FOREST FIRE BEHAVIOUR TABLES FOR WESTERN AUSTRALIA

FORESTS DEPARTMENT
WESTERN AUSTRALIA

FOREST FIRE BEHAVIOUR TABLES for Western Australia

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1. CONTENTS

2. INTRODUCTION

*Forest Fire Behaviour Tables 1976** represents the results of continued research and improved fire prediction information since Forest Fire Danger Tables were first published in 1968.

These tables are designed specifically for predictions of daily maximum and minimum litter moisture content and rate of forward spread for forest fires in the south-west of Western Australia.

In this edition, systems for predicting fuel moisture content have changed considerably from the method of fire hazard prediction used in earlier tables. This change was necessary to accommodate the complex drying processes for karri litter into a uniform system applicable to all forest types.

Fuel moisture contents are determined for litter fuels found in forest stands with approximately 60 per cent canopy cover, unburnt for five to seven years. It may be necessary to make some adjustment to the moisture contents of fuels which are either younger (shallower) or older (deeper), and found under more exposed or shaded sites.

The weather readings required for the moisture content predictions are normally measured at the divisional headquarters. Variations in weather, especially rainfall, within the divisional area can result in differences in moisture contents within that division. Where it is critical to know the exact moisture contents of the fuels in a particular forest block, it will be necessary to measure these directly with the use of one of two moisture meters† currently available. These meters should be used on a regular basis to correct the daily moisture calculations of the standard fuel types.

Fuel moisture sampling trials indicate that the moisture predictions are most reliable when moisture contents are less than 25 per cent, which is the moisture range in which fuels will ignite and burn.

* Data for all tables obtained by R. J. Sneeuwjagt and G. B. Peet.

† Marconi Moisture Meter—most suitable for dry hardwood litter. Speedie Meter—most suitable for pine needle litter.

3. DEFINITIONS

Surface Moisture Content (S.M.C.)—the moisture content expressed as a percentage of oven dry weight of the top 5-10 mm of leaf litter.

Profile Moisture Content (P.M.C.)—the moisture content expressed as a percentage of oven dry weight of the entire leaf litter bed above the mineral soil surface.

Fuel Quantity—the oven dry weight of litter, trash and scrub foliage expressed in tonnes per hectare.

Available Fuel Factor—the proportion of the litter bed that is available to burn.

Total Available Fuel Quantity—the sum of the fuel quantity of the litter, trash and scrub fuels that is available to burn.

Overnight Relative Humidity Count—represents the area enclosed by the overnight R.H. trace (to 0800 hours) and the 70 per cent R.H. level. The area is made up of basic unit squares of 2 per cent R.H. by two hours duration.

Basic Drying Unit (B.D.U.)—is obtained from the daily forecasted maximum temperature and minimum relative humidity. Thus, the B.D.U. is a measure of the day drying effect.

Scrub Structural Types—designated by numbers 1 to 6, each of which represents an individual foliage density-height profile.

Standard Fuel Types

Northern Jarrah—represents the fuel type common to the jarrah dominant forests which carries a sparse, low scrub component.

Southern Jarrah (Type 6)—represents the fuels common to the jarrah dominant and jarrah-marri associations and usually carries a low (1 m) dense understorey scrub layer.

Karri 3 and 6—found in the jarrah-marri and karri-marri associations and usually carries a low (up to 2 m) dense scrub layer.

Karri 4 and 5—found in the karri-marri and karri dominant forest types and carries a tall (up to 5 m) dense scrub layer.

Karri 1 and 2—found in the karri dominant forests and usually in wet, gully situations. The scrub type is tall (greater than 5 m) and dense.

Rate of Fire Spread—the forward rate of progress of the headfire expressed in metres per hour.

Fire Rate of Spread Index—the maximum rate of spread predicted from wind speed and surface moisture content for level topography, 60 per cent crown cover and standard fuel conditions for each forest type, namely:

Jarrah Five year old (i.e. five leaf falls) fuel ranging from 7·6 to 8·5 tonnes/ha.

Karri Five year old fuels which carry a combined total of 25 to 35 tonnes/ha of litter, trash and scrub fuels, or 15 to 19 tonnes/ha of available fuel.

Pines For pines, the rate of spread index will be based on 15 year old pines carrying approximately 11 to 20 tonnes/ha of litter, or 4 to 9 tonnes/ha of available fuel.

4. SURFACE MOISTURE CONTENT (S.M.C.)

Records should be commenced in early spring when litter beds are saturated. Moisture contents at that time to be determined by direct sampling or by approximations, i.e.

On first day after rain exceeding 10 mm assume:

S.M.C. = 100 per cent (Northern Jarrah)
P.M.C. = 150 per cent (Karri 4 and 5)

4.1. METHODS

N.B.—For purposes of recording:

Maximum S.M.C. applies to values at about 0800 hours.
Minimum S.M.C. applies to values at about 1500 hours.

4.1.1. Use table 4.3.1 to derive today's maximum S.M.C. if rain recorded in the 24-hour period to 0800 hours. See columns 2, 7, 8, 9 in example record sheet (page 9).

4.1.2. Use table 4.3.2 instead of table 4.3.1 if no rain has fallen before 0800 hours. See columns 3, 7, 8, 9.

4.1.3. Use table 4.3.3 to obtain today's basic drying unit (B.D.U.). Columns 4, 5, 6.

4.1.4. Apply B.D.U. in table 4.3.4 to derive day-drying and correct maximum S.M.C. at 0800 hours to obtain minimum S.M.C. for today. Columns 9, 10, 11.

4.1.5. Use table 4.3.5 to adjust northern jarrah S.M.C. for southern forest types. Columns 12 to 19.

4.1.6. Use table 4.3.6 to adjust northern jarrah S.M.C. for minimum S.M.C. in *Pinus pinaster* and *Pinus radiata* needle beds. Columns 20 to 23.

4.1.7. The number of columns 12 to 23 should be adjusted for local requirement to cover range of fuel types required.

4.1.8. S.M.C. values between 0800 hours and 1500 hours can be derived from the nomogram (figure 4.3.7) for planning prescribed burning.

4.2. WORKED EXAMPLE

SURFACE MOISTURE CONTENT RECORD SHEET

Station: MANJIMUP Year: 1975

Date (day, month)	Rain to 0800 hours	Overnight R.H. count and dew	Forecast maximum temperature, °C	Forecast minimum R.H.	Basic drying unit (Table 4.3.3)	Northern jarrah surface M.C.,%					Other fuel types (Tables 4.3.5 and 4.3.6)											
						Minimum S.M.C.% yesterday (1500 hours)	S.M.C.% correction for rain or R.H. count (Table 4.3.1 or 4.3.2)	Maximum S.M.C. today, 0800 hours	S.M.C. day-drying correction (Table 4.3.4)	Minimum S.M.C.% today (1500 hours)	Southern jarrah		Open karri (Types 3 and 6)		Medium/dense karri (Types 4 and 5)		Dense karri (Types 1 and 2)		*Pinus pinaster* needlebed		*Pinus radiata* needlebed	
											a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.	a.m.	p.m.
1	2	3	4	5	6	7	8	9	10†	11†	12	13	14	15	16	17	18	19	20	21	22	23
1/12 Mon	2·5	48	20	45	16	15*	+ 38 (rain)	53	−14	39	59	43	63	47	77	58	83	62	40	30	47	35
2/12 Tues	0	36	28	35	23	39	−7	32	−13	19	36	21	40	24	51	28	55	32	25	16	29	17
3/12 Wed	0	65	26	40	21	19	+ 6	25	−11	14	28	16	31	18	38	21	42	24	21	12	23	13
4/12 Thur	0	50	30	35	24	14	+ 5	19	−8	11	21	12	24	14	28	17	32	19	16	9	18	10
3/12 Fri	0	65 (dew)	24	50	18	11	+ 14 (dew)	25	−9	16	28	18	31	21	38	25	42	29	21	13	23	14
6/12 Sat	10·0	85	16	65	11	16	+ 95 (rain)	111	−20	91						Too high						
7/12 Sun	1·5	80	18	60	12	91	−11	80	−15	65						Too high						

* Starting S.M.C. percentage value may be obtained from previous day's calculations or from field measurement.

† As values in columns 10 and 11 are based on forecasted weather, these values must be corrected according to the actual weather before proceeding with the next day's calculations.

4.3. SURFACE MOISTURE TABLES

4.3.1. Jarrah Rainfall Correction Table

Use this table only if rain recorded at 0800 hours, otherwise use table 4.3.2.

Yesterday's minimum moisture content %	Rainfall amount recorded at 0800 hours (mm)									
	0·1 to 0·3	0·4 to 1·0	1·1 to 2·0	2·1 to 3·0	3·1 to 6·0	6·1 to 8·0	8·1 to 18·0	18·1 to 35·0	35·1 to 50·0	50·1 plus
	Moisture content addition, %									
5-20	+10	+16	+27	+38	+55	+80	+95	+115	+135	+145
21-40	+ 8	+12	+20	+30	+45	+70	+85	+105	+125	+135
41-60			+15	+23	+35	+55	+75	+ 95	+110	+120
61-80	For S.M.C. use the "Dew" column in Table 4.3.2. For P.M.C., add 5.		+10	+17	+25	+45	+60	+ 80	+100	+110
81-120				+11	+18	+30	+45	+ 65	+ 80	+ 90
121-160				+ 6	+10	+20	+35	+ 50	+ 65	+ 75
161 +				+ 3	+ 6	+12	+25	+ 35	+ 45	+ 55

1. Calculate rainfall correction percentage from rain amount (mm) and yesterday's minimum moisture content percentage (Y.M.C.). Record in column 8.
2. Add correction to Y.M.C. to give today's maximum moisture content per centage, and record in column 9.
3. Go to table 4.3.3.

4.3.2. Jarrah Surface Moisture Content Change During Rainless Nights

Yesterday's minimum S.M.C. %	Overnight relative humidity count. Read at 0800 hours					
	0-20	21-40	41-60	61-80	81-100	101+ or dew
	Overnight S.M.C. change, %					
3- 7	+ 4	+ 6	+ 9	+12	+15	+17
8- 12	+ 2	+ 4	+ 6	+ 9	+13	+14
13- 17	− 1	+ 2	+ 5	+ 8	+11	+13
18- 22	− 3	0	+ 3	+ 6	+ 9	+11
23- 27	− 5	− 2	+ 1	+ 4	+ 7	+ 9
28- 33	− 8	− 5	− 1	+ 2	+ 5	+ 7
34- 40	−10	− 7	− 4	− 1	+ 3	+ 4
41- 50	−16	−12	− 8	− 4	− 1	+ 2
51- 60	−21	−17	−13	− 9	− 5	− 1
61- 80	−27	−23	−19	−14	−10	− 6
81-100	−33	−29	−24	−19	−14	−11
101-120	−38	−33	−28	−23	−18	−15
121-150	−43	−38	−33	−28	−22	−19
151 +	−48	−43	−37	−32	−26	−23

1. Calculate overnight surface moisture change percentage from overnight R.H. count and yesterday's minimum S.M.C. percentage (Y.M.C.). Record in column 8.
2. Apply correction to Y.M.C. to give today's maximum S.M.C. percentage and record in column 9.
3. If the overnight R.H. count reading is not available assume overnight R.H. count to be 50.
4. Use "dew" column (extreme right) if dew is present up to 0800 hours on upslope sites.
5. Go to table 4.3.3.

4.3.3. Basic Drying Unit (B.D.U.)

B.D.U. is a measure of day drying effect.

Max. temp °C	Minimum relative humidity, %															
	90	80	70	65	60	55	50	45	40	35	30	25	20	15	10	5
8	1	3	4	5	6	7	8	9								
10	2	4	6	6	7	8	9	9	10							
12	3	5	7	8	8	9	10	11	12							
14	5	6	8	9	10	10	11	12	13							
16	6	8	10	11	11	12	13	14	14	15						
18	7	9	11	12	12	13	14	15	15	16	17	18				
20	9	10	12	13	14	14	15	16	17	18	18	19	20	21		
22	10	12	14	15	15	16	17	17	18	19	20	21	21	22	23	24
24		13	15	16	16	17	18	19	19	20	21	22	22	23	24	25
26			16	17	18	18	19	20	21	22	22	23	24	25	25	26
28				18	19	20	20	21	22	23	24	24	25	26	27	28
30				19	20	21	22	23	23	24	25	26	26	27	28	29
32				21	22	22	23	24	25	26	26	27	28	29	29	30
34				22	23	24	24	25	26	27	27	28	29	30	30	31
36					24	25	26	27	27	28	29	30	30	31	32	32
38					25	26	27	28	28	29	30	31	32	32	33	33
40						27	28	28	29	30	31	32	32	33	34	35
42							28	29	30	31	32	33	33	34	35	35

1. Calculate B.D.U. from maximum temperature and minimum R.H. percentage and record in column 6.
2. Apply the B.D.U. in table 4.3.4.

4.3.4. Jarrah Surface Moisture Content Day Drying Correction

Today's max. (0800 hours) S.M.C., %	Basic drying units							
	1-4	5-8	9-12	13-16	17-20	21-24	25-29	30-35
	Day drying correction, %							
7-11	+ 6	+ 4	+ 3	+ 2	0	− 1	− 3	− 5
12-16	+ 3	+ 1	− 1	− 2	− 3	− 5	− 7	− 9
17-21	+ 1	− 1	− 3	− 5	− 6	− 8	−10	−12
22-27	− 1	− 3	− 5	− 7	− 9	−11	−13	−15
28-33	− 2	− 5	− 7	− 9	−11	−13	−15	−18
34-40	− 4	− 6	− 9	−11	−13	−15	−18	−20
41-60	− 7	− 9	−12	−14	−16	−19	−21	−24
61-80	−10	−12	−15	−18	−20	−23	−25	−28
81-120	−15	−17	−20	−23	−25	−28	−31	−34
121-160	−21	−24	−27	−30	−33	−36	−38	−42
161 +	−30	−34	−37	−40	−44	−47	−50	−54

1. Calculate S.M.C. day drying correction percentage using the B.D.U. and today's maximum S.M.C. percentage. Record in column 10.
2. Deduct or add correction to today's maximum S.M.C. percentage to give the minimum S.M.C. (jarrah) today. Record in column 11.
3. If the minimum S.M.C. calculates to be less than 3 per cent, set minimum S.M.C. at 3 per cent.

4.3.5. Surface Moisture Content Adjustments for Other Major Hardwood Fuel Types in M.C. Percentages

Northern Jarrah	S. Jarrah, J., J.M.	Karri 3 & 6 K.M., K.M.J.	Karri 4 & 5 K.M., K. dom.	Karri 1 & 2 K. dom.	Open slash
	Surface moisture content adjustments, %				
4-6	+ 1	+ 2	+ 3	+ 5	0
7-9	+ 1	+ 2	+ 4	+ 7	− 1
10-12	+ 1	+ 3	+ 6	+ 8	− 2
13-15	+ 2	+ 4	+ 7	+10	− 3
16-20	+ 2	+ 5	+ 9	+13	− 5
21-30	+ 3	+ 6	+13	+17	− 7
31-40	+ 4	+ 8	+19	+23	−10
41 +	+ 6	+10	+24	+30	−14

1. Enter table 4.3.5 with northern jarrah S.M.C. percentage and obtain S.M.C. adjustment percentage for appropriate fuel types.
2. Make adjustment to northern jarrah S.M.C. percentage to yield S.M.C. percentage for particular fuel types. Record these in columns 12 to 19.

4.3.6. Surface Moisture Content Adjustment for Pine Fuels

Northern Jarrah S.M.C. %	*Pinus pinaster*		*Pinus radiata*	
	Needlebed litter	Tops/aerated needles	Needlebed litter	Tops/aerated needles
5-10	0	– 1	0	0
11-15	– 2	– 3	– 1	– 1
16-20	– 3	– 5	– 2	– 2
21-25	– 4	– 6	– 2	– 3
26-30	– 5	– 8	– 3	– 4
31-35	– 7	–10	– 3	– 5
36-40	– 9	–12	– 4	– 6
41-50	–11	–15	– 5	– 8
51-60	–13	–18	– 6	–10
61-70	–15	–21	– 8	–13
71-80	–17	–24	–10	–16

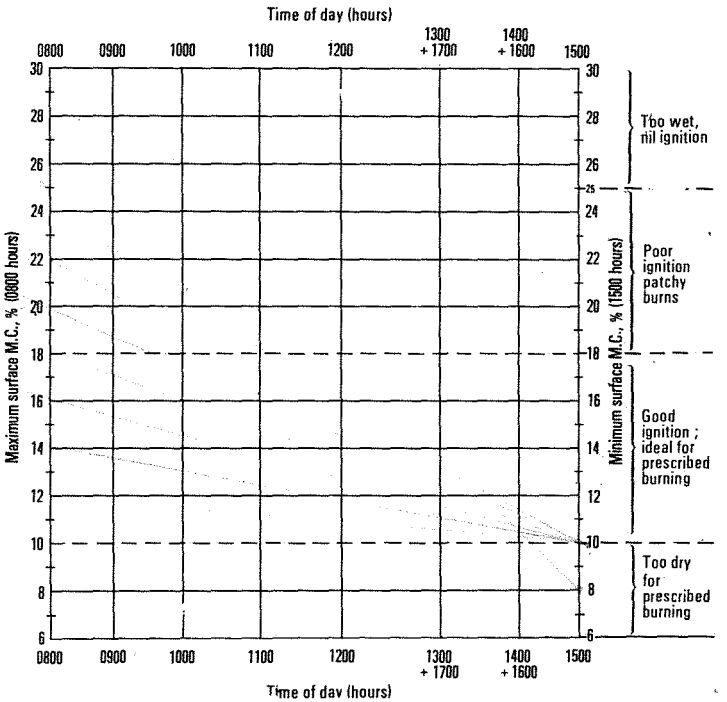
1. Enter table with predicted minimum S.M.C. (northern jarrah) and obtain S.M.C. adjustment for the particular pine fuel type.
2. Add or deduct adjustment to northern jarrah S.M.C. to yield the pine fuel S.M.C. percentage. Record in columns 20 to 23.
3. Apply the pine S.M.C. in table 6.7 to give the pine fire R.O.S. uncorrected for fuel quantity (see table 6.9).

N.B. The desirable S.M.C. percentage ranges for safe, successful needlebed burns under *Pinus radiata* and *Pinus pinaster* are 15-25 per cent and 20-30 per cent respectively.

The table values for needlebeds refer to those pine fuels found on loamy (*P. radiata*) or sand (*P. pinaster*) soils below a closed canopy inside a level compartment.

It is important to realise that fuels found on exposed edges, ridges or north slopes, or below open canopy will be somewhat drier than the table values. The opposite is true for fuels in gullies, or south slopes, or unpruned, unthinned stands.

4.3.7. Surface Moisture Content During the Day



1. Place a ruler on predicted maximum (left axis) and minimum S.M.C. percentage (right axis).
2. Read off the expected S.M.C. percentage at the intersection of the ruler at the required time(s) during the day, or read off the time of day that S.M.C. percentage will be suitable for prescribed burning.

5. PROFILE MOISTURE CONTENT (P.M.C.)

5.1. METHOD

N.B. P.M.C. calculations are required for fuel beds exceeding 20 mm in depth (mainly southern forest and pine plantation).

P.M.C. values determined in the tables apply to litter beds that average 25 mm in depth. Shallower fuels will have a lower P.M.C., and deeper fuels will have higher P.M.C. values.

P.M.C. values apply to karri types 4 and 5. P.M.C. for other southern types and pine fuels are derived from table 5.3.2.

5.1.1. Use table 4.3.1 to obtain today's maximum P.M.C. for karri 4 and 5 if rain recorded up to 0800 hours. Columns 29, 30, 31 of P.M.C. record sheet (page 19).

5.1.2. If no rain recorded, yesterday's minimum P.M.C. is carried forward as today's maximum P.M.C. (i.e. no over-night change). Columns 29, 31.

5.1.3. Use table 5.3.1 to derive the drying correction and the minimum P.M.C. percentage for karri 4 and 5. Columns 32, 33.

5.1.4. Adjust P.M.C. karri 4 and 5 in table 5.3.2 for other fuel types. Columns 34 to 38.

5.1.5. Derive available fuel factor (A.F.F.) for required fuel type from table 5.4.1H (hardwood) or table 5.4.1P (pines) by inserting today's minimum surface and minimum profile moisture content. Columns 39 to 44.

5.2. WORKED EXAMPLE

PROFILE MOISTURE CONTENT RECORD SHEET

Station: MANJIMUP Year: 1975

Date (day, month)	Rain to 0800 hours (mm)	Basic drying unit (see column 6, S.M.C. Record)	Karri 4 and 5 profile M.C., %					Minimum P.M.C. (1500 hours) for other fuel types (Table 5.3.2)					Available fuel factor (Tables 5.4.1H or 5.4.1P)					
			Yesterday's minimum P.M.C., %	P.M.C. % correction for rain (Table 4.3.1)	Maximum P.M.C. % 0800 hours today	P.M.C. % day-drying correction (Table 5.3.1)	Minimum P.M.C. % today (1500 hours)	Southern Jarrah	Karri 3 and 6	Karri 1 and 2	*Pinus pinaster*	*Pinus radiata*	Southern Jarrah	Karri 3 and 6	Karri 4 and 5	Karri 1 and 2	*Pinus pinaster*	*Pinus radiata*
26	27	28	29	30	31	32†	33†	34	35	36	37	38	39	40	41	42	43	44
1/12 Mon.	2·5	16	80*	+ 17 (rain)	97	−7	90	70	75	115	115	150	0	0	0	0	0	0
2/12 Tues.	–	23	90	0	90	−10	80	65	70	100	98	125	0·2	0·1	0	0	0·4	0·4
3/12 Wed.	–	21	80	0	80	−8	72	57	62	92	90	117	0·3	0·3	0·2	0·1	0·6	0·5
4/12 Thur.	–	24	72	0	72	−8	64	49	54	84	82	109	0·5	0·4	0·3	0·1	0·7	0·5
5/12 Fri.	–	18	64	0	64	−6	58	48	51	76	70	93	0·3	0·3	0·2	0	0·6	0·4
6/12 Sat.	10·0	11	58	+ 75 (rain)	133	−7	126	106	111	151	156	206	0	0	0	0	0	0
7/12 Sun.	1·5	12	126	+ 5 (rain)	131	−7	124	104	109	149	154	204	0	0	0	0	0	0

* Starting P.M.C. percentage value obtained either from previous day's calculations or from field measurement.

† As values in columns 32 and 33 are based on forecasted weather, these values must be corrected according to the actual weather before proceeding with the next day's calculations.

5.3. PROFILE MOISTURE CONTENT TABLES

5.3.1. Profile Moisture Content Day Drying Correction for Karri 4 and 5

N.B. First use table 4.3.1 to determine the P.M.C. change following rain. Record in columns 30 and 31.

If no rain is recorded to 0800 hours, then maximum P.M.C. today is equal to yesterday's minimum P.M.C.

Then use this table (5.3.1.) to determine the P.M.C. day drying correction.

Today's max. (0800 hours) P.M.C.) for Karri 4 & 5	Basic drying units						
	1 to 5	6 to 10	11 to 15	16 to 20	21 to 25	26 to 30	31 plus
%	P.M.C. drying correction, %						
11-15	+ 4	+ 4	+ 3	+ 2	+ 2	+ 1	0
16-20	+ 3	+ 2	+ 2	+ 1	0	− 1	− 2
21-30	+ 2	+ 1	0	− 1	− 2	− 3	− 4
31-40	+ 2	0	− 1	− 2	− 4	− 5	− 6
41-60	+ 1	− 1	− 2	− 4	− 6	− 7	− 9
61-80	0	− 2	− 4	− 6	− 8	−10	−12
81-120	− 1	− 3	− 5	− 7	−10	−12	−14
121-160	− 1	− 4	− 7	− 9	−12	−14	−17
161 +	− 2	− 6	− 9	−12	−15	−18	−21

1. Calculate P.M.C. day drying correction percentage for karri types 4 and 5 using the basic drying unit and today's maximum P.M.C. percentage for karri 4 and 5. Record in column 32.
2. Deduct or add correction to today's maximum P.M.C. percentage (karri 4 and 5) to obtain the minimum P.M.C. percentage today. Record in column 33.

5.3.2. Profile Moisture Content Adjustments for Southern Forest Types and Pine Fuels

Karri 4 & 5 profile moisture content, %	Southern jarrah (J.M.)	Karri 3 & 6 (K.M.)	Karri 1 & 2 (K. dom.)	*Pinus pinaster* needlebed	*Pinus radiata* needlebed
11-15	− 1	0	+ 5	+ 2	+ 8
16-20	− 2	0	+ 6	+ 3	+ 12
21-30	− 4	− 2	+ 9	+ 6	+ 18
31-40	− 7	− 4	+12	+ 9	+ 25
41-60	−10	− 7	+18	+12	+ 35
61-80	−15	−10	+20	+18	+ 45
81-120	−20	−15	+25	+25	+ 60
121-160	−20	−15	+25	+30	+ 80
161 +	−20	−15	+25	+40	+100

1. Enter table with minimum profile moisture content percentage for karri 4 and 5.
2. Read off the adjustment for particular fuel type and apply adjustment to the karri 4 and 5 P.M.C. percentage to yield the P.M.C. percentage for the particular fuel type. Record in columns 34 to 38.

5.4. AVAILABLE FUEL FACTOR (A.F.F.)

5.4.1H. Available Fuel Factor for Hardwood Litter

Defines proportion of *litter* fuel available for burning.

Minimum surface moisture content %	Minimum profile moisture content, %									
	10 to 14	15 to 19	20 to 24	25 to 30	31 to 40	41 to 60	61 to 80	81 to 120	121 to 160	161 plus
3-6	B	B	1·0	0·9	0·9	–	–	–	–	–
7-9	B	B	1·0	0·8	0·7	0·6	0·5	0·4	0·3	0·3
10-12	B	A	1·0	0·8	0·6	0·5	0·4	0·3	0·3	0·2
13-15	B	A	1·0	0·7	0·5	0·4	0·3	0·3	0·2	0·2
16-18	A	A	1·0	0·6	0·4	0·3	0·3	0·2	0·2	0·1
19-21	A	1·0	0·9	0·5	0·4	0·3	0·2	0·1	0·1	0·1
22-25	A	1·0	0·8	0·5	0·3	0·2	0·1	0·1	0·1	0·1
26 +	–	–	–	–	–	–	–	–	–	–

1. Enter table with the predicted minimum surface and profile moisture contents for the particular fuel type.
2. Read off the available fuel factor (i.e. the fraction of fuel that is available to burn). Record in columns 39 to 44.

N.B. Prescribed burning is most successful when the A.F.F. is between 0·3 and 0·7 inclusive.

Indices *A* and *B* equal 1·0 and represent dangerously dry fuel conditions.

5.4.1P. Available Fuel Factor for Pine Litter

Minimum surface moisture content %	Minimum profile moisture content, %								
	30 to 35	36 to 40	41 to 50	51 to 60	61 to 80	81 to 100	101 to 120	121 to 150	151 to 200
	Available fuel factor (pines)								
5-9	1·0	0·9	0·8	0·8	0·8	0·7	–	–	–
10-14	1·0	0·9	0·8	0·7	0·7	0·6	0·5	0·4	0·4
15-19	1·0	0·8	0·7	0·6	0·6	0·5	0·4	0·3	0·3
20-24	1·0	0·8	0·6	0·5	0·5	0·4	0·3	0·3	0·3
25-29	0·9	0·7	0·5	0·4	0·4	0·3	0·2	0·2	0·2
30-35	0·8	0·6	0·4	0·3	0·3	0·2	0·1	0·1	–
36 +	0·8	0·5	0·2	0·2	0·1	0·1	–	–	–

1. Enter table with minimum surface and profile moisture contents for either *Pinus pinaster* or *Pinus radiata* fuels.
2. Read off the available fuel factor (A.F.F.).

N.B. The A.F.F. indicates the portion of the needlebed that is readily available to burn. Thus:

Total fuel quantity x A.F.F. = Available fuel quantity.

Safe and satisfactory prescribed burns in pine litter are achieved when the A.F.F. occurs within the 0·3 to 0·6 range.

6. RATE OF FORWARD SPREAD OF HEADFIRE

6.1. METHOD—JARRAH FOREST

6.1.1. Select appropriate wind ratio for forest type under consideration. Table 6.5.

6.1.2. Select appropriate slope correction if applicable. Table 6.6.

6.1.3. Where jarrah litter beds exceed 20 mm in depth, calculate available fuel quantity from:

Available fuel factor (A.F.F.) x Total litter quantity = Available litter fuel quantity.

6.1.4. Enter table 6.7 with S.M.C., wind velocity and wind ratio to obtain rate of forward spread index (m/hr) in 7·6 to 8·5 tonnes/ha of litter fuel (R.O.S.I.).

6.1.5. Adjust rate of spread from table 6.7 for available fuel quantity by correction factor (C.F.) from table 6.8; i.e.

R.O.S.I. x C.F. = R.O.S. adjusted for fuel quantity

6.1.6. Multiply rate of spread adjusted for fuel quantity by slope correction factor for actual rate of spread.

6.2. EXAMPLE—JARRAH FOREST

6.2.1. Data

S.M.C. = 15 per cent (from S.M.C. daily record).

Wind 18 km/hr in 60 per cent canopy cover on ridge topography measured at 30 m above canopy.

A.F.F. = 0·7 (from daily record).

Total litter fuel = 10 tonnes/ha.

Slope = +10°.

6.2.2. Calculations

Wind ratio	= 5:1	(Table 6.5)
Slope factor	= 2·0	(Table 6.6)
Available litter quantity	= 10 x 0·7	
	= 7·0 tonnes/ha	
Fuel corrector	= 0·9	(Table 6.8)
Rate of spread index	= 20 m/hr	(Table 6.7)
R.O.S.I. x Fuel corrector	= 20 x 0·9 = 18 m/hr	
R.O.S. x Slope factor	= 18 x 2·0 = 36 m/hr	

6.3. METHOD—PINE FOREST

6.3.1. Use 6·1 wind ratio for dense stands and 4·1 for open stands.

6.3.2. Select slope, S.M.C. and A.F.F. as for jarrah.

6.3.3. Calculate available litter quantity as for jarrah (see 6.1.3).

6.3.4. Enter table 6.7 with pine S.M.C. (from S.M.C. record), wind ratio, and wind velocity. Calculate R.O.S. for 7·5 to 8·5 tonnes/ha of litter fuel.

6.3.5. Multiply R.O.S.I. from table 6.7 by fuel quantity correction factor from table 6.9.

6.3.6. Multiply rate of spread adjusted for fuel quantity by slope correction if applicable, to give actual rate of spread.

6.4. EXAMPLE—PINE FOREST

6.4.1. Data (*P. pinaster*)

Litter depth	= 40 mm	
Total litter quantity	= 20 tonnes/ha	(Table 7.2.1)
Pine S.M.C.	= 22 per cent	
Pine P.M.C.	= 95 per cent	
Therefore A.F.F.	= 0·4	(Table 5.4.1P)
Tower wind speed	= 21 km/hr, 6:1 ratio	
Slope	= 0°	

6.4.2. Calculations

Available litter quantity	= 20 x 0·4 = 8 tonnes/ha	
R.O.S. index	= 13 m/hr	(Table 6.7)
Fuel correction factor	= 1·5	(Table 6.9)
Slope correction factor	= 1·0	(Table 6.6)
R.O.S. corrected for fuel quantity and slope	= 13 x 1·5 x 1·0 = 19·5 m/hr.	

6.5. WIND RATIO TABLE

Wind velocity ratios for table 6.7.

Forest type	Height of tower above canopy (metres)		
	0	15	30
(*a*) Jarrah			
(i) 60 per cent canopy ridge	3:1	4:1	5:1
Lower slope	4:1	5:1	6:1
(ii) 30 per cent canopy ridge	2:1	3:1	4:1
Lower slope	3:1	4:1	5:1
(iii) Flats	1:1	2:1	2:1
(*b*) Pine forest			
Dense stands	5:1	6:1	7:1
Open stands	3:1	4:1	5:1

Select appropriate wind ratio for table 6.7 from topography and forest canopy over the area and height of tower above the general forest canopy.

6.6. McARTHUR SLOPE CORRECTIONS

Slope in degrees	Spread factor
−10	0·6
− 5	0·8
Level	1·0
+ 2	1·1
+ 4	1·3
+ 6	1·5
+ 8	1·7
+10	2·0
+15	2·8
+20	4·0

The factor is 1·0 for level ground and doubles for every 10° increase in slope.

6.7. JARRAH RATE OF SPREAD INDEX

Apply the surface moisture content and open wind velocity (tower wind). Read off the rate of spread index for 7·6 to 8·5 tonnes/ha of litter fuel in metres per hour. Fuel quantity and slope corrections are to be found in tables 6.8 and 6.6 respectively.

Wind ratio	Tower wind velocity (kilometres/hour)									
1:1	0·0 0·9	1·0 1·6	1·7 2·4	2·5 3·2	3·3 4·0	4·1 4·9	5·0 5·6	5·7 6·4	6·5 7·2	7·3 8·0
2:1	0·0 1·6	1·7 3·2	3·3 4·8	4·9 6·4	6·5 8·0	8·1 9·6	9·7 11·2	11·3 12·8	12·9 14·4	14·5 16·0
3:1	0·0 2·4	2·5 4·8	4·9 7·2	7·3 9·7	9·8 12·0	12·1 14·4	14·5 16·8	16·9 19·2	19·3 21·6	21·7 24·0
4:1	0·0 3·2	3·3 6·4	6·5 9·6	9·7 12·8	12·9 16·0	16·1 19·2	19·3 22·4	22·5 25·6	25·7 28·8	28·9 32·0
5:1	0·0 4·0	4·1 8·0	8·1 12·0	12·1 16·0	16·1 20·0	20·1 24·0	24·1 28·0	28·1 32·0	32·1 36·0	36·1 40·0
6:1	0·0 4·8	4·9 9·6	9·7 14·4	14·5 19·2	19·3 24·0	24·1 28·8	28·9 33·6	33·7 38·4	38·5 43·2	43·3 48·0

Surface M.C., %	Jarrah rate of spread index (metres/hour)													
50 +	2	2	3	3	4	5	6	7	9	11	15	20	26	36
40	4	4	5	6	7	8	10	12	15	19	25	33	45	60
36	4	5	6	7	8	10	12	15	18	23	30	40	54	73
34	5	6	7	8	9	11	14	16	19	26	35	47	60	85
32	6	6	7	9	10	12	15	17	20	27	36	48	64	87
30	6	7	8	9	10	13	15	18	21	28	37	49	66	90
28	6	7	8	10	11	14	16	18	22	29	37	50	68	92
26	7	8	9	10	12	14	16	19	23	30	38	52	70	94
24	7	8	9	11	12	15	17	20	24	31	39	53	71	97
22	8	9	10	11	13	15	18	21	25	31	41	54	72	99
20	8	9	10	12	14	16	18	21	26	32	42	55	75	101
19	9	10	11	13	15	17	20	24	29	36	46	61	83	112
18	10	11	12	14	16	19	22	26	31	39	51	67	91	123
17	11	12	13	15	17	20	24	28	33	42	54	72	97	131
16	11	13	14	16	19	22	25	30	36	45	58	77	104	141
15	12	14	15	18	20	23	27	32	38	49	63	83	112	152
14	13	15	17	19	22	26	30	35	42	53	68	85	120	163
13	15	17	19	21	24	28	32	38	46	57	74	88	128	174
12	17	18	20	23	26	30	36	41	50	62	79	91	137	186
11	20	22	24	27	30	35	40	47	56	70	90	116	154	207
10	24	26	29	32	37	42	45	56	68	85	108	140	186	250
9	28	30	34	37	41	46	53	62	74	91	116	150	198	274
8	32	35	38	42	47	52	59	69	81	99	127	166	223	306
7	40	43	47	51	57	63	72	84	98	122	157	205	278	386
6	48	50	53	58	63	71	81	95	114	142	184	243	332	463
5	62	65	69	74	82	91	104	122	146	183	237	314	427	595
4	92	95	100	107	120	130	148	173	207	262	340	449	610	855
3	137	141	148	159	173	192	220	256	308	390	500	666	905	1268

LOW MOD. HIGH VERY HIGH EXTREME

6.8. JARRAH—FUEL QUANTITY CORRECTION FACTORS

Select appropriate S.M.C. percentage class. Read off fuel correction factor opposite relative fuel weight or fuel age.

Fuel age falls (years)	Available fuel quantity (tonnes/ha)	Surface moisture content		
		16-24 %	10-15 %	3-9 %
2	3·5-5·0	0·8	0·7	0·6
3	5·1-6·5	0·9	0·8	0·7
4	6·6-7·5	0·9	0·9	0·9
5	7·6-8·5	1·0	1·0	1·0
6	8·6-10·0	1·0	1·1	1·2
7	10·1-11·5	1·1	1·2	1·3
8	11·6-13·0	1·1	1·3	1·6
8 +	13·1-15·0	1·2	1·5	1·8
8 +	15·1-17·5	1·3	1·7	2·1
8 +	17·6-20·0	1·4	1·9	2·4
8 +	20·1-22·5	1·5	2·1	2·7
8 +	22·6-25·0	1·6	2·3	3·0

Adjusted rate of spread = R.O.S. index x Fuel correction factor

6.9. PINE—FUEL QUANTITY CORRECTION FACTORS

Select appropriate S.M.C. class for either *P. pinaster* or *P. radiata.* Read off the fuel quantity correction factor opposite the relevant available fuel quantity. Multiply this factor by the rate of spread index obtained from the Jarrah Rate of Spread table (table 6.7) to determine the corrected rate of spread for pine fuel on level ground.

Available fuel quantity* tonne/ha	Surface moisture content classes, %							
	Pinus pinaster 35-40	30-34	26-29	22-25	18-21	13-17	8-12	3-7
	Pinus radiata 30-35	25-29	20-24	16-19	12-15	9-11	6-8	3-5
4-9	1·0	1·1	1·2	1·5	1·9	2·2	2·5	2·7
10-14	1·0	1·2	1·5	1·8	2·4	2·8	3·2	3·5
15-20	1·2	1·5	1·8	2·2	3·0	3·5	4·0	4·4
21 +	–	–	2·0	3·0	4·0	4·8	5·5	6·0

* Available fuel quantity = Total fuel quantity x A.F.F.

6.10. METHOD—SOUTHERN FOREST TYPES

6.10.1. Enter table 6.12 with S.M.C. and wind velocity for particular fuel type and obtain R.O.S.I. for 15-19 tonne/ha of available fuel.

6.10.2. Determine the total fuel quantity from the litter, trash and scrub fuel measurements (tables 7.2.1, 7.3.1 and 7.4.1 respectively).

6.10.3. Obtain the fuel quantity correction from table 6.13 using the total fuel quantity and available fuel factor.

6.10.4. Adjust the R.O.S.I. for fuel quantity by multiplying the R.O.S.I. for 15-19 tonne/ha by the fuel corrector.

6.10.5. Adjust the R.O.S.I. for slope with the slope factor obtained in table 6.6.

6.11. WORKED EXAMPLE—SOUTHERN FOREST TYPES

6.11.1. Data for Karri Scrub Type 3 (open karri-marri fuels)

S.M.C. (karri 3)	= 14 per cent (from S.M.C. record)
P.M.C. (karri 3)	= 50 per cent
Therefore A.F.F.	= 0·4 (Table 5.4.1H)
Total fuel quantity (litter, trash and scrub)	= 22 tonne/ha
Slope	= +6°

6.11.2. Calculations

R.O.S.I. (for 15-19 tonne/ha available fuel)	= 50 m/hr (Table 6.12)
Fuel corrector	= 0·8 (Table 6.13)
Fuel corrected R.O.S.I.	= 50 x 0·8 = 40 m/hr
Slope factor	= 1·5 (Table 6.6)
R.O.S.I. x Slope factor	= 40 x 1·5 = 60 m/hr

6.12. KARRI RATE OF SPREAD INDEX

1. Apply surface moisture content and tower (or ground) wind velocity for appropriate fuel types.
2. Read off the rate of spread index for standard karri fuel of 15-19 tonnes/ha available fuel quantity.

Fuel types	Tower wind velocity (kilometres per hour)									
South. jarrah	0-4	5-8	9-12	13-17	18-21	22-26	27-30	31-35	36-39	40 +
Karri 3 and 6	0-4	5-9	10-14	15-19	20-24	25-28	29-32	33-36	37-40	41 +
Karri 4 and 5	0-5	6-10	11-16	17-22	23-27	28-33	34-38	39-43	44-48	49 +
Karri 1 and 2	0-6	7-13	14-20	21-28	29-35	36-42	43-49	50-56	57-63	64 +
All types	Forest ground wind velocity (kilometres per hour)									
	0·0-0·7	0·8-1·5	1·6-2·3	2·4-3·1	3·2-3·9	4·0-4·7	4·8-5·5	5·6-6·3	6·4-7·1	7·2 +
S.M.C. %	Rate of spread (metres/hour)									
27 +	–	–	–	–	–	–	–	–	–	–
26	6	9	12	15	19	24	31	39	50	64
25	7	10	13	16	20	26	34	42	55	70
24	8	10	13	17	22	29	37	46	60	77
23	8	11	14	18	23	31	40	50	66	84
22	9	11	15	19	25	33	43	54	72	92
21	9	12	16	20	27	35	47	59	78	102
20	10	12	17	22	29	38	51	64	86	115
19	10	13	18	24	31	42	55	70	94	125
18	11	14	19	26	34	46	61	78	105	140
17	11	15	21	28	38	50	67	88	118	158
16	12	17	23	30	42	56	75	100	135	180
15	13	18	25	33	46	62	84	110	150	205
14	14	20	27	37	50	69	95	125	175	238
13	15	21	29	40	55	76	105	138	190	265
12	17	23	32	44	61	84	118	155	215	300
11	19	26	36	50	70	96	133	180	250	340
10	21	29	40	57	80	110	155	205	290	400
9	23	33	46	65	90	128	180	240	340	480
8	26	37	53	74	105	150	210	280	400	570
7	30	43	62	88	125	175	250	340	490	700
6	36	52	74	105	150	215	310	420	600	860
5	44	63	90	130	185	265	380	530	760	1150
4	55	80	118	170	245	350	510	710	1000	1500
3	75	110	160	230	340	490	700	1000	1400	2000

Low Mod. High Mod. High Very High Extreme

6.13. KARRI FUEL QUANTITY CORRECTION

Select known total fuel quantity (including litter, trash and scrub fuels) and the available fuel factor and read off the fuel correction factor.

Total fuel quantity tonnes/ha	Available fuel factor				
	0·1 to 0·2	0·2 to 0·8	0·9 to 1·0	A	B
6-11	0·6	0·7	0·9	1·1	1·3
12-17	0·6	0·8	1·0	1·2	1·5
18-23	0·7	0·8	1·1	1·3	1·6
24-29	0·8	0·9	1·2	1·4	1·8
30-36	0·9	1·0	1·3	1·5	2·0
37-43	0·9	1·1	1·3	1·6	2·2
44-50	1·0	1·2	1·4	1·8	2·4
51-57	1·1	1·3	1·5	1·9	2·6
58 +	1·2	1·4	1·6	2·0	2·8

Adjusted rate of spread = Rate of spread index x Fuel correction factor.

6.13.1. Karri Slope Correction Factors

Use table 6.6.

6.13.2. Total Available Fuel Quantity

= Total litter weight x A.F.F. (see table 7.2.1)
+ Available trash weight (see table 7.3.1)
+ Scrub foliage consumed (see table 7.4.1).

7. AIDS FOR PRESCRIBED BURNING

7.1. RATE OF LITTER ACCUMULATION

Tables show rate of accumulation of litter and twigs up to 10 mm diameter.

7.1.1. **Jarrah** (tonnes/ha)

No. of annual leaf falls	Canopy cover									
	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	100 %
1	0·2	1·0	1·5	1·7	2·2	2·5	2·7	3·0	3·2	3·5
2	0·7	1·7	2·2	2·7	3·2	3·5	4·0	4·2	4·5	4·7
3	1·5	2·5	3·2	4·0	4·5	4·7	5·2	5·5	5·7	6·2
4	2·2	3·5	4·5	5·2	5·7	6·2	6·7	7·0	7·5	7·7
5	3·2	4·7	6·0	6·7	7·2	8·0	8·2	8·7	9·2	9·5
6	4·5	6·2	7·5	8·2	9·0	9·7	10·2	10·7	11·2	11·5
10				10·0			15·0			

7.1.2. **Karri** (tonnes/ha)

No. of annual leaf falls	Canopy cover									
	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	100 %
1	2·5	3·2	4·0	5·0	6·0	7·0	8·2	9·5	11·0	12·5
2	4·2	5·2	6·2	7·2	8·5	9·7	11·2	12·7	14·2	16·0
3	6·0	7·0	8·2	9·5	10·7	12·2	13·7	15·5	17·2	19·0
4	7·5	8·7	10·0	11·5	13·0	14·5	16·2	18·0	19·7	21·7
5	9·0	10·5	11·7	13·2	15·0	16·7	18·5	20·2	22·2	24·2
6	10·5	12·0	13·5	15·2	16·7	18·7	20·5	22·5	24·7	26·7
7	12·0	13·5	15·2	17·0	18·7	20·7	22·7	24·7	27·0	29·2
8	13·5	15·2	17·0	18·7	20·3	22·5	24·7	26·7	29·0	31·5
9	15·0	16·7	18·5	20·5	22·5	24·5	26·7	29·0	31·2	33·7
10	16·5	18·2	20·2	22·2	24·2	26·2	28·5	31·0	33·2	36·0

7.2. LITTER DEPTH AND WEIGHT

7.2.1. Relationship Between Litter Depth and Total Litter Weight

Table includes twigs up to 10 mm diameter.

Litter depth mm	Forest type				
	Karri dominant	Mixed M., J., K.	Jarrah dominant	*P. pinaster* needle	*P. radiata* needle
	Litter weight (tonnes/ha)				
5	3·2	2·6	2·7	2·5	2·8
10	6·4	5·1	5·3	4·9	5·2
15	9·6	7·7	8·0	7·4	7·2
20	13·0	10·3	11·0	10·0	9·0
25	16·0	13·0	13·0	12·4	10·7
30	19·0	15·0	16·0	15·0	12·0
35	23·0	17·0	19·0	17·0	14·0
40	26·0	19·0	21·0	20·0	16·0
45	29·0	22·0	24·0	22·0	18·0
50	32·0	25·0	27·0	25·0	20·0
55	35·0	27·0	29·0	27·0	22·0
60	39·0			29·0	24·0
65	42·0			31·0	26·0
70	45·0			33·0	28·0
80	51·0			37·0	31·0
90	58·0			41·0	34·0
100	64·0			45·0	37·0

Enter table with litter depth and forest type and read off the total litter weight.

The available litter quantity is determined from product of total quantity and the available fuel factor (A.F.F.).

7.3. TRASH HEIGHT AND WEIGHT

7.3.1. Relationship Between Trash Height and Density in Southern Forest and Quantity for Burning

Trash includes dead tree branches and scrub debris of at least 10 mm diameter or thickness. Total weight refers to very dry conditions, and available weight to average prescribed burning conditions.

Depth of trash	Dense		Medium dense		Sparse	
metres	Total weight	Available weight	Total weight	Available weight	Total weight	Available weight
0·1	6	3	6	3	5	2·5
0·2	13	8	11	6	9	4·5
0·3	19	12	16	9	13	6·5
0·4	25	15	20	11	16	8
0·5	32	19	25	13	20	10
0·6	38	22	31	16	24	12
0·8	50	30	41	22	32	16
1·0	62	37	50	28	40	20
1·2	72	42	60	33	48	24
1·5	80	48	68	38	56	28

Read in the average trash depth (metres) and the trash density rating. Read off the weight (tonnes per hectare) or either the total trash or the available trash (less than 15 mm diameter).

The available component is the weight used for normal burn prescriptions.

7.4. WEIGHT OF UNDERSTOREY SCRUB FUEL AVAILABLE FOR BURNING

7.4.1. Scrub Fuel Weight (tonnes per hectare)

Scrub structural type	Average scrub height (m)	Total live scrub (consumed in intense wildfire)			Total foliage (consumed in moderate wildfires)			Low foliage (consumed in prescribed burning)		
		Dense	Medium	Sparse	Dense	Medium	Sparse	Dense	Medium	Sparse
1. For example, hazel, netic, K-wattle	7·0 +	40	35	31	9	8	7	0·5	0·3	0·3
	6·0	35	31	26	8	7	6	0·5	0·3	0·3
	5·5	30	27	23	7	6	5	0·5	0·3	0·2
	5·0–	23	20	17	5	5	4	0·5	0·3	0·2
2. For example, hazel or netic with *Acacia* sp. understorey	7·0 +	49	43	39	10	9	8	3	2·5	1·5
	6·0	43	38	33	9	8	7	3	2	1·5
	5·5	38	34	29	8	7	6	3	2	1·2
	5·0–	33	29	25	7	6	5	2·5	1·5	1·0
3. For example, hovea, *A. pulchella, A. strigosa, A. pentadenia*	3·5 +	19	13	9	6	5	3·5	2	1·5	1
	3·0	16	11	7	5	4	3	2	1·5	1
	2·5	13	9	6	4	3	2·5	2	1·8	1·2
	2·0	9	7	5	3	2·5	2	2·5	2	1·5
	1·5–	6	4	3	2·5	2	1·5	2·5	2	1·5
4. For example, *Agonis* sp. *pimelia*	5·5 +	32	25	20	6	5	4	1·5	1·2	1
	5·0	26	20	15	5	4	3	1·5	1·2	1
	4·5	23	17	11	4	3	2·5	1·2	1	1
	4·0	20	14	8	4	3	2	1·2	1	1
	3·5–	16	10	7	3	2·5	2	1	1	0·8
5. For example, netic, *A. urophylla*, young hazel	5·5 +	35	28	20	6	5	4	2	1·5	1
	5·0	28	22	16	5	4	3	2	1·5	1
	4·5	22	18	14	4	3	2·5	2	1·5	1
	4·0	19	15	11	4	3	2	1·5	1·2	1
	3·5–	14	12	9	3	2·5	2	1·5	1·2	1
6. For example, young scrub, creeper, tall grasses, jarrah, scrub	1·5 +	7	5	4	3·5	3	2·5	2·5	2	1·5
	1·2	5	4	3	3	2·5	2	2	1·5	1
	0·9	3	3	2	2·5	2	1·5	2	1·5	1
	0·6–	3	2	1·5	2	1·5	1	1·5	1	0.8

Enter table with scrub structural type, average height, and scrub density rating. Read off the scrub weight (tonne/ha) of either the total scrub (consumed by intense wild-fires), total foliage (burnt in moderate wild-fires), and foliage below 1·5 metres (burnt by prescribed fires).

7.5. RELATIONSHIP BETWEEN R.O.S., FUEL QUANTITY AND CROWN SCORCH HEIGHT

7.5.1. Jarrah and Pine Forest

16 to 22 per cent							Surface moisture content (per cent)	10 to 15 per cent							
13	11	9	8	7	5·5	4	Fuel quantity (tonnes/ha)	15	13	11	9	8	7	5·5	4
8	7	6	5	4	3	2	Number of leaf falls	8 +	8	7	6	5	4	3	2
Forward rate of spread (metres/hr)							Fire Danger	Forward rate of spread (metres/hr)							
10	10		8					12	12	10	10	8			
12	12	10	10				Low	16	14	12	12	10			
14	14	12	12	10			Maximum scorch:	18	16	14	14	12	10		
16	16	14	14	12	10		Spring 4·5 m	20	18	18	16	14	12	10	
20	18	16	16	14	12	10	Autumn 8·0 m	24	20	20	18	16	14	12	10
22	20	18	18	16	14	12		28	24	22	20	18	16	14	12
24	22	20	20	18	16	14		30	26	24	22	20	18	16	14
26	24	22	22	20	18	16		34	28	26	24	22	20	18	16
28	26	24	24	22	20	18	Mod.	36	32	28	26	24	22	18	18
30	28	26	26	24	22	20	Maximum scorch:	40	34	30	28	26	24	20	18
32	30	28	28	26	24	22	Spring 6·0 m	42	36	34	30	28	26	22	20
34	32	30	30	28	26	24	Autumn 10·5 m	46	40	36	34	30	28	24	22
36	34	32	32	30	28	26		48	42	38	36	32	28	26	22
40	36	34	34	32	30	28		52	44	40	38	34	30	28	24
42	40	36	36	34	32	30		54	46	44	40	36	32	28	26
44	42	40	38	36	34	32		58	50	46	42	38	34	30	28
46	44	42	40	38	36	34	High	60	52	48	44	40	36	32	28
48	46	44	42	40	38	36	Maximum scorch:		54	50	46	42	38	34	30
50	48	46	44	42	40	38	Spring 9·0 m		58	54	48	44	40	36	32
52	50	48	46	44	42	40	Autumn 13·5 m		60	56	50	46	42	36	32
56	52	50	48	46	44	42				58	52	48	44	38	34
58	54	52	50	48	46	44				60	56	50	46	40	34
60	56	54	52	50	48	46					58	52	48	42	36
	58	56	54	52	50	48					60	54	48	44	38
	60	58	56	54	52	50						56	50	44	40
		60	58	56	54	52						58	52	46	42
			60	58	56	54	Fuel age is					60	54	48	42
			62	60	58	56	applicable only where					62	56	50	44
			64		60	58	forest canopy approximates					64	58	50	46
			66			60	80 per cent					66	60	52	46
			68				(see Table 7.1.1)					68		54	48
			70									70		56	50

Enter table with calculated minimum S.M.C. percentage and locate the jarrah R.O.S.I. in the standard fuel column (5 years, 8 tonne/ha). Determine fuel-corrected R.O.S. by horizontal reference to column with actual fuel quantity (or age). Check that resulting scorch height class is suitable.

7.5.2. Southern Forest

Fuel-corrected Rate of Spread and Scorch Height

Maximum scorch height (metres)	Total available fuel quantity (tonnes/ha)						
	5-9	10-14	15-19	20-27	28-35	36-44	45 +
	Rate of forward spread (metres/hour)						
4 m			10	11	12	13	15
		11	12	13	14	16	18
	11	12	14	15	17	18	21
	13	14	16	18	19	21	24
	14	16	18	20	22	23	27
	16	18	20	22	24	26	30
	18	19	22	24	26	28	33
	Four	Six		Nine	Twelve	Fifteen	
	19	21	24	26	29	31	36
	21	23	26	29	31	34	39
6 m	22	25	28	31	34	36	42
	24	27	30	33	36	39	45
	25	29	32	35	38	42	48
	27	31	34	37	41	44	51
	29	32	36	40	43	47	54
	30	34	38	42	46	50	57
	32	36	40	44	48	52	60
	34	38	42	46	50	55	63
	35	40	44	48	53	57	66
	37	41	46	50	55	60	69
9 m	38	43	48	53	58	63	72
	40	45	50	55	60	65	75
	42	47	52	57	62	68	78
	Nine		Twelve	Fifteen		Twenty plus	
	43	49	54	59	65	70	81
	45	50	56	61	67	73	84
	46	52	58	63	70	76	87
	48	54	60	66	72	78	90
	50	56	62	68	75	81	93
	51	58	64	70	77	83	96
	53	59	66	72	79	86	99
	54	61	68	75	82	89	102
	56	63	70	77	84	91	105
12 m	58	65	72	79	86	94	108
	59	66	74	81	89	96	112

Locate the calculated karri R.O.S.I. (table 6.12) in the standard fuel column (15-19 tonne/ha available fuel). Determine the fuel-corrected rate of spread by horizontal reference to adjacent column with actual fuel quantity. Check that resulting scorch height class is suitable.

7.6. FIRE DANGER CLASSES

Fire Danger	Rate of spread	Type of burn
LOW	0·0 to 11·9 metres/hour	Coppice and pine
	12 to 20 metres/hour	Prescribed burning range
MOD.	21 to 40 metres/hour	
HIGH	41 to 60 metres/hour	
	61 to 140 metres/hour	Warm burns
VERY HIGH	141 to 240 metres/hour	
EXTREME	241 to 320 metres/hour	Large fire organisation
	321 to 400 metres/hour	
	401 + metres/hour	

7.7. LIGHTING PATTERN

7.7.1. Hours of Burning Time Available

Predicted minimum S.M.C. %	Start time	Jarrah burning hours		Karri burning hours	
		Spring	Autumn	Spring	Autumn
20	1430	0	1	0	1
18	1400	1	2	1	2
16	1230	4	5	2	3
14	1100	6	7	5	6
12	1000	8	9	7	8
10	0900	10	12	9	10
8	0830	12	14	11	12

Enter table 7.7.1 with predicted minimum S.M.C. and season. Read off the hours of burning time available and the likely start time of burning for either jarrah or karri forests.

7.7.2. Estimation of Strip Width

Strip width = Hours of burning time available x R.O.S.
Spot width = Half strip width.

Forward rate of spread (m/hour)	Hours of burning time available								
	2	3	4	5	6	7	8	9	10
10	20	30	40	50	60	70	80	90	100
12	24	36	48	60	72	84	96	108	120
14	28	42	56	70	84	98	112	126	140
16	32	48	64	80	96	112	128	144	160
18	36	54	72	90	108	126	144	162	180
20	40	60	80	100	120	140	160	180	200
22	44	66	88	110	132	154	176	198	220
24	48	72	96	120	144	168	192	216	240
26	52	78	104	130	156	182	208	234	260
28	56	84	112	140	168	196	224	252	280
30	60	90	120	150	180	210	240	270	300
32	64	96	128	160	192	224	256	288	320
34	68	102	136	170	204	238	272	306	340
36	72	108	144	180	216	252	288	324	360
38	76	114	152	190	228	266	304	342	380
40	80	120	160	200	240	280	320	360	400
42	84	126	168	210	252	294	336	378	420
44	88	132	176	220	264	308	352	396	440
46	92	138	184	230	276	322	368	414	460
48	96	144	192	240	288	336	384	432	480
50	100	150	200	250	300	350	400	450	500

7.8. OVERSEER'S BURNING TABLES

1. From table 6.7 for jarrah (table 6.12 for karri), use the surface moisture content and wind speed to determine the rate of forward spread for five-year-old fuel (7·6 to 8·5 tonnes/ha for jarrah; 15 to 19 tonnes/ha available for karri).
2. In table 7.5.1 for jarrah (table 7.5.2 for karri), locate the calculated rate of spread in the standard fuel (five-year-old) column and determine the corrected forward spread by reading across to the actual fuel quantity. Read off the

corresponding colour code or maximum acceptable scorch height for this fuel and decide if this is acceptable for the forest type under consideration.

3. From table 7.7.1 or figure 4.3.7 determine the hours of burning time available.
4. Use table 7.7.2 to derive strip width and spot distance.

Example 1—Northern Jarrah Forest Spring Burn

Predicted minimum S.M.C.		14 per cent
Wind at nearest tower (5:1 ratio)		18 km/hr
Rate of spread index (Table 6.7)		22 m/hr
Total weight of fuel (all available)		10·5 tonnes/ha
Rate of spread corrected for fuel (Table 7.5.1)		26 m/hr
Scorch height estimated (Table 7.5.1)		6 metres
Hours of burning available (Table 7.7.1)		6 hours
Strip width (Table 7.7.2), 26 x 6 hours	=	156 metres
Spot distances, 156 x ½		78 metres

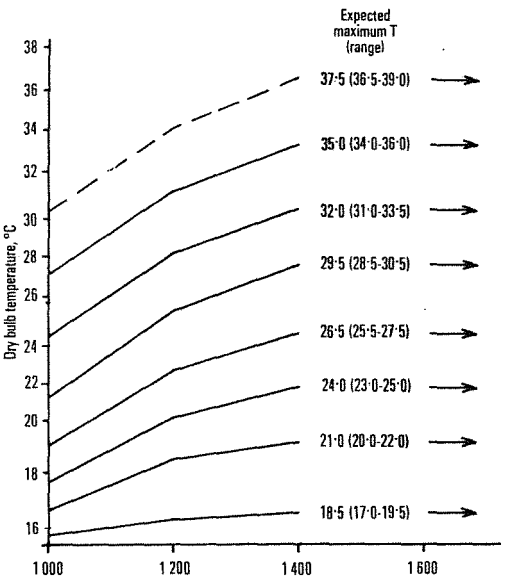
Example 2—Karri (4 and 5) Forest Spring Burn

Predicted minimum S.M.C.		14 per cent
Predicted maximum available fuel factor		0·5
Wind at nearest tower (scrub types 4 and 5)		20 km/hr
Rate of spread index (Table 6.12)		37 m/hr
Total available fuel weight (include litter, trash, scrub)		14 tonnes/ha
Rate of spread corrected for fuel (Table 7.5.2)		33 m/hr
Table 7.5.2 indicates scorch height about		9 metres
Hours of burning available (Table 7.7.1)		5 hours
Strip width (Table 7.7.2), 33 x 5 hours	=	165 metres
Distance between spots, 165 x ½		83 metres

8. AIDS FOR WEATHER FORECASTING

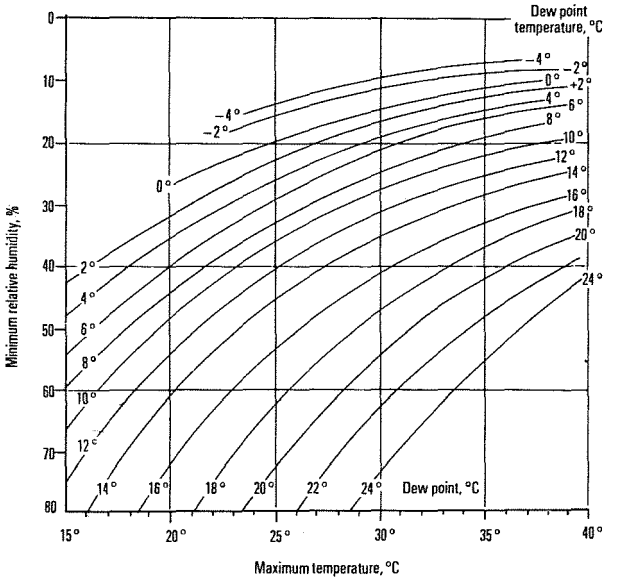
8.1. PREDICTION OF MAXIMUM TEMPERATURE

Time and Temperature Graph



Apply temperature and the time it was taken. Read off the expected maximum temperature from the arrowed line nearest which the data plots. This graph applies to clear skies. For daylight saving add one hour to graph times.

8.2. PREDICTION OF MINIMUM RELATIVE HUMIDITY



1. Obtain dew point temperature for today from wet and dry bulb temperature.

2. Apply maximum temperature (calculated or forecast) and dew point temperature and read off the minimum relative humidity.

8.3. DEW POINT CALCULATION

(Required for prediction of minimum relative humidity—see figure 8.2)

Dry Bulb Temp.(°C)	Wet bulb depression (°C)																	
	0	1·0	2·0	3·0	4·0	5·0	6·0	7·0	8·0	9·0	10·0	11·0	12·0	13·0	14·0	15·0	16·0	17·0	18·0
36	36	34	33	32	31	29	28	26	25	23	21	19	17	15	13	10	7	4	0
35	35	33	32	31	30	28	27	25	24	22	20	18	16	14	11	9	5	2	−3
34	34	32	31	30	29	27	26	24	22	21	19	17	15	12	10	7	3	−1	−7
33	33	32	30	29	27	26	24	23	21	19	17	15	13	11	8	5	1	−4	
32	32	31	29	28	26	25	23	22	20	18	16	14	12	9	6	2	−2		
31	31	30	28	27	25	24	22	20	19	17	15	12	10	7	4	0	−5		
30	30	29	27	26	24	23	21	19	17	15	13	11	8	5	2	−3			
29	29	28	26	25	23	22	20	18	16	14	12	9	6	3	−1				
28	28	27	25	24	22	21	19	17	15	13	10	8	5	1	−4				
27	27	26	24	23	21	19	17	16	13	11	9	6	3	−2					
26	26	25	23	21	20	18	16	14	12	10	7	4	0	−4					
25	25	23	22	20	19	17	15	13	11	8	5	2	−2						
24	24	22	21	19	18	16	14	12	9	7	4	0	−5						
23	23	21	20	18	16	15	12	10	8	5	2	−2							
22	22	20	19	17	15	13	11	9	6	3	0	−5							
21	21	19	18	16	14	12	10	7	5	1	−3								
20	20	18	17	15	13	11	9	6	3	−1	−5								
19	19	17	16	14	12	10	7	4	1	−3									
18	18	16	15	13	11	8	6	3	−1	−5									
17	17	15	13	11	9	7	4	1	−3										
16	16	14	12	10	8	6	3	−1	−5										
15	15	13	11	9	7	4	1	−2											
14	14	12	10	8	6	3	−1	−4											
13	13	11	9	7	4	1	−2												
12	12	10	8	6	3	0	−4												

1. Obtain wet bulb depression by subtracting wet bulb temperature from dry bulb temperature.
2. Apply dry bulb temperature and wet bulb depression and read off the dew point temperature.

N.B. It will be necessary to interpolate if temperatures are read to nearest 0·5°C.

9. FIRE SUPPRESSION

9.1. DESPATCH TABLES

Shows size of suppression force and equipment to be despatched for suppression of fires in jarrah, karri and pine fuels. Size depends on time to reach the fire.

9.1.1. Jarrah

Fire danger m/hr	Time between detection and attack															
	½ hour				1 hour				1½ hours				2 hours			
	G.	H.D.	L.T.	B.D.	G.	H.D.	L.T.	B.D.	G.	H.D.	L.T.	B.D.	G.	H.D.	L.T.	B.D.
0-12	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0
13-20	1	1	0	0	1	1	0	0	1	1	1	0	1	1	1	0
21-40	1	1	0	0	1	1	1	0	2	2	1	0	2	2	1	0
41-60	2	2	0	0	2	2	1	0	3	2	2	0	3	3	2	0
61-140	2	2	1	0	3	3	1	1	4	4	2	1	4	4	2	1
141-240	3	3	1	0	3	3	2	1	4	4	3	1	5	5	3	2
241-320	3	3	1	1	4	4	2	2	5	5	3	2	6	6	4	3
321-400	4	3	2	1	5	5	3	3	6	6	3	3	7	7	5	5
401+	4	4	2	2	6	6	3	4	7	7	4	4	8	8	5	6

G. Gang
H.D. Heavy duty
L.T. Light tractor (wheel blade or equivalent)
B.D. Bulldozer

9.1.2. Karri

Fire danger m/hr	Time between detection and attack															
	½ hour				1 hour				1½ hours				2 hours			
	G.	H.D.	L.T.	B.D.	G.	H.D.	L.T.	B.D.	G.	H.D.	L.T.	B.D.	G.	H.D.	L.T.	B.D.
0-12	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
13-20	1	1	1	0	1	1	1	0	1	1	1	1	2	1	1	1
21-40	1	1	1	0	2	1	1	1	2	2	1	1	3	2	2	2
41-60	2	1	1	1	2	2	2	1	3	2	1	2	4	3	3	3
61-140	2	2	2	1	3	3	2	1	4	4	3	3	5	5	4	4
141-240	2	3	2	1	3	4	3	2	4	5	3	4	6	6	5	5
241-320	3	3	2	1	4	5	3	2	5	6	4	4	6	6	5	5
321-400	4	3	3	2	5	6	4	3	6	7	4	5	7	7	6	7
401+	4	4	3	2	6	6	4	4	7	7	5	5	8	8	7	7

G. Gang
H.D. Heavy duty
L.T. Light tractor (wheel blade or equivalent)
B.D. Bulldozer

9.1.3. Pinus

Fire danger m/hr	Time between detection and attack														
	10 minutes			½ hour			1 hour			1½ hours			2 hours		
	G.	H.D.	B.D.	G.	H.D.	B.D.	G.	H.D.	B.D.	G.	H.D.	B.D.	G.	H.D.	B.D.
0-12	1	0	0	1	0	0	1	0	0	1	1	0	1	1	0
13-20	1	1	0	1	1	0	1	1	0	2	2	0	3	3	1
21-40	1	1	0	2	1	0	2	2	1	3	3	1	5	5	2
41-60	1	2	0	2	2	1	2	2	2	5	5	3	7	7	4
61-140	2	2	0	2	2	1	3	3	2	7	7	4	9	9	5
141-240	2	2	0	4	3	1	5	4	2	9	8	4			
241-320	2	2	1	5	4	1	7	5	2						
321-400	3	3	1	6	5	2	8	7	3						
401+	3	3	1	7	6	2	11	8	3						

G. Gang H.D. Heavy duty B.D. Bulldozer

9.2. INFORMATION FOR PLANNING SUPPRESSION STRATEGY AND TACTICS

9.2.1. Length of Fire Perimeter

To be used for fires running under severe conditions with constant wind direction.

To use this table, determine length of fire (i.e. start point or tail fire to head fire), select appropriate figure in column 1 and then read off perimeter in column 2.

Length of fire metres	Perimeter metres	Length of fire metres	Perimeter metres
50	150	3000	7500
100	300	3500	8500
200	600	4000	9500
400	1000	4500	11000
600	1600	5000	12000
800	2000	6000	15000
1000	2500	7000	17000
1500	3500	8000	19000
2000	5000	9000	21000
2500	6000	10000	24000

9.2.2. Plant Travel Times

9.2.2.1. *Rates of Travel Time for Transporting Bulldozers*

Type of road	D4 (average kph)		D6 (average kph)		D7 (average kph)		D8 (average kph)		Transporter (unladen) (average kph)
	1st hour*	Other hours	1st hour	Other hours	1st hour	Other hours	1st hour	Other hours	
Main highway (transporter)	25	50	25	50	22	45	20	40	60
Good gravel road (transporter)†	25	30	25	30	22	27	20	25	50
Forest track (transporter)	15	20	10	15	9	13	8	12	20
Walking time (bulldozer)	8	–	9	–	(Not recommended)				

*Time for the first hour includes loading the machine.
† Good gravel road–e.g. C.A.R.G. road, major logging road.

9.2.2.2. *Rates of Travel Times for Gang Trucks and Heavy Duties*

Type of road	Gang truck (average kph)	Heavy duty (average kph)
Main highway	60	50
Good gravel road	50	40
Forest track	30	25

This table assumes vehicles are carrying a full load of water.

9.2.3. Fireline Production Tables

9.2.3.1. *Rate of Fireline Production by Crews Using Hand Tools*

N.B. Line produced = Line constructed and held.

Crew strength (No. of men)	Fuels less than 10 tonnes/ha			Fuels more than 10 tonnes/ha		
	F.D.I. < 20	20 to 60	> 60	F.D.I. < 20	20 to 60	> 60
	metres/hour			metres/hour		
1	100	80	50	70	50	30
2	180	140	90	130	90	50
3	250	190	130	160	110	60
4	300	230	160	180	120	70
5	330	260	180	190	130	75
6	350	270	190	200	140	80

The table values have not been fully tested and are presented as a guide-line only.

9.2.3.2. *Rates of Fireline Production by Bulldozers*

Scrub/fuel type	Rate of production (metres/hour)		
	D8/D7E	D6	D4
Light fuel and scrub (e.g. jarrah)	1000	1000	1000
Heavy fuel and scrub (e.g. karri)	400	250	100

N.B. These are average values only, allowing for normal problems with slope, rock, logs and backing up to deal with hop-overs.

Fire-line production in pine plantations by tractor-drawn plough or shovel-loader: 3000 metres per hour.