REPORT

on a

STUDY OF THE EFFICACY OF FUEL BREAKS

A key Element of Wildfire Management in Central Victoria

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CONTENTS

1 INTRODUCTION

A long-standing method of preventing the spread of wildfire has been the preparation of fuel breaks by reducing or totally eliminating vegetation in certain areas.

The location of fuel breaks has traditionally been on the basis of collective local fire service opinion and actual fire incidence.

Many fuel breaks are scheduled and maintained on historic assumptions and have not taken account of wildfire research and changes in municipal, environmental and land use planning, and current fire management policies and practices. Indeed, in some cases there is no rationale for existing fuel breaks, except that they have always been listed on Municipal Fire Prevention Plans (MFPP). This is of concern.

There is also concern that maximum benefit is not being derived from municipal resources currently allocated to fire prevention, particularly construction and maintenance of fuel breaks.

Country Fire Authority Community Safety and Municipal personnel are concerned that generally, fuel breaks tend to be *ad-hoc*, rather than part of a multi-faceted or co-ordinated approach to preventing loss from wildfire. Consequently, this Study aims to provide planning information that will enable a cost-effective approach to the use of fuel breaks as an important element of wildfire management.

Under guidance from North West Area (Region 2) Manager, Community Safety, and with support from Municipal Fire Prevention Officers or representatives from City of Greater Bendigo, Shire of Mount Alexander and Shire of Loddon, Central Victoria was chosen as the area to be studied. This part of Victoria varies from rural landscapes and small settlements to the urban centres of Bendigo and Castlemaine.

Municipal Fire Prevention Plans (MFPP) for the three municipalities identify a broad range of risks within the context of the wildfire environment. These risks include the urban/rural interface where towns meet rural land, forest, urban development, farms and tourism enterprises, all of which are valuable community assets. These MFPPs have traditionally placed significant reliance on the use of firebreaks (fuel breaks) as a fire management tool.

These risk environments, together with the terrain and vegetation characteristics of the Study area are similar to much of the rest of Victoria. Therefore, it is considered that the knowledge gained from this Study can be applied elsewhere.

2 SCOPE

In order to resolve concerns about the value of fuel breaks and conflict between the needs of fire management and conservation of the natural environment, funding was obtained to assess the efficacy of fuel breaks generally.

The Project was limited, to address the worst-case scenario that of forest fire impacting on “the country area” of Central Victoria.

Scoping the Study took account of the limitations of existing digitised vegetation mapping of the Study area and that the Project could not extend to detailed ground-truthing of the vegetation. Consequently, the intention of the Project is to deliver conclusions and recommendations at the macro level.

The Project is further limited by using the Mk 5 Version of McArthur's Forest Fire Danger Meter, which may underestimate fire intensity at the micro level in some parts of the Study area. The Mk 5 Version was chosen, as it is the version commonly used by the CFA to calculate fire intensity and rate of spread in the forest environment.

Nevertheless, in the absence of any similar work, these limitations do not detract from the validity of the conclusions and recommendations.

The Project also considered real wildfire behaviour by assessing two major fires at Avoca in 1985 and Heathcote in 1987 to assist in better understanding actual fire behaviour across Central Victoria. It also looks at research conducted by CSIRO National Bush Fire Research Unit in 1988 which assessed the relationship between the probability of fuel break failure and variables such as fuel break width and fire line intensity.

3 PROJECT OBJECTIVES

3.1 Determine the validity of fuel breaks as an element of fire management strategy

This involved a consideration of what is currently sought from fuel breaks as a fire management tool based on current knowledge of wildfire behaviour in forest and grassland and the requirements and expectations of fire managers.

3.2 Assess the effectiveness of fuel breaks

This involved analysis of both macro level research by CFA on the performance and structure of fuel breaks, and grassland-specific research by CSIRO to gain an understanding of the effect of slope, aspect and vegetation types under varying Fire Danger Indices on fire spread in forest and grassland risk environments.

This knowledge was then used to develop a macro level model for determining fire intensity and identifying the wildfire threat and risk to people and assets and an aid to determining initial priorities for fuel breaks in "the country area" of Central Victoria. The micro level research by CSIRO was used to assist in the development of the layout of a proposed fuel break.

3.3 Recommend roles for fuel breaks as an element of fire management strategy in Central Victoria

Based on the conclusions of the Study, this involved the development of decision-making support to Municipal Fire Prevention Committees to better enable them to meet their statutory responsibilities in planning fire prevention.

Acknowledging the macro level conclusions and the limitations of the knowledge gained being applied at the micro level, the Study also identified a need for further and more detailed work in this area.

4 METHODOLOGY

The prime output of the Study was development of a model that incorporates the factors contributing to wildfire intensity and the consequent threat posed to life and property across Central Victoria. Fire behaviour from major fires within Central Victoria was assessed and research into the performance of liner fuel breaks by CSIRO was considered.

4.1 Fire intensity modelling

The first step was to use Geographic Information System (GIS) technology to analyse relevant data across more than one million hectares of Central Victoria. The analysis delivered data on wildfire intensity across the Study area under varying fire weather and fuel conditions. Fire intensity is measured as the amount of heat generated for a one (1) metre length of fire perimeter as kilowatts per metre (kW/m).

GIS-based maps showing the application of the wildfire intensity model were then produced. It is important to note that these maps must be viewed in the context of the limitations mentioned earlier in Scope. However, these maps, when considered along with other maps such as those showing *designated bushfire-prone areas*, Wildfire Management Overlays and road network modelling that measures emergency response times, are very useful in determining an order of priority for undertaking a detailed site-specific assessment of fuel break requirements.

The data considered the following factors.

4.1.1 Fire intensity mathematical equations

The calculation of fire intensities based on mathematical equations developed by Noble (1980) and Cheney and Sullivan (1997) was considered. These equations took into account fuel weight, rate of forward spread, fire danger index (derived from temperature, wind speed and dryness) and slope of the ground.

4.1.2 Vegetation types

Several vegetation types and structure models were evaluated. The readily (indeed only) available and consistent vegetation data across the Study area are tree density maps and aerial photographs stratifying tree cover into dense, medium and scattered layers.

Areas devoid of trees, other than built-up areas, lakes, and roads, were assigned as grassland. Built-up areas were assigned a value that would allow these areas to be shown on these maps.

4.1.3 Wildfire fuel (vegetation) loads

Fuel loads generally considered appropriate across the Study area were assigned to each of the vegetation categories.

Vegetation Density/Type	Medium fuel load (t/ha)	High fuel load (t/ha)
Urban	2	2
Grassland	3	5
Scattered Tree Cover	4	6
Medium Tree Cover	6	10
Dense Tree Cover	8	12

Fig 1 Standard fuel loads based on vegetation type and density

While these fuel loads are satisfactory for Box/Ironbark forest types, it should be noted that stringybark-type forest fuel loads generally begin at 10 t/ha and may reach as high as 20 t/ha. Consequently, the model reaches conclusions on fire intensity, which due to an inability to distinguish between the various types of tree canopy cover in aerial photography, may be misleading, particularly for a predominance of stringybark-type fuels. While this may result in under-prediction of fire intensity, and is considered as having questionable accuracy for stringybark forests, this under-prediction does not detract from the value of the maps as mentioned in subsection 4.1.

4.1.4 Ground slope and aspect

Digitised elevation data in the CFA's GIS data base (refer to Appendix B – Shamir Report s. 2.2.3 Topography Data) — similar to elevation data presented on contour maps — were used to prepare slope and aspect map layers for the Study area modelling.

This slope and aspect data are key elements in the preparation of fire intensity maps. For example, fire intensities on southeast slopes, resulting from a fire coming from the northwest are given a weighting to take account of the lower rates of spread.

4.2 Wildfire potential in Central Victoria

4.2.1 Causes of fire

To gain an understanding of the wildfire threat to Central Victoria, CFA Region 2 and DSE records were analysed, with the main causes of wildfire shown in Figure 2

Cause of Fire (DSE records)	**Percentage of Fires (%)**	**Cause of Fire (CFA records*)**	**Percentage of Fires (%)**
Deliberate lighting	32.9%	Discarded matches	11%
Carelessness with pipes. Cigarettes and matches	12.8%	Escape from private burning off	9.3 %
Escapes from campfire/barbecues	12.2%	Discarded cigarette	5.8%
Lightning	7.9%	Lighter, flame type	5.6 %
Escapes from burning operations	4.6%	Spark, ember, flame escaping from liquid fuelled equipment	4.4 %

Fig 2 Main causes of wildfire in Central Victoria

* CFA records show that the cause was not determined for 32% of 2099 rural fires that occurred during the period 1997–2004

4.2.2 Weather

Weather is a significant contributor to wildfire behaviour; the key factors being temperature, relative humidity and wind velocity.

In order to understand the role of weather in the wildfire threat to Central Victoria, Bureau of Meteorology data were collected from eleven recording stations across the Central Victoria, including Bendigo Airport. After analysis of these records, which revealed only minor variations between recording locations (refer to Appendix B – Shamir Report s. 2.2.1 Weather Data), it was decided that the Bendigo Airport data collected over 44 years would be used, as it is considered to be representative of weather experienced across Central Victoria.

The Bendigo Airport data were modelled to identify the frequency of conditions most conducive to the outbreak and spread of wildfire. The modelling identified a range of Forest Fire Danger Indices aligned to Central Victoria (Region 2) CFA daily operational preparedness levels.

These indices and the alignment of Region 2 operational preparedness directly relate to the likelihood of fire starting, its rate of spread and difficulty of suppression according to various combinations of temperature, relative humidity and wind speed, are shown in Figure 3.

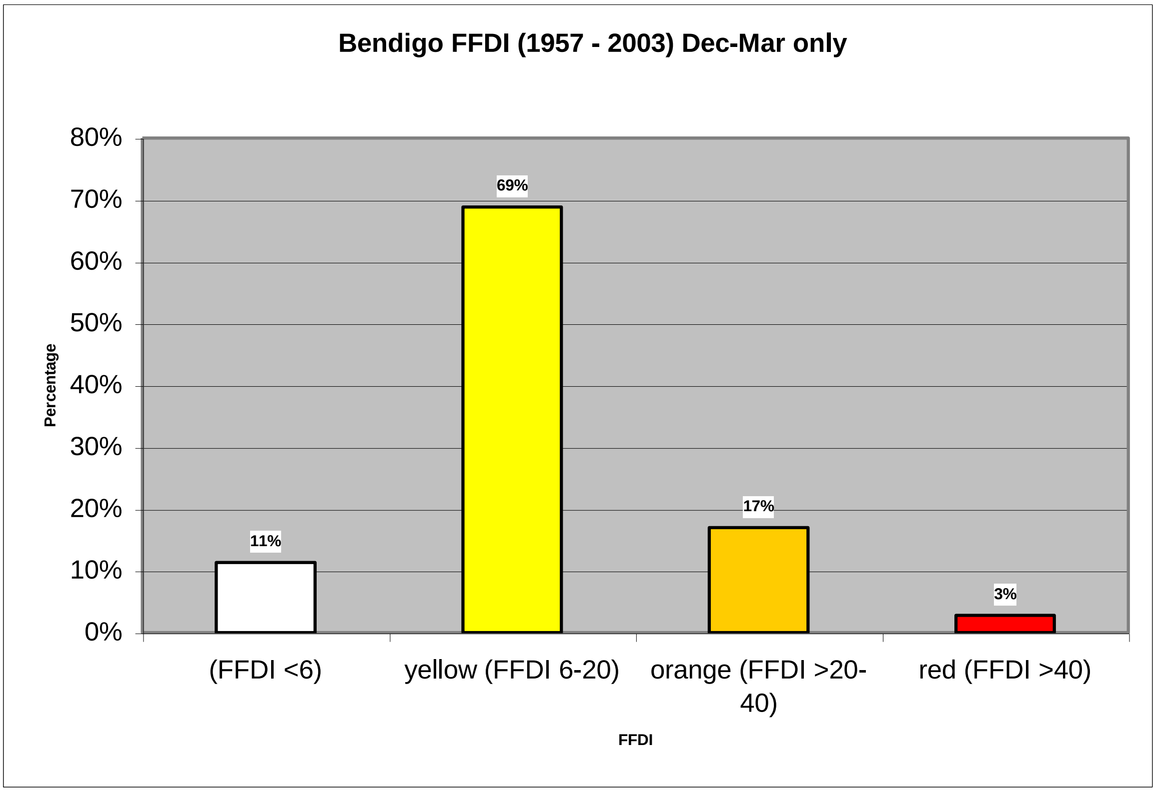


Fig 3 Frequency and distribution of FFDIs in Central Victoria for the December–March period

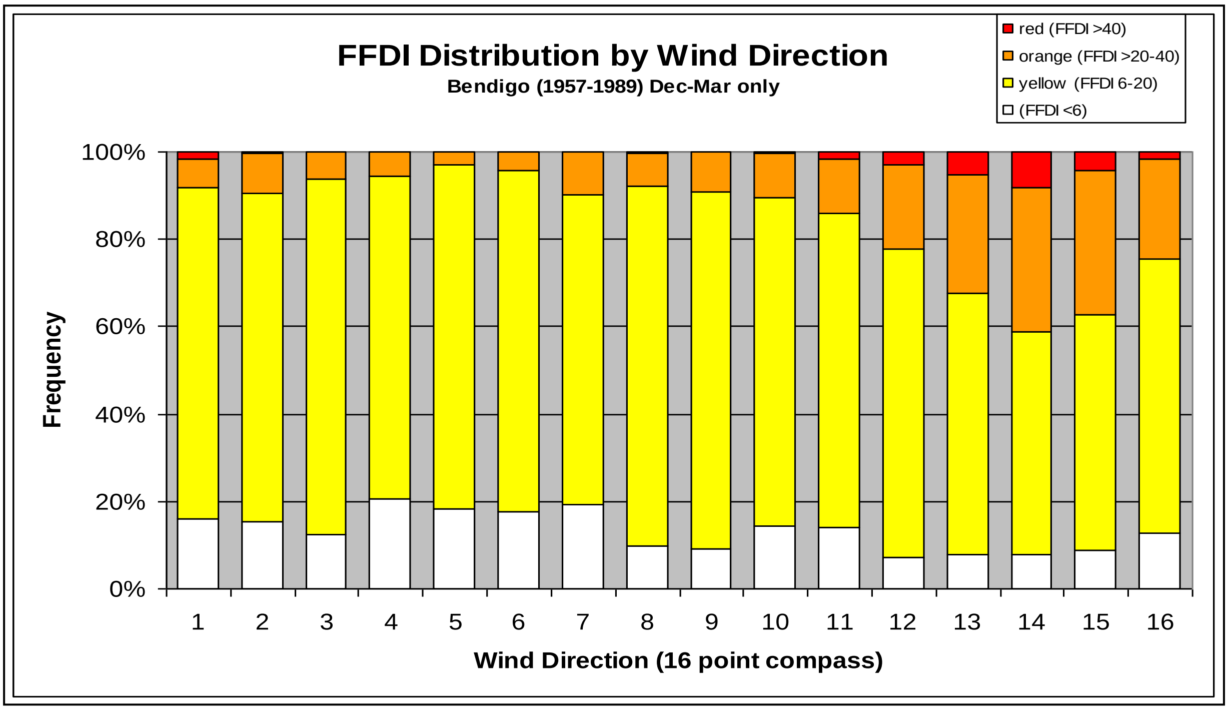
Figure 3 shows the frequency distribution of FFDIs for the December to March period and the bands correspond to the Region 2 classification system for FFDI values. On average, 20% of days during December and March will reach very high to extreme fire danger ratings. Fuel break performance becomes less effective as fire line intensity increase, which is most likely to occur on these days.

Wind direction and strength is the most dominant of the weather factors affecting fire behaviour. In Cental Victoria during the summer months, apart from wind velocity influencing the rate at which a fire spreads, north and north westerly winds usually bring hot, dry air from Central Australia, whereas southerly winds bring relatively cooler, moister air.

The moisture level of the surrounding air influences the moisture content of fine fuels such as cured grass and fallen eucalyptus leaves relatively quickly.

Figure 4 shows the relationship between wind direction and FFDI in Central Victoria. As can be seen, the wildfire threat is greatest when the wind is from the north or north-west during the summer wildfire season.

Knowledge of wind direction, as it contributes to the wildfire threat, is a very useful consideration in strategic planning, particularly in determining the location of fuel breaks to protect towns and other community assets.



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N

Fig 4 FFDI distribution by wind direction. This graph shows that the wildfire threat is greatest when the wind is from the north-west during the summer wildfire season.

4.3 Wildfire scenario modelling

To test the results of the Wildfire Intensity Modelling Methodology (Appendix B) developed as part of this Project and using FFDI values nominated in the modelling report, six wildfire intensity scenario models were constructed, (refer to Appendix B – Shamir Report s. 3.1 Fire Intensity Scenarios). For the purpose of this paper, two sample scenarios are included:

- FFDI 47
- FFDI 95

4.3.1 Scenario One

A wildfire scenario was generated with an FFDI of 47 and heavy fuel loads assigned to each vegetation type, the vegetation types being established from tree density maps and aerial photographs (refer to Appendix B – Shamir Report s. 3.3 Fire Intensity Scenario). Experience shows that FFDI 47 is reached on approximately 10 days each summer in Central Victoria.

Fire Intensity kW/m	Study Area Coverage
0 – 500	75 %
500 – 1,000	2 %
1,000 – 2,500	22 %
2,500 – 10,000	1 %
10,000 – 174,537	0%

Fig 5 Fire intensity and Study area coverage

Figure 5 shows fire intensity occurrence in percentage form modelled across Central Victoria. However, experience reveals that the occurrence of fire intensity of 2,500 kW/m and higher is actually greater than one per cent.

Deductions

- Fires that commence on very high fire danger days have the potential to cover large areas very quickly, and these fires will easily cross roads traditionally used as the basis for fuel breaks in Central Victoria.
- CSIRO research indicates that direct attack by dozers or air tankers will fail when the FFDI is very high to extreme in areas where the fuel loads are 7.5 t/ha or greater. This is equivalent to dense tree-covered areas (such as forest, or areas of interconnecting tree cover),
- CFA experience indicates that fire intensity of this order (greater than 2500 kW) is likely in areas located around Bendigo, Maldon, Wedderburn, Inglewood, Castlemaine and Heathcote. These areas can also be used as a guide to identifying other similar areas in Central Victoria.
- Under these conditions, it is probable that there would be extensive loss or damage to towns and urban/rural interface areas, if no prevention and preparedness planning and works have been done.

4.3.2 Scenario Two

To address an extreme fire danger day (upper end of fire danger scale nominally ends at 100), this scenario utilises an FFDI of 95 with high fuel loads assigned to each vegetation type, which is likely to occur once every 10 years, (refer to Appendix B – Shamir Report s. 3.4 Fire Intensity Scenario).

It is important to understand that based on the nominated range of fuel loads, nearly 73 per cent of the Study area will have fire intensities in the range of 1,000 kW/m to 2,500 kW/m. This area generally equates to the grassland areas without medium or dense tree cover.

Fire Intensity kW/m	Study Area Coverage
0 – 1,000	3%
1,000 – 2,500	73%
2,500 – 7,000	13%
7,000 – 10,000	10%
10,000 – 175,000	2%

Fig 6 Fire intensity and Study area coverage

The Avoca fire of 14 January 1985 covered later in this paper provides an example of fire behaviour at an FFDI of above 100. The weather conditions on the 14th January 1985 were: 41°, relative humidity 10.5% and strong northerly wind gusting up to 68 kilometres per hour. Under these conditions and considering fuel type (mixture of open grassland and box/ironbark forest) the forward rate of spread peaked at approximately 12 kilometres per hour and generated a fire intensity above 12,000 kW/m.

The actual fire conditions experienced confirm the model range. It is suggested, therefore, that in the absence of any other work available to assist in assessing the efficiency of fuel breaks, the model is helpful at the macro level and identifies a need for further research in this area.

Deductions

- Fires that commence on such days have the potential to cover large areas quickly, and they will easily cross roads, with or without slashed roadsides.
- It is most unlikely that suppression resources will be able to safely mount an effective direct attack on heat intensities of 10,000 kW/m or greater.
- CSIRO research indicates that direct attack by bulldozers or air tankers will fail where the fuel loads are 10 t/ha or greater and equivalent to dense tree-covered areas (such as forest, or areas of interconnecting tree cover), when the Fire Danger Index (FDI) is very high. Direct attack is more likely to succeed where the fuel loads do not exceed 7.5 t/ha.
- Under these conditions, it is likely that there will be losses at town boundaries and in urban/rural interface areas.
- Fires burning under extreme fire weather conditions in Central Victoria have the potential to travel at speeds up to 12 km/h and produces fire intensities which would make direct attack dangerous and unlikely to succeed.

4.4 Wildfire intensity maps

Wildfire intensity maps were prepared to illustrate the effect of combining fuel types and quantities, slope, aspect and predominant wind direction for high and extreme FFDIs, as a simple means of differentiating between the different levels of wildfire threat across the Region—note that FFDI 20 is the average (or normal) for Central Victoria wildfire season.

The maps, with "judgements" of the location of town boundaries or the "interface" of urban development rural lands, will assist the identification of high-risk areas around selected towns.

4.5 Wildfire behaviour assessment across Central Victoria

To assist in gaining a good understanding of real wildfire behaviour in Central Victoria, two major fires were considered: Avoca in 1985 and Heathcote in 1987. Though the following observations are useful in improving our knowledge of fire behaviour and the performance of fuel breaks, it must be noted that the information presented is based on ground observations. This may affect the accuracy of the estimate of forward rate of spread.

4.5.1 Avoca Fire 1985

- Area burnt 50,800 ha
- FFDI during the first afternoon peaked above 100 — similar to FFDIs recorded on Ash Wednesday 1983)
- 68 km/hr NW wind (max), 41°C 10.5 per cent Relative Humidity
- There was spotting activity up to two kilometres ahead of the main fire front

Extracts from Report	**Calculated Fire Intensity (2003)** **I = 500 x ROS x fuel load (uncorrected for slope *et al)***
FROS in grassland peaked at 12 km/h	If assume 4 t/ha, Intensity = 24,000 kW/m If assume 2 t/ha, Intensity = 12,000 kW/m
FROS in grassland and box-ironbark forest 6-7 km/h	If assume 4 t/ha, Intensity = 14,000 kW/m If assume 8 t /ha, Intensity = 28,000 kW/m
FROS in predominantly box-ironbark forest less than 5 km/h where fuel quantities were less than 15 t/ha	If assume 8 t/ha, Intensity = 20,000 kW/m If assume 15 t/ha, Intensity = 37,500 kW/m

Fig 7 FROS and fire intensities for the Avoca fire

4.5.2 HEATHCOTE FIRE 1987

- Area burnt 4,140 ha.
- At 1510 hrs, the FFDI was 95, with 60 km/hr winds from the W to NW and gusting above 70 km/hr.
- Note that the grasslands were not fully cured.

Extracts from Report	**Calculated Fire Intensity (2003)** **I = 500 x ROS x fuel load (uncorrected for slope *et al)***
FROS in grassland peaked at 11km/h in grassland, (3-5 t /ha) and in Lucerne paddocks down to 7 km/hr	If assume 4 t/ha 11 km/hr, Intensity = 22,000 kW/m If assume 4 t/ha 7 km/hr, Intensity = 14,000 kW/m
FROS in box-ironbark forest less than 0.4 km/h where fuel quantities were "quite low" 5 – 10 t/ha but at an earlier stage max FROS was 3.7 km/h in a fully cured grassland and box-ironbark forest	If assume 7.5 t/ha 0.4 km/hr, Intensity = 1,500 kW/m If assume 7.5 t/ha 3.7 km/hr, Intensity = 13,875 kW/m

Fig 8 FROS and fire intensities for the Heathcote fire

Deductions

Following are key issues identified from investigations into these two fires that are relevant to this Project:

- FFDI's peaked at 95, with winds exceeding 60 km/hr and gusting above 70 km/hr
- There was significant spotting activity ahead of the main fire front
- Calculated intensities for the lower end of assumed fuel loads ranged from 12,000 kW/m in grassland to 20,000 kW/m in forest
- Forward rate of spread: Heathcote fire peaked at approximately 11 kilometres per hour in grassland and Avoca fire peaked at approximately 12 kilometres per hour in grassland – forward rate of spread in grassland was about double that in Box/Ironbark forest
- Both fires apparently crossed roads and paddocks with low fuel loads unhindered

5. CSIRO RESEARCH INTO EFFECTIVENESS OF FUEL BREAKS

Research by scientists from the CSIRO National Bush Fire Research Unit in 1988 conducted an investigation into fire behaviour in relation to the effectiveness of fire breaks in grassland at Annaburroo Station, 120 km south-east of Darwin.

The aim of the research was to develop a relation between the probability of fuel break failure and variables such as fuel break width and fire line intensity, (that is the quantity of heat released per metre of fire front).

The aim was achieved by lighting experimental fires over large uninhabited areas during periods of very high fire danger.

Fuel types involved mostly kerosene grass, kangaroo grass and sorghum, which are similar to many found in the open grasslands of southern Australia. These grasses were almost fully cured, and low eucalyptus and paperbarks and occurred sparsely on the test site, (average 10 trees per hectare).

Systematic measurements of fuel characteristics found most fuel fell between 2 and 5 tonnes per hectare and grass height was usually between 0.15 and 0.55 m.

During the experiment, wind speed varied from 3 to 30 km per hour, relative humidity from 13 to 55% and air temperature from 19 to 36 degrees Celsius.

The test site was divided into 170 blocks, (200 x 200m or 100 x 100m in size). Fuel breaks were constructed 5, 10, or 15m wide by grading or burning strips of grass so that no flammable material remained.

To test the effectiveness of fuel breaks, 113 fires, either at a single point or in a line 60 to 200m in length were lit. The head fires burned 20 to 200m before reaching a fuel break. Their speed ranged from 0.4 to 8.0 km per hour. No trees stood within 20m of the fuel break for 58% of fires lit, for the remainder, the number of trees present was generally less than four, and almost always less than eight.

Proximity of trees proved a vital factor in determining whether a fuel break failed.

Research results were:

1. When trees were absent, none of the 4.5 to 15m wide fuel breaks were breached while 83% of those 1 to 3.5m wide were. Fuel breaks of 1 to 3.5m mainly failed because of direct flame contact, the fire actually 'reaching' across the barrier. All except the least-intense fires easily breached such breaks.
2. When trees were present within 20m of a fuel break, only 45% of the 4.5 to 15m wide fuel breaks managed to stop fires. These fires invariably jumped the fuel breaks directly apposite trees and firebrands (such as burning bark or leaves that are capable of starting spot fires) were the main cause.
3. Fuel breaks performance became less effective as fire line intensity increased. Of the 20 fires approaching breaks 1.0 to 3.5m wide with intensities less than 7,000 kW/m, 6 (30%) stopped; while of the 15 approaching breaks with an intensity of 7,000 kW/m or greater, none stopped.

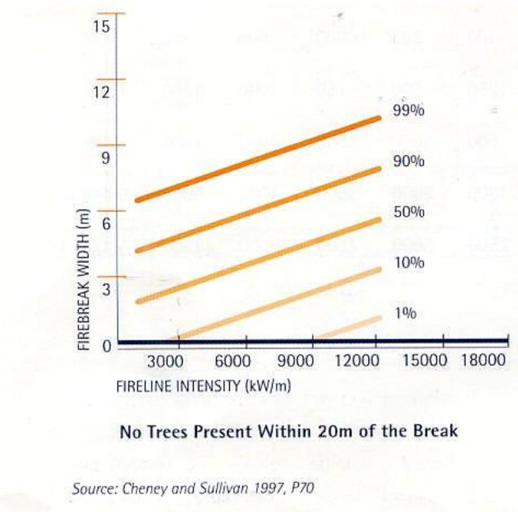
To put these results to practical use, CSIRO researcher Andrew Wilson developed a statistical model that assists in calculating the probability of fuel break breach under given conditions.

This model involved taking into account fire line intensity, the presence or absence of trees within 20m, and fuel break width. Generally the model predicts the fires breaks becomes less effective with increasing fire intensity, closer proximity of trees and / or decreasing fuel break width.

More specifically, the model as shown in Figures 9 and 10, predicts the following results:

1. A 3m wide fuel break has only a 50% probability of stopping a grass fire (no trees within 20m) that approaches head-on with an intensity of 5,000 kW/m
2. A 5m fuel break has a 90% probability of stopping the same fire.
3. A 9m wide fuel break has only a 50% probability of stopping a grass fire with trees within 20m of the break that approaches head-on with an intensity of 5,000 kW/m.
4. A 15m wide fuel break has a 90% probability of stopping the same fire.

Finally, it is important to remember that Wilson's work does not include consideration of the effect of slope, but this does not detract from the value of his work because, in the absence of any other similar research data, it provides useful information to help us better understand potential fire behaviour.



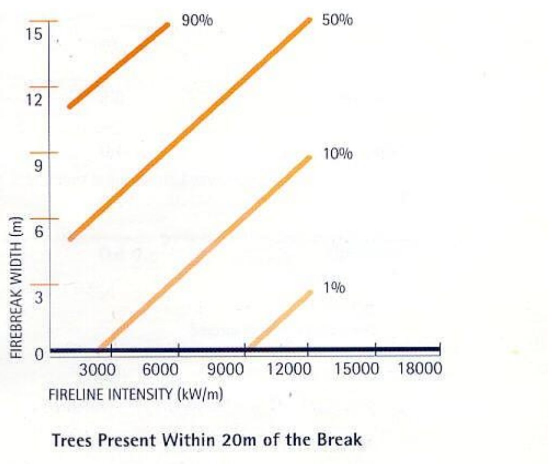


Fig 9 Probability of a head fire being controlled with no trees within 20m of the break

Fig 10 Probability of a head fire being controlled with trees present within 20m of the break

6 THE WILDFIRE THREAT TO CENTRAL VICTORIA

In seeking to address the wildfire threat to Central Victoria and who or what is actually at risk from a wildfire event, it is necessary to have an understanding of:

- The type and distribution of people (demographics) and their related level of vulnerability, from our current knowledge,
- How wildfire behaviour contributes to vulnerability; and
- The performance of fuel breaks in controlling the spread of wildfire.

6.1 People and assets at risk

The Central Victorian landscape varies from rural landscapes and small settlements to a major provincial city. Municipal Fire Prevention Plans (MFPP) for each municipality identify a broad range of risks within the context of the wildfire environments. They include the urban/rural interface, forests, towns, farms and tourism enterprises, all of which are considered valuable community assets.

Figure 11 provides useful local demographic information in terms of percentage of population for different age groups, visitor to the various townships, and dwelling numbers within the Study area. Data is provided from *Towns in Time – Data 2001* produced by the DSE based on Australian Bureau of Statistics 2001 census data.

Large Towns	**Population**	**Visitors on census night**	**Private dwellings**	**Age group % of population**
Bendigo	68,715	2,906	28,732	0–17, 25.8%. 18–49, 45.2% 50–75 + 29.1%
Castlemaine	8,287	259	3,858	0-17, 23.1% 18-49, 39.2% 50-75+ 37.3%
Elmore	665	14	332	0-17, 23.5% 18-49, 34% 50-75+ 42.6 %
Huntly	876	23	297	0-17, 34.6% 18-49, 44.6% 50-75+ 20.7%
Inglewood	685	21	338	0-17, 20.6% 18-49, 33% 50-75+, 46.4%
Maldon	1,231	130	672	0-17, 25.3% 18-49, 33% 50-75+, 41.6%
Wedderburn	656	22	395	0-17, 19.8% 18-49, 29.4% 50-75+, 50.9%
Small Towns	**Population**		**Private dwellings**	**Age group % of population**
Bridgewater	403		184	0-17, 21.7% 18-59 49.4% 60+ 28.9%
Goornong	261		115	0-17, 28.8% 18-59 52.9% 60+ 18.2%
Harcourt	422		173	0-17, 28.5% 18-59 56% 60+ 15.6%
Korong Vale	183		108	0-17, 26% 18-59 39.2% 60+ 34.8%
Marong	269		113	0-17, 28.8% 18-59 50.7% 60+ 20.5%

Fig 11 2001 census statistics for towns within the Study area

All of the towns listed in Figure 11 are either surrounded by grasslands and/or forests and could be at risk in the event of fire. Many evolved prior to the planning and building controls of today and only have minimal, if any, wildfire mitigation measures in place.

The risk is further increased due to an aging population, particularly in the rural area, which in many cases is vulnerable to both building fires and wildfire. Another vulnerable group is tourists, who may be unfamiliar with the specific local risks, both in terms of prevention and their survival needs.

6.2 Penetration of wildfires into urban/rural interface areas

Under the extreme forest fire danger scenario, with high winds and spotting, there could be fires with intensities greater than 10,000 kW/m along the western edge of urban areas, such as Bendigo. These fires are considered extremely difficult to stop by direct attack with tankers.

This intensity of fire, producing significant spotting activity, puts houses close to vegetation boundary at a higher risk of ignition compared to properties located further away. *AS 3959—1999 Construction of buildings in bushfire-prone areas* requires that houses within 100m of forest fuels require specific measures to mitigate ember attack.

Direct attack by fire brigades will not be possible well before a wildfire reaches its potential under extreme FFDIs, at which time resources may be better employed protecting important infrastructure assets and concentrations of people and buildings, such as in towns and settlements in the path of the fire.

Research by Ahern and Chladil (1999) revealed that there is a relationship between houses in towns and settlements burnt in bushfires and the distance they stand from a forest-type "vegetation boundary". This research shows that 70 per cent of houses lost will stand 50 metres or less from the forested vegetation boundary, 80 per cent lost are within 80 metres or less, 95 per cent lost are within 180 metres or less, leaving just five per cent of those lost are at a distance greater than 180 metres from a boundary of forest-type vegetation.

Ember spotting was the main cause of house fires, but they did not conclude how much influence the vegetation boundary actually had or define a "vegetation boundary". Grassland burns intensely in wildfires, but generally does not produce flying debris that could ignite a building. Shrubs, trees or adjoining burning buildings are more likely to be a source of ignition.

CSIRO research into how and why houses burnt down in the 2003 fires in Canberra found the primary attack mechanism was from embers. The risk from ember attack was influenced by a number of factors:

- The number of embers
- The quality of embers
- The amount of combustible wind-borne debris present during the ember attack,
- The duration of the ember attack
- The building design
- Type and condition of vegetation surrounding the building
- Ground fuel around the building
- Suppression activity before, during and after the ember attack.

The houses assessed were particularly vulnerable to this ember attack, as they had no specific requirements to mitigate the entry of embers into the structure. The stringent water restrictions and low rainfall left the vegetation immediately around most buildings in a very dry and vulnerable state.

This also led to the ground cover having very low moisture content and being of a greater thickness due to the lack of natural composting. Many of the vegetation types found were highly combustible.

There were very few residents and firefighting crews present during and after the impact of the fire front, these being the periods when ember attack was most prevalent. Community and agency suppression activities were effective in saving houses; if no suppression activity had occurred during the fire event, house loss would have approached 100 per cent. (CSIRO, Manufacturing & Infrastructure Technology, 2003)

There is sufficient evidence to show that on high to extreme fire weather days (above 40 FFDI) losses on the urban/rural boundary can be very high. Factors, which contribute to the levels of risk, include:

- Fire intensity at the urban/rural interface
- Dwelling and outbuilding distance and location from various "vegetation boundaries" and local fuel loads within land parcels
- Slope and aspect of the land in relation to the vegetation boundary
- Attendance by residence, and whether they have planned and prepared for fire and are physically capable of defending their property before, during and after the fire front passes
- Prevention and preparedness work done by neighbours, and the proximity of their dwelling and outbuildings to neighbouring dwellings and outbuildings,
- Distance of dwelling and outbuildings to significant fuel loads outside their parcel of land which will emit a dangerously high level of thermal radiation
- Surrounding vegetation in terms of fuel load and type, which will determine ignition potential, heat output and spotting potential,
- Ground fuel around buildings and fences.
- Quantity of water and pressure available for fighting purposes.

In order to ensure the appropriate mix of risk treatments is identified and applied, all factors impacting on communities must be analysed and assessed. Generally, post-fire analysis finds community understanding of wildfires ranges from complete ignorance to very well informed and prepared. A key factor for success of municipal fire management plans will be to empower communities to voluntarily adopt strategies to mitigate these risks.

6.3 Effectiveness of existing fuel breaks in Central Victoria

Fire research about linear fuel breaks indicates they may have limited value as the Fire Danger Index rises.

Under **low to moderate** fire danger with little or no wind, a six-metre-wide rural road may be effective in holding a head fire without brigade intervention. Increasing the width by slashing roadsides does not confer an increased level of effectiveness as the fuel load had not been fully removed. If trees are present within 20 metres of the fuel break, the effectiveness of the break to hold a head fire can be significantly reduced.

Under **high to extreme** forest fire conditions during the summer months, coupled with high winds and therefore spotting potential, rural roads would be easily breached without significant fire brigade intervention. Under high GFDI conditions fires will take less than one minute to reach the edge of a reserve that is 20 metres wide and therefore does not allow for brigade intervention.

In Central Victoria, the pavement width of most rural roads is approximately six metres. In most cases, the pavement provides the only completely fuel-free area of the road reserve.

6.4 Limitations of existing fuel breaks in Central Victoria

Currently, road maintenance slashing is considered in many areas as fire prevention slashing for the purpose of fuel breaks. It is arguable that this type of slashing, done under the name of fire prevention, may raise false expectations, as the breaks created will be of limited value during high fire danger periods. These limitations must be understood or the slashing activity be considered as road maintenance.

The existing road pavement is only effective as a fuel break during periods of low to medium FDI and is not enhanced in periods of higher FDI by additional slashing.

Currently, roadside slashing or burning is usually not deliberately linked to asset protection.

Fires starting on roadsides are not a major cause of rural grass or forest fires in the Study area.

Slashing of treed roadsides, which are often categorised as the areas of greatest conservation value, usually does not assist fire prevention, as these areas are easily compromised by leaf and bark litter. Such slashing may also be detrimental to ground cover plants.

Further education is required within the Study area to communicate under what fire conditions roads, with or without slashing or burning are effective in stopping a fire.

Deductions

Slashing roadsides to assist in controlling fires that start on roadsides has limited value for three reasons:

- Only a small percentage of fires start on roadsides
- Slashing has not been shown to prevent ignition on road sides
- Slashing does not reduce the rate of spread

7 TREATMENT OPTIONS

Traditionally in CFA, a key tool available to fire managers in seeking to stop the spread of wildfire is the strategic firebreak, other wise known as a fuel break.

Predominantly, these fuel breaks are located on road reserves (or roadsides) and mainly are prepared by slashing roadside grass and other low vegetation.

As has been stated earlier in this paper, most existing fuel breaks are of dubious value and their cost-effectiveness questionable. In some areas, the impact of fuel reduction works on the conservation value of roadside vegetation is also an issue of concern.

7.1 Definition of a strategic fuel break

To achieve cost effective outcomes, a definition of a fuel break is essential to assist in understanding what it can achieve, and under what conditions it is most likely to succeed.

Building on the findings in this paper, the following definition of a strategic fuel break is proposed:

> A strategic fuel break is an area of removed fuel that allows safe suppression activities of the head fire to protect identified assets.

The performance objectives relevant to Central Victoria to achieve this are set out in Figures 12 and 13.

7.2 Forest

Forest type	Box–Ironbark	Stringybark
Width of fuel break	300 metres	1000 metres
Trigger for treatment	Overall Fuel Hazard Rating is Moderate	Overall Fuel Hazard Rating is Moderate
Area of Strategic Fuel Break to be treated	90 per cent	90 per cent
Limitations to achieving objectives	Limited access between forest and asset Difficulty (legal and operational) when working in private forests	

Fig 12 Performance objectives for forest areas where asset protection is required. These are the parameters set by DSE in their recently approved fire protection plan for the Bendigo Fire District

7.3 Grassland

Grassland characteristics	No trees within 20m of fuel break	Trees within 20 m of fuel break
Fire Line Intensity	5,000 kW/m	5,000 kW/m
Probability of successful control	90 per cent	90 per cent
Dimensions	5 metres	5 metres plus 10 metres

Fig 13 Performance objectives for grassland areas where asset protection is required.

During high fire danger days — and research conducted by CSIRO National Bush Fire Research Unit in 1988 supports the fact — a fuel break constructed to the specifications shown in Figure 14 will have a high likelihood of performing as a strategic fuel break in grassland, where fuel loads range between one and five tonnes per hectare. During very high and extreme fire weather days, brigade intervention will be required to ensure the fuel break is not breached.

This form of treatment could be used along roadsides, where conservation values are high or in strategic locations to protect valuable assets.

A five metre fuel break is constructed pre-season. In the event of fire approaching where low to medium tree cover is present within 20m, the fuel break is increased by at least 10 metres from the original five metres to achieve a minimum fuel break of 15 metres.

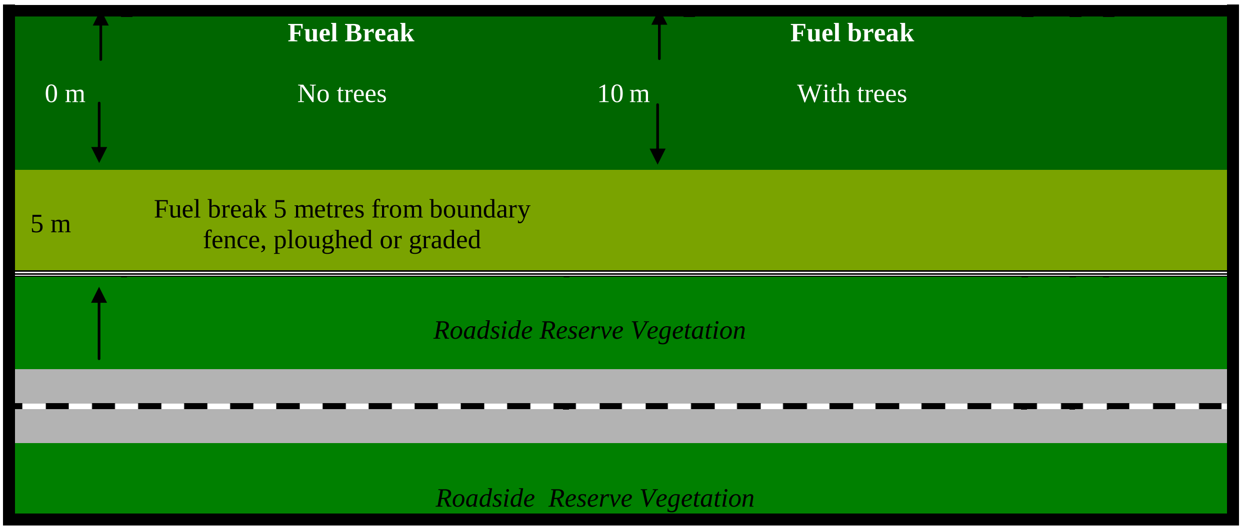


Fig 14 Diagrammatic layout of strategic fuel break is based on a fuel load of 1–5 tonnes/hectare producing an intensity of 5,000 kW/m.

The dimensions in Figure 14 could be used as the basis of an integrated fire prevention and suppression strategy where roadside conservation values are high. The same principle could also apply to protect an asset that is not located near or abutting a roadside.

It is contended that strategic fuel breaks in rural areas, without the co-operation of landowners, will be impossible to plan for, locate and maintain effectively. This means that is some areas, particularly where roadside conservation values are high and conflict with fuel reduction works, fuel breaks may better be established on adjoining private land.

Strategic fuel breaks around urban/rural interfaces also need a high level of planning and maintenance. However, it should be clearly understood that during very high and extreme fire weather days, strategic fuel breaks alone will have significantly reduced value in protecting properties, without intervention. Any fire with an intensity up to and greater than 10,000 kW/m will be extremely difficult to stop by direct attack using firefighting tankers without the benefit of a properly constructed fuel break.

Municipal Fire Prevention Committees (MFPC) must consider and decide on what is an acceptable level of risk to their communities and recommend the type and location of strategic fuel breaks for the protection of key community assets.

As part of the municipal fire prevention planning process, MFPC's will need to assess the risk-based likelihood of a fire occurring and the consequences to the community, both in terms of potential loss of life and community impact if key assets are damaged or destroyed.

During very high to extreme fire weather days, strategic fuel breaks will usually form an integral part of a municipal fire protection plan incorporating a range of suitable treatments, which when combined, will achieve a higher likelihood of success in terms of asset protection.

Fuel break performance will be measured by the part they play in helping to minimise loss of life and key assets. In this regard, fire danger ratings will determine if brigade intervention is required and the weight of attack needed to supplement a fuel break.

7.4 Resolving conflict between environmental conservation and fire prevention

As stated earlier, roadsides have traditionally been used extensively for fuel breaks. Community attitudes on conservation of the environment and consequent changes in land management practices, and a shift to a risk- based approach to emergency management require a consultative planning process which allows environmental and other values to be considered when identifying the location of strategic fuel breaks.

This consideration is required under both the Country Fire Authority Act 1958 and Flora and Fauna Guarantee Act 1988, which state:

Section 43(1) *Country Fire Authority Act 1958*:

It shall be the duty of every municipal council and every public authority to take all practicable steps to prevent the occurrence of fires on and to minimise the danger of the spread of fires on or from

- any land vested in it or under its control or management, and
- any highway, road, street, lane or thoroughfare, the maintenance of which is charged upon it.

Section 55A *Country Fire Authority Act 1958*:

Each municipal council must prepare and maintain a municipal fire prevention plan in accordance with the advice and recommendation of the MFPC. The plan must identify areas that are at particular risk, specify how these are to be treated and who is responsible for managing these risks.

Section 55 *Country Fire Authority Act 1958*:

The MFPC is to plan the burning or clearing of fire breaks within the area for which it is appointed and advise the appropriate authorities as to the existence of and steps to be taken for the removal of fire hazards within the area.

The *Flora and Fauna Guarantee Act 1988* includes the following objectives:

- that Victoria's flora and fauna can survive, flourish and retain their potential for evolutionary development in the wild;
- to conserve Victoria's communities of flora and fauna; and
- to manage potentially threatening processes.

A participative planning process to consider both conservation values and fire management needs should be established to consider both in the context of ensuring the safety of communities from fire. This can be best achieved by applying a risk management approach to assist in determining priority objectives when fire management strategies conflict with conservation issues. CFA Road Side Fire Management Guidelines provide such approach.

8. CONCLUSIONS

8.1 Need to Focus Mitigation Efforts on Community Assets

Municipalities and government agencies have limited funds to invest in fire prevention and therefore must focus their mitigation efforts on community assets to ensure any such investment achieves a cost effective result. Based on the findings of this research, there is a strong argument that municipalities, under the guidance of their MFPCs, need to consider shifting their fire prevention investments to broader mitigation strategies in areas, which have high value community assets such as towns, crops, industry, infrastructure, and the environment.

Fuel breaks need to be considered as one item in a suite of fire protection treatments which include community education programs, land use planning, land management and regulatory enforcement. A totally strategic approach will facilitate development of future Municipal Fire Management Plans, which will cover prevention, preparedness, response and recovery.

8.2 Fuel break effectiveness decreases as FFDI increases

In the absence of any similar research work, this Project has shown that the effectiveness of any fuel break is reduced with an increase in FDI. Clearly, in both forest and grassland environments, a fuel break becomes ineffective during very high to extreme fire conditions, unless integrated with other fire protection strategies. This must include pre-planned integration with fire suppression activities.

8.3 Fuel Breaks are a Valuable Tool

This work also reveals that fuel breaks, if properly located and constructed, can be effective in assisting in the control of fire as part of a range of treatments option previously mentioned.

8.4 Cost Effective Use of Resources

Finally, to maximise the return on investment in fuel breaks, the likely success of such works must be a prime consideration. Another key consideration must be the extent or quantity of lives and assets at risk. For example, in a tight fiscal environment protection of towns and settlements, with their concentration of lives, people's homes and community infrastructure should be considered for fire protection expenditure before some backcountry rural roads that carry very few vehicles each day.

9. FURTHER RESEARCH OR INVESTIGATION BEYOND THE SCOPE OF THIS STUDY SHOULD CONSIDER:

- Detailed analysis of vegetation in the rural/urban interface areas across Central Victoria will likely reveal very localised high risk areas
- Assessment of the potential for localised firebrand or ember attack on the edge of towns or settlements, based on fuel type and its potential to generate short and long distance spotting and the implications for local strategic fuel breaks.

- Measurement of fuel distribution, both surface and elevated fuel loads to determine threat levels (*Overall Fuel Hazard Guide*) and their depths on the north, west and south-west sides of towns and settlements.
- Review of Municipal Strategic Statements and other relevant aspects of Planning Schemes, with consideration given to re-zoning of Rural Land to Rural Living along the western and northern edges of towns and settlements. New housing patterns and densities allow the fuel distribution to be "broken-up", thereby reducing the potential for house-to-house ignitions.
- Identification of relevant education and other programs for residents, based on vulnerability to wildfire.
- Assessment of existing houses bordering the northern and western edges of towns and settlements to determine vulnerability and consequent minimum fire safety requirements, using WMO "objectives and outcomes" and requirements of AS 3959—1999 as benchmarks.

10 RECOMMENDED MEASURES FOR NEXT FIRE DANGER PERIOD

- Assess the value of existing strategic fuel breaks within forests and grassland.
- Assess local and broad operational preparedness and response capabilities by communities and their fire brigades.

11 RECOMMENDATIONS

- That the information in this report form the basis of a fresh approach to identifying, establishing and maintaining strategic fuel breaks.
- That fuel breaks involving roadsides be based on CFA's Roadside Fire Management Guidelines.
- That Municipal Fire Prevention Committees, in association with other stakeholders, identify key community assets and townships that will benefit from the establishment of strategic fuel breaks.
- That Municipalities consider environmental issues for the purpose of identifying, developing and maintaining strategic fuel breaks.
- That municipalities review their current fire prevention funding arrangements to reflect a wildfire risk management approach to their spending on fire prevention.
- That Municipal Fire Prevention Plans be amended to achieve an integration of passive wildfire protection and complementary emergency response (suppression) strategies and tactics.
- That CFA operational planning incorporates strategic fuel breaks and other treatments identified in Municipal Fire Management Plans.

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APPENDIX A

FIRE INTENSITY MAPS

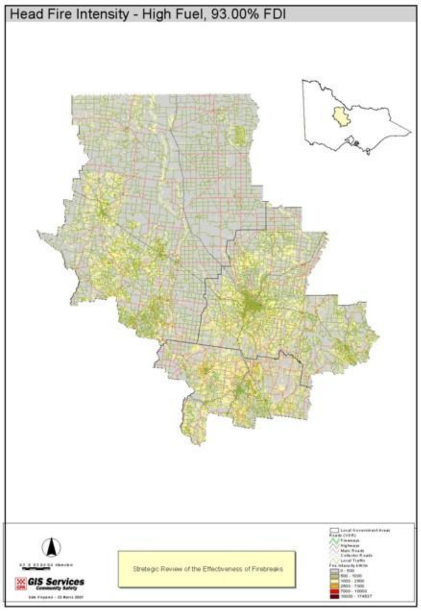

Figure 15.1 Study Area High Fuel FFDI 47

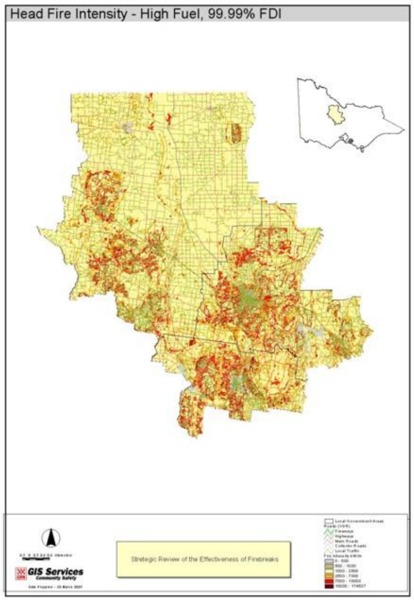

Figure 15.2 Study Area High Fuel FDI 95

APPENDIX B

LIMITATIONS OF FIRE INTENSITY (FIREBREAKS REVIEW) GIS METHODOLOGY – RON SHAMIR

1. Data Quality Project.

As with any model, the *accuracy* and *precision* of the fire intensity model relies heavily on the accuracy and precision of the model's input data. Of the 3 principal data sources used in the model, weather, topography and fuel data, I have a high degree of confidence with relation to the first two. With relation to the fuel data, it is important to note that the accuracy (e.g. location of forested areas) and precision (e.g. fuel loading associated with different forest types) of the TREEDEN25 (DSE tree density data) reflects directly on the model output. For example, if an area is described by TREEDEN25 as having "dense trees" then that area will have a comparatively high fuel load associated with it. Such an area may have been cleared since the acquisition of the satellite imagery used to derive the TREEDEN25 data. The opposite may occur in areas with regenerated vegetation that are described in TREEDEN25 as cleared.

2. Forest vs. Grass Forward Rate of Spread Models

The methodology utilised only the Forest (McArthur) Forward Rate of Spread (FROS) model as a component of modelling fire intensity. This was due to Forest intensity benchmarks used in the Project. However, where FROS (rather than just intensity) is required, or where both Forest and Grass benchmarks are available, it would be advisable to use both models to generate values for FROS in forest and grass areas, respectively.

3. Wind change

The methodology incorporates an innovative weighting of the effect of slope on intensity values based on aspect. For example, northwest facing areas are assumed to be exposed to the full effect of slope on fire behaviour because this is the predominant direction a fire is likely to approach from on a high FD day. In future, it may be useful to augment this slope effect by incorporating the effect of a typical Victorian wind change, making southwest aspects and eastern flanks more vulnerable after the change.

4. Built up areas

Where aerial photography was available, boundaries of built up areas were determined from subjective inspection of photography. No formal validation of this approach has been conducted.

5. Weather data

The weather data used for the model was deemed appropriate for the Project area. If the methodology was to be applied to a different area, relevant weather data for that area may require acquisition and pre-processing, similar to that undertaken for the Bendigo Airport weather data.

6. Fuel loads

The fuel loads used in the methodology and associated with various vegetation types are based on discussions with local experts. However, it should be noted that fuel load values used are reflective of *surface* fuel only, and are also considered conservative. Therefore, in spite of the use of terms such as “Extreme” conditions, it should be noted that the methodology has erred on the side of conservatism with respect to fuel loads in order to avoid the accusation of reflecting only very rare, worst-case conditions.

APPENDIX 'B'

WILDFIRE INTENSITY MODELLING METHODOLOGY

Developed For The Strategic Review Of The Effectiveness of Firebreaks