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Emergency Leaders for Climate Action

POWDER KEG: AUSTRALIA PRIMED TO BURN

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Emergency Leaders for Climate Action (ELCA) is a coalition of 40 former chiefs, commissioners and director generals of fire and emergency services from every state and territory. Formed in early 2019, ELCA exists to catalyse all levels of government to act on climate change.

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Cover image: Bushfires NSW; Firefighters from both the Rural Fire Service and the N.S.W Fire Brigade and two water bombing helicopters work to contain a grass fire in the Western Sydney Parklands in West Hoxton, Sydney. Photo by DEAN LEWINS, credit: AAP Image.

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The Climate Council acknowledges the Traditional Owners of the lands on which we live, meet and work. We wish to pay our respects to Elders past and present and recognise the continuous connection of Aboriginal and Torres Strait Islander people to Country.

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Key findings

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Australia's three years of cooler and wetter-than-average conditions, due to a protracted La Niña event, temporarily dampened our bushfire risk. However, this has led to prolific vegetation growth that's creating powder keg conditions for future fires.

- From 2020 to 2023, Australia experienced a multi-year 'protracted' La Niña episode that led to record-breaking rainfall and flooding along the east coast. These heavy rains led to prolific growth of grass and bushland, including rapid regrowth in areas scorched by the Black Summer bushfires.
- In some inland areas, fire fuel loads have a normal range of between 0.5 to 1.5 tonnes per hectare, but there are now between 4.5 and 6 tonnes per hectare following recent heavy rains. These same areas - so recently green - are now turning brown and yellow as heatwaves sweep across the country, priming grasslands to burn.
- The collective wisdom of firefighters, based on history and experience, suggests that grass fires are rarely as damaging as forest fires. However, this may not hold true during a grass fire event that occurs in conditions as extreme as the ones we now experience in a supercharged climate.
- Events in Australia, and overseas, prove that grass fires are dangerous when they occur in hot and dry conditions. If the third risk factor, of strong winds, also occurs then Australia could see grass fires unfold on a scale never-before experienced.

2

History shows that grass fires follow floods. Firefighters fear that the spring of 2023 and summer of 2023-2024 could see widespread grass fires, supercharged by climate change.

- Based on the views of fire and emergency services experts, there is an increased risk of major grass fires breaking out during periods of hot weather in Queensland, New South Wales, Victoria, South Australia and Western Australia up to and possibly including April 2023.
- History shows that grass fires follow floods. There have been three 'protracted' La Niña episodes since 1950: 1954 - 1957, 1973 - 1976, and 1998 - 2001. During each of these periods there was prolific growth of vegetation, followed by extensive grass fires across Australia, then by major forest fires causing loss of life and property on the east coast, particularly in New South Wales.
- Australia experienced the most widespread grass fires ever recorded in 1974 - 1975, with about 117 million hectares burnt nationally - or about 15 percent of Australia's land mass.
- Since then, climate change has worsened and is intensifying extreme weather. Because of this, firefighters fear that extensive grass fires that break out in hotter, drier, windier weather conditions than those experienced in 1974 - 1975 could be far more destructive and deadly, like those experienced in the United States in December 2021.

3

Australia's protracted La Niña episode is giving way to hotter and drier conditions including the possible formation of an El Niño event. As a result, we will almost certainly see a return to normal or above normal fire conditions across most of Australia in coming months.

- Current climate models indicate that Australia could see a return to warmer and drier 'neutral' or even El Niño conditions towards the second half of 2023. El Niño is a naturally occurring climate cycle in the Pacific Ocean that brings hotter, drier conditions to eastern Australia, making droughts and bushfires more likely.
- Bushfire danger across Australia is rising due to climate change. Significant bushfires in Tasmania and New South Wales in 2013, and the Black Summer bushfires in 2019 - 2020, showed that El Niño is no longer needed to produce a bad fire season - even a "neutral" phase of El Niño-Southern Oscillation (ENSO) can now produce periods of Extreme and Catastrophic fire danger.
- If an El Niño event does develop during 2023, this will further exacerbate the threat of both grassfires and major forest fires.

4

Governments must prepare for a potentially devastating fire season ahead, while stepping up efforts to move beyond fossil fuels and ensure greenhouse gas emissions plummet this decade.

- Governments at all levels should prepare for a dangerous fire season later in 2023, and help communities cope with worsening and compounding climate impacts while working to prevent or manage disasters more effectively.
- Emergency services and land management agencies need more funding to prevent, prepare for and to respond to escalating disasters, as well as needing more full-time staff and volunteers.
- Emergency management agencies, state and local governments also need permanent arrangements rather than ad hoc solutions to initiate and manage long-term disaster recovery efforts due to worsening climate change fuelled disasters.
- Communities need more funding for education and resilience projects.
- Efforts to adapt and build resilience to climate impacts must go hand-in-hand with much stronger efforts to move beyond fossil fuels and rapidly cut emissions if we are to avert even worse catastrophes.

1. Introduction

Australia has long been referred to as a land of "drought and flooding rains", prone to bushfires as well as intense rainfall events. Periods of hot, dry, windy weather have regularly dried out vegetation and made it susceptible to ignition, alternating with prolonged wet periods that have promoted rapid and widespread vegetation growth.

Climate change, driven by the burning of coal, oil, and gas, is worsening these extreme weather events (IPCC 2021a). The Black Summer bushfires in 2019-2020, as well as the record-breaking Great Deluge of 2022—both of which claimed lives, livelihoods, property and crops—were exacerbated by climate change (see, for example, Binskin et al. 2020; Climate Council 2022).

For the past three years, Australia has experienced wetter than average conditions, with record-breaking rainfall and floods across New South Wales (NSW), Queensland, Victoria, South Australia and Tasmania (BoM 2022). This has been due to a rare 'protracted' La Niña event together with a negative phase of the Indian Ocean Dipole and a positive phase of the Southern Annular Mode.

Given the years of rainfall since Black Summer, it is reasonable to expect that fire risk may have slipped from the Australian public's consciousness. However, very wet periods often make fire services nervous, because they are a double-edged sword. On one hand, rain keeps vegetation wet, reducing the likelihood of ignition and limiting fire spread during the wet period. On the other hand, it leads to prolific growth, even in 'desert' areas that typically have insufficient vegetation to pose any fire risk.

The wet weather also limits the ability of land managers and fire services to carry out fire prevention and mitigation works, for example, hazard reduction burning cannot be carried out during wet conditions. When wet weather inevitably gives way to hot, dry conditions, light grasses and shrubs die and dry out and we are then left with more vegetation available to burn.

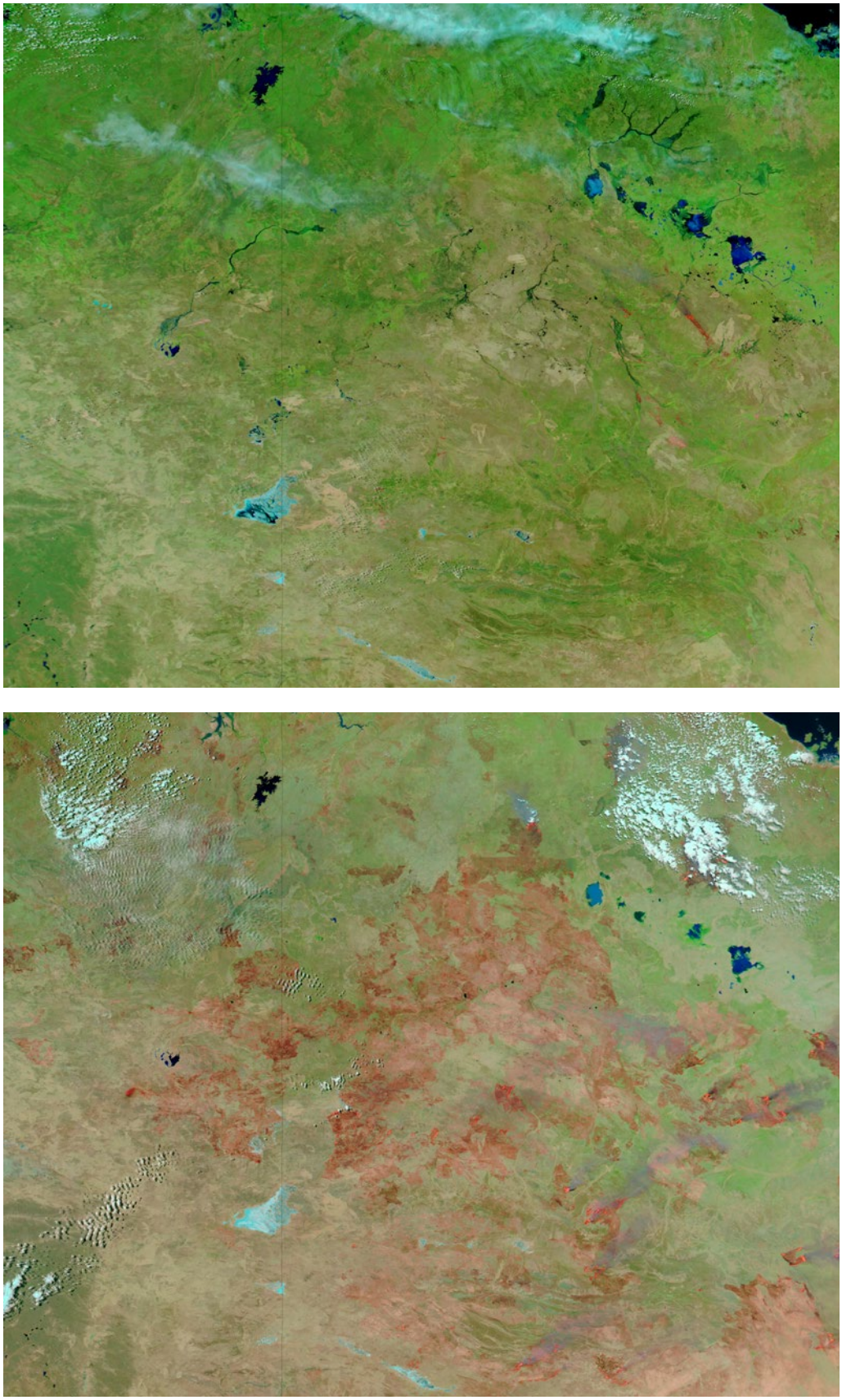


Figure 1: In late 2010 and early 2011, a strong La Niña brought drenching rain and floods to Australia. Thick grass grew in response to the rain, providing more fuel for fires. Much of Australia's Northern Territory was badly affected by grass fires in 2011. The top panel is a satellite image of the region in April 2011, lush with vegetation after La Niña rains. The bottom image shows a charred landscape in September 2011 after fires burned an area roughly the size of England. **Source:** NASA 2011.

This shift from wet to dry conditions is underway in Australia right now, and it brings higher fire danger; particularly an increased risk of grass fires — that is, fires in grass, crops, and grassy woodlands. The Bureau of Meteorology has stated that the La Niña that brought wetter-than-average conditions to much of Australia for the past three years is now waning (BoM 2023a). Current climate models indicate that Australia could see a return to a warmer, drier neutral phase or even hotter and drier conditions if an El Niño occurs in the second half of 2023 (BoM 2023b).

History shows us that grass fires follow floods. There have been three protracted La Niña events since the 1950s (BoM 2023c): 1954 - 1957, 1973 - 1976, and 1998 - 2001. After every one of these events, the red centre of Australia became green with prolific growth. When the rains reduced, the new vegetation quickly turned brown and yellow as the grasses dried off and died—a process called curing. Severe fires often followed, with many of those same areas then turning black. Climate change is worsening extreme weather, including fires.

In the summer of 1974 - 1975, during a protracted La Niña episode (1973 - 1976), at least 117 million hectares of grass and scrub across Central Australia burned - roughly 15 percent of the Australian continent (Luke and McArthur 1978). The fires were not particularly intense or damaging, as most were not affected by high winds. However, three people were killed in NSW and fires burned about 4.8 million hectares of grass and scrub, causing more than $5 million in damage (Luke and McArthur 1978; AIDR 2011).

History also shows us that extensive forest fires quickly return after heavy, sustained rains (BoM 2023c). In 1957, following the 1954 - 1957 protracted La Niña, there were extensive losses from bushfires, particularly in the Blue Mountains in NSW. In 1977, following the 1973 - 1976 protracted La Niña, the Blue Mountains burned again, then again in 2001 - 2002 following the protracted La Niña conditions of 1998 - 2001 (BoM 2023c). Urban interface areas surrounding Sydney and in the Lower Hunter were also impacted in 1957, 1977, and 2001 - 2002.

Grass fires are generally less intense than forest fires, but equally dangerous. They can spread much faster than forest fires, and can occur quickly after rain. Fully cured grasslands can dry out rapidly and even ignite within hours of rain. Standing dead grass serves as a 'flash fuel', and the high air flow in these landscapes provides plenty of oxygen to feed a fire. Resulting fires can be influenced strongly by changes in wind speed and direction, making grass fires on days of serious fire danger very dangerous and difficult to control.

As of February 2023, grass fires are already breaking out in western NSW near towns like Cobar and Wentworth and in Queensland's western Darling Downs where properties have been destroyed. As hot, dry conditions set in, the spring of 2023 and summer of 2023 - 2024 could be disastrous if extreme weather, driven by climate change, coincides with ignition of vegetation causing the outbreak of extensive grass and forest fires.

Hot, dry conditions in spring of 2023 and summer of 2023 - 2024 could lead to fires starting in a supercharged climate.

2. What are grass fires and why are they so dangerous?

In Australia, 'bushfire' is the generic term used to describe fires in the landscape. Bushfires can involve different types of forest, shrubland, tropical savanna, grass and crops.

Grass fires are fundamentally different to forest fires, and usually burn with less intensity because of the lighter fuels in grasslands compared to forests. Because standing grass is surrounded by oxygen, grass fires can spread much faster than forest fires, with flame fronts recorded at around 25 km per hour: far too fast for a person to outrun (CFA 2022; Cruz et al. 2022). Many people have been killed when trapped in the open or in cars by fast-moving, unpredictable bush and grass fires (Blanchi et al. 2014).

Though grass fires are generally less intense than forest fires, they can produce large flames and generate more than enough heat to kill people and destroy buildings. Fire intensity is measured in kilowatts per metre of fire front, and it is generally accepted that once fire intensity exceeds 4,000 kilowatts per metre (kW/m), it can be difficult for firefighters to gain control by direct attack methods. Major forest fires can generate intensities up to 100,000 kW/m, and intense grass fires 30,000 kW/m (Luke and McArthur 1978; Sullivan 2015).

Grass fires spread quickly and can be devastating, killing people and wildlife and destroying property.

BOX 1: LESSONS FROM VICTORIA'S DEADLY GRASS FIRES

At the end of 1968 following two years of La Niña, large parts of Victoria were covered in long, rapidly drying grass. January 8, 1969 was declared a day of total fire ban due to a forecast of high temperatures and strong, gusty winds. Hundreds of fires broke in tinder dry grasslands that day, ultimately destroying 230 houses and 21 other buildings, and consuming about 324,000 hectares. A fast-moving grass fire broke out near Lara and later approached the four lane Melbourne to Geelong Expressway. As a wind change drove smoke and flames directly across the freeway, motorists panicked. With the freeway cut off, several people left their cars and tried to run for safety. Seventeen people were killed, but six others who sheltered inside their cars survived – this resulted in fire services changing their safety advice, recommending that people should never leave their cars if caught by a fire, as a car can provide some protection from flames and radiant heat. A total of 23 people were killed by fires that day, and 100 were injured. The speed, intensity, and unpredictability of the grass fires were a major factor in the property losses and deaths.

Figure 2: Firefighters work to contain a grass fire in the Western Sydney Parklands in West Hoxton, Sydney on 16 November 2009. The fire came within 200m of fifty houses which border the parklands.

Introduced weed species are worsening fire problems across Australia. For example, around Alice Springs the predominant native vegetation, tussocky spinifex grass that can burn intensely but often self-limits fire spread because of its sparse nature, is being over-run by introduced buffel grass. Buffel grass produces higher fuel loadings, more intense fires, continuous fuels that ensure fast fire spread, and can drive out native plant species and associated ecosystems (Letnic et al. 2005). Further north in tropical savanna areas, invasive gamba grass is displacing native grasses. Gamba grass produces very high fuel loads—the loads can be equivalent to the lower range of expected fuel loads in a forest—therefore leading to very intense fires that can kill small trees and other native plants. Gamba grass can regenerate quickly after fires, sometimes burning more than once in a single fire season (Setterfield et al. 2013). Across southern Australia, coolatai grass—an invasive tussock-forming perennial grass—is increasing fuel loads, with its range predicted to increase due to the impacts of climate change including higher temperatures and changes in rainfall patterns (NSW DPI 2023). Coolatai grass is already well established in northern NSW.

There is evidence that cultural burning practices by Indigenous peoples once helped to limit fire spread, particularly in Australian savannas and rangelands, and this may have moderated the impact of previous La Niña events (Russell-Smith et al. 2009, Bliege et al. 2016).

The main influences on how dangerous a bushfire (grass or forest fire) can become are the interaction of weather conditions, terrain, proximity to people and infrastructure, and the burning characteristics and amounts of different types of vegetation. These various elements determine the behaviour of a bushfire, which is characterised by factors such as rate of spread (km/hr), intensity (kW/m) and spotting potential (km).

BOX 2: 2006 JAIL BREAK INN FIRE

In January 2006 the "Jail Break Inn fire" broke out near the southern NSW township of Junee. Over six days, it burned more than 25,000 hectares, causing significant property damage including the loss of 10 houses, four large shearing sheds, other buildings, and many cars. A local farmer was trapped while fighting the fire, suffering burns over 80 percent of his body.

More than 20,000 sheep and cattle died, large areas of valuable crops were lost and about 1,500 kilometres of fences were damaged. Most of the damage was caused in the first hours of the fire, with strong winds driving flames through long, dry grass as humidity plummeted and temperatures rose into the low 40s.

WEATHER

Weather conditions leading up to a fire can influence the likelihood of fires igniting, and how quickly and intensely they will spread. If conditions have been damp and humid (high levels of moisture in the air), living and dead vegetative matter (fire 'fuel') will absorb the moisture, making it harder to ignite and continue burning. The more moist the conditions, the easier it will be for firefighters to extinguish a fire. High temperatures, low humidity, and strong winds suck the moisture from living and dead vegetation, making it easier to ignite. The drier the fuel and the higher the temperature, the higher the intensity of the fire, because more fuel is available to burn and combustion is more complete. Increased fire intensity makes spot fires more likely, because stronger convection (rising hot air currents) is more likely to carry burning embers (pieces of burning bark, leaves and small twigs) ahead of the main fire.

Native grass species go through an annual natural process of curing, or drying out and dying. The degree of curing is measured in various ways, including through satellite observation, and is expressed as a percentage figure. Once grasslands are 80 percent cured, fires can spread quickly and produce high flames. Strong winds will make them more difficult to suppress (Cheney et al. 1998; Cruz et al. 2015). Bushfires often cause significant damage and can out position firefighters when wind changes alter the direction of the fire, turning a long fire flank into an intense fire front.

Grass fires are more directly affected by wind speed and direction than forest fires (Cruz et al. 2015). Firefighters can sometimes find themselves in the wrong location when a slight wind change steers a fire away from them. For the same reason, people have become trapped and killed by fast-moving grass fires when a seemingly safe location is suddenly over-run by flames. On a hot, windy day, a grass fire can spread over many kilometres and be almost impossible to control due to its speed and rapidly growing perimeter, until weather conditions improve overnight.

Grass fires can be destructive for rural and farming communities with crops and equipment destroyed, and loss of livestock and property.

TERRAIN

Fires move faster uphill than they do on flat ground. For every 10 degree increase in slope, the speed of a fire can double (Nogrady 2017). Fires in mountainous or hilly terrain can be very difficult to control, because accelerating fires increase in intensity producing higher flames, higher heat output, and more burning embers. Firefighters will never intentionally place themselves above a fire that is spreading uphill under extreme conditions, often having to fall back to a safer location where they can attack the fire as it burns more slowly and with less intensity downhill. Forest fires often "crown" (very high flames consuming tree canopies) when they crest the top of a hill or mountain, showering areas downwind with burning leaves, twigs and bark, starting new spot fires (Nogrady 2017).

The aspect, or direction that a location faces, also affects fire behaviour. Put simply, an area that faces the sun for most of the day will dry out faster than a shaded position, so fires in exposed areas will burn hotter and faster. For example, in coastal NSW, areas that face north or west are more hazardous than southerly or easterly aspects because they are more exposed to the sun, while easterly and southerly aspects are shaded for much of the day. These aspects are also more directly affected by hot, dry winds from the north and west that originate over hot, dry inland areas. Flat country, often covered in grass, scrub and crops and with limited tree cover, is exposed to the sun for most of the day. Light grass fuels are therefore more prone to the drying and heating effects of the sun than heavier, shaded forest fuels.

PEOPLE AND INFRASTRUCTURE

Fires have been burning on the Australian continent since before human occupation more than 60,000 years ago (Cavanagh 2021). There is ample evidence that the first Australians used fire to hunt and to modify landscapes (Levitus 2009; Gammage 2011; Pascoe 2019). Since European occupation, a different mindset about fire was imported from England and Europe, with first settlers expressing fear about fire and seeking to exclude it (Foster 1976). All fires were seen as "bad" and traditional cultural burning practices were increasingly excluded as Traditional Owners were dispossessed from Country, and prevented from burning (Pyne 2020).

Native bushland has adapted over millennia to different 'fire regimes' associated with long term climatic and weather patterns, with many different ecological responses to fire aimed at ensuring survivability of different plant species.

Grass fires are very dangerous because of how fast they move. While a sturdy building can provide safe sanctuary as a grass fire quickly passes through, a car may not. People caught on foot by an intense grass fire will be killed or seriously injured.

Farming communities are significantly affected by fires through the loss of crops, fencing, livestock, machinery, and buildings.

VEGETATION TYPES

In dry *sclerophyll* habitats, such as the eucalypt forests in the Blue Mountains west of Sydney, the main fuel for bushfires consists of dead and fallen trees, branches, leaves, twigs, bark, and native grasses, shrubs and other herbs. 'Available fuel' is a term used by firefighters and fire scientists to describe the type and amount of fuel that burns immediately as a fire front moves past a particular point. Large dead trees, logs and tree branches will continue to burn afterwards and can prolong the passing of the fire front compared to grass fires that quickly consume all fuel and pass by more quickly. When fuel loads are measured, all fuels on the ground up to six millimetres in diameter (pencil thickness), are weighed, together with grasses and shrubs that meet certain criteria. The fuel loading in tonnes per hectare is then calculated after the collected sample is dried to remove moisture content (Luke and McArthur 1978; Gould et al. 2007).

Depending on the type of forest, fuel loads can be 30 tonnes to the hectare or more, and the heat output of a fire in kilowatts per metre of fire front can be can be as high as 130,000 kW/m with a rate of spread up to 9km/hr. Typical grassland fuel loads are between 2.5 and 6 tonnes per hectare, so the heat output of a grass fire under the same weather conditions can be as high as 90,000 kW/m and importantly have a much higher rate of spread of up to 25km/hr (Cruz et al. 2015). It therefore needs to be understood that a fast-moving grass fire can produce more than enough energy and heat to kill, and be faster and more unpredictable than a forest fire (Cheney et al. 1998). Whilst grass fires can produce high intensities, the heat is sustained for a shorter time than a forest fire, because grass fires consume the light, aerated fuels quickly and pass a particular point faster. Forest fires take longer to consume the denser fuels and therefore produce heat at a given point for longer, often resulting in more damage.

HOW A PROTRACTED LA NIÑA EVENT CAN WORSEN GRASS FIRE RISK.

NORMAL SEASON

Arid and semi-arid areas have low levels of fire fuels, often discontinuous, and the threat of large, damaging fires is ususally low.

LA NIÑA

Widespread rains and flooding create ideal growing conditions for fast-growing grass and shrubs. Normally sparsely vegetated areas become covered in abnormal amounts of vegetation.

NEUTRAL OR EL NIÑO CONDITIONS

If hot, dry, windy weather occurs, all that is needed is an ignition source (lightning, harvesting accidents, arson, escaped burnoffs) for large, fast-moving grass fires to break out.

LA NIÑA ENDS

After rains end, grasslands go through a natural process of curing that results in green growth dying off and drying out, making it conducive to ignition and fire spread.

Figure 3: How a protracted La Niña event can worsen grass fire risk.

3. Grass fire outlook for Summer 2022 - 2023 to Spring 2023

Together with the peak council for fire and emergency services in Australia and New Zealand, the Australasian Fire & Emergency Service Authorities Council (AFAC), the Bureau of Meteorology regularly produces 'Seasonal Outlooks' explaining possible bushfire conditions in each state and territory for the forthcoming season (see Figure 4). The Outlooks take into consideration predicted weather conditions, fuel loads, and levels of fire service preparedness.

Since spring 2020 when La Niña conditions first developed and parts of the country experienced record rainfall and damaging floods, most of Australia has been experiencing below average bushfire danger conditions, apart from the southwest of Western Australia and parts of western Tasmania.

When published, the 'Seasonal Outlook Summer 2022' (AFAC 2022) took a lot of people - except farmers, fire scientists and firefighters - by surprise. Maps of Australia showed large swathes of 'above normal' fire potential: across most of western NSW (some of which was still flooded), south-western Queensland, and large parts of the Northern Territory around Alice Springs (AFAC 2022). Continuing above normal fire risk in western Tasmania and Western Australia was also detailed.

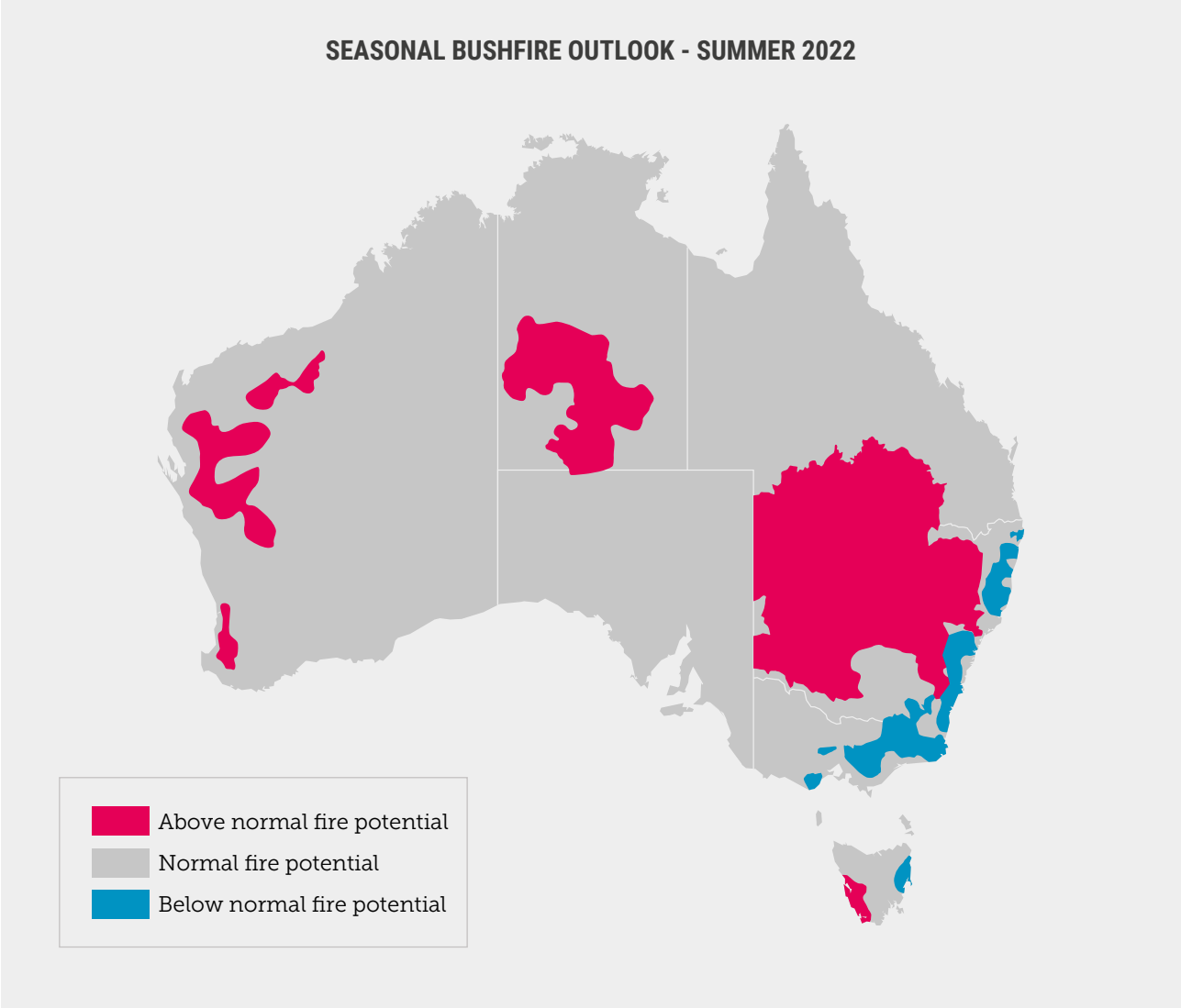


Figure 4: Seasonal Bushfire Outlook Summer 2022. Areas are based on vegetation classification regions for Australia and other geographical features. **Source:** adapted from AFAC (2022).

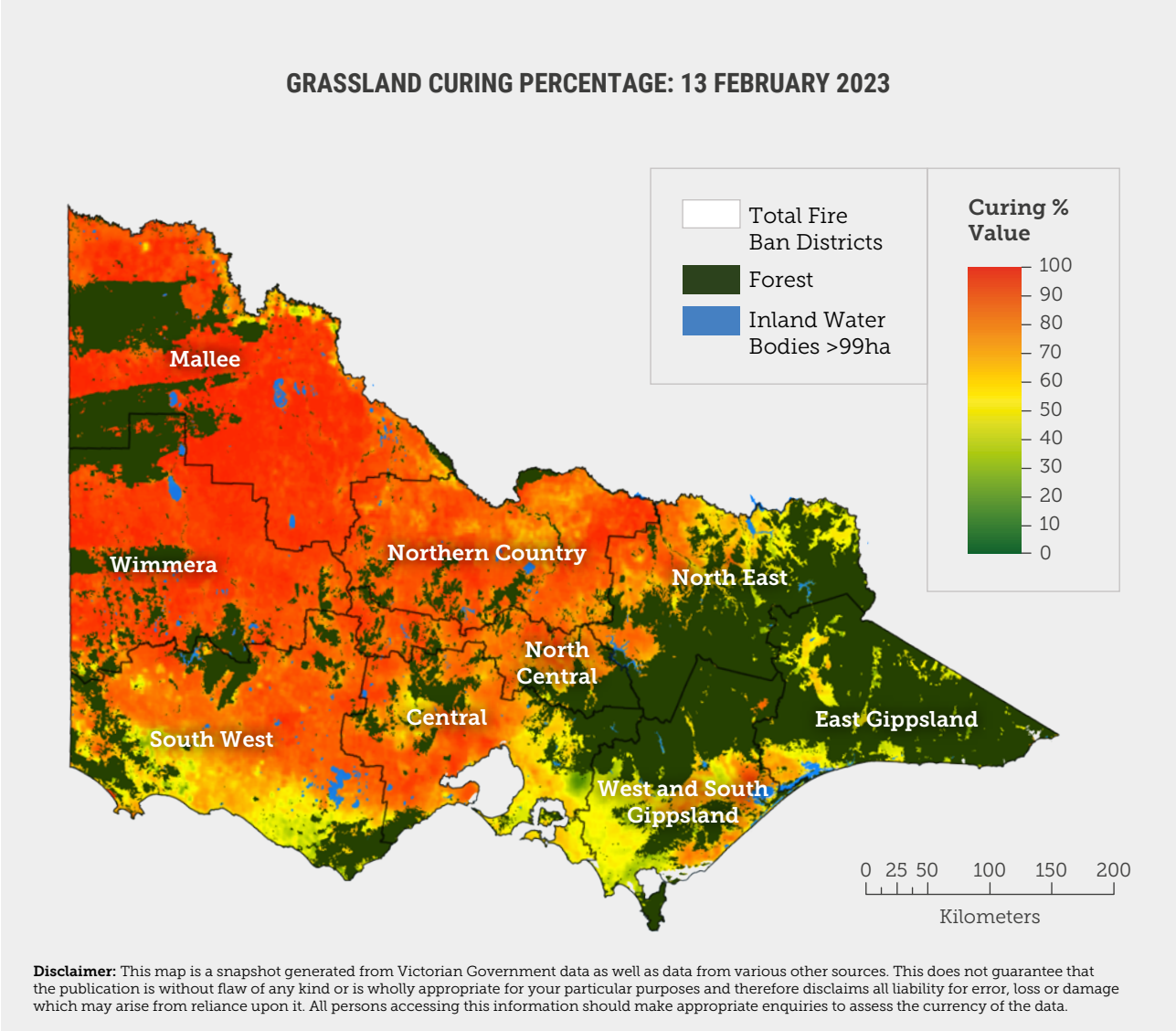
The AFAC Outlook stated:

> *Although many parts of Australia saw above average rainfall and significant flooding this year, the saturated ground in many of these regions supports enhanced vegetation and fuel load growth. This, coupled with expected warmer and drier conditions later in the season, is generating varied fire potential for summer 2022.*
>
> *(AFAC 2022, p1)*

At the time of writing (February 2023), significant grass fires have been breaking out on an almost daily basis in western NSW, north-western Victoria, and parts of South Australia, with most being controlled at an early stage, but some, on days of moderate winds, spreading across hundreds and sometimes thousands of hectares over a single day. This could be a portent of worse to come.

After La Niña rains and floods, vegetation dries out in hot, dry conditions causing tinderbox conditions.

The La Niña period that reduced bushfire risk over the years since Black Summer can be a double-edged sword, because it has also produced a powder-keg situation of prolific growth that will become extremely flammable when hot, dry weather almost inevitably returns. Heatwaves will accelerate the grassland curing process and quickly transform green country to tinder-dry brown, ready to burn.



Disclaimer: This map is a snapshot generated from Victorian Government data as well as data from various other sources. This does not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for error, loss or damage which may arise from reliance upon it. All persons accessing this information should make appropriate enquiries to assess the currency of the data.

Figure 5: Grassland 'curing' percentage as of 13 February 2023 that depicts the clear and present danger of grass fires in Victoria as vegetation dries out after the great deluge of 2022. **Source:** Adapted from CFA 2023.

Figure 6: Fire impacts on a property in New South Wales during the Black Christmas Fires of 2001.

As of February 2023, the BoM ENSO forecast is indicating that La Niña conditions are starting to transition to a more neutral (drier) phase, with a possible return to El Niño conditions from the second half of 2023 that could produce hotter, drier weather conditions (BoM 2023b). While the most serious bushfire seasons have historically occurred during an El Niño phase, the 2013 Tasmanian and NSW bushfires and 2019-2020 Black Summer fires occurred during a neutral phase (BoM 2023c). This may be indicative of the influence of accelerating climate change and the average increase in temperature in Australia (Abram et al. 2021). The amplifying effect of El Niño, which historically was considered by fire services and land management agencies to be a pre-requisite for a serious bushfire season, is no longer necessary to produce extreme and catastrophic fire weather.

Currently there is an increased risk of major grass fires breaking out during periods of hot weather in Queensland, NSW, Victoria, South Australia, and Western Australia up to and possibly including April 2023.

Firefighters will watch the Northern Territory closely from July, because this was where and when the widespread 1974 - 1975 grass fires started (Luke and McArthur 1978), with extensive grass fires later starting in every state and territory except Tasmania. The summer of 2023 - 2024 will almost certainly see a return to normal or above normal fire conditions across most of Australia and, given the prolonged wet period that Australia has experienced, it is quite possible that fires as large as those in 1974 - 1975 could occur. If an El Niño event becomes established during 2023, this will also exacerbate the threat of major forest fires.

While extensive areas were burned during the 2019 - 2020 Black Summer fires, nearly three years of heavy rains have promoted prolific growth—not just of grass, but also forest re-growth across many burnt areas. These forests, densely stocked with young tree and scrub regrowth, will dry out quickly in summer under drought conditions and be vulnerable to bushfires and further extensive damage to fragile, recovering ecosystems. There are large areas in Queensland, NSW and Victoria, including around the major population centres of Sydney, Newcastle and Wollongong, that were largely unaffected by the Black Summer fires. These could become vulnerable to bushfires under hot, dry conditions.

The only broad area approach for prevention from destructive bushfires in east coast forests is burning to manage fuel loads. While strategic burning is carried out when weather conditions allow to protect key assets, large area managed burning programs are not currently feasible for several reasons including three years of damp conditions that restricted burning.

The elephant in the room is the potential amplifying effect that climate change might have on fire weather in 2023 and 2024. The post La Niña fires of 1957, which devastated the NSW township of Leura destroying 170 buildings, of 1977 that destroyed 49 homes in the Lower Blue Mountains, then in 2001 - 2002 destroying homes in the Blue Mountains, NSW Central Coast, Illawarra and western Sydney, all broke out in weather conditions less intense than those experienced during Black Summer 2019 - 2020.

Firefighters fear that if extensive grass fires break out in hotter, drier, windier weather conditions than those experienced in 1974 – 1975, they could be far more destructive and deadly. Such fires are then likely to be followed by extensive forest fires.

Large parts of Queensland, NSW and Victoria that were unaffected by the Black Summer fires could become prone to bushfires under hot, dry conditions.

4. The influence of climate change on the grass fire threat

It is well established that climate change has a strong influence on weather patterns and extremes (IPCC 2021b). Extreme weather events are often associated with natural disasters, including fires, floods, cyclones and storms, as well as influencing other precursors for major bushfires, such as heatwaves and droughts.

Climate change has been shown to influence Australian bushfires in a number of ways (see, for example, Sharples et al. 2016; Dowdy 2018; Abram et al. 2021):

- **Drying effect:** warmer temperatures result in increased evaporation, in turn drying out vegetation.
- **'Faster' droughts:** A combination of lower-than-normal rainfall and higher temperatures together reduce overall land surface moisture, priming 'flash droughts' that develop over periods of weeks to months, compared to years or decades for conventional droughts (Nguyen et al. 2019; Pendergrass et al. 2020; Hadjimichael 2022).
- **More frequent serious fire weather:** Since 1950 there has been a marked increase in the number of days annually of Very High fire danger and above across Australia (BoM and CSIRO 2022). These are the days when large, damaging fires are more likely to occur, spread quickly, and cause more damage. (NOTE: after the 2022 changes to the Australian Fire Danger Rating System, the former rating of Very High now equates to "High").
- **Worsening fire weather:** extremes are becoming more extreme. After the 2009 Black Saturday bushfires in Victoria that killed 173 people and destroyed around 2,000 homes, fire services added a new category of fire danger: "Catastrophic", because it was becoming increasingly common to exceed the theoretical maximum fire danger index of 100 (Australian Academy of Science 2021). This is because weather conditions have become hotter, drier and windier on the worst fire weather days over recent decades.

Black Summer 2019-2020 was the most extreme bushfire season ever recorded in Australia, exceeding the previous record number of days of Very High, Severe, Extreme and Catastrophic fire danger by large margins (Owens and McKane 2020).

Fires behaved in ways never seen on such a large scale before, with dozens of formerly rare pyro-convective events (fire-generated storms or pyroCb) creating extremely dangerous and unpredictable bushfire conditions. Fire scientist, Professor David Bowman told the Royal Commission into National Natural Disaster Arrangements that scientists look out for 'Black Swan' events, but Black Summer produced so many pyroCb events that it could be likened to an unexpected 'flock' of Black Swans (Binskin et al. 2020). PyroCbs can create storm-force winds, and on one occasion near the NSW-Victorian border a fully loaded bushfire tanker was picked up and dropped on its roof, killing a volunteer firefighter and seriously injuring others (Owens and McKane 2020).

There is significant conjecture about what grass fires driven by similar weather conditions to those experienced in 2019 might look like. Black Summer showed that judgements based on historical experiences and expectations may no longer be reliable indicators of how future fires influenced by climate change will behave. Australian firefighters have never fought extensive grass and scrub fires in weather conditions that were experienced in 2019.

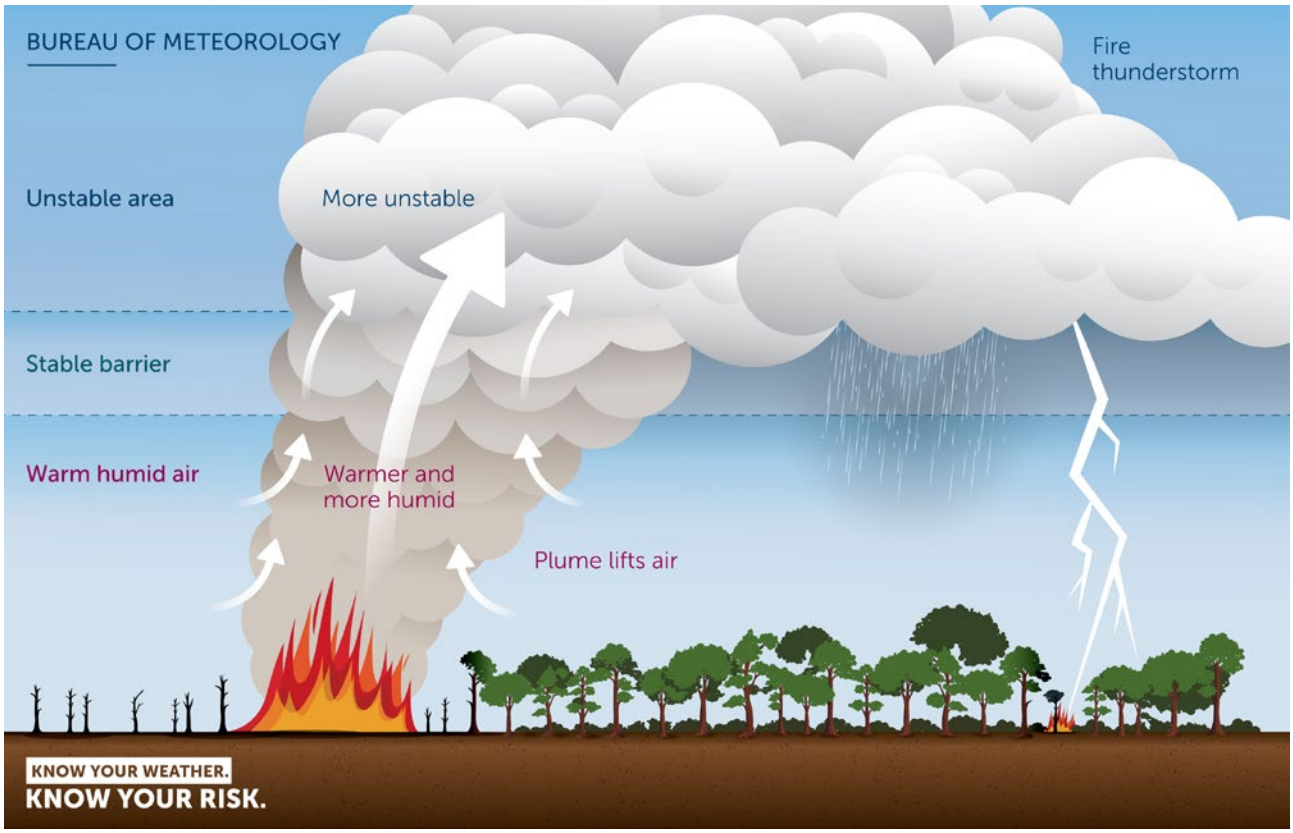


Figure 7: Pyrocumulonimbus cloud development. **Source:** Adapted from BoM 2020.

BOX 3: 2021 COLORADO GRASS FIRES

A major grass fire event that occurred in December 2021 in Colorado, USA, is an example of what a climate change-driven grass fire disaster might look like. In late December, the middle of the US winter when snowfall is normally being experienced, tens of thousands of residents near Denver were forced to flee grass fires driven by winds that reached 115 miles per hour (185 km per hour). The fires followed a period of drought that had parched the landscape. Hurricane force winds driving flames and embers transformed the grass fires into urban conflagrations as fires funnelled into streets and cul de sacs (NASA 2021). In a single afternoon, 1,100 homes were destroyed, and one person was killed. People were forced to shelter in a large shopping store as wild winds and fires raged outside, despite it being a cold day. It snowed the following day.

The Colorado experience demonstrates that just three factors can rapidly transform a grass fire into a disaster: drought, low humidity, and very strong winds. Mercifully, the Colorado fires broke out on a cold winter's day. Had it been hot, as well as dry and windy, the losses almost certainly would have been greater.

Unfortunately, it is likely that if grass fires break out and consume the vast La Niña-boosted grasslands in Australia, it will likely be during hot, dry spring and summer conditions. If the third risk factor, strong winds, is added, Australia could experience grass fires on a scale never seen before.

Figure 8: Homes destroyed in a burned neighbourhood from the Marshall wildfire, a grass fire in Louisville, Colorado in December 2021.

5. Grass fires follow floods: past grass fires after La Niña

A stark example of how protracted La Niña conditions can transform the threat of fires in the landscape is illustrated by the most widespread grass fires in Australia's recorded history that occurred over the spring and summer of 1974 – 1975 (Luke and McArthur 1978).

The 'anomalously high[1]' rainfall of 1973 and 1974 (BoM 2023) resulted in prolific growth of grass and scrub across arid and semi-arid areas stretching from western NSW to Western Australia and from Adelaide to Alice Springs, reinforcing the adage, "grass fires follow floods". A dry spring in 1974 saw rapid curing of the new vegetation, with fires initially starting on the Barkly Tableland in the Northern Territory, and new fires breaking out through June and July. By November and December fire weather reached its peak with fires as far south as Alice Springs. The season continued through to February, ultimately burning about 45 million hectares in the Northern Territory, with one fire alone consuming 2.4 million hectares (Luke and McArthur 1978).

Further fires followed in Western Australia, burning about 29 million hectares of remote and pastoral lands. Up to 16 million hectares were burnt in South Australia, 22 million hectares in Queensland, and about 4.8 million hectares in western NSW. Victoria was less affected with about 100,000 hectares of mallee scrub burnt. The total area burned was around 117 million hectares, or about 15 percent of Australia's land mass (Luke and McArthur 1978).

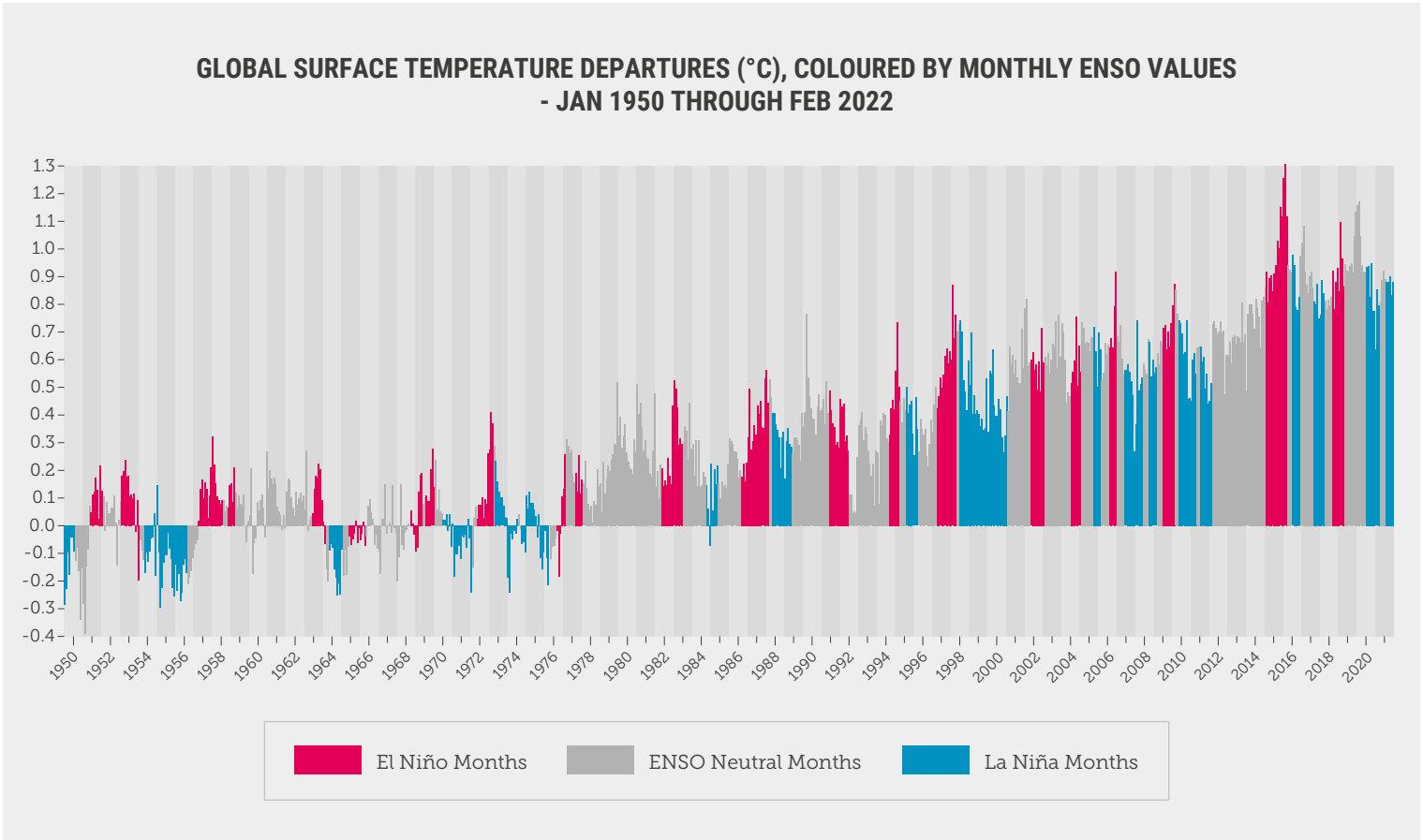
1 'anomalously high' rainfall denotes a significant statistical departure from the climatological average.

Luke and McArthur (1978) reported that while some fires were fanned by strong winds, most were not, resulting in surprisingly little damage and fewer stock losses than expected, except in NSW where losses of about 50,000 head were reported. The fires mainly affected sparsely populated and uninhabited areas, and a significant factor in fighting fires was the logistical challenge of marshalling enough firefighters and firefighting equipment in remote fire areas. For this reason, many fires were simply left to burn, some for months.

Following the protracted La Niña of 1998 - 2000 that also led to prolific growth, there were relatively few ignitions in NSW and Queensland. Despite this, large fires burned in Central Australia, including across the Simpson Desert and other remote locations.

As of February 2023, the current concern following record rains, floods and vegetation growth, is the increase across the country in the frequency and severity of fire weather since the 1950s. It is possible that if widespread grass fires break out during the spring of 2023 and summer of 2023-2024, they could burn during periods of Extreme or even Catastrophic fire danger. As seen in Colorado in late 2021, wind is the main factor in producing extreme fires once grassland fuels have cured and are ready to burn. Even in cold temperatures, strong winds can transform grass fires into an inferno capable of destroying buildings and taking lives.

Figure 9: ENSO not only affects global weather patterns, but it also affects global temperatures. During the warm phase of ENSO (El Niño), global temperatures tend to be warmer than ENSO-neutral or La Niña years, while global temperatures tend to be slightly cooler during cold phase ENSO episodes (La Niña). **Source:** Adapted from NOAA 2023.

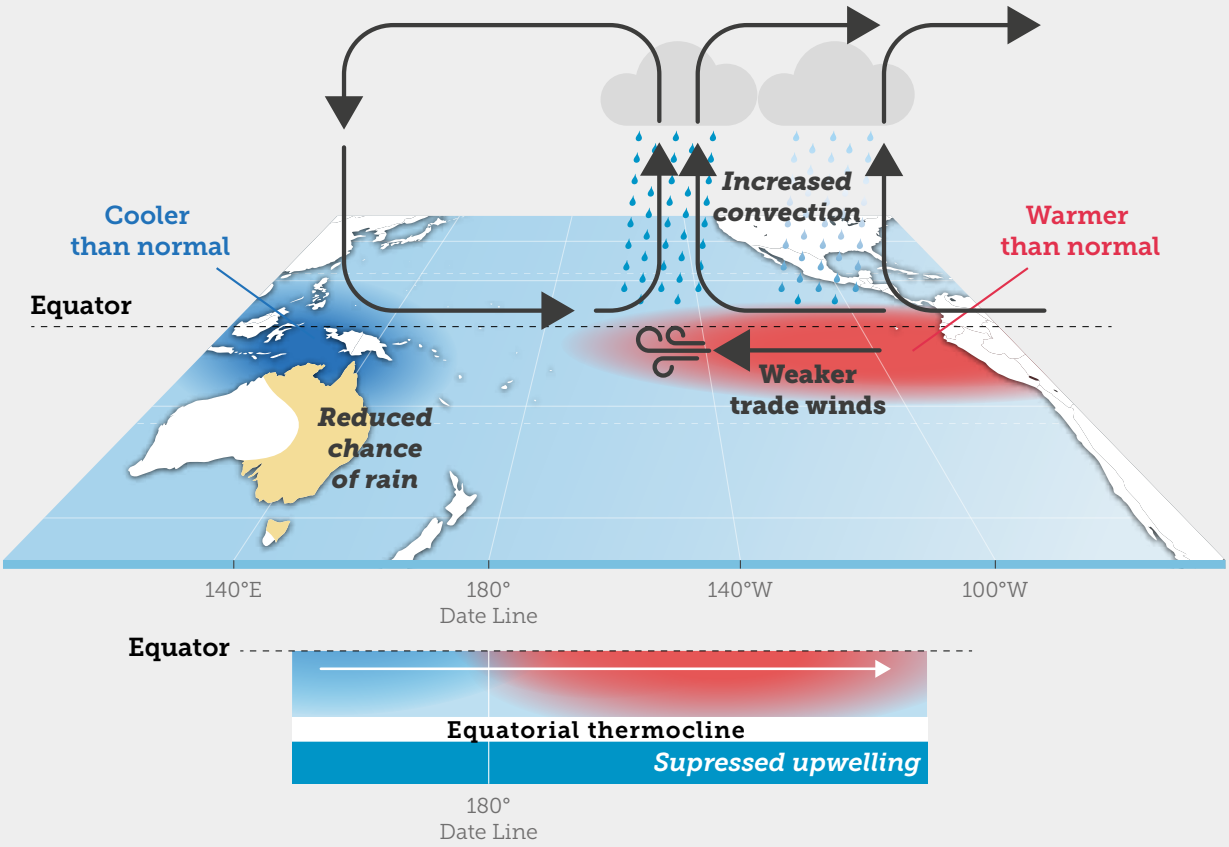


Global warming is resulting in changes to historically defined seasonal patterns and natural climate cycles (for example, El Niño and La Niña, see Figures 9 and 10), and they are now occurring in a climate 1.2°C warmer than during pre-industrial times (Gergis 2023). About 90 percent of heat accumulated from the burning of fossil fuels has been absorbed by the world's oceans, resulting in profound changes in the Earth's climate (IPCC 2021a). Ocean heat content – as measured by the energy absorbed by the upper 2,000 metres – reached a new all-time high in 2022, extending the run of record heat observed since 2019 (Cheng et al 2023), when the oceans absorbed about 10 Zetta joules of heat, which is roughly equivalent to 100 times the world's total annual electricity production (Berwin 2023).

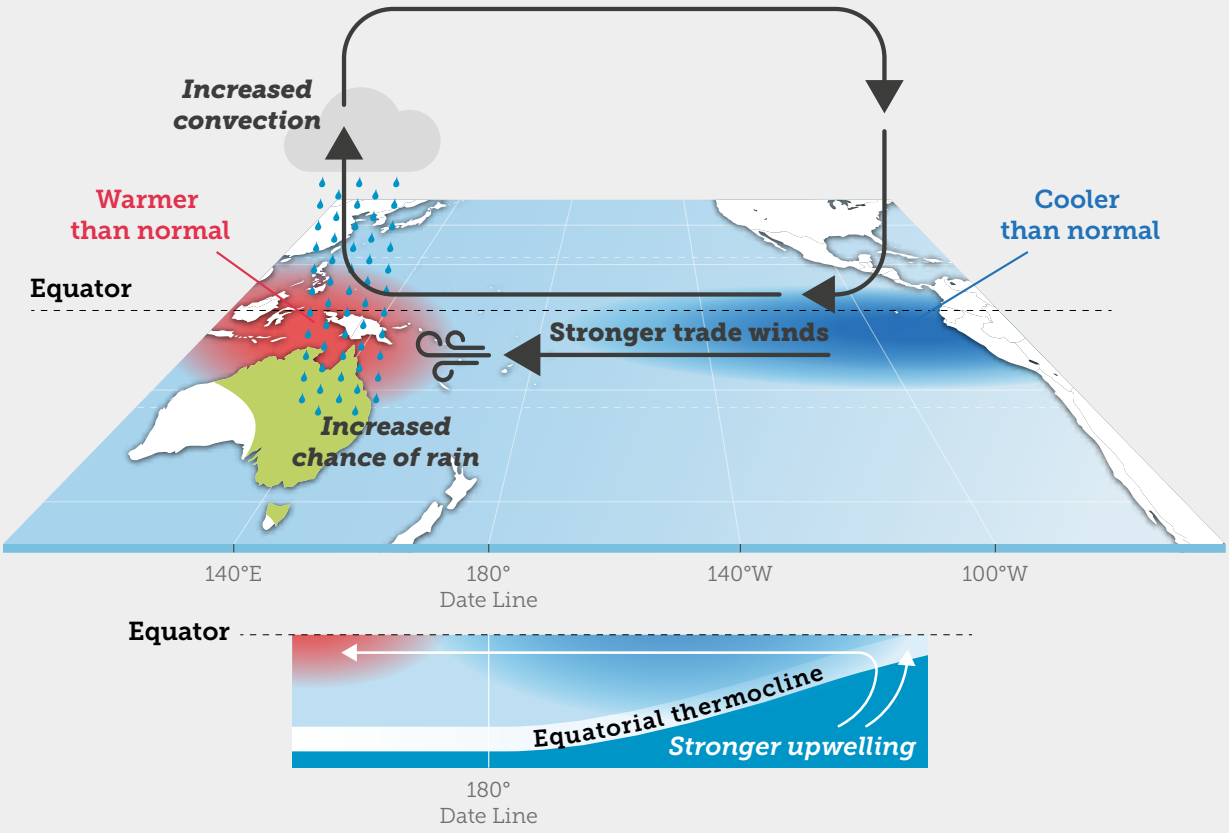
Currently there is approximately a 50-50 chance that an El Niño will develop by spring 2023 (BoM 2023b). When La Niña conditions decay, it is possible that a relaxation or reversal of the easterly trade winds could release the accumulated heat trapped in deeper layers of the western Pacific Ocean, triggering an El Niño event (Gergis 2023). When this happens, the ocean surface releases more heat into the atmosphere, with the associated rainbands shifting east (Gergis 2023). This causes hot and dry weather to prevail over Australia as our rainfall is displaced towards the Pacific Islands (Figure 10). During these events, there is a higher risk of intense heatwaves, bushfires and drought conditions over much of the country (Gergis 2023).

In autumn, there is less variation in the Pacific Ocean's temperature making it harder to forecast if an El Niño or La Niña will emerge this winter, i.e. we have to overcome the "autumn predictability barrier" (King 2023). However, historical records indicate that it is not uncommon for El Niño events to develop following La Niña events, and vice versa (Gergis 2023). This 'phase flipping' has happened several times in the past. For example, the protracted La Niñas of 1954-1957, 1973-1976 and 1998-2001 were followed by El Niño events in 1957-1958, 1977-1978 and 2002-2003, respectively (BoM 2023c; Gergis 2023). After sustained wet conditions that stimulated prolific growth of vegetation, each of these El Niños resulted in major bushfires in places such as NSW during the years 1957 and 1977 (Gergis 2023), and major forest fires in NSW, Victoria and the ACT in 2001, 2002 and 2003.

As natural climate drivers like El Niño are occurring against a background of increasing global average temperature, we must ramp up preparations for increased risk of grass fires and other extreme weather-driven events.



El Niño-Southern Oscillation (ENSO): **El Niño**



El Niño-Southern Oscillation (ENSO): **La Niña**

Figure 10: El Niño-Southern Oscillation (ENSO) is a coupled ocean atmosphere phenomenon – El Niño (top panel) is the phase of the ENSO cycle that brings hot and dry conditions to the Australian region. La Niña (bottom panel) tends to result in wetter-than-average conditions to much of Australia. **Source:** Adapted from BoM 2013.

6. The heat is on for decisive action this decade

It is sobering to note that the supercharged-climate disasters that have the ability to overwhelm governments and emergency services are occurring in a world that is 1.2°C warmer than pre-industrial times.

Climate change policies currently in place under the *Paris Agreement* will result in 2.8°C of warming by the end of this century (UNEP 2022).

Such high levels of global warming will have impacts that will be very difficult, if not impossible, for human societies and ecosystems to adapt to.

Figure 11: Climate impacts such as dangerous bushfire weather, floods, drought and storms will become much worse, unless we deeply cut emissions this decade.

This is why governments at all levels need to urgently invest in measures that help communities withstand and cope with worsening climate impacts, and prevent, manage and mitigate the impacts of disasters more effectively. Policy makers must urgently increase funding for community hazard prevention and emergency services, which also need more volunteers and full-time staff. Land management and forestry agencies also play a crucial role in fire management and need to be well resourced. State and local governments now require permanent arrangements rather than ad hoc solutions to initiate and manage long-term disaster recovery efforts, with additional funding and resources available from the Federal Government when needed.

Efforts to adapt and build our resilience to the impacts of climate change must go hand in hand with much stronger efforts to move beyond fossil fuels and ensure that greenhouse gas emissions in Australia and the rest of the world plummet this decade.

The Royal Commission into National Natural Disaster Arrangements in 2020 noted that further warming over the next two decades, driving worsening natural disasters, is inevitable given continuing emissions and greenhouse gases already in the atmosphere. What happens after that in terms of the frequency and scale of fires and other disasters will be "largely dependent on the trajectory of greenhouse gas emissions" (Binskin et al. 2020).

By the Climate Council's assessment, given the scale of the global emissions reduction task, and taking into account Australia's very high level of emissions and our huge renewable energy resources, Australia should aim to reduce its national emissions by 75 percent below 2005 levels by 2030, and to reach net zero emissions by 2035.

Our past failure to act has locked in another two decades of worsening natural disasters. What happens after that depends on our willingness to deeply and rapidly reduce global emissions.

7. Policy recommendations

Climate change has pushed us into a new era of increasingly severe and frequent disaster threats. Our emergency management, response and recovery arrangements, which were set up to cope with a much tamer environment in the 1990s, are not set up to deal with the scale and frequency of disasters happening today. Without major changes, they will certainly not be able to handle worsening threats as global warming escalates.

The following recommendations form the basis of a whole of government response to climate change-fuelled disasters. The recommendations primarily focus on reducing exposure and vulnerabilities to disasters before they occur. However, it is impossible to eliminate all risk and thus our recommendations are designed to improve the community's ability to respond and recover more generally.

GETTING EMISSIONS TO PLUMMET THIS DECADE

Climate change is worsening extreme weather events, destroying lives, livelihoods and our environment. The Federal Government should coordinate all levels of government in accelerating and increasing measures to tackle climate change. More substantial action is required this decade to reduce Australia's emissions.

Recommendation: 1

The Australian Government must urgently develop and mobilise strategies in all sectors of the economy to reduce greenhouse gas emissions to 75 percent below 2005 levels by 2030 and aim for net zero by 2035, recognising that climate change has become an existential threat.

STRENGTHENING DISASTER MANAGEMENT COORDINATION

Currently, Australia has different strategies for addressing climate change adaptation and disaster risks - including the National Climate Resilience and Adaptation Strategy and the National Disaster Risk Reduction Framework and supporting action plans. This makes little sense, as the two areas are intertwined and should be integrated across strategy, planning and institutional arrangements.

Recommendation: 2

The Australian Government should develop and resource a single integrated National Climate Adaptation and Disaster Resilience Strategy and supporting action plan with outcome measures and clear deadlines for implementation.

UNDERSTANDING RISK

There is an urgent need for a National Climate Change Risk Assessment to be conducted as a baseline for all levels of government to focus on and coordinate climate adaptation and mitigation efforts. The Assessment should underpin production of a national strategy and plan enabling climate risk information to be mainstreamed across all government agencies and sectors and at-risk communities.

Concurrent with development of the National Climate Change Risk Assessment, the National Emergency Management Agency and Australian Climate Service should focus on combining climate science and hazard analysis to produce downscaled climate modelling and make the data available to all levels of government in forms useful for both planning/policy and emergency management.

Recommendation: 3

The Australian Government should conduct a National Climate Change Risk Assessment as a baseline for all levels of government to focus on and coordinate climate adaptation and mitigation efforts. The Assessment should underpin production of a national strategy and plan enabling climate risk information to be mainstreamed across all government agencies and sectors and at-risk communities.

Recommendation: 4

Australian, state and territory governments should be routinely provided with regionally downscaled climate projections by the Australian Climate Service.

IMPLEMENTING RECOMMENDATIONS FROM EXPERT INQUIRIES

Since the 1939 bushfires there have been many major reviews and inquiries into disasters and extreme weather events in Australia, but most of their recommendations have not been implemented. Governments, at all levels, should coordinate to implement these recommendations, prioritising those from the Royal Commission into National Natural Disaster Arrangements, the NSW Bushfire Inquiry, the NSW 2022 Independent Flood Inquiry, and the independent inquiry into the 2019-2020 Victorian fire season.

Recommendation: 5

All levels of government should implement recommendations from expert inquiries and the National Emergency Management Agency should provide regular progress reports to National Cabinet on implementation of all recommendations from the Royal Commission into National Natural Disaster Arrangements.

PRIORITISING INVESTMENT IN RESILIENCE

Between 2005-2022, the Federal Government spent almost $24 billion on disaster recovery and relief, with just $0.51 billion allocated to resilience. Investing in risk reduction and resilience provides a 'triple dividend' of avoided loss and suffering, reduced disaster costs and potential economic and social benefits even in the absence of hazards occurring.

There is a need to upscale public investments in resilience and develop innovative financing pathways. The process for allocating public funds towards resilience projects must be independent and data driven, ideally deploying an accepted needs-based funding model that ensures funds focus on the most at-risk and vulnerable communities.

The Climate Council and Emergency Leaders for Climate Action welcome changes to the Emergency Response Fund, making an additional $1 billion available for adaptation over the next five years. This is a positive first step to reversing the funding trend that sees the vast majority of disaster-related funds going towards response and recovery, but investment in resilience clearly needs to increase. Previous failures to fund preparation and resilience measures have created a cycle of increasing response and recovery costs that can only be reduced by long-term investment in adaptation and resilience.

Recommendation: 6

Governments at all levels must collaborate to reverse the funding trend that sees most disaster-related funds going towards response and recovery, by increasing public investment in adaptation and resilience.

Recommendation: 7

Funding needs to be provided to local governments and emergency services to increase fire mitigation works leading into the 2023 – 2024 bushfire danger season, including fuel reduction, roadside slashing, other targeted fire prevention measures, and community information programs.

SUPPORTING COMMUNITIES TO 'BUILD BACK BETTER'

Disaster impacted towns, cities and communities must be rebuilt – where appropriate to do so – in a way that takes into account inevitable future changes in climate and ensures they will be more resilient. In some very high-risk locations, this may mean not rebuilding at all. Managed relocations must be discussed as an option for some of the most vulnerable and exposed communities.

The joint announcement between the New South Wales and Commonwealth governments on land buybacks and relocations in the aftermath of the 2022 NSW/QLD floods is an example of this. However, further schemes must be made available to communities at extreme risk before a disaster strikes so they can relocate as soon as practical.

Recommendation: 8

The Australian Government should work closely with state, territory and local governments to develop frameworks for improving community resilience when rebuilding after disasters with federal funds - including developing a process for managed relocations of communities which face ongoing and significant disaster risks due to climate change.

PUTTING COMMUNITY FIRST

Communities suffering due to climate change must be at the heart of all emergency and disaster prevention, preparation, response and recovery plans and arrangements. Governments at all levels – Australian, state and territory and local – must significantly increase funding that reduces risk and builds community resilience, improves infrastructure, and increases the capabilities of emergency response and recovery agencies, with a greater focus on planning and coordination between all levels of government.

The program aimed at providing basic disaster response skills to spontaneous community volunteers recommended by the 2022 Independent NSW Flood Inquiry, is a practical example of what this can look like, as are the Fire & Rescue NSW Community Fire Unit program and NSW Ambulance Community First Responder program. Similar programs build community skills and resilience, and should be funded equally by federal and state governments, and rolled out at pace nationally to at-risk communities.

Recommendation: 9

The Australian, State and Territory Governments should develop and fund programs which build community resilience to extreme weather and disasters, using examples such as the NSW program to train spontaneous community responders as a basis.

Recommendation: 10

Australian, state and territory governments should create simpler Disaster Recovery Funding Arrangements application processes.

Recommendation: 11

Australian, state and territory governments should refine arrangements to support localised planning and the delivery of appropriate mental health services following a natural disaster.

Recommendation: 12

States and territories should provide, in remote communities or communities deemed to be at extreme risk and with limited safe egress, dual-purpose community buildings capable of providing all community members with refuge in an extreme bushfire, flood or storm emergency.

CULTURAL BURNING - LANDSCAPE MANAGEMENT IN THE AGE OF CLIMATE CHANGE

The increasing intensity, scale and duration of bushfire seasons will increasingly overwhelm existing fire and landscape management approaches. While tackling the root cause of climate change is the highest priority, we must also work to increase and enhance hazard reduction through a long-term, year-round and cross tenure approach at landscape scale that supports Indigenous leadership, as well as existing agency efforts, empowers communities, and is backed by a strong research capability.

All levels of government should ensure expansion of and investment in Indigenous fire management and existing fire and land management workforces and budgets (forestry, national parks, and fire agencies).

Recommendation: 13

Governments at all levels need to work with traditional owners to incorporate cultural burning, where still practiced and being reintroduced, into broader fire mitigation programs. This will require removal of institutional and legislative barriers, including recognition that such works need to be paid for, as they are in the Northern Territory, rather than being viewed as a free, voluntary contribution.

8. Stay safe from grass fire threat

STAY INFORMED

Make sure you are connected to emergency information via the internet, television, radio and/or the emergency service apps. Follow all directions from emergency services.

EMERGENCIES

Telephone: Triple Zero ('000')

TTY: 106 (hearing / speech impaired)

If you are deaf, or have a hearing or speech impairment use the National Relay Service.

If you need an interpreter call 13 14 50.

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

Queensland Fire and Emergency Services
www.qfes.qld.gov.au
13 74 68

South Australia Country Fire Service
www.cfs.sa.gov.au
1800 362 361

Tasmania Fire Service
www.fire.tas.gov.au
03 6230 8600

Country Fire Authority (Victoria)
www.cfa.vic.gov.au
1800 226 226

WA Department of Fire and Emergency Services
www.dfes.wa.gov.au
13 33 37

ACT Rural Fire Service
http://esa.act.gov.au
13 22 81

Secure NT
https://securent.nt.gov.au/
https://securent.nt.gov.au/respond/bushfire-alerts

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Image credits

Front cover: Bushfires NSW; Firefighters from both the Rural Fire Service and the N.S.W Fire Brigade and two water bombing helicopters work to contain a grass fire in the Western Sydney Parklands in West Hoxton, Sydney. Photo by DEAN LEWINS, credit: AAP Image.

Figure 1 - Page 2: NASA (2011) Vast Area Burned in Australia. NASA earth observatory. Accessed at https://earthobservatory.nasa.gov/images/52354/vast-area-burned-in-australia.

Figure 2 - Page 5: Bushfires NSW; Firefighters from both the Rural Fire Service and the N.S.W Fire Brigade and two water bombing helicopters work to contain a grass fire in the Western Sydney Parklands in West Hoxton, Sydney. Photo by DEAN LEWINS, credit: AAP Image.

Figure 6 - Page 14: "Fire impact during the Black Christmas Fires, 2001." NSW Government.

Figure 8 - Page 18: "Burned neighborhood from Marshall wildfire, Louisville, Colorado 2021." Photo by Kent Raney on Shutterstock.

Figure 11 - Page 23: Junee, NSW Australia, January 05 2020: Australian Flag flies in a smoke filled sky as the nearby Dunn's Road Fire burns. Photo by Greg Stonham, credit: Shutterstock.

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

The Climate Council acknowledges the Traditional Owners of the lands on which we live, meet and work. We wish to pay our respects to Elders past and present and recognise the continuous connection of Aboriginal and Torres Strait Islander peoples to Country.

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