) studied fuel properties before and after first thinning in a 12 year old stand of radiata pine. This study extends that work by examining the same sites when the stand age reached 18 years. Changes in fuel properties have been assessed for stands which remained unthinned or first thinned, and for stands which were second thinned at 18 years.

INTRODUCTION

In 1975 Williams (1978) studied the effects on fuel distribution of first thinning in a 12 year old stand of radiata pine (*Pinus radiata*, D Don) near Myrtleford. In October 1981 a section of this same stand, now 18 years old, was thinned for a second time, while an adjacent section remained unthinned. This provided an opportunity to examine the differences in fuel properties caused by the different treatments applied in the three sections of the stand.

METHOD

This study was conducted in December 1981 and the characteristics of each area at this time are shown in Table 1, with their diameter distributions illustrated in Figure 1.

TABLE 1: STAND DETAILS

Stand	Stocking (stems/ha)			Basal Area	Top Height
	Live	Dead	Total	(m^2/ha)	(m)
Unthinned	1005	344	1349	43.2	29.7
*First thinned	716	22	738	37.2	29.8
**Second thinned	390	-	390	27.8	29.6

* *Sixth-row outrow with selection thinning in bays at age 12 (1975).*

** *First thinned as above plus selection thinning at age 18 years (1981).*

1 Tree fuels

A technique relying heavily upon regression analysis and previously employed by Stewart and Flinn (1981) was used to estimate the quantity and distribution of tree fuel components.

Five sample trees were felled in each of the unthinned and first-thinned stands. The ranges of tree diameter (dbhob) within each stand were divided into five equal classes and one tree selected to represent each class. Selection was random except that trees with major defects were excluded.

After felling the tree height, diameter at one metre intervals along the stem, height to the base of the green crown and the height above ground and diameter (measured 2 cm from the main stem) of all branches were recorded. Five sections cut from the stem of each tree were used to determine the wood density (388 kg/m^3)

which was then used to convert stem volume to weight.

To estimate the weight of branchwood and needle fuel in each sample tree a sub-sample of branch material was used to derive equations relating branch diameter to fuel weight. The sub-sample was selected to cover the range of height above ground and branch diameter combinations found during tree measurement. The regression relating branch diameter to the quantity of dead needle fuel was not significant, and an equation developed by Stewart and Flinn (1981) was used, together with the other equations derived and the complete information on branch diameters collected earlier, to estimate the weights of branchwood and needle fuels in each sample tree. The estimated weights of all fuel components in each of the sample trees are shown in Appendix 1.

To determine the vertical distribution of tree fuels each sample tree was divided into five sections of equal length, and the weights of live and dead needles and branches in each section calculated using the branch diameter data.

The study area also contained some dead trees and ten selected from the unthinned stand were felled and the needles collected from the crown and weighed after oven-drying. Branch and stem weights were calculated by first using the regressions derived from the live sample tree data and then correcting for the wood density of 359 kg/m^3 calculated for the dead trees.

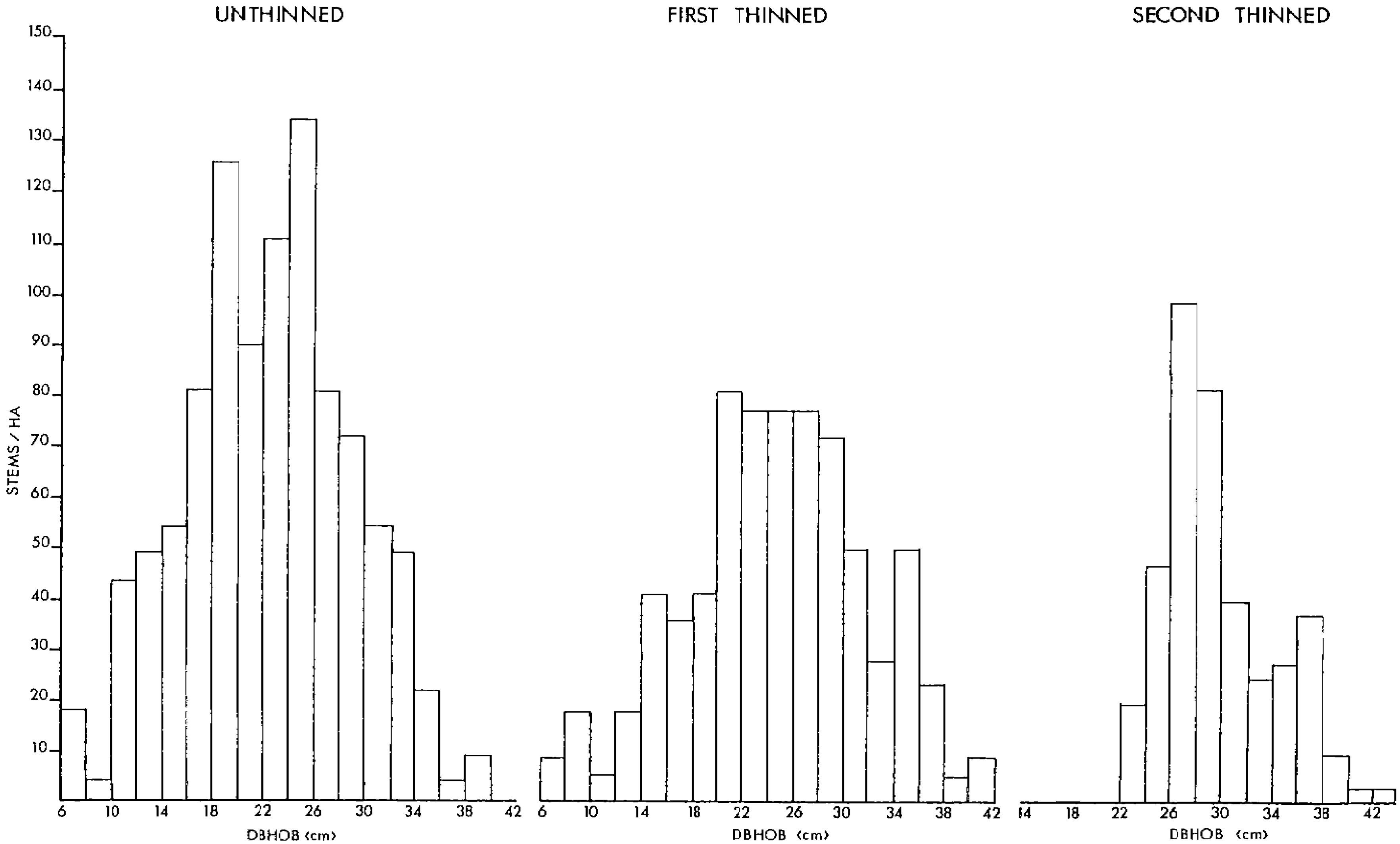
From these sample tree data further equations were derived which related the weights of each fuel component to dbhob. These equations were then used together with the known diameter distributions to estimate the total weights of tree fuel components in each of the three stands.

All regressions used are shown in Appendix 2.

2 Ground fuels

Ground fuel quantities in the unthinned and first thinned stands were estimated from thirty-five 0.33 m^2 fuel samples collected from each stand. Each sample was separated into living fuel, litter (dead fine fuel $<$ 6 mm diameter) duff (fuel fully decomposed

FIGURE 1 DIAMETER DISTRIBUTIONS AT 18 YEARS



or in an advanced state of decomposition) and medium fuel (diameter between 6 and 25 mm). The quantity of fuel with a diameter greater than 25 mm remaining from the first thinning was estimated using a line intersect technique (Van Wagner, 1968). Fourteen randomly located 40 m transects were used to estimate fuel volume which was then converted to weight using a wood density of 250 kg/m^3 obtained from samples cut from the old slash.

In the second thinned stand fuel weights added to the ground following thinning were estimated using the regression equations described earlier in conjunction with the known diameter distribution of trees removed during thinning.

RESULTS AND DISCUSSION

1 Tree fuels

A comparison of the quantities of tree fuel components in the unthinned and first thinned stands at age 12 and 18 is shown in Table 2. At age 12 there was 32.5 t/ha less fuel in the trees of the thinned stand and at age 18 years this difference had increased to 45.5 t/ha. However, the foliage fuel component will have the greatest influence on fire behaviour and although immediately following first thinning at age 12 there was 4.4 t/ha less foliage in the thinned stand, this difference had decreased to 1.2 t/ha by age 18.

TABLE 2: TREE FUEL QUANTITIES (T/HA) AT AGES 12 AND 18 YEARS

Fuel Component	Age 12 *		Age 18	
	Unthinned	First Thinned	Unthinned	First Thinned
Foliage - living	7.7	5.2	8.5	7.8
- dead	2.4	0.5	1.2	0.7
Branchwood - living	12.6	8.8	17.9	16.8
- dead	7.7	5.0	18.6	13.4
Stemwood - living	85.1	63.5	217.9	195.4
- dead	-	-	16.6	1.1
TOTALS:	115.5	83.0	280.7	235.2

* *from Williams (1978)*

The vertical distribution of fuel changes as the stand ages and Table 3 shows the crown fuel distributions for trees of mean diameter in the unthinned stand at age 12 and the unthinned and first thinned stands at age 18. The definition of crown fuel at each age is slightly different. Williams (1978) defined crown fuel to include branchwood, foliage and non-merchantable stemwood, while in this study only branchwood and foliage were included. This discrepancy does not have a major effect on the comparisons made below because the addition of non-merchantable stemwood only affects fuel distribution in the highest levels of the tree. Table 3 clearly shows that greater crown fuel concentrations exist in the lower levels of trees within the 12 year old stand. At this age the highest fuel concentration occurs between approximately 7-11 m. At 18 years the fuel distribution in trees within the unthinned and first thinned stands is very similar with the highest concentration occurring between approximately 16-22 m. These differences in fuel distribution, combined with an average green level of 10 m, mean that the level of hazard created by the crown fuels is much reduced at age 18 even if the stand has not received a first thinning.

2 Ground fuels

The ground fuel quantities in each of the unthinned and first thinned stands at ages 12 and 18 are shown in Table 4. Six years after first thinning the ground fuel quantity in the thinned stand has decreased by 13.0 t/ha. The heavy fuel quantity has been reduced by 5.4 t/ha and the fine fuel quantity by 7.6 t/ha. Although a substantial quantity of heavy fuel remains from the first thinning operation the fine fuels and, most importantly, the litter fuels have been decomposed and incorporated into the duff layer.

Second thinning added 17.5 t/ha of fuel to the forest floor, which was 8.5 t/ha less than the quantity added by first thinning (Table 5). However, the fuel quantity remaining from first thinning gives a total ground fuel quantity in the second thinned stand of approximately 46 t/ha, or 5.6 t/ha higher than the quantity recorded immediately following first thinning. Despite this greater fuel quantity second thinning is unlikely to increase the hazard above the level created by first thinning. The fine fuels, and in particular the needle fuels, have the greatest effect on the level of hazard because they

TABLE 3: VERTICAL FUEL DISTRIBUTION FOR TREES OF MEAN DIAMETER

	AGE 12* Unthinned			AGE 18 Unthinned			AGE 18 First Thinned		
Section Length (% of Ht)	Section Length (m)	Fuel Wt (kg)	Fuel Wt per m (kg)	Section Length (m)	Fuel Wt (kg)	Fuel Wt per m (kg)	Section Length (m)	Fuel Wt (kg)	Fuel Wt per m (kg)
0- 20	0- 3.6	3.1	0.9	0- 5.4	5.2	1.0	0- 5.4	6.2	1.1
21- 40	3.7- 7.1	10.6	2.9	5.5-10.8	7.7	1.4	5.5-10.8	9.1	1.7
41- 50	7.2-10.7	12.8	3.6	10.9-16.1	10.9	2.0	10.9-16.2	10.2	1.9
61- 80	10.8-14.2	7.1	2.0	16.2-21.5	12.1	2.2	16.3-21.6	11.0	2.0
81-100	14.3-17.8	1.3	0.4	21.6-26.9	2.9	0.5	21.7-27.0	3.4	0.6
Total Fuel Wt (kg)		34.9							
Non-merch. stem (kg)		9.3							
Crown Wt (kg)		25.6			38.8			39.9	

NOTE: *The mean tree dimensions are as follows:-*

1 Age 12 – dbhob = 17.1 cm

– height = 17.8 m

2 Age 18 – Unthinned – dbhob = 22.4 cm

– height = 26.9 m

– Thinned – dbhob = 24.7 cm

– height = 27.0 m

* From Williams (1978)

cure rapidly and are highly flammable. Second thinning added only 1.9 t/ha of needles, substantially less than the 4.9 t/ha added by first thinning.

TABLE 4: GROUND FUEL QUANTITIES (T/HA) AT AGE 12 AND 18 YEARS

Fuel Component		Age 12 *		Age 18	
		Unthinned	First Thinned	Unthinned	First Thinned
Heavy fuels **		-	18.3	0.4	12.9
Fine fuels ***	- duff	9.8	9.8	13.4	11.4
	- litter	5.6	13.3	4.4	4.1
	TOTALS:	15.4	41.4	18.2	28.4

* *From Williams (1978)*

** *Fuels > 6 mm diameter*

*** *Fuels ⩽ 6 mm diameter*

TABLE 5: FUEL QUANTITIES (T/HA) ADDED TO THE FOREST FLOOR FOLLOWING FIRST AND SECOND THINNING

Fuel Component	First Thinning at Age 12 *	Second Thinning at Age 18
Non-merchantable stemwood	13.8	7.3
Branchwood - living	3.7	3.5
- dead	3.6	3.5
Needles - living	2.8	1.6
- dead	2.1	0.3
Fuels derived from dead standing stems	-	1.3
TOTALS:	26.0	17.5

* *from Williams (1978)*

ACKNOWLEDGEMENTS

The field assistance of Mr A Morrow and the valuable advice given by Mr H Stewart are gratefully acknowledged.

APPENDIX I - SAMPLE TREE FUEL WEIGHTS

Tree	DBHOB (cm)	Height (m)	Height-base of green crown (m)	Total Stemwood (kg)	Live Branch-wood (kg)	Live Needles (kg)	Dead Branch-wood (kg)	Dead Needles (kg)
1	9.8	18.0	7.0	24.8	1.2	0.6	2.4	0.5
2	15.9	24.6	15.0	87.5	2.6	1.2	8.9	0.8
3	23.2	27.5	10.8	189.7	14.3	5.4	12.1	0.6
4	28.9	27.2	10.9	293.2	26.4	11.0	30.0	1.3
5	33.0	30.4	7.0	416.2	39.9	15.6	9.9	0.7
6	6.9	11.2	4.0	7.4	0.6	0.3	12.7	0.4
7	16.9	24.9	11.8	93.0	16.9	2.4	10.8	0.9
8	24.1	26.2	12.1	185.9	24.1	6.7	31.2	1.4
9	27.3	27.0	9.8	262.7	40.9	13.9	9.6	0.8
10	32.9	28.7	10.4	373.9	57.5	18.8	34.7	1.3

APPENDIX I - FIRE BEHAVIOUR INFORMATION

DATE	TIME/ PERIOD	TEMP (°C)	RH (%)	MOISTURE CONTENT (%)	WIND SPEED (km/hr)	FIRE BEHAVIOUR COMMENTS
8/9/1977	1245-1300	15	70	21	0-5	Vertical spread very fast.
9/9/1977	0935-1145	11.5-12.5	90	43-46	0	Ignition difficult but fires still spread
28/9/1977	2200-2300	14-15	73-76	23.5-25.6	0-5	Good effect.
1/11/1977	1240-1700	14.2-16.5	76-93	18.5-22.0	0-5	Ground fires igniting. Too dry.
10/5/1978	1400-1710	10-12.5	68-76	24-27	3-5	Fuels ignite readily.
17/5/1978	1300-1445	13.2-16.0	63-96	21.8-30.6	2-3	Good range of fire behaviour
13/7/1978	1330-1700	10-14	63-90	35.5-46.2	0-3	Fires difficult to ignite.
16/10/1979	1430-1740	13-17	60-85	22-26	0-10	Ground fuels too damp. Good fire behaviour.
17/10/1979	1400-1600	15-17	68-72	20.8-22	0-5	Ground fuels too damp. Good fire behaviour.
5/9/1980	0915-1400	15-17	68-80	19-23.2	0-10	OK at first but becoming too dry. Satisfactory at higher MC.
9/10/1980	1245-1600	13-18	65-92	20-24.3	0-5	Good fire behaviour but ground fires igniting. Marginal.
15/10/1980	0915-1130	13-18	72-90	20-25.8	0-5	Good results.
16/10/1980	0930-1045	12-16	68-82	21.7-28.8	0-5	Too dry. Ground fuels ignite.
4/11/1980	0930-1445	11.5-16.5	50-100	19.3-32	0-4	

ACKNOWLEDGEMENT

This work could not have been undertaken without the assistance of the staff and employees of the Heywood District.

REFERENCES

BILLING, P R (1979) Using fire to reduce fuel accumulations after first thinning in radiata pine plantations. Forests Commission Victoria Fire Research Branch Report No 4 (unpublished).

DEXTER, B D and WILLIAMS, D F (1976) Direct field estimation of fine fuel moisture content. Aust. For. 39(2) 140-144.

THOMSON, D S (1978) Low intensity prescribed burning in three Pinus radiata stand types. Forests Commission Victoria Fire Research Branch Report No 2 (unpublished).

WILLIAMS, D F (1977) Influence of fuel quantity, distribution and moisture content on fire management of radiata pine plantations. M F Thesis, University of Melbourne.

APPENDIX 2: REGRESSIONS DERIVED FROM SAMPLE TREE DATA

Component (Y kg)	Dimension (X cm)	$Log_{10}A$	B	n	Syx (Log_{10})	r^2	CF
Dead branchwood	Branch diameter						
(thinned)		-1.604	2.810	62	0.0668	0.89	1.2017
(unthinned)		-1.688	3.068	69	0.0047	0.94	1.1397
Live branchwood	Branch diameter	-1.737	2.981	131	0.0637	0.92	1.1827
Live foliage	Branch diameter						
(level 1		-2.365	2.640	24	0.1338	0.71	1.4213
(level 2)		-1.975	2.387	47	0.1070	0.83	1.3271
(level 3 & 4)		-1.870	2.745	30	0.0850	0.90	1.2525
(level 5)		-1.886	2.483	31	0.1384	0.68	1.4398
Dead branchwood	dbhob	-1.381	1.842	10	0.0462	0.81	1.1386
Live branchwood	dbhob	-1.835	2.949	10	0.0223	0.96	1.0064
Dead foliage	dbhob	-0.837	0.575	10	0.0196	0.52	1.0490
Live foliage	dbhob	-2.829	2.719	10	0.0002	0.99	1.0028
Total stemwood	dbhob	-1.029	2.442	10	0.0036	0.99	1.0094
Merchantable stemwood	dbhob	-1.036	2.392	10	0.0006	0.99	1.0015
Total crown fuels							
0-20% tree height	dbhob	-1.587	1.708	10	0.0822	0.84	1.2401
20-40%		-1.436	1.720	10	0.0586	0.75	1.1659
40-60% - thinned		-2.378	2.433	5	0.0099	0.97	1.0257
- unthinned		-2.164	2.371	5	0.0128	0.98	1.0328
60-80% - thinned		-2.654	2.653	5	0.0101	0.98	1.0258
- unthinned		-3.674	3.524	5	0.0171	0.99	1.0168
80-100%		-1.592	1.523	10	0.0170	0.89	1.0457
Standing dead trees							
Total foliage	dbhob	-2.065	1.756	10	0.1009	0.44	1.3040

REFERENCES:

STEWART H T L and FLINN D W (1981): Above ground biomass of Pinus radiata in South Gippsland Victoria. For. Comm. Vic. Res. Br. Rep. 174 (unpublished).

VAN WAGNER C E (1968): The line intersect method in forest fuel sampling. For. Sci. 14(1).

WILLIAMS D F (1977): Influence of fuel quantity, distribution and moisture content on fire management of radiata pine plantations. M F Thesis, Uni. of Melbourne.

WILLIAMS D F (1978): Fuel properties before and after thinning in young radiata pine plantations. For. Comm. Vic. Fire Res. Br. Rep. No 3.