8 After 'Black Saturday': adapting to bushfires in a changing climate

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On Saturday 7 February 2009, 173 people lost their lives and 2133 houses were destroyed by bushfires in the Australian State of Victoria (Figure 8.1; Teague et al., 2010). Fires burned under the most severe fire weather conditions experienced for more than one hundred years, with a record high maximum temperature of 46.4 ºC in Melbourne, record low relative humidity, and strong winds throughout the state (Karoly, 2009; National Climate Centre, 2009). The scale of life and property loss has raised fundamental questions about bushfire management and community safety in Victoria and throughout Australia. These include questions about Australia's 'prepare, stay and defend or leave early' policy, the adequacy of warning systems, the preparedness and responses of residents, fire authorities and other emergency services, and the land-use planning system that manages development in high fire-risk areas. These and other issues were investigated by the 2009 Victorian Bushfires Royal Commission, which handed down 67 recommendations in its final report to the Victorian Government in July 2010 (Teague et al., 2010). Although the Commission heard evidence of the increased likelihood of extreme fire weather conditions due to climate change, none of its recommendations explicitly address climate change and its associated risks.

This chapter explores the environmental and human dimensions of the 'Black Saturday' bushfire disaster of 7 February 2009. It discusses factors influencing the severity of the fires,

the vulnerability of people and property, and changes to bushfire policy and management following the 2009 Victorian Bushfires Royal Commission. The chapter concludes with a brief reflection on the prospects for adapting to bushfires in a changing climate.

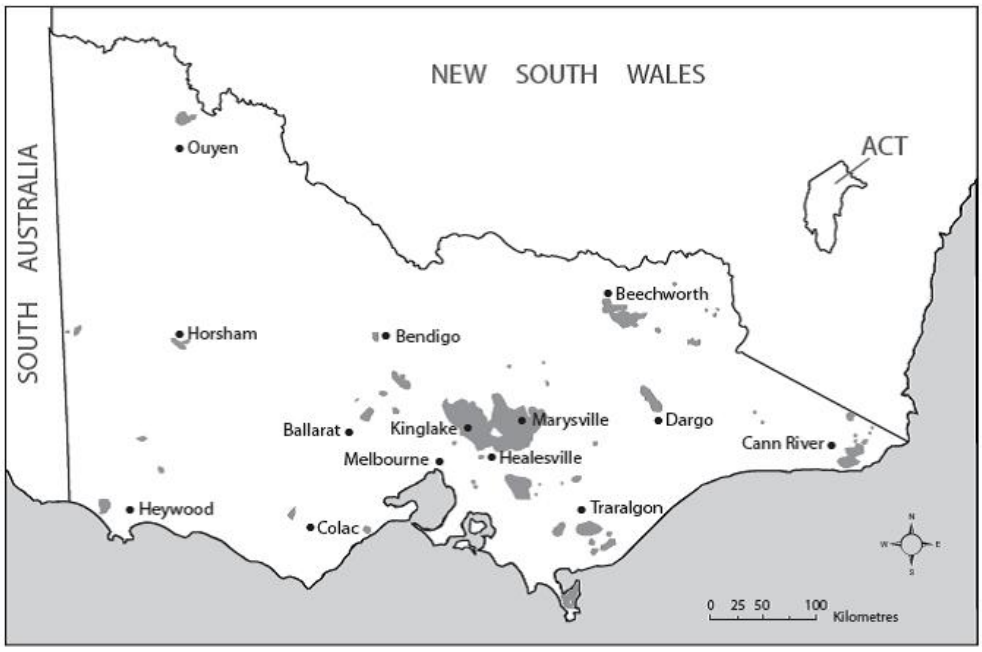

Figure 8.1 Location of the 2009 Victorian bushfires (shaded dark grey).

8.1 Environmental factors

Bushfires are a regular occurrence in south-east Australia, associated with typical weather conditions including high maximum temperatures, strong winds, low relative humidity, and a preceding period of very low rainfall. Previous disastrous fires in south-east Australia occurred on Ash Wednesday, 16 February 1983, and Black Friday, 13 January 1939, both of which led to significant losses of life and property and changes to bushfire policy and management (see Pyne, 1998).

The McArthur Forest Fire Danger Index (FFDI) was developed in the 1960s as an empirical indicator of weather conditions associated with high and extreme fire danger and the difficulty of fire suppression (McArthur, 1967). The FFDI is the product of non-linear terms related to maximum temperature, relative humidity, wind speed, and dryness of fuel (measured using a drought factor), each affecting the severity of bushfire conditions (Noble et al., 1980). The FFDI scale is used for the rating of fire danger and the declaration of total fire ban days in Victoria. It was developed so that the disastrous Black Friday fires in 1939 had an FFDI of 100.

Fuel load is not explicitly included in the FFDI, but it is crucial in determining the fire behaviour and intensity. Uncontrollable fire behaviour may occur at FFDI values of 100 for low fuel loads of only about 5 t/ha, much less than typical fuel loads of 12 t/ha for dry sclerophyll forest found in south-east Australia (Lucas et al., 2007). Fuel reduction burning prior to the Black Saturday fires in 2009 is believed to have inhibited the spread of several of these extreme fires (Teague et al., 2010).

To understand the environmental conditions associated with the catastrophic bushfires on 7 February 2009, we need to consider each of the factors in the FFDI.

Maximum temperature

Melbourne and much of Victoria had record high maximum temperatures on 7 February 2009 (National Climate Centre, 2009). Melbourne set a new record maximum of 46.4 °C based on

more than 100 years of observations. This new maximum was 0.8 °C hotter than the previous all-time record on Black Friday 1939 and 3 °C higher than the previous February record set on 8 February 1983 (the day of a dramatic dust storm in Melbourne). The urban heat island in Melbourne may have influenced these new records, but many other rural stations in Victoria set new all-time record maximum temperatures on 7 February. The high-quality rural site of Laverton, near Melbourne, set a new record maximum temperature of 47.5 °C, 2.5 °C higher than its previous record set in 1983. The extreme temperature on 7 February came after a record-setting heat wave ten days earlier, with Melbourne experiencing three days in a row with maximum temperatures higher than 43 °C during 28-30 January 2009, unprecedented in 154 years of Melbourne observations.

Drought factor

Melbourne and much of Victoria had received record low rainfall at the start of 2009. Melbourne had 35 days with no measurable rain up to 7 February, the second longest period on record with no rain. The period up to 8 February, with a total of only 2.2 mm, was the driest start to the year for Melbourne in more than 150 years (National Climate Centre, 2009). This was preceded by 12 years of below average rainfall over much of south-east Australia, with record low 12-year rainfall over southern Victoria (National Climate Centre, 2009). This contributed to extremely low fuel moisture (3-5 %) on 7 February 2009.

Relative humidity

Record low values of relative humidity were set in Melbourne and other sites in Victoria on 7 February with values as low as 5 % in the late afternoon. While long-term high quality records of humidity are not available for Australia, the very low humidity is likely associated

with the unprecedented low rainfall experienced from the start of 2009 in Melbourne and the protracted heat wave.

Wind speed

Extreme fire danger events in south-east Australia are associated with very strong, northerly winds bringing hot dry air from central Australia. The weather pattern and northerly winds on 7 February were similar to those on Ash Wednesday and Black Friday, and the very high winds do not appear to have been exceptional.

The combination of these factors led to unprecedented conditions for catastrophic fire danger on 7 February 2009 in Victoria, as shown in Table 8.1. Note that due to the non-linear and empirical relationships represented by the FFDI, this does not mean that the conditions for an FFDI of 170 are twice as bad as for an FFDI of 85, just substantially worse.

[Insert Table 8.1 around here]

8.2 Human factors

Victoria is recognised as one of the most fire-prone environments on earth due to its location, climate and vegetation (Luke and McArthur, 1978; Bradstock et al., 2002). However, human factors – such as ignition sources, the exposure of people and assets, and fire and emergency management capabilities – are equally important in determining bushfire risk.

Like many major Australian cities, Melbourne has seen increasing residential development and population growth at its suburban fringes. According to the Australian Bureau of Statistics, the largest population growth for 2008-09 occurred in five local government areas on Melbourne's outer suburban fringes (Australian Bureau of Statistics, 2010), with an already large population in the particularly high risk areas to the north-east and east. Parts of regional Victoria have also experienced growth as an increasing number of people move away from metropolitan areas for the amenity and lifestyle of coastal and rural settings (Burnley and Murphy, 2004; Costello, 2007). Reduced housing affordability within inner Melbourne (Wood et al., 2008; Yates, 2008) has also encouraged residential development and population growth in high bushfire risk areas. These areas also contain critical water, electricity and telecommunications infrastructure that serves much of Melbourne.

With the extreme fire weather conditions discussed above, 7 February saw the ignition of more than 400 fires across Victoria. Most of the major fires were started by fallen power lines or arson (Teague et al., 2010). Fires quickly burned out of control as communities came under threat with little or no official warning. Fire fighting capacities were limited in the face of such large and intense fires, leaving almost all residents to fend for themselves. Under the 'prepare, stay and defend or leave early policy' (Australasian Fire and Emergency Service Authorities Council, 2005) adopted by all Australian fire services, residents were advised to prepare to stay and defend their home from bushfires or leave well before a fire arrived in their area. The policy was based on evidence that well-prepared people can safely protect well-prepared houses from bushfires, and that a disproportionate number of deaths occur during late evacuations (see Handmer and Tibbits, 2005; Tibbits et al., 2008; Haynes et al., 2010). However, 173 people died in the 7 February fires – the largest number of fatalities in

any Australian bushfire event – and more than 2000 houses were destroyed. Almost immediately, the ‘stay or go’ policy was drawn into question (Australian Associated Press, 2009a), particularly considering police reports that 113 people died inside their homes (Australian Associated Press, 2009b). A number of studies provide insights into the human factors that contributed to the disaster.

Clearly, exposure to bushfire hazard was a major factor in the disaster. Crompton et al. (2010) found that 25 % of destroyed buildings in Marysville and Kinglake were located within the bushland boundary, while 60 % and 90 % were within 10 and 100 metres of bushland. The authors argue that distance to bushland was the most important factor influencing building damage in the fires. Nevertheless, interview and questionnaire research with households throughout the fire affected areas, discussed below, found that many residents successfully defended their homes from the fires, including in Marysville and Kinglake.

A survey of 1314 households affected by the fires (Whittaker et al., 2013) found varied levels of planning and preparedness, with residents in more suburban locations less likely to have considered themselves at risk from bushfires or to have taken measures to protect themselves. Half of those surveyed reported that they intended to stay and defend their homes and properties throughout the fire (49.8 %), with less than a fifth having a firm intention to leave *before* they came under threat (18.7 %). Significantly, more than a quarter of respondents intended to stay and defend but leave if they felt threatened (17.0 %) or wait and see what the fire was like before deciding whether to stay or leave (9.1 %). These ‘wait-and-see’ strategies

are particularly risky and ill-advised, as they increase the likelihood of late and dangerous evacuation.

Half of those surveyed actually stayed to defend their homes and properties from the fires (52.8 %). Of these, around one-third left at some stage during the fire because of perceived danger, the failure of equipment or utilities, or because their house had caught fire. Of those who left before or when the fires arrived (43.4 %), more than half considered themselves to have left ‘late’ or ‘very late’ and more than three-quarters perceived the level of danger to be ‘high’ or ‘very high’ when leaving. Many reported experiencing difficulties associated with smoke, poor visibility, traffic, embers, flames, and fallen trees. Most people did not receive an ‘official’ warning from police, fire or emergency services that a fire was threatening (62.1 %) but did receive ‘unofficial’ warnings from family, friends or neighbours (62.5 %). Crucially, interviews revealed that even where warnings were provided and received, many waited until they were directly threatened before taking action.

Contrary to prevailing media coverage and popular opinion, many people stayed and successfully defended their homes and properties from the fires. The aforementioned survey of households from across the fire affected areas found that rates of house damage and destruction were considerably lower among households where residents stayed and defended (Whittaker et al., 2013). In households where at least one person stayed to defend, just one in ten houses were destroyed. Half of the houses where all householders left, or sheltered without defending, were destroyed.

Handmer et al. (2010) reviewed each of the 172 civilian fatalities to identify factors that may have contributed to deaths. They found that around one-quarter of those who died had a chronic health condition that may have affected their mobility, judgement or stamina during the fire. Another 5 % were affected by an acute physical or mental condition that occurred on the day. Other factors found to have contributed to deaths included levels of planning and preparedness, with 58 % of those who died having made no apparent preparations and 53 % having no apparent fire plan or clear intention for what to do during a fire. The review found that more than two-thirds had been sheltering at the time they died (Handmer et al., 2010).

8.3 Changes to bushfire policy and management

On 16 February, the 2009 Victorian Bushfires Royal Commission was established to investigate the circumstances leading to widespread losses of human life and property in the fires. Royal Commissions are major public inquiries established to advise government on important policy issues, or to investigate allegations of impropriety, maladministration or major accidents (Prasser, 2006). The Commission's terms of reference were broad, covering a range of issues including: the causes and consequences of the fires, the preparedness and responses of government, emergency services and households; measures taken to prevent disruption to essential services; and any other matters deemed relevant by the Commissioners (Teague et al., 2010). The Commission heard evidence from 434 experts and lay witnesses and received more than 1200 public submissions. It handed down 67 recommendations to government in its final report, including recommendations for bushfire safety policy, ignition prevention, emergency and incident management, land use planning and building, land and fuel management, and organisational structure (see Teague et al., 2010 for a full list of

recommendations). Although the Commission heard evidence of the increased likelihood of extreme fire weather conditions due to climate change, none of the recommendations explicitly address climate change and its associated risks. Here, we focus on recommendations we believe have the greatest potential to reduce losses of life and property in the future.

The Commission's first and most fundamental recommendation was for Victoria to revise its bushfire safety policy. Despite acknowledging that '… the central tenets of the stay or go policy remain sound', the Commission noted that the 7 February fires had exposed weaknesses in the way it was applied (Teague et al., 2010: 5). It found that the policy did not adequately account for 'ferocious' fires, which it said require a different kind of response. The Commission recommended a greater emphasis on the heightened risk to life and property 'on the worst days' and on leaving early as the safest option.

Given the unprecedented fire danger experienced on 7 February, the Commission's interim report (Teague et al., 2009) had recommended revision of fire danger ratings to include an additional rating beyond 'Extreme' and for existing ratings to be adjusted to correspond to higher Fire Danger Index values. In response, the 'National Framework for Scaled Advice and Warnings to the Community' was developed (Australian Emergency Management Committee, 2009), which has seen the introduction of a 'Catastrophic' or 'Code Red' fire danger rating. In Victoria, the Country Fire Authority has developed scaled advice to more clearly communicate what residents should expect and do for different levels of fire danger (Table 8.2).

[Insert Table 8.2 around here]

Other recommendations related to bushfire safety include the enhanced provision of timely and informative advice and warnings, improved advice on the 'defendability' of individual houses, and an increase in the options available to people during fires, including community refuges and bushfire shelters (Teague et al., 2010). The latter recommendation reflected the Commission's view that the binary approach of 'stay and defend or leave early' does not adequately reflect the reality of what people do during fires: '… the reality [is] that people will continue to wait and see, and a comprehensive bushfire policy must accommodate this by providing for more options and different advice' (Teague et al., 2010: 5). In Victoria, the Country Fire Authority (CFA) and local governments have begun designating 'Neighbourhood Safer Places' as places of last resort, while the Australian Building Codes Board is developing standards for the design and construction of bushfire bunkers for personal use. It is important to recognise, however, that although these changes expand the range of options available to people during bushfires, they do not eliminate the dangers associated with the failure to adequately plan and prepare, the tendency to wait and see, and late evacuation. Nevertheless, the Commission recommended that authorities take greater responsibility for protecting those with limited capacities to protect themselves, for example, by developing plans for assisted evacuations (Teague et al., 2010).

The Royal Commission also offered a series of recommendations related to land use planning and building in high bushfire risk areas. The proposed changes aim to strengthen consideration of bushfire throughout the planning process in order to protect human life without imposing unacceptable biodiversity costs (Teague et al., 2010). They include

strengthening the Wildfire Management Overlay – the main mechanism for controlling new developments and subdivisions in high bushfire risk areas – and a ‘retreat and resettlement’ strategy, including a scheme for non-compulsory acquisition of land by the state ‘… in areas of unacceptably high bushfire risk’ (Teague et al., 2010: 33). The voluntary ‘buy-back’ scheme was the only recommendation rejected outright by the then state government, on the grounds that vacant properties that were not maintained would increase fire risk for those who remained and that the cost would be prohibitive. The government also indicated that costs prohibited the replacement of all single-wire earth return power lines with aerial bundled cable, underground cable or other technology to reduce the risk of bushfires (Willingham, 2010). A new state government, elected in November 2010, has vowed to implement all of the Royal Commission’s and has developed a voluntary ‘Bushfire buy-back’ scheme to acquire high-risk properties from landholders who lost their primary place of residence in the fires (Department of Justice, 2012).

8.4 Adapting to bushfires in a changing climate

Anthropogenic climate change is expected to continue to increase the frequency and severity of extreme fire danger in south-east Australia. In the IPCC Fourth Assessment Report of Working Group II, Hennessy et al. (2007) concluded that ‘an increase in fire danger in Australia is likely to be associated with a reduced interval between fires, increased fire intensity, a decrease in fire extinguishments and faster fire spread’. A modelling study indicates that the number of Extreme fire danger days in south-east Australia is likely to increase by 15-65 % by 2020 relative to 1990 and by 100-300 % by 2050 for a high rate of global warming (Lucas et al., 2007; CSIRO, 2009).

In other fire-prone regions around the world, observed and expected increases in forest fire activity have been linked to climate change in western USA (Westerling et al., 2006), in Canada (Gillett et al., 2004) and in Spain (Pausas, 2004). While it is difficult to separate the influences of climate variability, climate change, and changes in fire management strategies on the observed increases in fire weather, it is clear that climate change is increasing the likelihood of environmental conditions associated with extreme fire danger in south-east Australia (Lucas et al., 2007) and a number of other parts of the world.

As the frequency and severity of extreme fire danger increase, so too will the number of people and assets at risk. Victoria's population is projected to grow from 5.13 million in 2006 to 7.4 million in 2036 (Department of Planning and Community Development, 2009). Much of this growth will occur in coastal and inland areas near Melbourne and major regional centres (Department of Sustainability and Environment, 2005). The number of Victorian households is expected to grow even more rapidly, largely due to the ageing population, with an increase of 54.6 % from 2006 to 2036 (Department of Planning and Community Development, 2009). Consequently, there will be a greater concentration of people, homes, businesses and other assets in areas at risk from bushfire in the future.

The failure of land use planning to regulate development in high bushfire risk areas and the preparedness and responses of emergency services and residents have all been implicated in the Black Saturday bushfire disaster (Whittaker et al., 2009 a; b; Buxton et al., 2010; Crompton et al., 2010). While the Royal Commission's recommendations and subsequent government and agency responses address these and many other issues, it is too soon to

ascertain whether they will contribute meaningfully to adaptation. For example, it was envisaged that the introduction of Code Red warnings would alert residents to the potential for catastrophic bushfire and encourage them to leave early. However, research following a Code Red declaration during the 2009/10 fire season found that very few residents actually left their homes (see Whittaker and Handmer, 2010). The increasing concentration of people and assets in areas at risk from bushfires and the difficulties of engaging and motivating people to protect themselves highlight the challenges facing the adaptation process.

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Tables

Table 8.1 Forest Fire Danger Index (FFDI) and other environmental conditions for previous catastrophic fire events in Victoria. Temperature and rainfall were recorded in Melbourne.

Event	Date	FFDI	Maximum temperature (ºC)	Rainfall for preceding 30 days (mm)
Black Friday	13 Jan 1939	100	45.6	2.6
Ash Wednesday	16 Feb 1983	120	43.0	6.4
Black Saturday	7 Feb 2009	170	46.4	0

Table 8.2 The Country Fire Authority's scaled advice to the community. (Modified from Country Fire Authority, 2012)

	What does it mean?	What should I do?
Code Red (FFDI 100+)	These are the worst conditions for a bush or grass fire. Homes are not designed or constructed to withstand fires in these conditions. The safest place to be is away from high risk bushfire areas.	Leaving high risk bushfire areas the night before or early in the day is your safest option – do not wait and see. Avoid forested areas, thick bush or long, dry grass. Know your trigger – make a decision about: - when you will leave,

		- where you will go, - how you will get there, - when you will return, and - what you will do if you cannot leave.
Extreme (FFDI 75-99)	Expect extremely hot, dry, and windy conditions. If a fire starts and takes hold, it will be uncontrollable, unpredictable and fast moving. Spot fires will start, move quickly and come from many directions. Homes that are situated and constructed or modified to withstand a bushfire, that are well prepared and actively defended, may provide safety. You must be physically and mentally prepared to defend in these conditions.	Consider staying with your property only if you are prepared to the highest level. This means your home needs to be situated and constructed or modified to withstand a bushfire, you are well prepared and you can actively defend your home if a fire starts. If you are not prepared to the highest level, leaving high risk bushfire areas early in the day is your safest option. Be aware of local conditions and seek information by listening to ABC Local Radio, commercial radio stations or Sky News TV, go to cfa.vic.gov.au or call the Victorian Bushfire Information Line on 1800 240 667.
Severe (FFDI 50-74)	Expect hot, dry and possibly windy conditions. If a fire starts and takes hold, it may be uncontrollable. Well prepared homes that are actively defended can provide safety. You must be physically and mentally prepared to defend in these conditions.	Well prepared homes that are actively defended can provide safety – check your bushfire survival plan. If you are not prepared, leaving bushfire-prone areas early in the day is your safest option. Be aware of local conditions and seek information by listening to ABC Local Radio, commercial radio stations or Sky News TV, go to cfa.vic.gov.au or call the Victorian Bushfire Information Line on 1800 240 667.
Very high / High / Low-moderate (FFDI 0-49)	If a fire starts, it can most likely be controlled in these conditions and homes can provide safety. Be aware of how fires can start and minimise the risk. Controlled burning off may	Check your bushfire survival plan. Monitor conditions. Action may be needed. Leave if necessary.

	occur in these conditions if it is safe – check to see if permits apply.	