CLIMATE COUNCIL

BE PREPARED: CLIMATE CHANGE AND THE NSW BUSHFIRE THREAT

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Introduction

Residents of New South Wales (NSW) have often experienced the serious consequences of bushfires.

In 2013, bushfires in January and October burnt 768,000 hectares of land and destroyed 279 homes. Tragically, 2 people lost their lives and damages were in excess of an estimated $180 million.

Australians have always lived with fire and its consequences, but climate change is increasing fire danger weather and thus the risk of fires. In NSW the bushfire season has started early in 55 Local Government Areas and properties have already been destroyed. It is time to think very seriously about the risks that future fires will pose.

We begin this report by describing the background context of fire and its history in NSW. We then outline the link between bushfires and climate change, before considering how bushfire danger weather is intensifying in NSW 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 implications of bushfires for NSW fire managers, planners and emergency services.

Key Findings

1. **Climate change is already increasing the risk of bushfires in New South Wales (NSW).**
   - Extreme fire weather has increased over the last 30 years in NSW.
   - Hot, dry conditions have a major influence on bushfires. Climate change is making hot days hotter, and heatwaves longer and more frequent, with increasing drought conditions in Australia's southeast.
   - 2013 was Australia's hottest year on record and in NSW the annual mean temperature was 1.23°C above average. The summer of 2013/14 was also the driest summer that Sydney has experienced in 27 years. These conditions are driving up the likelihood of very high fire danger weather in the state.
   - Australia is a fire prone country and has always experienced bushfires. But 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.

2. **In NSW the fire season is starting earlier and lasting longer. Fire weather has been extending into Spring and Autumn.**
   - This year, the bushfire season has started early in parts of NSW. The state's statutory Bush Fire Danger Period begins on the 1st of October, but this year 55 Local Government Areas have started the season early with some beginning the danger period on the 1st of August and others on the 1st of September.
   - The fire season will continue to lengthen into the future, straining NSW's existing resources for fighting and managing fires.

3. **Recent severe fires in NSW have been influenced by record hot, dry conditions.**
   - Record breaking heat and hotter weather over the long term in NSW has worsened fire weather and contributed to an increase in the frequency and severity of bushfires.

- In October 2013, exceptionally dry conditions contributed to severe bushfires on the Central Coast and in the Blue Mountains of NSW, which early estimates suggest caused over $180 million in damages.
- At the beginning of August in 2014 volunteers were fighting 90 fires simultaneously and properties were destroyed.

4. The total economic costs of NSW bushfires in 2014 are projected to be $43 million. By around the middle of the century these costs will almost triple.

- Bushfires have caused significant economic damage, estimated at $337 million per year (2011$) in Australia. With a forecast growth in costs of 2.2% annually between 2014 and 2050, the total economic cost of bushfires is expected to reach $800 million annually by mid-century.
- These state and national projections do not incorporate increased bushfire incident rates due to climate change and could potentially be much higher.

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

- Fire severity and intensity is expected to increase substantially in coming decades, especially in those regions currently most affected by bushfires, and where a substantial proportion of the Australian population lives, such as NSW.
- Increased resources for our emergency services and fire management agencies will be required as fire risk increases. By 2030, it has been estimated that the number of professional firefighters in Australia will need to approximately double (compared to 2010) to keep pace with increased population, asset value, and fire danger weather.

6. This is the critical decade

- Australia must strive to cut 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

Figure 1: Hazard reduction burn in NSW

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).

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 (Climate Council 2014d). 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 the temperate forests of NSW, fire activity is strongly determined by weather conditions and the moisture content of the fuel. 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, typically occurring about every 5 to 30 years, with spring and summer being peak fire season (Clarke et al. 2011; Bradstock et al. 2012).

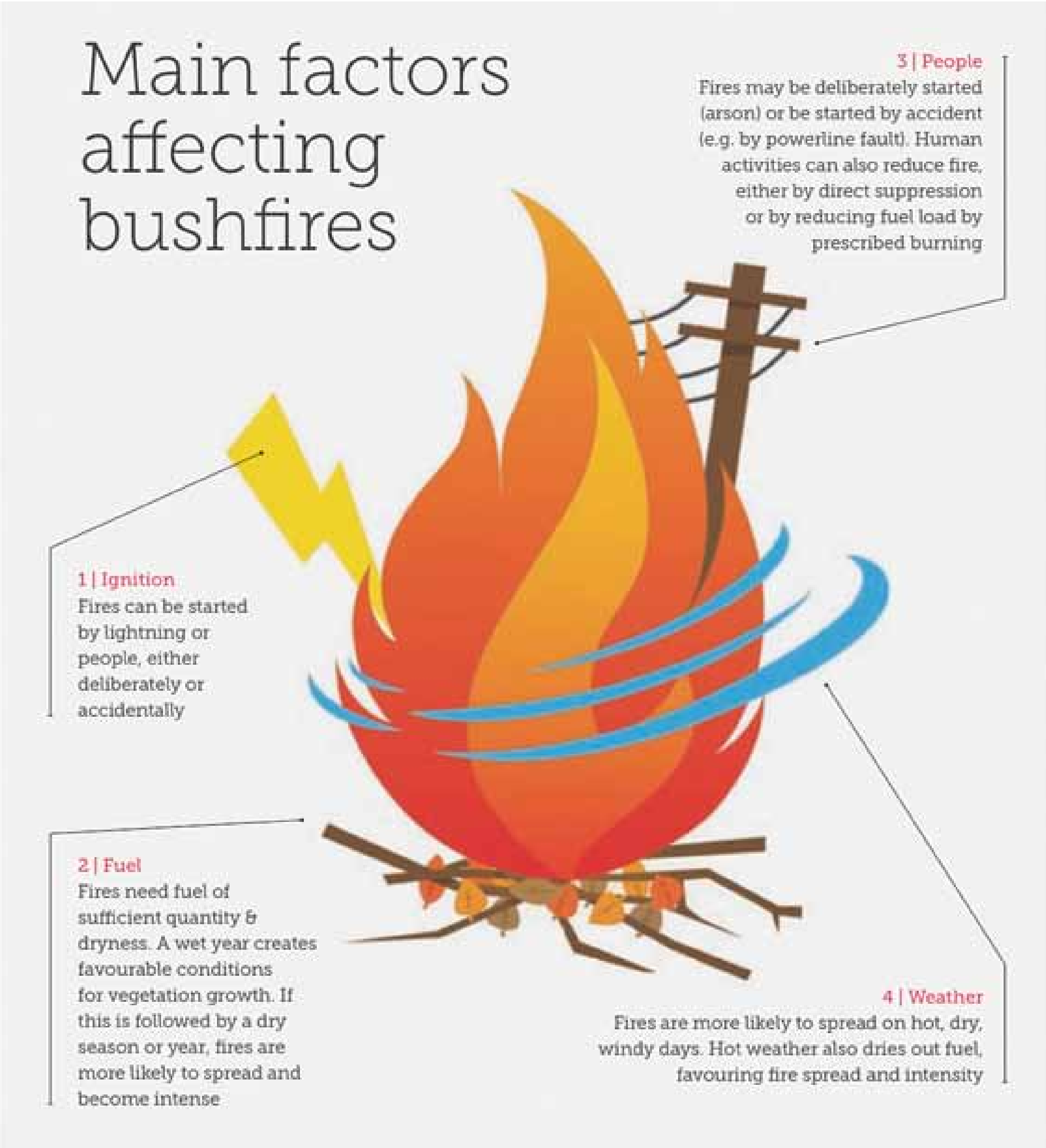

Figure 2: Main factors affecting bushfires

Since 1926, in NSW 27 significant bushfire events have affected hundreds of thousands of hectares of land and killed livestock, destroyed thousands of homes, and claimed 116 lives.

Since 1926, in NSW 27 significant bushfire events have affected hundreds of thousands of hectares of land and killed livestock, destroyed thousands of homes, and claimed 116 lives (NSW PRS 2014).

People are 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 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.

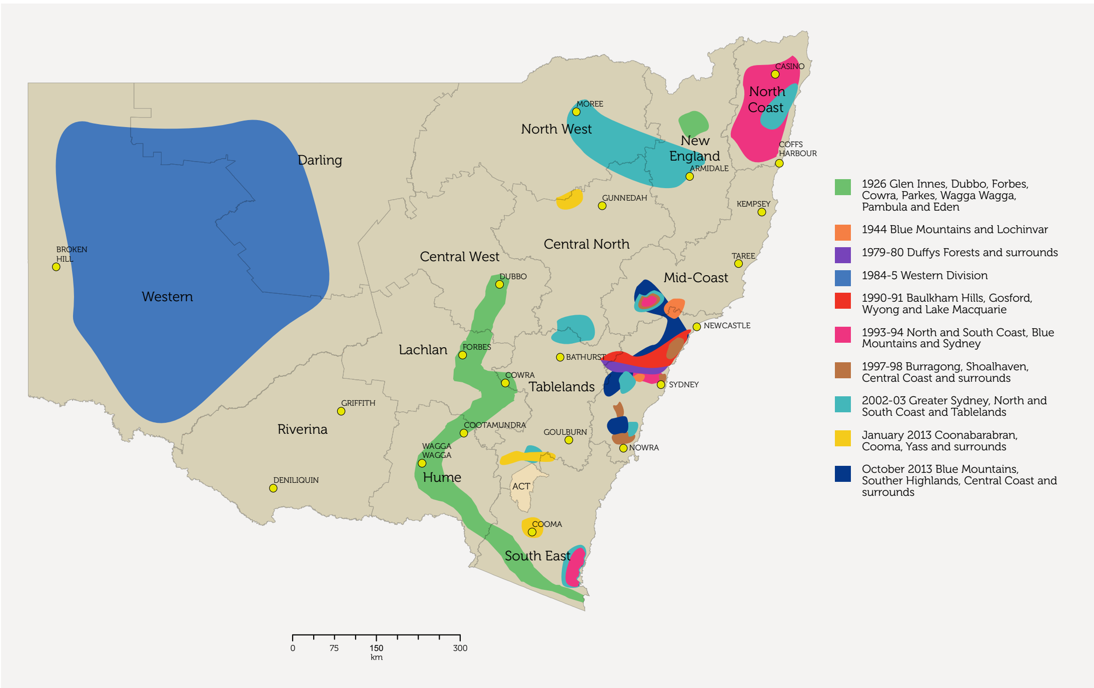

Figure 3: Ten major bushfires in NSW that have damaged homes, property, land and resulted in loss of life since 1926

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

Figure 4: The NSW Rural Fire Service in Belrose, NSW

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 ~27% of the ignitions in the Sydney region (Bradstock 2008) 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.

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 2013 October bushfires in the Blue Mountains of NSW illustrate the role of weather conditions in affecting fire severity. The bushfires were preceded by the warmest September on record for the state, the warmest 12 months on record for Australia, and below average rainfall in forested areas, leading to very dry fuels (Bushfire CRC 2013).

It is important to note that climate change is already increasing the intensity and frequency of some 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 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 NSW

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

While hot weather has always been common in Australia's southeast, it has become more common and severe over the past few decades, including in NSW (see Figure 5). The southeast of Australia has experienced significant warming during the last 50 years (Timbal et al. 2012). The summer of 2012/13 was the hottest on record nationally, with two intense and prolonged heatwaves in early January and March setting all time-high maximum temperatures in Sydney (Climate Council 2014c).

These heatwaves are becoming more intense over time, with average heatwave intensity increasing in Sydney by 1.5°C, since 1950 (BoM 2013a; Climate Council 2014c). Record high temperatures persisted into 2013, which proved to be Australia's hottest year on record, with the mean maximum temperature during the year 1.45°C above average (BoM 2014c; Climate Council 2014a). Temperatures soared in NSW, with annual mean temperature 1.23°C above average. The monthly average temperature record for NSW in September was shattered by 4.68°C and October was also the second warmest month on record in Sydney, at 3.6°C above the long-term average (BoM 2014d; Climate Commission 2013; Climate Council 2014a). 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 New South Wales (IPCC 2014).

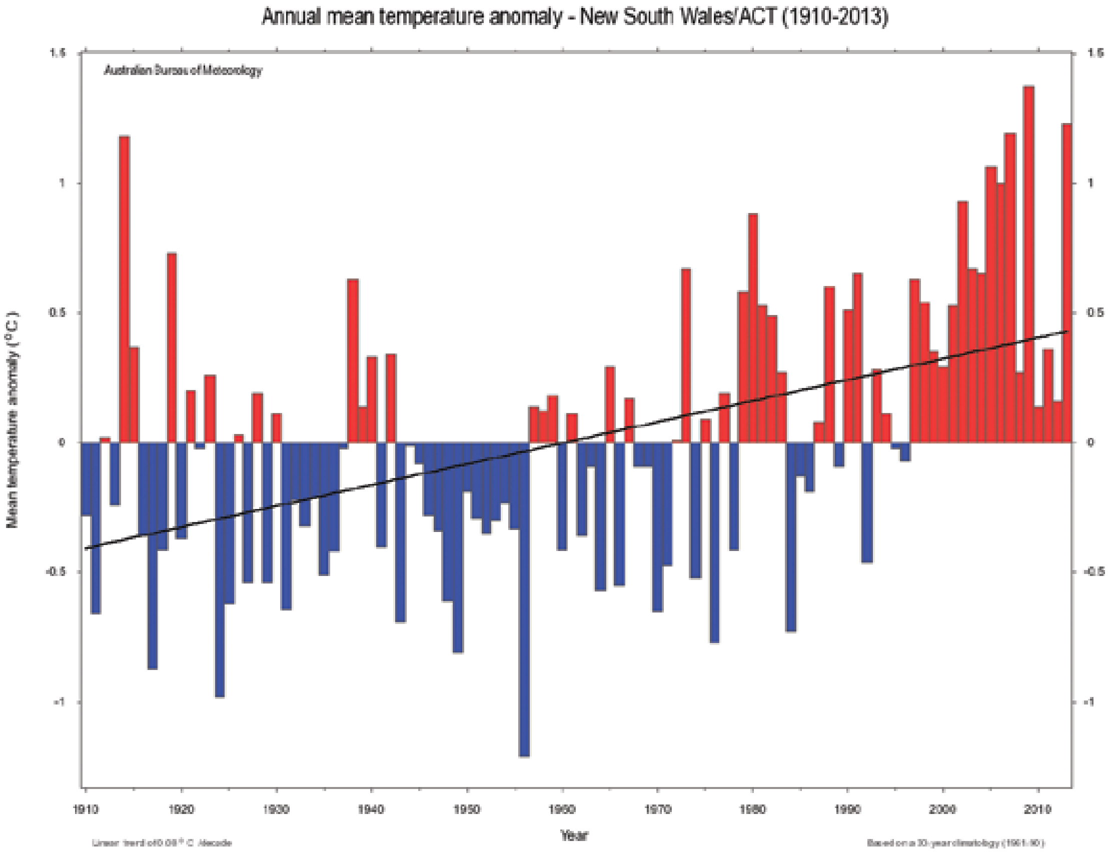

Figure 5: NSW/ACT increasing heat (Australian Bureau of Meteorology). Blue bars indicate years where annual temperatures were below average, and red bars indicate years of above average temperatures.

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 2013b; 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). Rainfall deficiencies for the eight months from December 2013 to July 2014 have increased in extent over northeastern NSW and the summer of 2013/14 was the driest summer that Sydney has experienced in 27 years (BoM 2014a; Climate Council 2014b). BoM projections indicate that this drying trend will persist this year, with a drier than normal October to December likely for most of eastern and northern NSW (BoM 2014b). This long-term rainfall deficit across southern Australia, coupled with above average temperatures, has reduced soil moisture and has lead to the drying of heavy fuels in forests, increasing bushfire potential in NSW (Bushfire and Natural Hazards CRC 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).

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.

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 2014). The influence of hotter, drier weather conditions on the likelihood of bushfire spread in NSW is captured by changes in the Forest Fire Danger Index (FFDI), an indicator of extreme fire weather. NSW has already experienced a significant increase in extreme fire weather since the 1970s, with the FFDI increasing significantly at 16 of 38 weather stations across Australia between 1973 and 2010, with the majority of these stations concentrated in Australia's southeast and 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.

This year the bushfire season has started early in parts of NSW. The state's statutory Bush Fire Danger Period begins on the 1st of October, but this year 55 Local Government Areas have started the season early with some beginning the danger period on the 1st of August and others on the 1st of September. At the beginning of August volunteers were fighting 90 fires simultaneously and properties were destroyed (NSW RFS 2014). The lengthening fire season means that opportunities for fuel reduction burning are reducing (Matthews et al. 2012). The Southern Australia Seasonal Bushfire Outlook for 2014/15 (see Figure 7) projects that due to the hotter, drier weather in southeast Australia, above normal fire activity can be expected in the coastal tablelands and central slopes of NSW (Bushfire and Natural Hazards CRC 2014).

Figure 6: Charred tree after a bushfire, NSW

The Southern Australia Seasonal Bushfire Outlook for 2014/15 projects that due to the hotter, drier weather in southeast Australia, above normal fire activity can be expected in the coastal tablelands and central slopes of NSW

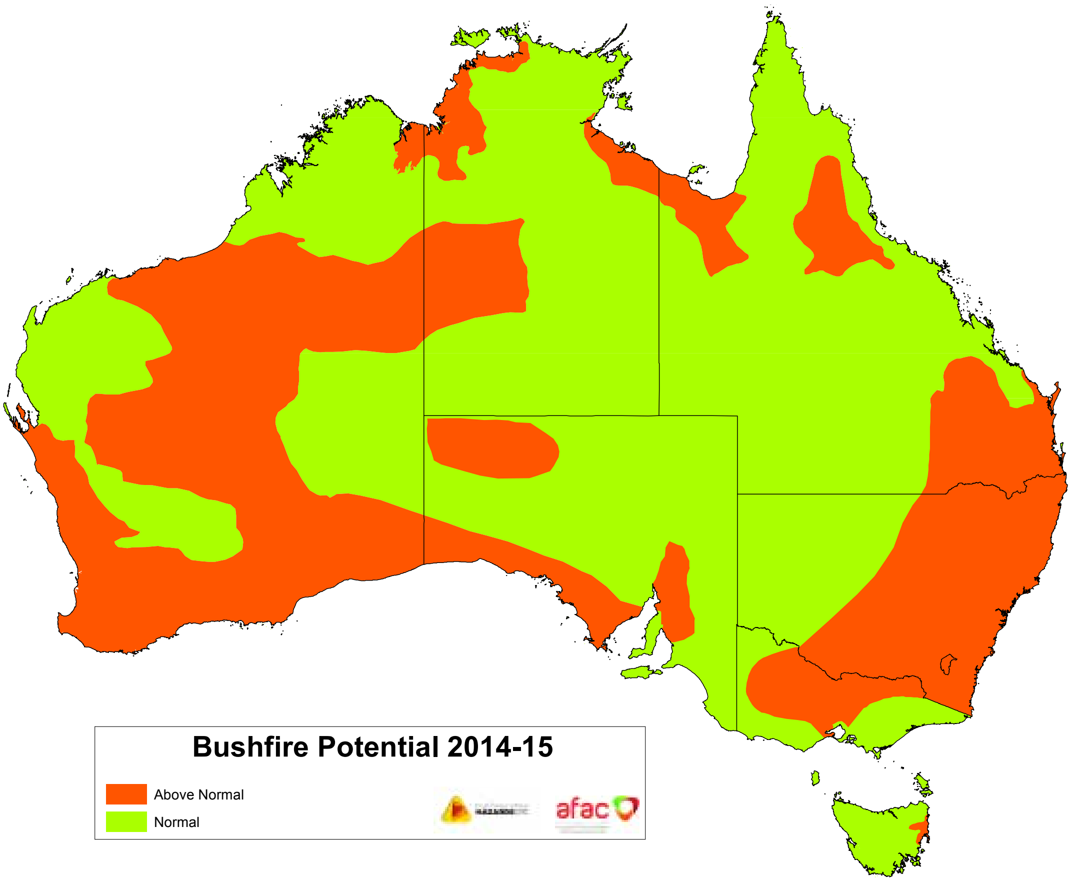

Figure 7: Southern Australia Seasonal Bushfire Outlook (Bushfire and Natural Hazards CRC 2014)

Research aimed at understanding future fire activity in NSW 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 climate 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 (Climate Council 2014d).

Future changes in the El Niño-Southern Oscillation (ENSO) phenomenon are also likely to have an influence on fire activity. There is a strong positive relationship between El Niño events and fire weather conditions in southeast and central Australia (Williams and Karoly 1999; Verdon et al. 2004; Lucas 2005) and between El Niño events and actual fire activity (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). Although there is no consensus on the influence of climate change on ENSO behaviour, 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 fire activity, in eastern Australia.

Table 1: Summary of projections from modelling studies aimed at projecting changes in fire risk in southeast Australia

Study	Projections
Beer et al. (1988)	10%–20% increase in FFDI in southeast
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
Cary and Banks (2000), Cary (2002)	Direct effects of a 3–4°C temperature increase in the ACT would more than double fire frequency, increase average fire intensity by 20%, increase the area burned in autumn, and reduce areas burned in spring
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.
Pitman et al. (2007)	Probability of extreme fire risk in 2050 increased by about 20% under both relatively low and relatively high scenarios, and increased dramatically (50%–100%) by 2100 under high scenario along the NSW coast and more than 100% along the QLD coast. In the Perth region, impact projected to be more limited (less than 25% in both 2050 and 2100 (less than 25% in both 2050 and 2100).
Bradstock et al. (2009)	20%-84% increase in potential ignition days for large (> 1000 ha) fires in the Blue Mountains and Central Coast regions by 2050
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

4. Impacts of bushfires in NSW

In NSW, 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).

4.1 Health Impacts

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

Communities in NSW are particularly vulnerable to bushfires because large populations live close to highly flammable native vegetation, such as eucalyptus trees, that are exposed to frequent severe fire weather (Chen and McAneney 2010; Handmer et al. 2012; Price and Bradstock 2013). For example, in the Blue Mountains, approximately 38,000 homes are within 200 metres of bushland, and 30,000 within 100 metres; with many of these homes backing directly onto bushland (McAneney 2013).

Large populations in NSW 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), and have contributed to 116 deaths since 1926 in NSW (NSW PRS 2014). 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). Smoke from bushfires in the Blue Mountains regularly affects Sydney's air quality. Days with severe pollution from bushfires around Sydney are associated with increases in all-cause mortality of around 5% (Johnston et al. 2011). The estimated annual health costs of bushfire smoke in Sydney are also high, at $8.2 million per annum (adjusted to 2011 values) (Deloitte Access Economics 2014).

During the Blue Mountains bushfires in October 2013, air quality levels in the Sydney region were measured at 50 times worse than normal. NSW Health recorded that 228 people attended hospital with breathing difficulties; 778 other individuals were treated by ambulance staff and there was a 124 per cent increase in patients with asthma conditions seeking hospital treatment (AEM 2013). A study of hospital admissions from 1994–2007 has found that hospital admissions for respiratory illness increased by 12 percent on days with bushfire smoke in Sydney (Martin et al. 2007). The health impacts of bushfire smoke are by no means confined to Sydney, with cities such as Newcastle and Wollongong also experiencing increases in hospital admissions due to respiratory conditions (Martin et al. 2007). 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). Following the 2013 Blue Mountains bushfires, mental health charity 'Beyond Blue' collaborated with the Australian Red Cross to develop resources to assist bushfire victims with increases in depression and anxiety (Beyond Blue 2013a; 2013b) and over 100 households requested wellbeing assistance from Red Cross volunteers (Red Cross 2013). Not for profit organisation, Nepean-Blue Mountains Medicare Local (NBMML) has also established a program to assist those with mental health problems resulting from the October disaster (NBMML

Figure 8: Bushfire smoke from the Blue Mountains blankets Sydney in 2013

2014)—although data on the numbers of patients involved in the program is not yet publicly available. Post-traumatic stress, 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).

4.2 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 2050 (Deloitte Access Economics 2014). The total economic costs of NSW bushfires for 2014 are projected to be $43 million (2011$). By about mid century these costs will almost triple, potentially reaching $103 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.

The total economic costs of NSW bushfires for 2014 are projected to be $43 million (2011$). By about mid century these costs will almost triple, potentially reaching $103 million

Figure 9: After a bushfire in Ku-ring-gai

Table 2: Damage and loss estimates in ten significant bushfire events in NSW since mid-1970s (NSW PRS 2014) (for full list of damages see Appendix A).

Date	Location	Area/Property Damage	Deaths /Injured	Normalised Cost ($2011 AUD)
1974–75	Far west, Cobar, Balranald & Moolah-Corinya	4,500,000 ha. 50,000 stock	6 deaths	n/a
1977–78	Blue Mountains	54,000 ha. 49 buildings destroyed	3 deaths	n/a
1979–80	Duffys Forest, Lucas Heights, Terry Hills, Ingleside, Belrose, Elanora Heights, Lithgow, Mt Wilson, Mt Tomah & Grose Valley	> 1,000,000 ha. 28 houses destroyed. 20 houses damaged	13 deaths	n/a
1984–85	Western Division	3,500,000 ha. 40,000 stock	5 deaths	$179m
1990–91	Baulkham Hills, Gosford, Wyong & Lake Macquarie	14 houses destroyed	2 deaths	$54m
1993–94	North coast, Hunter, South coast, Blue Mountains & Sydney	> 800,000 ha. 206 houses destroyed	4 deaths	$215m
1997–98	Burragorang, Pilliga, Hawkesbury, Hunter, Shoalhaven, Central Coast & Menai	> 500,000 ha. 10 houses destroyed	4 deaths	$8m
2001–02	44 LGAs in Greater Sydney, Hunter, North Coast, Mid North Coast, Northern Tablelands & Central Tablelands	744,000 ha. 109 houses destroyed. 40 houses damaged 6,000 stock	0 deaths	$131m
2002–03	81 LGAs in Greater Sydney, Hunter, North Coast, Northern Tablelands, Northern Rivers, north-west slopes, north-west plains, Central Tablelands, Southern Tablelands, Illawarra & South Coast	1,464,000 ha. 86 houses destroyed. 11 houses damaged 3,400 stock	3 deaths	$43m (October 2002 fires)
October 2013	Blue Mountains, Port Stephens, Lake Munmorah, Hunter, Hawkesbury, Central Coast & Southern Highlands	118,000 ha. 222 houses destroyed, 168 houses damaged	2 deaths	$183.4m (early figures)

NSW has already experienced a significant increase in extreme fire weather since the 1970s, and bushfires occurring in NSW from 1970–2013 have contributed to 60 deaths, the destruction of nearly 800 properties and have affected over 14 million hectares of land (Table 2). Indirect costs, such as impacts on local tourism industries can also be significant. For example, a month after the 2013 Blue Mountains bushfires, tourism operators estimated losses of nearly $30 million due to declines in visitors and cancellations alone.

Bushfires can cause significant losses in farming areas of regional and rural NSW. As shown in Table 2, bushfires can cause the death of hundreds of thousands of livestock and affect significant amounts of farming land. 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). Smoke damage can also taint fruit and vegetable crops, with wine grapes particularly susceptible (Stephenson 2010). For example, bushfires in 2003 significantly tainted grapes in NSW with smoky, burnt, ash aromas, making them unusable (Jiranek 2011).

It is important to note that these economic losses shown in Table 2 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).

4.3 Environmental Impacts

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

4.3.1 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). For example, bushfires in January 2003 devastated almost all of the Cotter catchment in the Australian Capital Territory, causing unprecedented levels or turbidity, iron and manganese and significantly disrupting water supply. Fires can also affect water infrastructure. Fires in the Sydney region in 2002 affected the Woronora pumping station and water filtration plants, resulting in a community alert to boil drinking water (WRF 2013).

Figure 10: Brogo Dam, NSW

4.3.2 Impact 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). Deliberate fuel reduction burning can also destroy habitats if not managed properly. For example in the Shoalhaven region of NSW, the threatened eastern bristlebird and the glossy black cockatoo face the potential destruction of their habitats which overlap with areas of bushland that are being targeted in hazard reduction burning (Whelan et al. 2009).

Figure 11: A glossy black cockatoo in NSW

5. Implications of increasing fire activity

The population of NSW is expected to grow from 7.4 million people (as of June 2013), up to 12.6 million people by 2061 (ABS 2013a; 2013b). The steady urban encroachment into bushland, along with increasing fire danger weather, present significant and growing challenges for the state. This challenge is exemplified in Greater Sydney, a region considered to be one of the more bushfire-prone areas in Australia. It is home to a quarter of Australia's population, and 2005 projections have found that 190,000 homes were exposed to greater bushfire risk due to their close proximity (within 80m) to dense bushland (Chen 2005). The Rural Fire Service Commissioner Shane Fitzsimmons has said that during this bushfire season more than a million NSW homes are at risk (Sydney Morning Herald 2014).

The economic, social and environmental costs of increasing bushfire activity in NSW are potentially immense. In one of the few analyses to consider projected costs of bushfires in NSW, Deloitte Access Economics (2014) calculated the potential insured losses and broader social costs, to forecast total economic costs of bushfires in selected Australia states, finding that bushfires in NSW will cost $103 million by about mid century (2011$). In addition to insured and social losses, health costs from particulate matter emitted during bushfires in NSW are projected to cost $8.2 million per annum. Attempting to mitigate these damages through practices such as prescribed burning can also be costly. For example, it is likely that NSW is burning around 0.5% of bushland in any given year, at a cost of 13.3 tonnes of carbon equivalent emissions per hectare (Deloitte Access Economics 2014). The Deloitte analysis notes that climate change will increase very high fire danger weather and associated bushfire incidents over time. Despite this, the Deloitte projections do not incorporate increased bushfire incident rates due to climate change, making them conservative economic forecasts that could be significantly higher if climate change was incorporated into the projections (Deloitte Access Economics 2014). As NSW bushfires increase in frequency and intensity, a detailed cost benefit analyses of bushfire mitigation and adaptation are needed.

Health costs from particulate matter emitted during bushfires in NSW are projected to cost $8.2 million per annum.

Figure 12: A hazard reduction burn being conducted by the NSW RFS in Belrose, 2011

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 and 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 practise of prescribed burning, where fires are lit in cool weather to reduce the volume of fuel. For example, during 2012–13, the largest ever hazard reduction burn was conducted in NSW, with 330 burns carried out over 205, 890 ha of national parks (NSW Government 2014). 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). The increasing length of the fire season will reduce the window of opportunity for hazard reduction at the same time that the need for hazard reduction becomes greater.

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

Australia's premier 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 substantial 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 will need to increase from approximately 11,000 in 2010 to 14,000 by 2020 and 17,000 by 2030 (NIEIR, 2013). When the increased incidence of extreme fire weather under a realistic warming scenario is also taken into account, a further 2000 firefighters will be needed by 2020, and 5000 by 2030 (NIEIR, 2013). Overall, this represents a doubling of professional firefighter numbers needed by 2030, compared to 2010. These estimates are likely to be conservative because they do not account for the potential lengthening of the fire season, in addition to increased fire weather. Further, they do not account for the increased pressures on the professional firefighting services due to declining numbers of volunteer firefighters (NIEIR, 2013).

6. 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. We are now more confident than ever that the emission of greenhouse gases by human activities, mainly carbon dioxide from the combustion 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 NSW, 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.

Appendix A: Cost of bushfires in NSW

Date	Location	Area/Property Damage	Deaths /Injured	Normalised Cost ($2011 AUD)
1969–70	Roto & Riverina	280,000 ha.	1 death	n/a
1972–73	Kosciusko, Eden, Queanbeyan & Burrinjuck Dam	300,000 ha	0 deaths	n/a
1974–75	Far west, Cobar, Balranald & Moolah-Corinya	4,500,000 ha. 50,000 stock	6 deaths	n/a
1976–77	Blue Mountains & Hornsby	74,000 ha. 3 houses destroyed	0 deaths	n/a
1977–78	Blue Mountains	54,000 ha. 49 buildings destroyed.	3 deaths	n/a
1978–79	Southern Highlands & South West Slopes	> 50,000 ha. 5 houses destroyed. Heavy stock losses	0 deaths	n/a
1979–80	Duffys Forest, Lucas Heights, Terry Hills, Ingleside, Belrose, Elanora Heights, Lithgow, Mt Wilson, Mt Tomah & Grose Valley	> 1,000,000 ha. 28 houses destroyed. 20 houses damaged.	13 deaths	n/a
November 1980	Waterfall	n/a	5 deaths	n/a
1982–83	Blue Mountains, Sutherland & Southern NSW	60,000 ha	3 deaths	n/a
1984–85	Western Division	3,500,000 ha. 40,000 stock	5 deaths	$179m
1986	Mt Kaputar National Park	10,000 ha	0 deaths	n/a
1987–88	Bethungra, Warurillah/ Yanco, Kosciusko, Sutherland & Penrith	180,000 ha	4 deaths. 20 injured	n/a
1990–91	Baulkham Hills, Gosford, Wyong & Lake Macquarie	14 houses destroyed	2 deaths	$54m
1993–94	North coast, Hunter, South coast, Blue Mountains & Sydney	> 800,000 ha. 206 houses destroyed.	4 deaths	$215m

Date	Location	Area/Property Damage	Deaths /Injured	Normalised Cost ($2011 AUD)
1997–98	Burragorang, Pilliga, Hawkesbury, Hunter, Shoalhaven, Central Coast & Menai	> 500,000 ha. 10 houses destroyed	4 deaths	$8m
June 2000	Mt Ku-ring-gai	n/a	4 deaths. 3 injured	n/a
2001–02	44 LGAs in Greater Sydney, Hunter, North Coast, Mid North Coast, Northern Tablelands & Central Tablelands	744,000 ha. 109 houses destroyed. 40 houses damaged. 6,000 stock	0 deaths	$131m
2002–03	81 LGAs in Greater Sydney, Hunter, North Coast, Northern Tablelands, Northern Rivers, north-west slopes, north-west plains, Central Tablelands, Southern Tablelands, Illawarra & South Coast	1,464,000 ha. 86 houses destroyed. 11 houses damaged. 3,400 stock.	3 deaths	$43m (October 2002 fires)
January 2013	Coonabarabran, Yass, Cooma, Shoalhaven, Jugiong & Gundaroo	650,000 ha. 57 houses destroyed. 22 houses damaged. 14,500 stock.	0 deaths. 1 injured	n/a
October 2013	Blue Mountains, Port Stephens, Lake Munmorah, Hunter, Hawkesbury, Central Coast & Southern Highlands	118,000 ha. 222 houses destroyed. 168 houses damaged	2 deaths	$183.4m (early figures)

Source: NSW Parliamentary Research Service (PRS) (2014)

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IMAGE CREDITS

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Preparing for a Bushfire in NSW

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

What can I do to prepare for a bushfire?

INFORM YOURSELF

The NSW Rural 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 NSW Rural Fire Service are also available to assist you to assess your level of risk from bushfire. Take advantage of them. Visit: http://www.rfs.nsw.gov.au/plan-and-prepare/know-your-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. Download the new MyFirePlan app to make your Bush Fire Survival Plan: http://www.rfs.nsw.gov.au/plan-and-prepare/bush-fire-survival-plan

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. Download the property factsheet: http://www.rfs.nsw.gov.au/plan-and-prepare/prepare-your-property

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

NSW RFS:
www.rfs.nsw.gov.au
1800 679 737

Bushfire Survival Plan App:
http://www.rfs.nsw.gov.au/plan-and-prepare/bush-fire-survival-plan (Available for iOS and Android)

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