

Field Guide

Fuel Assessment and Fire Behaviour Prediction in Dry Eucalypt Forest

Interim Edition 2007

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Fuel Assessment and Fire Behaviour Prediction in Dry Eucalypt Forest

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Preface

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Persons involved with making fire behaviour predictions are encouraged to communicate their assessment of this interim edition of this field guide to the authors. For further information contact:

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Warning: The fire behaviour information provided by this field guide is a guide only. No warranties, guarantees or representation are made that it is 100% accurate.



About this Guide

The purpose of this guide is to provide a systematic method for assessing fuel hazard and predicting potential fire behaviour (rate of spread, flame height, spotting distance) in dry eucalypt forest. Fuel assessment is based on the hazard scoring system employed during Project Vesta which investigated the effects of fuel age and understorey vegetation structure on fire behaviour in dry eucalypt forest. The Project Vesta fuel hazard scoring system is similar to the Victorian system (developed by Wilson 1992a, 1992b, 1993) and revised by McCarthy *et al.* (1999), which is also receiving some usage in Queensland and NSW. The scale that underlies the scores, however, relates directly to fire behaviour (hence indirectly to fire suppression) rather than directly to difficulty of fire suppression. The system used in South Australia (Department of Environment and Heritage 2006) is based largely on the Victorian system and preliminary results from Project Vesta. This guide is primarily intended for use in dry eucalypt forest with a litter and shrub understorey but has not yet been validated in forest with a predominantly grassy understorey.

Information provided in this guide can be used to:

1. Define and identify different fuel layers and components of fuel structure and hazard.
2. Determine the hazard score of surface and near-surface fuel layers and the height of the near-surface fuel for fire spread prediction.
3. Determine elevated fuel height for flame height prediction.
4. Determine surface fuel hazard score and bark hazard score for spotting distance prediction.

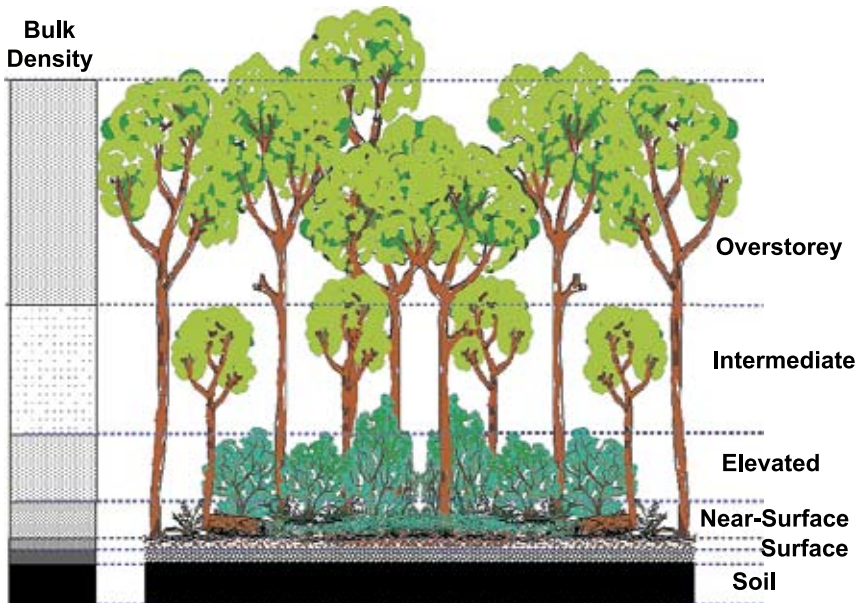
Users of this guide need to be aware that the fire spread model used to develop the tables has a number of underlying assumptions which are discussed in the following paragraphs. Predictions from the model compare well with wildfire data across a broad range of burning conditions but this may not always be the case if field conditions differ from those assumed by the model.

- The fire spread model predicts the potential quasi–steady rate of spread of a fire burning under summer conditions after the fire has undergone its initial growth phase. The model has been developed using data from experimental fires with a head fire width of around 100 m and should accurately predict the potential rate of spread of wildfires when wind speed is less than 20 kmh⁻¹. Fires burning under stronger winds may not reach a quasi–steady rate of spread until the head fire is wider than 300 m.
- The model does not predict the rate of spread during the build–up period of a fire starting from a point ignition. Fires can burn at a quasi–steady rate that is well below the potential rate if the head fire is constrained. Experimental evidence from grassland fires shows that the time taken to reach potential rate of spread for a mean wind speed of 15 km h⁻¹ may be as short as 12 minutes or as long as 45 minutes depending on the frequency and magnitude of wind shifts.
- Forest fires will take considerably longer than grass fires to reach their potential rate of spread because a number of factors tend to constrain the widening of the head fire. These factors include:
 - Heavy fuel burning out slowly can develop a convective centre behind the flame zone which draws the local wind along flanks and pushes the flames back over the burnt ground, thus restricting the lateral development of the fire.
 - Wind gusts in the forest persist only for short periods.
 - Fires burning up slopes are constrained in lateral spread.
 - Large logs or rocky ground may restrict the initial development of the fire.
- The fire behaviour tables are designed for summer conditions when all of the surface and near–surface fuel is available to burn. Fire behaviour may be less severe than predicted by the tables if the amount of moisture present in the fuel bed is sufficient to limit the consumption of the surface and near–surface fuel layers.
- Practical use of the prediction tables in this guide requires good input data. Fuel assessment based on systematic estimation of the hazard score and height of critical fuel layers is relatively straight forward and is more reliable than estimation of fuel load. Hazard assessment, in combination with predictions of fire behaviour, will also be useful for estimating suppression difficulty and overall fire threat.

Fuel Assessment



Fuel Layers



Layers of fuel within the forest that can be identified visually. The grey scale on the side indicates the relative bulk density of each layer.

Fine fuel is consumed in the flaming zone of a fire, typically being dead plant material < 6 mm thick and live plant material < 3 mm thick.

Fuels in open dry eucalypt forest can be divided into four visually obvious layers that can be linked to observed fire behaviour. These layers can be broadly identified by a change in bulk density and are illustrated in the figure above.

The four main layers are:

1. Surface fuel – including leaf litter, fine twigs and duff
2. Near-surface fuel
3. Elevated fuel
4. Intermediate and Overstorey bark fuel (this layer only considers the characteristic and condition of the bark fuel).

Fuel Assessment (F)

There are 4 key attributes of fuel that need to be considered in assessing the fuel:

1. the thickness of fuel elements
2. the degree of horizontal and vertical continuity
3. the proportion of dead fine fuel in the fuel bed
4. the height of the most continuous fuel stratum

Fuel assessment is achieved by taking the average of 10 hazard score assessments and height measurements over a 300 m walk through. At each sampling point (approximately 30 m apart) the surface fuel, near-surface fuel and elevated fuel is visually assessed for its fuel hazard rating/score within a 5 m radius of the sample point. The average top-height of the near-surface fuel and elevated fuel is measured. Bark fuel is visually assessed within a 10 m radius of the sample point and the bark hazard rating/score is noted.

The fuel assessment for the fire behaviour guide only relates to open dry eucalypt forest. To use this guide, only the surface fuel hazard score, the near-surface fine fuel hazard score and the near-surface fuel height (cm) will be needed.

SURFACE FUEL LAYER (SF) – dead leaves, twigs and bark of overstorey and understorey plants (litter fuel). Fuel components are generally horizontally layered. This layer usually makes up the bulk of the fuel consumed and provides most of the energy released by the fire. Surface fuel burns both by flaming and smouldering combustion and determines the flame depth of a surface fire.

Low Surface Fuel Hazard (Surface fuel hazard score=1)



Moderate Surface Fuel Hazard (Surface fuel hazard score=2)



High Surface Fuel Hazard (Surface fuel hazard score=3)



Extreme Surface Fuel Hazard (Surface fuel hazard score=4)

Table F1 Surface Fuel Hazard Rating

Hazard Rating	Description	Hazard Score	Litter depth (mm)*	Available fuel (t/ha)*
Nil	No surface litter, bare ground	0	-	0
Low	Very thin layer, no decomposition, discontinuous	1	<10	2-6
Moderate	Thin layer, no decomposition, continuous	2	10-20	6-10
High	Established litter layer, continuous, decomposing	3	15-25	10-14
Very High	Thick litter layer, continuous, decomposing, duff layer may be present	3.5	15-25	12-16
Extreme	Very thick continuous layer of litter with duff present	4	>25	16+

* Fine fuel load likely to be consumed under summer conditions

NEAR-SURFACE FUEL LAYER (NSF) – grasses, low shrubs, creepers, and collapsed understorey usually containing suspended leaf, twig and bark from the overstorey vegetation. The height of this layer can vary from a few centimetres to over a metre above the ground. The orientation of the fuel layer components includes a mixture ranging from horizontal to vertical and capable of supporting leaf, twig and bark material above the ground.

Low Near-surface Fuel Hazard (Near-surface fuel hazard score=1)



Moderate Near-surface Fuel Hazard (Near-surface fuel hazard score=2)



High Near-surface Fuel Hazard (Near-surface fuel hazard score=3)



Extreme Near-surface Fuel Hazard (Near-surface fuel hazard score=4)

Table F2 Near-surface Fuel Hazard

Hazard Rating	Description	Hazard Score	Available fuel (t/ha)
Nil	No near-surface fuel	0	0
Low	Sparse dispersed fuel, dead material virtually absent	1	1
Moderate	Scattered suspended leaves, twigs and bark, proportion of dead material is <20%	2	2
High	Suspended leaves, twigs and bark, starting to obscure logs and rocks, proportion of dead material is 20–50%	3	3
Very High	Suspended leaves and bark with a cover of 40–60% cover, proportion of dead material is 20–50%	3.5	3.5
Extreme	Very large amounts of suspended leaves, twigs and bark, high proportion of dead material >50%, vegetation is senescent, obscuring logs and rocks.	4	4

Near-surface fuel hazard – Tussock Grasses, Sedges/Rushes, and Hummock Grasses assessed as per SA guide.

Near-surface fuel Height (cm) – average of 10 measurements

ELEVATED FUEL LAYER (EF) – tall shrubs and other understorey plants without significant suspended material. This layer may include regeneration of the overstorey species intermixed with shrubs. The individual fuel components generally have an upright orientation and include live and dead material.

Low Elevated Fuel Hazard (Elevated fuel hazard score=1)



Moderate Elevated Fuel Hazard (Elevated fuel hazard score=2)



High Elevated Fuel Hazard (Elevated fuel hazard score=3)



Extreme Elevated Fuel Hazard (Elevated fuel hazard score=4)

Table F3 Elevated Fuel Hazard

Hazard Rating	Description	Fraction Dead (%)	Hazard Score	Available fuel (t/ha)
Nil	No elevated fuel	0	0	0
Low	Sparse and dispersed	< 5%	1	0-1
Moderate	Sparse and dispersed, brush against occasionally	< 20%	2	1-2
High	Little fine fuel at base, patchy or mesic shrubs	10-30%	3	2-3
Very High	Difficult to walk through, good vertical continuity of dead material	20+%	3.5	3-5
Extreme	Difficult to walk through, vertical continuity of fine dead fuel from ground up	30+%	4	5-8

Flame Height

Elevated fuel height (m) – average of 5 measurements

Intermediate and Overstorey Bark (BF) – the bark on the bole and branches, either alive or dead, extending right back to the cambial layer.

- a. *Smooth bark* – as found on gum-barked eucalypts, characterised by the annual shedding of old bark layers and the exposure of a smooth living bark. Long strips of bark, half a metre or more fall off the stem and often drape over branches. This bark may burn for half an hour or more and is sometimes called “candle” bark.
- b. *Platy and sub-fibrous barks* – as found on peppermints, box, bloodwoods, ironbarks, pines and deciduous hardwoods and characterised by layers of old, dead bark tightly held to the bole and branches, but capable of flaking and losing small chunks as a result of burning or weathering.
- c. *Stringybarks* – as found on stringybark and ash eucalypts and characterised by persistent old dead bark forming deep fissures and a relatively spongy fibrous mass and falling off in wads when very old or as a result of burning. Long-unburnt trees can produce massive amounts of burning embers.



Low Bark Hazard (Bark hazard score=0, recently charred stringybark)



Low Bark Hazard (Bark hazard score=0, entirely smooth bark)

Moderate Bark Hazard
(Bark hazard score=1,
smooth or gum bark with
no long ribbons of bark)

Moderate Bark Hazard (Bark hazard
score=1, well charred stringybarks)



High Bark Hazard (Bark hazard score=2,
few pieces of stringybark loosely held
char still present)



High Bark Hazard (Bark
hazard score=2, Long
ribbon of bark, but smooth
trunk)

Very High Bark Hazard
(Bark hazard score=3,
sub-fibrous loose bark)

Very High Bark Hazard (Bark hazard
score=3, few pieces of stringybark
loosely held char still present)



Extreme Bark Hazard
(Bark hazard score=4)

Extreme Bark Hazard
(Bark hazard score=4)

Table F4 Bark Fuel Hazard Rating

Hazard Rating	Description	Hazard Score	Available fuel (t/ha)
Low	No fibrous bark, no spotting	0	0
Moderate	<ul style="list-style-type: none"> - stringybark where bark is well charred and tightly held on whole trunk - ironbarks with very tight, platy or fibrous bark - smooth-barks, which do not produce long ribbons of bark 	1	1
High	<ul style="list-style-type: none"> - stringybark where most of bark is black on the lower trunk - few pieces of bark are loosely attached to trunks - bloodwood with tight fibrous bark which has not been burnt for many years - smooth / candle bark which shed long ribbons of bark but have smooth bark down to ground level 	2	2
Very High	<ul style="list-style-type: none"> - stringybarks where <50% of surface area of the trees is black - upper parts of trunk may not be charred - smooth / candle barks with long ribbons of bark which are loose - fibrous or platy bark on lower trunk, which have not been burnt for many years 	3	5
Extreme	<ul style="list-style-type: none"> - stringybark with large flakes of bark that can be easily dislodged - huge amounts of bark are available for spotting - outer bark on the trees is attached weakly - minimal evidence of charring (complete grey appearance on trunks) 	4	7

Rate of Spread



Rate of Spread Tables (R)

The fire behaviour tables are a systematic method for predicting forest fire behaviour in dry eucalypt forest. They are derived from mathematical equations relating wind, fuel structure, fuel moisture and slope for different fuel hazard ratings (scores). This guide is intended mainly to be used as a field reference. Certain simplifications were made so that the fire behaviour predictions could be presented in tabular form.

A complete technical description of the dry eucalypt forest fire behaviour prediction system is given in the technical report Gould JS, McCaw WL, Cheney NP, Ellis PF, Knight IK, Sullivan AL. (2007) *Project Vesta – Fire in Dry Eucalypt Forest: fuel structure, fuel dynamics and fire behaviour*. Ensis–CSIRO, Canberra, ACT and Department of Environment and Conservation, Perth, WA.

Use of the Fire Behaviour Tables

1. Select the appropriate fuel hazard score for the surface fuel and near–surface fuel from Table F1 and F2 and the estimated near–surface fuel height (cm).
2. Input the mean wind speed at height of 10 m in the open over level ground for a period of 15–20 minutes. You may need to use a measurement made at an appropriate nearby weather station, or a reliable forecast of wind speed. Measurements of wind at 2 m in the open can be adjusted to 10 m wind speed by multiplying by 1.25 (i.e. ratio between wind at 10 m in the open and wind speed at 2 m in the open is 10:8).

Measurement of wind in the forest is not recommended because of the great difficulty in finding a site that represents the mean of the variations induced by the topography and the vegetation.

If you must do it you will need an appropriate ratio to determine the standard 10 m wind speed above the canopy:

- Measure the wind speed on a windward slope at 2 m in a location away from tall shrubs or tree trunks for 20 minutes.
- Multiply the average reading by 3.0.

One of the major sources of error in the application of any fire spread model based on wind in the forest is the selection of an appropriate ratio to relate the wind in the open or above canopy to the wind in the forest. We would expect the model to over-predict fire spread in tall dense forest where the ratio of the wind above the canopy to the wind at 2 m in the forest to is likely be 5:1 or even 6:1.

If an anemometer is not available, a trained observer may assess wind speed with reasonable accuracy by means of the Beaufort scale, which relates the movement of objects to wind speed. Reproduction of the Beaufort scale from Luke and McArthur (1978) is given in Table W1.

3. Tables R1.0 to R4.4 predict the forward rate of spread for 7% fuel moisture content (FMC) on level ground.
4. Use Table M1, M2 or M3 to determine a representative fuel moisture content and Table M4.1 to M4.4 to adjust the rate of spread for fuel moisture.
5. Use Table S1 to adjust the rate of spread for slope.
6. The model predicts rate of spread of a fully-developed fire in dry eucalypt forest with a shrub understorey and should be applicable to any eucalypt fuel that is dominated by leaf litter and native shrubs with only a relatively small fraction of grass in the understorey. The predicted rate of spread will be the potential quasi-steady rate of spread of a fire burning under summer conditions after the fire has undergone its initial growth phase.
7. Use Table Fh1 to determine the flame height related to forward rate of spread and elevated fuel height.
8. Table Sd1.1 to Sd4.4 to determine the maximum spotting distance in dry eucalypt forest that contains stringybark trees.

Table W1 Beaufort scale for estimating wind velocity

Beaufort Number	Term	Description	Wind speed (km h ⁻¹)
0	Calm	Smoke rises vertically	<1
1	Light air	Smoke drifts slowly; wind vanes not affected	1–5
2	Light breeze	Wind felt on face; leaves rustle; ordinary wind vanes move	6–11
3	Gentle breeze	Leaves and twigs in motion; wind extends light flag	12–19
4	Moderate breeze	Dust and loose paper raised; small branches move	20–28
5	Fresh breeze	Small trees sway	29–38
6	Strong breeze	Large branches in motion; whistling heard in telephone wires	39–49
7	Near gale	Whole trees in motion; inconvenience felt when walking against wind	50–61
8	Gale	Twigs broken off trees; progress of walkers impeded	62–74
9	Strong gale	Branches broken off trees	75–88

Table R1.0

Score = 1–4 Surface Fuel Hazard Score only

Score = 0 Near-surface fuel absent

Rate of spread on level ground at 7% fuel moisture content (m/hr)

SFH score	10 m wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
1	40	50	65	75	90	105	120	130	145	160
1.5	40	50	70	85	100	115	130	145	160	175
2	40	55	75	95	110	130	145	165	180	200
2.5	45	55	80	100	125	145	165	185	205	225
3	45	60	85	115	135	160	185	210	230	255
3.5	50	65	95	125	155	180	210	235	260	285
4	50	70	105	140	170	205	235	265	295	325

Table R1.1

Surface fuel hazard score = 1 (Low)

Near-surface fuel hazard score = 1 (Low)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	50	65	95	125	150	180	205	230	255	280
10	50	65	100	130	160	190	215	245	270	300
15	50	70	105	135	170	200	230	260	285	315
20	50	70	110	145	175	210	240	275	305	335
25	55	75	115	150	185	220	255	290	325	355
30	55	80	120	160	200	235	270	310	345	380
35	55	80	125	170	210	250	290	325	365	405
40	60	85	130	180	220	265	305	345	390	430
45	60	90	140	190	235	280	325	370	415	455
50	65	90	145	200	250	295	345	390	440	485

Table R1.1.5

Surface fuel hazard score = 1 (Low)

Near-surface fuel hazard score = 1.5 (Low-Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	55	75	120	155	195	230	265	300	335	370
10	55	80	125	165	205	245	280	320	355	395
15	60	85	130	175	215	260	300	340	380	420
20	60	85	135	185	230	275	320	360	405	445
25	60	90	145	195	245	290	335	385	430	475
30	65	95	150	205	260	310	360	410	455	505
35	65	100	160	220	275	330	380	435	485	535
40	70	105	170	230	290	350	405	460	515	570
45	70	110	180	245	310	370	430	490	550	605
50	75	115	190	260	325	395	460	520	585	645

Table R1.2

Surface fuel hazard score = 1 (Low)

Near-surface fuel hazard score = 2 (Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	65	95	150	200	250	300	350	400	445	490
10	65	100	155	215	265	320	370	425	475	520
15	70	105	165	225	285	340	395	450	500	560
20	70	105	175	240	300	360	420	480	540	590
25	75	115	185	255	320	385	445	510	570	630
30	75	120	195	270	340	410	475	540	610	670
35	80	125	205	285	360	435	510	580	650	720
40	85	130	220	300	385	460	540	610	690	760
45	85	140	230	320	405	490	570	650	730	810
50	90	145	245	340	430	520	610	700	780	870

Table R1.2.5

Surface fuel hazard score = 1 (Low)

Near-surface fuel hazard score = 2.5 (Moderate-High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	75	115	190	265	330	400	465	530	590	660
10	80	120	200	280	350	425	495	560	630	700
15	80	130	215	295	375	450	530	600	670	750
20	85	135	225	315	400	480	560	640	720	790
25	90	140	240	335	425	510	600	680	760	850
30	95	150	255	355	450	540	630	730	810	900
35	100	160	270	375	480	580	680	770	870	960
40	105	165	285	400	510	620	720	820	930	1050
45	110	175	305	425	540	660	770	880	990	1100
50	115	185	320	450	580	700	820	940	1050	1150

Table R1.3

Surface fuel hazard score = 1 (Low)

Near-surface fuel hazard score = 3 (High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	90	145	250	345	440	530	620	710	800	880
10	95	155	265	365	465	560	660	750	850	940
15	100	165	280	390	495	600	700	800	900	1000
20	105	175	295	415	530	640	750	860	960	1050
25	110	180	315	440	560	680	800	910	1050	1150
30	115	195	335	470	600	730	850	970	1100	1200
35	125	205	355	500	640	770	910	1050	1150	1300
40	130	215	375	530	680	820	970	1100	1250	1400
45	135	230	400	570	720	880	1050	1200	1350	1450
50	145	240	425	600	770	940	1100	1250	1400	1550

Table R1.3.5

Surface fuel hazard score = 1 (Low)

Near-surface fuel hazard score = 3.5 (Very High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	115	190	325	460	590	710	830	950	1050	1200
10	120	200	345	490	620	760	890	1000	1150	1250
15	125	210	370	520	660	810	940	1080	1200	1350
20	135	225	390	550	710	860	1000	1150	1300	1450
25	140	235	415	590	750	910	1050	1230	1400	1550
30	150	250	445	630	800	980	1150	1300	1450	1650
35	155	265	470	670	860	1050	1200	1400	1550	1750
40	165	280	500	710	910	1100	1300	1500	1700	1850
45	175	300	530	760	970	1200	1400	1600	1800	2000
50	185	320	570	810	1050	1250	1500	1700	1900	2100

Table R1.4

Surface fuel hazard score = 1 (Low)

Near-surface hazard score = 4 (Extreme)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	145	245	435	610	780	950	1100	1300	1450	1600
10	155	260	460	650	840	1000	1200	1350	1550	1700
15	160	275	490	690	890	1100	1250	1450	1650	1800
20	170	295	520	740	950	1150	1350	1550	1750	1950
25	180	310	550	790	1000	1250	1450	1650	1850	2050
30	190	330	590	840	1100	1300	1550	1750	2000	2200
35	200	350	630	890	1150	1400	1650	1900	2100	2350
40	215	370	670	950	1250	1500	1750	2000	2250	2500
45	225	395	710	1000	1300	1600	1850	2150	2400	2700
50	240	420	760	1100	1400	1700	2000	2300	2600	2850

Table R2.1

Surface fuel hazard score = 2 (Moderate)

Near-surface fuel hazard score = 1 (Low)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	55	75	115	155	190	225	260	295	330	360
10	55	80	120	160	200	240	275	310	350	385
15	55	80	125	170	210	255	290	330	370	410
20	60	85	135	180	225	270	310	350	395	435
25	60	90	140	190	240	285	330	375	420	460
30	65	95	150	200	250	300	350	400	445	490
35	65	100	155	215	265	320	370	425	475	520
40	70	100	165	225	285	340	395	450	500	560
45	70	105	175	240	300	360	420	480	540	590
50	75	115	185	255	320	385	445	510	570	630

Table R2.1.5

Surface fuel hazard score = 2 (Moderate)

Near-surface fuel hazard score = 1.5 (Low-Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	65	90	145	195	245	295	340	390	435	480
10	65	95	155	210	260	315	365	415	460	510
15	65	100	160	220	275	330	385	440	490	540
20	70	105	170	235	295	355	410	465	520	580
25	75	110	180	245	310	375	435	495	560	620
30	75	115	190	260	330	400	465	530	590	660
35	80	120	200	280	350	425	495	560	630	700
40	80	130	215	295	375	450	530	600	670	740
45	85	135	225	315	395	480	560	640	720	790
50	90	140	240	330	420	510	600	680	760	850

Table R2.2

Surface fuel hazard Score = 2 (Moderate)

Near-surface fuel hazard score = 2 (Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	75	115	185	255	325	390	455	520	580	640
10	75	120	200	270	345	415	480	550	620	680
15	80	125	210	290	365	440	510	590	660	730
20	85	130	220	305	390	470	550	620	700	770
25	90	140	235	325	410	500	580	660	750	830
30	90	145	250	345	440	530	620	710	790	880
35	95	155	265	365	465	560	660	750	850	940
40	100	165	280	390	495	600	700	800	900	1000
45	105	170	295	415	530	640	750	860	960	1050
50	110	180	315	440	560	680	800	910	1000	1150

Table R2.2.5

Surface fuel hazard score = 2 (Moderate)

Near-surface fuel hazard score = 2.5 (Moderate-High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	90	145	245	335	430	520	600	690	780	860
10	95	150	260	360	455	550	640	740	830	920
15	100	160	275	380	485	590	690	780	880	980
20	105	170	290	405	520	620	730	840	940	1050
25	110	180	310	430	550	660	780	890	1000	1100
30	115	190	325	460	580	710	830	950	1050	1200
35	120	200	345	485	620	750	880	1000	1150	1250
40	125	210	370	520	660	800	940	1100	1200	1350
45	135	225	390	550	710	860	1000	1150	1300	1450
50	140	235	415	590	750	910	1050	1250	1400	1550

Table R2.3

Surface fuel hazard score = 2 (Moderate)

Near-surface fuel hazard score = 3 (High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	110	185	320	450	570	690	810	930	1050	1150
10	120	195	340	480	610	740	860	990	1100	1250
15	125	205	360	510	650	790	920	1050	1200	1300
20	130	220	385	540	690	840	980	1100	1250	1400
25	135	230	405	570	730	890	1050	1200	1350	1500
30	145	245	430	610	780	950	1100	1300	1450	1600
35	150	260	460	650	830	1000	1200	1350	1550	1700
40	160	275	490	690	890	1100	1250	1450	1650	1800
45	170	290	520	740	950	1150	1350	1550	1750	1950
50	180	310	550	790	1000	1250	1450	1650	1850	2050

Table R2.3.5

Surface fuel hazard score = 2 (Moderate)

Near-surface fuel hazard score = 3.5 (Very High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	140	240	425	600	760	930	1100	1250	1400	1550
10	150	255	450	630	810	990	1150	1350	1500	1650
15	160	270	480	680	870	1050	1250	1400	1600	1750
20	165	285	510	720	920	1100	1300	1500	1700	1900
25	175	305	540	770	990	1200	1400	1600	1800	2000
30	185	320	580	820	1050	1300	1500	1700	1950	2150
35	195	340	610	870	1100	1350	1600	1850	2050	2300
40	210	365	650	930	1200	1450	1700	1950	2200	2450
45	220	385	700	990	1250	1550	1850	2100	2350	2600
50	235	410	740	1050	1350	1650	1950	2250	2500	2800

Table R2.4

Surface fuel hazard score = 2 (Moderate)

Near-surface fuel hazard score = 4 (Extreme)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	180	315	560	800	1000	1200	1500	1700	1900	2100
10	190	335	600	900	1100	1300	1600	1800	2000	2200
15	205	355	640	900	1200	1400	1700	1900	2200	2400
20	215	375	680	1000	1200	1500	1800	2000	2300	2600
25	230	400	720	1000	1300	1600	1900	2200	2500	2700
30	240	425	770	1100	1400	1700	2000	2300	2600	2900
35	255	455	820	1200	1500	1800	2200	2500	2800	3100
40	270	480	880	1200	1600	2000	2300	2700	3000	3300
45	290	510	930	1300	1700	2100	2500	2800	3200	3500
50	305	550	1000	1400	1800	2200	2600	3000	3400	3800

Table R2.5.1

Surface fuel hazard score = 2.5 (Moderate-High)

Near-surface fuel hazard score = 1 (Low)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	60	80	130	170	215	255	295	335	375	410
10	60	85	135	180	225	270	310	355	395	435
15	60	90	140	190	240	285	330	375	420	465
20	65	95	150	200	255	305	350	400	450	495
25	65	100	160	215	270	320	375	425	475	530
30	70	105	165	225	285	340	400	455	510	560
35	70	110	175	240	300	365	425	480	540	600
40	75	115	185	255	320	385	450	510	570	640
45	75	120	195	270	340	410	480	550	610	680
50	80	125	210	285	360	435	510	580	650	720

Table R2.5.1.5

Surface fuel hazard score = 2.5 (Moderate-High)

Near-surface fuel hazard score = 1.5 (Low-Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	70	100	165	220	280	335	390	440	495	550
10	70	105	170	235	295	355	415	470	530	580
15	75	110	180	250	315	375	440	500	560	620
20	75	115	190	265	335	400	465	530	600	660
25	80	125	205	280	355	425	495	570	640	700
30	80	130	215	295	375	455	530	600	680	750
35	85	135	230	315	400	480	560	640	720	800
40	90	145	240	335	425	510	600	680	770	850
45	95	150	255	355	450	550	640	730	820	910
50	100	160	270	380	480	580	680	780	870	970

Table R2.5.2

Surface fuel hazard score = 2.5 (Moderate-High)

Near-surface fuel hazard score = 2 (Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	80	125	210	290	370	440	520	590	660	730
10	85	135	225	310	390	470	550	630	700	780
15	90	140	235	325	415	500	590	670	750	830
20	90	150	250	345	440	530	620	710	800	890
25	95	155	265	370	470	570	660	760	850	940
30	100	165	280	390	500	600	710	810	910	1000
35	105	175	300	415	530	640	750	860	970	1050
40	110	185	315	445	570	690	800	920	1050	1150
45	115	195	335	470	600	730	860	980	1100	1200
50	125	205	355	500	640	780	910	1050	1150	1300

Table R2.5.2.5

Surface fuel hazard score = 2.5 (Moderate-High)

Near-surface fuel hazard score = 2.5 (Moderate-High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	100	160	275	385	490	590	690	790	890	985
10	105	170	290	410	520	630	740	840	950	1050
15	110	180	310	435	550	670	780	900	1000	1100
20	115	190	330	460	590	710	840	960	1050	1200
25	120	200	350	490	630	760	890	1000	1150	1250
30	125	210	370	520	670	810	950	1100	1200	1350
35	135	225	395	560	710	860	1000	1150	1300	1450
40	140	240	420	590	760	920	1100	1250	1400	1550
45	150	250	445	630	810	980	1150	1300	1500	1650
50	155	265	475	670	860	1050	1250	1400	1600	1750

Table R2.5.3

Surface fuel hazard score = 2.5 (Moderate-High)

Near-surface fuel hazard score = 3 (High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	125	210	365	510	650	790	930	1050	1200	1300
10	130	220	385	540	690	840	990	1150	1250	1400
15	140	235	410	580	740	900	1050	1200	1350	1500
20	145	245	435	610	790	960	1100	1300	1450	1600
25	155	260	465	650	840	1000	1200	1350	1550	1700
30	160	275	495	700	900	1100	1300	1450	1650	1850
35	170	295	520	740	950	1150	1350	1550	1750	1950
40	180	310	560	790	1000	1250	1450	1650	1900	2100
45	190	330	590	840	1100	1300	1550	1800	2000	2200
50	200	350	630	900	1150	1400	1650	1900	2150	2350

Table R2.5.3.5

Surface fuel hazard score = 2.5 (Moderate-High)

Near-surface fuel hazard score = 3.5 (Very High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	160	270	480	680	870	1050	1250	1450	1600	1800
10	165	290	510	730	930	1150	1350	1500	1700	1900
15	175	305	550	770	990	1200	1400	1650	1850	2050
20	185	325	580	820	1050	1300	1500	1750	1950	2150
25	200	345	620	880	1150	1350	1600	1850	2100	2300
30	210	365	660	940	1200	1450	1700	2000	2250	2450
35	220	390	700	1000	1300	1550	1850	2100	2400	2650
40	235	415	750	1050	1350	1650	1950	2250	2550	2800
45	250	440	800	1150	1450	1800	2100	2400	2700	3000
50	265	465	850	1200	1550	1900	2250	2550	2900	3200

Table R2.5.4

Surface fuel hazard score = 2.5 (Moderate-High)

Near-surface fuel hazard score = 4 (Extreme)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	205	360	640	910	1200	1450	1700	1950	2150	2400
10	215	380	680	970	1250	1550	1800	2050	2300	2600
15	230	405	730	1050	1350	1650	1900	2200	2450	2750
20	245	430	780	1100	1450	1750	2050	2350	2650	2950
25	260	455	830	1200	1500	1850	2200	2500	2800	3150
30	275	485	880	1250	1600	2000	2350	2650	3000	3350
35	290	520	940	1350	1750	2100	2500	2850	3200	3550
40	310	550	1000	1450	1850	2250	2650	3050	3450	3800
45	325	590	1050	1550	1950	2400	2850	3250	3650	4050
50	345	620	1150	1650	2100	2550	3000	3450	3900	4350

Table R3.1

Surface fuel hazard score = 3 (High)

Near-surface fuel hazard score = 1 (Low)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	60	90	145	195	240	290	335	380	425	470
10	65	95	150	205	255	305	355	405	450	500
15	65	100	160	215	270	325	375	430	480	530
20	70	105	165	230	285	345	400	455	510	560
25	70	110	175	240	305	365	425	485	540	600
30	75	115	185	255	325	390	455	520	580	640
35	75	120	195	270	345	415	480	550	620	680
40	80	125	210	290	365	440	510	580	660	730
45	85	130	220	305	385	465	550	620	700	770
50	90	140	235	325	410	495	580	660	740	820

Table R3.1.5

Surface fuel hazard score = 3 (High)

Near-surface fuel hazard score = 1.5 (Low-Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	75	110	185	250	315	380	440	500	560	620
10	75	115	195	265	335	405	470	540	600	670
15	80	125	205	280	355	430	500	570	640	710
20	85	130	215	300	380	455	530	610	680	760
25	85	135	230	315	400	485	570	650	730	800
30	90	145	245	335	430	520	600	690	770	860
35	95	150	255	360	455	550	640	730	820	910
40	100	160	275	380	485	590	680	780	880	970
45	105	170	290	405	510	620	730	830	940	1050
50	110	180	305	430	550	660	780	890	1000	1100

Table R3.2

Surface fuel hazard score = 3 (High)

Near-surface fuel hazard score = 2 (Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	90	140	240	330	420	500	590	670	760	840
10	95	150	250	350	445	540	630	720	810	890
15	95	155	265	370	475	570	670	760	860	950
20	100	165	285	395	500	610	710	810	910	1000
25	105	175	300	420	540	650	760	870	980	1100
30	110	185	320	445	570	690	810	930	1050	1150
35	120	195	340	475	610	740	860	990	1100	1250
40	125	205	360	510	650	780	920	1050	1200	1300
45	130	220	380	540	690	840	980	1100	1250	1400
50	135	230	405	570	730	890	1050	1200	1350	1500

Table R3.2.5

Surface fuel hazard score = 3 (High)

Near-surface fuel hazard score = 2.5 (Moderate-High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	110	180	310	435	560	670	790	900	1000	1150
10	115	190	330	465	590	720	840	960	1100	1200
15	120	200	350	495	630	770	900	1050	1150	1300
20	130	215	375	530	670	820	960	1100	1250	1350
25	135	225	395	560	720	870	1000	1150	1300	1450
30	140	240	420	600	760	930	1100	1250	1400	1550
35	150	255	450	630	810	990	1150	1350	1500	1650
40	155	270	475	670	870	1050	1250	1400	1600	1750
45	165	285	510	720	920	1100	1300	1500	1700	1900
50	175	305	540	770	980	1200	1400	1600	1800	2000

Table R3.3

Surface fuel hazard score = 3 (High)

Near-surface fuel hazard score = 3 (High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	140	235	410	580	750	900	1050	1200	1350	1500
10	145	250	440	620	790	960	1150	1300	1450	1600
15	155	265	465	660	850	1050	1200	1400	1550	1750
20	165	280	495	700	900	1100	1300	1450	1650	1850
25	170	295	530	750	960	1150	1350	1550	1750	1950
30	180	315	560	800	1000	1250	1450	1700	1900	2100
35	190	335	600	850	1100	1350	1550	1800	2000	2250
40	205	355	640	910	1150	1400	1650	1900	2150	2400
45	215	375	680	960	1250	1500	1800	2050	2300	2550
50	230	400	720	1050	1350	1600	1900	2200	2450	2700

Table R3.3.5

Surface fuel hazard score = 3 (High)

Near-surface fuel hazard score = 3.5 (Very High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	180	310	550	780	1000	1200	1450	1650	1850	2050
10	190	325	580	830	1050	1300	1500	1750	1950	2200
15	200	345	620	880	1150	1400	1650	1850	2100	2350
20	210	370	660	940	1200	1500	1750	2000	2250	2500
25	225	390	710	1000	1300	1600	1850	2100	2400	2650
30	235	415	750	1050	1400	1700	2000	2250	2550	2850
35	250	440	800	1150	1450	1800	2100	2400	2750	3050
40	265	470	850	1200	1550	1900	2250	2600	2900	3250
45	280	500	910	1300	1700	2050	2400	2750	3100	3450
50	300	530	970	1400	1800	2200	2550	2950	3300	3700

Table R3.4

Surface fuel hazard score = 3 (High)

Near-surface fuel hazard score = 4 (Extreme)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	230	405	730	1050	1350	1650	1950	2200	2500	2750
10	245	430	780	1110	1450	1750	2050	2350	2650	2950
15	260	460	830	1190	1550	1850	2200	2500	2850	3150
20	275	490	890	1270	1650	2000	2350	2700	3050	3350
25	290	520	950	1350	1750	2150	2500	2850	3250	3600
30	310	555	1010	1450	1850	2250	2650	3050	3450	3850
35	330	590	1080	1550	2000	2400	2850	3250	3700	4100
40	350	630	1150	1650	2100	2600	3050	3500	3950	4400
45	370	670	1220	1750	2250	2750	3250	3750	4200	4650
50	395	710	1310	1850	2400	2950	3450	4000	4500	5000

Table R3.5.1

Surface fuel hazard score = 3.5 (Very High)

Near-surface fuel hazard score = 1 (Low)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	65	100	160	215	270	325	380	430	485	530
10	70	105	170	230	290	345	405	460	510	570
15	70	110	180	245	305	370	430	490	550	610
20	75	115	190	260	325	390	455	520	580	640
25	80	120	200	275	345	415	485	550	620	690
30	80	125	210	290	365	440	520	590	660	730
35	85	135	225	310	390	470	550	630	700	780
40	90	140	235	325	415	500	580	670	750	830
45	90	145	250	345	440	530	620	710	800	880
50	95	155	265	370	470	570	660	760	850	940

Table R3.5.1.5

Surface fuel hazard score = 3.5 (Very High)

Near-surface fuel hazard score = 1.5 (Low-Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	80	125	205	285	360	430	500	580	640	710
10	85	130	220	300	380	460	540	610	690	760
15	85	135	230	320	405	490	570	650	730	810
20	90	145	245	340	430	520	610	690	780	860
25	95	150	260	360	460	550	650	740	830	920
30	100	160	275	385	485	590	690	790	890	980
35	105	170	290	405	520	630	730	840	940	1050
40	110	180	310	435	550	670	780	900	1000	1100
45	115	190	330	460	590	710	830	955	1050	1200
50	120	200	350	490	630	760	890	1000	1150	1250

Table R3.5.2

Surface fuel hazard score = 3.5 (Very High)

Near-surface fuel hazard score = 2 (Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	100	160	270	375	475	580	670	770	860	960
10	100	165	285	400	510	610	720	820	920	1000
15	105	175	300	425	540	650	760	870	980	1100
20	115	185	320	450	570	700	810	930	1050	1150
25	120	195	340	480	610	740	870	990	1100	1250
30	125	210	360	510	650	790	930	1050	1200	1300
35	130	220	385	540	690	840	990	1150	1250	1400
40	140	235	410	580	740	900	1050	1200	1350	1500
45	145	245	435	610	790	955	1100	1300	1450	1600
50	155	260	460	650	840	1000	1200	1350	1550	1700

Table R3.5.2.5

Surface fuel hazard score = 3.5 (Very High)

Near-surface fuel hazard score = 2.5 (Moderate-High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	120	205	355	495	640	770	900	1050	1150	1300
10	130	215	375	530	680	820	960	1100	1250	1400
15	135	230	400	560	720	880	1050	1200	1300	1450
20	140	240	425	600	770	930	1100	1250	1400	1550
25	150	255	450	640	820	990	1150	1350	1500	1650
30	160	270	480	680	870	1050	1250	1450	1600	1800
35	165	285	510	720	930	1150	1350	1500	1700	1900
40	175	305	540	770	990	1200	1400	1600	1850	2050
45	185	325	580	820	1050	1300	1500	1750	1950	2150
50	195	345	620	880	1150	1350	1600	1850	2100	2300

Table R3.5.3

Surface fuel hazard score = 3.5 (Very High)

Near-surface fuel hazard score = 3 (High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	155	265	470	660	850	1050	1200	1400	1550	1750
10	165	280	500	710	910	1100	1300	1500	1650	1850
15	175	300	530	750	970	1200	1400	1600	1800	2000
20	185	315	570	800	1050	1250	1500	1700	1900	2100
25	195	335	600	860	1100	1350	1550	1800	2050	2250
30	205	355	640	910	1150	1450	1700	1950	2150	2400
35	215	380	680	970	1250	1500	1800	2050	2300	2550
40	230	405	730	1050	1350	1650	1900	2200	2450	2750
45	245	430	780	1100	1400	1750	2050	2350	2650	2950
50	255	455	830	1200	1500	1850	2200	2500	2800	3150

Table R3.5.3.5

Surface fuel hazard score = 3.5 (Very High)

Near-surface fuel hazard score = 3.5 (Very High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	200	350	630	890	1150	1400	1650	1900	2100	2350
10	210	370	670	950	1200	1500	1750	2000	2250	2500
15	225	395	710	1000	1300	1600	1850	2150	2400	2700
20	235	420	760	1100	1400	1700	2000	2300	2550	2850
25	250	445	810	1150	1500	1800	2100	2450	2750	3050
30	265	475	860	1250	1600	1950	2250	2600	2950	3250
35	285	500	920	1300	1700	2050	2400	2800	3150	3500
40	300	540	975	1400	1800	2200	2600	2950	3350	3700
45	320	570	1050	1500	1900	2350	2750	3150	3550	3950
50	340	610	1100	1600	2050	2500	2950	3400	3800	4250

Table R3.5.4

Surface fuel hazard score = 3.5 (Very High)

Near-surface fuel hazard score = 4 (Extreme)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	260	465	840	1200	1550	1900	2200	2550	2850	3200
10	275	495	890	1300	1650	2000	2350	2700	3050	3400
15	295	520	950	1350	1750	2150	2500	2900	3250	3600
20	310	560	1000	1450	1900	2300	2700	3100	3500	3850
25	330	590	1100	1550	2000	2450	2850	3300	3700	4150
30	350	630	1150	1650	2150	2600	3050	3500	3950	4400
35	375	670	1250	1750	2300	2800	3250	3750	4250	4700
40	395	720	1300	1900	2450	2950	3500	4000	4500	5050
45	420	760	1400	2000	2600	3150	3750	4300	4850	5350
50	450	810	1500	2150	2750	3400	4000	4600	5150	5750

Table R4.1

Surface fuel hazard score = 4 (Extreme)

Near-surface fuel hazard score = 1 (Low)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	70	110	180	245	310	370	430	490	550	610
10	75	115	190	260	330	395	460	520	590	650
15	80	120	200	275	350	420	490	560	620	690
20	80	125	210	290	370	445	520	590	660	740
25	85	135	225	310	395	475	550	630	710	780
30	90	140	235	330	415	500	590	670	750	840
35	95	150	250	350	445	540	630	720	800	890
40	95	155	265	370	470	570	670	760	860	950
45	100	165	285	395	500	610	710	810	910	1000
50	105	175	300	420	530	650	760	870	970	1100

Table R4.1.5

Surface fuel hazard score = 4 (Extreme)

Near-surface fuel hazard score = 1.5 (Low-Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	85	140	230	320	410	490	580	660	740	820
10	90	145	245	340	435	520	610	700	790	870
15	95	155	260	365	460	560	650	750	840	930
20	100	160	275	385	490	590	690	790	890	990
25	105	170	295	410	520	630	740	850	950	1050
30	110	180	310	435	560	670	790	900	1000	1100
35	115	190	330	465	590	720	840	960	1100	1200
40	120	200	350	495	630	760	900	1000	1150	1300
45	130	215	375	520	670	810	950	1100	1250	1350
50	135	225	395	560	710	870	1000	1150	1300	1450

Table R4.2

Surface fuel hazard score = 4 (Extreme)

Near-surface fuel hazard score = 2 (Moderate)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	110	175	305	425	540	660	770	880	990	1100
10	115	185	325	455	580	700	820	940	1050	1150
15	120	195	345	480	620	750	870	1000	1100	1250
20	125	210	365	510	660	800	930	1050	1200	1350
25	130	220	385	550	700	850	990	1150	1300	1400
30	140	235	410	580	740	900	1050	1200	1350	1500
35	145	250	440	620	790	960	1150	1300	1450	1600
40	155	265	465	660	840	1050	1200	1400	1550	1700
45	165	280	495	700	900	1100	1300	1450	1650	1850
50	170	295	530	750	960	1150	1350	1550	1750	1950

Table R4.2.5

Surface fuel hazard score = 4 (Extreme)

Near-surface fuel hazard score = 2.5 (Moderate-High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	135	230	400	570	730	880	1050	1200	1350	1500
10	145	245	430	600	770	940	1100	1250	1400	1600
15	150	255	455	640	820	1000	1200	1350	1500	1700
20	160	275	485	680	880	1050	1250	1450	1600	1800
25	170	290	510	730	940	1150	1350	1550	1750	1900
30	180	305	550	780	1000	1200	1450	1650	1850	2050
35	190	325	580	830	1050	1300	1500	1750	1950	2200
40	200	345	620	880	1150	1400	1600	1850	2100	2350
45	210	370	660	940	1200	1450	1750	2000	2250	2500
50	220	390	700	1000	1300	1550	1850	2100	2400	2650

Table R4.3

Surface fuel hazard score = 4 (Extreme)

Near-surface fuel hazard score = 3 (High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	175	300	540	760	980	1200	1400	1600	1800	2000
10	185	320	570	810	1050	1250	1500	1700	1900	2150
15	195	340	610	860	1100	1350	1600	1800	2050	2250
20	205	360	650	920	1200	1450	1700	1950	2200	2450
25	220	380	690	980	1250	1550	1800	2050	2350	2600
30	230	405	730	1050	1350	1650	1950	2200	2500	2750
35	245	430	780	1100	1450	1750	2050	2350	2650	2950
40	260	460	830	1200	1550	1850	2200	2500	2850	3150
45	275	490	890	1250	1650	2000	2350	2700	3050	3350
50	290	520	950	1350	1750	2100	2500	2850	3250	3600

Table R4.3.5

Surface fuel hazard score = 4 (Extreme)

Near-surface fuel hazard score = 3.5 (Very High)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	225	395	720	1000	1300	1600	1900	2150	2450	2700
10	240	420	760	1100	1400	1700	2000	2300	2600	2900
15	255	450	810	1150	1500	1800	2150	2450	2750	3050
20	270	475	870	1250	1600	1950	2300	2600	2950	3300
25	285	510	920	1300	1700	2050	2450	2800	3150	3500
30	300	540	980	1400	1800	2200	2600	3000	3350	3750
35	320	570	1050	1500	1950	2350	2800	3200	3600	4000
40	340	610	1100	1600	2050	2500	2950	3400	3850	4250
45	360	650	1200	1700	2200	2700	3150	3650	4100	4550
50	385	690	1250	1800	2350	2850	3400	3900	4350	4850

Table R4.4

Surface fuel hazard score = 4 (Extreme)

Near-surface fuel hazard score = 4 (Extreme)

Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h)									
	7.5	10	15	20	25	30	35	40	45	50
5	295	530	960	1350	1750	2150	2550	2900	3300	3650
10	315	560	1000	1450	1900	2300	2700	3100	3500	3900
15	335	600	1100	1550	2000	2450	2900	3300	3750	4150
20	355	640	1150	1650	2150	2650	3100	3550	4000	4450
25	375	680	1250	1800	2300	2800	3300	3800	4250	4750
30	400	720	1300	1900	2450	3000	3500	4050	4550	5050
35	425	770	1400	2000	2600	3200	3750	4300	4850	5400
40	450	820	1500	2150	2800	3400	4000	4600	5200	5800
45	480	870	1600	2300	3000	3650	4300	4900	5550	6150
50	510	930	1700	2450	3200	3900	4600	5250	5950	6600

Fuel Moisture Content



Fuel Moisture Content (M)

These three models are used to predict the fuel moisture content of surface fuels in dry eucalypt forest. They are to be used for dry conditions with no recent rain. Use Model 1 when:

- The month is November, December, January, or February.
- The time is from 1300–1700 local daylight savings time (1200 – 1600 standard time).
- Cloud cover is less than 4/8.

For all other times during the day use Model 2. At night use Model 3. If dew has fallen overnight then the models will under-predict fuel moisture until the dew has evaporated.

Models 1 and 2 have been tested and found to be satisfactory in jarrah forest using observations from Project Vesta and an additional 6 months of daily observations. Model 3 has been tested using only 3 nights of observations from eucalypt mallee woodland. The accuracy of Model 3 is thus uncertain and it should be used with caution.

Table M1

Model 1 Relative humidity	Air temperature (°C)			
	10	20	30	40
5	3	3	3	3
10	3.5	3	3	3
15	4.5	4	4	3.5
20	5	4.5	4.5	4.5
25	6	5.5	5.5	5
30	6.5	6	6	6
35	7	7	7	6.5
40	8	7.5	7.5	7
45	8.5	8	8	7.5
50	9	8.5	8.5	8.5
55	9.5	9.5	9	9
60	10	10	9.5	9.5
65	10.5	10.5	10	10
70	11	11	11	10.5
75	11.5	11.5	11.5	11
80	12.5	12	12	12

Blue shaded areas are outside the validation bounds of the fuel moisture model.

Table M2

Model 2 Relative humidity	Air temperature (°C)			
	10	20	30	40
5	3	3	3	3
10	4.5	4	4	3.5
15	5.5	5.5	5	4.5
20	6.5	6.5	6	5.5
25	7.5	7	6.5	6.5
30	8.5	8	7.5	7.0
35	9.5	9	8.5	8.0
40	10	9.5	9	8.5
45	11	10	10	9.5
50	11.5	11	10.5	10.0
55	12.5	12	11.5	11.0
60	13	12.5	12	12.0
65	14	13.5	13	12.5
70	15	14.5	14	13.5
75	16	15	14.5	14.0
80	17	16	15.5	15.0
85	18	17	16.5	16.0
90	19	18.5	18	17.5

Blue shaded areas are outside the validation bounds of the fuel moisture model.

Table M3

Model 3 Relative humidity	Air temperature (°C)		
	10	20	30
20	6.5	6.5	6
25	7.5	7	6.5
30	8.5	8	7.5
35	9.5	9	8.5
40	10.5	10	9.5
45	11.5	11	10.5
50	12.5	12	11.5
55	13.5	13	12.5
60	14.5	14	13.5
65	15.5	15	14.5
70	16.5	16	15.5
75	17.5	17	16.5
80	18.5	18	17.5
85	19.5	19	18.5
90	20.5	20	19.5

Blue shaded areas are outside the validation bounds of the fuel moisture model.

Fuel Moisture Correction Factor (M)

Table M3

Surface fuel moisture content (%)	Spread correction factor for fuel moisture
5	1.65
6	1.26
7	1.00
8	0.82
9	0.69
10	0.59
12	0.45
14	0.35
16	0.29
18	0.24
20	0.21

Source: Burrows (1999).

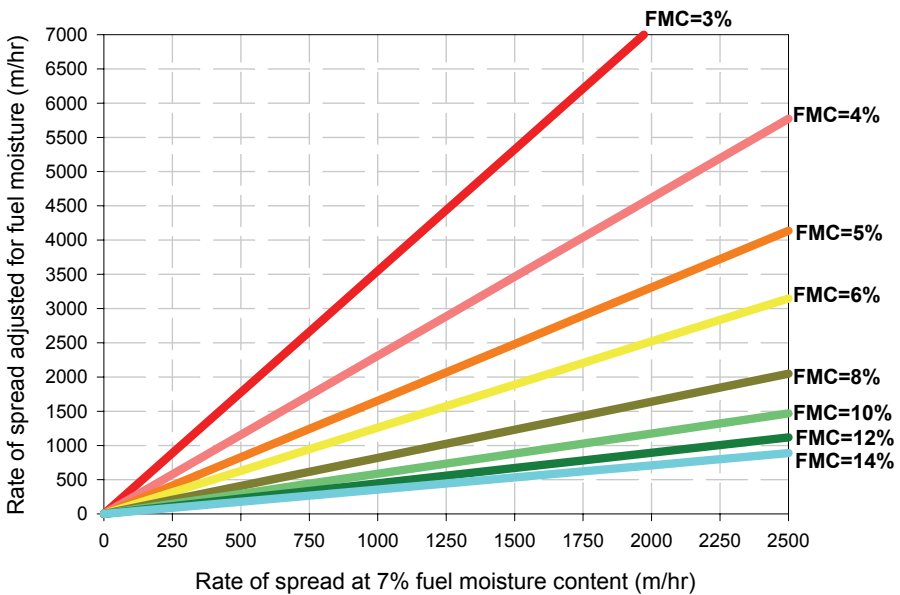


Table M4.1

Adjusted Rate of Spread: Fuel Moisture Correction Factor

Fuel moisture 7% rate of spread between 30 – 500 m/hr

Fuel Moisture Content [%]												
3%	4%	5%	6%	7%	8%	9%	10%	12%	14%	16%	18%	20%
105	70	50	40	30	25	20	20	15	10	10	5	5
125	80	60	45	35	30	25	20	15	10	10	10	5
140	90	65	50	40	35	25	25	20	15	10	10	10
160	105	75	55	45	35	30	25	20	15	15	10	10
180	115	85	65	50	40	35	30	20	20	15	10	10
195	125	90	70	55	45	40	30	25	20	15	15	10
215	140	100	75	60	50	40	35	25	20	15	15	10
230	150	110	80	65	55	45	40	30	25	20	15	15
250	160	115	90	70	55	50	40	30	25	20	15	15
265	175	125	95	75	60	50	45	35	25	20	20	15
285	185	130	100	80	65	55	45	35	30	25	20	15
300	195	140	105	85	70	60	50	40	30	25	20	20
320	210	150	115	90	75	60	55	40	30	25	20	20
335	220	155	120	95	80	65	55	40	35	30	25	20
355	230	165	125	100	80	70	60	45	35	30	25	20
445	290	205	155	125	100	85	75	55	45	35	30	25
530	345	250	190	150	125	105	90	65	55	45	35	30
620	405	290	220	175	145	120	105	80	60	50	45	35
710	460	330	250	200	165	135	115	90	70	60	50	40
800	520	370	285	225	185	155	130	100	80	65	55	45
890	580	415	315	250	205	170	145	110	90	75	60	50
980	640	455	345	275	225	190	160	125	100	80	65	55
1050	690	495	380	300	245	205	175	135	105	85	75	60
1150	750	540	410	325	265	225	190	145	115	95	80	70
1250	810	580	440	350	285	240	205	155	125	100	85	75
1350	870	620	470	375	305	260	220	170	135	110	90	80
1400	920	660	500	400	330	275	235	180	140	115	100	85
1500	980	700	540	425	350	290	250	190	150	125	105	90
1600	1050	740	570	450	370	310	265	200	160	130	110	95
1700	1100	790	600	475	390	325	280	210	170	140	115	100
1800	1150	830	630	500	410	345	295	225	175	145	120	105

Table M4.2

Adjusted Rate of Spread: Fuel Moisture Correction Factor

Fuel moisture 7% rate of spread between 530 – 1500 m/hr

Fuel Moisture Content (%)												
3%	4%	5%	6%	7%	8%	9%	10%	12%	14%	16%	18%	20%
1850	1200	870	660	530	430	360	310	235	185	155	130	110
1950	1250	910	690	550	450	380	325	245	195	160	135	115
2050	1350	950	720	580	470	395	335	255	205	165	140	120
2150	1400	990	760	600	490	410	350	270	215	175	145	125
2200	1450	1050	790	630	510	430	365	280	220	180	150	130
2300	1500	1100	820	650	530	445	380	290	230	190	160	135
2400	1550	1100	850	680	550	465	395	300	240	195	165	140
2500	1600	1150	880	700	570	480	410	315	250	205	170	145
2550	1650	1200	910	730	590	500	425	325	255	210	175	150
2650	1750	1250	940	750	610	520	440	335	265	220	185	155
2750	1800	1300	980	780	640	530	455	345	275	225	190	160
2850	1850	1300	1000	800	660	550	470	360	285	235	195	165
2950	1900	1350	1050	830	680	570	485	370	295	240	200	170
3000	1950	1400	1050	850	700	580	500	380	300	245	205	175
3100	2000	1450	1100	880	720	600	510	390	310	255	215	180
3200	2100	1500	1150	900	740	620	530	400	320	260	220	185
3300	2150	1550	1150	930	760	640	540	415	330	270	225	195
3350	2200	1550	1200	950	780	650	560	425	335	275	230	200
3450	2250	1600	1250	980	800	670	570	435	345	285	240	205
3550	2300	1650	1250	1000	820	690	590	445	355	290	245	210
3750	2450	1750	1300	1050	860	720	620	470	375	305	255	220
3900	2550	1800	1400	1100	900	760	650	490	390	320	270	230
4100	2650	1900	1450	1150	940	790	670	510	410	335	280	240
4250	2750	2000	1500	1200	980	820	700	540	425	350	295	250
4450	2900	2050	1550	1250	1000	860	730	560	445	365	305	260
4600	3000	2150	1650	1300	1050	890	760	580	460	380	315	270
4800	3100	2250	1700	1350	1100	930	790	600	480	390	330	280
4950	3250	2300	1750	1400	1150	960	820	630	495	405	340	290
5100	3350	2400	1850	1450	1200	1000	850	650	510	420	355	300
5300	3450	2500	1900	1500	1250	1050	880	670	530	435	365	310

Table M4.3

Adjusted Rate of Spread: Fuel Moisture Correction Factor

Fuel moisture 7% rate of spread between 1550 – 4500 m/hr

Fuel Moisture Content (%)												
3%	4%	5%	6%	7%	8%	9%	10%	12%	14%	16%	18%	20%
5500	3600	2550	1950	1550	1250	1050	910	690	550	450	380	325
5700	3700	2650	2000	1600	1300	1100	940	720	570	465	390	335
5900	3800	2750	2100	1650	1350	1150	970	740	590	480	400	345
6000	3950	2800	2150	1700	1400	1150	1000	760	600	495	415	355
6200	4050	2900	2200	1750	1450	1200	1050	780	620	510	425	365
6400	4150	3000	2250	1800	1450	1250	1050	800	640	520	440	375
6600	4250	3050	2350	1850	1500	1250	1100	830	660	540	450	385
6700	4400	3150	2400	1900	1550	1300	1100	850	670	550	465	395
6900	4500	3250	2450	1950	1600	1350	1150	870	690	570	475	405
7100	4600	3300	2500	2000	1650	1350	1150	890	710	580	490	415
7300	4750	3400	2600	2050	1700	1400	1200	920	730	600	500	425
7500	4850	3450	2650	2100	1700	1450	1250	940	750	610	510	435
7600	4950	3550	2700	2150	1750	1500	1250	960	760	630	520	450
7800	5100	3650	2750	2200	1800	1500	1300	980	780	640	540	460
8000	5200	3700	2850	2250	1850	1550	1300	1000	800	650	550	470
8200	5300	3800	2900	2300	1900	1600	1350	1050	820	670	560	480
8300	5400	3900	2950	2350	1950	1600	1400	1050	830	680	570	490
8500	5500	3950	3000	2400	1950	1650	1400	1050	850	700	590	500
8700	5700	4050	3100	2450	2000	1700	1450	1100	870	710	600	510
8900	5800	4150	3150	2500	2050	1700	1450	1100	890	730	610	520
9200	6000	4300	3300	2600	2150	1800	1550	1150	920	760	630	540
9600	6200	4450	3400	2700	2200	1850	1600	1200	960	780	660	560
9900	6500	4650	3550	2800	2300	1900	1650	1250	990	810	680	580
10300	6700	4800	3650	2900	2400	2000	1700	1300	1050	840	710	600
10700	6900	4950	3800	3000	2450	2050	1750	1350	1050	870	730	620
11000	7200	5100	3900	3100	2550	2150	1800	1400	1100	900	760	650
11400	7400	5300	4050	3200	2600	2200	1900	1450	1150	930	780	670
11700	7600	5500	4150	3300	2700	2250	1950	1450	1150	960	800	690
12100	7900	5600	4300	3400	2800	2350	2000	1500	1200	990	830	710
12400	8100	5800	4400	3500	2850	2400	2050	1550	1250	1000	850	730
12800	8300	6000	4550	3600	2950	2450	2100	1600	1300	1050	880	750
13100	8500	6100	4650	3700	3050	2550	2150	1650	1300	1100	900	770
13500	8800	6300	4800	3800	3100	2600	2250	1700	1350	1100	930	790
13800	9000	6500	4900	3900	3200	2700	2300	1750	1400	1150	950	810
14200	9200	6600	5000	4000	3300	2750	2350	1800	1400	1150	980	830
14600	9500	6800	5200	4100	3350	2800	2400	1850	1450	1200	1000	850
14900	9700	6900	5300	4200	3450	2900	2450	1900	1500	1200	1000	870
15300	9900	7100	5400	4300	3500	2950	2500	1900	1550	1250	1050	900
15600	10200	7300	5500	4400	3600	3000	2600	1950	1550	1300	1050	920
16000	10400	7400	5700	4500	3700	3100	2650	2000	1600	1300	1100	940

Table M4.4

Adjusted Rate of Spread: Fuel Moisture Correction Factor

Fuel moisture 7% rate of spread between 4600 – 7500 m/hr

Fuel Moisture Content (%)												
3%	4%	5%	6%	7%	8%	9%	10%	12%	14%	16%	18%	20%
16300	10600	7600	5800	4600	3750	3150	2700	2050	1650	1350	1100	960
16700	10900	7800	5900	4700	3850	3250	2750	2100	1650	1350	1150	980
17000	11100	7900	6000	4800	3950	3300	2800	2150	1700	1400	1150	1000
17400	11300	8100	6200	4900	4000	3350	2900	2200	1750	1400	1200	1000
17800	11500	8300	6300	5000	4100	3450	2950	2250	1750	1450	1200	1050
18100	11800	8400	6400	5100	4200	3500	3000	2300	1800	1500	1250	1050
18500	12000	8600	6600	5200	4250	3550	3050	2300	1850	1500	1250	1100
18800	12200	8800	6700	5300	4350	3650	3100	2350	1900	1550	1300	1100
19200	12500	8900	6800	5400	4400	3700	3150	2400	1900	1550	1300	1100
19500	12700	9100	6900	5500	4500	3800	3250	2450	1950	1600	1350	1150
19900	12900	9300	7100	5600	4600	3850	3300	2500	2000	1650	1350	1150
20200	13200	9400	7200	5700	4650	3900	3350	2550	2000	1650	1400	1200
20600	13400	9600	7300	5800	4750	4000	3400	2600	2050	1700	1400	1200
20900	13600	9800	7400	5900	4850	4050	3450	2650	2100	1700	1450	1250
21300	13900	9900	7600	6000	4900	4100	3500	2700	2150	1750	1450	1250
21700	14100	10100	7700	6100	5000	4200	3600	2750	2150	1750	1500	1250
22000	14300	10300	7800	6200	5100	4250	3650	2750	2200	1800	1500	1300
22400	14600	10400	7900	6300	5200	4350	3700	2800	2250	1850	1550	1300
22700	14800	10600	8100	6400	5200	4400	3750	2850	2250	1850	1550	1350
23100	15000	10800	8200	6500	5300	4450	3800	2900	2300	1900	1600	1350
23400	15200	10900	8300	6600	5400	4550	3850	2950	2350	1900	1600	1350
23800	15500	11100	8400	6700	5500	4600	3950	3000	2400	1950	1650	1400
24100	15700	11200	8600	6800	5600	4650	4000	3050	2400	2000	1650	1400
24500	15900	11400	8700	6900	5700	4750	4050	3100	2450	2000	1700	1450
24900	16200	11600	8800	7000	5700	4800	4100	3150	2500	2050	1700	1450
25200	16400	11700	8900	7100	5800	4900	4150	3150	2500	2050	1750	1500
25600	16600	11900	9100	7200	5900	4950	4250	3200	2550	2100	1750	1500
25900	16900	12100	9200	7300	6000	5000	4300	3250	2600	2100	1800	1500
26300	17100	12200	9300	7400	6100	5100	4350	3300	2650	2150	1800	1550
26600	17300	12400	9400	7500	6100	5200	4400	3350	2650	2200	1850	1550

Slope Correction



Slope Correction Factor

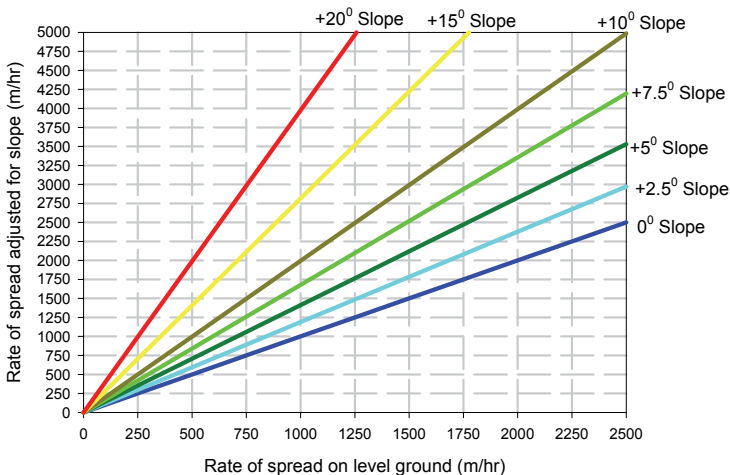
Fire travels upslope with the prevailing wind faster than on level ground. A five degree slope increases forward rate of spread by 30 percent; a ten degree slope by a factor of two; and a twenty degree slope by a factor of four. There is no satisfactory model to predict the movement of fire down slope. Terrain and fire-induced eddies on lee slopes can result in fire being checked after cresting relatively low ridges and spreading as a backing fire on the lee slope. When the burning conditions are extreme, spotting will ignite the enough of the lee slope to carry the fire onto the next windward slope.

Table S1

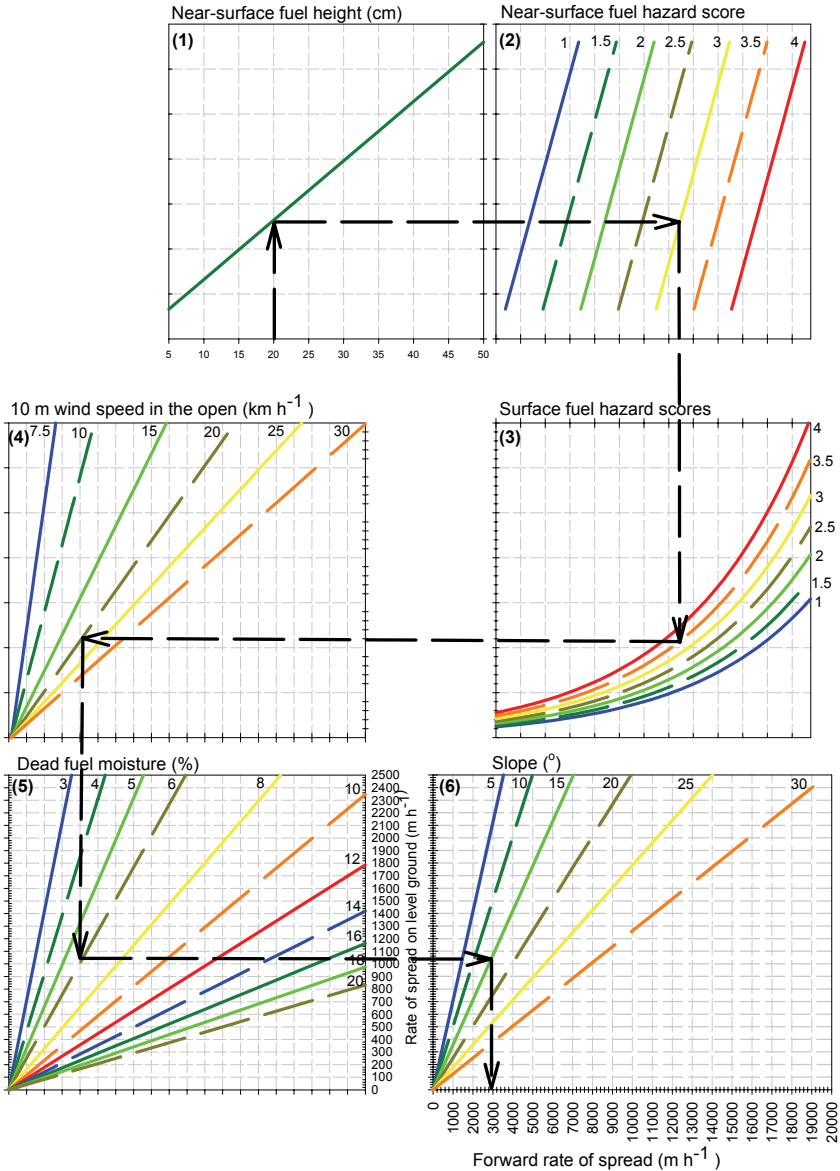
Slope in degrees	Spread correction factor
Level	1.0
+ 2 ½	1.2
+ 5	1.4
+ 7 ½	1.7
+10	2.0
+12 ½	2.4
+15	2.8
+17 ½	3.3
+20	4.0

Source: McArthur (1967) and Noble, Bary and Gill (1980)

$R_s = R \cdot \exp(0.069 \cdot s)$ where: R_s = slope adjusted rate of spread, s = slope (degrees), R = rate of spread on level ground).



National Fire Spread Model for Dry Eucalypt Forest



Nomogram Procedures

The rate of forward spread is estimated by tracing a line through the graphs to connect the values of the variables of near-surface fuel height (cm), near-surface fuel hazard score (Table F2), surface fuel hazard score (Table F1), wind speed (U_{10}) and dead fuel moisture content (Tables M1, M2 or M3). Example above for calculating the rate of spread under the following conditions:

- near-surface fuel height 20 cm
 - near-surface fuel hazard score 3 (Table F2)
 - surface fuel hazard score 3.5 (Table F1)
 - average wind speed at 10 m in the open 20 km h⁻¹
 - dead fine surface fuel moisture content 6% (Table M1= temperature= 30°C and relative humidity= 30%)
 - slope 15°
1. Starting in graph (1), trace a vertical line from 20 cm near-surface fuel height to the diagonal line.
 2. At the point of intercept, trace a horizontal line to the near-surface fuel score graph (2) to intercept the appropriate line for the near-surface fuel hazard score 3
 3. From this point of intercept in graph (2), trace a vertical line downward into graph (3) until it intercepts the appropriate surface fuel hazard score 3.5.
 4. From this intercept trace a horizontal line into graph (4) until it intercepts the appropriate 10 m wind speed of 20 km h⁻¹.
 5. From this intercept trace a vertical line into graph (5) until it intercept the appropriate fine dead fuel moisture content 6%.
 6. From this intercept trace a horizontal line to the right hand axis of graph (5) to read the rate of spread on level ground value of approximately 1050 m h⁻¹ (between 1000 and 1100 m h⁻¹)
 7. From this intercept continue to trace the horizontal line into graph (6) until it intercept the appropriate slope (15°). From the slope intercept line trace a vertical line to the bottom axis to read the rate of spread value of approximately 3000 m h⁻¹.

Flame height (Fh)

Flame height is difficult to estimate accurately but can be related to head fire rate of spread and elevated fuel height up to 2 m. The flame height model predicts reasonably well when flame height of surface fires is up to 8 m. When predicted flame height exceeds 8 m there is likely to be torching or crown fires in the intermediate and overstorey canopies depending on the bark hazard and the density of the intermediate and overstorey layers.

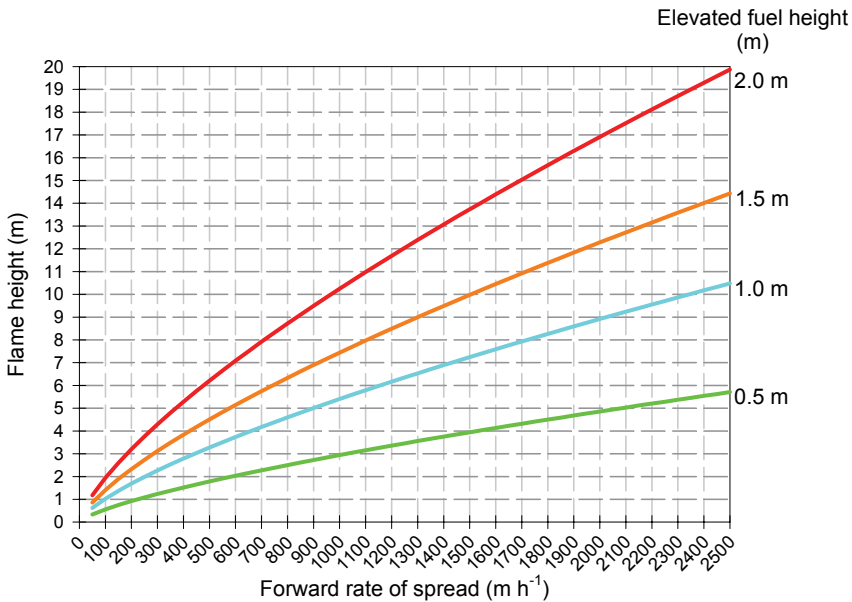


Table Fh1

Flame height for spread between 50 – 1000 m/hr				
Rate of spread (m/h)	Elevated fuel height (m)			
	0.5	1.0	1.5	2.0
50	0.5	0.5	1.0	1.0
100	0.5	1.0	1.5	2.0
150	0.5	1.5	2.0	2.5
200	1.0	1.5	2.5	3.0
250	1.0	2.0	2.5	4.0
300	1.0	2.5	3.0	4.5
350	1.5	2.5	3.5	5.0
400	1.5	3.0	4.0	5.5
450	1.5	3.0	4.0	6.0
500	2.0	3.5	4.5	6.0
550	2.0	3.5	5.0	6.5
600	2.0	3.5	5.0	7.0
650	2.0	4.0	5.5	7.5
700	2.5	4.0	5.5	8.0
750	2.5	4.5	6.0	8.5
800	2.5	4.5	6.5	8.5
850	2.5	5.0	6.5	9.0
900	2.5	5.0	7.0	9.5
950	3.0	5.0	7.0	10.0
1000	3.0	5.5	7.5	10.0

Flame height for spread between 1000 – 2500 m/hr				
Rate of spread (m/h)	Elevated fuel height (m)			
	0.5	1.0	1.5	2.0
1000	3.0	5.5	7.5	10.0
1050	3.0	5.5	7.5	10.5
1100	3.0	6.0	8.0	11.0
1150	3.5	6.0	8.0	11.5
1200	3.5	6.0	8.5	11.5
1250	3.5	6.5	8.5	12.0
1300	3.5	6.5	9.0	12.5
1350	3.5	6.5	9.0	12.5
1400	4.0	7.0	9.5	13.0
1450	4.0	7.0	9.5	13.5
1500	4.0	7.0	10.0	13.5
1550	4.0	7.5	10.0	14.0
1600	4.0	7.5	10.5	14.5
1650	4.0	8.0	10.5	14.5
1700	4.5	8.0	11.0	15.0
1750	4.5	8.0	11.0	15.5
1800	4.5	8.5	11.5	15.5
1850	4.5	8.5	11.5	16.0
1900	4.5	8.5	12.0	16.5
1950	5.0	9.0	12.0	16.5
2000	5.0	9.0	12.5	17.0
2050	5.0	9.0	12.5	17.0
2100	5.0	9.0	12.5	17.5
2150	5.0	9.5	13.0	18.0
2200	5.0	9.5	13.0	18.0
2250	5.5	9.5	13.5	18.5
2300	5.5	10.0	13.5	18.5
2350	5.5	10.0	14.0	19.0
2400	5.5	10.0	14.0	19.5
2450	5.5	10.5	14.0	19.5
2500	5.5	10.5	14.5	20.0

Maximum Spotting Distance



Spotting Distance Tables (Sd)

The tables predict maximum spotting distance in dry eucalypt forest that contains stringybark trees. It is assumed that maximum spotting distance coincides with peak rates of spread, which typically involve elevated and bark fuels in addition to surface fuels, causing pulses in fire intensity and convective activity.

The surface, near-surface and elevated fine fuel loads are estimated using fuel hazard scores. The 'base' fire intensity is calculated using peak rate of spread and combined surface and near-surface fine fuel load. It is assumed that elevated fine fuel will contribute to fire intensity when the base fire intensity exceeds 1000 kW m^{-1} . Bark consumption is estimated as functions of bark hazard score and base fire intensity, using relationships tabled in Gould *et al.* (2007) (Chapter 9 The contribution of bark as fuel). It is assumed that half the mass of bark consumed contributes to the intensity of the fire-front. Peak fire intensity is then calculated using peak rate of spread and the estimated of fine fuel load from the above fuel strata.

The model does not presently predict spotting distances from small patches of vegetation containing fine fuel loads significantly greater than indicated by the average fuel hazard scores for the whole area.

The model of Ellis (2000) derives maximum spotting distance by plotting the transport of particles with the firebrand characteristics of stringybark within a simple plume model where updraft velocity is derived by Raupach (1990). The relationships between maximum spotting distance and fire intensity were modelled for each 5 km hr^{-1} category of wind speed at 10 m in the open. These models were then used to calculate maximum spotting distance for tabulated values of predicted rate of spread for given surface fuel hazard score, bark hazard score and category of wind speed.

The spotting tables do not give distances for all combinations of predicted spread rate and 10 m open wind speed because the model does not determine spotting distances for these combinations.

The model does not predict the spotting distance of firebrands transported directly from the boles and branches of trees by wind alone. In strong winds, this mechanism can result in spotting distances exceeding 100 m.

Table Sd1.1

Surface Fuel Hazard Score = 1 (Low)

Bark hazard score = 1 (Moderate)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50										
100										
150	40									
200	55									
250		80								
300		110								
350		140								
400		170	110							
450		210	140							
500		240	170							
600		310	240	200						
700		390	320	260						
800		470	400	320	300					
1000			560	450	420	400	380	360		
1500			1000	800	750	680	700	640	650	
2000				1130	1100	1000	950	920	930	940
2500				1470	1450	1280	1250	1200	1220	1220
3000					1780	1600	1550	1500	1500	1500
4000						2250	2200	2200	2100	2100
6000									3400	3350

Table Sd1.2

Surface Fuel Hazard Score = 1 (Low)

Bark hazard score = 2 (High)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50										
100										
150	40									
200	55									
250		95								
300		125								
350		160								
400		200	140							
450		240	180							
500		280	210							
600		360	290	240						
700		450	380	310						
800		550	470	380	360					
1000			660	540	500	460	440	420		
1500			1150	920	880	800	800	740	750	
2000				1310	1260	1130	1100	1100	1050	1100
2500				1720	1660	1450	1450	1400	1400	1400
3000					2100	1840	1800	1800	1800	1750
4000						2600	2600	2500	2500	2400
6000									3900	3900

Table Sd1.3

Surface Fuel Hazard Score = 1 (Low)

Bark hazard score = 3 (Very High)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50										
100										
150	40									
200	55									
250	130	105								
300		150								
350		180								
400		250	170							
450		270	210							
500		320	250							
600		410	340	290						
700		510	440	360						
800		620	540	450	410					
1000			750	620	580	530	510	490		
1500			1310	1050	1000	910	880	840	850	
2000			1900	1500	1450	1300	1250	1200	1200	1200
2500				1950	1900	1680	1630	1600	1600	1600
3000				2400	2400	2100	2100	2000	1950	1950
4000					3300	3000	2850	2800	2750	2700
6000					5300	4700	4600	4500	4400	4300

Table Sd1.4

Surface Fuel Hazard Score = 1 (Low)

Bark hazard score = 4 (Extreme)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50										
100										
150	40									
200	55									
250	150	120								
300		160								
350		210								
400		250	190							
450		300	240							
500		350	290							
600		450	390	330						
700		570	500	420						
800		700	600	510	470					
1000			850	700	650	600	570	550		
1500			1460	1200	1150	1010	980	950	940	
2000				1700	1600	1440	1400	1350	1350	1350
2500				2200	2100	1880	1850	1800	1750	1750
3000					2600	2350	2300	2200	2200	2100
4000						3250	3200	3100	3000	3000
6000									4900	4800

Table Sd2.1

Surface Fuel Hazard Score = 2 (Moderate)

Bark hazard score = 1 (Moderate)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50										
100	55	25								
150	100	65								
200	150	100	60							
250	200	150	100	85						
300	250	185	135	120						
350		240	180	160	140					
400		290	230	200	180					
450		340	280	240	220	210				
500		400	330	290	260	240	230			
600		500	440	370	340	320	300	290		
700		620	550	460	420	400	380	350		
800		750	660	550	510	470	450	440	440	
1000			880	750	680	650	600	570	600	590
1500			1500	1200	1150	1050	1000	1000	1000	960
2000				1700	1650	1500	1450	1370	1360	1350
2500				2800	2700	2400	2300	2300	2200	2200
3000					3800	3400	3300	3200	3100	3050
4000						4300	4200	4100	4000	4000
6000									6000	5800

Table Sd2.2

Surface Fuel Hazard Score = 2 (Moderate)

Bark hazard score = 2 (High)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50										
100	55	25								
150	110	70								
200	150	110	65							
250	200	160	110	100						
300		200	160	140						
350		260	210	180	160					
400		310	260	250	200					
450		370	310	2280	240	230				
500		450	370	320	300	270	250			
600		550	500	420	380	350	340	320		
700		670	600	520	470	440	410	400		
800		800	720	620	600	520	490	470	480	
1000			1000	800	750	700	660	650	650	640
1500			1650	1350	1250	1150	1100	1050	1040	1040
2000				1900	1800	1620	1600	1500	1500	1500
2500				3050	2900	2600	2600	2500	2450	2400
3000				4250	4100	3650	3600	3500	3400	3350
4000					5400	4750	4650	4500	4450	4300
6000					7900	7000	6850	6700	6500	6400

Table Sd2.3

Surface Fuel Hazard Score = 2 (Moderate)

Bark hazard score = 3 (Very High)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50										
100	55	25								
150	120	75								
200	150	120	75							
250	220	170	120	110						
300	300	220	170	160						
350		275	230	200	180					
400		350	280	250	220					
450		400	350	300	270	260				
500		500	400	350	320	300	280			
600		600	550	460	420	400	370	350		
700		725	700	560	520	500	450	440		
800		860	800	670	620	600	540	520	520	
1000		1150	1100	900	850	750	720	700	700	690
1500			1800	1450	1400	1250	1200	1150	1150	1130
2000			2600	2100	2000	1800	1700	1650	1600	1600
2500			4200	3300	3200	2850	2800	2700	2650	2600
3000					4500	4000	3900	3800	3700	3650
4000						5200	5100	4900	4800	4700
6000									6500	6400

Table Sd2.4

Surface Fuel Hazard Score = 2 (Moderate)

Bark hazard score = 4 (Extreme)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50										
100	55	25								
150	110	80								
200	150	125	85							
250	200	180	140	130						
300		250	190	180						
350		300	250	230	200					
400		360	310	280	240					
450		450	370	330	290	280				
500		500	450	400	350	350	300			
600		650	600	500	450	420	400	380		
700		800	700	600	550	520	500	460		
800		950	850	750	700	620	600	550	550	
1000		1250	1150	1000	900	800	800	750	750	740
1500			1900	1600	1500	1400	1300	1250	1220	1220
2000			2750	2250	2150	1900	1850	1800	1750	1750
2500			4500	3600	3450	3100	3000	2900	2850	2800
3000			6500	5000	4900	4300	4200	4100	4000	3900
4000							5450	5300	5200	5100
6000								6600	6500	6400

Table Sd3.1

Surface Fuel Hazard Score = 3 (High)

Bark hazard score = 1 (Moderate)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50	40	10								
100	199	45	20							
150	150	85	50	50						
200	200	150	100	100						
250		200	150	150	120					
300		250	200	200	160	160				
350		350	260	250	210	200	200			
400		400	320	300	260	250	230	220		
450		440	400	350	300	300	270	250		
500		510	450	400	350	350	300	300		
600		650	580	500	460	450	400	400	400	
700		800	750	650	600	550	500	500	500	
800		950	900	750	700	620	600	600	600	570
1000		1250	1200	1000	900	850	800	750	750	750
1500		2100	2000	1600	1500	1400	1300	1250	1250	1250
2000			2800	2300	2200	1950	1900	1800	1800	1750
2500				5100	4900	4400	4300	4150	4100	4000
3000						6700	6500	6300	6200	6100
4000								6850	6700	6600
6000										7000

Table Sd3.2

Surface Fuel Hazard Score = 3 (High)

Bark hazard score = 2 (High)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50	40	10								
100	100	50	20							
150	160	90	60	60						
200	220	150	110	100						
250		200	160	150	130					
300		260	220	200	180	170				
350		330	300	260	230	220	200			
400		400	350	320	280	270	250	230		
450		470	420	400	350	320	300	270		
500		540	500	450	400	360	340	320		
600		670	620	550	500	460	430	410	410	
700		840	800	700	600	580	530	500	500	
800		1000	950	800	750	700	650	600	600	600
1000		1350	1250	1100	1000	900	850	800	800	800
1500		2200	2100	1700	1650	1500	1400	1350	1320	1300
2000			3000	2450	2300	2100	2000	1950	1900	1850
2500				5450	5300	4700	4600	4400	4300	4200
3000						6650	6500	6300	6200	6100
4000								6850	6700	6600
6000										6700

Table Sd3.3

Surface Fuel Hazard Score = 3 (High)

Bark hazard score = 3 (Very High)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50	40	10								
100	110	50	20							
150	180	100	70	65						
200	250	150	120	110						
250		220	180	170	150					
300		280	240	230	200	190				
350		350	300	280	250	240	220			
400		430	380	350	300	290	270	250		
450		500	450	400	360	340	320	290		
500		600	520	470	410	400	370	340		
600		750	700	590	530	500	470	440	440	
700		900	850	720	650	600	570	550	540	
800		1100	1000	850	800	720	700	640	640	640
1000		1400	1350	1150	1050	950	900	850	850	840
1500		2350	2250	1850	1750	1550	1500	1450	1400	1400
2000			3200	2600	2500	2200	2200	2100	2000	2000
2500				5800	5600	5000	4900	4700	4600	4500
3000						6700	6500	6300	6200	6100
4000								6900	6700	6600
6000										7000

Table Sd3.4

Surface Fuel Hazard Score = 3 (High)

Bark hazard score = 4 (Extreme)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50	40	10								
100	120	50	30							
150	190	100	90	70						
200	260	160	130	120						
250	330	230	190	180	150					
300	400	300	250	240	210	200				
350		370	330	300	260	250	230			
400		450	400	370	320	300	280	260		
450		530	470	430	380	360	330	310		
500		600	550	500	440	410	390	360		
600		800	720	630	570	530	500	460	460	
700		950	870	770	690	640	600	570	570	
800		1150	1050	900	850	760	720	700	680	680
1000		1500	1400	1200	1100	1000	950	910	900	900
1500		2500	2400	2000	1850	1700	1600	1550	1500	1500
2000			3400	2800	2600	2400	2300	2200	2150	2100
2500				6200	6000	5300	5200	5000	4900	4800
3000						6700	6500	6300	6200	6100
4000								6900	6700	6600
6000										7000

Table Sd4.1

Surface Fuel Hazard Score = 4 (Extreme)

Bark hazard score = 1 (Moderate)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50	55	15								
100	130	60	30							
150	200	110	80	75						
200	270	170	130	130	110					
250	340	230	200	190	160	160				
300	420	300	260	250	210	210	200			
350	500	380	330	310	270	260	240	220		
400	550	450	400	370	330	310	300	270		
450	650	530	470	440	380	360	340	320		
500		610	550	500	450	420	400	370	370	
600		800	720	650	600	530	500	480	470	
700		950	900	800	700	650	620	600	600	600
800		1150	1100	900	850	800	750	700	700	700
1000		1500	1450	1200	1100	1050	1000	950	900	900
1500		2500	2400	2000	1900	1700	1600	1550	1500	1500
2000		3600	3400	3000	2700	2400	2300	2200	2200	2100
2500		8200	8000	6300	6100	5400	5200	5100	4900	4800
3000			10000	8000	7500	6700	6500	6300	6200	6100
4000					8100	7200	7000	6900	6700	6600
6000							7400	7300	7100	7000

Table Sd4.2

Surface Fuel Hazard Score = 4 (Extreme)

Bark hazard score = 2 (High)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50	55	15								
100	140	55	30							
150	210	110	80	85						
200	290	170	140	140	120					
250	360	240	210	200	170	160				
300	440	320	280	270	230	220	200			
350	520	400	350	330	290	270	250	230		
400	590	470	430	400	350	330	300	280		
450	670	560	500	470	400	380	360	330		
500		640	590	540	470	440	420	390	390	
600		820	760	680	600	560	530	500	500	
700		1000	930	830	740	690	650	600	600	600
800		1200	1100	1000	880	820	770	720	720	720
1000		1600	1500	1300	1200	1100	1050	1000	950	950
1500		2600	2500	2100	2000	1800	1700	1600	1600	1600
2000		3800	3600	3000	2800	2500	2400	2300	2200	2200
2500		8600	8300	6600	6400	5700	5500	5300	5200	5100
3000			10000	8000	7500	6700	6500	6300	6200	6100
4000					8100	7200	7000	6900	6700	6600
6000							7400	7300	7100	7000

Table Sd4.3

Surface Fuel Hazard Score = 4 (Extreme)

Bark hazard score = 3 (Very High)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50	55	15								
100	140	60	35							
150	220	110	85	90						
200	300	180	150	150	120					
250	400	250	220	210	180	180				
300	470	330	290	280	250	230	220			
350	550	410	370	350	300	290	270	250		
400	630	500	450	420	360	340	320	300		
450	700	580	530	490	430	400	380	350		
500		670	620	560	500	460	430	400	400	
600		850	790	720	650	600	560	520	520	
700		1050	980	900	800	720	680	650	640	640
800		1250	1200	1050	950	850	800	760	750	750
1000		1650	1600	1350	1250	1150	1100	1050	1000	1000
1500		2750	2600	2200	2100	1900	1800	1700	1650	1650
2000		4000	3800	3100	3000	2700	2550	2450	2400	2300
2500		9000	9000	7000	7000	6000	5800	5600	5400	5300
3000			10000	8000	7500	6700	6500	6300	6200	6100
4000					8100	7100	7000	6800	6700	6600
6000							7400	7200	7100	7000

Table Sd4.4

Surface Fuel Hazard Score = 4 (Extreme)

Bark hazard score = 4 (Extreme)

Maximum spotting distance (m)

Predicted ROS (m/hr)	10 m open wind speed (km/h)									
	5	10	15	20	25	30	35	40	45	50
30										
50	55	15								
100	150	60	40							
150	240	120	100	100						
200	320	200	160	160	130					
250	410	260	230	230	190	190				
300	500	350	300	300	250	240	230			
350	580	430	400	370	320	300	280	260		
400	670	520	470	450	380	360	340	310		
450	750	600	550	520	450	430	400	370		
500		700	650	600	520	490	460	430	430	
600		900	830	750	670	620	580	540	540	
700		1100	1050	910	820	760	720	670	670	660
800		1300	1200	1100	1000	900	850	800	800	780
1000		1700	1650	1450	1300	1200	1150	1100	1050	1050
1500		2900	2750	2300	2150	2000	1900	1800	1750	1700
2000		4100	4000	3300	3100	2800	2700	2550	2500	2450
2500		9100	9000	7000	6700	6000	5800	5600	5450	5300
3000			10000	7700	7500	6700	6500	6300	6200	6100
4000					8100	7200	7000	6900	6700	6600
6000							7400	7300	7100	7000

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Fuel Assessment Field Sheet

Date:	Location:
Assessor:	Map reference:

		Plot number										
		1	2	3	4	5	6	7	8	9	10	Ave
Surface	Depth (mm)											
	FHS											
Near-surface	Height (cm)											
	FHS											
Elevated	Height (m)											
	FHS											
Bark	FHS											

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