

SUMMER OF CRISIS



Thank you for supporting the Climate Council.

The Climate Council is an independent, crowd-funded organisation providing quality information on climate change to the Australian public.

Published by the Climate Council of Australia Limited.

ISBN: 978-1-922404-01-5 (print)
978-1-922404-00-8 (digital)

© Climate Council of Australia Ltd 2020.

This work is copyright the Climate Council of Australia Ltd. All material contained in this work is copyright the Climate Council of Australia Ltd except where a third party source is indicated.

Climate Council of Australia Ltd copyright material is licensed under the Creative Commons Attribution 3.0 Australia License. To view a copy of this license visit <http://creativecommons.org.au>.

You are free to copy, communicate and adapt the Climate Council of Australia Ltd copyright material so long as you attribute the Climate Council of Australia Ltd and the authors in the following manner: Summer of Crisis.

Authors: Lesley Hughes, Will Steffen, Greg Mullins, Annika Dean, Ella Weisbrot and Martin Rice.



Cover image: Batemans Bay New Years Eve bushfires - Australia. PA / AAP Image.

This report is printed on 100% recycled paper.



Professor Lesley Hughes
Climate Councillor



Professor Will Steffen
Climate Councillor



Greg Mullins
AO, AFSM
Climate Councillor



Dr Annika Dean
Senior Researcher



Ella Weisbrot
Researcher



Dr Martin Rice
Head of Research



facebook.com/climatecouncil



info@climatecouncil.org.au



twitter.com/climatecouncil



climatecouncil.org.au

Contents

Key Findings	ii
1. Introduction.....	1
2. Summer of 2019-20 in Detail	3
Drought, heatwaves and bushfires	3
Impacts	10
When it Rains it Pours: From Bushfires to Floods	19
4. Conclusion: Time to Act.....	23
References	24
Image Credits	27

Key Findings

1

Climate change fuelled Australia's devastating Black Summer.

- › Extremely hot, dry conditions, underpinned by years of reduced rainfall and a severe drought, set the scene for this summer's unprecedented fires.
- › Cool season rainfall has declined in southeast Australia over the last two to three decades, while temperature records have been broken over and over. 2019 was Australia's hottest, driest year on record. 2018-2019 was southeast Australia's driest two-year period on record.
- › The Australian fire season has lengthened in NSW, decreasing the ability of land managers to conduct hazard reduction burns and increasing the number of fire danger days.

2

Australia's Black Summer was unprecedented in scale and harm. The bushfire season was the worst on record for New South Wales in terms of the scale of the bushfires, the number of properties lost and the amount of area burned.

- › People and animals affected:
 - Nearly 80 percent of Australians were affected either directly or indirectly by the bushfires.
 - One billion animals were killed by the bushfires, 800 million in NSW.
- › Area burnt:
 - The Gospers Mountain fire was the largest forest fire ever recorded in Australia, burning more than 500,000 hectares.
- This season's fires were incredibly large in area, even compared to forests all around the world. Around 21 percent of Australian temperate broadleaf and mixed forests was burnt. The average annual area burnt for most continents, including Australia, is well below 5%, except for Africa and Asia, which have average annual areas burnt of 8-9%.
- › Record breaking weather:
 - Catastrophic fire danger ratings were experienced at locations and times of the year never before recorded.
 - For the first time ever catastrophic fire conditions were forecast for Greater Sydney.

3

The bushfires are estimated to have spewed between 650 million and 1.2 billion tonnes of carbon dioxide into the atmosphere. That is equivalent to the annual emissions from commercial aircraft worldwide and is far higher than Australia's annual emissions of around 531 million tonnes.

- › The amount of carbon dioxide released by the bushfires is also more than the annual emissions of Germany.

4

Climate change events are becoming increasingly economically devastating.

- › The tourism sector alone is set to lose at least \$4.5 billion because of the bushfires. It is estimated that there was a 10-20 percent drop in international visitors booking holidays to Australia.
- › The bushfire smoke that blanketed Sydney is estimated to have cost the city \$12-50 million per day.
- › More than 23,000 bushfire-related insurance claims were lodged across New South Wales, Queensland, South Australia and Victoria between November and February, totalling an estimated value of \$1.9 billion.

5

The summer of 2019-20 saw unprecedented climate impacts fuelled by the burning of coal, oil and gas.

- › The hot, dry conditions that fuelled these fires will continue to worsen without substantial, concerted action to rapidly phase out coal, oil and gas.
- › Australia urgently needs a plan to cut our domestic greenhouse gas emissions to net zero and to phase out fossil fuel exports because we are one of the world's largest polluters.
- › Taking action now will provide a chance to stabilise, then eventually reduce disaster risks for future generations.
- › Clearly, what Australia does matters and the longer we delay, the harder the problem will be to solve. We simply cannot leave this mess for our children to try to fix.

**SUMMER
2019-20**

CLIMATE IMPACTS IN NSW/ACT



Three 7-day State of Emergency declarations were made for NSW in November, December and January due to dangerous bushfire conditions.

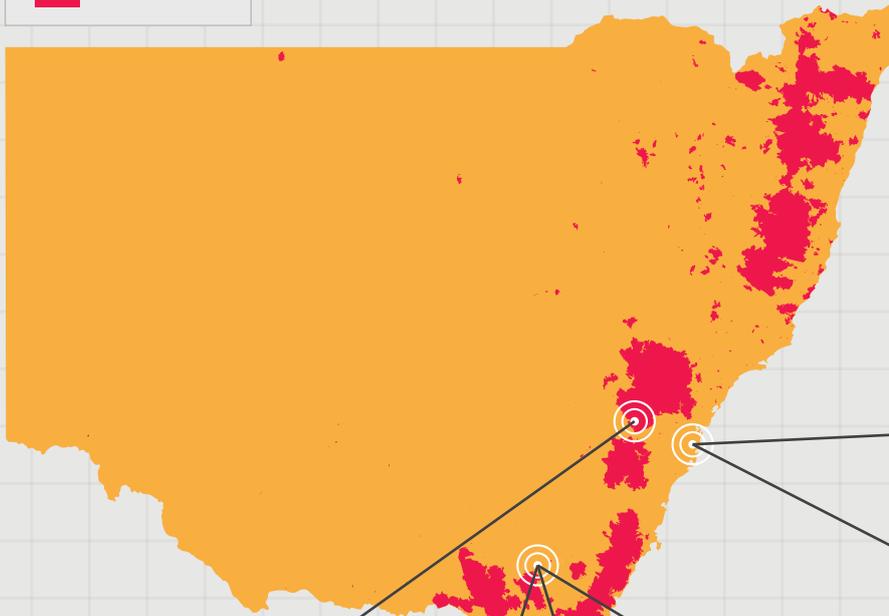


5.4 million hectares burned in NSW, which equates to 6.82% of the state – the worst on record.



11,141 bush & grass fires across NSW from the beginning of July.

Area burned



An estimated 800 million animals killed by the bushfires in NSW.



25 deaths from bushfires in NSW, and 33 nationally.



2,439 homes destroyed in NSW – worst on record.



Parts of Sydney experienced air quality more than 12 times the hazardous level.



Sydney four-day rainfall total = 392 mm (6-10 February 2020), highest 4-day rainfall total in 30 years.



81 percent of the Blue Mountains World Heritage Area and 54 percent of the Gondwana Rainforests in NSW and QLD burned.



A State of Emergency declared for the ACT on 31 January 2020.



The air quality index in parts of Canberra (Monash) reached 4,650 – more than 23 times the hazardous level.



Canberra hailstorm with wind gusts up to 117km/h (20 January 2020) - ACT Emergency Services Agency received a record number of calls (1,900) and over 37,000 insurance claims made.

Figure 1: Summer 2019-20 climate impacts in NSW and ACT.

1. Introduction

Australia's Black Summer of 2019-20 was characterised by catastrophic bushfires. The bushfire season started in winter and was the worst on record for New South Wales in terms of its intensity, the area burned, and the number of properties lost. It was also the worst season on record for properties lost in Queensland.

This report focuses on New South Wales and the Australian Capital Territory, because the effects of the bushfires were most severe in these areas, but we acknowledge that the bushfires affected Victoria, Queensland, South Australia, Western Australia and Tasmania.

According to a recent study, almost 80 percent of the adult Australian population was affected either directly or indirectly by the bushfires, making the crisis truly national in its scale (Biddle et al. 2020). A poll of over 3,000 people indicated that 14 percent of the adult population (2.9 million adults) was directly affected—with their homes lost, damaged or threatened, or their family forced to evacuate. A further 15.4 million Australians were indirectly affected, such as by having a friend or family member who lost a home, being affected by bushfire smoke or having holiday plans disrupted (Biddle et al. 2020). Major population centres such as Sydney, Brisbane, Melbourne and Canberra were affected by dangerous air quality due to bushfire smoke for many weeks.

According to early estimates, the bushfires likely released between 650 million and 1.2 billion tonnes of carbon dioxide (median of around 900 million tonnes) into the atmosphere. 900 million tonnes is roughly equivalent to the annual emissions from commercial aircraft worldwide, and is higher than the annual emissions of Germany (Global Carbon Atlas 2019; ICCT 2019; Bloomberg 2020). This is also far more than Australia's annual emissions of around 531 million tonnes (Australian Government 2020).

2019-20 was an unprecedented summer of climate impacts fuelled by the burning of coal, oil and gas.

A long-term drought and sustained high temperatures throughout the year set the scene for the catastrophic bushfires. The bushfires were followed by torrential rainfall, damaging gales, hailstorms and flooding in many areas, including northern New South Wales, Sydney and the Illawarra region (southeast Queensland also experienced heavy rainfall and flooding at the same time). Unfortunately, this rainfall did not penetrate inland very far, leaving most of New South Wales still in drought.

Above average temperatures have been recorded for most Australian summers since the late 1970s (compared to a 1961-1990 baseline). This summer (2019-20) has been the second hottest on record nationally, sitting 1.88°C above the 1961-1990 average (the hottest summer was

the 2018-19 summer, which was 2.60°C above the long-term average). In New South Wales, this summer was the fourth hottest on record, at 2.33°C above the 1961-1990 average (BoM 2020a). This follows previous climate change-driven Angry Summers in 2018-19, 2016-17, 2013-14 and 2012-13, with Australians enduring worsening extreme weather events throughout this past decade. The summer of 2019-20 illustrates how climate change can drive 'compound events', where extreme weather events occur simultaneously or follow each other in close succession, resulting in greater impacts.

Figure 1 provides an overview of some of the devastating climate impacts that affected New South Wales and the Australian Capital Territory over summer 2019-20.

Climate change is increasing the likelihood of 'compound events', where multiple extremes coincide or occur in close succession, resulting in greater impacts.

2. Summer of 2019-20 in Detail

DROUGHT, HEATWAVES AND BUSHFIRES

The ongoing drought coupled with increasing periods of extreme heat, both aggravated by climate change, set the scene for the catastrophic fires in the summer of 2019-20.

Bushfires rely on five main factors to take hold and spread: high temperatures, low rainfall, low humidity, strong winds and a suitable fuel source. 2019 was the hottest year on record across Australia with mean temperature 1.52°C above average and mean maximum temperature 2.09°C above average (BoM 2020b) (see Figure 2 below). It was also the driest year on record across Australia with rainfall 40 percent below average (BoM 2020b). For the January to October period, rainfall was 70 to 80 percent below average in some locations in northern New South Wales and southern Queensland (BoM 2019a). The dry conditions throughout the year came on the back of prolonged rainfall deficiencies across most of southeastern Australia since the beginning of 2017, underpinning one of the worst droughts on record (Figure 3 below shows the 2018 to 2019 rainfall trends). The drought has challenged water supplies in rural towns, reduced agricultural productivity, and dried out rivers and wetlands, causing mass fish deaths.

Hot, dry conditions exacerbated by climate change primed conditions for dangerous bushfires.

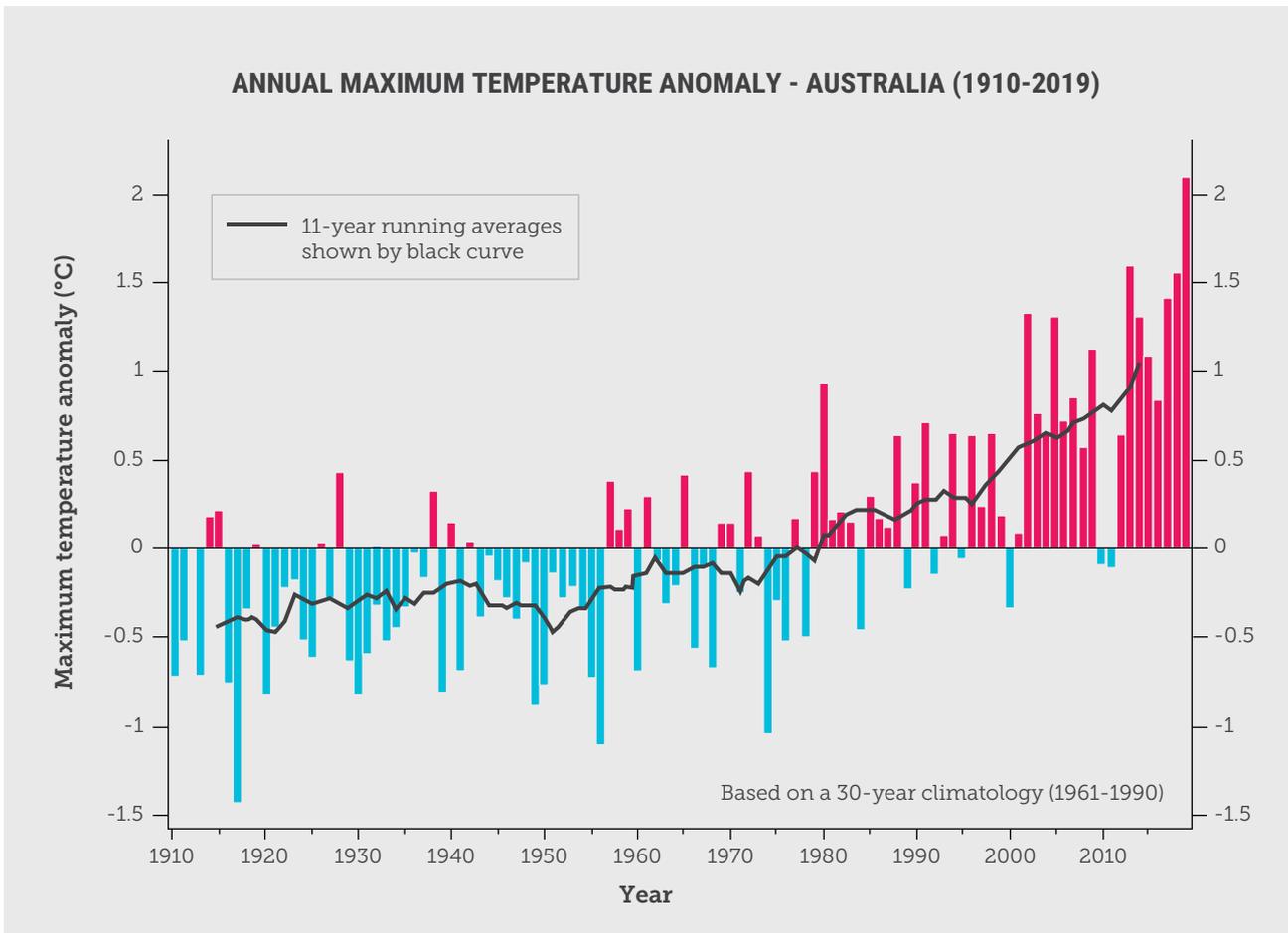


Figure 2: Annual maximum temperature anomaly Australia (1910 to 2019). Source: BoM (2020e).

In eastern Australia, the prolonged dry conditions over the year contributed to drying out vegetation, making it more flammable, and creating the perfect conditions for fires to take hold and spread, given a source of ignition and the right weather. Prolonged heat also increased evaporative demand, further exacerbating

soil and vegetation dryness. Unsurprisingly, the annual accumulated McArthur Forest Fire Danger Index (FFDI) was the highest on record in 2019 (measured since 1950) (BOM 2020b). The McArthur Forest Fire Danger Index is a measure of bushfire weather, and is based on measurements of rainfall, temperature, humidity and wind speeds.

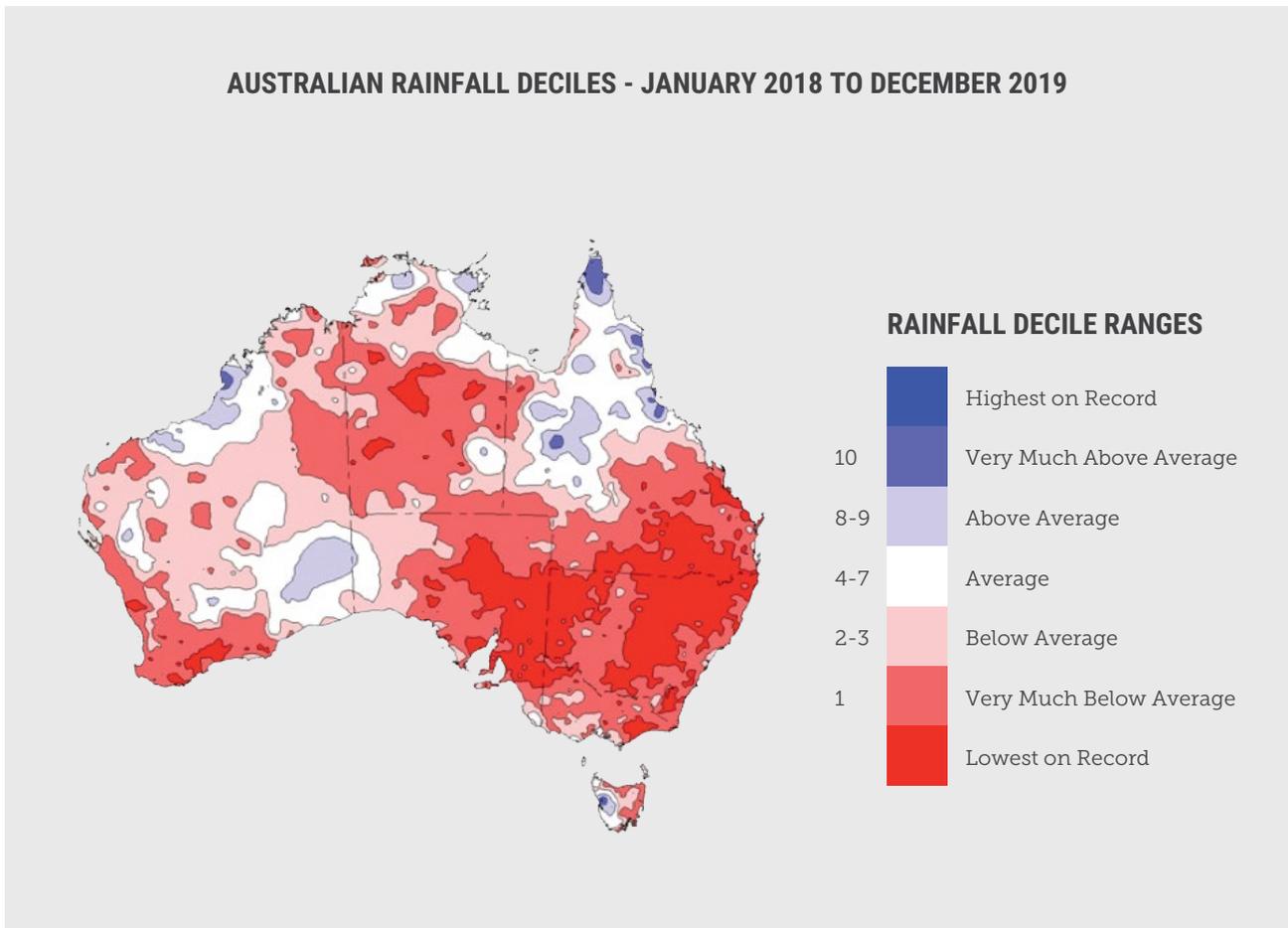


Figure 3: Australian rainfall deciles – 1 January 2018 to 31 December 2019. Source: BoM (2020f).

Catastrophic bushfire conditions were recorded in some places in New South Wales as early as September.

Australia's climate has warmed by more than 1°C since 1910 (CSIRO and BoM 2018). Every year since 2013 has been amongst the ten hottest years on record for Australia, with only one of the ten hottest years (1998) occurring before 2005 (BoM 2020c). Cool season rainfall has also been declining across southern Australia over recent decades. In the southwest of Australia, May-July rainfall has decreased by around 20 percent since 1970 and in the southeast, April-October rainfall has decreased by around 11 percent since the 1990s (CSIRO and BoM 2018). These trends have contributed to an increase in the length of fire seasons and to the severity of dangerous fire weather across large parts of the continent (CSIRO and BoM 2018).

Although the El Niño–Southern Oscillation remained neutral throughout 2019, a very strong positive Indian Ocean Dipole also contributed to low rainfall across Australia over the past year, building upon longer-term rainfall deficiencies in eastern Australia since the beginning of 2017. Apart from 2013, all previous major bushfire seasons with heavy losses of property occurred during El Niño events, but climate change is increasingly swamping the influence of natural variability (Gergis and Carey 2020).

As the climate continues to change, bushfire seasons are starting earlier and lasting longer. Twenty-one local government areas in New South Wales commenced their Bushfire Danger Period in August 2019, and a further 53 local government areas commenced their Bushfire Danger Period in September (NSW RFS 2019a). These declarations were in contrast to the statutory Bushfire Danger Period in New South Wales, which officially spans from the beginning of October to the end of March. Commencement of serious bushfire weather and outbreaks of serious fires from August in New South Wales has become common in recent years.

The bushfire season in New South Wales was well established by early spring 2019. Across Australia as a whole, the highest ever spring fire weather danger, as measured by the FFDI, was observed, with record high values in areas of all states and territories (BoM 2020c). Catastrophic fire danger ratings (FFDI above 100) were recorded at some locations in New South Wales on 6 September, which marked the onset or spread of numerous large fires in eastern Australia. Catastrophic, the highest fire danger rating, was introduced after the 2009 Black Saturday fires to describe “off the (McArthur) scale” fire danger indices (i.e. over 100). Fires that occur in catastrophic conditions simply cannot be fought safely, and lives and homes are put in at risk.

In most districts of northeast New South Wales, 6 September 2019 had the highest regionally averaged daily FFDI in September, based on all years since 1950 (BoM 2019b). Numerous bushfires burned across southern Queensland and northern New South Wales over the 5-9 September period, destroying several homes. On October 26, the Gospers Mountain fire was ignited by lightning in the Wollemi National Park. The fire burned through more than 512,000 hectares throughout November, December and January, making it the largest forest fire ever recorded in Australia (see Figure 4). It was eventually extinguished by heavy rains in February.

In late spring, catastrophic fire danger ratings were again experienced at locations and times of the year never before recorded. From 8 November, fire conditions flared in the Clarence Valley Council area in New South Wales, destroying hundreds of homes across the region. For the first time since the catastrophic fire danger rating was introduced in 2009, the rating was forecast for Greater Sydney on 12 November 2019 (NSW RFS 2019b). A seven-day State of Emergency was declared for New South Wales. A number of fires started in Lane Cove National Park and quickly reached emergency warning level, threatening homes in Turrumurra. Despite atmospheric stability readings indicating that it would be very unlikely, several fires created their own weather systems and pyrocumulonimbus clouds on that day, leading to very rapid fire spread, long-distance spotting, and intense fire conditions. Catastrophic fire conditions were also forecast in numerous places in South Australia on 20 November and parts of Victoria on 21 November 2019 (catastrophic conditions are known as Code Red in Victoria).

One of the effects of this extreme bushfire season has been an increase in the number of fire-caused storms (or pyrocumulonimbus events). These events, previously considered rare, occur when bushfires couple with the atmosphere, generating explosive thunderstorms that can include strong downdrafts, lightning and even black hail, making bushfire behaviour very unpredictable. Australia experienced only two confirmed and two possible fire-caused storms between 1978 and 2001 (McRae et al. 2015). Since 2001, 78 fire-caused storms have been recorded, including a staggering 33 percent increase in 2019 (with around 15 fire-caused storms in the Victorian high country in March 2019 alone). Fire researchers estimate that an additional 30 fire-caused storms have occurred since September 2019, with a further 15 fire-caused storms being investigated (Guardian 2019). This represents an astounding shift in the frequency of these events.

In December 2019, more than 2000 bush and grass fires burned throughout the month in New South Wales, and other significant fires broke out in South Australia, Tasmania and Victoria. From 12 December, a slow-moving hot air mass developed over western Australia and started to move from west to east across the country. This resulted in a series of days above 40°C in Perth from 13-15 December and then a swathe of broken records for daily December maximum temperatures in locations across South Australia, Victoria, ACT and New South Wales, southeast Queensland, Central Australia, and much of Tasmania. For a number of locations, records were set for the warmest day for any time of the year, and on two consecutive days (17 and 18 December) records were broken for the national area-averaged maximum temperature (40.9°C and 41.9°C respectively) (BoM 2020b). Heavy smoke blanketed Sydney, especially throughout December, as the Gospers Mountain Fire burned out of control.



Figure 4: The Gospers Mountain Fire rages (21 December 2019), devastating areas such as Bilpin.

As the heatwave arrived on the east coast, catastrophic conditions were again forecast for the Greater Sydney Region (the second time this has ever occurred), marking the beginning of another seven-day State of Emergency for New South Wales from 19 December. The week ending 24 December 2019 was Australia's hottest week on record, and the month as a whole was Australia's hottest December on record (3.21°C above average, surpassing the previous December record set in 2018 by more than a full degree). It was also the hottest month on record for minimum and maximum temperatures, with the national maximum temperature an astounding 4.15°C above average. The monthly accumulated FFDI was also the highest on record for any month (BoM 2019c).

The end of 2019 and the first days of 2020 brought particularly extreme fire weather to southeastern New South Wales and eastern Victoria, with numerous locations recording their warmest January day on record on 4

or 5 January across southeastern Australia. Bushfires flared on New Year's Eve 2019, hitting many small towns on the south coast of New South Wales, destroying hundreds of houses including around Batemans Bay, Mogo, Lake Conjola and Cobargo and tragically killing nine people. In an unprecedented move, the New South Wales Government issued evacuation orders for the south coast prior to New Year's Eve, a move which probably saved many lives. Another seven-day State of Emergency was declared from 3 January 2020 for New South Wales. From 27 January until the end of the month, a very hot air mass brought high temperatures to southern Australia. On 31 January, as temperature records were broken in locations across New South Wales, Victoria and Tasmania, a State of Emergency was declared in the Australian Capital Territory as the Orroral bushfire grew to eight percent of the territory's land area, threatening homes and properties there and in New South Wales (ACT Government 2020).

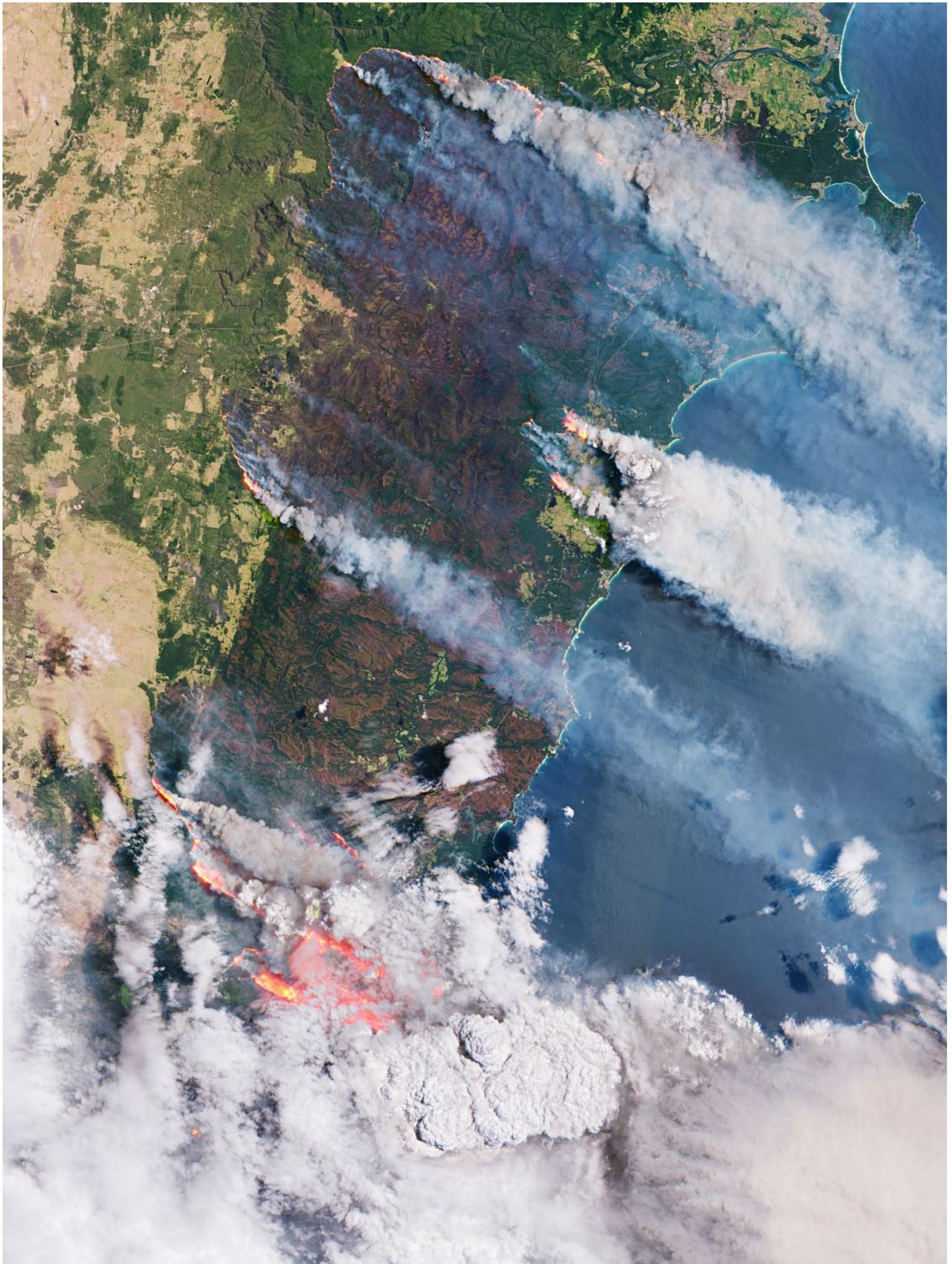


Figure 5: Aerial photo showing fires burning on the east coast of Australia, 31 December 2019.

NSW experienced its worst bushfire season on record in 2019-20.

IMPACTS

Loss of lives and property

The bushfire season has been the worst on record for New South Wales. Thirty-three people have tragically lost their lives in the fires across Australia, with 25 of those deaths occurring in New South Wales, including three volunteer firefighters and three aerial firefighting crew. The 2019-20 bushfire season has also been the worst on record for property loss, with 2,439 homes destroyed and 1,021 homes damaged, as at 13 February 2020 (NSW RFS 2020). In addition, thousands of facilities and outbuildings were destroyed and damaged. The number of homes destroyed in the 2019-20 bushfire season is almost ten times more than 2013-14, which was the previous worst season for homes destroyed by bushfires in New South Wales. We must also acknowledge that due to the efforts of firefighters, more than 14,000 homes at risk were saved (NSW RFS 2020).

Loss of wildlife, forests and ecosystems

In New South Wales, the bushfires burned around 5.4 million hectares (roughly 6.82 percent of the state) (NSW RFS 2020). This is worse than the four million hectares burned in the western division in 1974-75, which was the previous worst season for area burned by bushfires in New South Wales (Luke & McArthur 1978). It is notable that the 1974-75 fires burned through grass and scrubland whereas the 2019-20 bushfires burned through forests, making these two seasons not fairly comparable.

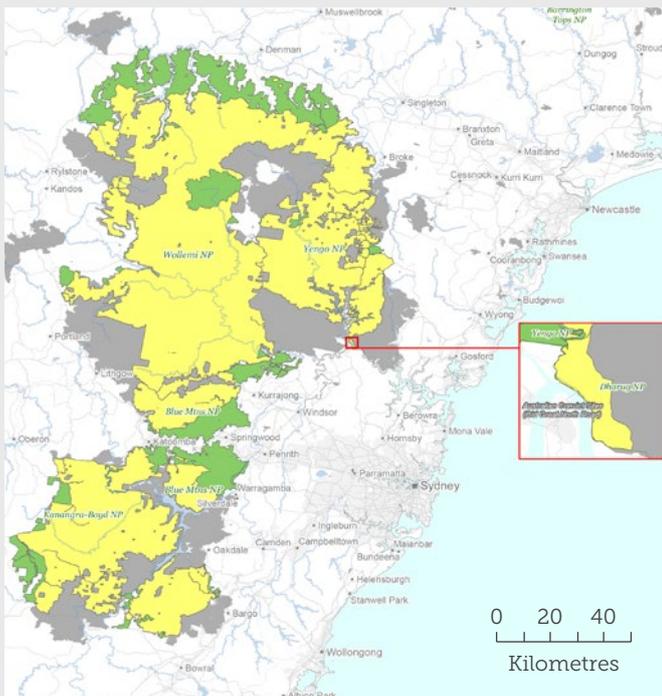
Firefighters managed to save 14,000 properties under threat from bushfires in NSW.

The bushfires have had extensive ecological impacts. An estimated 800 million animals were killed by the bushfires in New South Wales, with an estimated national impact of more than one billion animals (University of Sydney 2020). These figures are likely underestimated, as they only include mammals, reptiles and birds, and do not include animals that would have starved post bushfires in burned habitats. The fires burned through around 81 percent of the Blue Mountains World Heritage Area (see Figure 6, Left). The fires also burned through around 54 percent of the Gondwana Rainforests in New South Wales and Queensland, including areas of Washpool National Park, Gibraltar Range National Park, Main Range National Park, Lamington National Park, Mt Barney National Park, Oxley Wild Rivers National

At least 800 million animals have been killed in NSW by horrific bushfires in 2019-20 summer.

Park, Werrikimbe National Park, New England National Park, and Barrington Tops National Park (Department of Agriculture, Water and the Environment 2020) (see Figure 6, Right).

Area burned in the Blue Mountains World Heritage Area



Area burned in the Gondwana World Heritage rainforests

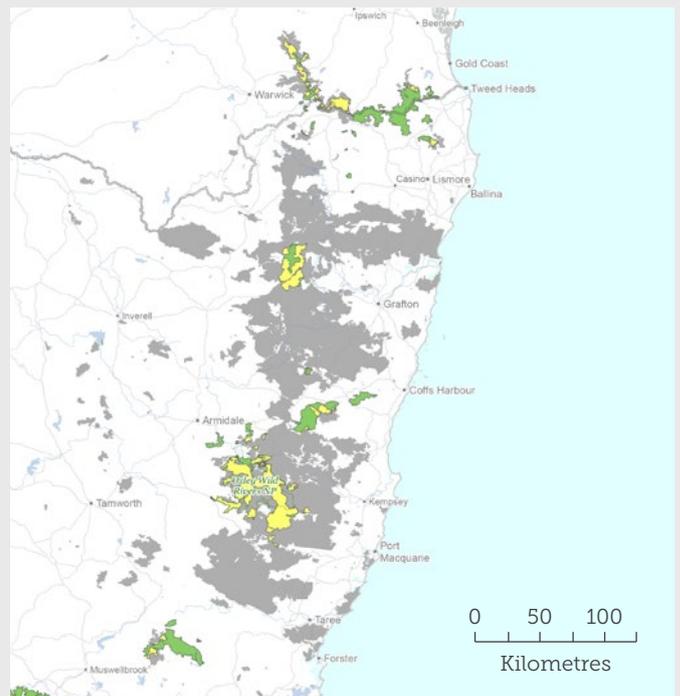


Figure 6: Left: Area burned in the Blue Mountains World Heritage Area. Right: Area burned in the Gondwana World Heritage rainforests. Note: Yellow shows world heritage areas burned, green shows world heritage areas unburned and grey shows burned areas that are not world heritage. Source: Department of Agriculture, Water and the Environment (2020).

The bushfires were so severe that ancient rainforests burned.

The Gondwana rainforests include species that date back to the time of the Gondwana supercontinent, before the modern continents split apart around 180 million years ago. The Gondwana rainforests include the largest areas of subtropical rainforest on the planet, some warm temperate rainforest and nearly all the world's Antarctic beech cool temperate rainforest.

The Gondwanan rainforests have developed over millions of years in a fire-free state and have usually been considered too damp to burn. Whilst it is known that more than half of these rainforests have been affected by bushfires in the 2019-20 season, the severity of the fires is unclear. Rainforests are not well adapted to recovery from fire, and it is unlikely that these areas will return to their previous ecological state. This follows the burning of World Heritage rainforests in Tasmania in 2016 and again in 2018, and subtropical rainforests near Mackay in Queensland in 2018 – areas previously considered too wet to burn.

Between September 2019 and early January 2020, around 5.8 million hectares of mainly temperate broadleaf forest were burned in New South Wales and Victoria. The temperate broadleaf and mixed forests cover around 27 million hectares in Australia, stretching from southeast Queensland along the east coast of New South Wales and into Victoria and Tasmania. This forest biome is typified by genera such as *Eucalyptus* and *Acacia*. Around half of the temperate and broadleaf mixed forest biome in Australia occurs in New South Wales, and one fifth occurs in Victoria. Judging only by the burned area in New South Wales and Victoria, around 21 percent of this forest biome has so far been burned in this past single season. The average annual area of forest burned for most continents is well below 5%, except for Africa and Asia, which have average annual areas burnt of 8-9%. In Australia, typically below 2% of temperate broadleaf forests burn annually, even in extreme fire seasons. This makes the 2019-20 forest fires globally unprecedented in terms of the percentage of any continental forest biome burned in one season (Boer et al. 2020).

The extent of temperate broadleaf and mixed forests that burned along the east coast of Australia in the past fire season is globally unprecedented.

According to initial assessments, around 327 threatened species of plants and animals have at least ten percent of their range (the range in which they are known to occur) in areas that were burned by the

bushfires. These include 272 plant species, 16 mammal species, 14 frog species, nine birds, seven reptiles, four insects, four fish and one spider species (Department of Agriculture, Water and the Environment 2020).

Figure 7: Fires burn through forested areas near Casino, northern New South Wales.



Out of these 327 species, 31 species are recognised as Critically Endangered, 110 species are recognised as Endangered and 186 species are recognised as Vulnerable under the federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). For some threatened species, the range that has been affected by bushfires is larger than for others:

- › 49 threatened species of plants and animals have more than 80 percent of their range within areas burned by the bushfires. These include the Critically Endangered Nightcap Oak, native to New South Wales, and the Endangered Kangaroo Island Dunnart, native to South Australia.
- › 65 threatened species have more than 50 but less than 80 percent of their range within areas burned by the bushfires. These include the Endangered Glossy Black Cockatoo native to Kangaroo Island and South Australia and the Endangered Long-footed Potoroo, native to New South Wales and Victoria.
- › 77 threatened species of plants and animals have more than 30 but less than 50 percent of their known range within areas burned by the fires. These include the Vulnerable Brush-tailed Rock-wallaby, native to New South Wales, Victoria and Queensland and the Critically Endangered Bellinger River Snapping Turtle.
- › 136 species have more than ten percent and less than 30 percent of their range within areas burned by the bushfires. These include the Critically Endangered Regent Honeyeater, native to New South Wales, the Australian Capital Territory, Queensland, South Australia and Victoria, and the Endangered Mountain Pygmy-possum, native to New South Wales and Victoria.

327 threatened species of plants and animals have at least ten percent of their range (the range in which they are known to occur) in areas that were burned by the bushfires. These species include:

 272 plants

 16 mammals

 14 frogs

 9 birds

 7 reptiles

 4 insects

 4 fish

 1 spiders

The survey results are indicative only, as some areas were more severely affected by bushfires than others, and patches of unburnt or only minimally burnt area occur within the fire extent. For example, whilst the Wollemi Pine occurs within areas marked as burnt by the bushfires, and whilst some individual trees were charred by the bushfires, a scientific assessment deems that the species will continue in the wild due to the efforts of a team of remote-area firefighters.

Air quality

Bushfire smoke blanketed population centres including Brisbane, Sydney, Melbourne and Canberra during the bushfire crisis. In the Sydney CBD, the Daily Air Quality Index reached over 2000 in December, more than ten times higher than the 'hazardous' threshold (see Figure 8 below). Other parts of Sydney reached even higher readings.

In parts of Canberra (Monash) the Hourly Air Quality Index reached 4,650 on New Year's Day – more than 23 times the hazardous threshold. In Sydney, schools were forced to close. Others cancelled

play and sports activities (SMH 2019a). In Melbourne, hazardous air quality disrupted the Australian Open, causing one player to retire with breathing problems and causing other matches to be delayed or abandoned (The Guardian 2020). In Canberra, public servants were instructed to stay home and the airport was closed on two occasions, one because of a local fire threatening the airport itself (ABC 2020a). A Big Bash League cricket match at Manuka Oval, Canberra, was suspended mid-match when the umpires deemed it unsafe to continue as a thick cloud of smoke blew in across the oval (ABC 2020b).

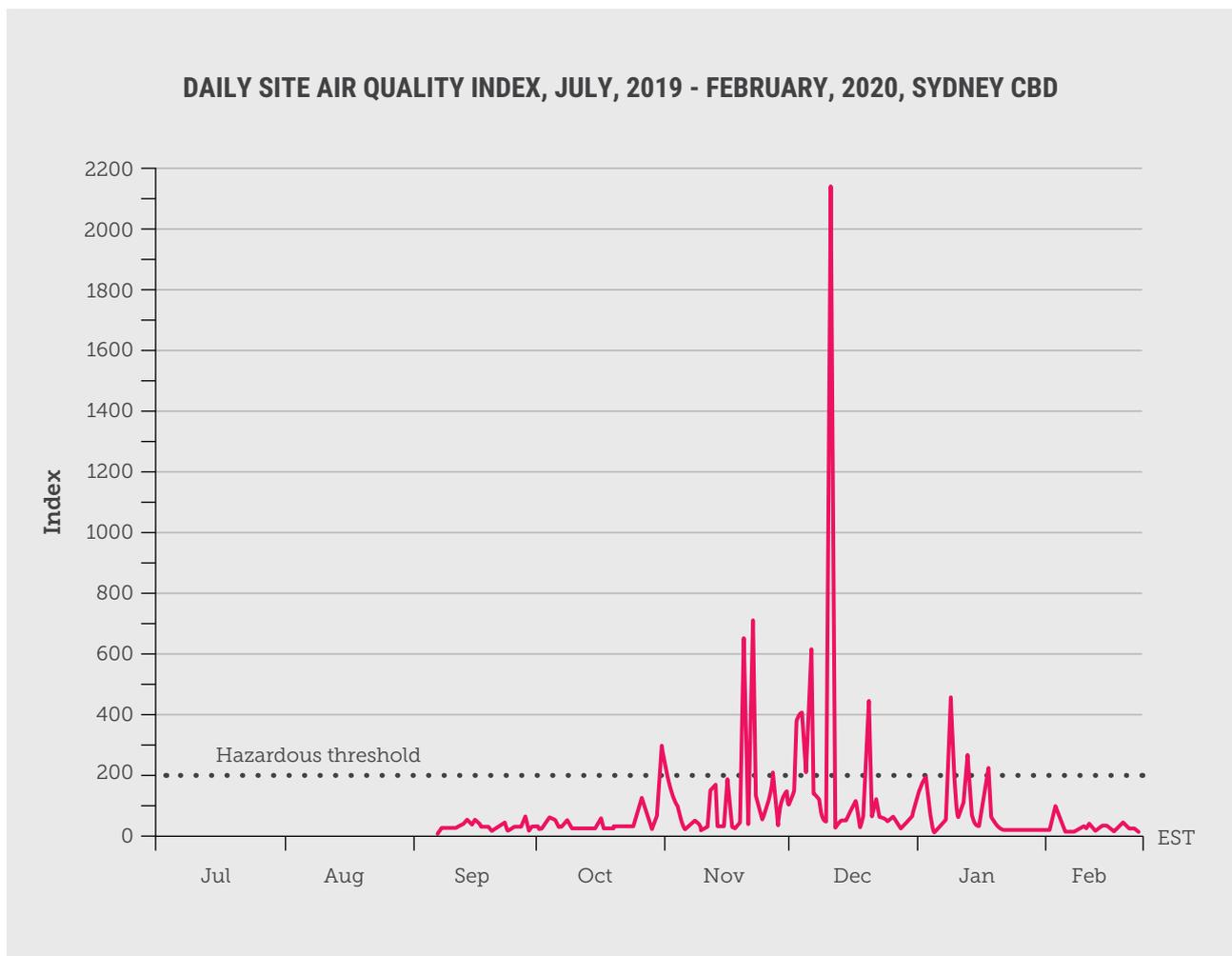


Figure 8: Daily Air Quality Index for Sydney CBD from July 2019 to Feb 2020. An AQI of 200 is considered hazardous. The Daily Air Quality Index in the Sydney CBD reached hazardous levels on numerous occasions, and at one point peaked at over 2000. Source: DPIE (2020).



Figure 9: Parliament House surrounded by smoke haze, January 5, 2020.

Bushfire smoke contains air pollutants such as particulate matter, and carcinogens such as benzene and formaldehyde (Bernstein and Rice 2013). Smoke events have been associated with increases in hospital admissions and mortality from a range of respiratory and cardiovascular diseases (Johnston et al. 2011; Martin et al. 2013; Johnston et al. 2014).

The health effects associated with exposure to poor air quality range from acute to chronic. The long-term consequences of exposure to poor air quality during the 2019-20 summer are not known, but epidemiological studies will no doubt reveal some metrics that are measurable in time, such as the number of excess (premature) deaths, and emergency department admissions.

Bushfire smoke shrouded capital cities, rural and regional areas exposing people to unprecedented levels of toxic air.

The tourism sector is set to lose at least \$4.5 billion because of the bushfires.

Economic impacts

At a national level, the 2019-20 bushfire season is expected to break new records for economic costs from bushfires (ANZ Research 2020). It is too early to estimate the total cost of the 2019-20 bushfire season in New South Wales, as the costs continue to mount. The effects of this devastating bushfire season will be felt across the economy, including in key sectors such as tourism, agriculture, and health.

The tourism industry, including in many regional areas of New South Wales, was affected badly by the bushfires. It is estimated that there was a 10-20 percent drop in international visitors booking holidays to Australia and the tourism sector is set to lose at least \$4.5 billion because of the bushfires (AFR 2020). An Australian Tourism Export Council survey found that there have been tourist cancellations for 70 per cent of its 850 members, with cancelled trips ranging in value from \$5,000 to \$500,000 (SBS 2020b).

Tourism operators in Canberra, which was badly affected by bushfire smoke, reported a 20 percent cancellation rate (SMH 2020). Hotels across Sydney reported a 10 percent decline in guest numbers in December, and Scenic World in the Blue Mountains had 50 percent fewer visitors in December than the previous year, a loss of 50,000 visitors (Reuters 2020). The Federal Government has announced a stimulus package of \$76 million to assist the tourism industry, with the money set to come from the \$2 billion National Bushfire Recovery Fund (Prime Minister of Australia 2020).

The bushfire smoke that blanketed Sydney is estimated to have cost the city \$12-50 million per day.

In Sydney, the bushfire smoke that blanketed the city caused a significant hit to the economy. The cost of economic disruptions from the smoke, such as workers unable to work, shoppers staying home, and transport interruptions was estimated at \$12-50 million per day in Sydney alone (SMH 2019b). Images seen around the world of Sydney shrouded in smoke may also have longer term impacts on Sydney's 'global brand' as a place to live or travel (SMH 2019b).

Between 8 November 2019 and 14 February 2020, over 23,000 bushfire-related insurance claims were lodged across New South Wales, Queensland, South Australia and Victoria, totalling an estimated value of \$1.9 billion. The vast majority of these claims (81 percent or nearly 19,000 claims) are in New South Wales (ICA 2020a). This likely underestimates the total damage to private property as claims from this bushfire season will continue to be lodged, and many properties are either uninsured or underinsured. For example, only 75 percent of residents in bushfire affected areas have contents insurance (ICA 2020a).

Nearly 19,000 bushfire-related insurance claims have been lodged since November 2019 in New South Wales.

WHEN IT RAINS IT POURS: FROM BUSHFIRES TO FLOODS

Climate change is making the atmosphere more energetic, increasing the likelihood of intense rainfall events.

In the first half of February 2020, very heavy rainfall was recorded in South Australia, inland Western Australia and the east coast (east of the Great Dividing Range). Rainfall was particularly heavy

around northeast New South Wales and southeast Queensland, Sydney and the Illawarra region. Sydney saw 392 mm fall over four days, which is more rain than the total rainfall received in the second half of 2019. It is also more than three times the average rainfall for February, breaking a 30-year record for four-day rainfall between 6 and 10 February (BoM 2020d).

Figure 10: Flooded streets in Byron Bay, northern New South Wales, Sunday, 9 February 2020.



The heavy rainfall brought flash flooding to parts of Sydney, with flood evacuation orders issued to thousands of homes, and fallen trees causing damage to powerlines and cutting power to thousands of customers due to gale force winds. Up to 25 metres of beach was washed away at Collaroy and Narrabeen by storm surges. The storms and floods were declared a catastrophe by the Insurance Council of Australia, with more than 10,000 claims received between 5 and 10 February, with the value of claims estimated at \$45 million (ICA 2020b).

On the east coast, the rains since the start of February increased water storage volumes from 42 percent to 79 percent in the Greater Sydney Region, and from 56 percent to 76 percent in southeast Queensland (Jones et al. 2020). Most of Greater Sydney is no longer drought declared as of 23 February 2020. Unfortunately, the rain did not fall evenly across the eastern states, and many places in southern and western New South Wales received minimal rainfall. For example, Broken Hill has received just 8 mm of rain since the beginning of January. As illustrated in Figure 11 below, most of New South Wales remains drought affected, drought declared or in intense drought at time of writing.

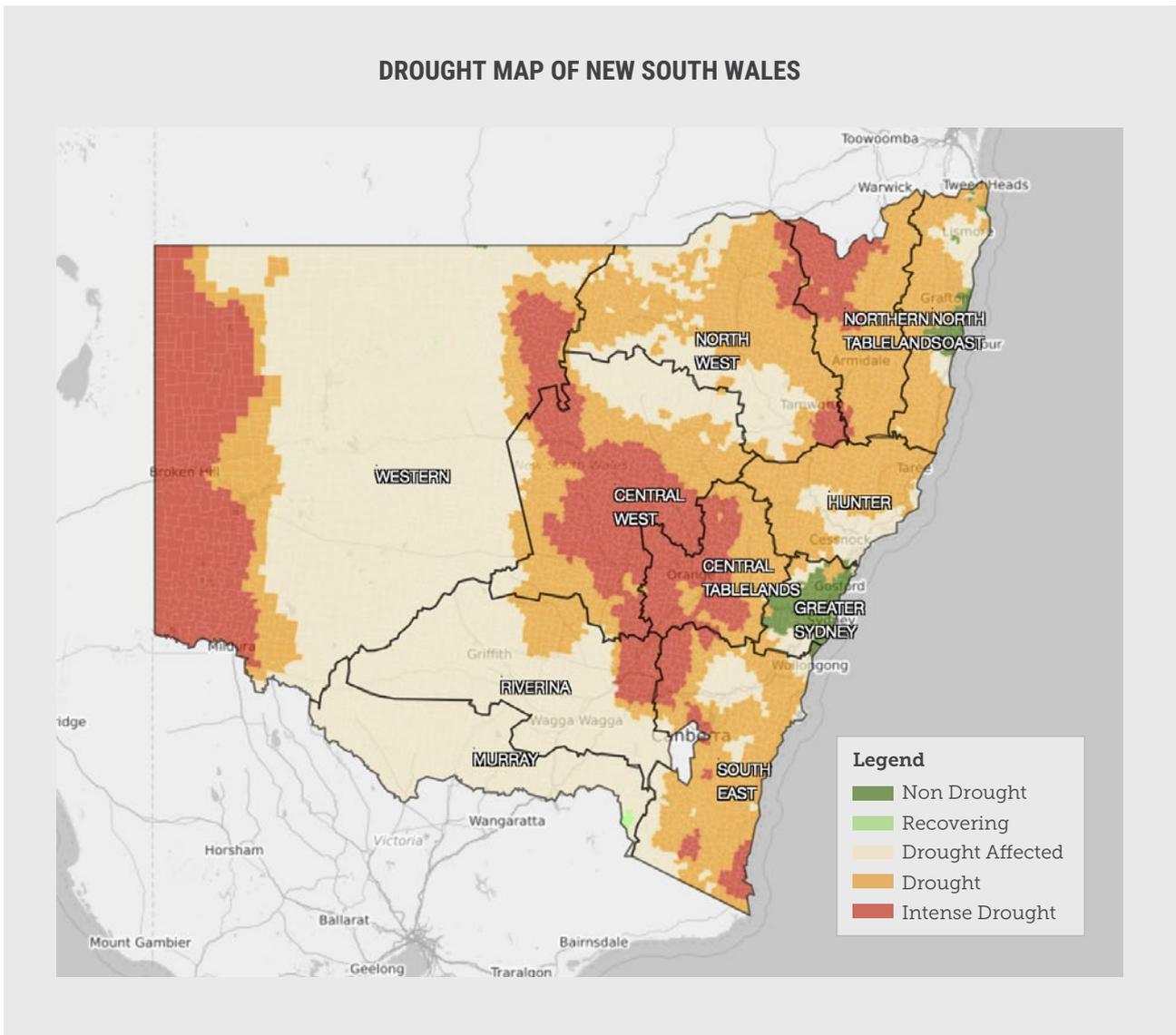


Figure 11: Drought map of New South Wales (Data current to 23/2/2020 (AEDT)). Source: Department of Primary Industries (2020).

Heavy rain has not been the only severe event experienced following the worst of the fire period. On 20 January 2020, Canberra experienced a severe hailstorm with golf ball-sized hail and strong wind gusts (117km/h reported at Canberra airport). The ACT Emergency Services Agency received a record number of calls (1,900) between midday and 8pm, more than triple the annual average. Hail-damaged properties, included the National Museum of Australia, the Australian Academy of Science’s heritage-listed Shine Dome, the Australian National Botanic Gardens and eighty buildings at the Australian National University (SBS 2020a; Canberra Times

2020). Many CSIRO research projects were badly affected – 65 glasshouses were damaged during the hailstorm, resulting in years of research lost, including crops of wheat, barley, legumes and cotton that were part of a study to improve crop sustainability (SBS 2020a). Wildlife were also severely affected, with over 300 flying foxes killed and birds injured (ABC 2020c). The storm cell that moved through the Australian Capital Territory on January 20 also affected parts of New South Wales and Victoria, resulting in \$638 million worth of damage. Nearly 70,000 claims have already been made, according to the Insurance Council of Australia, 53 percent from the ACT (Canberra Times 2020).

A severe hail storm on 20 January 2020 badly affected Canberra, damaging property and killing or injuring wildlife.

4. Conclusion: Time to Act

Climate change has fuelled the extreme weather we have seen this summer. The severity and frequency of these extreme weather events – bushfires and smoke, heatwaves, floods, hailstorms and drought – will continue to increase in coming decades, with commensurate increases in costs, due to the greenhouse gas emissions that we have already emitted, and continue to emit. If we fail to take strong action to rapidly phase out coal, oil and gas as part of a global effort, the impacts of climate change, including worsening extreme weather, will continue to escalate.

The Australian Government has ignored repeated warnings from scientists over at least a decade, and more recently from retired fire and emergency service chiefs from April 2019 about an impending bushfire disaster. Simplistic arguments about arson, hazard reduction and “green tape” do not stand up to scrutiny, and are not responsible for what was clearly a series of weather-driven disasters. Worsening extreme weather is clearly driven by a warming climate. Further denial and delay in taking action on emissions guarantees a worsening of disasters into the future. Taking action now will provide a chance to stabilise, then eventually reduce disaster risks for future generations.

Australia urgently needs a plan to cut our domestic greenhouse gas emissions to net zero and to phase out fossil fuel exports, because we are one of the world’s largest polluters. We are the 14th largest emitter of greenhouse gases globally and emit more per person than any other developed country. We are also the third largest exporter of fossil fuels (The Australia Institute 2019). Clearly, what Australia does matters and the longer we delay, the harder the problem will be to solve. We cannot call on other countries to take action if we fail to do so. We simply cannot leave this mess for our children to try to fix.

References

- ABC (Australian Broadcasting Corporation) (2020a) Canberra air quality still poor as smoke forces Home Affairs and Border Force to close doors. Accessed at: <https://www.abc.net.au/news/2020-01-05/nsw-fires-blanket-canberra-in-thick-smoke/11841546>.
- ABC (2020b) BBL match cancelled due to hazardous bushfire smoke. Accessed at: <https://www.abc.net.au/news/2019-12-22/bbl-match-cancelled-due-to-hazardous-bushfire-smoke/11821736>.
- ABC (2020c) Canberra hailstorm damages valuable research as record number of emergency calls lodged. Accessed at: <https://www.abc.net.au/news/2020-01-21/years-of-scientific-research-lost-in-canberra-hailstorm/11884062>.
- ACT Government (2020) State of Emergency Declared for ACT (media release, 31/01/2020). Accessed at: https://www.cmtedd.act.gov.au/open_government/inform/act_government_media_releases/barr/2020/state-of-emergency-declared-for-act.
- AFR (Australian Financial Review) (2020) Tourism loses \$4.5b to bushfires as overseas visitors cancel. Accessed at: <https://www.afr.com/companies/tourism/tourism-loses-4-5b-to-bushfires-as-overseas-visitors-cancel-20200116-p53s0s>.
- ANZ Research (2020) Australian bushfires: impacting GDP. Accessed at: <https://bluenotes.anz.com/posts/2020/01/anz-research-australian-bushfires-economic-impact-gdp>.
- Australian Government (2020) Quarterly Update of Australia's National Greenhouse Gas Inventory: September 2019 Incorporating emissions from the NEM up to December 2019. Accessed at: <https://www.industry.gov.au/sites/default/files/2020-02/nggi-quarterly-update-sep-2019.pdf>.
- Bernstein AS and Rice MB (2013) Lungs in a warming world: climate change and respiratory health, *Chest*, 143: 1455–9.
- Biddle N, Edwards B, Herz D, and Makkai T (2020) Exposure and the impact on attitudes of the 2019-20 Australian Bushfires. ANU Centre for Social Research Methods. Accessed at: https://csrm.cass.anu.edu.au/sites/default/files/docs/2020/2/Exposure_and_impact_on_attitudes_of_the_2019-20_Australian_Bushfires_publication.pdf.
- Bloomberg (2020) Australia's Fires Likely Emitted as Much Carbon as All Planes. Accessed at: <https://www.bloomberg.com/news/articles/2020-01-21/australia-wildfires-cause-greenhouse-gas-emissions-to-double>.
- Boer MM, Resco de Dios V, & Bradstock RA (2020) Unprecedented burn area of Australian mega forest fires, *Nature Climate Change*. Accessed at: <https://doi.org/10.1038/s41558-020-0716-1>.
- BoM (Bureau of Meteorology) (2019a) Special Climate Statement 70 update—drought conditions in Australia and impact on water resources in the Murray–Darling Basin. Accessed at: <http://www.bom.gov.au/climate/current/statements/scs70.pdf>
- BoM (2019b) Special Climate Statement 71—severe fire weather conditions in southeast Queensland and northeast New South Wales in September 2019. Accessed at: <http://www.bom.gov.au/climate/current/statements/scs71.pdf>.
- BoM (2019c) Australia in December 2019. Accessed at: http://www.bom.gov.au/climate/current/statement_archives.shtml?region=aus&period=month.
- BoM (2020a) Australia in summer 2019-20. Accessed at: <http://www.bom.gov.au/climate/current/season/aus/summary.shtml>.
- BoM (2020b) Annual climate statement 2019. Accessed at: <http://www.bom.gov.au/climate/current/annual/aus/>
- BoM (2020c) Australia in Spring 2019. Accessed at: <http://www.bom.gov.au/climate/current/>.
- BoM (2020d) @BoM_NSW TweetDeck 10 February 2020. Accessed at: https://twitter.com/bom_nsw/status/1226635872419958785?lang=en.
- BoM (2020e) Climate change – trends and extremes. Accessed at: http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=timeseries&tQ=graph%3Dmax%26area%3Daus%26season%3D0112%26ave_yr%3D0.
- BoM (2020f) Australian in December 2019. Accessed at: <http://www.bom.gov.au/climate/current/month/aus/archive/201912.summary.shtml>.
- Canberra Times (2020) Canberra hailstorm: Largest and most dense hailstones since 1999, more than 37,000 claims made. Accessed at: <https://www.canberratimes.com.au/story/6636982/canberra-hailstones-the-largest-most-dense-since-1999/>.
- CSIRO and BoM (2018) State of the Climate 2018. Accessed at: <http://www.bom.gov.au/state-of-the-climate/State-of-the-Climate-2018.pdf>.
- Department of Agriculture, Water and the Environment (2020) Wildlife and threatened species bushfire recovery research and resources. Accessed at: <http://www.environment.gov.au/biodiversity/bushfire-recovery/research-and-resources>.
- Department of Primary Industries (2020) Combined Drought Indicator. Accessed at: <https://edis.dpi.nsw.gov.au/>.

- DPIE (Department of Planning Industry and Environment) (2020) Daily Site Air Quality Index July-Feb, Cook and Phillip. Accessed at: <https://www.dpie.nsw.gov.au/air-quality/search-for-and-download-air-quality-data>.
- Di Virgilio G, Evans JP, Blake SA, Armstrong M, Dowdy AJ, Sharples J & McRae R (2019) Climate Change Increases the Potential for Extreme Wildfires, *Geophysical Research Letters*, 46. Accessed at: <https://doi.org/10.1029/2019GL083699>.
- Gergis J and Carey G (2020) Some say we've seen bushfires worse than this before. But they're ignoring a few key facts, *The Conversation*. Accessed at: <https://theconversation.com/some-say-weve-seen-bushfires-worse-than-this-before-but-theyre-ignoring-a-few-key-facts-129391>.
- Global Carbon Atlas (2019) CO₂ Emissions. Accessed at: [http://www.globalcarbonatlas.org/en/CO₂-emissions](http://www.globalcarbonatlas.org/en/CO2-emissions).
- ICA (Insurance Council of Australia) (2020a) CAT195 Australian Bushfire Season (2019/20) NSW, QLD, SA, VIC. Accessed at: <https://disasters.org.au/current-catastrophes/2019/11/13/november-bushfires>.
- ICA (2020b) Insurers declare Catastrophe for east coast storms and flooding (media release 10/02/2020). Accessed at: https://www.insurancecouncil.com.au/assets/media_release/2020/100220%20Insurers%20declare%20Catastrophe%20for%20east%20coast%20storms%20and%20flooding.pdf.
- ICCT (International Council on Clean Transportation) (2019) CO₂ Emissions from Commercial Aviation 2018. Working paper 2019 - 16. Accessed at: [https://theicct.org/sites/default/files/publications/ICCT_CO₂-commercial-aviation-2018_20190918.pdf](https://theicct.org/sites/default/files/publications/ICCT_CO2-commercial-aviation-2018_20190918.pdf).
- Johnston F, Hanigan I, Henderson S, Morgan G and Bowman D (2011) Extreme air pollution events from bushfires and dust storms and their association with mortality in Sydney, Australia 1994–2007, *Environmental Research*, 11: 811–6.
- Johnston F H, Purdie S, Jalaludin B, Martin K L, Henderson S B and Morgan G G (2014) Air pollution events from forest fires and emergency department attendances in Sydney, Australia 1996–2007: a case-crossover analysis, *Environmental Health: A Global Access Science Source*, 13 (105). Accessed at: <https://doi.org/10.1186/1476-069X-13-105>.
- Jones D, Watkins A, Donnelly C, Betio L and Coulton M (2020) Rain has eased the dry, but more is needed to break the drought, *The Conversation*. Accessed at: <https://theconversation.com/rain-has-eased-the-dry-but-more-is-needed-to-break-the-drought-131660>.
- Luke RH, McArthur AG (1978) Bushfires in Australia. Australian Government Publishing Service, Canberra.
- Martin KL, Hanigan IC, Morgan GG, Henderson SB and Johnston FH (2013) Air pollution from bushfires and their association with hospital admissions in Sydney, Newcastle and Wollongong, Australia 1994–2007, *Australian and New Zealand Journal of Public Health*, 37: 238–43.
- McRae RHD, Sharples JJ & Fromm M 2015, Linking local wildfire dynamics to pyroCb development, *Natural Hazards and Earth System Sciences*, 15: 417–428.
- NSW RFS (NSW Rural Fire Service) (2019a) Bush Fire Danger Period starts in a further 53 areas this weekend. Accessed at: https://www.rfs.nsw.gov.au/_data/assets/pdf_file/0013/111208/190830-Bush-fire-danger-1-September-FINAL.pdf.
- NSW RFS (2019b) Dangerous fire conditions forecast for Tuesday 12 November. 10 November. Accessed at: <https://www.rfs.nsw.gov.au/about-us/our-districts/blue-mountains/latest-news/dangerous-fire-conditions-forecast-for-tuesday-12-november>.
- NSW RFS (2020) @NSWRFS TweetDeck, 13/02/2020. Accessed at: <https://twitter.com/NSWRFS/status/1227802995435491330>.
- Prime Minister of Australia (2020) Rebuilding Australian Tourism. Accessed at: <https://www.pm.gov.au/media/rebuilding-australian-tourism>.
- Reuters (2020) 'They told people not to come': Australia's bushfires ravage tourism industry. Accessed at: <https://www.reuters.com/article/us-australia-bushfires-tourism/they-told-people-not-to-come-australias-bushfires-ravage-tourism-industry-idUSKBN1Z20AD>.
- SBS (Special Broadcasting Service) (2020a) Unprecedented Canberra hailstorm 'destroys years of CSIRO research'. Accessed at: <https://www.sbs.com.au/news/unprecedented-canberra-hailstorm-destroys-years-of-csiro-research>.
- SBS (2020b) Tourism strategy promised after bushfires cost the industry \$4.5 billion. Accessed at: <https://www.sbs.com.au/news/tourism-strategy-promised-after-bushfires-cost-the-industry-4-5-billion>.
- SMH (Sydney Morning Herald) (2019a) Many schools close, cancel playtime and sport because of poor air quality. Accessed at: <https://www.smh.com.au/national/nsw/many-schools-close-cancel-playtime-and-sport-because-of-poor-air-quality-20191205-p53hby.html>.

SMH (2019b) The economic cost of bushfires on Sydney revealed: up to \$50 million a day and rising. Accessed at: <https://www.smh.com.au/national/nsw/the-economic-cost-of-bushfires-on-sydney-revealed-up-to-50-million-a-day-and-rising-20191212-p53jbq.html>.

SMH (2020) Tourism industry takes \$1b hit as Australians cancel their holidays. Accessed at: <https://www.smh.com.au/politics/federal/tourism-industry-takes-1b-hit-as-australians-cancel-their-holidays-20200115-p53rr1.html>.

The Australia Institute (2019) High Carbon from a Land Down Under: Quantifying CO₂ from Australia's fossil fuel mining and exports. Accessed at: <https://www.tai.org.au/content/high-carbon-land-down-under-quantifying-co2-australia-s-fossil-fuel-mining-and-exports>.

The Guardian (2019) Scientists fear surge in supersized bushfires that create their own violent thunderstorms. Accessed at: <https://www.theguardian.com/environment/2019/dec/20/scientists-fear-surge-insupersized-bushfires-that-create-their-own-violentthunderstorms>.

The Guardian (2020) Australian Open players affected by bushfire smoke. Accessed at: <https://www.theguardian.com/australia-news/2020/jan/14/australian-open-in-doubt-as-bushfire-smoke-endangers-players>.

University of Sydney (2020) More than one billion animals killed in Australian bushfires. Accessed at: <https://sydney.edu.au/news-opinion/news/2020/01/08/australian-bushfires-more-than-one-billion-animals-impacted.html>.

Image Credits

Cover Image: Batemans Bay New Years Eve bushfires - Australia. PA / AAP Image.

Page 8: Figure 4 - NSW Rural Fire Service crews fight the Gospers Mountain Fire as it impacts a structure at Bilpin, Saturday, December 21, 2019. AAP Image/Dan Himbrechts.

Page 9: Figure 5 - Smoke, flames and burn scars over the east coast of Australia, 31 December 2019. ESA (European Space Agency) Image/EPA. Contains modified Copernicus Sentinel data (2019). License: CC BY-SA 3.0 IGO.

Page 13: Figure 7 - Bushfires in Casino, NSW. Petri Miniotas/ @petrifilms. Reproduced with permission.

Page 16: Figure 9 - A man cleans the forecourt of Parliament House surrounded by smoke haze early morning in Canberra, Sunday, January 5, 2020. AAP Image/Lukas Coch.

Page 19: Figure 10 - Flooded streets in Byron Bay, Northern NSW, Sunday, February 9, 2020. AAP Image/Danielle Smith.

Thank you for supporting the Climate Council.

The Climate Council is an independent, crowd-funded organisation providing quality information on climate change to the Australian public.

CLIMATE COUNCIL

 facebook.com/climatecouncil

 twitter.com/climatecouncil

 info@climatecouncil.org.au

 climatecouncil.org.au

The Climate Council is a not-for-profit organisation and does not receive any money from the Federal Government. We rely upon donations from the public. We really appreciate your contributions.

DONATE

climatecouncil.org.au/donate