CLIMATE COUNCIL

Briefing paper

12 November 2019

'This is Not Normal': Climate change and escalating bushfire risk

1. Key Findings

1. The catastrophic, unprecedented fire conditions currently affecting NSW and Queensland have been aggravated by climate change. Bushfire risk was exacerbated by record breaking drought, very dry fuels and soils, and record-breaking heat.
2. Bushfire conditions are now more dangerous than in the past. The risks to people and property have increased and fire seasons have lengthened. It is becoming more dangerous to fight fires in Australia.
3. The fire season has lengthened so substantially that it has already reduced opportunities for fuel reduction burning. This means it is harder to prepare for worsening conditions.
4. The costs of fighting fires are increasing. Australia relies on resource sharing arrangements between countries and states and territories within Australia. As seasons overlap and fires become more destructive, governments will be increasingly constrained in their ability to share resources and the costs of tackling fires will increase.
5. The government must develop an urgent plan to (1) prepare Australian communities, health and emergency services for escalating fire danger; and (2) rapidly phase out the burning of coal oil and gas which is driving more dangerous fires.

2. Introduction

This is not normal. As we write, New South Wales and Queensland have declared a state of emergency. There are also fires in South Australia and Western Australia. For the first time catastrophic bushfire conditions have been declared for Greater Sydney. Climate change has worsened the catastrophic bushfire conditions.

The nature of bushfires in Australia has changed. Bushfire conditions are now more dangerous than in the past, and the risk to people and property has increased. For well over 20 years scientists have warned that climate

change would increase the risk of extreme bushfires in Australia. This warning was accurate. Scientists expect extreme fire weather will continue to become more frequent and severe without substantial and rapid action to reduce greenhouse gas emissions.

Climate change is driving worsening bushfires in Australia.

The burning of coal, oil and gas is driving up global temperatures, leading to hotter Australian conditions. Since the mid-1990s, southeast Australia has experienced a 15% decline in late autumn and early winter rainfall and a 25% decline in average rainfall in April and May. Across Australia average temperature has increased leading to more record-breaking hot weather. Extreme fire danger days have increased.

Climate change has worsened the current bushfire crisis.

This year bushfire risk in parts of northeast New South Wales and southeast Queensland has been exacerbated by drought, very dry fuels and soils, and heat. All of these factors have been aggravated by climate change.

Rainfall for January to August 2019 was the lowest on record in the Southern Downs (Queensland) and Northern Tablelands (New South Wales). For example, Tenterfield and Stanthorpe were 77% below the long-term average. Vegetation has been very dry with parts of New South Wales and Queensland experiencing record low soil moisture. The low soil moisture is symptomatic of both the recent intense dry conditions, as well as longer-term below average rainfall since 2017. Drought means vegetation is more flammable and therefore more likely to support extreme fire behaviour and spot fires. Heat is a factor too, both exacerbating dry conditions and enabling sparks to take hold. For instance, virtually the whole of the Murray-Darling Basin has experienced record-breaking heat this year.

Climate change is lengthening the bushfire season. The northern and southern hemisphere seasons are now overlapping, making it difficult to pool resources such as personnel and firefighting equipment. The opportunity for hazard reduction burning to limit the threat of bushfires is closing, with all year round bushfires.

Fire risk will continue to escalate in the future without sustained and substantial efforts to tackle climate change.

Australia is a substantial contributor to global climate change through the domestic burning of coal, oil and gas, as well as our fossil fuel exports. We are the 16th largest emitter globally and one of the largest exporters of coal and gas in the world. Our emissions have increased the past five years without a credible Federal policy to reduce emissions.

This briefing paper unpacks the unprecedented bushfire conditions unfolding in southern Australia, explaining why the conditions are so unusual, the influence of climate change on bushfires, and the challenges of responding to the growing bushfire threat.

3. What is so unusual about these bushfire conditions?

Catastrophic fire danger ratings are in place for Tuesday 12 November across Greater Sydney (including the Blue Mountains and Central Coast), the Greater Hunter and the Illawarra and Shoalhaven regions. This is the first time that a catastrophic fire danger rating has been forecast for Sydney since the catastrophic fire danger rating was introduced in 2009. It is also the first time a catastrophic bushfire danger rating has been declared over such a densely populated area – covering around six million residents across eastern New South Wales. Severe and Extreme fire danger ratings are in place across large tracts of the rest of the state.

Catastrophic is the highest fire danger rating. Fires in catastrophic conditions cannot be fought safely and homes are not built to withstand fires in these conditions. Lives and homes are at serious risk if a fire starts under these conditions. Total fire bans are in place across the whole of NSW, and a State of Emergency has been declared across New South Wales. Queensland has also declared a State of Emergency.

Already, fires have burned through one million hectares in New South Wales. With months left of the fire season, this is almost as much as has been burned in New South Wales during the last three fire seasons combined. In New South Wales, the worst fire seasons have generally been during El Niño events, and the worst property losses have occurred from November to February. There have only been a handful of occasions when property losses have exceeded 100 homes over the whole bushfire season. As at Sunday night (10 November) 178 homes and 28 public buildings had been destroyed. An additional 50 homes were destroyed or damaged on Tuesday 12 November. That means, at least 256 properties have already been lost this year by early November, and this amount is likely to rise as the bushfire season progresses. There is only one occasion when more homes have been lost earlier in the bushfire season in New South Wales – the October 2013 fires that destroyed more than 200 homes in the Blue Mountains. This fire was made worse due to climate change exacerbating hot, dry conditions.

On Friday 8 November, the NSW Rural Fire Service sent out an alert that fires were creating their own thunderstorms (an example of pyroconvection). This leads to extremely dangerous bushfires, with strong winds and lightning generated from the storms, worsening the bushfires on the ground. The 2003 Canberra bushfires and the 2009 Black Saturday bushfires were examples of pyroconvective events. These conditions are more likely to occur when atmospheric instability is high, combined with dangerous near-surface conditions (e.g. low humidity, strong winds and high temperatures). But on Friday, the atmosphere was relatively stable and therefore shouldn't have been conducive to these wildly unpredictable and dangerous events. Yet it happened.

Today (12 November) the catastrophic conditions are occurring due to high temperatures, strong winds and low humidity. Temperatures reached 36.1°C in Sydney. Later in the day, a southerly change is forecast, which could increase fire risk. Once a fire has started, a cool change accompanied by strong winds from a different direction can expand the size of a bushfire or quickly change the longer fire flanks into an intense and uncontrollable fire front.

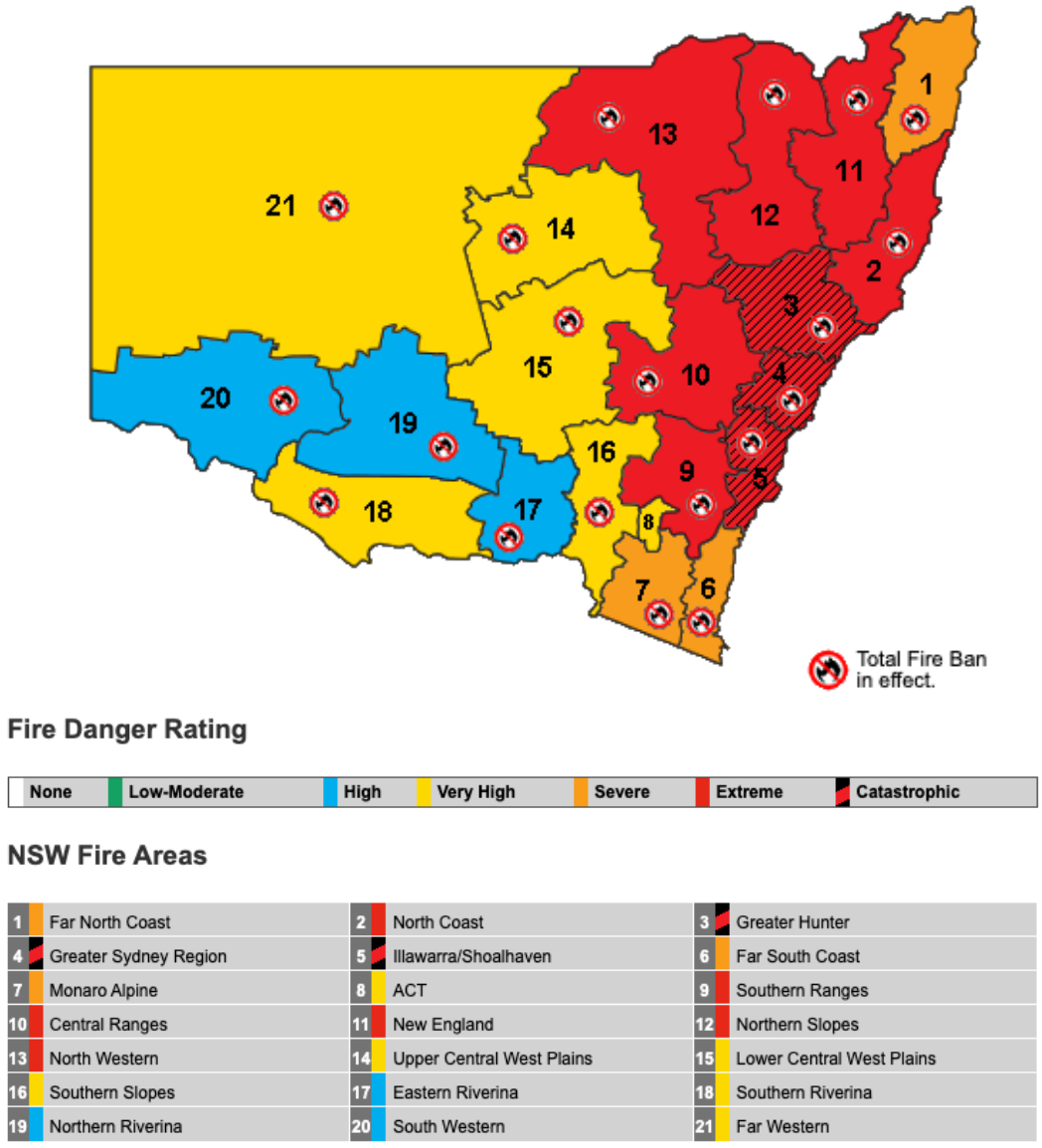

Figure 1: Fire Danger Ratings for Tuesday 12 November 2019, 3pm.

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.

4. How is climate change influencing bushfires?

A fire needs to be started (ignition), it needs something to burn (fuel), and it needs conditions that are conducive to its spread (suitable weather) (Figure 2). Climate change, primarily driven by the burning of fossil fuels – coal, oil and gas – can affect all of these factors in both straightforward and more complex ways.

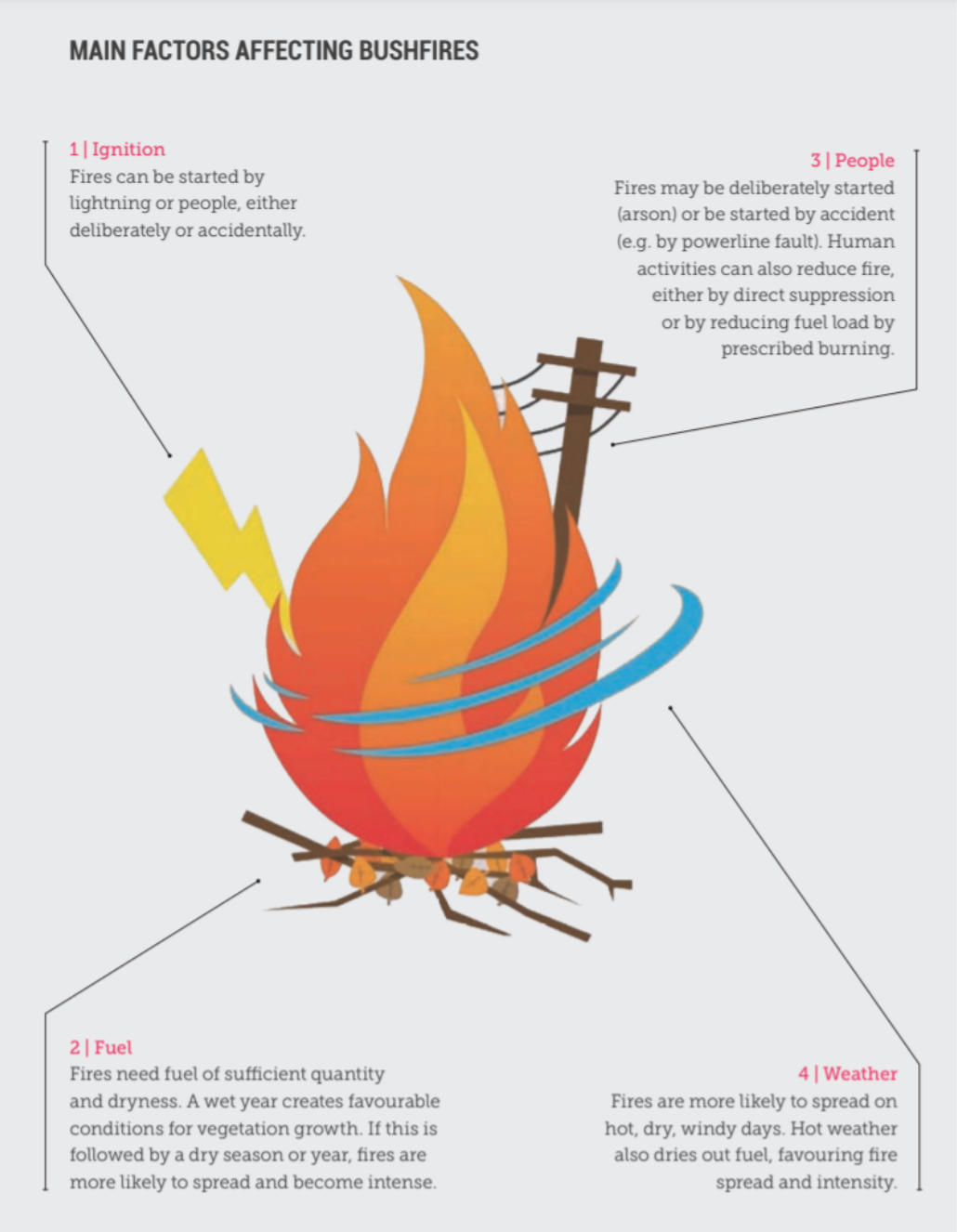

Figure 2: Main factors affecting bushfires: ignition, fuel, people and weather.

Long-term global warming, now about 1°C above pre-industrial levels, is increasing temperatures. Nine of Australia's top ten warmest years on record have occurred since 2005 (BoM 2019a). At the same time, a decline in cool season rainfall in southeast Australia is contributing to an increased likelihood of more dangerous bushfires.

Extreme fire weather has increased over the last 30 years in south and east Australia. The most extreme 10 per cent of fire weather days has increased in recent decades across many regions of Australia, especially in southern and eastern Australia (BoM 2019b; Figure 3).

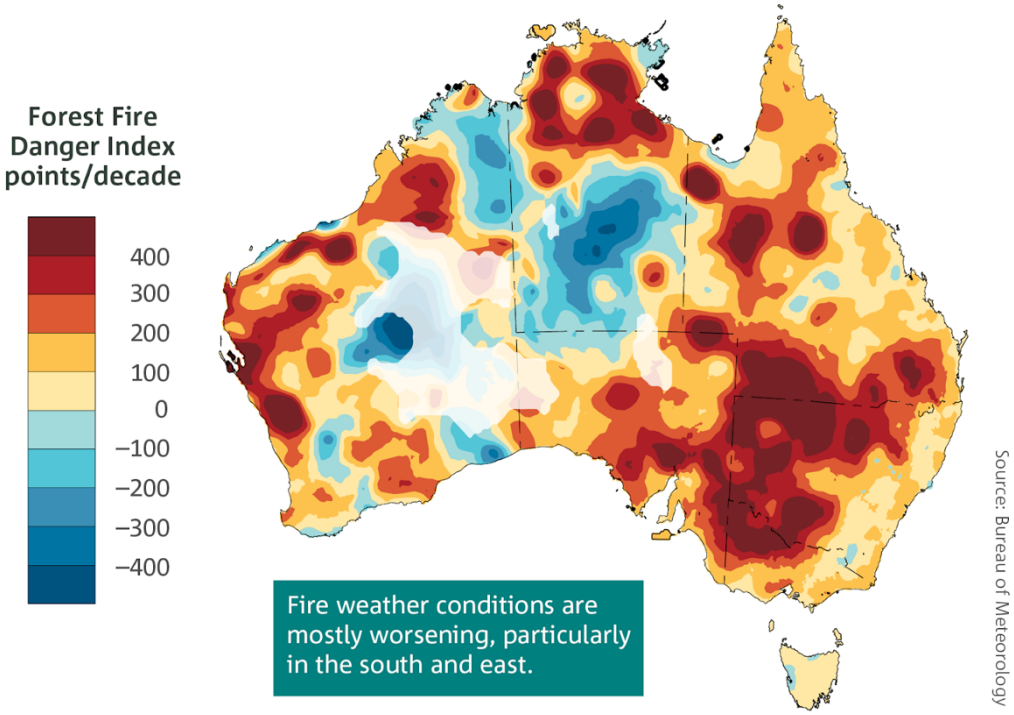

Figure 3: Trends from 1978 to 2017 in the annual (July to June) sum of the daily Forest Fire Danger Index—an indicator of the severity of fire weather conditions. Positive trends, shown in the yellow to red colours, are indicative of an increasing length and intensity of the fire weather season. A trend of 300 FFDI points per decade is equivalent to an average trend of 30 FFDI points per year. Areas where there are sparse data coverage such as central parts of Western Australia are faded. Source: BoM 2019b.

Hot days and heatwaves

The most direct link between bushfires and climate change comes from the long-term trend towards a hotter climate. Climate change is now making hot days hotter, and heatwaves longer and more frequent.

In Australia, the annual number of hot days (above 35°C) and very hot days (above 40°C) has also increased strongly over most areas since 1950. Heatwaves are also lasting longer, reaching higher maximum temperatures and occurring more frequently over many regions of Australia (Perkins-Kirkpatrick et al. 2016).

In Melbourne from 1951–2011, the average intensity of heatwaves has increased by 1.5°C and the average intensity of the peak day during a heatwave has increased by 2°C. This has implications for bushfire danger weather. For example, the 2009 Black Saturday fires in Victoria were preceded by a decade-long drought with a string of record hot years, coupled with a severe heatwave in the preceding week. The weather conditions on February 7 broke temperature records, with maximum temperatures up to 23°C above the February average in Victoria and record

high temperatures for February set in over 87% of the state (BoM 2009a; BoM 2009b). Over this period, the Forest Fire Danger Index (FFDI) ranged from 120 to 190, the highest values ever recorded (Karoly 2009).

In 2019, New South Wales and Queensland had an early and devastating start to the bushfire season with hot temperatures throughout the year making many districts primed for high bushfire danger ratings. In 2019, New South Wales had its warmest January to August period on record for overall mean temperature (1.85 °C above average), and Australia as a whole had its warmest on record such period for maximum (daytime) temperature (1.71 °C above average) and was second-warmest for mean temperature (1.30 °C above average, behind 2016). Maximum temperatures on the 5th and 6th September were more than 10 °C above average in some areas (BoM 2019b).

The high fire dangers in September 2019 included areas of the Murray–Darling Basin. For the Murray–Darling Basin as a whole, the four overall warmest January to August periods on record since 1910, in order, have been in 2019, 2016, 2018, and 2017. Maximum temperature deciles for the January to August period from 2017 to 2019 are shown in Figure 4, with virtually the whole of the Murray–Darling Basin showing warmest on record. These high temperatures contribute to higher values of the drought factor and lower values of relative humidity, as well as directly raise the FFDI, which increases with temperature (BoM 2019c).

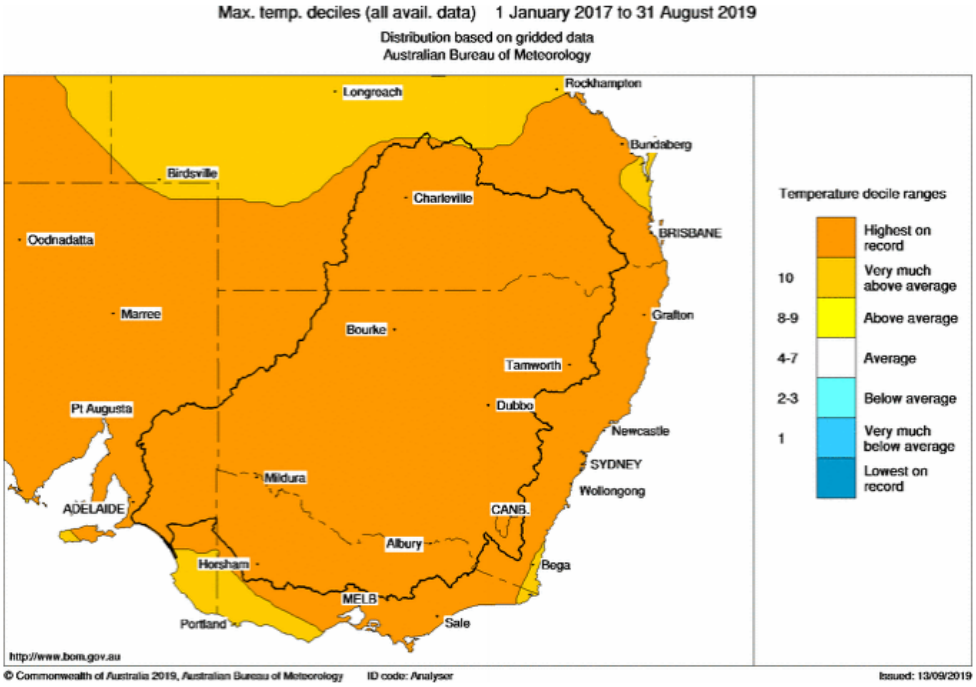

Figure 4: Map of the Murray–Darling Basin (black outline) showing the mean maximum temperature deciles for the period January to August in 2017, 2018, and 2019 (based on all years since 1910). Source: BoM 2019c.

Low Rainfall

Declining cool season rainfall has had a significant impact on increasing bushfire risk. Since the mid-1990s, southeast Australia has experienced a 15% decline in late autumn and early winter rainfall and a 25% decline in average rainfall in April and May. Climate change is influencing this drying trend.

The 2019-20 bushfire season in New South Wales and southeast Queensland had an early and devastating start in August 2019. From 9 August, bushfire risk in parts of northeast New South Wales and southeast Queensland was exacerbated by rainfall that was below average on a range of timescales from months to years leading to a prolonged and severe drought, and very high dryness factors for fuels. Rainfall for January to August 2019 was lowest on record in the Southern Downs (Queensland) and Northern Tablelands (New South Wales). For example, Tenterfield and Stanthorpe were each more than 20% below their previous record low January–August rainfall (and 77% below the long-term average) (BoM 2019c). The soils were also very dry. The top 100 cm of the soil profile was below average to driest on record for the first week of September 2019 over most of southeast Queensland and northeast New South Wales. The low soil moisture is symptomatic of both the recent intense dry conditions, as well as longer-term below average rainfall since 2017. Low soil moisture means high stress in the vegetation and fuels that might not normally burn become prone to bushfires (BoM 2019c).

Fuelled by a long and deepening drought, more than 100 fires burned in forest and bush areas in southeast Queensland and northeast New south Wales, including in some areas of subtropical rainforest and wet eucalyptus forests that do not often experience fire (NASA 2019; Figure 5). The drying effect of the drought makes vegetation more flammable, and therefore more likely to support extreme fire behaviour. It also makes vegetation more susceptible to spot fires ahead of the main fires when weather conditions deteriorate (high temperatures, low relative humidity, strong winds).

Figure 5: Drought exacerbates New South Wales Bushfires in September 2019. Strong winds fanned the flames and carried smoke more than 100 kilometres. Source NASA 2019.

Lengthening seasons

Since the 1970s, there has been an increase in extreme fire weather and a lengthening of the fire season across large parts of Australia, particularly in southern and eastern regions, due to increases in extreme hot days and drying. The lengthening seasons are reducing opportunities for fuel reduction burning (Matthews et al. 2012; Ximenes et al. 2017) and increasing the resource needs of firefighting services. The lengthening fire season means that opportunities for fuel reduction burning are decreasing.

5. What are the challenges in responding to these changing fire conditions?

When fires start during catastrophic conditions, it is often impossible to control them. It makes the situation extremely dangerous for communities and firefighters. Therefore the best thing to do if you live in a bushfire prone area is to leave early.

The challenges in responding to catastrophic fire conditions are exacerbated by lack of sufficient resources. This has been compounded by recent funding cuts for firefighting in the New South Wales Government's 2019-20 budget. In the latest state budget, expenses were cut by $26.7 million to the Office of the NSW Rural Fire Service and by $12.9 million to Fire and Rescue NSW. At the same time, capital expenditure to Fire and Rescue NSW declined by $28.5 million relative to 2018-19 and by $49.9 million relative to 2018-19 for the Office of the NSW Rural Fire Service (NSW Government, 2019). Such funding cuts are unwise given the bushfire danger forecasts for the 2019-20 fire season, and given the long-term increase in fire danger driven by climate change. Resourcing constraints are being compounded in drought-stricken regions such as the Darling-Downs, and the Granite Belt region west of Brisbane, as dams are dry and fire tanks are depleted following the extended drought.

Victoria's Country Fire Authority has sent around 300 members and a fleet of fire tankers and operational support vehicles to help NSW during this fire crisis. New Zealand has also sent specialist firefighters to the NSW/QLD emergency, and is offering further support. But, resource sharing arrangements will become increasingly challenged as climate change causes fire seasons in states and territories within Australia, and in the northern hemisphere and the southern hemisphere, to overlap. As a result, governments will be increasingly constrained in their ability to share resources and deal with larger, more destructive bushfires.

6. What is expected in the future?

Climate change is exacerbating catastrophic bushfire conditions. By 2020, the number of 'very high' or 'extreme' fire days could increase by 4-25%, and 15-70% by 2050 (Hennessy et al. 2005; The Australia Institute 2007).

A number of studies on future fire activity all point in the same direction – weather conditions conducive to fire in the southeast of the continent, including New South Wales and southeast Queensland, are becoming increasingly frequent; especially in those regions currently most affected by bushfires, and where a substantial proportion of the Australian population lives (Table 1). For example, FFDI values are expected to increase substantially by the end of the century (e.g. Clarke et al. 2011; CSIRO and BoM 2015; Clarke et al. 2016). Additionally, the number of severe fire weather days and severe fires is predicted to increase (CSIRO and BoM 2015; Zhu et al. 2015).

Study	Projections
Beer and Williams (1995)	Increase in FFDI with doubling of atmospheric carbon dioxide, commonly >10% across most of continent, especially in the southeast, with a few small areas showing decreases.
Williams et al. (2001)	General trend towards decreasing frequency of low and moderate fire danger rating days, but an increasing frequency of very high and in some cases extreme fire danger days.
Hennessy (2007)	Potential increase of very high and extreme FFDI days in the range of 4–25% by 2020 and 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 are projected to occur in the arid and semi-arid interior of NSW and northern Victoria.
Hasson et al. (2009)	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)	In the southeast, FFDI is projected to increase strongly by end of the 21st century, with the fire season extending in length and starting earlier.
Matthews et al. (2012)	A warming and drying climate is projected to produce drier, more flammable fuel, and to increase rate of fire spread.
Jones et al. (2013)	Projected increases in FFDI for the Melbourne area.
CSIRO and BoM (2015)	Projections of warming and drying in southern and eastern Australia will lead to increases in FFDI and a greater number of days with severe fire danger. In a business as usual scenario (worst case, driest scenario), severe fire days increase by up to 160-190% by 2090.

Table 1: Summary of projections from modelling studies investigating changes in fire risk in southeast Australia. Source: Climate Council 2017.

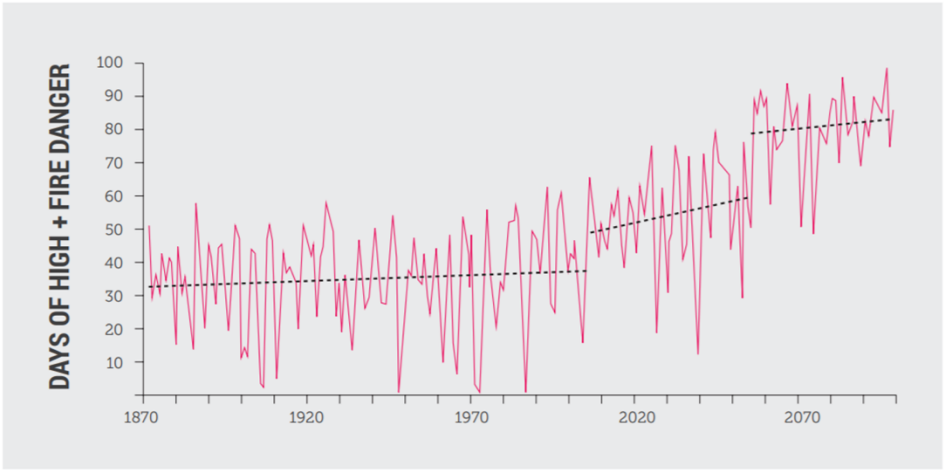

Figure 6: Estimated changes in days of high to catastrophic fire danger (based single model run of annual maximum temperature and total rainfall from a grid square over Melbourne from the CSIRO Mark 3.5 A1B model, based on Laverton data). Source: Jones et al., 2013.

Sadly, the catastrophic events that are unfolding in Australia are a prelude to the future. This is not normal. Now is the time to act decisively and swiftly by deeply and rapidly reducing greenhouse gas emissions and preparing our brave emergency and fire services and communities for the growing bushfire threat.

7. What can be done?

As bushfire conditions are forecast to escalate, the most important thing is to stay alert and listen to the official warnings and directions of the emergency services.

- In NSW, by visiting the NSW Rural Fire Service Fires Near Me page and downloading the app.
- In Queensland, by visiting the Queensland Rural Fire Service page here.
- If these apps and sites become unavailable, the official data is duplicated at: http://google.org/crisismap/australia.
- Your local ABC radio should be reporting regularly on the status of bushfires in your area, or follow ABC Emergency on Facebook for regular updates from emergency services.

Policy/government preparedness for bushfires

> "We need urgent emissions reductions, and a coordinated national effort on coping with worsening extreme weather disasters". Greg Mullins, Climate Councillor, member of the Emergency Leaders for Climate Action and Former NSW Fire and Rescue Commissioner (Climate Council 2019).

The government must develop a plan for escalating fire danger in Australia. It is crucial that communities, emergency services, and health services are well prepared for the increasing severity and frequency of extreme fire conditions. As fire risk increases, disaster risk reduction and adaptation policies will play a critical role in reducing risks to people and their assets. Increased resources for our emergency services and fire management agencies will be required (Climate Council 2014b; Climate Council 2014c). In particular, we will need increasing numbers of firefighters. These calls for planning and preparedness are not new, but the government has repeatedly failed to heed these calls. In 2013, Mr Gary Morgan, CEO Bushfire CRC, told the Senate Inquiry into Recent trends in and preparedness for extreme weather events "current practices will not sustain [fire agencies] into 2020" (Climate Council 2014a).

We must cut our greenhouse gas emissions rapidly and deeply to reduce the impact of future bushfires and other extreme events. Burning fossil fuels, like coal, oil and gas, must be phased out. Yet Australia's emissions have been rising year-on-year for the past five years (Department of the Environment and Energy 2019) and the Federal Government has no credible policy to reduce greenhouse gas pollution. Australia is not on track to meet even its dismal Paris target of 26-28% below 2005 levels by

2030. We have the solutions at our disposal to tackle climate change: we need to accelerate the transition to renewables and storage technologies, and non-polluting transport, infrastructure, and food production. Now we need to Federal Government to step up to protect Australian lives from worsening disasters in the future.

8. References

BoM (Bureau of Meteorology) (2009a) Modelling challenges from the Black Saturday 2009 Event. Accessed at: http://www.cawcr.gov.au/technical-reports/CTR_017.pdf.

BoM (2009b) Bushfires in Victoria, 7–8 February 2009. Accessed at: http://www.bom.gov.au/vic/sevwx/fire/20090207/20090207_bushfire.shtml.

BoM (2019a) Annual climate statement 2018. Accessed at http://www.bom.gov.au/climate/current/annual/aus/.

BoM (2019b) State of the Climate 2018. Accessed at http://www.bom.gov.au/state-of-the-climate/australias-changing-climate.shtml.

BoM (2019c) Special Climate Statement 71—severe fire weather southeast Queensland and northeast New South Wales in September 2019. Accessed at http://www.bom.gov.au/climate/current/statements/scs71.pdf.

Clarke H, Smith Pl and Pitman AJ (2011) Regional signatures of future fire weather over eastern Australia from global climate models. International Journal of Wildland Fire, 20: 550–562.

Clarke H, Pitman AJ, Kala J et al. (2016) An investigation of future fuel load and fire weather in Australia. Climatic Change, 139: 591–605.

Climate Council (2019) Australia not prepared for new overlapping bushfire seasons. Accessed at: https://www.climatecouncil.org.au/resources/australia-not-prepared-for-new-overlapping-bushfire-seasons/

Climate Council (2014a) Climate Change & the Australian Bushfire Threat. Accessed at: https://www.climatecouncil.org.au/resources/be-prepared/.

Climate Council (2014b) Be Prepared: climate change and the South Australia bushfire threat. Accessed at: https://www.climatecouncil.org.au/uploads/7e9851016b27d77a54e76fcac0c3480c.pdf.

Climate Council (2014c) Be Prepared: climate change and the ACT bushfire threat. Accessed at:

http://www.climatecouncil.org.au/uploads/a56c563caa5bb336050ed88c60dba7e4.pdf.

Climate Council (2017) Earlier, More Frequent, More Dangerous: Bushfires in New South Wales by Professor Lesley Hughes and Dr David Alexander. Accessed at: https://www.climatecouncil.org.au/resources/nsw-bushfires-2017/.

CSIRO and BoM (2015) Climate Change in Australia – Technical Report 2015. CSIRO and BoM, Melbourne.

Department of the Environment and Energy (2019) Quarterly Update of Australia's National Greenhouse Gas Inventory for March 2019. Accessed at: http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/quarterly-update-australias-nggi-mar-2019.

Hennessy, K., C. Lucas, N. Nicholls, J. Bathols, R. Suppiah and J. Ricketts, 2005: Climate change impacts on fire-weather in south-east Australia. Consultancy report for the New South Wales Greenhouse Office, Victorian Dept. of Sustainability and Environment, ACT Government, Tasmanian Department of Primary Industries, Water and Environment and the Australian Greenhouse Office. CSIRO Marine and Atmospheric Research and Australian Government Bureau of Meteorology, 88 pp. Accessed at: http://www.cmar.csiro.au/eprint/open/hennessykj_2005b.pdf.

Karoly D (2009) The recent bushfires and extreme heat in southeast Australia. Bulletin of the Australian Meteorological and Oceanographic Society, 22: 10–13.

Matthews S, Sullivan AL, Watson P and Williams RJ (2012) Climate Change, fuel and fire behaviour in a eucalypt forest. Global Change Biology, 18: 3212–3223.

NASA (2019) Drought Exacerbates Australian Fires. Accessed https://earthobservatory.nasa.gov/images/145599/drought-exacerbates-australian-fires.

NSW Government (2019) Infrastructure Statement 2019-20, Budget Paper No. 2. Accessed: https://www.budget.nsw.gov.au/sites/default/files/budget-2019-06/Budget_Paper_2-Infrastructure%20Statement-Budget_201920.pdf?fbclid=IwAR3IhANFPnQKNRL5PGdXXRyDuBRhafqaEUQALenCgXGMoG1JrhFCH17lwec.

Perkins-Kirkpatrick SE, White CJ, Alexander LV, Argüeso D, Boschat G, Cowan T, Evans JP, Ekström M, Oliver ECJ, Phatak A, Purich A (2016) Natural Hazards: Heatwaves, Climatic Change, 131(1): 101-114.

The Australia Institute (2007) Bushfire Weather in South East Australia. Policy Brief. Accessed at http://www.climateinstitute.org.au/articles/publications/briefing-bushfire-weather-in-south-east-australia.html/section/478.

Ximenes F, Stephens M and Brown M (2017) Mechanical fuel load reduction in Australia: a potential tool for bushfire mitigation. Australian Forestry, 80: 88–98, DOI: 10.1080/00049158.2017.1311200.

Zhu Q, Yang X and Yuc Q (2015) Climate change impact on bushfire risk in New South Wales, Australia. 2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), pp 1413–1416.

About the Climate Council

The Climate Council is an independent non-profit organisation funded by donations by the public. Our mission is to provide authoritative, expert advice to the Australian public on climate change.

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