Natural Resources and Environment

AGRICULTURE
RESOURCES
CONSERVATION
LAND MANAGEMENT

Overall Fuel Hazard Guide

Third Edition

May 1999

Fire Management

Victoria ON THE MOVE

Overall Fuel Hazard Guide

G.J. McCarthy, K.G. Tolhurst
& K. Chatto

Third Edition
May 1999

Fire Management
Research Report No.47

Natural Resources and Environment
AGRICULTURE • RESOURCES • CONSERVATION • LAND MANAGEMENT

CFTT CENTRE FOR FOREST TREE TECHNOLOGY

Important Notes

General Note 1: Wildfire in south-eastern Australia can at times represent a significant threat to life and property. Paradoxically, fire also plays an integral role in the maintenance of many of our native ecosystems. New users of this guide are urged to familiarise themselves with Victoria's *Code of Practice for Fire Management on Public Land*. The Code provides a framework for fire management procedures and practices on public land in Victoria.

General Note 2 : Potential users of this guide, who are unfamiliar with Victorian ecosystems, are advised that for a number of reasons, fire is not always the appropriate tool for reducing fuel hazards. Intending users of this Guide are welcome to contact NRE for further advice.

Safety Note : Some photos depicting fuel hazard classes contain a hardhat for scale reference. For safety do not remove your your hardhat to reproduce these conditions. If necessary use a spare hardhat.

Published by the Department of Natural Resources and Environment - Fire Management Branch, 250 Victoria Pde East Melbourne, Victoria 3002, Australia.

http://www.nre.vic.gov.au

ISBN:0 7311 4463 5

Design: W. Havard

Contents

About this guide

Overall Fuel Hazard is defined as follows:

Overall Fuel Hazard = (the sum of the influences of) Bark Hazard+ Elevated Fuel Hazard+ Surface Fine Fuel Hazard

This approach represents a significant change in the philosophy of assessing the fuel factors affecting fire behaviour. Rather than simply considering surface fine fuel loads (in tonnes/hectare) as in the past, it shifts the emphasis to considering the whole fuel complex, and particularly the bark and elevated fuels—bark and elevated fuels being the fuel elements principally responsible for both first attack failure and also for general suppression difficulty in Victorian forests, woodlands, deserts, heathlands and shrublands (*see* McCarthy and Tolhurst 1998).

The purpose of this guide is to assist land managers, and supervisors of fire control operations or prescribed burns, in assessing the hazard posed by Bark Fuel, Elevated Fuel, and Surface Fine Fuel. It builds on the principles of fuel hazard assessment already established in the previously published Eucalypt Bark Hazard Guide (Wilson 1992a) and in the Elevated Fuel Guide (Wilson 1993). It replaces those Guides.

Using this guide will assist with:

- defining, in a consistent way, fuel management objectives, i.e. ensuring that there is statewide consistency in achieving appropriate Overall Fuel Hazard levels for Fuel Management Zones;
- identifying fuel hazards during fire suppression operations, from first attack through to the conduct of complex final suppression strategies, in particular back-burning;
- identifying fuel hazards in order to conduct prescribed burning or back-burning in the most effective way - i.e. effectively reducing fuel hazards to ensure that control lines are not breached;
- increasing the safety of fireline personnel, by recognising fuel hazards which may give rise to uncontrollable fire behaviour;
- identifying fuel hazards in forested areas which may pose a significant threat to adjoining houses or other assets.

This Guide describes five categories of Overall Fuel Hazard. These categories are based on the ability of suppression forces to control a fire in these fuels, as discussed in detail by Wilson (1992b).

Assessing surface fine fuel hazard

The structure of surface fine fuel has been found to be better related to fire behaviour than the surface fine fuel load (McCarthy ***in prep***). Surface Fine Fuel Hazard can be assessed by measuring litter-bed height. Litter-bed height should be measured using a simple depth gauge constructed from a ruler and a circular piece of masonite or plywood as shown in Figure 1. A small gap is made in the litter-bed down to mineral soil and the end of the ruler is placed resting on the mineral soil surface. The disc is pushed down with a very light pressure, and the ruler is read off level with the top of the disc. (Note that the end of the ruler beyond the scale has been adjusted to match the thickness of the disc.)

At least 5 measurements of litter-bed height should be made at each sampling site. Measurements should be taken at convenient intervals (suggested 200 m to 1000 m) around a burning block so that the prevailing range of fuel types is sampled.

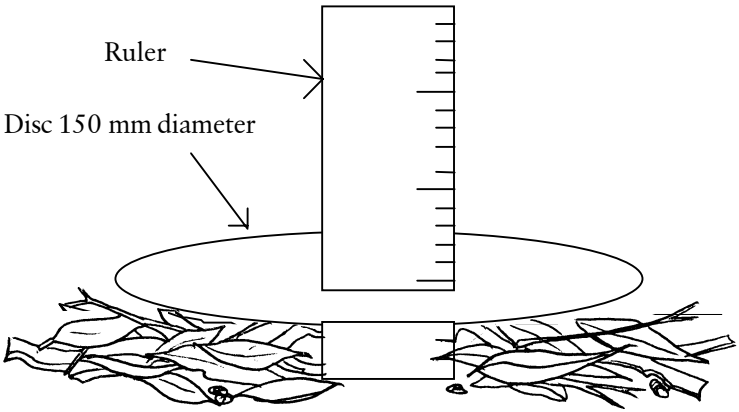

Figure 1. Fuel depth gauge

The following table can be used to convert litter-bed height to Surface Fine Fuel Hazard

Table 1. Surface Fine Fuel Hazard rating system based on Litter-bed height

Surface Fine Fuel Hazard Rating	Low	Moderate	High	Very high	Extreme
Litter-bed Height (mm)	< 15	15–25	25–35	35–50	50 >
Equivalent Litter Load (t/ha)	< 4	4–8	8–12	12–20	20+

Near-surface fuels

Near-surface fuels—i.e. grass tussocks, dead bracken, low shrubs or low wiregrass up to 0.5 m high—interact with the surface litter to increase fire behaviour, and therefore need to be compensated for when assessing Surface Fine Fuel Hazard (see McCarthy *in prep*). If the site has high cover values of near-surface fuels, then you should assign the next higher Surface Fine Fuel Hazard rating to it than would normally have been the case for that litter-bed height. For example, a site with 30 mm of litter-bed height, but with the site covered by grass tussocks with cover values of 40% or greater, would go into the Very High class rather than the High class.

Moderate
Surface Fine
Fuel Hazard

High
Surface Fine
Fuel Hazard

Very High Surface Fine Fuel Hazard

Extreme Surface Fine Fuel Hazard

Assessing elevated fuel hazard

Elevated fuel comprises shrub, heath, and suspended material. The level of hazard depends on the fuel continuity (horizontal and vertical), height, amount (weight), proportion of dead material, thickness of the foliage and twigs, and flammability of the live foliage.

The flammability of the elevated fuel is highest when: the foliage, twigs and other fuel particles are very fine (e.g. maximum thickness 1–2 mm); the proportion of dead material is high; the fuels are arranged with a high level of density and horizontal and vertical continuity that promotes the spread of flames; and the live foliage has low live fuel moisture contents.

The vegetation type and the time since the most recent fire substantially determine the level of elevated fuel hazard.

The characterising descriptions, in italics and quotation marks at the beginning of each category description, should not be used on their own, but read in conjunction with the rest of the category description.

Low Elevated Fuel Hazard

'Easy to walk through in any direction.'
Elevated fuel virtually absent.

Moderate Elevated Fuel Hazard

Description

'Easy to walk through, but vegetation does brush against legs occasionally.'

Elevated fuels add very little to the flame height or rate of spread of a fire except at Extreme levels of fire danger. The Overall Fuel Hazard of the site depends almost entirely on the bark and surface fine fuels, except at Extreme levels of fire danger.

This category is characterised by:

- sparse understorey vegetation;
- bracken and heath or shrubs that are re-establishing after a fire.

The elevated fuels generally have the following characteristics:

- elevated material is sparse/dispersed or arranged so that it does not sustain flames readily;
- dead material is virtually absent.

High Elevated Fuel Hazard

Description

'Moderately easy to walk through, but brush against or step over vegetation most of the time.'

Elevated fuels cause some patchy increases in the flame height and/or rate of spread of a fire.

This category is characterised by vegetation such as:

- Bracken which has moderate density and age;
- Wiregrass which contains a low proportion of dead material or which is less than 0.5 m high;
- grass which is less than about 0.3 m high;
- shrubs with moderate density and moderate flammability of live foliage (e.g. *Cassinia spp.*, *Goodenia spp.*);
- tall shrubs (i.e. at least 5 m high) with not much fine fuel for the first few metres above the ground (e.g. *Pomaderris spp.*, *Bedfordia spp.*);
- Broombrush (*Melaleuca uncinata*).

The elevated fuels generally have the following characteristics:

- moderately dense;
- the proportion of dead material is 0–20% (by dry weight);
- if tall (i.e. at least 5 m), then there is not much fine fuel for at least the first 2–4 m above the ground.

high

Very High Elevated Fuel Hazard

Description

'Difficult to walk through. Need to carefully select path and step high.'

Elevated fuels mostly dictate the flame height and rate of spread of a fire. Elevated fuels are a dominant part of the Overall Fuel Hazard of the site. Surface fuels are less important; fires may even spread when the surface fuels are wet. The additional presence of taller shrubs (e.g. Banksias, Hakeas, Wattles) may further enhance the hazard. This category is characterised by vegetation such as:

- heath which contains 20–30% dead material; bracken which contains 20–30% dead material and which is dense enough to suspend other material such as eucalypt bark;
- wiregrass of which a substantial proportion is 0.5–1 m high and which is dense enough to suspend eucalypt leaves and other fine fuel above the ground;
- shrub understoreys that are dense, contain 20–30% dead material, and which are at least 1 m high;
- grasses and annuals that are dense, greater than 1 m high and which are or will be at least 80% cured.

The elevated fuels generally have the following characteristics:

- the density and continuity (vertical and horizontal) are high;
- the proportion of dead material is 20–30%;
- the general height of the vegetation is at least 0.5 m and usually at least 1 m;
- the fuel particles are mostly less than 2 mm thick.

Extreme Elevated Fuel Hazard

Description

'Very difficult to see where you are going. Need to use arms to push through vegetation.'

Elevated fuels almost entirely determine the flame height and rate of spread of a fire.

The Overall Fuel Hazard of the site is Extreme irrespective of the bark and surface fuels.

This category is characterised by vegetation such as:

- Tea tree, Melaleuca or heath that is at least 2–3 m high and where fine fuels are present from top to bottom of the vegetation;
- Wiregrass that is dense and at least 2–3 m high.

The elevated fuels generally have the following characteristics:

- vegetation is tall (at least 2–3 m), dense and continuous from top to bottom;
- large amounts of leaves, twigs and other fuel particles with maximum thickness less than 2 mm are distributed from ground level to the top of the vegetation;
- proportion of dead material is 30%–50% (or greater);
- the weight of living and dead elevated fine fuel is high (greater than about 10 t/ha).

Assessing bark hazard

Bark Hazard can defeat control in wildfire or prescribed burn situations at low to moderate FDIs (Forest Fire Danger Indices, McArthur 1967) by producing short range spotting. It can defeat control in wildfire situations at High to Very High (or Extreme) FDIs by producing short and long distance spotting, and also by acting as a link between ground and crown fuels to produce crown fires.

The important considerations when looking at bark fuel hazard are:

- amount of loose fibrous bark – particularly 'stringybark';
- amount of bark burnt off in any previous wildfire or fuel reduction burn, both at the base of the tree and up the bole;
- amount of long loose 'ribbony' bark.

Low Bark Hazard

No bark present that could contribute to fire behaviour.

low

Moderate Bark Hazard

Description

Very little bark is available to allow spotting to occur. Fires with a flame height of 0.5 m to 1.0 m will not 'climb' these trees, and so spotting generally does not cause a problem. Moderate Bark Hazard is characterised by:

- Stringybarks – the bark is black for a substantial distance up the bole of most trees;
- other bark types – where the fibrous/subfibrous bark is fine textured and held very tightly to the bole of the tree, e.g. Box, Ironbark.

Assessment of bark hazard

Stringybarks	Bark tightly held > 90% of bole charred
Platy and Subfibrous barks	Very tight bark e.g. Ironbarks, Boxes
Smooth or Gum barks	No long ribbons of bark e.g. Red Gum, Yellow Gum, Snow Gum, Swamp Gum

bark hazard

moderate

High Bark Hazard

Description

A limited amount of bark is available to cause spotting. Fires with a flame height of 0.5 m to 1.0 m will 'climb' some of these trees and cause sporadic spotting. High Bark Hazard is characterised by:

- Stringybarks – most of the bole is blackened especially the lower part of the trunk;
- other fibrous or subfibrous bark types (e.g. Box, Peppermint, Mahogany, Bloodwood) – the bark is held tightly to the trunk and some of the lower portions may have been removed in an FRB or wildfire;
- < 10% of Stringybark trees per hectare in a mixed species stand, but having a bark hazard up to Very High.

Assessment of bark hazard

Stringybarks	Few pieces of bark loosely held 50% to 90% of bole charred
Platy and Subfibrous barks	Tight bark, long unburnt e.g. Boxes, Peppermints, Bloodwoods
Smooth or Gum barks	Long ribbons of bark, but smooth trunk e.g. Manna Gum, Candlebark

high

Very High Bark Hazard

Description

Significant amounts of bark are available to cause spotting. Fires with a flame height of 0.5 m to 1.0 m will 'climb' most of these trees and cause significant spotting. Very High Bark Hazard is characterised by:

- Stringybarks – where less than 50% of bole is black and substantial quantities of bark are loosely held;
- Southern Mahogany – where trees are large and have loose fibrous bark, particularly in the upper branches;
- Mallee eucalypts – where strips of bark are suspended above the ground;
- Coastal Manna Gum (or similar species) – with loose fibrous bark around the base and long ribbons of bark in the upper branches.

Assessment of bark hazard

Fibrous or Stringybarks	Significant amounts of bark loosely held 10% to 50% of bole charred. e.g. Mature Mountain Ash
Platy and Subfibrous barks	Loose bark e.g. Southern Mahogany, Gippsland Grey Box, Silvertop
Smooth or Gum barks	Long ribbons of bark to ground level e.g. Rough-barked Manna Gum, Mallee species

very high

Extreme Bark Hazard

Description

Huge amounts of bark are available to cause spotting. Fires with a flame height of 0.5 m to 1.0 m will 'climb' virtually all these trees, and the bark sustains the flames easily, even when there is little heating from below. Strong updrafts during almost any fire are likely to dislodge numerous 'firebrands'. Extreme Bark Hazard is characterised by:

- Messmate and other Stringybarks – where large amounts of loosely held bark are present from the bole to the upper branches (i.e. generally long unburnt);
- Alpine Ash – where large amounts of fibrous bark are loosely held on the bole, and long ribbons of bark are present in the upper branches.

Assessment of bark hazard

Fibrous or Stringybarks	Outer bark weakly attached, bark easily dislodged < 10% of bole charred e.g. Messmate, Alpine Ash, Brown Stringybark
Platy and Subfibrous barks	Does not occur
Smooth or Gum barks	Does not occur

extreme

Overall fuel hazard

The following tables are used to combine the assessed levels of Bark, Elevated and Surface Fine Fuel Hazard to give an Overall Fuel Hazard rating for a site. The starting point for these tables is Bark Hazard, so this should be used as the first input.

Table 2.1 Bark Hazard: Low/Moderate

Elevated Fuel Hazard	Surface Fine Fuel Hazard: L	M	H	VH	E
L	L	M	M	H	H
M	L	M	M	H	H
H	L	M	H	VH	VH
VH	VH	VH	VH	VH	VH
E	E	E	E	E	E

Table 2.2 Bark Hazard: High

Elevated Fuel Hazard	Surface Fine Fuel Hazard: L	M	H	VH	E
L	L	M	H	H	H
M	L	M	H	H	H
H	L	H	H	VH	VH
VH	VH	VH	VH	VH	E
E	E	E	E	E	E

Table 2.3 Bark Hazard: Very High/Extreme

Elevated Fuel Hazard	Surface Fine Fuel Hazard: L	M	H	VH	E
L	M	VH	VH	VH	E
M	M	VH	VH	E	E
H	M	VH	E	E	E
VH	E	E	E	E	E
E	E	E	E	E	E

First attack success

Overall fuel hazard and its implications for first attack success and/or the need for an extended first attack effort.

Data from a study into first attack effectiveness by NRE in the period 1991/92 - 1994/95 (McCarthy and Tolhurst 1998) indicate the following probabilities of (normal) first attack success (e.g. 6 crew, 1 or 2 slip-ons, 1 D3/D4) for given Overall Fuel Hazard levels and FDIs. Extended First Attack (>10 crew, large tankers and slip-ons, D6 dozer/s, aircraft etc.) may be required to improve success rates at low to moderate FDIs on Very High and Extreme Overall sites, and at high to very high FDIs on High Overall sites.

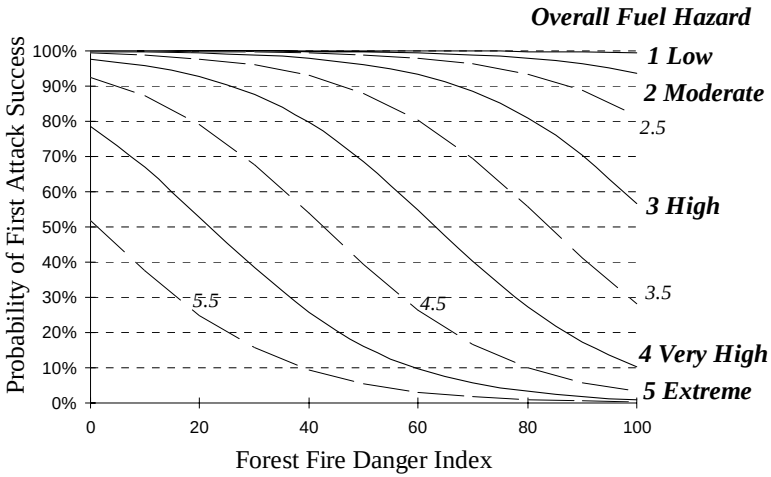

Figure 2. Probability of first attack success

Fuel hazard levels and NRE fuel management zones (FMZ)

Proposed Overall Fuel Hazards for the FMZs

FMZ 1 Moderate
FMZ 2 High
FMZ 3 High on 50% (rest may be higher)

Given the above probabilities of first attack outcome, the protection requirements of the Fuel Management Zones (FMZ –CNR 1995, formerly Priority Burning Zones P1, P2, P3) that are used by NRE may be met by maintaining each fuel component **at or below** the following maximum levels:

FMZ 1 Moderate Overall

- Surface Fine Moderate (litter-bed ht. 15–25 mm);
- Bark High (unless Surface Fine Low);
- Elevated High.

FMZ 2 High Overall

- Surface Fine High (litter-bed ht. 25–35 mm);
- Bark High (unless Surface Fine Low);
- Elevated High.

FMZ 3 High Overall on 50%

- Surface Fine High (litter-bed ht. 25–35 mm) on 50% of the zone;
- Bark High on 50% of the zone (unless Surface Fine Low);
- Elevated High on 50% of the zone.

These criteria are derived from an Overall Fuel Hazard (see Tables 2.1, 2.2,& 2.3) based on the proposition that the Overall Fuel Hazard should be no greater than Moderate in FMZ 1, High in FMZ 2, and High on 50% of the zone in FMZ 3. (i.e. it can be greater than High for the remainder)

Equivalent fuel loads (t/ha) for given hazard ratings

The following table gives average equivalent fuel loads for the various hazard levels for each fuel component.

Table 3. Equivalent fuels loads (t/ha) for given hazard ratings

FUEL	Low	Mod	High	V. High	Extreme
Bark	0	0	2	5	7
Surface Fine	2	5	10	16	20
Elevtd.	0	0	2	6	10

e.g.

High Bark		High Surface		V. High Elevated
2	+	10	+	6

Thus use : 2 + 10 + 6 = 18 t/ha Overall

The total can then be applied to the McArthur Forest Fire Danger Meter Mk. V (1973) for predictions of forward rate of spread and flame height.

Other factors affecting fire threat

Three classes of fuel—Elevated, Bark and Surface Fine fuel—should each be assessed. The results can then be combined to determine the Overall Fuel Hazard of a site, using the method described.

The overall fire threat at a particular site will depend on the fuel hazard levels, the ignition risk, the assets needing protection, the ground slope, the moisture regime (e.g. the fuel hazard on southern aspects or at higher elevations may be mitigated by moisture in many seasons), the presence of rocks and logs, and the typical weather patterns.

References

CNR (1995). *Code of Practice for Fire Management on Public Land.* Dept. of Conservation and Natural Resources, Vic. 38pp.

McArthur, A.G. (1967). *Fire Behavior in Eucalypt Forests.* Leaflet No. 107, Forest Research Institute, Forestry and Timber Bureau, Commonwealth of Australia, Canberra.

McArthur, A.G. (1973). *Forest Fire Danger Meter, Mk 5*. Forest Research Institute, Forestry and Timber Bureau, Canberra.

McCarthy G.J. (in prep.) *Fuel Hazard rating for Forest Fuels – Surface Fine Fuel Hazard.* Research Report No. 44. Fire Management , Dept. of Natural Resources and Environment, Vic.

McCarthy G.J. and Tolhurst K.G. (1998). *Effectiveness of Fire-fighting First Attack Operations, NRE Victoria 1991/92–1994/95*. Research Report No. 45. Fire Management. Dept of Natural Resources and Environment, Vic. 32pp + appendices.

Wilson A.A.G. (1992a). *Eucalypt Bark Hazard Guide.* Research Report No. 32, Fire Management Branch, Department of Conservation and Environment, Victoria. 16pp.

Wilson A.A.G. (1992b). *Assessing the Fire Hazard on Public Lands in Victoria: Fire Management Needs, and Practical Research Objectives.* Research Report No. 31, Fire Management Branch, Department of Conservation and Environment – Victoria. 11pp.

Wilson A.A.G. (1993). *Elevated Fuel Guide.* Research Report No. 35. Fire Management Branch, Department of Conservation and Natural Resources, Victoria. 27pp.

Acknowledgements

Andrew Wilson laid the foundations for this Guide with his Eucalypt Bark Hazard Guide and Elevated Fuel Guide, and particularly with the conceptual framework set out in Research Report No.31. Andrew Buckley (Bairnsdale) has supported this fuel appraisal work throughout and has assisted with photos.

Further information

For further information please contact a Fire Research Officer:

Orbost - 03 51541208

Creswick - 03 53214162
03 53214181