CLIMATE COUNCIL

THE HEAT IS ON: CLIMATE CHANGE, EXTREME HEAT AND BUSHFIRES IN WESTERN AUSTRALIA

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Published by the Climate Council of Australia Limited

ISBN: 978-0-9942453-6-6 (print)
978-0-9942453-5-9 (web)

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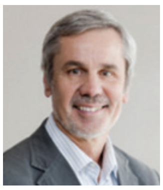

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Introduction

Western Australia has the fastest growing population of all states and territories in Australia and is home to a diversity of plants and animals found nowhere else on the planet. Climate change, driven by emissions from fossil fuels like coal and oil, is driving up the likelihood of extreme events such as heatwaves and bushfires in the state. Western Australia and its unique environment are extremely vulnerable and the economic, social and environmental costs of extreme heat and increasing bushfire activity in Western Australia are potentially immense.

Over the past 100 years extreme heat has caused more deaths in Australia than any other natural hazard. In Perth, the number of heatwave days has increased 50% since 1950. Hot weather is increasing in Western Australia, with the state recording its highest annual average maximum temperature in 2014.

Bushfires have also caused significant damage; in January 2014 bushfires in Perth Hills burnt a total of 650 hectares of land, that's roughly the size of 650 rugby pitches, and caused $15 million in damages (2011$).

The 2015 bushfire season has already been ferocious with the Department of Fire and Emergency Services (DFES) confirming approximately 1000 bushfires have burnt around Western Australia since January 1 2015, some of them quite severe. In early February communities in Western Australia's south west battled a fire that burnt over 80,000 hectares, one of the largest fires in the state's recent history; the fire was declared a national disaster.

This report describes the background context of extreme heat and bushfires in Western Australia and how climate change is intensifying these events. We explore the impacts of fire and extreme heat on people, property, the environment and ecosystems before considering the future implications of a changing climate for fire managers, planners and emergency services.

Key Findings

1. **Climate change is increasing the intensity and frequency of heatwaves in Western Australia and driving up the likelihood of very high fire danger weather.**
   - Western Australia is experiencing a long-term increase in average temperatures and in 2014 the state recorded its highest ever annual average maximum temperature.
   - The number of heatwave days in Perth has increased by 50% since 1950.
   - Nine of Western Australia's hottest Januarys on record have occurred in the last 10 years.
   - The number of days per year with severe fire danger weather is projected to almost double in south west Western Australia by 2090 if global carbon emissions are not drastically reduced.

2. **Recent fires in Western Australia have been influenced by record hot dry conditions.**
   - The long-term trend to hotter weather in Western Australia has worsened fire weather and contributed to an increase in the frequency and severity of bushfires.
   - The concept of a normal bushfire season is rapidly changing as bushfires increase in number, burn for longer and affect larger areas of land.
   - By 2030, the number of professional firefighters in WA will need to more than double to meet the increasing risk of bushfires.

3. The economic, social and environmental costs of increased extreme heat and bushfire activity is likely to be immense.

- In Perth, from 1994-2006, there were over 20 heat attributable deaths per year. If average maximum temperatures were 2°C warmer, this number would almost double to 40 deaths.
- Some of Western Australia's most fire-prone regions may become unlivable as the risks to lives and property caused by bushfires continue to increase.
- Without effective action on climate change, there will be 20 times the number of dangerous days for outdoor workers by 2070, reducing productivity.

4. Tackling climate change is critical to protecting Western Australia's prosperity.

- As a nation we must join the global effort to substantially reduce emissions and rapidly move away from fossil fuels to renewable energy if we are to limit the severity of extreme heat and bushfires both in Western Australia and nationally.

1. Extreme Heat in Western Australia

Western Australia is experiencing an increase in extreme heat, driven by climate change. Heatwaves are becoming hotter, lasting longer and occurring more often in many regions of the state (Figure 1). Western Australia is also experiencing a warming trend with record-breaking temperatures; nine of Western Australia's ten hottest years on record have all occurred since 1991(BoM 2015a; Figure 2).

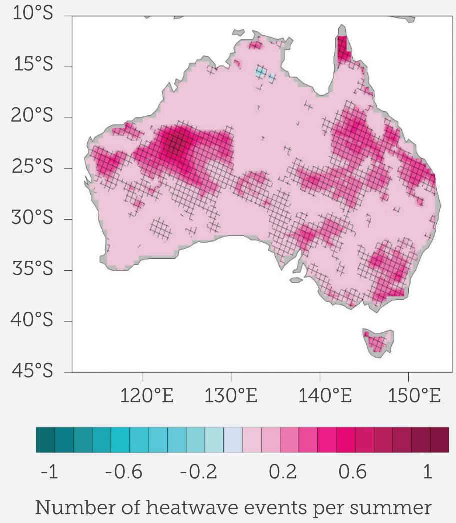
In Australia, a heatwave is defined as a period of at least three days where the combined effect of high temperatures and excess heat is unusual within the local climate (BoM 2012; Nairn and Fawcett 2013). Climate change is already increasing the intensity and frequency of heatwaves both in Western Australia and nationally. The increase in greenhouses gases in the atmosphere, primarily caused by the burning of fossil fuels, particularly coal, is trapping more heat in the lower atmosphere, which in turn is driving up heatwave activity and decreasing the likelihood of cold weather (IPCC 2013).

In Perth, the number of heatwave days has increased 50% since 1950, the average intensity of the peak heatwave day has increased by 1.5°C, and the first heatwave of the summer is occurring earlier (Trewin 2013; Nairn and Fawcett 2013; Perkins and Alexander 2013; Climate Council 2014a). In north west Western Australia the number of heatwave days and the frequency of heatwave events are increasing. The first heatwave of the season is also occurring earlier, the peak heatwave day is becoming hotter and the duration of heatwaves is increasing (Perkins and Alexander 2013; Climate Council 2014a; Figure 1).

The annual number of record hot days across Australia has more than doubled in the last fifty years (CSIRO and BoM 2012), and the number of extreme heat records has outnumbered extreme cool records by almost 3 to 1 for daytime maximum temperatures, and almost 5 to 1 for nighttime minimum temperatures since 2001 (CSIRO and BoM 2015). 2013 was Australia's hottest year since records began in 1910. Other records broken in 2013 included the hottest summer, warmest spring, hottest summer day and warmest winter day (BoM 2013; BoM 2014a; Climate Council 2014b).

Climate change is already increasing the intensity and frequency of heatwaves both in Western Australia and nationally.

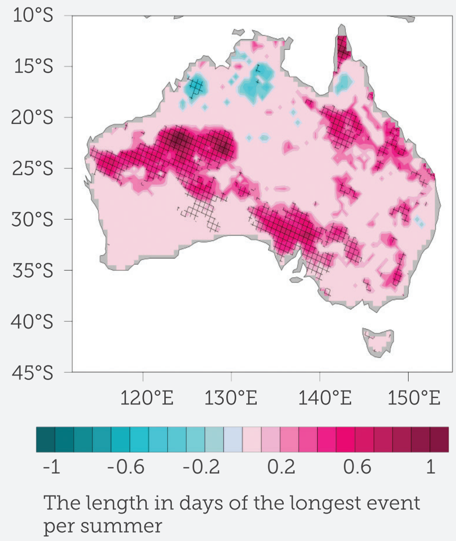
Each decade in Western Australia since the 1950s has been warmer than the last.



HEATWAVES ARE OCCURING MORE FREQUENTLY

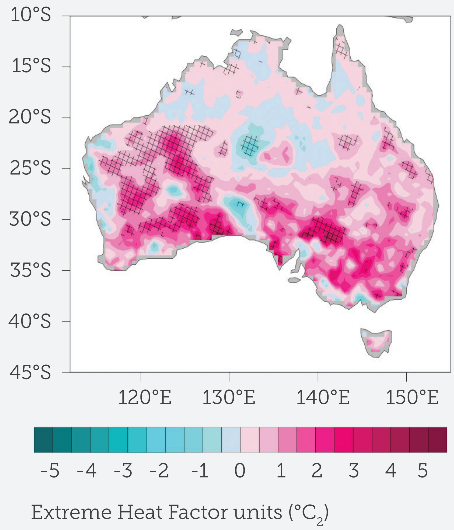
Red indicates an increase in the number of heatwave events per summer.

An increase in the number of heatwave days in turn influences the number of heatwave events and/or their duration, and although smaller, areas of increasing trends in heatwave frequency and duration of the longest yearly event are consistent with that of the heatwave days. Note that changes in heatwave events and duration will generally lag behind that of heatwave days—while an increase in the number of days is required to increase the duration and frequency, both cannot occur at the same time. That is, for each extra heatwave day that is gained, the new day can only contribute to heatwave duration or frequency.



THE DURATION OF THE LONGEST YEARLY HEATWAVE IS INCREASING

Red indicates an increase in the number of days of the longest heatwave of a summer.



THE HOTTEST DAY OF A HEATWAVE IS BECOMING HOTTER

Red shows increasing temperatures and shows that the hottest day of a heatwave, ie. its peak, has a detectable increase for almost all of Australia below the Tropics. Such trends are consistent with, and continue on from those reported by (Perkins et al. 2012), since they include the latest complete Australian summer data.

Figure 1: Heatwaves in many parts of Western Australia are becoming hotter, lasting longer and occurring more often. Source: Climate Council 2014a, modified from Perkins and Alexander 2013.

Nine of Western Australia's hottest Januarys on record have occurred in the last 10 years.

The summer of 2013/14 saw over 156 extreme weather records broken around Australia, including records for dry conditions and extreme heat. Very warm conditions reappeared in spring 2014, which was the hottest on record, lengthening the 2014/2015 heatwave season by creating an early start (BoM 2014b; Climate Council 2014a). This warming trend is also clear in Western Australia; nine of Western Australia's hottest Januarys on record have occurred in the last 10 years (BoM 2014c) and each decade in Western Australia since the 1950s has been warmer than the last (AECOM 2013). Western Australia also recorded its highest ever annual average maximum temperature in 2014, 1.17°C above average (BoM 2014d; Figure 3).

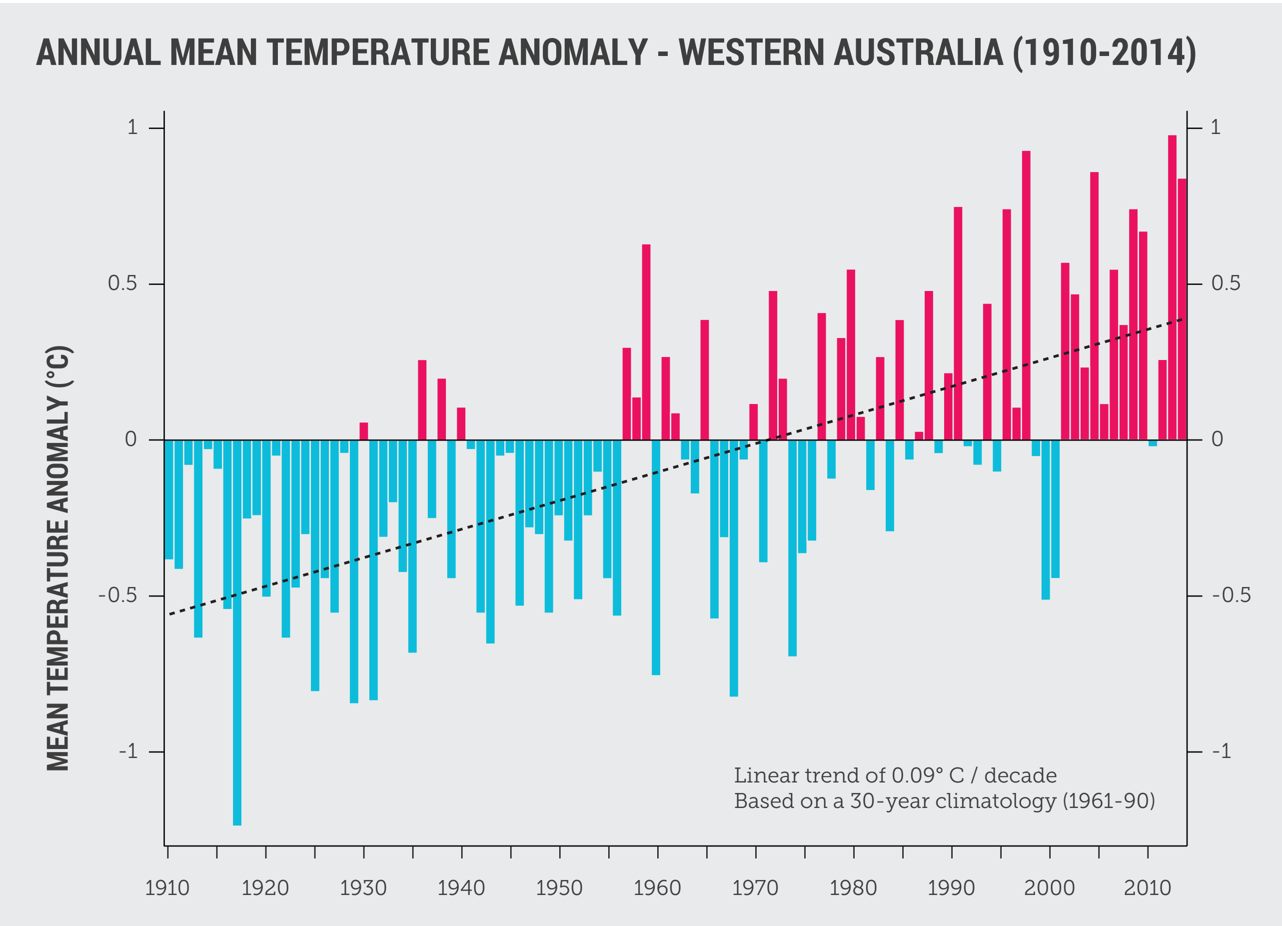


Figure 2: Western Australia is experiencing a long-term increase in annual average temperatures. Magneta bars indicate years of above average temperatures (Adapted from BoM 2015a).

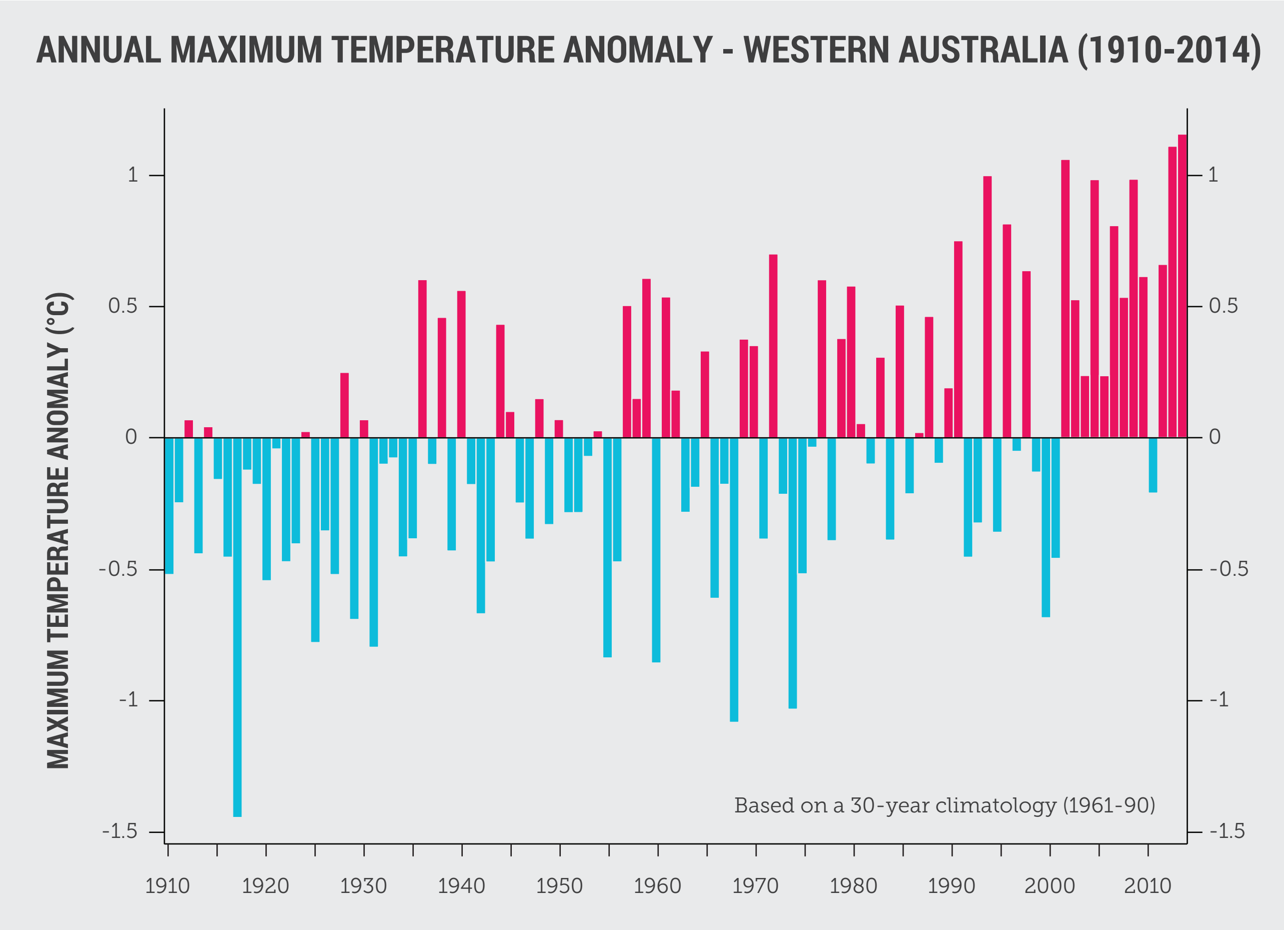


Figure 3: Western Australia is experiencing a long-term increase in annual maximum temperatures. Magenta bars indicate years of above average maximum temperatures (Adapted from BoM 2015c).

Western Australia recorded its highest ever-annual average maximum temperature in 2014.

2. The Nature of Bushfires in Western Australia

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).

South west Western Australia is one of the most fire-prone regions in the world.

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. 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 very important health, 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) (Figure 4). Fire activity is strongly influenced by weather, fuel, terrain, ignition agents and people, but local weather conditions are the most important influence on fire activity (Climate Council 2014c). 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 2014c).

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 vegetation types such as heathlands and dry sclerophyll forests, fires typically occur 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. Although some of Australia's most catastrophic bushfires have been ignited by powerline faults, many fires are deliberately 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). 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 (Climate Council 2014c).

Figure 4: Main factors affecting bushfires.

Main factors affecting bushfires

3 | People
Fires may be deliberately started (arson) or be started by accident (e.g. by powerline fault). Human activities can also reduce fire, either by direct suppression or by reducing fuel load by prescribed burning.

1 | Ignition
Fires can be started by lightning or people, either deliberately or accidentally.

2 | Fuel
Fires need fuel of sufficient quantity & dryness. A wet year creates favourable conditions for vegetation growth. If this is followed by a dry season or year, fires are more likely to spread and become intense.

4 | Weather
Fires are more likely to spread on hot, dry, windy days. Hot weather also dries out fuel, favouring fire spread and intensity.

The 2015 bushfire season has already seen 1000 bushfires in Western Australia since January 1.

Western Australia is no stranger to bushfires (Figure 5); south west Western Australia is one of the most fire-prone regions in the world (Bushfire CRC & AFAC 2010). The region has been affected by bushfires throughout its history. For example, in January 1961 temperatures reached 40°C and severe bushfires, described as some of the worst in the state's history, destroyed the township of Dwellingup (ABS 2010). In December 2007 a fire in Boorabbin National Park killed three people (AEM 2014a) and in December 2009, bushfires in Toodyay caused $50 million in damages (Noetic Solutions 2010). In February 2011 two major bushfires in Perth Hills destroyed 72 homes and in November of the same year fires in Margaret River caused $54 million in damages (2011$) (AEM 2014b; 2014c). In January 2014 bushfires in Perth Hills burnt a total of 650 hectares of land (AEM 2014d). The Western Australian DFES has confirmed that the 2015 bushfire season has already seen 1000 bushfires in Western Australia since January 1, including the fire in Western Australia's south west that burnt over 80,000 hectares. This fire was one of the largest in the state's recent history, which threatened several communities and was declared a national disaster (The Guardian 2015a; 2015b).

Figure 5: A fire burns in Kings Park, Western Australia in 2009.

As described earlier, extreme heat in Western Australia is increasing, and in various parts of the state heatwaves are becoming hotter, lasting longer and/or occurring more often (Section 1; Figure 1). Extreme heat drives up bushfire danger weather, with significant implications for Western Australia. For example, the Borrabbin National Park fire in 2007 was preceeded by maximum temperatures of 41.7°C, creating extreme fire weather conditions (AEM 2014a). The Intergovernmental Panel on Climate Change (IPCC) projects with virtual certainty that warming in Australia will continue throughout the 21st century (IPCC 2014). BoM and CSIRO, in their most comprehensive Australian climate projections to date, suggest that southern and eastern Australia, including parts of south west Western Australia, will continue to experience harsher fire weather (CSIRO and BoM 2015).

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 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 within a season (November 2014) due to unseasonably hot, dry weather (Figure 6). The seasonal outlook for Western Australia predicts that fire potential will be above normal across much of the state including in the wheatbelt region, south west, midwest and the Nullarbor (Bushfire and Natural Hazards CRC 2014a; Bushfire and Natural Hazards CRC 2014b).

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 seasonal outlook for Western Australia predicts that fire potential will be above normal across much of the state.

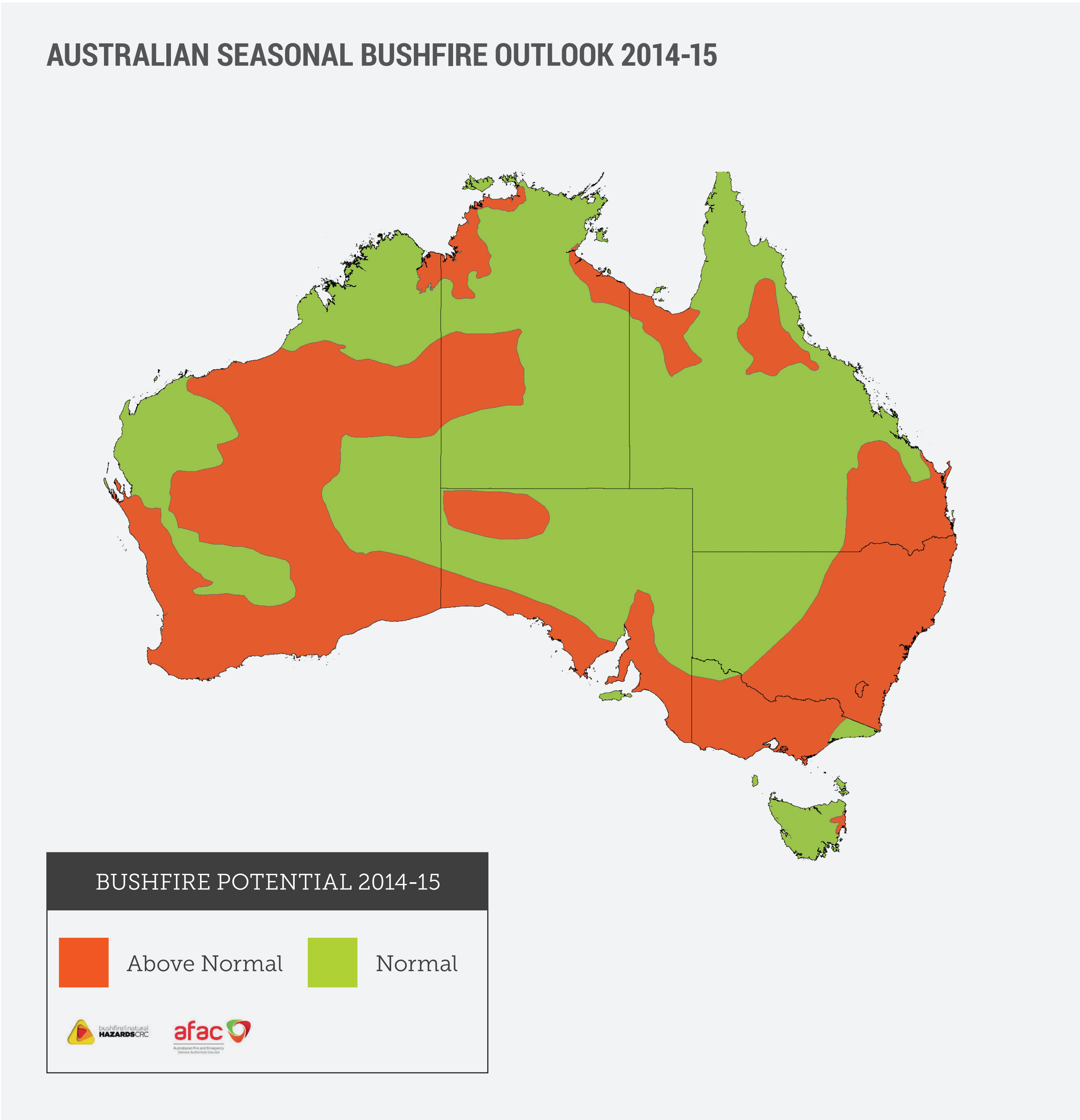


Figure 6: The updated Australian Seasonal Bushfire Outlook (Bushfire and Natural Hazards CRC 2014b).

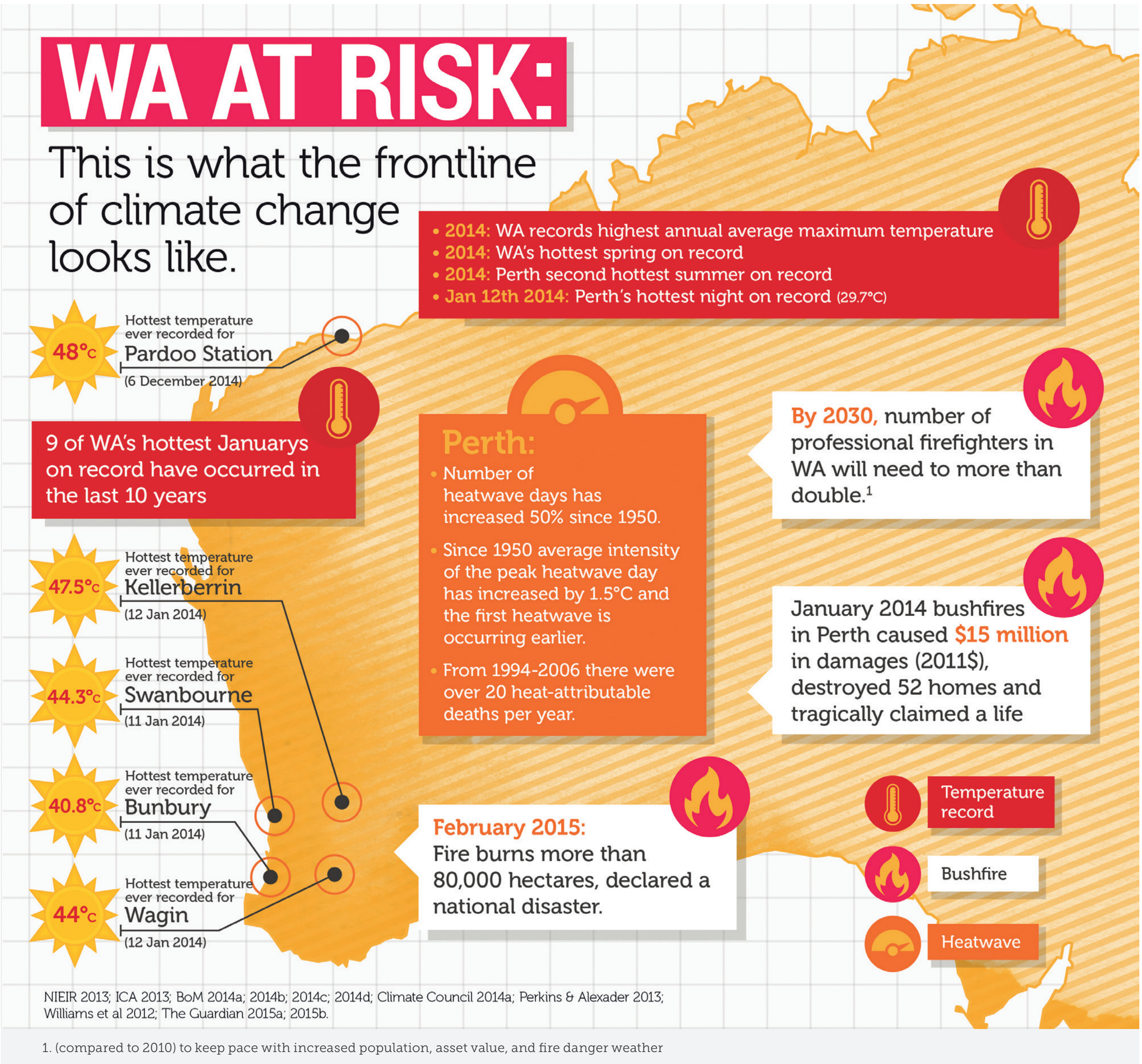


Figure 7: WA at risk.

3. Extreme Heat, Bushfires and Climate Change

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 2). 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 its influence on 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). In early February 2015, 120 fires were ignited by lightning in a single week in Western Australia (DFES 2015). 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 direct and measurable influence on fire activity (Climate Council 2014c).

Figure 8: Trees burn and smoulder in an Australian bushfire.

Climate change is increasing the frequency and severity of very hot days and is driving up the likelihood of very high fire danger weather.

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 – and therefore 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.

There has been an increase in the FFDI, measured cumulatively over an annual (July-June) period, from 1973 to 2010 at all 38 analysed sites across Australia, with 16 of these sites showing statistically significant increases, including the site near Perth. This increase in high fire danger weather has resulted in an extension of the fire season into spring and autumn. These observations suggest that extreme fire weather days have indeed become more frequent over the past several decades (Clarke et al. 2013).

In the future even more severe bushfire weather is expected in southern Australia, including south west Western Australia, consistent with the rising temperatures and the projected decrease in rainfall. The combination of warming and drying will likely dry out the fuel load and thus increase its flammability. The projected climate changes will very likely drive increases in the average forest fire danger index (FFDI) and in the number of days with severe fire danger weather. For example, the number of days per year with severe fire danger weather is projected to nearly double in south west Western Australia by 2090 under a high emissions scenario (CSIRO and BoM 2015).

4. Impacts of Extreme Heat

Over the past 100 years heatwaves have caused more deaths in Australia than any other natural hazard (PwC 2011; Climate Council 2014a). Heatwaves don't just have serious effects on human health, they also affect workplace safety and productivity, infrastructure, agriculture and natural ecosystems.

Over the past 100 years heatwaves have caused more deaths in Australia than any other natural hazard.

Figure 9: Electricity pylons during a heatwave; extreme heat puts increasing pressure on infrastructure.

4.1 Health

Heatwaves pose a widespread risk for Australians as they affect people in all capital cities and most regional areas. Extreme and prolonged heat directly affects our health by causing heat stress and, under very severe conditions, death.

Our bodies operate at a core temperature of 37°C and must maintain that temperature within a very narrow range (Parsons 2003; Hanna et al. 2011). If core body temperature rises to 38°C for several hours, heat exhaustion occurs, and mental and physical capacity becomes impaired (Parsons 2003; Berry et al. 2010). If core temperature goes above 42°C, even for just a few hours, heat stroke and death can result (Parsons 2003).

Those most at risk from heatwaves include the very old, the very young, Aboriginal and Torres Strait Islander communities, and those who work outdoors or whose physical and mental wellbeing has been compromised. In Perth from 1994-2006 there were over 20 heat-attributable deaths per year. If average maximum temperatures were 2°C warmer, this number would have almost doubled to 40 deaths (Williams et al 2012).

In Perth from 1994-2006 there were over 20 heat-attributable deaths per year.

Figure 10: A floodway shimmers in the heat in Ashburton, Western Australia.

4.2 Economic costs

Heatwaves can restrict work capacity and decrease the productivity of exposed workers. One measure of the risk to workers of extreme heat is the "dangerous day" concept. A dangerous day occurs when sweating cannot cool the body and core body temperature rises by 2.5°C over less than two hours (Maloney and Forbes 2011). Applying this measure to Perth for those workers accustomed to working in hot climates, the number of dangerous days is projected to rise from the current value of one per year to as much as 21 days per year by 2070, depending on the emissions scenario used (Maloney and Forbes 2011). This will have significant risks for outdoor workers and effectively reduce days they can safely work.

The impacts of extreme heat on worker wellbeing and productivity can also be measured in economic terms (Kjellstrom and McMichael 2013), the underlying cause being a general slowing down of work or the complete stopping of work on very hot days. For example, Fisk (2000) estimated the cost of suboptimal workplace temperatures in the US to be in the billions of dollars. In Australia, workers at the Port of Melbourne are permitted to stop work when the temperature reaches 38°C. During an extended heatwave, this slows the loading and unloading process, which in turn delays vessels and disrupts shipping schedules. Labour costs, of course, are significantly increased in such conditions (QUT 2010).

Reduced labor productivity from future heatwaves will not only be costly, but will force changes in the workplace. Measures such as introducing air-conditioning to workplaces to enhance worker productivity may be costly and unreliable. Similarly, workers may need to take more frequent breaks, or work at a slower pace, affecting productivity (Kjellstrom et al. 2009). Iron ore mining staff in north western Australia are particularly vulnerable to thermal stress

Iron ore mining staff in north western Australia are particularly vulnerable to thermal stress from increasing heat.

from increasing heat, with a study finding 22% of workers reached or exceeded safety guidelines for core body temperature, endangering their health and safety (Peiffer and Abbiss 2013).

Extreme heat can also damage infrastructure such as electricity distribution and transport systems, causing flow-on effects. Financial losses from the 2009 heatwave in south east Australia, for example, have been estimated at $800 million, mainly due to power outages and disruptions to the transport system in Australia's south east, particularly in Melbourne and Adelaide (Chhetri et al. 2012). Increasing heat in Western Australia is also damaging key pieces of infrastructure. For example Main Roads WA (2010) found that there will be a greater reduction in the seal life of pavements in southern regions of the state due to projected temperature changes, and fixing this could incur significant costs.

Heat stress can also reduce crop yields and decrease livestock productivity. High temperatures over several days can reduce crop yield substantially, through both direct and indirect effects. The direct effect is through damage to the crop's reproductive parts, responsible for producing grain, and thus reducing productive potential. Indirectly, extreme temperatures increase plant water stress, which if not addressed can result in cessation of photosynthesis and possibly death (Schlenker and Roberts 2009). In 2014 a period of 42°C days saw Western Australia's southern mango growers lose nearly a quarter of their crop (ABC Rural 2014). High temperatures, especially when combined with high humidity and low air movement, can also exceed the ability of livestock to cope, resulting in a loss of appetite, productivity, reproductive vigor and sometimes death (Lefcourt et al. 1996).

> In 2014 a period of 42°C days saw Western Australia's southern mango growers lose nearly a quarter of their crop.

4.3 Impacts on ecosystems

Plants and animals, like humans, are susceptible to extreme heat events. Western Australia's south west region has the highest concentration of rare and endangered species on the continent, and increases in extreme heat will place species throughout the state under further stress.

Figure 11: In 2009 a heatwave killed thousands of birds, including Zebra Finches.

The January 2009 heatwave, when air temperatures were above 45°C for several consecutive days, caused the deaths of thousands of birds, mostly zebra finches (Figure 11) and budgerigars in Western Australia (McKechnie et al. 2012). Another event in January 2010, where temperatures up to 48°C were combined with very low humidity and a hot northerly wind, had similar impacts, with the deaths of over 200 of the endangered Carnaby's Black Cockatoo recorded near Hopetoun (Saunders et al. 2011).

Heatwaves, combined with extended droughts, have also been observed to cause mass mortality in koalas (Gordon et al. 1988), and to affect forest productivity (Ciais et al. 2005), frog reproduction (Neveu 2009), cyanobacterial blooms in lakes (Huber et al. 2012), and increase the success of some invasive species (Daufresne et al. 2007).

Western Australia's south west region has the highest concentration of rare and endangered species on the continent.

The increasing aridity of south western Australia due to climate change threatens the quokka's habitat.

Increasing hot, dry conditions threatens the habitat of many species and may lead to ongoing reduction in the size of their geographic range and populations. For example, the increasing aridity of south western Australia due to climate change threatens the habitat of the quokka (Figure 12). Under the most severe climate change scenario, quokka's could potentially lose almost all range by 2070 (Gibson et al. 2010).

Figure 12: The increasing aridity of south western Australia due to climate change threatens the habitat of the quokka.

Figure 13: Healthy coral on Ningaloo reef, one of the longest fringing barrier reefs in the world.

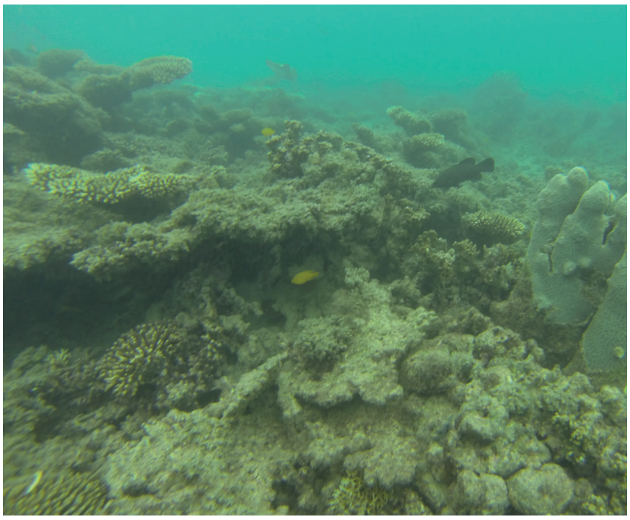


Figure 14: The 2011 marine heatwave in Western Australia caused the first-ever reported bleaching of Ningaloo reef.

The 2011 marine heatwave in Western Australia caused the first-ever reported bleaching of Ningaloo reef.

Marine organisms are also affected by the impacts of severe heat. Heatwaves can occur in the surface waters of the ocean, sometimes leading to dramatic impacts on marine ecosystems. When coral reefs are repeatedly subject to sea surface temperatures more than 1–2°C above average summer maximum temperatures for repeated extended periods, the corals can bleach and die. For example, the 2011 marine heatwave in Western Australia caused the first-ever reported bleaching of Ningaloo reef, one of the longest fringing barrier reefs in the world (Wernberg et al. 2012; Figure 13). Temperatures peaked at 28.7°C off the Houtman Abrolhos Islands, 5°C above the long-term average (Smale and Wernberg 2012).

The ability to recover from bleaching events varies among coral species and among regions, but there is only limited evidence so far that corals can adapt to rising temperatures and to ocean acidification (Hoegh-Guldberg et al. 2007; Climate Council 2014a). Large coral reefs like Ningaloo take hundreds of years to develop and are unlikely to extend their southern range at a rate that can keep up with climate change. The degradation of the reef will significantly reduce the ability of Ningaloo to support industries such as tourism, which brings an annual $127 million to the region, and will decrease its role in other important areas such as coastal protection against storms and large waves (Climate Commission 2011; AECOM 2013).

5. Impacts of Bushfires

Bushfires have a 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).

Figure 15: Bushfire smoke fills the air in Beechboro, Western Australia.

5.1 Health

Populations in Western Australia 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). Bushfires have claimed lives and caused severe injuries in Western Australia, for example the 2007 Borrabbin National Park killed 3 people, whilst the Perth Hills 2011 fires injured 12 (AEM 2014a; 2014b).

In addition to fatalities, bushfire smoke can seriously affect health (Figure 15). Smoke contains not only respiratory irritants, but also inflammatory and cancer-causing chemicals (Bernstein and Rice 2013). An analysis of bushfire smoke in Western Australia has found smoke contains damaging toxins including formaldehyde, prolonged exposure to which can result in the development of cancer (De Vos and Cook 2008). 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). Post Traumatic Stress Disorder (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).

5.2 Economic costs

In January 2014 bushfires in Perth Hills caused $15 million in damages (2011).

The economic cost of bushfires – including loss of life, injury, 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). Bushfires have incurred significant costs in Western Australia. In January 2014 bushfires in Perth Hills caused $15 million in damages (2011$) alone, claiming one life (ICA 2013; AEM 2014e).

The 2011 bushfires in Perth Hills destroyed 72 homes and damaged 39, whilst the 2014 fires in the same region destroyed 52 homes (AEM 2014b; 2014d). Infrastructure such as powerlines and roads can also be damaged. The 2014 Perth Hills bushfires damaged a significant number of power poles, leaving more than 400 homes without electricity (AEM 2014d). In addition to the costs incurred by direct damage to properties and infrastructure, injuries can also prove costly. For example, the estimated cost of injury due to fire in Western Australia in 2003 was approximately $38 million (Ashe at al. 2009).

Bushfires have significant impacts in farming areas. Although literature specific to Western Australia is limited, statistics from other states illustrate the damage that bushfires can have on livestock. For example, recent fires in Victoria in January 2015 killed more than 1000 sheep (ABC News 2015b) and during the 2005-6 Grampians fire approximately 65,000 livestock were killed (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). The 2015 bushfire in the Northcliffe area threatened wineries in Pemberton and Northcliffe, but luckily these wineries have managed to avoid smoke taint, although it remains an on-going risk for wineries in the area (ABC News 2015a). Increased livestock mortality due to more severe bushfire has significant implications for Western Australia's agricultural sector, with the gross value of agricultural production in Western Australia estimated to be $7.5 billion in 2011-12 (Government of Western Australia 2014). Whilst the

Figure 16: A vineyard destroyed by a bushfire in South Australia.

impacts of the February 2015 bushfires in Northcliffe and surrounds are still being assessed, the blaze has reportedly had a substantial impact on farmland, with large numbers of livestock affected by burnt feed and hay (ABC News 2015a).

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).

The estimated cost of injury due to fire in Western Australia in 2003 was approximately $38 million.

5.3 Environmental impacts

Large-scale high intensity fires that remove vegetation can 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 were pumped to safer storage locations because of fears it would be contaminated (Johnston 2009).

A review conducted of the 2009 Toodyay fires in Western Australia found that the clearing of areas in the aftermath of bushfires also has potential risks for water supplies, because clearing can increase soil erosion (Noetic Solutions 2010). Fire also has longer-term affects on water flow in forested catchments. A study of the potential effect of the 2009 wildfire on Melbourne's water supply also found that 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 (Feikema et al. 2013).

Figure 17: Bushfire smoke at the upper Yarra dam, Victoria.

5.4 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). The Noisy Scrub-bird found in Western Australia is not a strong flyer and its habitat tends to consist of highly flammable, dense vegetation. This leaves the Noisy Scrub-bird particularly vulnerable to changes in fire regimes, such as increases in fire extent and intensity (Enright et al. 2012).

6. Can we cope with extreme heat and increasing fire activity in Western Australia?

There has been increasing research into how best to adapt to heatwaves in Australia. Without adaptation, it has been estimated that heatwaves could cause an additional 6214 deaths (or 402 deaths annually) by 2050 in Victoria alone (Keating and Handmer 2013). This translates to an additional $6.4 billion loss or $218 million per year (based on the CSIRO3.5 climate model, a 5% discount rate and 2011 $AUD) (Keating and Handmer 2013; see also Jones et al. 2013).

The impacts on work capacity, labour productivity and the local economy in places affected by heatwaves will be increasingly important (Kjellstrom et al. 2009). The reduction of labour productivity globally due to heat is projected to be as large as USD one trillion by 2030 (Kjellstrom and McMichael 2013). Although Australians are better adapted than workers in many Northern Hemisphere temperate countries to deal with extreme heat, our economy will not be spared the impacts of heat on productivity. Considering that the number of full working days in a year is often estimated at 200, a loss of only four working days due to a heatwave means that 2% of the annual work time is lost. In terms of the consequences for the annual economic output, even small increases of heatwave days can cause significant losses.

Some government agencies and community services are increasing their efforts and resources to manage some of the risks associated with extreme heat. The Bureau of Meteorology, for example, has developed a pilot heatwave forecasting system (BoM 2015d) and the Western Australian government provides heatwave emergency management guidance (Western Australia Government 2015).

While some adaptation is occurring, there are barriers and limits to this adaptation (CSIRO 2011). Our biodiversity and natural environment face even more immense challenges. While human management to reduce the impact of other stresses may increase resilience, the rate of climatic change is generally considered to be occurring too quickly for many species to adapt "under their own steam" (Steffen et al. 2009). Loss of species will have flow-on effects

The economic, social and environmental costs of extreme heat and increasing bushfire activity in Western Australia are potentially immense.

to ecological communities and the services that ecosystems provide. For example, loss of the Ningaloo reef due to bleaching from heat stress will reduce the number of tourists that visit the reef, a trade that currently brings an annual $127 million to the region (Climate Commission 2011; AECOM 2013). More importantly, many forms of life, such as coral reefs, ultimately face threats to their very survival.

The economic, social and environmental costs of extreme heat and increasing bushfire activity in Western Australia are potentially immense.

Western Australia's current population is approximately 2.4 million but could increase to 6.4 million by 2061 (ABS 2014; 2013).

Figure 18: Ningaloo reef from above. Tourism brings approximately $127 million to the region.

Figure 19: A firefighter at work in Western Australia.

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

The state's increasing population and built assets, coupled with increasing fire danger weather, present significant and growing challenges for the state (Section 5). Already fire prone regions are becoming more fire prone and risks to lives and property continue to increase in parts of Western Australia as populations continue to expand into at-risk areas (AECOM 2013). Hard decisions will have to be made about the on-going livability of those regions as they become increasingly dangerous to live in.

The prospect of increasing extreme heat events and heatwaves also has important implications for the state's health and health services, its economy, its infrastructure and its environment. With older adults forming an increasingly large proportion of Australia's population in future, population health policy, public health programs and emergency services will need to be sufficiently supported to keep pace. Over the year ending on 30 June 2014 the population of Western Australia experienced an increase in population aged 65 and over (4.2%) and 85 years and over (5.0%) (ABS 2015). This challenges the capacity of Western Australia's infrastructure, emergency

The number of professional firefighters in Western Australia will need to more than double by 2030.

services, and social planning systems (Luber et al. 2008). Increasing peak electrical demand as people become more reliant on air conditioning will also increase household costs (Saman et al. 2013).

There is also 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). 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. Debates over the effectiveness of prescribed burning are occurring in Western Australia; for example in 2014 south west fire managers stated that hazard reduction burning should not be reliant on a set target of hectares to burn per year, whilst a south west Member for the Legislative Council (MLC) suggested the need for a higher rate of burning (ABC 2014).

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 Western Australia will need to increase from 989 in 2010 to 1559 by 2020 and 2002 by 2030. When the increased incidence of extreme fire weather under a realistic warming scenario is also taken into account, a further 192 firefighters will be needed by 2020, and 472 by 2030 – this means that numbers will need to more than double compared to 2010 (NIEIR 2013).

7. We are halfway through the critical decade

The link between climate change, extreme heat and bushfires is clear. 2015 is the halfway point in the critical decade for action on climate change and more action is needed if we are to limit the severity of extreme heat and bushfires in Western Australia, as well as in the rest of Australia and globally. Global emissions are still rising and Australian emissions have yet to make a decisive turn downwards.

To stabilise the climate and eventually halt the rising trend of extreme heat, carbon emissions need to be cut rapidly and deeply. Most of the world's known reserves of coal, oil and gas will need to be left in the ground, including over 90% of Australia's coal reserves (McGlade and Etkins 2015).

Fortunately, we are making headway in our transition to a low-carbon economy. Clean energy technologies, such as solar and wind, are advancing rapidly and are now competitive in price with fossil fuel technologies in many places (Citigroup 2013; IRENA 2014). In Australia, more than one million households have installed solar PV and in Western Australia, Mandurah is the top solar postcode with over 7,300 solar PV systems, totaling 14.5 MW (Climate Council 2014d; 2014e; Australian PV Institute 2014). International action is strengthening with significant commitments from the world's two largest emitters, China and the USA. Continuing this transition over the next five years will be essential, as Australia joins international efforts to tackle climate change.

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What to do in a heatwave

Dr Liz Hanna Health Expert

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

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- Take care of yourself – everyone is at risk
- Stay cool
- Stay hydrated
- Stay informed – Listen to local ABC Radio Station
- Keep in touch with family, friends and neighbours

STAY COOL

- Minimise exertion
- Keep out of the sun. Minimise heat exposure for yourself and others.
- Limit trips outside and reschedule work meetings and tasks wherever possible
- Spend time in cooled, well air-conditioned places. If you do not have air-conditioning at home spend time in places that do, such as public libraries, cinemas etc.
- Keep your building cool. Close blinds during the day, and open to cool in the evening
- Wear cool, comfortable clothes
- Spray misted water onto body and clothes
- Spend time lying on and under a wet sheet. Indoor fans can be helpful
- Avoid using a fan where the indoor temperature is higher than 37°C
- Remind the elderly of these cooling strategies, and assist them to achieve optimal cooling
- Check with your local council to hear their heatwave response plan

STAY HYDRATED

- Drink plenty of fluids, chilled if possible
- Drink enough to urinate at least 3 times a day, and urine should be very pale in colour. If yellow, or darker, keep drinking. Avoid tea, coffee and alcohol.

FOOD

- Ensure that food is refrigerated properly
- Dispose of spoilt food

TRANSPORT/INFRASTRUCTURE

- Stay informed and up-to-date about planned blackouts
- Have a backup plan in case electricity or transport (road/rail) infrastructure fails

WILDLIFE

- Leave out shallow containers of water for birds, possums and other animals. Place small stones in the bottom of the container and ensure that the water is left in a shady, protected environment (out of view from birds of prey and high enough to be safe from cats).
- If you find injured or heat-stressed wildlife, bring them into cooler environments and lightly mist them with water
- If you are concerned about an animal, call a wildlife rescue centre near you

PETS

- If dogs or cats appear heat stressed, panting or restless, bathe them in cool water. Call your vet if your are concerned.
- Bring your pets indoors when it's very hot, or ensure they have outdoor shelter
- Leave out two bowls of cool drinking water (in case one is knocked over)
- Never leave your pets alone in the car

Preparing for a Bushfire in Western Australia

IN AN EMERGENCY, CALL TRIPLE ZERO (106 FOR PEOPLE WITH A HEARING OR SPEECH IMPAIRMENT) 132 500 FOR SES ASSISTANCE

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What can I do to prepare for a bushfire?

INFORM YOURSELF

The Government of Western Australia's Department of Fire and Emergency Services 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 Department of Fire and Emergency Services are available to assist you to assess your level of risk from bushfire. Take advantage of them. Visit: http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/BushfireManualsandGuides/DFES-Bushfire-Am_I_at_risk_from_bushfire.pdf

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 checklist for preparing your bushfire survival kit: http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/BushfireChecklists/DFES_Bushfire_Checklist-Preparing_your_survival_kit.pdf

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 Department of Fire and Emergency Services to help recognise exactly what you need to prepare your property: http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/BushfireFactsheets/DFES_Bushfire_Factsheet-Calendar_for_Preparation.pdf

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.

Department of Fires and Emergency Services:
http://www.dfes.wa.gov.au/Pages/Default.aspx

13 DFES (13 3337)

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