CLIMATE COUNCIL

BE PREPARED: CLIMATE CHANGE AND THE VICTORIAN BUSHFIRE THREAT

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Introduction

Residents of Victoria have experienced the serious consequences of bushfires. Although Victoria comprises only 3% of Australia's land mass, more than half of all known fatalities due to bushfires have occurred in Victoria, and the state has sustained around 50% of the economic damage.

Australians have always lived with fire and its consequences, but climate change is increasing fire danger weather and thus the risk of fires. It is time to think very seriously about the risks that future fires will pose.

This report first describes the background context of fire and its history in Victoria. We then outline the link between bushfires and climate change, before considering how bushfire danger weather is increasing in Victoria and what this means for the immediate future. We explore the impacts of fire on people, property, water supply and biodiversity, before considering the future influence of climate change on bushfires, and the implications for Victorian fire managers, planners and emergency services.

Key Findings

1. Climate change is increasing the risk of bushfires in Victoria and lengthening the fire season.

- Extreme fire weather has increased over the last 30 years in Victoria. The fire season in Victoria is starting earlier and lasting longer. Fire weather has been extending into October and into March.
- Australia is a fire prone country and Victoria has always experienced bushfires. Today climate change is making hot days hotter, and heatwaves longer and more frequent, with increasing drought conditions in Australia's southeast.
- Record breaking heat and hotter weather over the long term in Victoria has worsened fire weather and contributed to an increase in the frequency and severity of bushfires.

2. Victoria is the state most affected by bushfires and is on the frontline of increasing bushfire risk.

- Over half of known fatalities due to bushfires in Australia have occurred in Victoria.
- Victoria has sustained around 50% of the economic damage from bushfires despite covering only 3% of Australia.
- Victoria's 2014–15 bushfire season outlook has been upgraded from an "above normal" fire season to a "major" fire season following record October warmth and expected ongoing hot, dry conditions.

3. Recent severe fires in Victoria have been influenced by record hot, dry conditions.

- The 2009 Black Saturday fires in Victoria were preceded by a record breaking decade-long drought with a string of record hot years, coupled with a severe heatwave in the preceding week.
- In the lead up to the bushfires on Saturday 7th 2009, maximum temperatures were up to 23°C above the February average in Victoria and record high temperatures for February were set in over 87% of the state.

4. In Victoria the economic cost of bushfires, including loss of life, livelihoods, property damage and emergency services responses, is very high.

- The total economic costs of bushfires in Victoria in 2014 are projected to be more than $172 million. By around the middle of the century these costs will more than double.

- These projections do not incorporate increased bushfire incident rates due to climate change and so could potentially be much higher.
- Livestock losses were estimated at 13,000 in the 2003 Alpine fires in Victoria, 65,000 in the 2005–6 Grampians fire and more than 11,000 in the Black Saturday fires.

5. In the future, Victoria is very likely to experience an increased number of days with extreme fire danger. Communities, emergency services and health services across Victoria must prepare.

- Fire severity and intensity is expected to increase substantially in coming decades in Victoria. The fire season will continue to lengthen, further reducing the opportunities for safe hazard reduction burning.
- Increasing severity, frequency and the lengthening fire season will strain Victoria's existing resources for fighting and managing fires.
- By 2030, it has been estimated that the number of professional firefighters in Victoria will need to approximately double (compared to 2010) to keep pace with increased population, asset value, and fire danger weather.
- Australia must cut its emissions rapidly and deeply to join global efforts to stabilise the world's climate and to reduce the risk of even more extreme events, including bushfires.

1. The nature of bushfires

Fire has been a feature of the Australian environment for at least 65 million years (Cary et al. 2012). Human management of fires also has a long history, starting with fire use by indigenous Australians ("fire-stick farming") up to 60,000 years ago. Between 3% and 10% of Australia's land area burns every year (Western Australian Land Information Authority 2013).

In Australia, the Forest Fire Danger Index (FFDI) is used to measure the degree of risk of fire in our forests (Luke and Macarthur 1978). The Bureau of Meteorology (BoM) and fire management agencies use the FFDI to assess fire risk and issue warnings. The index was originally designed on a scale from 0 to 100, with fires between 75 and 100 considered 'extreme'.

The unprecedented ferocity of the 2009 Black Saturday bushfires in Victoria saw a new 'catastrophic' category added to the FFDI for events exceeding the existing scale.

The concept of "fire regimes" is important for understanding the nature of bushfires in Australia, and for assessing changes in fire behaviour caused by both human and climatic factors (Figure 2). A fire regime describes *a recurrent pattern of fire*, with the most important characteristics being the frequency, intensity, and seasonality of the fire. Significant changes in any of these features of a fire regime can have a very important influence on its ecological and economic impacts (Williams et al. 2009).

Figure 1: Trees burn in Bullumwaal, Victoria

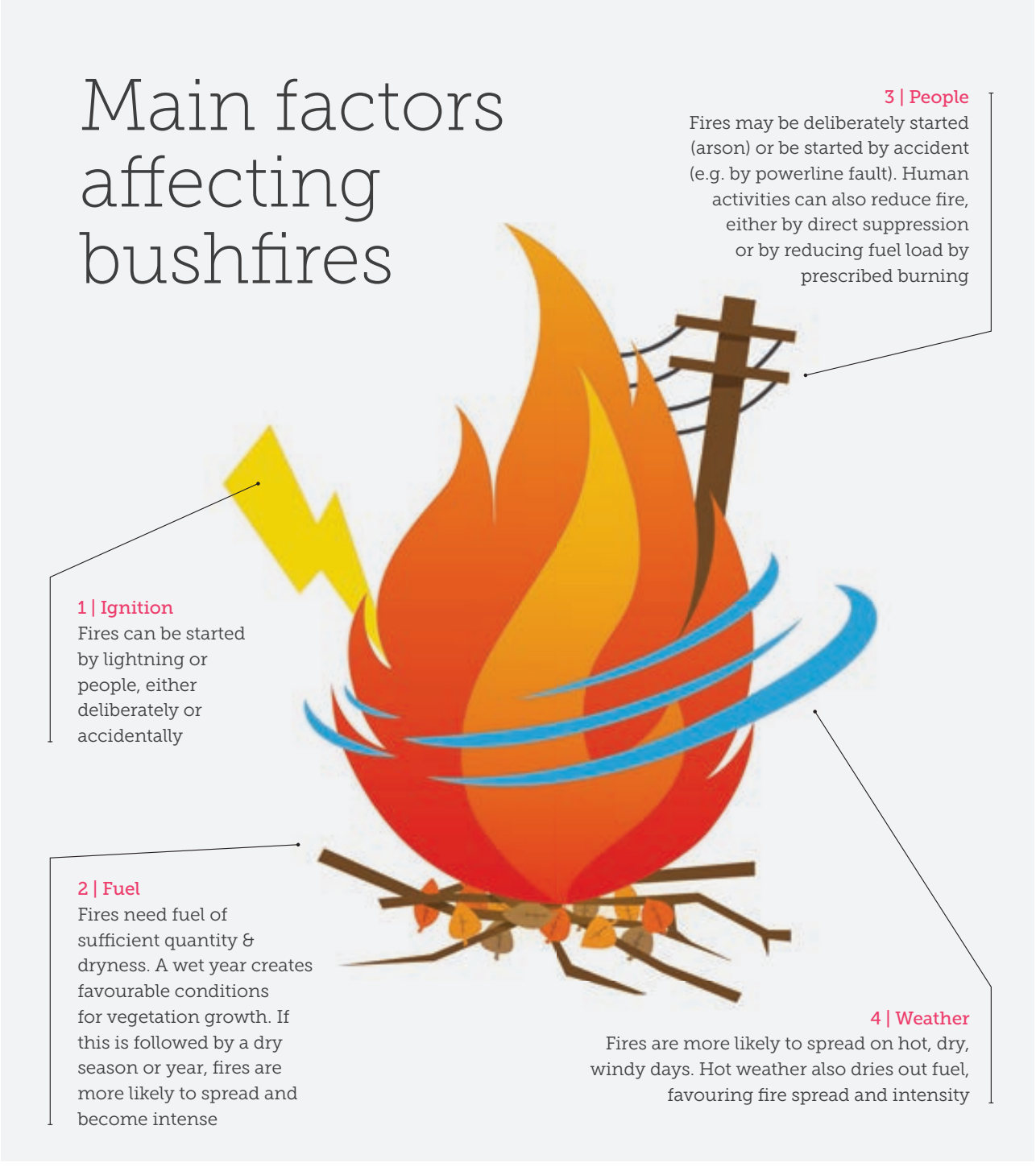


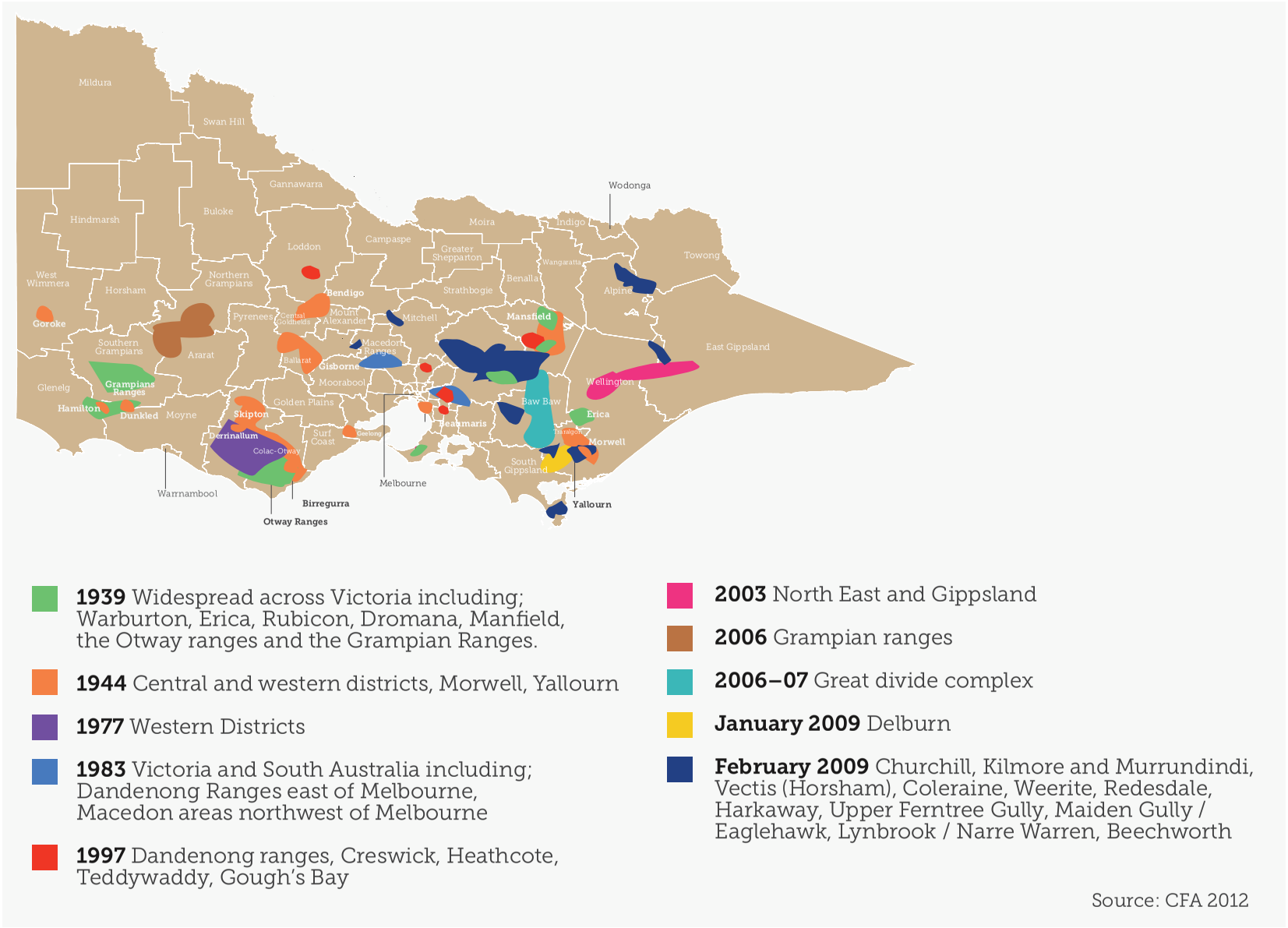
Figure 2: Main factors affecting bushfires

Fire is a complex process that is very variable in space and time. A fire needs to be started (ignition), it needs something to burn (fuel) and it needs conditions that are conducive to its spread (weather and topography) (see Figure 2). Fire activity is strongly influenced by weather, fuel, terrain, ignition agents and people. The most important aspects of weather that affect fire and fuels are temperature, precipitation, wind and humidity. Once a fire is ignited, very hot days with low humidity and high winds are conducive to its spread. The type, amount, and moisture level of fuel available are also critical determinants of fire behaviour, extent and intensity. The relationship between rainfall and fuel is complex. Wet seasons can lead to increased plant growth and therefore increase fuel buildup in the months or years before a fire is ignited (Bradstock et al. 2009). Warmer temperatures and low rainfall in the period immediately preceding an ignition, however, can lead to drier vegetation and soil, making the existing fuel more flammable. Warmer temperatures can also be associated with a higher incidence of lightning activity (Jayaratne and Kuleshov, 2006), increasing the risk of ignition. In many regions local weather conditions are the most important influence on fire activity (Climate Council 2014a).

"The most important aspects of weather that affect fire and fuels are temperature, precipitation, wind and humidity".

As fire weather conditions become more severe, fuel moisture content declines, making the fuel more flammable. By contrast, in arid regions, vegetation and thus fuel in most years is sparsely distributed and fires, if ignited, rarely spread far. In Australia's southeast, fires are common in the heathlands and dry sclerophyll forests, such as the mountain ash forests in Victoria, typically occurring about every 5 to 30 years, with spring and summer being peak fire season (Clarke et al. 2011; Bradstock et al. 2012).

People are also a very important component of the fire equation. Many fires are either deliberately or accidentally lit, and in places where population density is high, the probability of a fire igniting increases close to roads and settlements (Willis 2005; Penman et al. 2013). Some of Australia's most catastrophic bushfires have been ignited by powerline faults. But people also play an important role in reducing fire risk, by vegetation management including prescribed burning to reduce fuel



1939 Widespread across Victoria including; Warburton, Erica, Rubicon, Dromana, Manfield, the Otway ranges and the Grampian Ranges.

1944 Central and western districts, Morwell, Yallourn

1977 Western Districts

1983 Victoria and South Australia including; Dandenong Ranges east of Melbourne, Macedon areas northwest of Melbourne

1997 Dandenong ranges, Creswick, Heathcote, Teddywaddy, Gough's Bay

2003 North East and Gippsland

2006 Grampian ranges

2006–07 Great divide complex

January 2009 Delburn

February 2009 Churchill, Kilmore and Murrundindi, Vectis (Horsham), Coleraine, Weerite, Redesdale, Harkaway, Upper Ferntree Gully, Maiden Gully / Eaglehawk, Lynbrook / Narre Warren, Beechworth

Source: CFA 2012

Figure 3: Ten major bushfires in VIC that have damaged homes, property, land and resulted in loss of life since 1939

load and conducting fire suppression activities. Interventions such as total fire ban days also play a pivotal role in reducing ignitions under dangerous fire conditions (Climate Council 2014a).

Victoria is no stranger to bushfires. The state has been affected by bushfires throughout its history (see Figure 3). A study of significant Australian bushfires from 1900–2008 found that over half of all known fatalities due to bushfires in Australia have occurred in Victoria (296 deaths). Extreme fires have also destroyed and damaged property more frequently in Victoria than in any other state (Haynes et al. 2010). Significant bushfires in Victoria's recent history that have damaged property and resulted in loss of life include the Ash Wednesday and Black Saturday fires (see Figure 3 and Table 2). Ash Wednesday occurred in February 1983 in Victoria and South Australia. The fires claimed a total of 75 lives (47 in Victoria, 28 in South Australia) and over 2,300 homes were destroyed (BoM 2011). The Black Saturday bushfires occurred in February 2009, killing 173 people and destroying over 2000 homes (CFA 2012).

2. What is the link between bushfires and climate change?

Figure 4: Aftermath of the Black Saturday bushfires, Victoria

A fire needs to be started (ignition), it needs something to burn (fuel) and it needs conditions that are conducive to its spread (weather) (Section 1). Climate change can affect all of these factors in both straightforward and more complex ways.

The role of climate change in ignition is likely to be relatively small compared to the fuel and weather, but may still be significant. For example, lightning accounts for about 25% of the ignitions in Victoria (Attiwill and Adams 2011) and the incidence of lightning is sensitive

to weather conditions, including temperature (Jayaratne and Kuleshov 2006). Climate change can also affect fuel. For example, a lack of rainfall can dry out the soil and vegetation, making existing fuel more combustible. But whilst climate change can affect ignition and fuel, it is the impact of climate change on weather that has the most significant influence on fire activity (Climate Council 2014a).

Very hot, dry and windy days create very high bushfire risk. The most direct link between bushfires and climate change therefore comes from the relationship between the long-term trend towards a warmer climate due to increasing greenhouse gas emissions – the increasing amount of heat in the atmosphere – and the incidence of very hot days. Put simply, climate change is increasing the frequency and severity of very hot days (IPCC 2012; 2013), and is driving up the likelihood of very high fire danger weather (see Section 3). The Black Saturday fires in Victoria were preceded by a decade-long drought with a string of record hot years, coupled with a severe heatwave in the preceding week. The weather conditions on February 7th broke temperature records, with maximum temperatures up to 23°C above the February average in Victoria and record high temperatures for February set in over 87% of the state (BoM 2009a; BoM 2009b). In addition the FFDI ranged from 120 to 190, the highest vales ever recorded (Karoly 2009).

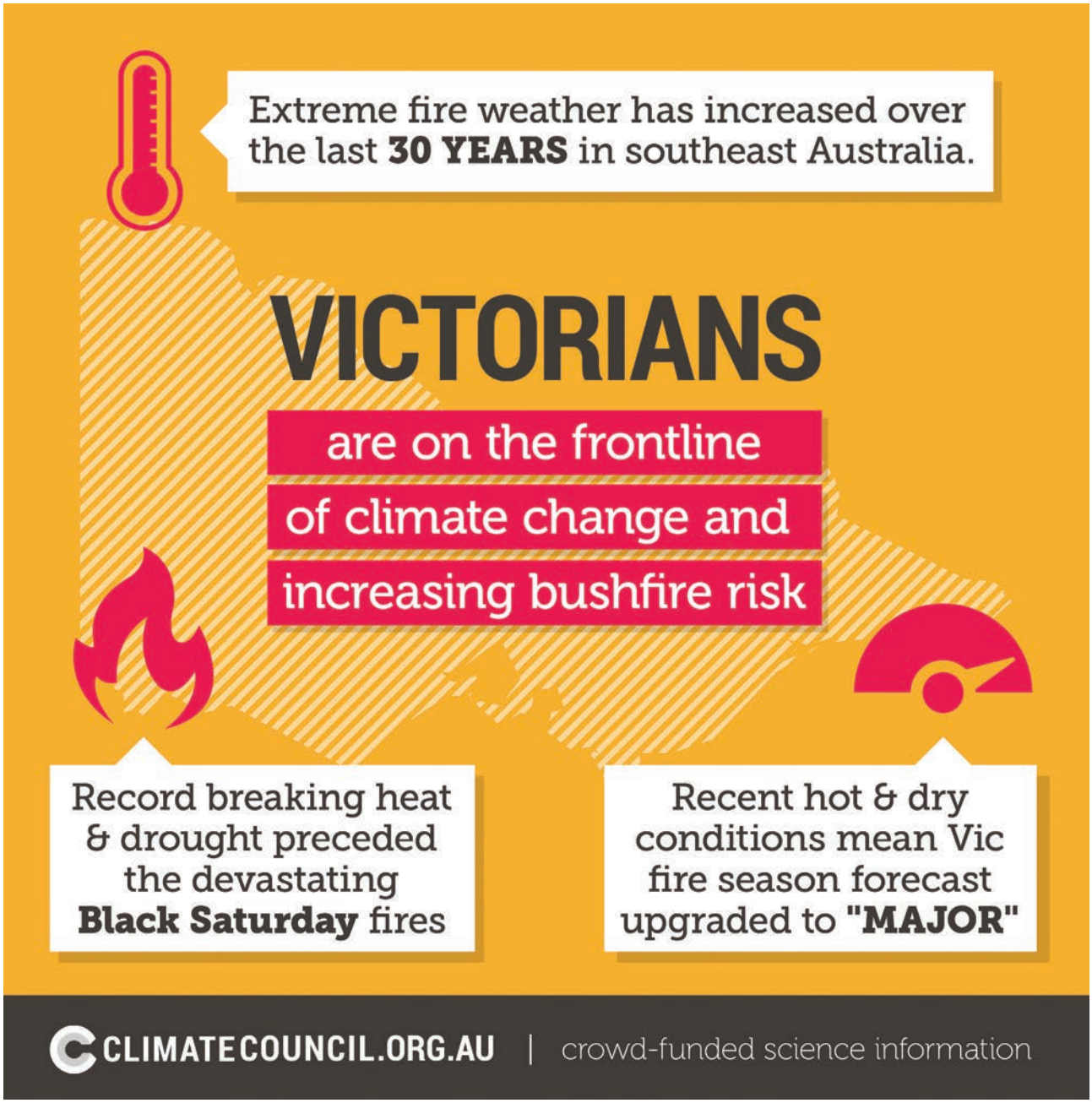


Figure 5: Climate change and the bushfire threat in Victoria

It is important to note that climate change is already increasing the intensity and frequency of many extreme events such as very hot days and droughts. The strength of trends and the confidence in their attribution, however, varies between regions and between different types of event (IPCC 2012; 2013; 2014). Extreme weather events, like bushfires, are influenced by a number of different factors. That's why asking if a weather event is "caused" by climate change is the wrong question. *All* extreme weather events are now being influenced by climate change because they are occurring in a climate system that is hotter and moister than it was 50 years ago (Trenberth 2012). The latest IPCC report confirms with high confidence (95% likelihood) that climate change is expected to increase the number of days with very high and extreme fire weather, particularly in southern Australia (IPCC 2014).

"Climate change is expected to increase the number of days with very high and extreme fire weather, particularly in southern Australia".

3. Observations of changing bushfire danger weather in Victoria

Increasing hot days, heatwaves and rainfall deficiencies in Victoria are driving up the likelihood of very high fire danger weather in the state.

While hot weather has always occurred in Australia's southeast, it has become more common and severe over the past few decades, including in Victoria (see Figure 7). The southeast of Australia has experienced significant warming during the last 50 years (Timbal et al. 2012). 2013 was the hottest year on record and during the summer of 2013–14 Victoria experienced its hottest four days on record from the 14–17th of January. Melbourne set a record for four consecutive days at 41°C and above, and two nights in a row at 27°C or above (BoM 2014a; Climate Council 2014b). Heatwaves in Victoria are increasing in frequency, intensity and duration.

For example, in Melbourne from 1951–2011, the average intensity of heatwaves has increased by 1.5°C and the average intensity of the peak day during a heatwave has increased by 2°C (Climate Council 2014c). This has implications for bushfire danger weather; for example the heatwave prior to the 2009 Black Saturday bushfires was notable both for its peak intensity and duration, with maximum temperatures up to 23°C above the February average in Victoria (BoM 2009a; BoM 2009b). The IPCC projects with virtual certainty that warming in Australia will continue throughout the 21st century and predicts with high confidence that bushfire danger weather will increase in most of southern Australia, including Victoria (IPCC 2014).

Figure 6: Cars destroyed in the Black Saturday bushfires, Victoria

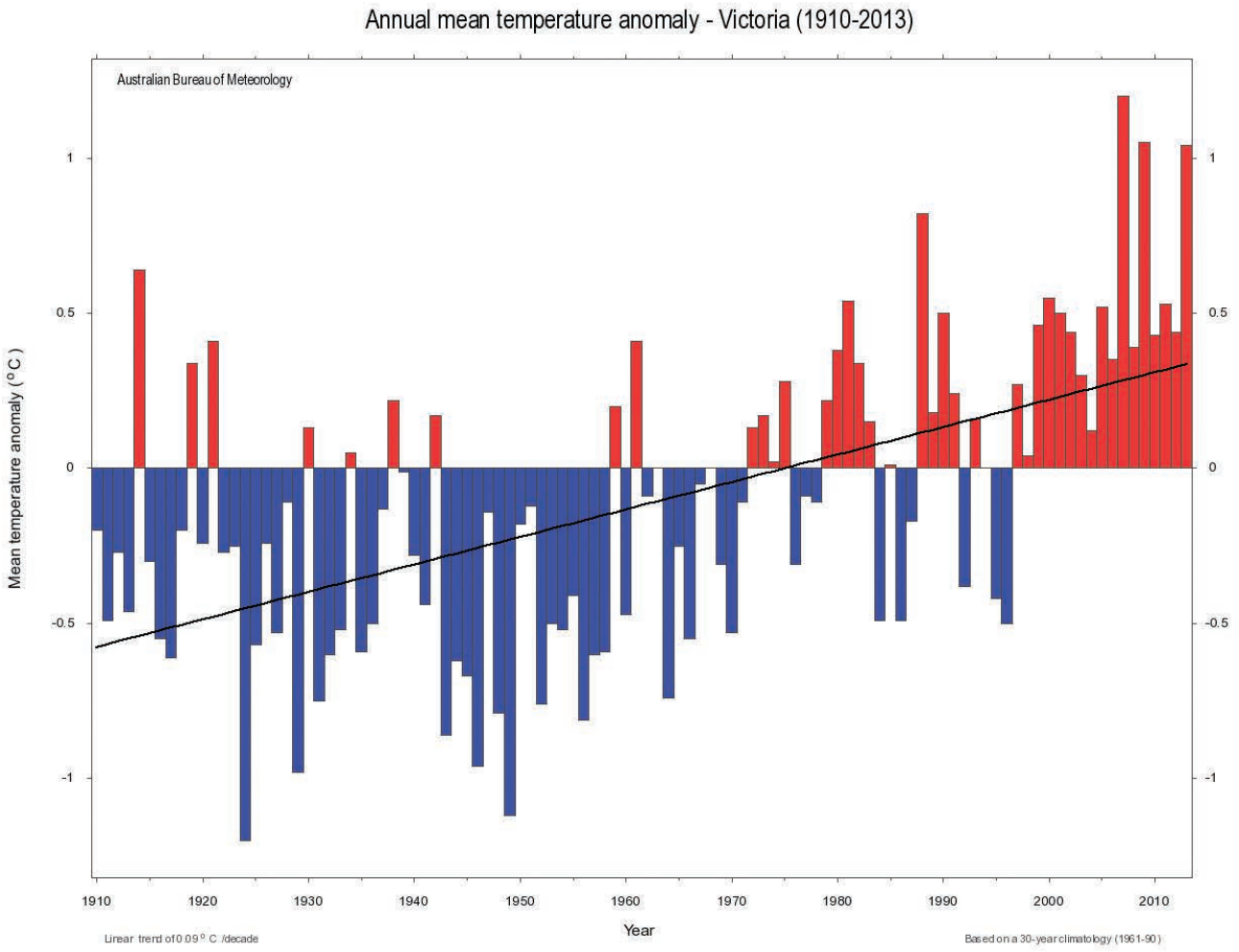


Figure 7: Victoria's increasing heat (Australian Bureau of Meteorology). Blue bars indicate years where annual temperatures were below average, and red bars indicate years of above average temperatures.

“Rainfall has declined in southeast Australia over the last 20 years”.

Much of eastern Australia has become drier since the 1970s, with the southeast experiencing a drying trend due to declines in rainfall combined with increased temperatures (BoM 2013; Climate Commission 2013). Since the mid-1990s, southeast Australia has experienced a 15 percent decline in late autumn and early winter rainfall and a 25 percent decline in average rainfall in April and May (CSIRO & BoM 2014). It is very likely that an increased incidence of drought in the southeast-coupled with consecutive hot and dry days – will in turn result in longer fire seasons and an ever larger number of days of extreme fire danger in coming decades (e.g. Clarke et al. 2011; 2013).

“Bushfires continue to increase in number, burn for longer and affect larger areas of land”.

The concept of a ‘normal’ bushfire season is rapidly changing as bushfires continue to increase in number, burn for longer and affect larger areas of land (Bushfire and Natural Hazards CRC 2014a). The influence of hotter, drier weather conditions on the likelihood of bushfire spread in Victoria is captured by changes in the Forest Fire Danger Index (FFDI), an indicator of extreme fire weather. Some regions of Australia, especially in the south and southeast (Victoria, South Australia and New South Wales) have already experienced a significant increase in extreme fire weather since the 1970s, as indicated by changes in the FFDI. The FFDI increased significantly at 16 of 38 weather stations across Australia between 1973 and 2010, with none of the stations recording a significant decrease (Clarke et al. 2013). These changes have been most marked in spring, indicating a lengthening fire season across southern Australia, with fire weather extending into October and March. The lengthening fire season means that opportunities for fuel reduction burning are decreasing (Matthews et al. 2012).

Victoria is currently experiencing persistent rainfall deficiencies, with severe deficiencies (lowest 5% of records) emerging in parts of Victoria over the last 11-months. Below average October rainfall across much of eastern Australia has also worsened rainfall deficiencies over the last four months in northern Victoria (BoM 2014b).

The Australia Seasonal Bushfire Outlook for 2014–15, issued in September 2014, anticipates the severity of the bushfire season in different states. For the first time this outlook has been reissued (November 2014) due to unseasonably hot, dry weather in Australia's southeast (See Figure 8). Victoria's 2014–15 bushfire season outlook has been upgraded from an above normal fire season to a major fire season. All Victorian districts, except the Mallee and East Gippsland, may expect above normal fire potential (Bushfire and Natural Hazards CRC 2014b).

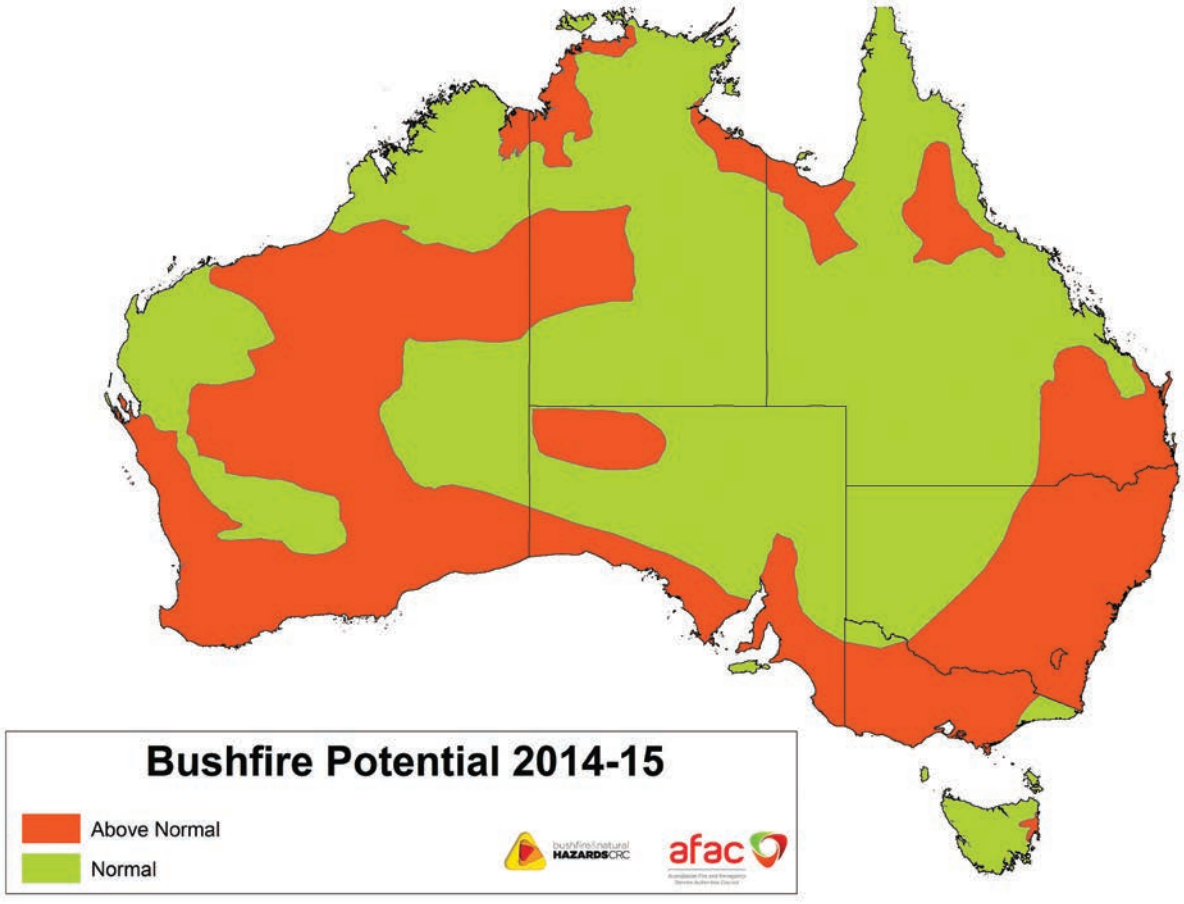


Figure 8: The Updated Australia Seasonal Bushfire Outlook (Bushfire and Natural Hazards CRC 2014b)

4. Future projections of fire activity in southeast Australia

Research aimed at understanding future fire activity in Australia's southeast has a long history (Table 1). While the detailed results of these studies vary due to the use of different global circulation models (GCMs) and different emission scenarios, their collective conclusion is clear – weather conditions conducive to fire in the southeast and southwest of the continent are becoming increasingly frequent and this trend will continue. From the 1980s scientist's projections have demonstrated that bushfire conditions would be elevated as global temperatures increased from rising greenhouse gases.

Future changes in the El Niño-Southern Oscillation (ENSO) phenomenon are also likely to have an influence on fire activity. El Niño events worsen fire weather conditions and increase actual fire activity in southeast and central Australia (Williams and Karoly 1999; Verdon et al. 2004; Lucas 2005; Harris et al. 2013). Significant changes have occurred in the nature of ENSO since the 1970s, with the phenomenon being more active and intense during the 1979–2009 period than at any other time in the past 600 years (Aiken et al. 2013). It is likely that climate change is and will continue to influence ENSO behaviour, although there is currently no consensus on the nature, extent or direction of this influence. Recent projections suggest increases in El Niño-driven drying in the western Pacific Ocean by mid-to late 21st century (Power et al. 2013); such a change would increase the incidence of heat and drought, and potentially increase fire activity in eastern Australia.

SUMMARY OF PROJECTIONS FROM MODELLING STUDIES INVESTIGATING CHANGES IN FIRE RISK IN SOUTHEAST AUSTRALIA.

Study	Projections
Beer et al. (1988)	10%–20% increase in FFDI in southeast Australia
Beer and Williams (1995)	Increase in FFDI with doubling of atmospheric CO_2, commonly >10% across most of continent, especially in the southeast, with a few small areas showing decreases
Williams et al. (2001)	General trend towards decreasing frequency of low and moderate fire danger rating days, but an increasing frequency of very high and in some cases extreme fire danger days
Hennessy (2007)	Potential increase of very high and extreme FFDI days 4%–25% by 2020, 15%–70% by 2050
Lucas et al. (2007)	Increases in annual FFDI of up to 30% by 2050 over historical levels in southeast Australia and up to a trebling in the number of days per year where the uppermost values of the index are exceeded. The largest changes projected to occur in the arid and semi-arid interior of NSW and northern Victoria.
Hasson et al. (2009)	Analysed likelihood of increase in incidence of synoptic weather pattern in southeast Australia known to be associated with extreme fire events. Projected potential frequency of extreme events to increase from around 1 event every 2 years during the late 20th century to around 1 event per year in the middle of the 21st century, and to around 1 to 2 events per year by the end of the 21st century
Clarke et al. (2011)	FFDI projected to decrease or show little change in the tropical northeast. In the southeast, FFDI projected to increase strongly by end of the 21st century, with the fire season extending in length and starting earlier
Matthews et al. (2012)	Warming and drying climate projected to produce drier, more flammable fuel, and to increase rate of fire spread
Jones et al. (2013)	Projected increases in FFDI for Melbourne area

Table 1: Summary of projections from modelling studies investigating changes in fire risk in southeast Australia.

5. Impacts of Bushfires in Victoria

Bushfires have had a very wide range of human and environmental impacts, including loss of life and severe health effects, damage to property, devastation of communities and effects on water and natural ecosystems (Stephenson 2010).

5.1 Health Impacts

"From 1900–2008 over half of all known bushfire fatalities in Australia occurred in Victoria".

Populations in Victoria are at risk from the health impacts of bushfires, which have contributed to physical and mental illness as well as death.

Tragically, in Australia bushfires have accounted for more than 800 deaths since 1850 (Cameron et al. 2009; King et al. 2013), with more than half of the deaths (1900–2008) occurring in Victoria (296 deaths) (Haynes et al. 2010). The Black Saturday bushfires in Victoria in February 2009 accounted for 173 deaths, ranking as one of the world's ten most deadly recorded bushfires (Teague et al. 2010). A large proportion of the fatalities (44%) were children younger than 12 years old, people over 70 years and those with either chronic or acute disabilities (O'Neill and Handmer 2012).

In addition to fatalities, bushfire smoke can seriously affect health. Smoke contains not only respiratory irritants, but also inflammatory and cancer-causing chemicals (Bernstein and Rice 2013). Smoke can be transported in the atmosphere for hundreds or even thousands of kilometres from the fire front, exposing large populations to its impacts (Spracklen et al. 2009; Dennekamp and Abramson 2011; Bernstein and Rice 2013). For example in Melbourne, cardiac arrests outside hospitals increase by almost 50% on bushfire smoke-affected days (Dennekamp et al. 2011). Firefighters are also faced with higher risks to their long-term health with an elevated chance of developing a variety of cancers (Youakim 2006). The impacts of bushfire smoke in the community are also uneven, with the elderly, infants and those with chronic heart or lung diseases at higher risk (Morgan et al. 2010).

In addition to physical health impacts, the trauma and stress of experiencing a bushfire can also increase depression, anxiety, and other mental health issues, both in the immediate aftermath of the trauma and for months or years afterwards (McFarlane and Raphael 1984; Sim 2002; Whittaker et al. 2012). For example, a study conducted 3–4 years after the Black Saturday bushfires in Victoria found that some members of the affected community developed Post Traumatic Stress Disorder (PTSD), major depressive episodes and increased alcohol use (Bryant et al. 2014). A study of over 1500 people who experienced losses in the 1983 Ash Wednesday bushfires found that after 12 months, 42% were suffering a decline in mental health ("psychiatric morbidity") (McFarlane et al. 1997). PTSD, major depression, anxiety and suicide can also manifest among firefighters, sometimes only becoming evident many months after an extreme event (McFarlane 1988; Cook et al. 2013).

Figure 9: Bushfire smoke blankets Melbourne in 2006

5.2 Economic Costs

The economic cost of bushfires – including loss of life, livelihoods, property damage and emergency services responses – is very high. The total economic cost of bushfires, a measure that includes insured losses as well as broader social costs, is estimated to be $337 million per year in Australia (2011$), a figure that is expected to reach $800 million by around 2050 (Deloitte Access Economics 2014). The total economic costs of bushfires in Victoria for 2014 are projected to be $172 million (2011$). By about mid century these costs will more than double, potentially reaching $378 million (Deloitte Access Economics 2014). These estimates take into account increases in the number of households, growth in the value of housing stock, population growth and increasing infrastructure density. These estimates do not, however, include the potential for climate change to increase bushfire frequency or intensity, so must be considered conservative. Even though Victoria comprises only 3% of the country's landmass, it has sustained around 50% of the economic damage from bushfires (Buxton et al. 2011).

"Even though Victoria comprises only 3% of the country's landmass, it has sustained around 50% of the economic damage from bushfires".

RECORDED LOSSES FROM MAJOR BUSHFIRE EVENTS IN VICTORIA SINCE 1939

Date	**FIRE EVENT**	Location	**LOSSES** (including residential property, stock)	Deaths	**SIGNIFICANT INSURED LOSSES** (normalised to 2011 values)[1]
1939	Black Friday	Widespread across Victoria including; Warburton, Erica, Rubicon, Dromana, Manfield, the Otway ranges and the Grampian Ranges.	1000+ homes (*ABS 2004; AIC 2004*)	71 (*AIC 2004; Reuters 2009*)	n/a
1977		Victoria, Western Districts	>100 homes (*CFA 2012*)	4 (*CFA 2012*)	$ 101 million (*ICA 2013*)
1983	Ash Wednesday	Victoria and South Australia including; Dandenong Ranges east of Melbourne, Macedon areas northwest of Melbourne	>2,300 homes (Ramsay et al. 1996; AIC 2004; McAeney et al 2009) >200,000 stock (Ramsay et al. 1996; AIC 2004)	75 (*AIC 2004; Reuters 2009*)	$1.796 billion (*ICA 2013*)
2003	Gippsland Fires	Victoria, North East and Gippsland fires	>41 homes >10,000 livestock (*CFA 2012*)	0 (*CFA 2012*)	$24 million (*ICA 2013*)
2006	Grampians Fires	Victoria, Grampian ranges	> 40 homes >65,000 stock (*CFA 2012*)	2 (*CFA 2012*)	$28 million (*ICA 2013*)
2009	Black Saturday	Churchill, Kilmore and Murrundindi, Vectis (Horsham), Coleraine, Weerite, Redesdale, Harkaway, Upper Ferntree Gully, Maiden Gully / Eaglehawk, Lynbrook / Narre Warren, Beechworth	>2000 houses (*CFA 2012; Stephenson et al. 2013*) 8000–11,800 stock (*Teague et al 2010; Stephenson et al. 2013*)	173 (*Teague et al. 2010; Stephenson et al 2013*)	$ 1.266 billion (*ICA 2013*)

Table 2: Recorded losses from major bushfire events in Victoria since 1939.

1. Insured losses shown have been normalized to 2011 values (taking inflation and wealth changes into account).

Bushfires can cause direct damage to properties; for example, the Black Saturday bushfires destroyed over 2000 homes (see Table 2). Infrastructure such as powerlines and roads can also be damaged. In the 2003 alpine fires in Victoria, for example, about 4,500 km of roads were damaged and local businesses reported a 50–100% economic downturn in the fire aftermath (Stephenson 2010).

Bushfires have significant impacts in farming areas. For example, livestock losses were estimated at 13,000 in the 2003 Alpine fires in Victoria, 65,000 in the 2005–6 Grampians fire and more than 11,000 in the Black Saturday fires (Stephenson 2010; Teague et al. 2010). Stock that survives the initial bushfires can face starvation in the post-fire period, as well as threats from predators due to the destruction of fences around properties (Stephenson 2010). Over 8,000 km of fences were lost in the Black Saturday fires (Stephenson 2010). Smoke damage can also taint fruit and vegetable crops, with wine grapes particularly susceptible (Stephenson 2010).

A study by Keating and Handmer (2013) provides one of the few full economic assessments of bushfire impacts on primary industry. This study conservatively estimated that bushfires directly cost the Victorian agricultural industry around $42 million per year. When business disruption was included more broadly, the costs to the entire Victorian economy from this impact were estimated to be $92 million per year. A similar analysis for the Victorian timber industry estimated direct costs at $74 million per year, and state-wide costs at $185 million (Keating and Handmer 2013). In the future, with no adaptive change, increased damage to the agricultural industry in Victoria by 2050 could add $1.4 billion (or $46.6 million per year) to the existing costs of $92 million per year (Keating and Handmer 2013). Similarly, the additional cost of bushfires to the Victorian timber industry is estimated to be $2.85 billion ($96.2 million per year), over and above the present day estimate of $185 million per year.

"Bushfires directly cost the Victorian agricultural industry around $42 million per year".

It is important to note that these economic losses do not account for the full range of costs associated with bushfires – few attempts have been made to account for loss of life, social disruption and trauma, opportunity costs for volunteer fire fighters, fixed costs for bushfire fighting services, government contributions for rebuilding and compensation, impacts on health, and ecosystem services (King et al. 2013).

Figure 10: A firefighter observes the wreckage of a home in Kinglake, Victoria

5.3 Environmental Impacts

Fire can affect the quality and quantity of water in catchments and have significant impacts on ecosystems.

5.3.1 IMPACT ON WATER QUALITY AND QUANTITY

Large-scale high intensity fires that remove vegetation expose topsoils to erosion and increased runoff after subsequent rainfall (Shakesby et al. 2007). This can increase sediment and nutrient concentrations in nearby waterways, potentially making water supplies unfit for human consumption (Smith et al. 2011; IPCC 2014). During the Black Saturday fires 10 billion litres of Melbourne's drinking water was pumped to safer storage locations because of fears it would be contaminated (Johnston 2009). Fire also has longer-term affects on water flow in forested catchments. Immediately after the fire there may be an increase in water flow. But as the forests regenerate, the new growth usually uses more water than the mature trees they have replaced (Langford 1976, Feikema et al. 2013). Seven years after the 2003 fires in the mountain ash forests of Victoria, the regrowth was still using twice the water of adjacent mature forest (Buckley et al. 2012). This pattern, known as the "Kuczera effect", can last for several decades after a fire, with water yields from forested catchments being reduced by up to 50% (Kuczera 1985; Brookhouse et al. 2013). Fires can also affect water infrastructure; the Black Saturday bushfires in 2009 affected about 30% of the catchments that supply Melbourne's drinking water. Melbourne Water estimated the post-fire recovery costs, including water-monitoring programs, to be over $2 billion (WRF 2013).

Figure 11: Bushfire smoke at the Upper Yarra Dam, Victoria.

5.3.2 IMPACTS ON ECOSYSTEMS

Fire is a regular occurrence in many Australian ecosystems, and many species have evolved strategies over millions of years to not only withstand fire, but to benefit from it (Crisp et al. 2011; Bowman et al. 2012). Fire does not "destroy" bushland, as is often reported; rather, it acts as a major disturbance with a range of complex impacts on different species and communities. Particular fire regimes (especially specific combinations of fire frequency and intensity) can favour some species and disadvantage others. If fires are too frequent, plant species can become vulnerable to local extinction as the supply of seeds in the soil declines. Conversely, if the interval between fires is too long, plant species that rely on fire for reproduction may be eliminated from an ecological community. Animals are also affected by bushfires, for example if they are restricted to localised habitats and cannot move quickly, and/or reproduce slowly, they may be at risk from intense large-scale fires that occur at short intervals (Yates et al. 2008).

Ecosystems in which the natural fire interval is very long (>100 years) can undergo substantial change if the fire frequency increases. After successive fires in 2003 and 2006–7 in Victoria, Acacia shrublands have replaced some mountain and alpine ash forests because there was insufficient time between fires for the ash trees to become reproductively mature (Lindenmayer et al. 2011; Bowman et al. 2013). This change in vegetation has important flow-on effects for other species, especially the ~40 vertebrate species that rely on the hollows of 120–150 year old mountain ash trees for habitat, such as the endangered Leadbeater's possum; an estimated 42% of the possum's habitat was burned in the 2009 bushfires (Lindenmayer 2013) (Figure 12).

Figure 12: The Black Saturday 2009 bushfires affected much of the habitat of the already endangered Leadbeater's possum.

6. Implications of increasing fire activity

"Melbourne's rural-urban fringe is among the most vulnerable in the world to the bushfire hazard".

The risk that bushfires pose to people are particularly acute in southern Australia, where large populations live close to highly flammable native vegetation that is exposed to frequent severe fire weather. The population of Victoria could potentially grow to 10 million by 2051, with 2.2 million in Victoria's regions and 7.8 million in Greater Melbourne (Victorian Government 2014). Melbourne's rural-urban fringe is among the most vulnerable in the world to the bushfire hazard (Buxton et al. 2011). The population of Melbourne is continuing to spread, encroaching into surrounding bushland, increasing risk to life and property from bushfires. For example, many of the homes destroyed in Marysville and Kingslake, two communities devastated by the 2009 Victorian bushfires, were either surrounded by or located less than 10 metres from bushland (Chen and McAneney 2010; Crompton et al. 2010).

The increasing population and built assets, coupled with increasing fire danger weather, present significant and growing challenges for the state. Already fire prone regions are becoming more fire prone and risks to lives and property continue to increase in parts of Victoria. Hard decisions will have to be made about the on-going livability of those regions, as they become increasingly dangerous to live in.

The economic, social and environmental costs of increasing bushfire activity in Victoria are potentially immense. As noted in Section 5.2, an analyses of projected costs of bushfires in Victoria by Deloitte Access Economics (2014) forecast that bushfires in Victoria could cost $378 million by about mid-century (2011$), based only on population and asset increases, but not including increased risk due to climate change.

"The economic, social and environmental costs of increasing bushfire activity in Victoria are potentially immense".

There is increasing interest in how adaptation to an increasingly bushfire-prone world may reduce vulnerability. Current initiatives centre on planning and regulations, building designs to reduce flammability, burying powerlines in high risk areas, retrofitting electricity systems, fuel management, fire detection and suppression, improved early warning systems, and community education (Preston et al. 2009; Buxton et al. 2011; O'Neill and Handmer 2012; King et al. 2013). Responses to bushfires can be controversial, particularly the practice of prescribed burning, where fires are lit in cool weather to reduce the volume of fuel. Fire managers are constantly faced with the challenge of balancing the need to reduce risk to life and property whilst simultaneously conserving biodiversity and environmental amenity, and controlling air pollution near urban areas (Penman et al. 2011; Williams and Bowman 2012; Adams 2013; Altangerel and Kull 2013). In the wake of the Black Saturday bushfires, the Royal Commission recommended treating at least 5% of Victorian public land per year (and up to 8%) by prescribed burning (Teague et al. 2010). The "5% solution" is being imported to some other states, even though fire ecologists stress that the frequency and amount of prescribed burning required to reduce risk varies greatly between different landscapes (Penman et al. 2011; Williams and Bowman 2012). The Tasmania Bushfire Inquiry noted that a strategic approach to prescribed burning was "preferable to a quantitative target" (TBI 2013). The prospect of increasing fire risk as the climate warms brings the prescribed burning issue into even sharper focus. The increasing length of the fire season will reduce the window of opportunity for hazard reduction at the same time as the need for hazard reduction becomes greater.

"Australia's fire and emergency services agencies have recognised the implications of climate change for bushfire risk and fire-fighting resources for some time".

Australia's fire and emergency services agencies have recognised the implications of climate change for bushfire risk and fire-fighting resources for some time (AFAC 2009; 2010). Longer fire seasons have implications for the availability and costs of fire-fighting equipment that is leased from fire fighting agencies in the Northern Hemisphere. As fire seasons in the two hemispheres increasingly overlap, such arrangements may become increasingly impractical (Handmer et al. 2012). Substantially increased resources for fire suppression and control will be required. Most importantly, a significant increase in the number of both professional and volunteer firefighters will be needed. To keep pace with asset growth and population, it has been estimated that the number of professional firefighters in Victoria will need to increase from approximately 2,400 in 2010 to 3,000 by 2020 and 3,700 by 2030. When the increased incidence of extreme fire weather under a realistic warming scenario is also taken into account, a further 500 firefighters will be needed by 2020, and 900 by 2030 – this represents an overall doubling of numbers compared to 2010 (NIEIR 2013).

"In Victoria the number of professional firefighters will need to double by 2030, to keep pace with increased population, asset growth, and fire risk from climate change".

Figure 13: The Victorian Country Fire Authority on patrol

7. This is the Critical Decade

The impacts of climate change are already being observed. Sea levels are rising, oceans are becoming more acidic, and heatwaves have become longer and hotter. Greenhouse gases from human activities, particularly the burning of fossil fuels, is the primary cause for the changes in climate over the past half-century (IPCC 2013; 2014).

Projections of future climate change and its impacts have convinced nations that the global average temperature, now at 0.9°C above the pre-industrial level, must not be allowed to rise beyond 2°C – the so-called '2°C guardrail'. Societies will have to adapt to even more serious impacts as the temperature rises. For Victoria, these impacts include increased fire danger weather and longer bushfire seasons. Ensuring that this guardrail is not exceeded will prevent even worse impacts from occurring.

The evidence is clear and compelling. The trend of increasing global emissions must be halted within the next few years and emissions must be trending downwards by 2020. Investment in renewable, clean energy must therefore increase rapidly. And, critically, most of the known fossil fuel reserves must remain in the ground.

This is the critical decade to get on with the job.

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IMAGE CREDITS

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Preparing for a Bushfire in Victoria

IN AN EMERGENCY, CALL TRIPLE ZERO (000) (106 FOR PEOPLE WITH A HEARING OR SPEECH IMPAIRMENT)

000

What can I do to prepare for a bushfire?

INFORM YOURSELF

The Victorian Country Fire Service has the resources available to help you prepare for a bushfire. Use these resources to inform yourself and your family.

ASSESS YOUR LEVEL OF RISK

The excellent resources of the Victorian Country Fire Service are available to assist you to assess your level of risk from bushfire. Take advantage of them. Visit: http://www.cfa.vic.gov.au/plan-prepare/am-I-at-risk/

MAKE A BUSHFIRE SURVIVAL PLAN

Even if your household is not at high risk from bushfire (such as suburbs over 1 km from bushland), you should still educate yourself about bushfires, and take steps to protect yourself and your property. Access the bushfire ready self assessment tool: http://www.cfa.vic.gov.au/plan-prepare/fire-ready-kit/

PREPARE YOUR PROPERTY

Regardless of whether you decide to leave early or to stay and actively defend, you need to prepare your property for bushfire, An important consideration is retrofitting older houses to bring them in alignment with current building codes for fire risk and assessing the flammability of your garden. Use the Victorian Country Fire Service Fire Ready Kit to help recognise exactly what you need to prepare your property: http://www.cfa.vic.gov.au/plan-prepare/fire-ready-kit/

PREPARE YOURSELF AND YOUR FAMILY

Preparation is not only about the physical steps you take to prepare – e.g., preparing your house and making a bushfire survival plan. Preparing yourself and your family also involves considering your physical, mental and emotional preparedness for a bushfire and its effects. Take the time to talk to your family and to thoroughly prepare yourself on all levels.

Key Links

VIC CFS:
http://www.cfa.vic.gov.au/
1800 240 667

Fire Ready Kit
http://www.cfa.vic.gov.au/plan-prepare/fire-ready-kit/

Fire Watch Map:
http://myfirewatch.landgate.wa.gov.au/