Riparian land and bushfire

Resource Document

VICTORIA State Government | Environment, Land, Water and Planning

CFA

This document has been prepared by Helen Bull, obliqua pty ltd, with input from the Project Working Group and other contributors.

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Cover photograph

Revegetated riparian land, Boolarra, Gippsland

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Summary

Many landholders with river frontages have voiced concerns that fencing and revegetating riparian land may result in a fire risk to their property. These concerns may be contributing to reluctance from landholders to participate in catchment management authority (CMA) programs to protect and improve riparian land.

The likelihood of a bushfire starting and its rate of spread and intensity in a riparian area will depend upon the presence of an ignition source, fuel, topography and weather.

The relative degree to which fuel, topography and weather will determine fire behaviour and its impact will vary from site to site.

In well-managed riparian vegetation with limited grass and weed growth and low slopes, and under a Low to Moderate Fire Danger Rating, bushfire may be difficult to ignite and may only burn very slowly and at a low intensity.

Under protracted drought, and extreme fire weather, such as experienced during February 2009, all vegetation can burn. Historically, extreme bushfire events of this scale are relatively rare. However, their frequency is expected to increase under climate change.

As the amount of riparian land is limited, compared with other land uses, riparian land can be expected to have only a limited influence on bushfire spread at a landscape scale. In addition, if spotting is limited, a fire burning in a forested riparian area is expected to be slower and therefore less likely to contribute to fire spread at a landscape scale than a fire burning in grass or crops.

Contrary to some beliefs, riparian areas do not generally act as a 'wick' or 'fuse'. Fires will generally only burn in the direction of the wind (while spreading more slowly sideways) or slope if burning under lighter wind conditions.

Fire in newly revegetated areas which have significant grass cover is likely to behave in the same way as fire burning in neighbouring pasture or crops and spread rapidly but its contribution to spread at a landscape scale will be determined by the presence of continuous fuel (e.g. cured pasture) around it. Barriers such as grazed areas, roads or firebreaks may slow or prevent fire spread from grassy riparian areas.

While revegetated riparian land may have only a limited influence on bushfire spread at a landscape scale, compared with other land uses, extensive areas of native vegetation may pose a direct threat to nearby houses and agricultural assets.

However, revegetation proposals which involve creating narrow vegetated strips which are remote from assets, may not significantly add to bushfire threat.

In addition, trees may filter some embers as well as reducing wind speed and the rate of spread and intensity of fire.

Fire behaviour and the threat it poses is only one aspect that needs to be taken into consideration in determining bushfire risk associated with riparian areas. Other factors which need to be considered include the likelihood of a fire starting or reaching the assets and the vulnerability of the asset to fire.

Bushfire controls do not directly affect riparian revegetation proposals at present. However, bushfire planning and building controls can be used as a guide for planning the separation of riparian revegetation proposals from houses or other accommodation, or other community buildings such as schools.

Fire management needs to be considered in riparian management activities. For example, setback distances from the vegetated riparian land to assets need to be considered in conjunction with the landholder, fire planners, and where appropriate, the broader community.

Access points need to be established not only for managing the riparian land but also to allow access for fire suppression, and particularly reliable water supplies.

Bushfire risk can be substantially reduced by reducing vulnerability of assets. It is important that all landholders have measures in place to minimise the vulnerability of assets to fire, including protecting homes, sheds and stock from flame contact, radiant heat and embers.

It is important that revegetation planning addresses actual rather than perceived risks to both community safety (from revegetation proposals) and environmental values (from bushfire management).

Where, after exploring options, a conflict between conservation and community safety objectives cannot be achieved, priority should be given to protection of human life.

Options for managing risk also include accepting any risk that cannot be practically treated.

Definitions and abbreviations

Adapted from: CFA (2012a, 2012b) where applicable, except as cited.

Risk management definitions

Bushfire risk: The chance (likelihood) of a bushfire igniting, spreading and causing damage to the community or the assets they value (consequences)

Bushfire threat: Potential impact of bushfire on assets based upon fuel hazard, separation distance and the slope under a given climatic condition. Can be described by the Bushfire Attack level (BAL)

Consequence: Outcome or impact of a bushfire event

Fuel hazard: Vegetation or other material that contributes to bushfire threat

Likelihood: The chance of a bushfire igniting and spreading

Risk acceptance: An informed decision to accept the consequences and the likelihood of a particular risk

Risk treatment: The process of selection and implementation of measures to modify risk

Residual risk: Risk remaining after risk treatment (*AS 31000:2009*)

Vulnerability: The susceptibility of an asset to the impacts of bushfire taking into consideration property preparedness, ability of landholders to defend their own property, access for fire control and egress for leaving early

Other definitions

AFAC: Australasian Fire Authorities Council

Assets: Anything valued by people including houses, crops, heritage buildings and places, infrastructure, the environment, businesses and forests that may be at risk from bushfire

APZ: Asset Protection Zone

BAL: Bushfire Attack Level. A measure of the severity of a building's potential exposure (threat) to ember attack, radiant heat and direct flame contact, based on radiant heat (*AS 3959:2009*)

BMO: Bushfire Management Overlay

Bushfire: An unplanned vegetation fire. A generic term which includes grass fires, forest fires and scrub fires

Curing: Curing is the annual drying and death of grass which increases its ability to burn

CFA: Country Fire Authority

CMA: catchment management authority

DAFF: Department of Agriculture, Fisheries and Forestry

Defendable space: An area of land around a building where vegetation is managed to reduce the effects of bushfire on it

DELWP: Department of Environment, Land, Water and Planning (formerly DEPI and DSE)

DEPI: (Former) Department of Environment and Primary Industries

DPCD: (Former) Department of Planning and Community Development (as of July 2013, the Department of Transport, Planning and Local Infrastructure)

DSE: (Former) Department of Sustainability and Environment

Ecological Vegetation Classification (EVC): Vegetation classification system

Forest Fire Danger Index (FFDI): Measure of the chances of a fire starting, its rate of spread, intensity and difficulty of suppression in forest

Fire Danger Rating (FDR): Measure of fire danger or the difficulty of putting out any fires which may occur which is based on FDIs for forest and grass

Grass Fire Danger Index (GFDI): Measure of the chances of a fire starting, its rate of spread, intensity and difficulty of suppression in grass

MFMP: Municipal Fire Management Plan

MFMPC: Municipal Fire Management Planning Committee

Victorian Fire Risk Register (VFRR): A register of assets, bushfire risk, treatments and gaps as assessed by local emergency managers

1. Introduction

1.1 Purpose of this document

This document provides information about bushfire behaviour and how to manage any actual or perceived bushfire risks associated with riparian land and riparian management programs.

It is intended to assist catchment management authorities (CMAs), the Country Fire Authority (CFA), the Department of Environment, Land, Water and Planning (DELWP) and other agencies in their discussions with rural landholders about riparian land and fire.

While this document focuses on rural land, riparian revegetation may also affect urban areas, and so a short section is included on fire management in these areas.

Riparian land is defined in this document as land in predominantly cleared agricultural landscapes that adjoins rivers, creeks, estuaries, lakes and wetlands. Riparian land can vary in width from a narrow strip to a wide corridor, and is often the only area of remnant vegetation in the landscape. Riparian land is also often referred to as 'frontage'.

1.2 Riparian management

As part of Government's Waterway Management Program, which implements the *Victorian Waterway Management Strategy* (DEPI 2013), millions of dollars are allocated each year through CMAs to riparian protection and improvement projects. The projects involve CMAs working collaboratively with landowners to undertake works such as stock management fencing, revegetation, weed management and provision of infrastructure to support off-stream stock watering. Most riparian works are carried out within about 20 metres of waterways and on lower slopes on both public and private land.

Over the last fifteen years, hundreds of kilometres of fencing have been erected along Victoria's rivers each year through this program. Other programs, such as Landcare and many other agency biodiversity programs, also support riparian projects.

This work provides many benefits to the community and landholders through improved water quality, improved recreational access, better stock management and improved river health.

1.3 Fire management

Landholders and agencies involved in riparian revegetation and management need to consider the effects of their programs on bushfire safety as well as their legal obligations (which are summarised in section 7.12).

The *Victorian Bushfire Safety Policy Framework* (Fire Services Commissioner 2013) outlines principles for response to bushfire risk by agencies and the community. These include:

- 'The protection of human life is paramount.
- Risk management is fundamental to bushfire safety.
- Bushfire safety is a shared responsibility between the government and a range of stakeholders. However, individuals are ultimately responsible for making their own decisions about how to respond to the bushfire risk'.

Fire management across Victoria is guided by the *State Fire Management Strategy* (Emergency Management Victoria 2014) and bushfire plans at the state, regional and municipal levels that take into account vegetation and its effect on bushfire risk. Bushfire management on public land is guided by the *Code of practice for bushfire management on public land* (DSE 2012) and through Crown land licences. While the Code focuses on government rather than a landholder's responsibilities, this document has been developed to be consistent with the Code as well as guidance produced for private land.

1.4 Riparian land and fire: what are the concerns?

Once riparian areas are fenced and excluded from grazing, the growth of weeds, grasses and other vegetation may increase. As a result, many landholders with river frontages are concerned that fencing and revegetating riparian land may result in a fire risk to their property (Nicholas and Mack, 1996). These concerns may be contributing to reluctance from landholders to participate in CMA programs to protect and improve riparian lands.

The perceived fire risk may also influence the management of a frontage by landholders. Slashing and mowing to 'clean up' a site where not justified from a fire safety point of view is of concern given the likely impacts on the regeneration process of native vegetation. Also, many landholders and fire service personnel are concerned about riparian management works impacting on the ability of fire suppression services to access properties during a fire, particularly to access reliable water supplies for tankers.

2. Bushfire behaviour

This section provides general information about bushfire occurrence and behaviour and focuses on the more 'typical' bushfires experienced in Victoria. The next section provides information on bushfire behaviour that is more typical of riparian areas in agricultural landscapes.

2.1 Bushfire occurrence

Most bushfires result from human activities. Long-term records maintained for public land (DSE 2011) indicate that 74% result from human activities including arson (25%), agricultural burns (16%) and campfires (10%). 26% are caused by lightning.

This century has seen a significant increase in bushfire, with major events occurring following protracted drought in 2003 (Alpine fires), 2006-7 (Great Divide fires) and 2009 (Black Saturday fires).

Severe bushfire events are expected to increase under climate change. The number of days of Very High or Extreme fire danger conditions are projected to increase by up to 20% by 2020 and up to 60% by 2050 (Hennessy et al 2005).

However, historically, extreme bushfire events of this scale are relatively rare. More than 80% of Victorian fires are contained as small fires (less than five hectares). The remaining 20% of fires result in 90% of the area burnt and most of the life and property loss (Government of Victoria 2008).

2.2 Bushfire behaviour

Bushfire behaviour can be described by the spread and intensity of the fire. Fire spread occurs primarily through flame contact, the spread of burning embers and radiant heat.

The key factors that influence bushfire behaviour are fuel, topography and weather. Some general information about their effects is summarised in Table 1. The relative degree to which these factors will determine fire behaviour and its impact will vary from site to site.

Under milder conditions, fire will spread more slowly and at a lower intensity and may take some time to develop to its peak rate of spread and intensity. Research carried out by Gould et al (2007) indicates that forest fires do not reach their peak rate of spread and intensity until the head of the fire is at least 100 metres wide at low wind speeds and up to 450 metres wide in higher wind speeds).

Under protracted drought, and extreme fire weather, such as experienced during February 2009, all vegetation can burn. The peak rate of spread in forest fires under these conditions may be achieved within minutes. For example, the 'build-up phase' for the February 2009 Bunyip fire was recorded as taking only 8 to 10 minutes (Gellie et al, undated).

Intense fires in forests and woodlands are characterised by crown fires and spotting (where embers are carried ahead of the fire and ignite to form new fires). Intense grass fires burn quickly and may spot over short distances.

The likelihood of a fire starting and its rate of spread and intensity will depend upon the presence of an ignition source, and the fuel, topography and weather.

For further information on bushfire behaviour and riparian areas, refer to the FAQs in section 7. In particular:

- What general conclusions can be drawn about fire behaviour in riparian areas? (FAQ 7.1)
- Is a fire more or less likely to start in riparian areas revegetated with native species compared to degraded riparian land (dominated by non-native species) and to the adjacent agricultural land? (FAQ 7.2)
- Is a fire more or less likely to spread within riparian areas revegetated with native species compared to degraded riparian land (dominated by non-native species)? (FAQ 7.3)

Table 1 – Factors that affect bushfire behaviour

FUEL	Fuel hazard (type, size, quantity and arrangement)	Increasing quantities of dead fine forest fuel (< 6mm in diameter) result in fires with greater rates of spread, intensity and flame height. The rate of spread approximately doubles with fine fuel quantity. Bark and other fine fuels contribute to short to long distance spotting. The major fuel factor influencing grass fire spread is fuel continuity but not quantity. Quantity will influence intensity and suppression difficulty. Short distance spotting (100 metres) can be expected. Weed growth is expected to increase fuel hazard. An increase in elevated fuel (e.g. shrub and ladder fuels such as hanging bark on gums) will increase flame height, rate of spread and intensity. Continuous fuel from surface to tree crowns will support crown fires. Surface and ladder fuel is required to support crown fire.
	Fuel moisture content	The moisture content of dead fuel affects ease of ignition, rate of fire spread, intensity and probability of spotting. In most eucalypt forests, fires generally self-extinguish when the fuel moisture content (FMC) exceeds 20%. Above 15%, fire intensity is low and behaviour predictable even at relatively high wind speeds During the 2008-09 fire season, FMC was extremely low and fuel available for combustion was at an all-time high (Gellie et al 2011). Fires will not spread in grasslands under light winds when FMC > 20%. Fires will not spread when grasslands are less than 50% cured (dried and dead). In well-cured grasslands, the effects of rain can be gone within a day or two and the lag time between changes in relative humidity and fuel moisture may be as little as 30 minutes. In forests, effects of rainfall may last several days and fuel moisture content lag times are much longer (up to two to three hours, sometimes longer).
TOPOGRAPHY	Slope	Slope can affect the rate of spread of a fire and its intensity. For every 10 degrees of upslope, the rate of spread doubles. For every 10 degrees of downslope, the rate of spread halves.
	Aspect	Aspect (direction in which a slope faces) can affect fuel quantity, type and moisture content. More severe fire behaviour can be expected on northern and western aspects. In drought conditions, the greater fuel load normally found on sheltered aspects and in gullies could be available to burn and could carry high intensity fire.
WEATHER	Wind	The way that wind interacts with terrain can be complex. Exposed faces of hills and ridges will have increased wind speeds. In some circumstances, the lee side of ridges can have turbulent winds blowing in the opposite direction. Valleys may channel winds, and increase wind speed and fire spread.
	Temperature and relative humidity	Higher temperatures reduce the ability of the atmosphere to retain moisture. As a result, fuel is warmer, drier and more easily ignited. Temperature and relative humidity and as a result, fire intensity can vary during the day. There is a lag time between changes in weather conditions and the effects on fuel moisture content and fire behaviour.
	Wind speed and direction	The predominant wind directions that carry fire are from the NW and after a wind change, the SW. Wind speed is important in determining the speed and intensity of a fire. It supplies oxygen to the fire, slants the flames closer to the fuel and carries burning material ahead of the fire. Wind speed and direction may be affected by topography. For example, valleys may channel winds. Tree cover will reduce wind speeds. In open country, vegetation such as shelterbelts alters the wind speed, direction and turbulence in the same way as topography. Where the wind is perpendicular to a relatively impermeable wind break, turbulence and reduced wind speeds are experienced for five times the height of the trees upwind and fifteen times down wind. Wind speed and direction can vary with time of day. Katabatic winds are downslope night-time winds caused by slopes cooling on clear still nights. Anabatic winds are upslope winds caused by warming of the air.
	Atmospheric stability	Atmospheric stability (the vertical movement of air masses when hot air rises and is replaced by cooler air) can affect local wind patterns and cloud development. In stable conditions, winds are generally light and predictable. In unstable conditions, winds are gusty and fire behaviour unpredictable.
	Drought	Drought (more than 3 months of below average rainfall) can increase dead fine fuel loads in forests by several tonnes/ha (due to increased shedding of leaves and bark to reduce moisture stress). Under drought a greater proportion of deep surface fine fuel beds and heavy fuels will be dry and available to burn, contributing to more intense wildfires. Drought will reduce the normal impact of aspect and vegetation type on fuel moisture. Sheltered aspects (including riparian areas) may be as dry as exposed aspects. Drought will normally shift the fire season forward by a month or more. In an extended drought, fuel will be reduced through retarded growth, and grazing.

Adapted from AFAC (1996a), AFAC (1996b), AFAC (2002) and other references as cited

3. Bushfire behaviour and riparian areas

This section provides information on bushfire behaviour that is more typical of riparian areas in agricultural landscapes.

3.1 Riparian areas and bushfire ignition and spread

Only a limited number of fires each year are reported as starting in riparian areas. CFA data (CFA 2011b) indicates that of 27,328 vegetation fires reported in Victoria in the period 1 January 2006 to 30 June 2012, 249 or less than 1% are reported as starting in riparian areas.

The image of North East Victoria in Figure 1 does show a concentration of bushfire ignitions around riparian areas, particularly around popular camping spots (such as along the Murray River) and around settlements. However, as shown in Figure 2, major fires in this area during the same period are in heavily forested areas with steep inaccessible terrain, rather than riparian areas.

The amount of vegetated riparian land in the Victorian rural landscape is generally low, and riparian areas are usually narrow (less than 100 metres wide). As a result, while riparian land may have local effects on bushfire behaviour, it can be expected to have only a limited influence on bushfire spread at a landscape scale, compared with other land uses.

This view is supported by the strategic bushfire assessments recently prepared by DELWP for each of the 7 'risk landscapes' in Victoria, using the methodology described by DELWP (2015).

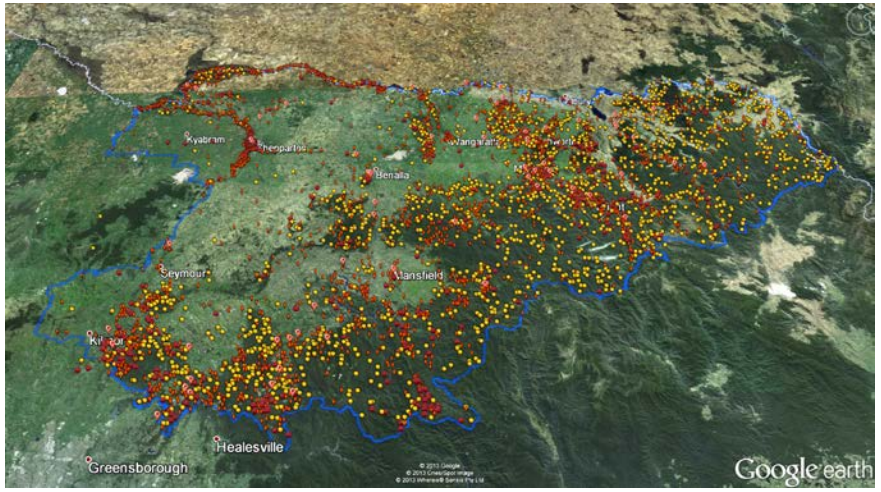


Figure 1 - Image of North East Victoria showing bushfire ignitions attended by DELWP and predecessor organisations over 40 years from 1972 to 2013. Ignitions shown are from lightning (yellow) and other causes (red)

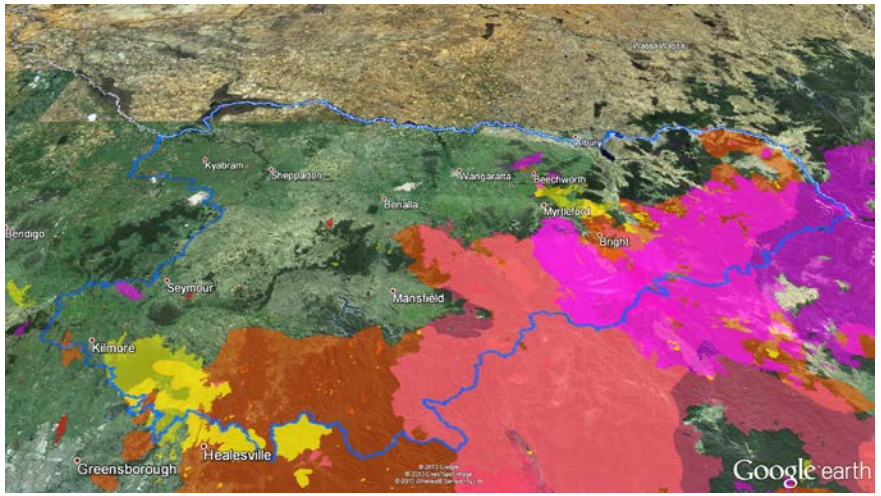


Figure 2 - Image of North East Victoria showing locations burnt by major bushfires over 40 years from 1972 to 2013

3.2 Comparison of bushfire spread in riparian areas and other vegetation types

Fire behaviour and spread can vary significantly with vegetation type, and its management.

As riparian areas are generally narrow, they are less likely to generate long distance or extensive spotting than larger areas of forest. This is because a fire burning:

- across a narrow forested riparian area will only contribute embers for a short period
- along a forested riparian area which is narrower than the 100 to 450 metres threshold required for peak spread and intensity (Gould et al 2007) is not expected to generate sufficient updraft to carry embers far.

If there is only limited localised spotting, as shown in Table 2, a fire burning in a forested riparian area is expected to be slower and therefore less likely to contribute to fire spread than a fire burning in grass or crops.

Figure 3 – Coliban River at Redesdale which was burnt in February 2009, showing intact, unburnt riparian canopy.

Fire burning in cured grassy riparian areas does have the potential to spread rapidly, but it is likely to be slower than a grass fire, as trees will reduce the speed of the wind that is driving the fire. In addition, sheltered slopes, or moister areas within the riparian area, and barriers outside the riparian area (such as grazed areas, roads or firebreaks) may slow or prevent fire spread within and from riparian areas, although this cannot be relied upon in more extreme weather conditions. These features may have contributed to the unburnt riparian crowns shown in Figure 3, although the patchy burn through the grassland suggests that other factors may also have contributed.

For further information on bushfire spread associated with riparian and surrounding areas, go to the FAQs (particularly FAQs 7.3 to 7.6) and bushfire scenarios (section 5).

Table 2 – Vegetation type and peak fire behaviour

	Forest	Scrub	Grassland	Crop
Fuel load	H (< 35 t/ha)	M (< 25 t/ha)	L-M (< 6 t/ha)	M 8 t/ha (1)
Rate of spread	L (<5 km/h)	H (<10 km/h)	H (< 20 km/h) Difference between natural and grazed grass = 20% (2)	After harvest, fire behaviour will be influenced by the presence of weeds, grass and bare ground below the stubble
Residual burning time	Long	Short	Short	
Spotting	Up to 2-3 km (35 km recorded for large fires) Limited localised spotting from narrow forested riparian areas (3)	Short distance	Limited short distance (100 m)	

L =Low, M=Moderate, H=High

Based on AFAC (2002) and (1) DAFF (2011), (2) Cheney and Sullivan 2008, (3) Gould (2007) and *AS 3959:2009* (fuel weights)

4. Bushfire threat and risk

This section provides information on bushfire threat and risk, and how it can be assessed.

4.1 Bushfire risk

The *Victorian Fire Risk Register – Reference Guide* (CFA 2012a) defines bushfire risk as '*The chance (likelihood) of a bushfire igniting, spreading and causing damage to the community or the assets they value (consequences)*'.

Assets that may be affected by bushfire are shown in Table 3. This document focuses primarily on risk to houses and other buildings where people may congregate, although the principles can be applied to other assets.

Table 3 – Assets that may be affected by bushfire

Human settlement	Houses and 'vulnerable congregations' such as schools, hospitals and nursing homes
Economic assets	Agricultural assets (including equipment sheds, crops and stock) Commercial assets (including shops) Infrastructure (including roads and utilities) Tourist/recreational assets Drinking water catchments
Environmental and cultural assets	Assets of significance as defined by legislation or the municipal planning scheme, or community opinion such as: • Rare or threatened plant or animal species or communities • Cultural heritage sites such as middens, trees, buildings and landscapes Vegetation that has a low tolerance of fire (including riparian species) Vegetation that is outside of its 'tolerable fire interval' so that if burnt it may die and may not be able to reproduce itself (for example before it can set seed or after its seed store has been exhausted)

Adapted from CFA (2011c, 2012a)

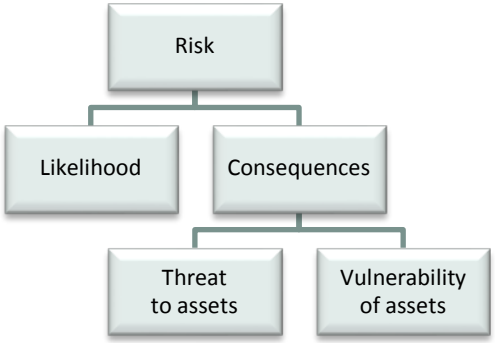


Figure 4 - Components of risk

Adapted from CFA (2012a)

All of the components shown in Figure 4 are important factors in determining bushfire risk, and should be considered in risk assessments. They can be defined as follows.

Table 4 – Definitions of risk components

Likelihood	The chance of a bushfire igniting and spreading
Consequences	The outcomes of bushfire attack which depend not only on the threat posed by the fire but also the vulnerability of the assets to the threat
Threat	Potential impact of bushfire on assets based upon fuel hazard, separation distance and the slope under a given climatic condition. Threat at the property level can be described by the Bushfire Attack Level (BAL) which is a measure of radiant heat
Vulnerability	The susceptibility of an asset to the impacts of bushfire, taking into consideration property preparedness, ability of landholders to defend their own property, access for fire control and egress for leaving early

Adapted from CFA (2012a)

4.2 Predicting bushfire threat at the property scale

While as discussed in section 3, riparian land may have only a limited influence on bushfire spread at a landscape scale, compared with other land uses, it may pose a direct threat to nearby assets.

Bushfire affects houses and other assets through direct flame contact, radiant heat and ember attack. Wind can also damage buildings and allow embers to enter.

Research on house and life loss from bushfire in Australia shows that most houses that have been lost to bushfire were located within 100 m of bushland and most have been lost to ember attack (Blanchi and Leonard 2005, Chen and McAneney 2010).

The Bushfire Attack Level (BAL) provides a measure of the level of threat to buildings (and human life) from bushfire. It is defined in the Australian Standard *Construction of buildings in bushfire-prone areas* (*AS 3959:2009*) as 'a means of measuring the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact' using units of radiant heat in kW for each square metre of the building's surface. 1 kW/m^2 equals the amount of heat from one bar radiator on an area of 1 metre x 1 metre.

A worksheet for estimating threat at the property scale from riparian and other vegetation using the 'simplified' method (Method 1) of *AS 3959:2009* is provided in Appendix 1.

This worksheet combines values provided in Tables 2 and 3 of the Bushfire Management Overlay (Clause 52.47 of all planning schemes). These values are based on *AS 3959:2009* for a Forest Fire Danger Index (FFDI) of 100 (Extreme fire danger).

This worksheet allows estimation of threat based on vegetation and slope categories, and the separation between the vegetation and the asset.

For a given Fire Danger Rating, the threat to assets from flame contact, radiant heat or embers from a bushfire which may spread through a riparian area is likely to be lower where:

- Slopes are less steep
- Fuel hazard is lower (lower fuel quantity and continuity)
- There is sufficient separation between the hazard and the asset
- The hazard is small and isolated from other hazards.

Table 5 – Typical effects of bushfire

BAL 12.5 LOW THREAT	BAL 19 MODERATE THREAT	BAL 29 HIGH THREAT	BAL 40 VERY HIGH THREAT	BAL_FZ EXTREME THREAT
Low ember attack Low radiant heat (up to 12.5kW/m^2)	Moderate ember attack Moderate radiant heat (up to 19kW/m^2)	High ember attack High radiant heat (up to 29kW/m^2)	Very high ember attack Very high radiant heat (up to 40kW/m^2) Some flame contact from fire front	Extreme ember attack Extreme radiant heat (over 40kW/m^2) Flame contact from fire front
Pain after 3 seconds Critical conditions for firefighters Possible failure: float glass	Ignition of timber after a long time Possible failure: screened float glass Possible ignition: plastics (tanks + bins)	Ignition of most timbers after 3 minutes	Ignition of cotton fabric after 5 seconds	Ignition of timber after 20 seconds

Adapted from *AS3959-2009* and Bowditch (2006)

The more detailed Method 2 of *AS 3959:2009* provides experienced practitioners the opportunity to fine-tune threat (and potentially reduce) threat predictions through considering features of the site and how a fire might react to them, including:

- Forest Fire Danger Indices (FFDIs) which may be more representative of expected weather (taking climate change into account) and the level of risk that is considered acceptable by the community.
- Likely peak fuel hazard. Alternative sources of information on fuel hazard include the *Overall Fuel Hazard Assessment Guide* (DSE 2010) and fuel hazard tables used by DELWP for statewide fuel hazard mapping.
- Depth, width and exposure of the vegetation to wind (which influences flame width, flame length and rate of spread) and radiant heat
- Flame temperature.

Detailed explanation of Method 2 and how to apply it is beyond the scope of this document. However, the scenario in section 5.5 provides an example of how this method can help in accounting for small, fragmented or isolated areas of vegetation, including riparian areas.

Not all vegetation will pose a significant threat to assets. Trees can filter radiant heat and embers as well as reducing wind speed and the rate of spread and intensity of fire. In addition, revegetation proposals which involve creating narrow vegetated strips which are remote from assets, may not significantly add to bushfire threat from radiant heat.

AS 3959:2009 identifies circumstances in which narrow, isolated or remote areas of vegetation may pose a very low threat from radiant heat. These include vegetation that is more than 100 m from assets. However, this exemption underestimates the radiant heat impacts from forest and woodland on steeper slopes, and is inconsistent with the current Victorian planning controls for bushfire which requires assessment of threat within 150 m of assets. It may also underestimate the threat of ember attack from more extensive and contiguous vegetation. However, while care should be taken in relying solely on setback distances without consideration of other factors that influence bushfire risk, in this document, riparian revegetation and other smaller areas of vegetation may be generally be considered a very low threat if they meet one or more of the following criteria:

- Vegetation more than 150 m from the building
- Single areas less than 1 ha in area and not within 100 m of other vegetation that does not meet the criteria for very low threat
- Multiple areas less than 0.25 ha in area or strips less than 20 m wide and not within 20 m of the building, or each other, or other vegetation that does not meet the criteria for very low threat
- Grassland less than 100 mm in height during the declared Fire Danger Period
- Vegetation meets the standards for 'defendable space' as set out in the Standard planning permit conditions for new houses located in the BMO (CFA 2014b) or low overall fuel hazard (DSE 2010).

4.3 Predicting bushfire risk at the property scale

A worksheet for estimating bushfire risk at the property scale is provided in Appendix 2.

This worksheet enables the estimation of risk using the threat from the worksheet provided in Appendix 1, or an alternative method, as well as the likelihood of fire starting and reaching assets, and the vulnerability of the assets to fire.

This worksheet is based on the *Victorian Fire Risk Register – Reference Guide* (CFA 2012a) which is currently used by Victorian emergency managers to assess and prioritise bushfire risk, but uses the threat rating from *AS 3959:2009* instead of the system used by the Victorian Fire Risk Register (VFRR). CFA advises that the method used in the VFRR is to be updated to align with AS3959:2009 and the Victorian planning and building controls in the future.

Experienced bushfire planners (from CFA, your local Council, DELWP or private practice) can provide information on the likelihood of fire starting and reaching assets. This information is summarised in the VFRR maintained by emergency management staff in Victorian Councils.

The criteria for assessing vulnerability of buildings and their occupants have been adapted from the VFRR and CFA guidance for planning and building (CFA 2012b). These criteria include the type of use, proximity to safer areas, property preparedness, and provision of access and water for firefighting in accordance with CFA guidelines. These criteria may need modification if assets other than houses are being considered.

Figure 5 - Riparian vegetation at Horsham (L, left) and Genoa (K, right)

4.4 Predicting bushfire risk from urban riparian areas

While this document focuses on rural land, riparian revegetation may also be carried out in (or affect) urban areas.

A fire starting in or burning into smaller and/or isolated urban riparian areas, such as shown in Figure 5 and the scenario in section 5.5 could present a lower threat and risk to the surrounding community as:

- The fire has much less time to grow in length and width before reaching assets and may not achieve peak behaviour (fire generally needs to be at least 100 to 450 m wide before it achieves peak rates of spread based on Gould et al (2007))
- Fire growth may be restricted by lower fuel areas such as paths or roads
- Early detection by the surrounding community is more likely
- While houses may be at risk, occupants are probably less reliant on houses to survive fire, as they can walk to low fuel areas deeper in the urban area (although exposure to smoke and heat may still cause issues for more vulnerable members of the community).

However, fire may still pose a risk to urban development, particularly where:

- The community has a low awareness of fire risk
- Neighbouring properties are not well-prepared
- There are larger areas of fuel or long potential fire runs adjacent to urban areas
- Fuel management in riparian areas is limited by access and other management considerations including the need to protect water quality.

As explained in in section 4.4, and shown by the scenario in section 5.5, the more detailed Method 2 of *AS 3959:2009* provides experienced practitioners the opportunity to fine-tune (and potentially reduce) threat predictions for smaller or narrow blocks of vegetation.

Alternatively, a relative risk approach being developed by Melbourne Water (MW) may be of assistance, particularly where the vegetation is modified and variable and access is poor or where extensive areas are involved.

The MW system combines field assessment with use of infra-red images and LiDAR (laser-based aerial technology) to categorise and prioritise bushfire risk, and determine the separation of the highest risk areas from buildings.

MW's system uses the following factors, most of which can be considered either directly or indirectly in Method 2 of *AS 3959:2009*:

- Aspect and slope
- Vegetation height, structure (density in each layer) and continuity
- Likely fire path (length and direction) and head fire width
- Separation of buildings from vegetation
- Bushfire weather conditions (FFDI).

The following images show how this system was used to prioritise bushfire risk in the Little Boggy Creek and adjacent reserves in Frankston (which are shown in Figure 6).

Figure 6 – Little Boggy Creek Reserve, Frankston

Figure 7 shows how the risk categories (A, B and C) are defined based on the inputs shown. Mid-height vegetation is 3.0 to 6.9m high, shallow (mid-range) slopes are 4.0 to 8.9 degrees.

Bushfire risk levels				
Vegetation level	Aspect	Slope category	Risk level	Risk level with 70% understorey
Tall	NW	Steep	A	A
Tall	SW	Steep	A	A
Mid	NW	Steep	A	A
Tall	NW	Shallow	A	A
Tall	SW	Shallow	A	A
Mid	NW	Shallow	A	A
Mid	SW	Steep	A	A
Low	NW	Steep	A	A
Tall	_	Flat	B	B
Mid	_	Flat	B	B
Mid	W	Shallow	B	B
Low	NW	Shallow	B	A
Low	SW	Steep	B	A
Tall	SE	Shallow	C	C
Low	_	Flat	C	A
Low	SW	Shallow	C	A
Tall	SE	Steep	C	C
Mid	SE	Shallow	C	C
Mid	SE	Steep	C	C
Low	SE	Shallow	C	A
Low	SE	Steep	C	A

Figure 7 –Melbourne Water risk classification template

Figure 8 shows the buildings (outlined in purple) that adjoin the reserve (outlined in blue) and risk categories in the reserve (A, B and C).

Figure 9 shows the highest category risk (A) in red. The bands of color show the current separation between the high-risk fuel and buildings. This separation can then be increased through fuel management.

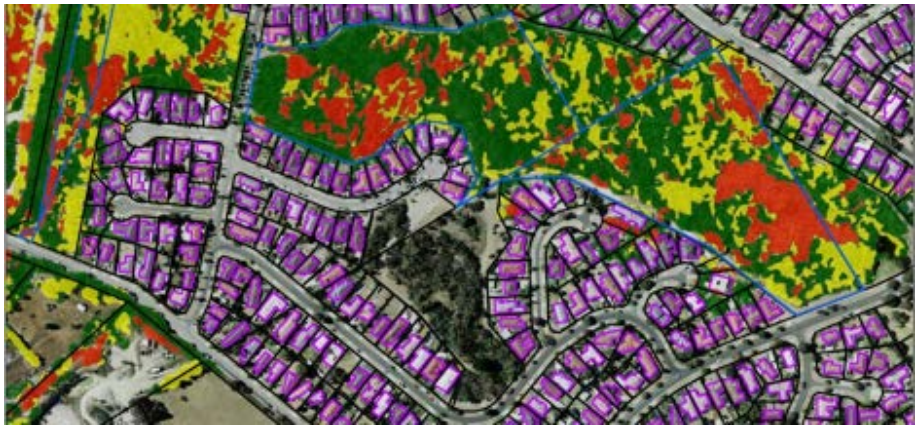


Figure 8 – Risk classification (Risk level A (red), B (yellow) or C (green)), Little Boggy Creek Reserve, Frankston

Figure 9 – Separation of the highest risk areas (Risk level A (red)) from buildings (purple), Little Boggy Creek Reserve, Frankston

5. Bushfire threat and risk scenarios

The following sections provide examples of fire threat and risk for the following scenarios in riparian land:

- Revegetation of overstorey
- Revegetation of overstorey and understorey
- Alternative fuel types (comparing revegetation to crops and pasture)
- Pasture which is closer to the asset than vegetated riparian areas
- Isolated, small or narrow areas of vegetation (including urban riparian areas)

The scenarios are based upon the photographs in this section, the processes set out in Appendices 1, 2 and 3 and the inputs and assumptions listed in Appendix 4. All revegetation is carried out using native vegetation.

Threat (radiant heat) was estimated using the simplified method, Method 1 of *AS 3959:2009* which is currently used in Victoria's planning and building system.

An experienced fire planner can refine threat calculations using Method 2 of *AS 3959:2009*. Some examples of the effect of Method 2 on threat are shown in section 5.5.

All threat calculations assume that the revegetation areas are substantial (for example, over 20 metres wide, or connected to significant patches of vegetation nearby) and does not meet the exemption criteria as outlined in section 4.2.

Consequently, the revegetation areas used in these scenarios may be larger and wider than many of those currently established in Victoria, and the level of risk may be over-estimated for smaller revegetation projects. However, even for smaller revegetation projects, the scenarios can provide a useful illustration of how threat and risk changes with vegetation type, separation from assets and vulnerability.

The scenarios are not meant to be representative of all landscapes. The predictions are limited by the models and the inputs used. They are intended to illustrate general trends only, and should not be used as a replacement for on-site fire risk assessment by personnel with appropriate expertise. Refer to section 8 for sources of assistance.

5.1 Revegetation of overstorey

This scenario compares fire spread rate, threat and risk predicted for different stages of overstorey revegetation shown in the images below, up to canopy closure.

A Prior to revegetation

B Following planting

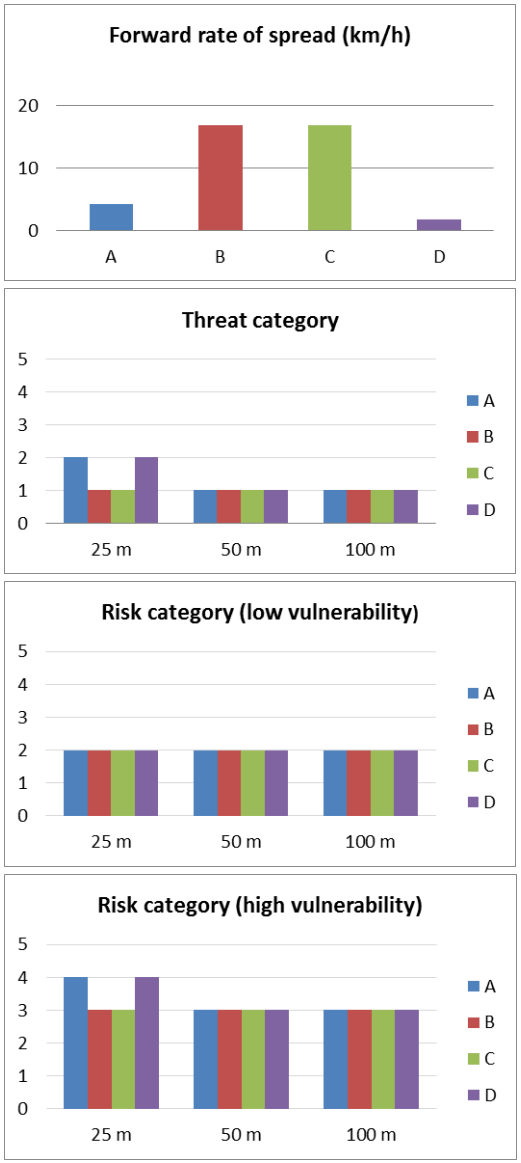
C Prior to canopy closure

D After canopy closure

Figure 10 – Riparian revegetation stages (overstorey only)

Predictions for this scenario show that:

- Grass cover in riparian areas (B and C) can significantly increase the rate of spread of fire in a riparian area
- The closing of the canopy (D) may support crown fire
- Revegetation (D) can increase the fire threat and risk compared with grass when close to assets
- However, threat and risk decrease with separation between the hazard and the assets and better preparedness (decreasing vulnerability).



Threat/Risk category: 1 = Low, 2 = Medium, 3 = High, 4 = Very High, 5 = Extreme
Distances refer to separation between the hazards and the assets
All predictions are for flat land and will change significantly with slope

Figure 11 – Fire spread rate, threat and risk for riparian revegetation stages (overstorey only)

5.2 Revegetation of overstorey and understorey

This scenario compares fire spread rate, threat and risk predicted for revegetation of overstorey and understorey. This scenario is based upon revegetation carried out on the Genoa River. Photograph E shows the site prior to revegetation. Photographs F and K show revegetation of overstorey and understorey species carried out in 2009.

E Prior to revegetation

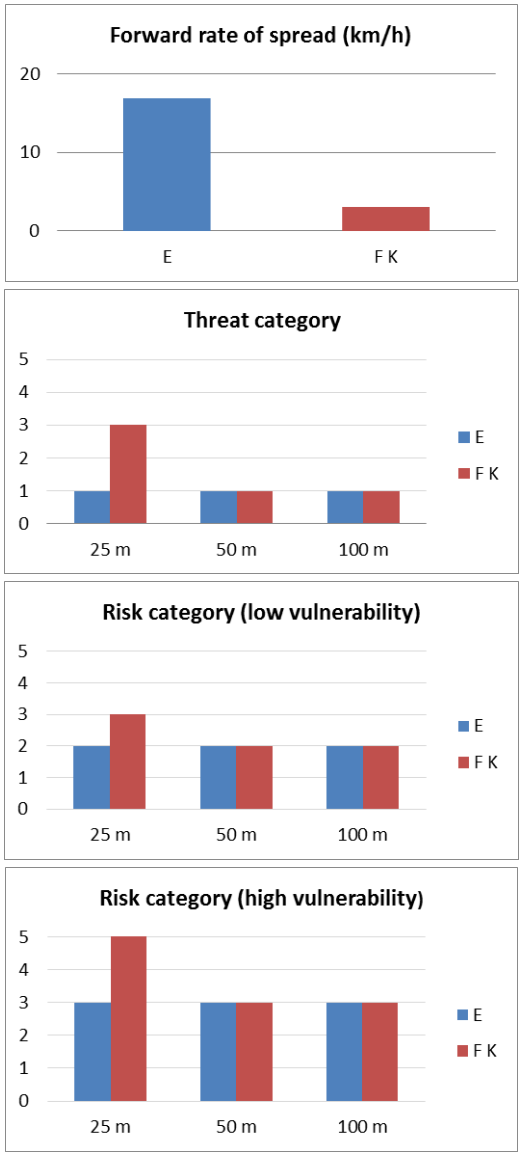
F Shrub/tree canopy closure – aerial view

K Shrub/tree canopy closure

Figure 12 – Riparian revegetation stages (overstorey and understorey)

Predictions for this scenario show that:

- Replacement of pasture with a native tree and shrub canopy can significantly reduce fire spread but increase threat and risk
- Including a shrub layer in the revegetation can increase fire threat and risk compared with a tree canopy and grass control only (section 0, Photograph D)
- The closed canopy of F and K is likely to support crown fire
- Threat and risk decrease with separation between the hazard and the assets and better preparedness (decreasing vulnerability).



Threat/Risk category: 1 = Low, 2 = Medium, 3 = High, 4 = Very High, 5 = Extreme
Distances refer to separation between the hazards and the assets
All predictions are for flat land and will change significantly with slope

Figure 13 – Fire spread rate, threat and risk for riparian revegetation stages (overstorey and understorey)

5.3 Alternative fuel types

This scenario compares fire spread rate, threat and risk predicted for revegetated riparian land (Photographs D and K) and crops and pasture grazed to varying levels.

D Native vegetation – no shrubs

K Native vegetation – including shrubs

G Crops

H Prior to revegetation – heavy grass

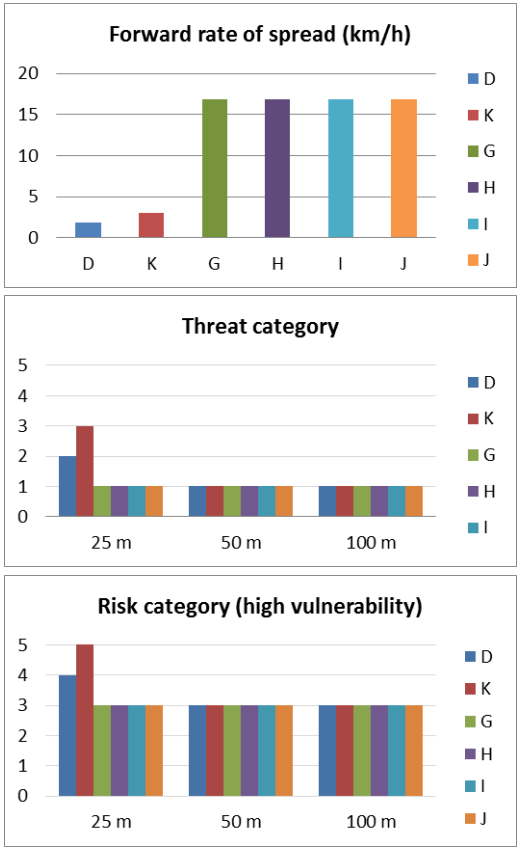
I Pasture - grazed

J Pasture – heavily grazed

Figure 14 – Riparian revegetation, pasture and crops as examples of different types of fuel.

Predictions for this scenario show that:

- Fire will spread more slowly through revegetated riparian areas (Photographs D and K) than other fuel types
- Revegetation can increase the fire threat and risk compared with grass closer to assets
- Threat and risk decrease with separation between the hazard and the assets.



Threat/Risk category: 1 = Low, 2 = Medium, 3 = High, 4 = Very High, 5 = Extreme
Distances refer to separation between the hazards and the assets
All predictions are for flat land and will change significantly with slope

Figure 15 – Fire spread rate, threat and risk for riparian revegetation compared to other fuel types

5.4 Effect of separation distance and vulnerability

This scenario compares the threat and risk associated with a typical bushfire risk management approach which has heavily grazed pasture (J) located close to an asset, lightly grazed pasture (I) which is further away, and revegetated riparian land (K) which is more remote.

J Pasture – heavily grazed
Location: 25 to 49 metres from asset

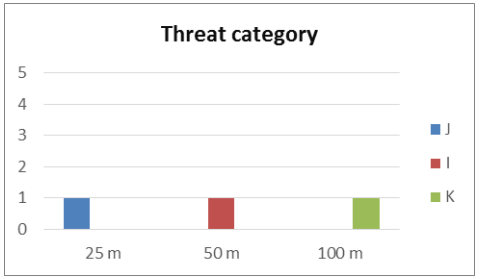
I Pasture
Location: 50 to 99 metres from asset

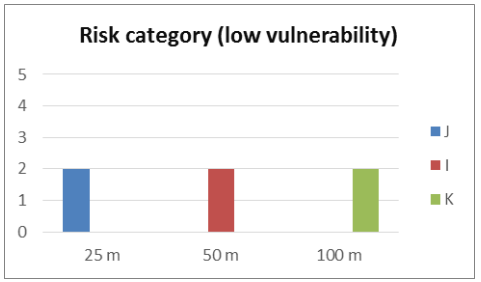
K Revegetation - shrub/tree canopy closure
Location: 100 metres from asset

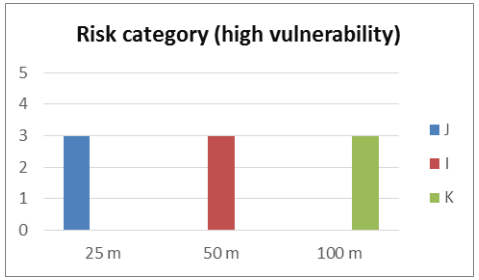
Figure 16 – Riparian revegetation at different distances from farm assets

Predictions for this scenario show that:

- While the riparian area (Photograph K) has a higher fuel hazard, this does not necessarily lead to a higher threat or risk to the asset than that presented by pasture which is closer to the asset
- Decreasing vulnerability through better preparedness has a significant effect on risk.







Threat/Risk category: 1 = Low, 2 = Medium, 3 = High, 4 = Very High, 5 = Extreme
Distances refer to separation between the hazards and the assets
All predictions are for flat land and will change significantly with slope

Figure 17 – Fire threat and risk for riparian revegetation and pasture at different distances from farm assets

5.5 Effect of using a site-specific method (Method 2 of *AS 3959:2009*)

This scenario shows how use of a site-specific method (Method 2 of *AS 3959:2009*) can affect threat and risk calculations for narrow or small areas of vegetation, particularly in urban areas where they are isolated from other vegetation.

L Isolated, small or narrow areas of vegetation

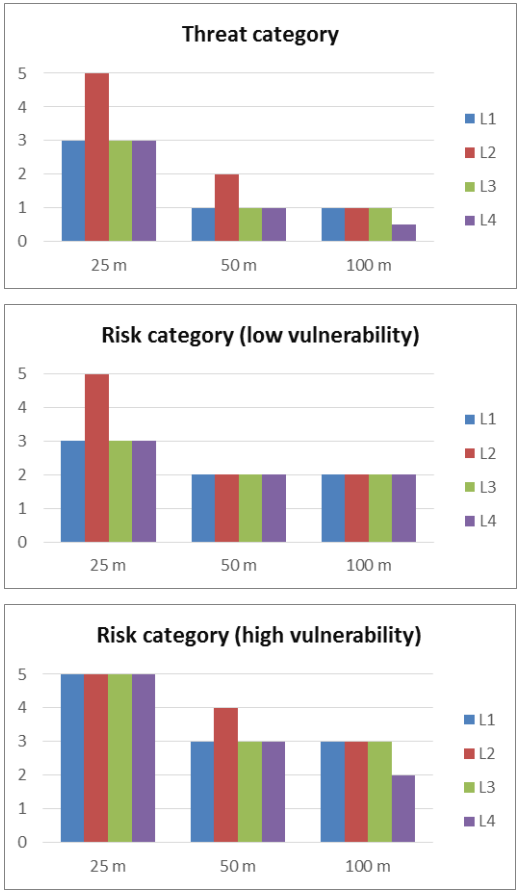
Figure 18 – Riparian vegetation that is isolated, small or narrow

Calculations are based on the following assumptions:

- The land is flat and fuel loads are the maximum standard fuel load provided in *AS 3959:2009* (35 t/ha maximum total fuel)
- L1 is based on Method 1 of *AS 3959:2009*. L2, L3 and L4 are based on Method 2 of *AS 3959:2009*, with a flame temperature of 1200 degrees Kelvin (which is higher than assumed for Method 1)
- Calculations for L3 and L4 have been adjusted to make allowances for narrow or small areas of vegetation, as set out in Appendix 4.
- L3 assumes that fire has been burning for some time along an isolated forested riparian corridor that is 60 m wide (for example on the eastern side of Figure 18). Because the forest is much narrower than the width required for development of peak fire behaviour, the rate of spread and threat is reduced.
- L4 assumes that a fire has started on the edge of a small isolated riparian reserve (for example in the centre of Figure 18) and burns across the reserve for only 60 m before reaching assets, and does not have sufficient time to build to its peak rate of spread.

Predictions for this scenario show that, compared with Method 2, the simplified method, Method 1 of *AS 3959:2009*, may:

- Underestimate the threat and risk from larger areas of vegetation, particularly those that are not isolated and where fire has had time to develop its peak rate of spread (such as L2)
- Overestimate the threat and risk from isolated, narrow and small areas of vegetation (L3 and L4), where assets are more than 50 m away, and where fuel load is lower than the standard assumptions.



Threat/Risk category: 1 = Low, 2 = Medium, 3 = High, 4 = Very High, 5 = Extreme
Distances refer to separation between the hazards and the assets
All predictions are for flat land and will change significantly with slope and fuel load

Figure 19 – Fire threat and risk for riparian vegetation that is isolated, small or narrow

6. Managing bushfire risk from riparian revegetation programs

6.1 Risk management responsibilities

Under the *Country Fire Authority Act 1958*, landholders have a responsibility to minimise the risk of starting an unplanned fire. CFA also advises landholders to carry out activities that will minimise fire spread (CFA 2011a).

Agricultural licences granted under section 130 of the Land Act 1958 for use of Crown land specify that the licensee will undertake '*all fire protection works on the licensed land required by law to the satisfaction of the Licensor and the responsible fire authority*' (DSE 2003).

6.2 Risk management options

The Australian/New Zealand Standard AS/NZS ISO 31000:2009 *Risk Management* (Standards Australia and Standards New Zealand 2009b) notes that options for treating risk can include the following:

- avoiding the risk
- changing the likelihood
- changing the consequences
- sharing the risk
- accepting the risk by informed decision.

Table 6 outlines some options for managing bushfire risk associated with riparian revegetation and other management proposals. Considerations for selection of risk management options are outlined in section 6.3.

Table 6 – Some bushfire risk management options

Avoid the risk	Design major revegetation programs in conjunction with Council, fire services, natural resource management agencies and the community to ensure bushfire risks are identified and taken into account Site and design revegetation to avoid an unacceptable increase in risk to assets. Refer to section 6.3 and Appendices 1 to 4 for further information
Reduce the likelihood that fire will ignite, spread and reach assets	Encourage landholders to take steps to reduce the vulnerability of their assets including houses, sheds, stock and crops to fire Provide adequate access to and across riparian areas for emergency vehicles Provide adequate access to water for emergency vehicles Refer to *On the Land* (CFA 2011a) and *Standard planning permit conditions* (CFA 2014b)
Reduce the threat that riparian vegetation may pose to assets	Limit species or density of species with higher bark hazard (such as stringybarks, which cause short-distance ember attack) Limit revegetation of understorey species where the understorey will act as a ladder into the crowns and there are limited alternative options for reducing risk Carry out weed control, particularly grass control up to the time of canopy closure, and woody weeds Manage the layers in the vegetation (particularly lower layers) to reduce fuel and break up the vertical and horizontal continuity of fuel, taking care to minimise soil disturbance and weed invasion. Minimise disturbance of canopy that can help to suppress weed growth If considering burning, consider small-scale (small heap burns) to minimise crown scorch and weed invasion. Consider bark burning of mature stringybark (but not gum-barked species) in mild conditions. Burning should only be carried out by appropriately experienced and well-equipped people, in consultation with CFA Consider timing revegetation of understorey after trees are mature to create a separation between the crown and other fuel layers Refer to the *Fire Ecology Guide* (CFA 2011c)
Understand the risk	Work with fire services, natural resource management agencies and the community to distinguish perceived as opposed to actual risks from bushfire and to riparian values from proposed bushfire risk management Be aware of predicted changes to bushfire frequency and severity due to climate change and potential changes to community expectations
Accept residual risk by informed decision	Work with fire services, natural resource management agencies and the community to gain their acceptance of any risk to community safety or riparian values that cannot be practically reduced

6.3 Selecting bushfire risk management options

Implementation of a range of treatments (such as those provided in Table 7) provides a more robust approach to managing bushfire risk, as reliance on one method only may lead to failure.

Priority should be given, where practical, to avoiding risk and minimising the likelihood of fire spread. Threat reduction measures may also be required to adequately reduce bushfire risk.

The scenarios provided in section 5 show that risk can be substantially reduced by increasing the separation between their assets and vegetation. In addition, all landholders should have measures in place to minimise the vulnerability of their assets to fire, including protecting homes, sheds and stock from flame contact, radiant heat and embers.

Where the bushfire risk associated with revegetation proposals cannot be adequately reduced, consideration should be given to working with fire service personnel and other fire planners, natural resource management agencies, landholders and the surrounding community to help them to understand and accept any risk to community safety or riparian values that cannot be practically managed. Contacts for people who could assist you are provided in section 8.

6.4 Dealing with potentially conflicting objectives

Some revegetation proposals may appear to be in conflict with community safety objectives. Similarly, some bushfire risk management options such as reducing the width of revegetation areas, modifying vegetation structure or fuel management may be, or may appear to be, in conflict with revegetation objectives.

It is important that revegetation planning addresses actual rather than perceived risks to both community safety (from revegetation proposals) and environmental values (from bushfire treatments).

Revegetation proposals may only involve creating narrow vegetated strips which do not significantly add to bushfire threat.

Similarly, bushfire risk management options may only need to make minor changes to the proposed vegetation structure (such as through thinning of shrubs), or make changes over only a small portion of a riparian area.

In some cases, fire management may be ecologically beneficial.

For example, fuel management such as weed control will have ecological benefits as well as reducing fire threats. As shown in the scenarios in section 5, the presence of grass can significantly increase fire spread.

In addition, many species require fire or appropriate ecological disturbance to persist on a site, although care should be taken in using fire in riparian areas as many species (including gums) are vulnerable.

For further information on environmentally sustainable bushfire management, including minimising harm and the use of fire to improve ecological benefits, refer to the *Fire Ecology Guide* (CFA 2011c).

Where a conflict between conservation and community safety objectives cannot be resolved, priority should be given to protection of human life in accordance with the Victorian Government's *Bushfire Safety Policy Framework* (Fire Services Commissioner 2013) which states: 'The protection of human life is paramount'.

To ensure that bushfire risks are identified and managed appropriately, substantial revegetation programs should be designed with input from the Municipal Fire Management Planning Committee, which has responsibility for planning for fire risk management at the municipal level.

In addition, adjacent landholders must be assisted to understand the actual bushfire risk associated with riparian revegetation programs (as opposed to perceived risk) and to take action to treat the risk in a way which, wherever possible, minimises harm to both people and the environment.

6.5 Design of revegetation setbacks

Current bushfire controls do not directly affect riparian revegetation proposals. However, the methods used in current Victorian planning and building controls, including the Bushfire Attack Level (BAL) can be used as a guide for planning the separation of riparian revegetation proposals from houses and other buildings where people congregate.

It is recognised that houses are not necessarily the only or most valuable part of a rural property, however, they are critical to the survival of people in the event of bushfire.

As described in section 4.2, the Bushfire Attack Level (BAL) provides a measure of the level of threat from bushfire. It is defined in the Australian Standard *Construction of buildings in bushfire-prone areas* (*AS 3959:2009*) as 'a means of measuring the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact' using units of radiant heat in kW for each square metre of the asset's surface.

As well as predicting threat, the Bushfire Attack Level can be used to estimate the separation between vegetation and buildings needed to reduce the threat to specified levels.

A worksheet for estimating separation from buildings, based on the 'simplified' method (Method 1) for calculating the Bushfire Attack Level is provided in Appendix 3.

Like Worksheet 1, Worksheet 3 combines values provided in Tables 2 and 3 of Clause 52.47 of all planning schemes which sets out requirements for development under the Bushfire Management Overlay (BMO). These values are based on *AS 3959:2009* for a Forest Fire Danger Index (FFDI) of 100 (Extreme fire danger).

It also allows exclusion of vegetation not considered to pose a significant threat, although care should be taken before relying upon solely on setback distances without consideration of other factors that influence bushfire risk.

Revegetation should be designed so that buildings are not exposed to more radiant heat than they have been designed to withstand, using the planning controls as a guide. For example, under government requirements:

- New buildings in the designated Bushfire Prone Area must meet a minimum construction standard of BAL 12.5 (or a radiant heat exposure) of 12.5 kW/m^2
- Similarly, new 'vulnerable uses' such as schools and aged care facilities located within the BMO must meet a minimum construction standard (or a radiant heat exposure) of 10 kW/m^2.

It should be assumed that older buildings are (at best) able to withstand 12.5 kW/m^2 of threat.

As pointed out by Leonard (2006), *AS 3959:2009* does have weaknesses, and so, where practical, the separation distance selected for riparian revegetation using Worksheet 3 should be regarded as a minimum.

A more conservative approach would be to aim for a minimum separation from buildings of 150 m.

A less conservative approach that may be applicable in less hazardous areas would be to base separation on the '10/30 and 10/50' rules (exemptions) set out in Clause 52.48 of all planning schemes (except for some metropolitan municipalities).

These rules allow subject to conditions, the removal, destruction or lopping of vegetation to create defendable space (separation from hazardous vegetation) for buildings used for accommodation including:

- trees within 10 metres
- any other vegetation except trees within 30 metres
- in Bushfire Management Overlay areas, any other vegetation except trees within 50 metres of an existing building used for accommodation.

Use of Method 2 of *AS 3959:2009* by an experienced fire planner taking into account advice from the relevant fire service provides scope to vary inputs into setback calculations to better reflect site conditions or the level of acceptable risk including:

- Forest Fire Danger Indices (FFDIs) which may be more representative of expected weather (taking climate change into account) and/or the level of risk that is considered acceptable by the community.
- Likely peak fuel hazard. Alternative sources of information on fuel hazard include the *Overall Fuel Hazard Guide* (DSE 2010) and fuel hazard tables used by DELWP for statewide fuel hazard mapping.
- Depth, width and exposure of the vegetation to wind (which influences flame width, flame length and rate of spread)
- Flame temperature
- Shielding from radiant heat by structures or vegetation.

Features of these 4 options are summarised in Table 7.

Table 7 – Comparison of options for planning the separation of new riparian revegetation areas from assets

Options		Relative effect of options on #			Basis of option and limitations
Location	Revegetation options (based on current planning and building controls for new building as a guide)	Embers	Radiant heat	Flame contact	
All areas	Avoid revegetation unless the vegetation meets one or more criteria for very low threat as set out in Step 1 of Worksheets 1 and 3: ▪ Vegetation more than 150 m from the building ▪ Single areas less than 1 ha in area and not within 100 m of other vegetation that does not meet the criteria for very low threat ▪ Multiple areas less than 0.25 ha in area or strips less than 20 m wide and not within 20 m of the building, or each other, or other vegetation that does not meet the criteria for very low threat ▪ Grassland less than 100 mm in height during the Fire Danger Period ▪ Vegetation meets the standards for 'defendable space' as set out in *Standard planning permit conditions* for new houses located in the BMO (CFA 2014b) or low overall fuel hazard (DSE 2010)	●	●	●	Based on exemptions for very low threat in *AS 3959:2009* (with separation increased to 150 m to align with the assessment area specified in current Victorian planning controls). These criteria may underestimate the threat of ember attack from more extensive and more contiguous vegetation.
Bushfire Management Overlay (BMO) areas (Higher bushfire risk) Bushfire Prone Areas (BPA) (Moderate to high bushfire risk)	Using Worksheet 3 (Appendix 3) as a guide, avoid revegetation within a distance likely to expose buildings to radiant heat beyond the following levels: ▪ Existing houses: minimum of 12.5 kW/m^2 (unless they have been built in accordance with *AS 3959:2009* as indicated by the building permit) ▪ 'Vulnerable uses' (such as schools): minimum of 10 kW/m^2 (as specified for new development in the BMO)	●	●	●	Based on *AS 3959:2009* as set out in Tables 2 and 3 of Clause 52.47 of all planning schemes. May over or underestimate radiant heat compared with Method 2 of *AS 3959:2009*
Other areas not included in the BMO or BPA and where revegetation which meets exemptions for size and distribution set out in Step 1 of Worksheets 1 and 3	Avoid revegetation within: ▪ 50 metres of buildings in the BMO ▪ 30 metres of buildings located elsewhere	•	•	•	The '10/30 or 10/50 rules (exemptions)' (Clause 52.48 of planning schemes May underestimate the setback required for riparian areas May overestimate setbacks in urban areas or for isolated bushland areas
Where a more site-specific solution is required	Avoid revegetation within a distance likely to expose buildings to unacceptable levels of radiant heat	●	●	●	Method 2 of *AS 3959:2009* provides scope for an experienced fire planner to vary inputs into setback calculations to better reflect site conditions or acceptable risk including FFDI, likely peak fuel hazard, slope and extent of vegetation present as well as the radiant heat exposure target

Larger dots represent a greater relative effect on bushfire impacts, smaller dots represent a smaller relative effect

7. Frequently asked questions

7.1 What general conclusions can be drawn about fire behaviour in riparian areas?

As riparian areas vary significantly in their topography and vegetation and the amount of surface and sub-surface water present, fire burning in each riparian area will behave differently.

While riparian areas and the conditions they will be exposed to will differ significantly across Victoria, the following general conclusions can be drawn about fire behaviour in riparian areas:

- In well-managed riparian vegetation with limited grass and weed growth and low slopes, and under a Low to Moderate Fire Danger Rating, bushfire may be difficult to ignite and may only burn very slowly and at a low intensity.
- Under more severe conditions, any vegetation will burn, and any significant patch of vegetation situated close to assets may pose a fire threat.

7.2 Is a fire more or less likely to start in riparian areas revegetated with native species compared to degraded riparian land (dominated by non-native species) and to the adjacent agricultural land?

Based on fire history records, fire is less likely to start in riparian areas. CFA data for the period 1 January 2006 to 30 June 2011 indicates that of over 27,000 vegetation fires reported in the Country Area of Victoria (land outside the Melbourne metropolitan area and public land managed by the then DSE), less than 1% started in riparian areas.

The likelihood of a fire starting in a riparian area is dependent upon a number of factors, including fuel. A bushfire is less likely to start in areas which:

- Are not located in areas prone to lightning strikes
- Are remote from roads and recreation areas and where there is limited access, particularly for arsonists
- Have patchy fuel, limited dead fuel and/or fuel which is not yet dry enough to burn
- Are sheltered from the wind and sun.

These features are typical of many riparian areas.

The type of fuel (e.g. native or non-native species) is likely to be less important than the amount, distribution and moisture content of the fuel in determining whether a fire will ignite.

7.3 Is a fire more or less likely to spread within riparian areas revegetated with native species compared to degraded riparian land (dominated by non-native species)?

The likelihood of a fire spreading in a riparian area is dependent upon a number of factors, including fuel, topography and weather.

Bushfire is likely to spread less rapidly and result in a lower intensity fire in areas where:

- The fire has just started and has yet to reach peak intensity
- Fuel hazard is lower (lower fuel quantity and vertical and horizontal continuity, presence of water)
- Fuel moisture is higher (due to daily or seasonal conditions, aspect, shading, wind protection or proximity to surface water)
- Slopes are lower and topography does not channel the wind
- Fire Danger Rating is Low to Moderate.

The type of fuel (e.g. native or non-native species) is likely to be less important than the amount, distribution and moisture content of the fuel in determining whether a fire will spread.

Fire in riparian areas where the grass is dried and dead (cured) has the potential to spread rapidly, but its contribution to spread at a landscape scale will be determined by the presence of continuous fuel (e.g. cured pasture) around it. Barriers such as grazed areas, roads or firebreaks may slow or prevent fire spread from grassy riparian areas.

If there is only limited localised spotting, a fire burning in a forested riparian area is expected to be slower and therefore less likely to contribute to fire spread at a landscape scale.

7.4 How does vegetated riparian land behave in a fire compared to the surrounding agricultural landscape?

As shown in section 3.2, fire burning in forested land (such as a revegetated riparian area) with only limited localised spotting is expected to burn more slowly than in the surrounding agricultural landscape and therefore be less likely to contribute to fire spread at a landscape scale. However, depending upon the fuel hazard, it may burn more intensely with longer flame lengths, making it harder to suppress, and more likely to impact on assets which are close to the riparian area.

The relative threat from riparian areas and other parts of a landholder's property to assets will depend upon the expected fire behaviour, proximity to the threat and the fire management work carried out.

While the fuel hazard in a forested riparian area is likely to be greater than in pasture, the threat from pasture which is closer to assets may be the same as or greater than that posed by the more distant riparian area. Refer to the scenario provided in section 5.4 for further information.

7.5 Can riparian areas act as 'wicks'?

In some circumstances, fire may spread along riparian areas which are not aligned with the prevailing wind direction, but which carry more fuel than adjacent eaten-out pastures (for example, at the 2009 Vectis fire (Strickland, 2009)), or where the adjoining grassland is not fully cured (for example at the 2016 Lancefield fire (Mark Holland, CFA Service Delivery Team Leader, personal communication 20 June 2016)). In addition, valleys may channel and change the direction of wind flows and lead to increased wind and fire speeds.

However, in general, riparian areas do not generally act as a 'wick' or 'fuse'. Fires generally only burn in the direction of the wind (while spreading more slowly sideways), or slope if burning under lighter wind conditions.

7.6 Is vegetated riparian land more or less likely to aid or reduce the spread of a fire?

The contribution of a riparian area to fire spread and intensity at a landscape scale will generally be influenced, amongst other things, by the small amount of riparian land in the landscape and the behaviour of fire in the riparian area compared with that on surrounding land.

As shown in section 3.2, fire burning through a cured crop or pasture is likely to spread rapidly and contribute significantly to fire spread at a landscape scale.

Where spotting is limited, a fire burning in a forested riparian area is expected to be slower and therefore less likely to contribute to fire spread at a landscape scale than a fire burning in grass or crops.

The contribution of a grassy riparian area to spread at a landscape scale will be influenced by the presence of continuous fuel (e.g. cured pasture) around it. Barriers such as grazed areas, roads or firebreaks may slow or prevent fire spread from grassy riparian areas.

Refer to section 3.2 for further information.

7.7 Can riparian land act as a fire break?

Riparian land may slow the rate of spread of a fire where:

- The fire has just started and has yet to reach peak intensity
- Fuel hazard is lower (lower fuel quantity and vertical and horizontal continuity, presence of water)
- Fuel moisture is higher (due to daily or seasonal conditions, aspect, shading, wind protection or proximity to surface water)
- Slopes are lower and topography does not channel the wind
- Fire Danger Rating is Low to Moderate, with low wind.

However, vegetated land should not be relied upon to act as a firebreak where there is a risk of fire spread, particularly through spotting.

7.8 Is the fire threat only high in particular phases of revegetation (such as before canopy closure when tall grass dominates)?

Fire in newly revegetated areas which have significant grass cover and limited or no tree canopy is likely to behave in the same way as fire burning in neighbouring pasture or crops, and spread rapidly.

However, barriers such as grazed areas, roads or firebreaks may slow or prevent fire spread from grassy riparian areas.

Fire spread rates and the contribution of riparian areas to fire spread at a landscape scale could be expected to decrease as grass cover in newly revegetated riparian areas is replaced through weed control or by shrub and tree cover, provided spread by spotting is limited. However, the intensity of fire and the radiant heat impact on nearby assets is likely to increase as forest cover matures. This may only present a risk to assets if the riparian area and assets are close.

Refer to section 3.2 and the scenario in section 0 for further information.

7.9 How does any bushfire threat to a landholder's assets from forested riparian areas compare with other parts of a property and the way it is managed?

The relative threat of bushfire to assets from riparian areas and other parts of a farm will depend upon the hazard level and the expected fire behaviour, proximity to the hazard, and the work carried out to manage the threat it poses to assets.

Bushfire hazards on a property include living vegetation such as grass, weeds, food and timber crops, windbreaks and native vegetation.

While revegetated riparian land may have only a limited influence on bushfire spread at a landscape scale, compared with other vegetation, it may pose a direct threat to assets.

As shown in the scenario provided in section 5.2, extensive revegetation of forest understorey and overstorey (shown in photographs F and K) could pose a high threat when separated from assets by 50 metres. In this scenario, the threat to an asset from nearby pasture is much lower but still significant.

Not all vegetation will pose a significant threat to assets. Trees may filter some embers as well as reducing wind speed and the rate of spread and intensity of fire. In addition, revegetation proposals which involve creating narrow vegetated strips which are remote from assets, may not significantly add to bushfire threat from radiant heat.

Circumstances in which narrow, isolated or remote areas of vegetation may be considered a very low threat are summarised in the appendices. Refer to section 4.2 for further information.

Apart from living vegetation, other potential fire hazards on a farm include storages of firewood, hay, decomposing compost or manure, fuel, gas and chemicals, building and other materials, and structures.

Management of a property can also have a significant impact on bushfire risk. Bushfires may start from a range of potential ignition sources including pilot lights, exhausts of vehicles and machinery, moving parts of machinery (such as slasher blades), faults in power lines or electric fences and escapes from burning of crops or other vegetation or rubbish.

Assessment of the relative risk of bushfire from these factors is beyond the scope of this document, however it is important that all potential sources of risk be managed. For further information on managing these risks refer to *On the Land* (CFA 2011a).

7.10 In extreme bushfire events, such as the February 2009 fires, do riparian areas respond differently to the fire than other elements of the landscape?

Key factors that influence fire behaviour are summarised in Table 1. The relative degree to which fuel, topography and weather will determine fire behaviour and its impact will vary from site to site.

Under milder conditions, fire will spread more slowly and at a lower intensity and may take some time to develop to its peak rate of spread and intensity.

Under protracted drought, and extreme fire weather, such as experienced during February 2009, all vegetation can burn.

There are documented examples of where bushfire in riparian areas did and did not behave differently from that in the surrounding landscape during the February 2009 bushfires. A key message from this is that caution should be applied in extrapolating from examples to other locations and circumstances.

In a witness statement provided to the Victorian Bushfires Royal Commission (Strickland 2009) noted many examples where *'the shape of the fire during its main run was essentially unaltered by the presence of roads, rivers or creeks (…for example, the Hume Freeway and other roads near Wandong, the Princes Highway at Weerite, the Bunyip River at Tonimbuk)'*.

However, Strickland (2009) also noted that *'shortly after crossing Labertouche Road the (Bunyip Ridge) fire slowed along a line parallel with the creek, probably due to higher fuel moistures and a degree of sheltering from the wind in the creek environs'*. The following image taken at 14.37 hours on 7 February

2009 shows that where a spot fire located to the south of the creek line travelled over one kilometre, the rest of the fire front travelled only a few hundred metres away from the riparian area. However, this difference in fire spread could be reduced over the life of a fire where there are differences in fuel or other conditions affecting spread.

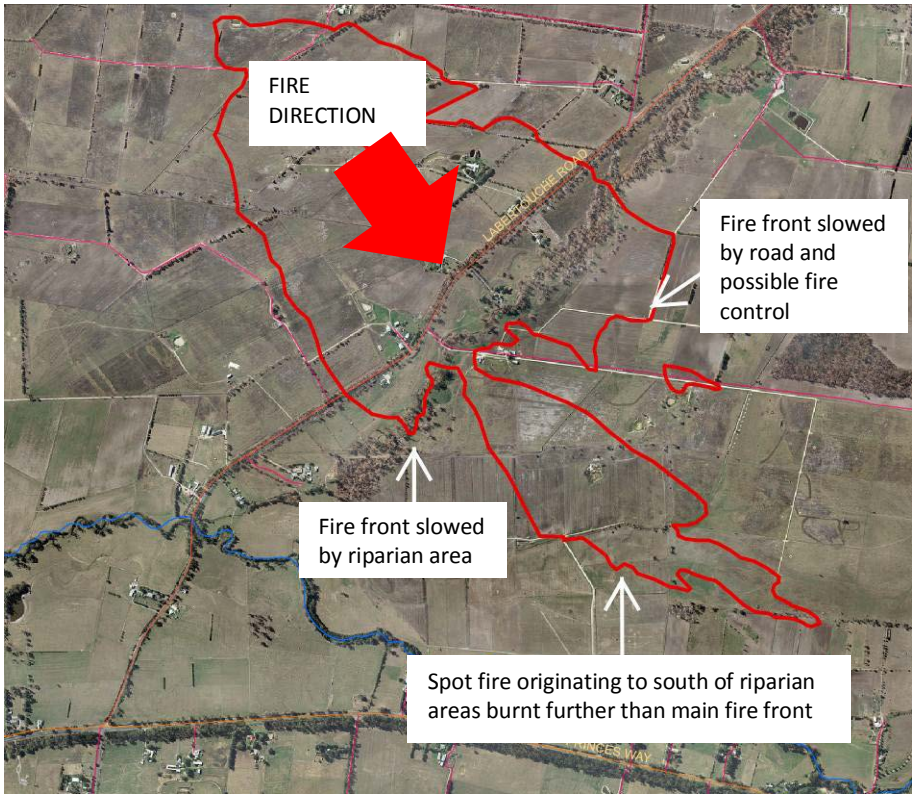


Figure 20 – Spotfire on the boundary of the Bunyip Ridge fire, Labertouche Road February 2009

7.11 What factors other than fire threat need to be considered in determining the risk to assets?

Fire behaviour and the threat it poses is only one aspect that needs to be taken into consideration in determining bushfire risk associated with riparian areas.

Risk assessment also needs to consider the likelihood of a fire starting and reaching assets, and the vulnerability of assets to the threat.

The risk to assets from a bushfire which may spread through a riparian area is likely to be lower where:

- The likelihood of a fire starting or reaching the assets is lower (due to infrequent fire history, low chance of ignition, discontinuous or eaten-out fuel surrounding the asset)
- The threat of exposure to flame contact, radiant heat or embers is lower because of fuel, topography or weather factors and separation from the fuel hazard
- The vulnerability of the asset is lower (for example the assets and the owners are well-prepared for fire, and there is adequate water supply, access for fire control and egress for leaving early).

7.12 Who is responsible for managing bushfire risk associated with riparian revegetation proposals?

Under the *CFA Act 1958*, landholders have a responsibility to minimise the risk of starting an unplanned fire. CFA also advises landholders to carry out activities that will minimise fire spread (CFA 2011a).

Agricultural licences granted under section 130 of the Land Act 1958 for use of Crown land specify that the licensee will undertake 'all fire protection works on the licensed land required by law to the satisfaction of the Licensor and the responsible fire authority' (DSE 2003).

7.13 How can actual risks be best managed?

Options for managing risk can include the following:

- avoiding the risk
- changing the likelihood
- changing the consequences
- sharing the risk
- accepting the risk by informed decision.

Table 6 outlines some options for managing bushfire risk associated with riparian revegetation and other management proposals. Further information is provided in the references listed in section 8.

The scenarios provided in section 5 show that risk can be substantially reduced by reducing vulnerability of assets to ember attack, flame contact and radiant heat. However, implementation of a range of approaches to treat the risk is recommended, as reliance on one measure alone could lead to failure.

To ensure that risks are identified and treated appropriately, substantial revegetation programs (such as those greater than 20 metres in total width) should be designed with input from the Municipal Fire Management Committee, which has responsibility for fire risk management at the municipal level.

In addition, successful bushfire risk reduction requires the understanding and cooperation of the adjacent landholders and the wider community.

7.14 What if some risk management options are in conflict with revegetation objectives and standards?

Some revegetation proposals may appear to be in conflict with community safety objectives. Similarly, some bushfire risk management options such as reducing the width of revegetation areas, modifying vegetation structure or fuel management may be, or may appear to be, in conflict with revegetation objectives.

It is important that revegetation planning addresses actual rather than perceived risks to both community safety (from revegetation proposals) and environmental values (from bushfire management).

Revegetation proposals which involve creating narrow vegetated strips which are remote from assets and may not significantly add to bushfire threat.

Similarly, bushfire risk management may only involve making minor changes to the proposed vegetation structure (such as through thinning of shrubs), or make changes over only a small portion of a riparian area.

In some cases, fire management may be ecologically beneficial. For example, fuel management such as weed control will have ecological benefits as well as reducing fire threats. As shown in section 3.2, the presence of grass can significantly increase fire spread.

In addition, many species require fire or appropriate ecological disturbance to persist on a site, although care should be taken in using fire in riparian areas as many species (including gums) are vulnerable.

For further information on environmentally sustainable bushfire management, including minimising harm and the use of fire to improve ecological benefits, refer to the *Fire Ecology Guide* (CFA 2011c).

Where, after exploring options with stakeholders, a conflict between conservation and community safety objectives cannot be resolved, priority should be given to protection of human life in accordance with the Victorian Government's *Bushfire Safety Policy Framework* (Fire Services Commissioner 2013) which states: 'The protection of human life is paramount'.

To ensure that bushfire risks are identified and treated appropriately, substantial revegetation programs should be designed with input from the Municipal Fire Management Planning Committee, which has responsibility for planning for fire risk management at the municipal level.

In addition, adjacent landholders must be assisted to understand the actual bushfire risk associated with riparian revegetation programs (as opposed to perceived risk) and to take action to treat the risk in a way which, wherever possible, minimises harm to both people and the environment.

7.15 How can the separation of riparian revegetation programs from houses or other buildings be determined?

Planning and building controls for bushfire protection do not directly affect riparian revegetation proposals. However, these controls can be used as a guide for planning the separation of the proposed riparian revegetation from existing houses or other accommodation or other community buildings such as schools.

Options include:

- Avoiding revegetation within 150 metres of houses or other buildings
- Avoiding revegetation within a distance likely to expose buildings to unacceptable levels of radiant heat, using tables developed for designated Bushfire Management Overlay areas or Bushfire Prone Areas
- Avoiding revegetation within 30 or 50 metres of buildings based on the '10/30 or 10/50 rules (exemptions)' (clause 52.48 of planning schemes)
- Where a more site-specific solution is required, identifying vegetation setbacks using Method 2 of the Australian Standard *AS 3959:2009*.

These options aim to limit the impacts of flame contact, radiant heat and ember attack on houses or other buildings, although only the first option is aimed at significantly reducing the impacts of embers. However, as only limited ember attack is expected from riparian areas in agricultural landscapes that are isolated from significant patches of native vegetation, this option may overestimate the vegetation setback required. Where ember attack is considered to be a significant issue, additional options such as fuel management should be considered.

For further information, refer to section 6.5. A process for determining the separation of riparian revegetation or existing vegetation from assets is set out in Worksheet 3 (Appendix 3).

7.16 Are some revegetation proposals too small or too narrow to be considered a bushfire risk?

Not all vegetation will pose a significant threat to assets. Trees can filter radiant heat and embers as well as reducing wind speed and the rate of spread and intensity of fire. In addition, revegetation proposals which involve creating narrow vegetated strips which are remote from assets, may not significantly add to bushfire threat from radiant heat.

AS 3959:2009 identifies circumstances in which narrow, isolated or remote areas of vegetation may pose a very low threat from radiant heat. These include vegetation that is more than 100 m from assets. However, this exemption underestimates the radiant heat impacts from forest and woodland on steeper slopes, and is inconsistent with the current Victorian planning controls for bushfire which requires assessment of threat within 150 m of assets. It may also underestimate the threat of ember attack from more extensive and contiguous vegetation. However, while care should be taken in relying solely on setback distances without consideration of other factors that influence bushfire risk, in this document, riparian revegetation and other smaller areas of vegetation may generally be considered a very low threat if they meet one or more of the following criteria:

- Vegetation more than 150 m from the building
- Single areas less than 1 ha in area and not within 100 m of other vegetation that does not meet the criteria for very low threat
- Multiple areas less than 0.25 ha in area or strips less than 20 m wide and not within 20 m of the building, or each other, or other vegetation that does not meet the criteria for very low threat
- Grassland less than 100 mm in height during the declared Fire Danger Period
- Vegetation meets the standards for 'defendable space' as set out in the Standard planning permit conditions for new houses located in the BMO (CFA 2014b) or low overall fuel hazard (DSE 2010).

7.17 How do bushfire planning controls affect riparian revegetation proposals?

Planning and building controls for bushfire protection do not directly affect riparian revegetation proposals. However, these controls can be used as a guide for planning the separation of the proposed riparian revegetation from existing houses or other buildings.

Planning controls for bushfire are administered through the Bushfire Management overlay (Clause 52.47 of all planning schemes). Land affected by the BMO is shown at http://planningschemes.dpcd.vic.gov.au.

Building controls for bushfire apply to new development located in the declared Bushfire Prone Area which is shown at http://services.land.vic.gov.au/landchannel/jsp/map/BushfireProneMapsIntro.jsp

For further information, refer to sections 4.2 (Predicting bushfire threat at the property scale) or 6.5 (Design of revegetation setbacks).

8. Further information

CFA Vegetation Management Officers	Assistance with preparing risk assessments and advice on risk treatments
Municipal Fire Prevention (or Management) Officers	Links to Municipal Fire Management Committees for input into design of major revegetation programs
DELWP Fire Management Officers	Advice on fuel hazard tables used by DELWP for statewide fuel hazard mapping
Catchment Management Authority staff	Design and implementation of riparian revegetation programs
Bushfire Planning and Design (BPAD) practitioners	Practitioners accredited by the Fire Protection Association of Australia (FPAA) provide advice on all facets of planning for bushfire safety, including prediction of threat and risk
CFA publications	CFA (2011a) *On the Land. Agricultural Fire Management Guidelines* CFA (2011d) *Fire Ready Kit* CFA (2004) *Guidelines for Operating Private Equipment at Fires* CFA (2012c) *Can I or Can't I* CFA (2000) *Grassland curing guide* CFA (2011c) *Fire Ecology. Guide to environmentally sustainable bushfire management in rural Victoria* (for guidance on fuel management planning and implementation) CFA (2014b) *Standard planning permit conditions* (for guidance on design of access and water supply as well as defendable space (low fuel areas) around houses) CFA (2014a) *Vegetation Classes: Victorian Bushfire Management Overlay* (for assistance in using Worksheets 1 and 3)

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Appendix 1: Worksheet 1 – Estimating bushfire threat from radiant heat

This worksheet will to help you to estimate the bushfire threat to houses and other buildings where people live or congregate, where slopes are less than 20°. It is based on current planning and building controls for new houses and should be regarded as the minimum required for bushfire safety. Seek expert advice as needed.

Step 1: Does or will your vegetation pose a very low threat when mature?

- ☐ Vegetation more than 150 m from the building
- ☐ Single areas less than 1 ha in area and not within 100 m of other vegetation#
- ☐ Multiple areas less than 0.25 ha in area or strips less than 20 m wide and not within 20 m of the building, or each other, or other vegetation#
- ☐ Grassland less than 100 mm in height during the declared Fire Danger Period
- ☐ Vegetation meets the standards for 'defendable space' as set out in *Standard planning permit conditions* for new houses located in the BMO (CFA 2014b) or low overall fuel hazard (DSE 2010)

'Other vegetation' refers to vegetation not meeting the requirements of this step

Yes ☐▶ This vegetation poses a very low threat from radiant heat

No ☐▶ Go to Step 2

Step 2: What is the slope under the vegetation located within 150 m?

Appendix 4 will help you to estimate slope

- ☐ Upslope (fire would burn downhill towards the building)
- ☐ Flat
- ☐ Flat to 5°
- ☐ 5° to 10°
- ☐ 10° to 15°
- ☐ 15° to 20°
- ☐ More than 20°

Step 3: What is the class of vegetation (at maturity) located within 150 m?

Refer to *Vegetation Classes: Victorian Bushfire Management Overlay* (CFA 2014)

- ☐ Forest
- ☐ Woodland
- ☐ Shrubland
- ☐ Scrub
- ☐ Mallee
- ☐ Rainforest
- ☐ Grassland

Step 4: Determine the level of threat from radiant heat

Use the following table to select the slope and vegetation class, then determine the threat level for the nearest (but lowest) separation.

SLOPE	VEGETATION CLASS	THREAT LEVEL				
		LOW 10 kW/m²	LOW 12.5 kW/m²	MEDIUM 19 kW/m²	HIGH 29 kW/m²	VERY HIGH 40 kW/m²
		Separation/Defendable space (metres)				
All upslopes 0 degrees	Forest	60	48	35	25	19
	Woodland	40	33	24	16	12
	Shrubland	25	19	13	9	7
	Scrub	35	27	19	13	10
	Mallee	23	17	12	8	6
	Rainforest	30	23	16	11	8
	Grassland	35	19	13	9	6
Downslope >0 to 5 degrees	Forest	70	57	43	32	24
	Woodland	50	41	29	21	15
	Shrubland	28	22	15	10	7
	Scrub	40	31	22	15	11
	Mallee	26	20	13	9	7
	Rainforest	36	29	20	14	10
	Grassland	40	22	15	10	7
Downslope >5 to 10 degrees	Forest	85	69	53	39	31
	Woodland	62	50	37	26	20
	Shrubland	32	25	17	11	8
	Scrub	45	35	24	17	12
	Mallee	30	23	15	10	7
	Rainforest	46	36	26	18	13
	Grassland	45	25	17	11	8
Downslope >10 to 15 degrees	Forest	105	82	64	49	39
	Woodland	75	60	45	33	25
	Shrubland	36	28	19	13	9
	Scrub	50	39	28	19	14
	Mallee	35	26	18	11	8
	Rainforest	60	45	33	23	17
	Grassland	50	28	20	13	9
Downslope >15 to 20 degrees	Forest	125	98	78	61	50
	Woodland	95	73	56	41	32
	Shrubland	41	31	22	15	10
	Scrub	55	43	31	21	15
	Mallee	40	29	20	13	9
	Rainforest	70	56	42	29	22
	Grassland	55	32	23	15	11

Source: Tables 2 and 3 of clause 52.47 of all planning schemes which are based on *AS 3959:2009*

Appendix 2: Worksheet 2 – Estimating bushfire risk

This worksheet will to help you to estimate the bushfire risk to houses and other buildings where people live or congregate. It is based on the Australian Standard *AS 3959:2009* and the Victorian Fire Risk Register (VFRR) and should be regarded as the minimum required for bushfire safety. Seek expert advice as needed.

Step 1: What is the likelihood of fires starting and reaching the site?

How frequent are fires in this locality?

☐ Fires occur frequently ☐ Fires occur infrequently

If fires start nearby under extreme fire danger conditions, are they expected to reach the site?

☐ There is contiguous fuel between the vegetation and the site and/or likelihood of significant ember attack and therefore fires are expected to reach the site

☐ Fires are not expected to reach the site

Step 2: What is the threat to the site from radiant heat?

Use your answer from Worksheet 1 to estimate the threat from radiant heat

☐ Very Low ☐ Low ☐ Medium ☐ High ☐ Very High

Step 3: What are the consequences of fire reaching the site?

How vulnerable is the site and its occupants to fire?

Vulnerability	Criteria
☐ Low	☐ The building and site is well-prepared for fire, for example: ☐ Low-fuel condition ☐ Construction is appropriate to the threat from the proposed revegetation (*AS 3959:2009)* ☐ All-weather 2WD access with clearance of 4m ☐ 10,000 litres of tank water with CFA fittings dedicated to firefighting
☐ Moderate	☐ Vulnerability criteria for 'Low' not fully met, but the building is in a built-up urban area and it is possible to walk to low fuel areas
☐ High	☐ Vulnerability criteria for 'Low' not fully met and the site is not within or adjacent to an urban or low fuel area ☐ 'Vulnerable use' eg school, nursing home

What are the consequences?

Use the following table to determine the consequences of fire based on the threat level (Step 2) and vulnerability (Step 3).

Step 4: What is the bushfire risk?

Use the following table to determine the risk of fire based on the consequences (Step 3) and likelihood (Step 1).

Step 1: Likelihood

	Fires are expected to spread and reach assets	Fires are not expected to spread and reach assets
Fires occur frequently	Almost certain	Possible
Fires occur infrequently	Likely	Unlikely

Step 2: Threat from radiant heat - site level

0 to 2 kW/m^2	Very Low
2 to 12.5 kW/m^2	Low
12.5 to 19 kW/m^2	Medium
19 to 29 kW/m^2	High
29 to 40 kW/m^2	Very High
> 40 kW/m^2	Extreme

Step 3: Consequences

Threat / Vulnerability	Low	Medium	High	Very High	Extreme
High vulnerability	Moderate	Major	Catastrophic	Catastrophic	Catastrophic
Moderate vulnerability	Minor	Moderate	Major	Catastrophic	Catastrophic
Low vulnerability	Minor	Minor	Moderate	Major	Catastrophic

Very Low threat = Minor consequences

Step 4: Risk

Consequences / Likelihood	Minor	Moderate	Major	Catastrophic
Almost certain	High	Very High	Extreme	Extreme
Likely	Medium	High	Very High	Extreme
Possible	Low	Medium	High	Very High
Unlikely	Low	Low	Medium	High

Adapted from: Australian Standard AS 3959:2009 (Threat) and *Victorian Fire Risk Register – Reference Guide* (CFA 2012a)

Appendix 3: Worksheet 3 – Estimating vegetation setbacks

This worksheet will help you to plan your revegetation or management of existing riparian vegetation to minimise bushfire threat to houses or other buildings where people live and congregate, and where slopes are less than 20°. It is based on current planning and building controls for new houses and should be regarded as the minimum required for bushfire safety. Seek expert advice as needed.

Step 1: Does or will your vegetation pose a very low threat?

- ☐ Vegetation more than 150 m from the building
- ☐ Single areas less than 1 ha in area and not within 100 m of other vegetation#
- ☐ Multiple areas less than 0.25 ha in area or strips less than 20 m wide and not within 20 m of the building, or each other, or other vegetation#
- ☐ Grassland less than 100 mm in height during the declared Fire Danger Period
- ☐ Vegetation meets the standards for 'defendable space' as set out in *Standard planning permit conditions* for new houses located in the BMO (CFA 2014b) or low overall fuel hazard (DSE 2010)

'Other vegetation' refers to vegetation not meeting the requirements of this step

Yes ☐▶ This vegetation poses a very low threat from radiant heat

No ☐▶ Go to Step 2

Step 2: What is the slope under the vegetation located within 150 m?

- ☐ Upslope (fire would burn downhill towards the building)
- ☐ Flat
- ☐ Flat to 5°
- ☐ 5° to 10°
- ☐ 10° to 15°
- ☐ 15° to 20°
- ☐ More than 20°

Appendix 4 will help you to estimate slope

Step 3: What is the class (at maturity) of vegetation located within 150 m?

- ☐ Forest
- ☐ Woodland
- ☐ Shrubland
- ☐ Scrub
- ☐ Mallee
- ☐ Rainforest
- ☐ Grassland

Refer to *Vegetation Classes: Victorian Bushfire Management Overlay* (CFA 2014)

Step 4: What is the level that you want to reduce the bushfire threat to?

Threat	Minimum suggested for
☐ Low	Vulnerable uses eg schools or where evacuation may be required (10 kW/m^2 max) and older houses (12.5 kW/m^2 max)
☐ Medium to High	May be appropriate for relatively new houses built to bushfire standards (check planning or building permit)
☐ Very High	If only protection from flames required (eg track)

Step 5: Select the separation between the vegetation and the assets

Use the following table to select the separation required to reduce the threat from radiant heat in for each combination of slope, vegetation class and bushfire threat level.

SLOPE	VEGETATION CLASS	THREAT LEVEL				
		LOW 10 kW/m^2	LOW 12.5 kW/m^2	MEDIUM 19 kW/m^2	HIGH 29 kW/m^2	VERY HIGH 40 kW/m^2
		Separation/Defendable space (metres)				
All upslopes 0 degrees	Forest	60	48	35	25	19
	Woodland	40	33	24	16	12
	Shrubland	25	19	13	9	7
	Scrub	35	27	19	13	10
	Mallee	23	17	12	8	6
	Rainforest	30	23	16	11	8
	Grassland	35	19	13	9	6
Downslope >0 to 5 degrees	Forest	70	57	43	32	24
	Woodland	50	41	29	21	15
	Shrubland	28	22	15	10	7
	Scrub	40	31	22	15	11
	Mallee	26	20	13	9	7
	Rainforest	36	29	20	14	10
	Grassland	40	22	15	10	7
Downslope >5 to 10 degrees	Forest	85	69	53	39	31
	Woodland	62	50	37	26	20
	Shrubland	32	25	17	11	8
	Scrub	45	35	24	17	12
	Mallee	30	23	15	10	7
	Rainforest	46	36	26	18	13
	Grassland	45	25	17	11	8
Downslope >10 to 15 degrees	Forest	105	82	64	49	39
	Woodland	75	60	45	33	25
	Shrubland	36	28	19	13	9
	Scrub	50	39	28	19	14
	Mallee	35	26	18	11	8
	Rainforest	60	45	33	23	17
	Grassland	50	28	20	13	9
Downslope >15 to 20 degrees	Forest	125	98	78	61	50
	Woodland	95	73	56	41	32
	Shrubland	41	31	22	15	10
	Scrub	55	43	31	21	15
	Mallee	40	29	20	13	9
	Rainforest	70	56	42	29	22
	Grassland	55	32	23	15	11

Source: Tables 2 and 3 of clause 52.47 of all planning schemes which are based on *AS 3959:2009*

Appendix 4: Scenarios - inputs and assumptions

Fuel and topography

Fuel hazard images are from sites located near Flowerdale, Bengworden, Genoa and Horsham, Victoria. Fuel loads were derived from the *Roadside Fire Management Guidelines* (CFA 2001) for grass, statistics for wheat yield (DAFF 2011), and Table B2 of *AS 3959:2009* for scrub, forest and woodlands. Fuel hazard exemptions given in section 2.2.3.2 of *AS 3959:2009* for small areas of vegetation were assumed not to apply. Crown fuel loads were not added. All calculations assume flat ground.

Fire behaviour, threat and risk

Simplified calculation method (scenarios in sections 0 to 5.5): Values are based on Method 1 of *AS 3959:2009* and current Victorian planning controls (Tables 2 and 3 of Clause 52.47 which are based on FFDI=100 and a flame temperature of 1090K)

Site-specific calculation method (scenario in section 5.5): Values are calculated using *AS 3959:2009* (Method 2), with FFDI =100, flame temperature = 1200K (based on Wotton 2012) and fuel loads based on Table B2 of *AS 3959:2009*. In this scenario, calculations for the rate of spread and therefore radiant heat for L3 are modified using equations for narrow areas of fuel provided by Tolhurst (2014). L4 is modified based on Cheney and Bary (1969).

Risk: Risk calculations are based on the template shown in Appendix 2. This template was derived from the *Victorian Fire Risk Register (VFRR) – Reference Guide* (CFA 2012a) but using *AS 3959:2009* for threat (to be consistent with current Victorian planning controls and proposed changes to the VFRR).

A Prior to revegetation

B Following planting

C Prior to canopy closure

D After canopy closure

E Prior to revegetation

F Shrub/tree canopy closure

G Crops

H Prior to revegetation

I Pasture

J Pasture – heavily grazed

K Shrub/tree canopy closure

L Isolated, small or narrow areas of vegetation

Calculations used in scenarios

Fire behaviour and risk calculations for flat ground, Forest Fire Danger Index (FFDI) = 100, Grass Fire Danger Index (GFDI) = 130
FROS = forward rate of spread
Threat/risk legend: 0.5 = Very Low, 1 = Low, 2 = Medium, 3 = High, 4 = Very High, 5 = Extreme based on radiant heat (bushfire attack) levels as set out in *AS 3959:2009*

Fire behaviour

Fuel type	Photo number	Surface fuel (t/ha)	Total fuel (t/ha)	FROS surface fuel only (km/h)	Intensity (MW/m) rounded
Crop (Method 1)	G	8	8	17	70
Grass - Natural (Method 1)	B C H	6	6	17	55
Grass - Grazed (Method 1)	E I	4	4	17	35
Grass - Eaten out (Method 1)	J	2	2	17	20
Gorse (Method 1)	A	25	25	4	55
Gum woodland - grass (Method 1)	D	15	25	2	15
Riparian forest - shrub (Method 1)	F K	25	35	3	40
Urban - forest (Method 1)	L1	25	35	3	40
Urban - forest (Method 2, no corrections, 1200K)	L2	25	35	3	40
Urban - forest (Method 2, 60m wide, 1200K)	L3	25	35	2	20
Urban - forest (Method 2, fire burns for 60m, 1200K)	L4	25	35	2	25

Threat and risk

Distance between assets and fuel type = 25m

Fuel type / Calculation method (*AS 3959:2009*)	Photo number	Radiant heat (kW/m2)	BAL	Threat level	Threat category	Consequences (Vulnerability LOW)	Risk to assets (Vulnerability LOW)	Risk category	Consequences (Vulnerability HIGH)	Risk to assets (Vulnerability HIGH)	Risk category
Crop (Method 1)	G		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Grass - Natural (Method 1)	B C H		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Grass - Grazed (Method 1)	E I		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Grass - Eaten out (Method 1)	J		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Gorse (Method 1)	A		BAL 19	Medium	2	Minor	Medium	2	Major	Very High	4
Gum woodland - grass (Method 1)	D		BAL 19	Medium	2	Minor	Medium	2	Major	Very High	4
Riparian forest - shrub (Method 1)	F K		BAL 29	High	3	Moderate	High	3	Catastrophic	Extreme	5
Urban - forest (Method 1)	L1		BAL 29	High	3	Moderate	High	3	Catastrophic	Extreme	5
Urban - forest (Method 2, no corrections, 1200K)	L2	44	BAL-FZ	Extreme	5	Catastrophic	Extreme	5	Catastrophic	Extreme	5
Urban - forest (Method 2, 60m wide, 1200K)	L3	24	BAL 29	High	3	Moderate	High	3	Catastrophic	Extreme	5
Urban - forest (Method 2, fire burns for 60m, 1200K)	L4	27	BAL 29	High	3	Moderate	High	3	Catastrophic	Extreme	5

Distance between assets and fuel type = 50m

Fuel type / Calculation method (*AS 3959:2009*)	Photo number	Radiant heat (kW/m2)	BAL	Threat level	Threat category	Consequences (Vulnerability LOW)	Risk to assets (Vulnerability LOW)	Risk category	Consequences (Vulnerability HIGH)	Risk to assets (Vulnerability HIGH)	Risk category
Crop (Method 1)	G		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Grass - Natural (Method 1)	B C H		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Grass - Grazed (Method 1)	E I		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Grass - Eaten out (Method 1)	J		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Gorse (Method 1)	A		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Gum woodland - grass (Method 1)	D		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Riparian forest - shrub (Method 1)	F K		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Urban - forest (Method 1)	L1		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Urban - forest (Method 2, no corrections, 1200K)	L2	17	BAL 19	Medium	2	Minor	Medium	2	Major	Very High	4
Urban - forest (Method 2, 60m wide, 1200K)	L3	8	BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Urban - forest (Method 2, fire burns for 60m, 1200K)	L4	7	BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3

Distance between assets and fuel type = 100m

Fuel type / Calculation method (*AS 3959:2009*)	Photo number	Radiant heat (kW/m2)	BAL	Threat level	Threat category	Consequences (Vulnerability LOW)	Risk to assets (Vulnerability LOW)	Risk category	Consequences (Vulnerability HIGH)	Risk to assets (Vulnerability HIGH)	Risk category
Crop (Method 1)	G		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Grass - Natural (Method 1)	B C H		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Grass - Grazed (Method 1)	E I		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Grass - Eaten out (Method 1)	J		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Gorse (Method 1)	A		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Gum woodland - grass (Method 1)	D		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Riparian forest - shrub (Method 1)	F K		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Urban - forest (Method 1)	L1		BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Urban - forest (Method 2, no corrections, 1200K)	L2	5	BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Urban - forest (Method 2, 60m wide, 1200K)	L3	2	BAL 12.5	Low	1	Minor	Medium	2	Moderate	High	3
Urban - forest (Method 2, fire burns for 60m, 1200K)	L4	1	BAL 2	Very Low	0.5	Minor	Medium	2	Minor	Medium	2