bnhcrc.com.au

bushfire&natural HAZARDSCRC

EFFECT OF PRESCRIBED BURNING ON WILDFIRE SEVERITY - A LANDSCAPE CASE STUDY FROM THE 2003 FIRES IN VICTORIA

Peer reviewed research proceedings from the Bushfire and Natural Hazards CRC & AFAC conference
Brisbane, 30 August – 1 September 2016

Kevin Tolhurst[1 3], Greg McCarthy[2]
1. The University of Melbourne
2. Department of Environment, Land, Water and Planning, VIC

Corresponding author: greg.mccarthy@delwp.vic.gov.au

Version	Release history	Date
1.0	Initial release of document	30/08/2016

Disclaimer:
The University of Melbourne, The Department of Environment, Land, Water and Planning and the Bushfire and Natural Hazards CRC advise that the information contained in this publication comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or unable to be used in any specific situation. No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice. To the extent permitted by law, the University of Melbourne, the Department of Environment, Land, Water and Planning and the Bushfire and Natural Hazards CRC (including its employees and consultants) exclude all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

Publisher:
Bushfire and Natural Hazards CRC

August 2016

Cover: Backburning during the 2003 fires in Victoria.

Photo: Department of Environment, Land, Water and Planning, Victoria

INTRODUCTION

This study examined the effect of previous fuel reduction burning (FRB) on the severity of the 1 million ha+ 2003 Alpine Fire in eastern Victoria, which was one of the most extensive and severe fires to have occurred in south-eastern Australia in the preceding century. Over one million hectares of largely forests, woodlands and alpine vegetation was burnt in January and February 2003 in the state of Victoria, and another contiguous 600,000 ha was burnt in New South Wales and the Australian Capital Territory, making these the most extensive fires in the area since 1939.

Some of the unusual features of this fire were that it burnt a large contiguous area stretching 180 km from east to west and 110 km from north to south in Victoria, and it burnt over a full two-month period. The size of the fire and the severity of the seasonal conditions (Bureau of Meteorology 2003) meant that about 49 per cent of the area burnt resulted in complete overstorey canopy removal, either through crown fire or scorching and resultant leaf loss. Very few areas remained unburnt within the perimeter of the fire. As the burnt area contained 100+ recent fuel reduction burns and wildfires (last 10 years, Fig. 1), this posed a rare opportunity to assess the effectiveness of prescribed burning on such a large scale and subjected to such high-intensity fires.

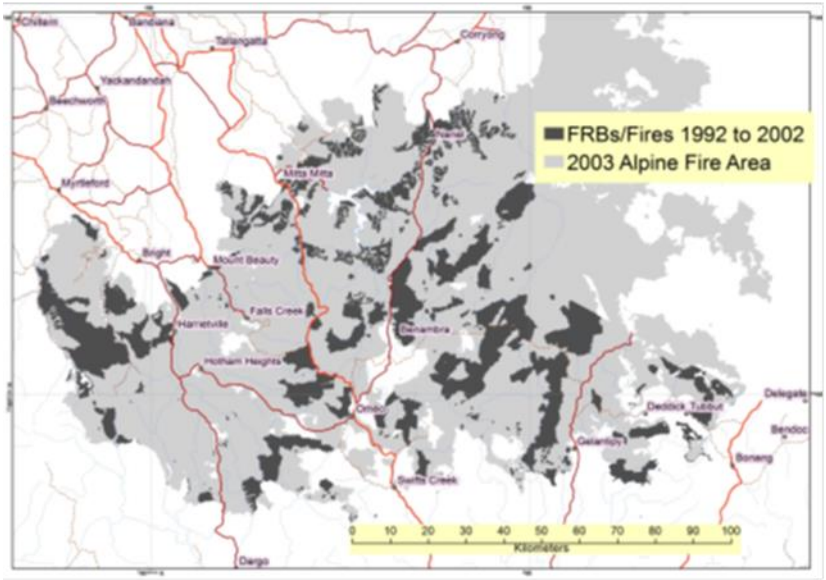

FIGURE 1. EXTENT AND LOCATION OF THE PRESCRIBED FIRES AND WILDFIRES THAT HAD OCCURRED IN THE 10 YEARS PRIOR TO 2003 AND WITHIN THE 2003 ALPINE FIRE AREA IN VICTORIA.

Various Australian researchers had looked at individual fire events where previous fuel reduction modified fire behaviour (Cheney 2010, Rawson et al. 1985, Billing 1981, Grant & Wouters 1993, McCaw 2010, Underwood *et al.* 1985). Cheney (1996) had earlier summarised generalised findings in relation to fuel reduction effectiveness in fire management around Australia, and various researchers had looked at the generalised effects of fuel reduction on both fuels and ecology (Bradstock et al. 1998, Gill and McCarthy 1998, Gill 2009, Adams and Attiwill 2011). Project Vesta (Gould et al. 2007) tested fire behaviour experimentally in dry eucalypt forests in Western Australia, and found some specific effects of fuel age on potentially reducing likely wildfire behaviour. In Victoria McCarthy and Tolhurst (2001) looked at the effect of previous fuel reduction burning on the suppression of 100+ fires statewide, and modelled the likely effects of fuel age, fuel hazard and fire weather on possible suppression assistance.

Internationally Fernandes and Bothelo (2003) reviewed fuel reduction burning effectiveness around the most fire prone parts of the world. This review concluded that the best effects of fuel reduction burning on decreasing wildfire severity were generally reported for the first two to four– years following planned burning, but that current results were not conclusive on longer-term effects. They also reported that there were few studies to comprehensively examine this issue, and that there was a definite need for well-designed scientific studies to better study fuel reduction effects at the landscape level.

The main objective of this study was to examine areas affected by previous fuel reduction within the million hectare burnt area, to see if they reduced fire behaviour and potentially reduced suppression difficulty, compared with similar areas with fuels mostly unchanged by recent burning. A further objective of this analysis was to identify the principal factors responsible for determining fire severity differences at a landscape level.

METHODS

Sixty-five paired observations (130 total) of fire severity were completed across the broad fire area using GIS analysis (ArcGIS 3.x, ESRI 2000). The impact of the fire in areas previously burnt (by either prescribed burning or wildfire) was undertaken by comparing the fire severity within a previously burnt area with a comparative area nearby (hence the paired observations). The comparative area was chosen to be similar in its size, vegetation, elevation and time of burning by the 2003 wildfire. Selection was based on paired areas where there was the best reliability of them being burnt at the same time, and under the same weather conditions (Fig. 2).

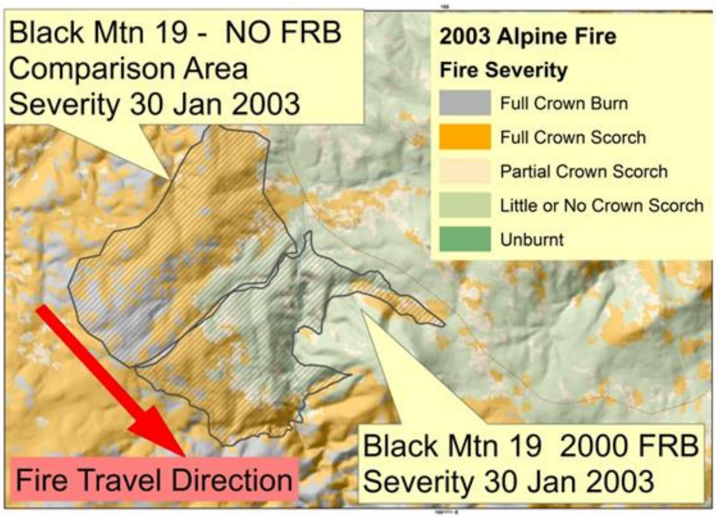

FIGURE 2. EXAMPLE OF PAIRED POLYGONS FOR FIRE SEVERITY ANALYSIS – POLYGON AFFECTED BY PREVIOUS FRB AND ADJACENT POLYGON UNAFFECTED BY PREVIOUS FRB

A Fire Severity Index (FSI) was calculated (for each area of each fire severity class) as a single indicator of fire severity. This FSI was calculated using the proportion of fire severity in each of the four severity classes (mentioned previously) within the sampled polygons. A weighting of 1.0 was applied to Full Crown Burn, 0.7 to Severe (Full) Crown Scorch, 0.3 to Moderate (Partial) Crown Scorch and 0.05 to Light Scorch/Unburnt areas to calculate the FSI.

$$FSI = 0.2256 + 0.00778 FDIwt + 0.047 \ln FIREage - 0.118 AspectNW$$

($n=142$, $p<0.001$, $r^2=0.4343$)

where: *FSI* = Fire Severity Index
FDIwt = weighted Forest Fire Danger Index
FIREage = time since last fire in area (yrs)
AspectNW = proportion of area with a northerly or westerly aspect

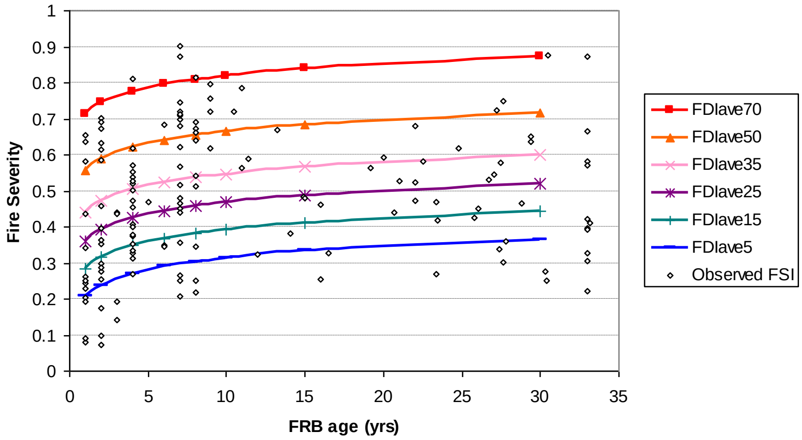

FIGURE 3. COMBINED EFFECT OF FIRE DANGER INDEX AND FIRE AGE ON FIRE SEVERITY.

The most important finding was that the reduction in fire severity and suppression assistance effects of previous fuel-reduction burning started to decline substantially when the FFDI exceeded 50. Above FFDI 50, landscape-scale fires became 'weather-dominated' and variations in fuel and topography became less important to continued fire spread.

The weather conditions under which fuels, the fire, topography, or the weather itself dominate fire behaviour can be shown relative to the McArthur's (1967, 1977) Forest Fire Danger Index (Fig. 4). This interplay of dominance could be expressed in terms of the amount of energy being contributed by each factor relative to the others. In the case of topography and unstable weather conditions, it represents the lack of resistance to fire growth which results in the need for less energy to be provided by the fire, fuel or weather to enable the fire to grow rapidly.

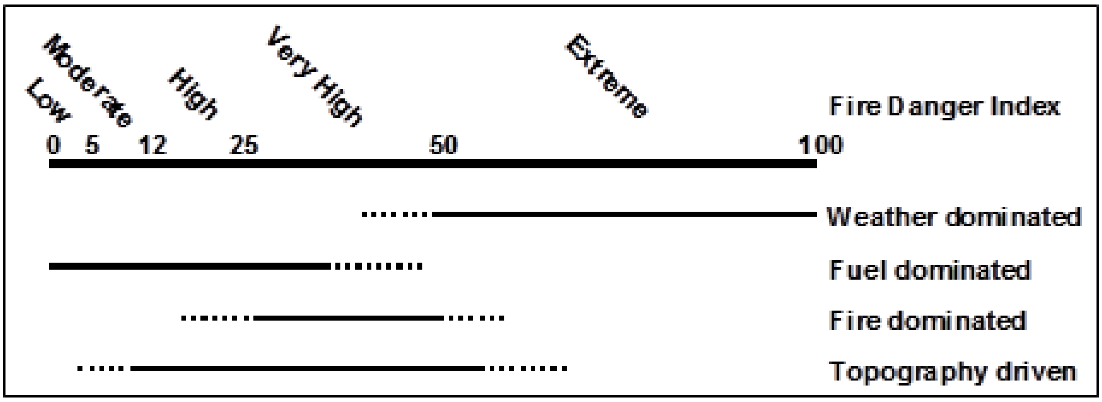

FIGURE 4. FIRE WEATHER CONDITIONS (MCARTHUR 1967) IN WHICH DIFFERENT FACTORS MAY DOMINATE FIRE BEHAVIOUR (TOLHURST 2004).

Some fire-severity reduction effects were still evident for FRBs up to 10 years old, but there was almost no evidence of FRBs older than 10 years having any effect on fire-severity. The greatest effects of previous FRB in reducing wildfire severity and in assisting fire suppression occurred when (1) the FFDI fell to 25 or less (late in the evening and overnight); (2) the age of the FRB was less than 3 years (i.e. when all three components of fuel—surface, bark and elevated material—were still substantially reduced). This gave substantial confirmation to the trends found in an earlier study of the effectiveness of fuel reduction burning from 2001 (Fig 5 and Fig 6).

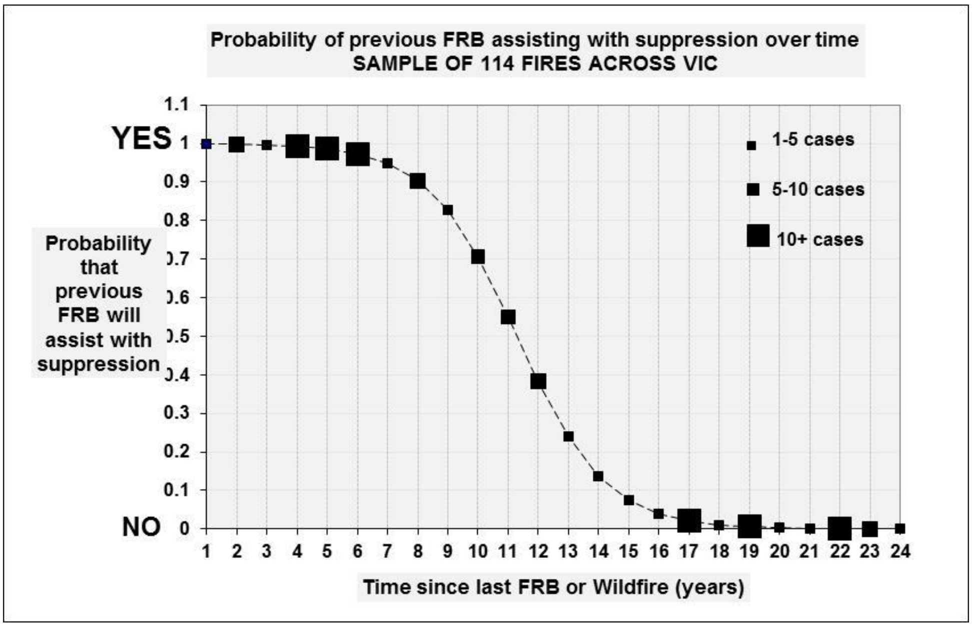

FIGURE 5. PROBABILITY OF A PREVIOUS FRB ASSISTING WITH SUPPRESSION OF A SUBSEQUENT WILDFIRE ON THE SAME SITE, AS A FUNCTION OF TIME SINCE THE LAST FRB OR WILDFIRE. LOGISTIC MODEL FROM MCCARTHY AND TOLHURST (2001) – SAMPLE OF 114 FIRES FROM ACROSS VICTORIA.

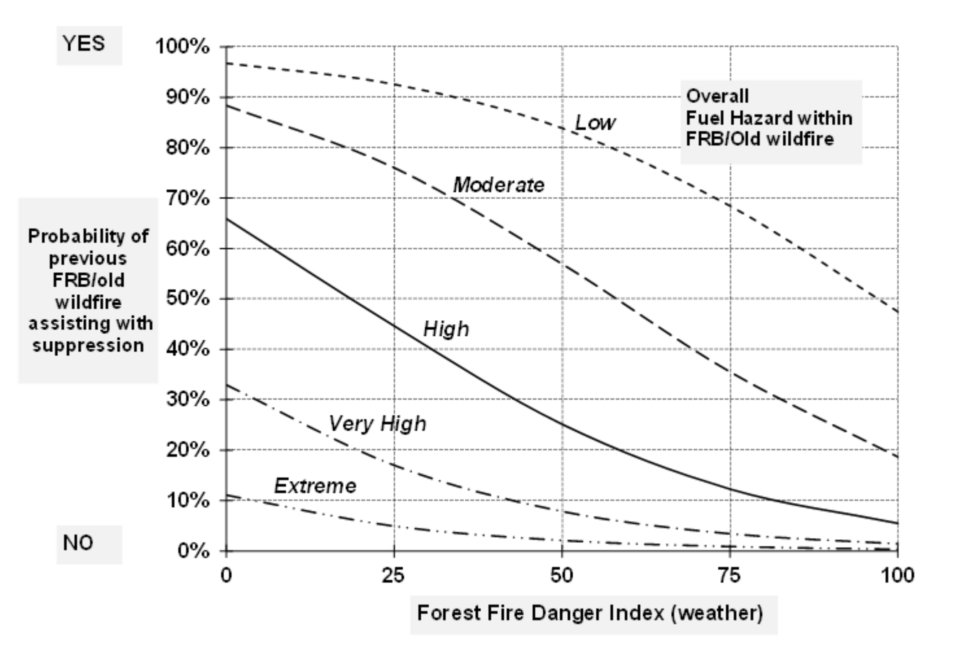

FIGURE 6. RELATIONSHIP BETWEEN FRB ASSISTANCE WITH SUBSEQUENT SUPPRESSION, AND FUEL AND WEATHER CONDITIONS (MCCARTHY AND TOLHURST 2001).

FRBs up to 10 years old also had measurable effects on increasing burnt area patchiness and decreasing canopy loss, both of which have ecological implications (Figs. 7 and 8).

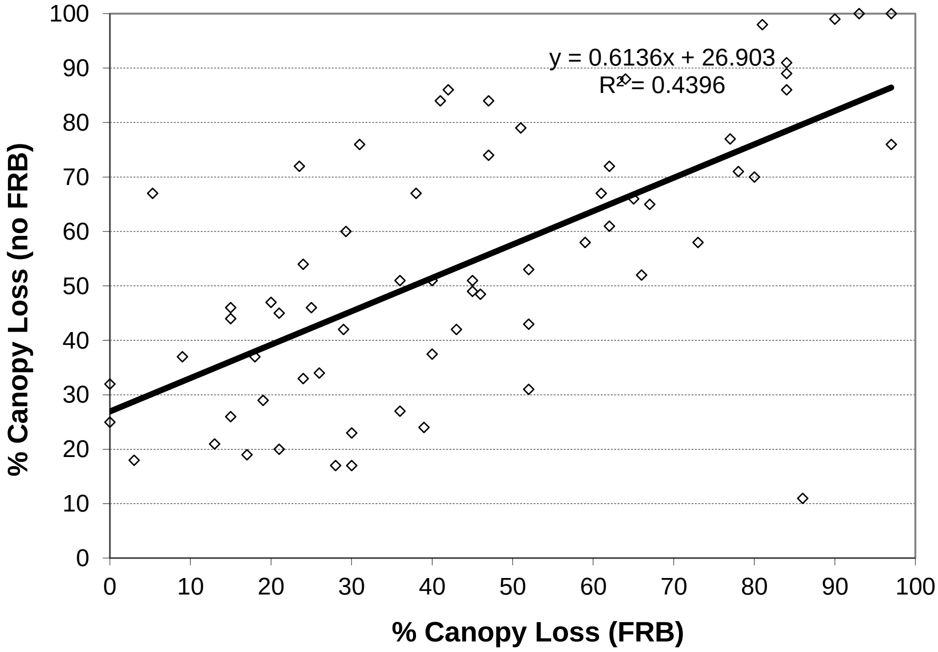

FIGURE 7. COMPARISON IN THE PERCENTAGE OF AREA WITH PATCHILY BURNT BETWEEN THE AREAS BURNT IN THE 10 YEARS BEFORE 2003 (FRB) AND THOSE AREAS LONGER UNBURNT (NO FRB).

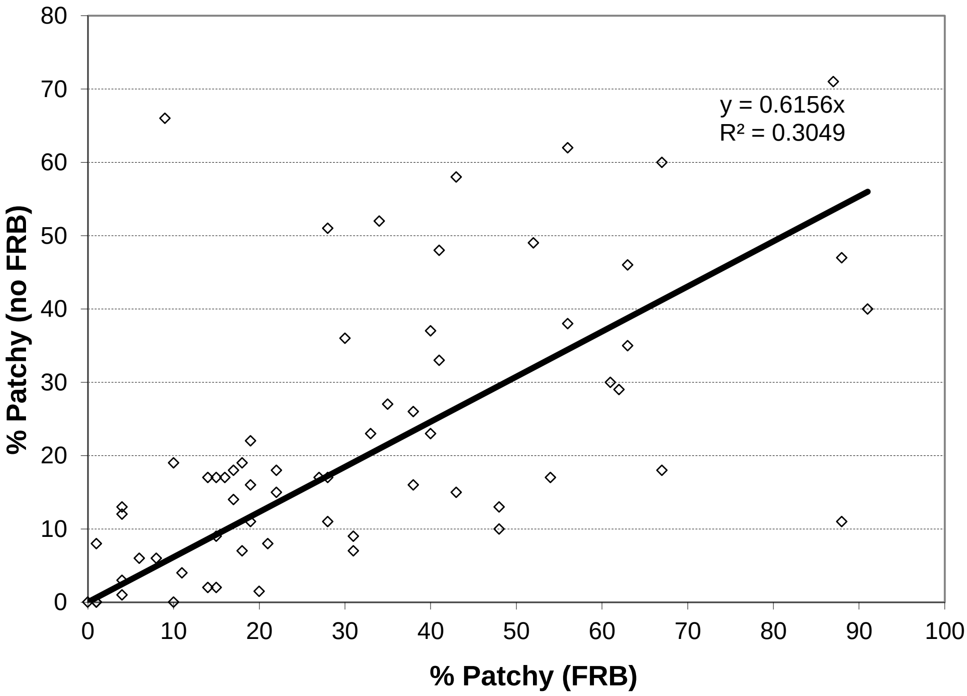

FIGURE 8. COMPARISON IN THE PERCENTAGE OF AREA WITH COMPLETE CANOPY LOSS BETWEEN THE AREAS BURNT IN THE 10 YEARS BEFORE 2003 (FRB) AND THOSE AREAS LONGER UNBURNT (NO FRB).

At the other end of the fire severity range, complete canopy loss was more common in the long-unburnt areas. The intercept in Figure 20 shows no complete canopy loss in the recently burnt areas (previous 10 years), compared with 27 per cent complete canopy loss in the long unburnt areas. The benefit of recent burning decreased as the fire intensity and hence severity increased, so that when there was 100 per cent of the burnt area with complete canopy loss in the long-unburnt areas, there was also 100 per cent complete canopy loss in the recently burnt areas as well. The main benefit in reducing fire severity was therefore greatest under less severe fire behaviour. As fire behaviour decreased, the benefit to the recently burnt area became increasingly great.

DISCUSSION

The broad scatter of fire severity data shown here indicates that fire severity at any point in the landscape is a result of many interacting factors. This scatter of data also indicates that it would be possible to selectively choose examples (case studies) to support a range of arguments, extending from prescribed burning being extremely effective in reducing fire severity, through to arguments that prescribed burning is completely ineffective at reducing fire severity, and not worth the cost and effort to undertake. This demonstrates a potential limitation in the selective case-study approach of assessing the effectiveness of prescribed burning in reducing fire severity (Billing 1981, Underwood et al. 1985, Grant and Wouters 1993, Cheney 2010). Selective case studies may present 'successful' cases, while not reporting on 'unsuccessful' cases. This study provided a rare opportunity to assess the effectiveness of prescribed burning in a single event, but with many independent cases, burnt under a wide range of weather and fire intensity conditions. Thus it allowed both 'successful' and 'unsuccessful' cases to be studied simultaneously.

An earlier study (McCarthy & Tolhurst 1998) of 50 fires showed that the two main factors affecting the effectiveness of first attack suppression was the Forest Fire Danger Index (the fire weather) and the Overall Fuel Hazard level (McCarthy et al. 1999). In this study, there were no pre-fire fuel assessments available in either the recently burnt sites or the longer unburnt sites. The best factors correlated to fuel hazard levels were time since last fire (FIREage), broad vegetation type (HEDMS), aspect and to some extent elevation.

A more recent study on the effectiveness of broadscale fuel reduction burning in assisting with wildfire control in Victoria (McCarthy & Tolhurst 2001) concluded that fuel reduction burning had been effective in assisting with fire control. Results of this study (114 fires) indicated that areas which had been burnt for fuel management, had a measurable effect on assisting in fire suppressing for up to about 15 years, but began to become less helpful after about age 10–11 (Fig. 2).

As with the first attack effectiveness study (McCarthy & Tolhurst 1998), the effectiveness of previous burning had been found to be dependent on the Forest Fire Danger Index and the Overall Fuel Hazard levels. These results reinforce the findings of this study, where there has been a measurable reduction in fire severity in areas fuel reduced less than 10 years previously. The dryness of the seasonal conditions (driest period in 100 years of records) may have been the cause for the difference in the period of effective reduction in fire severity being only 10 years in this study compared with 15 years in the 2001 study. This indicates that the effectiveness of previous burning was probably affected by the seasonal dryness, as well as the scale of the fire impacting on the fuel reduced area.

Despite the limitations of the data, there was still a clear indication that the major factors affecting fire severity were the Forest Fire Danger Index (fire weather, including long and short-term drought effects), the time since last fire (most probably a surrogate for fuel hazard levels), and topographic aspect (also probably fuel related). The importance of assessing the effectiveness of prescribed burning in reducing fire severity, and in assisting fire suppression, must be made in the context of the factors dominating fire behaviour at any particular time. Whilst recent burning locally reduced the amount of total canopy loss and increased the abundance of unburnt or patchily burnt areas, these effects are less likely when the fire is weather dominated.

This study provides fire managers planning rotational landscape FRB with important information on likely effects of the burning on fire severity. Particularly it indicates: (1) how frequently fuel reduction burning must be undertaken to remain effective at reducing fire severity; (2) that the most effective and longest lasting fuel reduction burns remove both surface and elevated fuels (most effectively achieved on northern and western aspects); and (3) that above FFDI 50, fires tend to become 'weather-dominated' and variations in fuel (including even recent FRBs) become less important in restricting fire spread.

CONCLUSIONS

Previous fuel reduction burning significantly reduced the severity of the 2003 fire. Fuel reduced areas less than 10 years old on average experienced lower fire severity.

Fire severity across the 2003 fire area was modelled using a Fire Severity Index, the variations in which were best explained by fire weather (FDI), the age of the previous fire, and the amount of NW aspect. This clearly indicated that, at FDIs greater than 50, even recent fuel reduction burns may not have much effect on reducing fire severity. At these higher FDIs, major fire runs in the 2003 fire area became weather-dominated, and variations in fuel became much less important to determining fire severity.

Recently fuel reduced areas (<10 years) contributed a significant proportion of the final fire boundary, confirming the importance of these areas to fire control.

Very recent fuel reduction burns (three years old or less) had the greatest effect on reducing fire severity. This accords with previous studies of prescribed burn age and effectiveness. It is likely that this effect is due to surface fuels, in addition to bark and elevated fuels, being also substantially reduced for this immediate post fire period.

REFERENCES

Adams M, Attiwill P (2011) Burning Issues- sustainability and management of Australian's southern forest. CSIRO Publishing, Collingwood VIC (i.e., Chapter 7)

Billing, P. (1981) The effectiveness of fuel-reduction burning: five case histories. Fire Management, Research Report No. 10. Dept. Conservation and Environment, Victoria. 13pp.

Bradstock, R.A., Bedward, M., Kenny, B.J., and Scott, J. (1998) Spatially-explicit simulation of the effect of prescribed burning on fire regimes and plant extinctions in shrublands typical of south-eastern Australia. *Biological Conservation* **86**, 83-95.

Bureau of Meteorology (2003) Submission to House of Representatives Select Committee on the Recent Australian Bushires. Submission 369. (www.aph.gov.au/house/committee/bushfires/inquiry/subs/sub369.pdf) 38pp.

Cheney N.P. (1996) The effectiveness of fuel reduction burning for fire management. In "Fire and biodiversity: effects and effectiveness of fire management", Paper No 8, Department of the Environment, Sport and Territories , (Paper 1)(Also see: Tolhurst KG, Paper 2; Meredith CW, Paper 19;Good RB, Paper 23)

Cheney N.P. (2010) Fire behaviour during the Pickering Book wildfire. January 2005 (Perth Hills Fire 71-80). Conservation Science Western Australia 7,451-468.

ESRI (2000) Arcview GIS software – Version 3.2a release Sept 2000. ESRI Corporation, Redlands CA, USA

Fernandes, P.M and Bothelo, H.S. (2003) A review of prescribed burning effectiveness in fire hazard reduction. *International Journal of Wildland Fire* **12**: 117-128.

Gill AM, McCarthy MA (1998) Intervals between prescribed fires in Australia: what intrinsic varitoin should be apply? Biological Conservation, 85,161-160.

Gill AM (2009) Underpinnings of fire management for biodiversity conservation in reserves. Fire and adaptive management Report no. 73, Department of Sustainability and Environment (See Chapter 3).

Gould J.S., McCaw W.L., Cheney N.P., Ellis P.F., Knight I.K., Sullivan A.L. (2007) Project Vesta, Fire in Dry Eucalypt Forest : Fuel Structure, Fuel Dynamics and Fire Behaviour. Commonwealth Scientific and Industrial Research Organisation, and Department of Environment and Conservation, Western Australia.

Grant, S.R. and Wouters, M.A. (1993) The effects of fuel reduction burning on the suppression of four wildfires in Western Victoria. Fire Management, Research Report No.41. Dept. Conservation and Natural Resources, Victoria. 17pp.

McArthur, A.G. (1967) Fire behaviour in eucalypt forests. Forestry and Timber Bureau, Australia. Leaflet No. 107. 36pp.

McArthur, A.G. (1977) Forest Fire Danger Meter, MkV. Forestry and Timber Bureau, Commonwealth of Australia, Canberra.

McCarthy, G.J. and Tolhurst, K.G. (1998) Effectiveness of firefighting first attack operations by the Department of Natural Resources and Environment from 1991/92 – 1994/95. Fire Management, Research Report No.45. Dept. Natural Resources and Environment, Victoria. 46pp.

McCarthy, G.J. and Tolhurst, K.G. (2001) Effectiveness of broadscale fuel reduction burning in assisting with wildfire control in Parks and Forests in Victoria. Fire Management, Research Report No.51. Dept. Natural Resources and Environment, Victoria. 26pp.

McCarthy, G.J., Tolhurst, K.G. and Chatto, K. (1999) Overall Fuel Hazard Guide. Fire Management, Research Report No.47. Dept. Natural Resources and Environment, Victoria. 28pp.

McCaw WL (2010) Report on effect of fuel reduction burning on the behaviour and severity of the Victorian Bushfires of 7 February 2009. A report prepared for the 2009 Victorian Bushfire Royal Commission, pp 22.

Poringneaux J-M, (2010) Fuel hazard accumulation in three fire-prone Victorian forest types. Thesis for Master of Science, Leeds University, UK.

Rawson, R., Billing, P. and Rees, B. (1985) Effectiveness of fuel-reduction burning. Fire Management, Research Report No.25. Department of Conservation and Environment, Victoria. 49pp.

Tolhurst, K.G. (2004) Changing our perceptions of fire in the environment. Paper presented to National Conference of Parliamentary Environment and Public Works Committees, 11-14 July, 2004. Cumberland Resort, Lorne, Victoria. 8pp.

Underwood, R.J., Sneeuwjagt, R.J. and Styles, H.G. (1985) The contribution of prescribed burning to fire control in Western Australia: case studies. In: Ford, J.R. (ed.) *Fire ecology and management of Western Australian ecosystems*. Western Australian Institute of Technology Environmental Studies Group, Perth.