Riparian land and bushfire risk

Resource Document

State Government Victoria
Department of Environment and Primary Industries

CFA

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

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Cover photograph

Revegetated riparian land, Boolarra, Gippsland

Departmental changes

In July 2012, the Department of Sustainability and Environment (DSE) and the Department of Primary Industries merged to become the Department of Environment and Primary Industries (DEPI). This document was prepared prior to the merger so the Working Group members and data sources at the time have been left as DSE. Where appropriate, the document refers to the current name for the Department, DEPI.

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Contents

Summary of key points

Many landholders with river frontages have voiced concerns that fencing and revegetating riparian land may result in a fire hazard 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 lands.

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.

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.

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.

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 existing houses or other assets.

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.

1. Introduction

1.1 Purpose of this document

This document provides information about the behaviour of fire in riparian land, the fire risk associated with riparian land and riparian management programs (including the relative contribution of riparian land to fire risk compared with other aspects of rural properties) and how to manage fire risk on riparian land.

It is intended to assist catchment management authorities (CMAs), the Country Fire Authority (CFA), the Department of Environment and Primary Industries (DEPI) and other natural resource and fire management agencies in their discussions with rural landholders about riparian land and fire.

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, being undertaken under the auspice of the Victorian Waterway Management Strategy (DEPI, 2012), millions of dollars are allocated to riparian protection and improvement projects each year through CMAs. 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. Approximately 800km of fencing has been erected along Victoria's rivers each year for the last fifteen years through the program. Other programs, such as Landcare and many other agency biodiversity programs, also support riparian projects.

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

Most riparian works are carried out within about 20 metres of waterways and on lower slopes on both public and private land.

1.3 Fire management

The State Fire Management Strategy (IFMP 2009) has been developed to guide fire management across Victoria that delivers:

- active participation of community, the sector and government, working together in fire management planning to reduce the destructive impact of fire on communities and the environment
- communities that are resilient to the effects of fire
- greater understanding of the fire sector within the community
- healthy natural, social, built and economic environments'.

Amongst other things, this strategy provides the framework for the preparation of bushfire plans at the state, regional and local levels (such as Municipal Fire Management Plans) which take into account vegetation and its effect on bushfire risk.

The *Victorian Bushfire Safety Policy Framework v3* (Fire Services Commissioner 2011) outlines principles for response to bushfire risk by the community including:

1. *'The protection of human life is paramount.*
2. *Risk management is fundamental to bushfire safety.*
3. *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'*.

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 DEPI's 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. Some landholders have carried out slashing and mowing to 'clean up' a site. It is not known if these management practices are justified from a fire safety point of view. If not, they are 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.

This document will focus on the more 'typical' bushfires experienced in Victoria. There is still great debate amongst researchers about the factors that drove the February 2009 fires, and detailed analysis of these fires is beyond the scope of this document.

2.1 Bushfire occurrence

Most bushfires result from human activities. Long-term records maintained by DSE 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.

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.

Table 1 – Factors that affect bushfire behaviour

Factors	How does this factor affect fire 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 (FMC)	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. 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.
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.

Factors	How does this factor affect fire behaviour?
Weather	
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

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.

Bushfire is likely to spread more rapidly and result in a higher intensity fire in areas where:

- The fire has been burning for some time and has reached peak intensity
- Fuel hazard is significant and there is potential for spotting
- Fuel moisture is lower (due to daily or seasonal conditions, aspect and exposure to wind and sun)
- Slopes are steeper or where topography channels the wind
- Fire Danger Rating is High to Extreme and the atmosphere is unstable.

3. Riparian areas, bushfire behaviour and threat

This section describes how bushfire behaviour expected on riparian land may contribute to bushfire threat at both a landscape and property scale.

Bushfire threat can be defined as the *'potential impact of bushfire on assets based upon fuel hazard, separation distance and the slope, under a given climatic condition'* (CFA 2012a).

Threat is only one aspect that needs to be taken into consideration in determining bushfire risk. Further information on risk associated with riparian areas is provided in section 4.

3.1 Contribution of riparian areas to bushfire threat at a landscape scale

The contribution of a riparian area to fire spread and intensity across the landscape will generally be influenced, amongst other things, by the:

- occurrence of bushfires in riparian areas
- amount of riparian land in the landscape
- land use and vegetation type in and around the riparian area.

3.1.1 Bushfire occurrence in riparian areas

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 the period 1 January 2006 to 30 June 2012, 249 or less than 1% are reported as starting in riparian areas.

3.1.2 Amount of vegetated riparian land in the landscape

As shown in the following image of Flowerdale, which is the location of two sites used in scenarios set out in section 5, the amount of vegetated riparian land (surrounding the blue lines) 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.

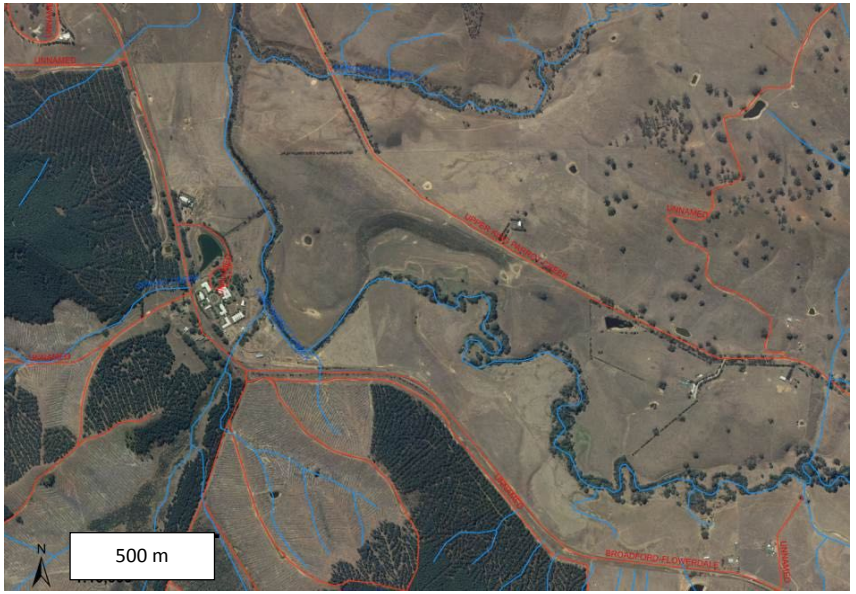

Figure 1 – Image of Flowerdale area showing waterways (blue) and roads (red)

3.1.3 Land use and vegetation type in and around the riparian area

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

Table 2 – Vegetation type and peak fire behaviour

	Vegetation type			
	Forest	Scrub	Grassland	Crop
Fuel load	H (up to 35 t/ha)	M	L-M (<6 t/ha)	May exceed grassland loads by 2 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	Extensive spotting up to 2 to 3 km and recorded up to 35 km away (based on large forest fires) Limited mainly localised spotting expected from narrow forested riparian areas (3)	Short distance spotting	Limited short distance spotting (100 m)	

L =Low, M=Moderate, H=High
Adapted from AFAC (2002) and (1) DAFF (2011), (2) Cheney and Sullivan 2008, (3) Gould (2007)

As shown in Table 2, fire burning through a cured (dry) crop or pasture is likely to spread rapidly and contribute significantly to fire spread at a landscape scale.

Fire in cured grassy riparian areas also has the potential to spread rapidly, but its contribution 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.

As riparian areas are generally narrow, they are less likely to generate long distance or extensive spotting than large 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, 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.

This difference in fire spread for different vegetation types is illustrated by modelling carried out by the then DSE shown in Figure 2 for grassland (light green) and a hypothetical 5 km wide strip of forested vegetation (dark green). The modelling uses weather recorded for 7 February 2009 and the fires run from 10 am to 5 pm. The fire modelled for forested vegetation spreads much more slowly than the fire modelled for grassland.

A fire that burnt in the vicinity of the Coliban River at Redesdale post the February 2009 fires also illustrates this point (Figure 3). The fire spread in the moister vegetated riparian area was limited compared to the adjacent pasture.

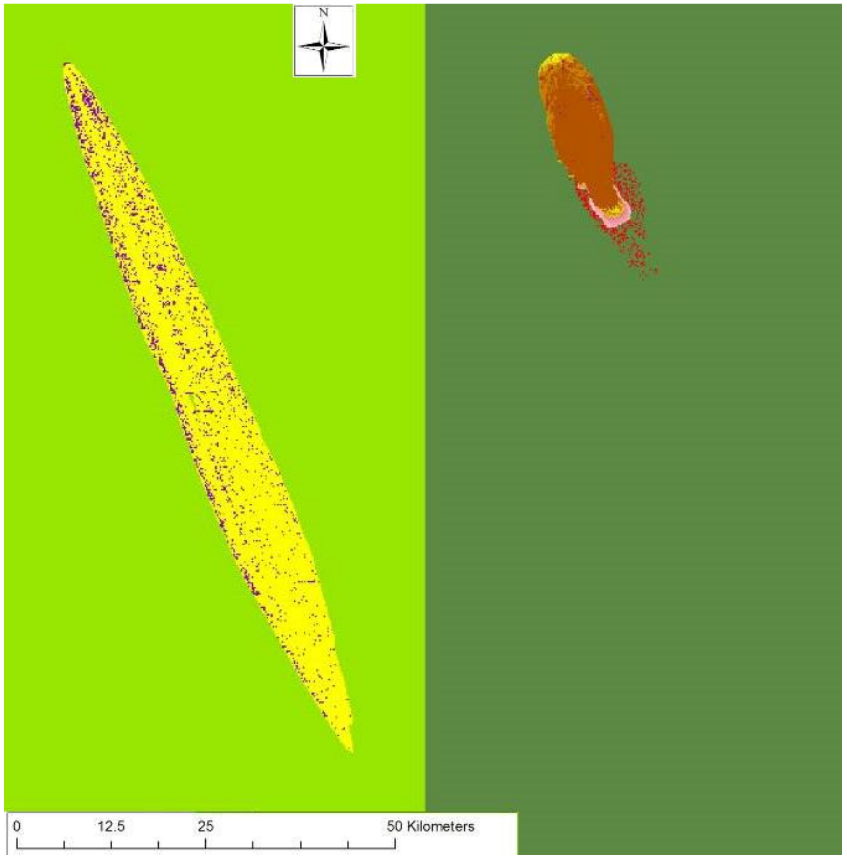

Figure 2 – Modelled fire spread for grassland (light green) and forest (dark green).

Figure 3 – Coliban River at Redesdale showing a fire that burnt post the February 2009 fires. The canopy of the riparian red gums is intact compared to the surrounding landscape which is predominately cleared with scattered paddock trees.

3.2 Contribution of riparian areas to bushfire threat at a property scale

While revegetated 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.

Assets that may be affected by bushfire are shown in Table 3. This report only considers houses and agricultural assets.

Table 3 – Assets that may be affected by bushfire

Human settlement	Houses, 'vulnerable congregations' e.g. schools, townships
Economic assets	Agricultural assets (e.g. equipment sheds, crops, stock) Commercial assets (e.g. shops) Infrastructure (e.g. roads, utilities) Tourist/recreational assets Drinking water catchments
Environmental and cultural assets	Sites and assets of significance exposed to bushfire which is inappropriate to their needs including riparian species which may have low tolerance to fire

Adapted from CFA (2012a)

Bushfire affects houses and other assets through direct flame contact, radiant heat and ember attack. As described previously, bushfire threat can be described as the 'potential impact of bushfire on assets based upon fuel hazard, separation distance and the slope under a given climatic condition' (CFA 2012a).

The Bushfire Attack Level (BAL) provides a measure of the level of threat to an asset (and human life) from bushfire. It is defined in the Australian Standard Construction of buildings in bushfire-prone areas (AS3959-2009) 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.

In Victoria's planning system, threat (radiant heat) calculations are based on AS3959-2009, with a number of inputs adapted to better reflect Victorian conditions. Typical radiant heat effects are shown in Table 4.

Table 4 – Typical radiant heat effects from bushfire

Pain to humans after 10 to 20 seconds	4 kW/m^2
Pain to humans after 3 seconds	10 kW/m^2
Ignition of timber after a long time	25 kW/m^2
Ignition of timber in 10 seconds	50 kW/m^2

Source: AS3959-2009

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.

The scenario in section 5.2 provides an example of the potential bushfire threat to an asset from vegetation. While forest understorey and overstorey (as shown in photographs F and K) could pose a high threat when separated from assets by 50 metres, the threat is expected to decrease with separation of the hazard and the assets.

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.

Fuel hazard exemptions given in AS3959 identify circumstances in which narrow, isolated or remote areas of vegetation may be considered a very low threat. However, before applying these exemptions, advice should be sought from an experienced fire planner. Refer to section 6.5.4 for further information.

4. Riparian areas and bushfire risk

Bushfire 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.

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)*'.

Consequences depend not only on the threat posed by the fire but also the vulnerability of the assets to the threat.

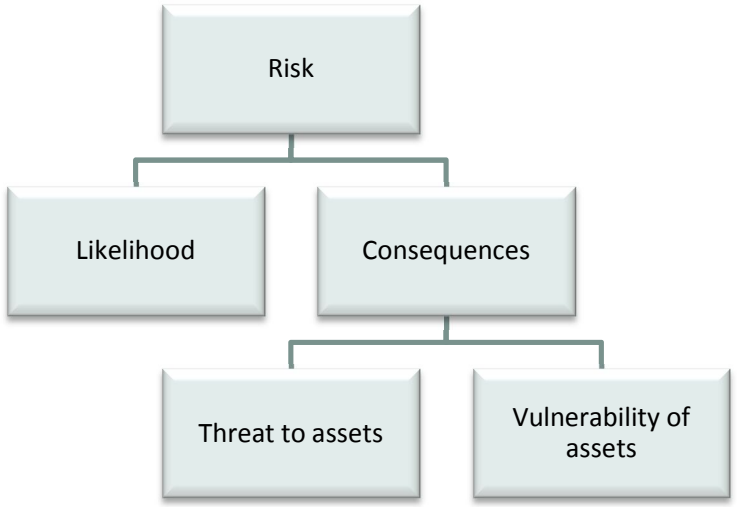

Figure 4 – Components of risk

Adapted from CFA (2012a)

Each component of risk can be defined as follows.

Table 5 – Definitions of risk components

Likelihood	The chance of a bushfire igniting and spreading
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)
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)

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, fuel hazard extent and separation from the fuel hazard
- The vulnerability of the asset is lower (for example the asset owner and the community are well-prepared for fire, and are likely to be able to defend their property from fire, and there is adequate water supply, access for fire control and egress for leaving early).

As well as fire threat, likelihood and vulnerability are important factors in determining bushfire risk. The following example illustrates the effect of vulnerability.

4.2 The effect of vulnerability on bushfire risk

Vulnerability is an important factor in determining bushfire risk. The following example illustrates the effect of vulnerability.

This example is based on the scenario in section 5.4. Data for revegetated riparian land which is separated from the asset by 100 metres of pasture (Figure 5), and the following steps in *Figure 6*, is used to calculate bushfire risk:

Step 1: Likelihood	Where fires occur infrequently and are expected to spread and reach assets: ▪ Likelihood is Likely
Step 2: Threat	Where the radiant heat is less than 12.5 kW/m^2: ▪ Threat to assets is Low
Step 3: Consequences	Where the threat is Low: ▪ High vulnerability will result in Moderate consequences ▪ Low vulnerability will result in Minor consequences
Step 4: Risk	Where the likelihood is Likely: ▪ Moderate consequences will result in High risk ▪ Minor consequences will result in Medium risk

As shown by this example, changing the vulnerability of assets from High to Low can reduce risk significantly (in this case from High to Medium). Information on reducing vulnerability is included in section 6.

Figure 5 – Revegetated riparian land (shrub/tree canopy closure)

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

Very Low	Radiant heat less than 2 kW/m^2
Low	Radiant heat 2 to less than 10 kW/m^2
Medium	Radiant heat 12.5 to less than 19 kW/m^2
High	Radiant heat 19 to less than 29 kW/m^2
Very High	Radiant heat 29 to less than 40 kW/m^2
Extreme	Radiant heat greater than 40 kW/m^2

Step 3: Consequences

Vulnerability \ Threat	Low	Medium	High	Very High
High Vulnerability	Moderate	Major	Catastrophic	Catastrophic
Moderate Vulnerability	Minor	Moderate	Major	Catastrophic
Low Vulnerability	Minor	Minor	Moderate	Major

Step 4: Risk

Likelihood \ Consequences	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

Figure 6 – Risk assessment table

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

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.

The scenarios are based upon the photographs in this section, the corresponding calculations shown in Appendix 2, and the inputs and assumptions listed in Appendix 3. All revegetation is carried out using native vegetation.

Threat (radiant heat) calculations are based on AS3959-2009, which is the standard used in Victoria's planning system for calculating bushfire threat, with the following exceptions:

- Forest Fire Danger Index (FFDI) of 120
- Flame temperature of 1200 degrees Kelvin

It should be noted however, that while an FFDI of 120 was used in these scenarios, most days during the declared Fire Danger Period are rated at Very High (FFDI=49) or less, and this FFDI may be considered adequate for planning setbacks from assets.

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 the vegetation does not meet the exemption criteria from AS3959 as outlined in section 6.5.4.

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 four stages of overstorey revegetation, up to canopy closure.

A Prior to revegetation

B Following planting

C Prior to canopy closure

D After canopy closure

Figure 7 – Four stages of riparian revegetation (overstorey only)

Predictions for this scenario show that:

- Grass cover in riparian areas can significantly increase the rate of spread of fire in a riparian area
- The closing of the canopy (D) may support crown fire
- Revegetation 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).

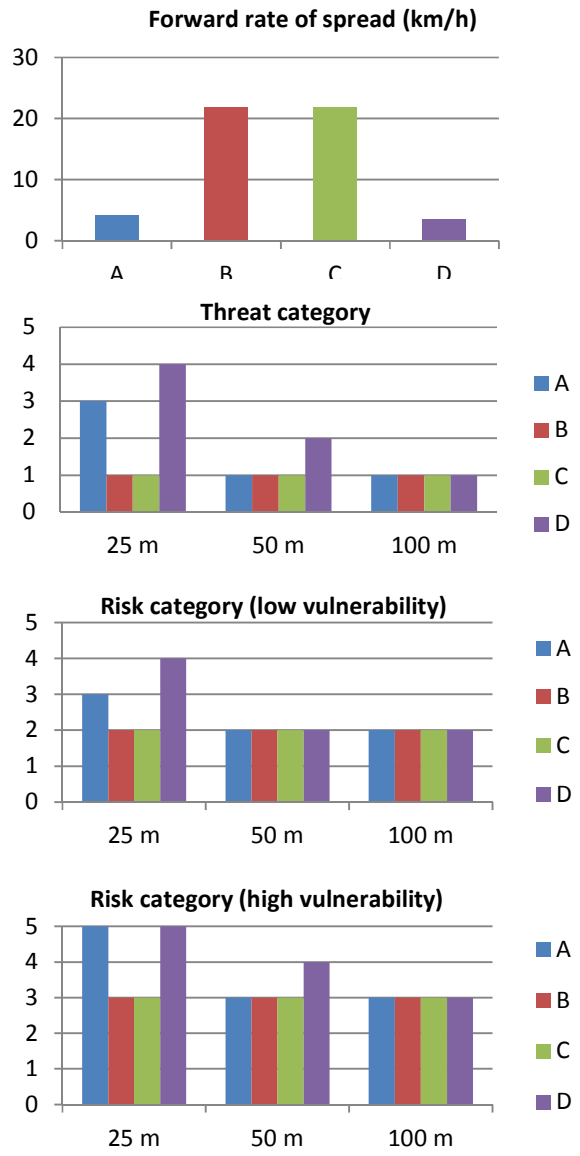

Figure 8 – Fire spread rate, threat and risk for stages of riparian revegetation (overstorey only).

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.

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 9 – Stages of riparian revegetation (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 intensity and risk compared with a tree canopy and grass control only (scenario 4.1, 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).

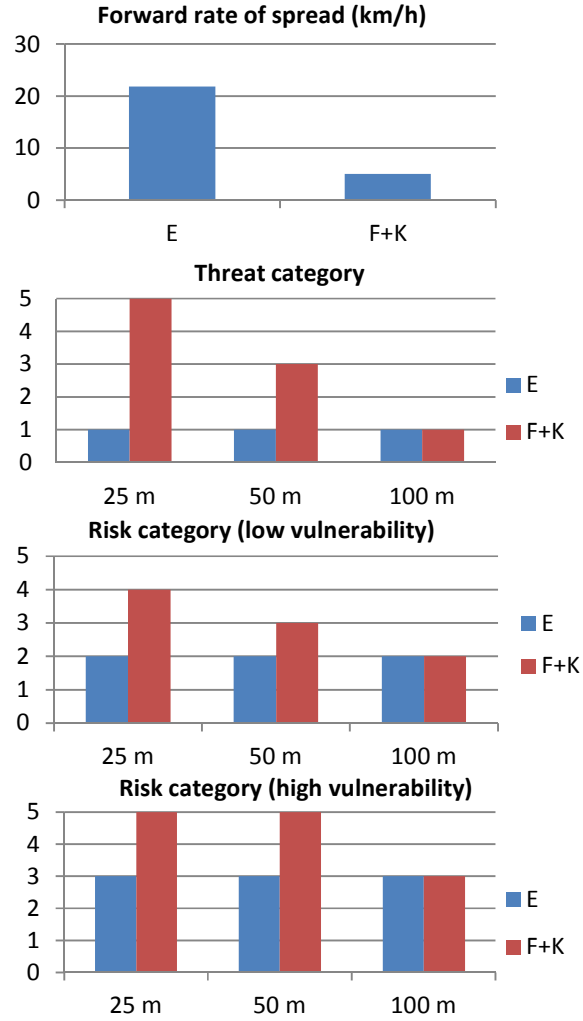

Figure 10 – Fire spread rate, threat and risk for stages of riparian revegetation (overstorey and understorey).

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

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 11 – 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.

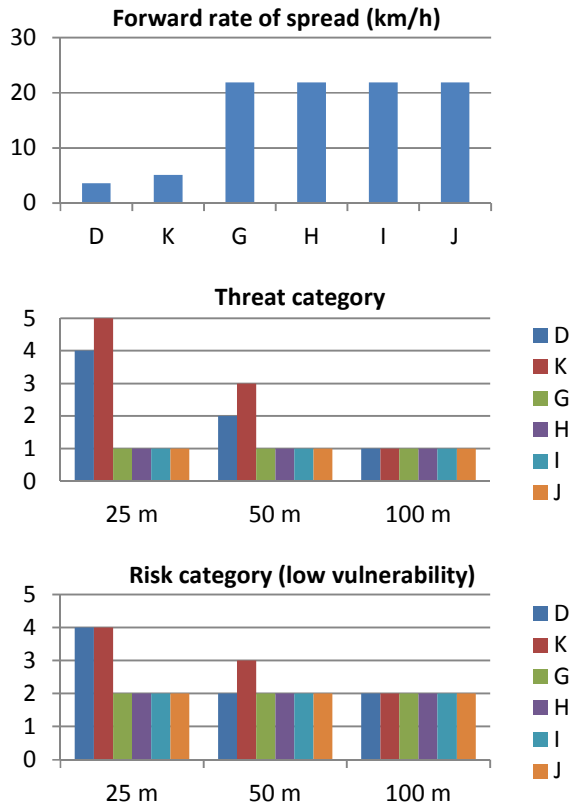

Figure 12 – Fire spread rate, threat and risk for riparian revegetation compared to other fuel types

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

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 13 – 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.

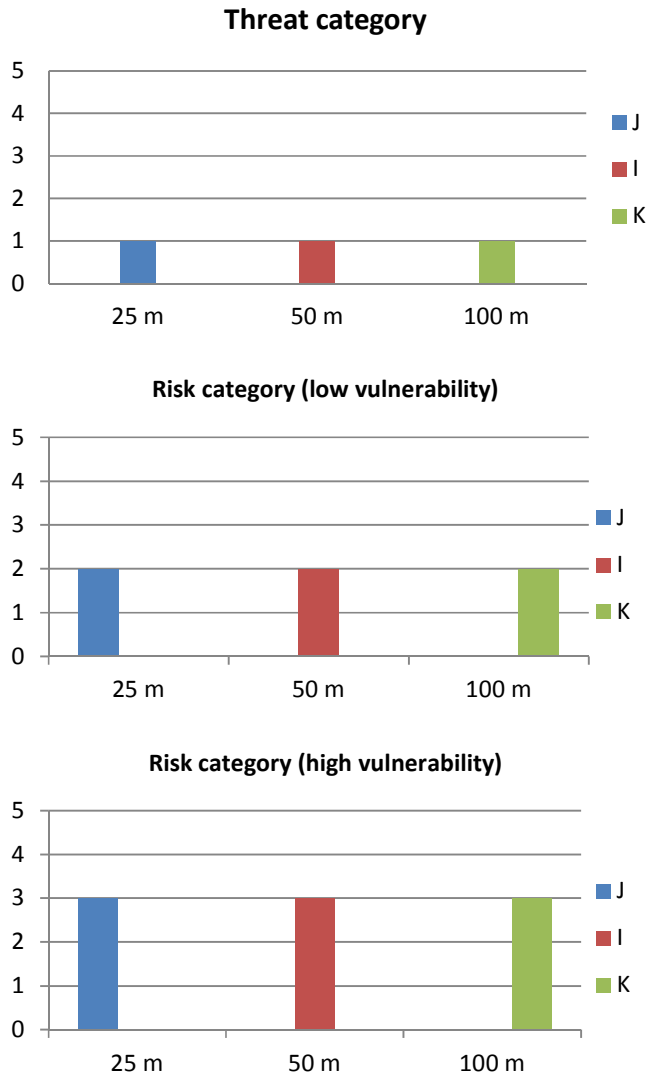

Figure 14 – Fire threat and risk for riparian revegetation and pasture at different distances from farm assets

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

6. Managing bushfire risk associated with 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 revegetation of riparian areas to avoid locations where this will lead to an unacceptable increase in risk to assets. Refer to section 6.4 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) for further information
Reduce the threat that riparian vegetation may pose to assets	Undertake targeted fuel management to reduce bark, elevated and surface fuel hazard where required to support other treatments, giving priority to weed control Consider species that have lower bark hazard 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 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) for information on environmentally sustainable bushfire management
Understand the risk	Work with fire service personnel and other fire planners, landholders, natural resource management agencies and the surrounding community to distinguish perceived as opposed to actual risks from bushfire and to riparian values from proposed bushfire risk management
Accept residual risk by informed decision	Work with fire service personnel and other fire planners, landholders, natural resource management agencies and the surrounding 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 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 reducing vulnerability of assets to ember attack, flame contact and radiant heat. In particular, 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.

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, after exploring options 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 2011) 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 from assets

Current bushfire controls do not directly affect riparian revegetation proposals. However both planning and building controls can be used as a guide for planning the separation of riparian revegetation proposals from existing houses or other assets.

6.5.1 The planning system and bushfire

The Bushfire Management Overlay (BMO) includes land assessed by government as having the highest bushfire hazard and a 150 metre buffer to allow for the heaviest ember attack. Riparian areas located in agricultural landscapes are less likely to be in a designated BMO. Maps of the BMO can be accessed at www.planningschemes.dpcd.vic.gov.au/.

The purpose of the BMO is to 'identify areas where the bushfire hazard requires specified bushfire protection measures for subdivision and buildings and works to be implemented' (Clause 44.06 of planning schemes). In particular, this clause requires the creation of 'defendable space' around new buildings used to accommodate people located in the BMO.

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

The defendable space requirements for buildings in the BMO are set out in clause 52.47 of planning schemes.

These requirements are based on the approach set out in Method 2 of the Australian Standard for construction of buildings in bushfire-prone areas (AS3959-2009), using an FFDI of 120 and a flame temperature of 1200 Kelvin.

These requirements aim to ensure that:

- 'vulnerable uses' such as hospitals are located so that they are not exposed to a radiant heat flux of more than 10kw/m^2 which provides some potential to evacuate or defend buildings
- new houses have defendable space that reduces radiant heat exposure to the building's construction standard (mostly BAL 29 or 29 kW/m^2).

The '10/30 and 10/50' rules (exemptions) (Clause 52.48 of all planning schemes, except for some metropolitan municipalities) apply to existing as well as new development. They allow, subject to conditions, the removal, destruction or lopping of any vegetation including:

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

6.5.2 The building system and bushfire

Designated bushfire prone areas are used in the building system to ensure that bushfire protection is considered as part of the building permit. They are defined as 'areas that are subject to or likely to be subject to bushfires' (DPCD 2011).

The bushfire prone area is separate to the BMO and the BMO maps in planning schemes. The bushfire prone area maps can be viewed at http://services.land.vic.gov.au/landchannel/jsp/map/BushfireProneMapsIntro.jsp

New buildings in a bushfire prone area must meet a minimum construction standard of BAL 12.5 (or a radiant heat exposure of 12.5 kW/m^2) as defined in AS3959-2009.

In the building system, radiant heat exposures are calculated using different inputs to those used in the planning system. They use an FFDI of 100 and a flame temperature of 1090 Kelvin.

6.5.3 Vegetation setback options

Options for planning the separation of new riparian revegetation areas from existing houses or other assets, using the planning and building controls as a guide, include:

- Applying the standards outlined in the controls for designated areas
- Applying higher standards than those applicable to the designated areas
- Applying more site-specific solutions.

Table 7 outlines these options in more detail.

All of these options aim to limit the impacts of flame contact, radiant heat and ember attack on houses or other assets. However, some of the options have a greater effect on bushfire impacts than others.

Only the first option in Table 7 (labelled 'All areas') is aimed at significantly reducing the impacts of embers. This option is based upon analysis of house loss during the 2009 bushfires (for example, see Chen and McAneney (2010). 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 there is significant vegetation already in the landscape, such as in designated Bushfire Management Overlay areas, the planning controls should be considered for use in determining minimum revegetation setbacks.

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

Options			Relative effect of options on impacts from#			Comments
Location	Map source	Revegetation recommendations and methods for calculating separation of revegetation from existing buildings	Embers	Radiant heat	Flame contact	
All areas		Avoid revegetation within 150 metres of buildings	●	●	●	Improved ember protection May overestimate the setback required for riparian areas
Bushfire Management Overlay (BMO) areas	http://planningschemes.dpcd.vic.gov.au	Avoid revegetation within a distance likely to expose buildings to radiant heat in excess of 12.5 kW/m^2 Method: ▪ The total of the 'inner' and 'outer zones' in Table 1 of clause 52.47 of all planning schemes which is based on radiant heat of 12.5 kW/m^2, an FFDI of 120 and flame temperature of 1200K ▪ For revegetation near 'vulnerable uses' (e.g. schools) or other locations where a more conservative approach is needed, use Table 2 of clause 52.47 which is based upon radiant heat of 10 kW/m^2, an FFDI of 120 and flame temperature of 1200K	●	●	●	Setback for forested land depending upon the slope: ▪ Using Clause 52.47 Table 1: between 69 and 134 metres ▪ Using Clause 52.47 Table 2: between 80 and 165 metres Most riparian areas are not expected to be in a BMO May overestimate the setback required for riparian areas
Bushfire Prone Areas (BPA)	http://services.land.vic.gov.au/landchannel/jsp/map/BushfireProneMapsIntro.jsp	Avoid revegetation within a distance likely to expose buildings to radiant heat in excess of 12.5 kW/m^2 Method: The 'inner zone' calculations in Table 1 of clause 52.47 of all planning schemes, which is based upon radiant heat of 12.5 kW/m^2, an FFDI of 100 and flame temperature of 1090K as used in AS3959	●	●	●	Setback is between 48 and 100 metres for forested land depending upon slope May overestimate the setback required for narrow or isolated riparian areas
Other areas and for revegetation which meets exemptions (s2.2.3.2 of AS 3959)		Avoid revegetation within 30 metres of buildings located in the BPA or 50 metres of buildings in the BMO Method: The '10/30 or 10/50 rules (exemptions)' (DPCD 2011 and clause 52.48 of planning schemes)	•	•	•	May underestimate the setback required for riparian 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: Method 2 of AS3959-2009	●	●	●	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

The total distances shown in Table 1 of clause 52.47 to all planning schemes provide a guide to minimum revegetation setbacks from existing houses. This table is based upon a radiant heat exposure of 12.5 kW/$m^{2,}$ an FFDI of 120 and a flame temperature of 1200 degrees. For more vulnerable buildings such as schools, or other locations where a more conservative approach is needed, Table 2 of clause 52.47 may be more appropriate. Table 2 is based upon the same FFDI and flame temperature as Table 1, but uses a radiant heat exposure of 10 kW/m^2.

In designated bushfire prone areas or areas which have limited vegetation or few or no houses, the 'inner zone' distances shown in Table 1 of clause 52.47, which uses the approach of AS3959-2009 and is based upon a radiant heat exposure of 12.5 kW/m^2, an FFDI of 100 and a flame temperature of 1090 degrees, may be considered appropriate.

Use of Method 2 of AS3959-2009 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 weather experienced during February 2009, or more likely to occur, and which reflect the level of risk that is considered acceptable. As most days during the declared Fire Danger Period are rated at Very High (FFDI=49) or less, this rating may be considered adequate for planning setbacks from some assets.
- 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 DSE for statewide fuel hazard mapping.
- Width of revegetation planned and the amount of other vegetation in the vicinity.
- Slope of the land.
- Level of acceptable radiant heat exposure.

6.5.4 Exemptions for very low threat vegetation

As stated in section 3.2, not all vegetation will pose a significant threat to assets. Fuel hazard exemptions given in section 2.2.3.2 of AS3959 identify circumstances in which narrow, isolated or remote areas of vegetation may be considered a very low threat or non-hazardous.

Section 2.2.3.2 of the Australian Standard AS3959-2009 lists circumstances in which narrow and/or isolated areas of vegetation may be considered a very low threat.

It states:

'The Bushfire Attack Level shall be classified BAL—LOW (threat is 'very low') where the vegetation is one or a combination of any of the following:

(a) Vegetation of any type that is more than 100 m from the site.

(b) Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified.

(c) Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other.

(d) Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified.

(e) Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops.

(f) Low threat vegetation, including grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks.

NOTE: Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognizable as short-cropped grass for example, to a nominal height of 100 mm).'

These dimensions should be treated with caution as they do not take account of FFDIs in excess of 100 or flame temperatures in excess of 1090 degrees Kelvin, the 'ember buffer' of 150 metres as used in the planning system, local conditions, or the BAL rating to which a house is built. Before applying these exemptions, advice should be sought from an experienced fire planner.

7. Frequently asked questions

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?

Based on fire history records, fire is less likely to start in riparian areas. CFA data 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) for the period 1 January 2006 to 30 June 2011, 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.

7.2 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)?

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 cured grassy riparian areas 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.

7.3 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.

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

As shown in section 3.1.3, 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 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 fire 'wicks' and facilitate the spread of fire across agricultural landscapes?

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.

However in some circumstances, fire may spread along riparian areas which are not aligned with the wind direction, but where they carry more fuel compared with adjacent eaten-out pastures, or where wind speeds are low. In addition, valleys may channel wind flows and lead to increased wind and fire speeds.

At the February 2009 Vectis fire (west of Horsham) Strickland (2009) noted that in a few places fire spread laterally along creek lines and roadsides for a few hundred meters at most. This was thought to be likely to be due to the presence of fine grass fuels and lack of suppression activity.

However, 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 3.1.3, a fire burning through a crop or pasture is likely to spread rapidly and contribute significantly to fire spread at a landscape scale.

With 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 than a fire burning in grass or crops.

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

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 3.1.3, fire burning through a cured crop or pasture is likely to spread rapidly and contribute significantly to fire spread at a landscape scale.

With 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 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 3.1.3 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 3.3 and the scenario in section 5.1 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.

Fuel hazard exemptions given in AS3959 identify circumstances in which narrow, isolated or remote areas of vegetation may be considered a very low threat. Before applying these exemptions, advice should be sought from an experienced fire planner. Refer to section 6.5.4 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 the 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.

There is still great debate amongst researchers about the factors that drove the February 2009 fires, however 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.

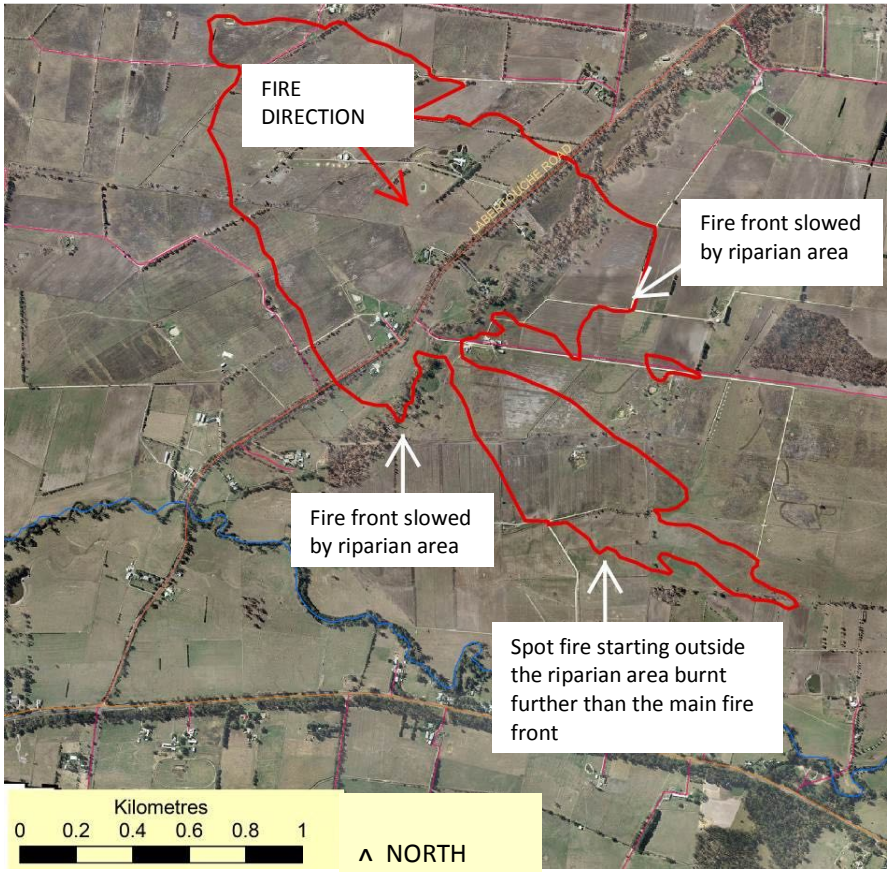

Figure 15 – Bunyip Ridge fire boundary, Labertouche Road February 2009

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 asset owner and the community 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 7 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 3.1.3, 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 2011) 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 existing houses or other assets be determined?

Current bushfire controls do not directly affect riparian revegetation proposals. However both planning and building controls can be used as a guide for planning the separation of riparian revegetation proposals from existing houses or other assets.

Options include:

- Avoiding locating revegetation within 150 metres of houses
- Avoiding locating 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 locating revegetation within 30 or 50 metres of assets using the '10/30 or 10/50 rules (exemptions)' (DPCD 2011 and clause 52.48 of planning schemes)
- Where a more site-specific solution is required, identifying vegetation setbacks using Method 2 of the Australian Standard AS3959-2009.

These options aim to limit the impacts of flame contact, radiant heat and ember attack on houses or other assets, 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 6.5.3.

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. Section 2.2.3.2 of AS3959-2009 lists circumstances in which narrow and/or isolated areas of vegetation may be considered a very low threat.

It states:

'The Bushfire Attack Level shall be classified BAL—LOW (threat is 'very low') where the vegetation is one or a combination of any of the following:

(a) Vegetation of any type that is more than 100 m from the site.

(b) Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified.

(c) Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other.

(d) Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified.

(e) Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops.

(f) Low threat vegetation, including grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks.'

However, these dimensions should be treated with caution as they do not take account of Forest Fire Danger Indices in excess of 100 or flame temperatures in excess of 1090 degrees Kelvin, the 'ember buffer' of 150 metres as used in the planning system, local conditions, or the BAL rating to which a house is built. Before applying these exemptions, advice should be sought from a fire planner.

7.17 How do bushfire planning controls affect riparian revegetation proposals?

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

For further information, refer to section 6.5.3.

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
DEPI Fire Management Officers	Advice on fuel hazard tables used by DEPI for statewide fuel hazard mapping
Catchment Management Authority staff	Design and implementation of riparian revegetation programs
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 (2012b) *Can I or Can't I* CFA (2000) *Grassland curing guide* CFA (2011c) *Fire Ecology. Guide to environmentally sustainable bushfire management in rural Victoria*

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Appendix 1: Definitions and abbreviations

Adapted from: CFA (2012a) 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: The 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 (AS3959-2009)

BOM: Bureau of Meteorology

BMO: Bushfire Management Overlay

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

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

DEPI: Department of Environment and Primary Industries

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

DSE: Department of Sustainability and Environment

Ecological Vegetation Classification (EVC): A native vegetation classification unit

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 (BOM 2011) which is based on FDIs for forest and grass

FMC: fuel moisture content

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

IFMP: Integrated Fire Management Planning

MFMP: Municipal Fire Management Plan

MFMPC: Municipal Fire Management Planning Committee

Victorian Fire Risk Register (VFRR): A systematic process that identifies assets at risk from bushfire, the risk, treatments and gaps

Appendix 2: Scenarios: photographs and calculations

This Appendix shows the photographs and calculations used to prepare the scenarios in section 5. Inputs and assumptions are listed in Appendix 3.

Photographs

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

Fire behaviour and risk calculations –flat ground, FFDI=120, GFDI=168
Threat/risk legend: 1 = Low (L), 2 = Medium (M), 3 = High (H), 4 = Very High (VH), 5 = Extreme (E)

Calculations

Fuel type	Photo	Surface fuel (t/ha)	Total fuel (t/ha)	FROS (km/h)	Intensity (MW/m) rounded	Threat category at 25 metres	Risk to assets (Vulnerability LOW)	Risk category	Risk to assets (Vulnerability HIGH)	Risk category	Threat category at 50 metres	Risk to assets (Vulnerability LOW)	Risk category	Risk to assets (Vulnerability HIGH)	Risk category	Threat category at 100 metres	Risk to assets (Vulnerability LOW)	Risk category	Risk to assets (Vulnerability HIGH)	Risk category
Crop	G	8	8	22	95	1	M	2	H	3	1	M	2	H	3	1	M	2	H	3
Grass - Natural	B C H	6	6	22	70	1	M	2	H	3	1	M	2	H	3	1	M	2	H	3
Grass - Grazed	E I	4	4	22	50	1	M	2	H	3	1	M	2	H	3	1	M	2	H	3
Grass - Eaten out	J	2	2	22	25	1	M	2	H	3	1	M	2	H	3	1	M	2	H	3
Gorse	A	25	25	4	55	3	H	3	E	5	1	M	2	H	3	1	M	2	H	3
Gum woodland - grass	D	15	25	4	50	4	VH	4	E	5	2	M	2	VH	4	1	M	2	H	3
Riparian forest - shrub	F K	25	35	5	95	5	VH	4	E	5	3	H	3	E	5	1	M	2	H	3

Appendix 3: Scenarios: inputs and assumptions

The following sources of information and assumptions have been used to develop the scenarios shown in section 5:

Risk

Risk calculations (Table 5) were derived from the Victorian Fire Risk Register – Reference Guide (CFA 2012a) and AS3959-2009 for threat.

Threat

Threat (radiant heat) calculations are based on AS3959-2009, which is the standard used in Victoria's planning system for calculating bushfire threat, but with a Forest Fire Danger Index (FFDI) of 120 flame temperature of 1200 degrees Kelvin.

Threat calculations (radiant heat for fuel types other than grass) were made using Flamesol (2013) calculator for AS3959-2009 Method 2.

Threat calculations (radiant heat) for grass were interpreted from Table 2 of clause 52.47 of planning schemes.

Grassland fire behaviour

Fire behaviour (peak rate of spread and intensity) for grass is based on Fire behaviour calculations for southern Australia (Tolhurst 2008).

Fuel

Fuel hazard photographs are taken from sites located near Flowerdale, Bengworden and Genoa, Victoria.

Fuel hazard has been derived from the Roadside Fire Management Guidelines (CFA 2001) for grass, statistics for wheat yield (DAFF 2011), and AS3959 for scrub, forest and woodlands. As stated in AS3959, fuel hazard can be varied upon advice of the fire authority. In this case, AS3959 was used to provide more conservative fuel hazard estimates, consistent with those used in the planning system.

Fuel hazard exemptions given in section 2.2.3.2 of AS3959 for remote, narrow or isolated areas of vegetation were assumed not to apply.

All revegetation is carried out using native vegetation.