

GAME, SET, MATCH: CALLING TIME ON CLIMATE INACTION



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Key findings

1

Australia's summer of sport is under threat from climate change.

- › Climate change, driven largely by the burning of fossil fuels (coal, oil and gas), is worsening extreme weather events and disrupting Australian sport.
- › Australia's summer sports calendar, which includes Big Bash League (BBL) cricket, AFLW games, the Tour Down Under cycling race, the Australian Open tennis, A and W-League football and community sports is threatened by climate change.

2

By 2040, heatwaves in Sydney and Melbourne could reach highs of 50°C, threatening the viability of summer sport as it is currently played.

- › Heatwaves are becoming hotter, lasting longer and occurring more often.
- › While 2010-2019 was the warmest decade over the past century, it is also likely to be the coolest decade of the century ahead.
- › 2019 was Australia's warmest year on record, with 33 days that exceeded 39°C – more than the total number between 1960 and 2018.
- › If global emissions continue to increase, Australian sports will have to make significant changes, such as playing summer games in the evening or switching schedules to spring and autumn.

3

No athlete, whether an elite professional or a community player, is immune to our increasingly hot summers, which are a health hazard for those playing and watching sport.

- › Climate change is driving longer and more intense bushfire seasons, exposing athletes and spectators to dangerous air pollution, for which professional players are a particularly sensitive group.
- › Many athletes and spectators have fallen seriously ill following exposure to extreme heat in recent years. For example:
 - **Tennis:** Temperatures at the Australian Open Tennis in Melbourne have repeatedly hit +40°C with games suspended and players taken to hospital. In 2014, almost 1,000 spectators were treated for heat exhaustion.

4

- **Triathlon:** On 2 March 2016, temperatures reached 34°C in Penrith during the NSW All Schools Triathlon Championships at the nearby Sydney International Regatta Centre. Paramedics were called following reports of nine people suffering from heat exposure during the event.
- **Cricket:** In January 2018, at the Sydney Ashes Test, England's captain Joe Root was hospitalised as air temperature hit 41.9°C. In December 2019, New Zealand cancelled part of a warmup match in Melbourne because the temperature was forecast to reach 45°C.
- > Prolonged drought in Australia has resulted in an increase in shoulder injuries due to sport being played on harder, rain-parched grounds. For example, shoulder injuries increased by 23 percent in 2001 (during the Millennium Drought), compared to 1994 levels.

Australian sport is worth \$50 billion to the economy and employs over 220,000 people, but governments are not adequately prepared for escalating climate risks.

- > None of Australia's major sports plans, including the Federal Government's first national sports plan, discuss or tackle the implications of climate change on sport.
- > Climate disruption is a growing cost for sport in Australia, including infrastructure maintenance and rising insurance premiums.
- > Elite venues may be able to afford expensive upgrades, but local venues will not.
- > Australia can help protect sport by becoming part of the global solution to climate change by rapidly and deeply reducing its greenhouse gas emissions and transitioning to renewable energy and storage.

5

Sport is a contributor to climate change, but it can also be an integral part of the solution.

- > Sporting clubs and codes contribute to climate change but can rapidly cut their own greenhouse gas emissions by changing the way they build venues, power events, travel and by cutting waste.
- > Athletes and other sporting leaders can become powerful advocates for change, both within sport and outside of it, by using their star appeal to educate and influence others.
- > Professional and community sports can switch sponsorship from fossil fuel-backed companies to ones that invest in climate solutions.
- > All sporting codes and leagues should have science-based, regularly updated policies that cover heat, bushfire smoke and other extreme weather events to protect athletes and spectators.

Foreword

As a kid growing up in Zimbabwe I knew Australia was a sporting nation. The absolute dominance of Australia's cricket teams, the Wallabies winning the 1999 Rugby World Cup, Cathy Freeman winning gold in the 400m at the Sydney Olympics, Ian Thorpe smashing records in the pool. Now, as an Australian, I know this passion firsthand.

We watch sport, we talk about sport, we play sport; from the Boxing Day Test to footy finals fever, from early mornings paddling out at breaks around the country to park runs in hundreds of cities and towns. Every weekend thousands of boys and girls take to fields, courts, pitches and ovals to have fun, test themselves and learn skills that will serve them throughout their life, while weekend warriors run around with their mates years after their bodies have told them it's time to pick another hobby.

Unfortunately, the climate crisis is threatening the way of life we love.

We've seen soaring temperatures at the tennis with forced early retirements at the Australian Open. Bushfire smoke led to the cancellation of summer sporting events and relocation of matches and training. My old team, the ACT Brumbies, along with the Canberra Raiders, had to relocate their preseasons during the bushfires of 2019/20. Insurance premiums have risen dramatically for local clubs in the expanding fire and flood-prone parts of the country and prolonged droughts cancelled games and entire seasons.

Unfortunately, the climate crisis is threatening the way of life we love.

Whether you're a professional athlete or one of the millions of Australians playing or watching their favourite sport on weekends, things are going to get worse unless we act now.

It's not just sport, Australia stands to lose so much from the breakdown of the climate as we've known it. We live on a continent of incredible and unique beauty – the Great Barrier Reef, the best beaches in the world, ancient forests, animals not found anywhere else. But we also live in a climate of extremes – extremes that will worsen dramatically if climate change remains unchecked.

As the developed country that stands to lose the most from inaction, we also stand to gain the most from bold climate action. With an economy built on the back of our mineral wealth, we find ourselves with the unique opportunity to transition our workforce and industries and become a renewable superpower. It will take courage to make these changes but there's no reason we can't lead the world on climate action and build an even stronger economy.

As an athlete reading through the findings in this Climate Council report I couldn't help but think that, while sport's future is more uncertain than ever, its power has never been more important.

We often hear from our politicians that sport and politics shouldn't mix but as South African President, Nelson Mandela famously said, *"Sport has the power to overcome old divisions and create the bond of common aspirations."*

As the following pages demonstrate, the climate crisis we are facing poses an existential threat to the future of sport, as well as the people and places we love. It also shows how little sport is currently doing to tackle this challenge – which means there is huge opportunity for sport to lift its game and lead.

This is the greatest challenge we have ever faced and, while our politicians love to delay taking serious climate action while reminding us that we have a relatively small population, we are a country used to punching above our weight. We've seen that time and again from our sporting heroes on the world stage.

It's time for athletes, sporting organisations and all of us to use that power, to step up, speak up and lead the transformation to a better future for all of us. If we take that attitude, and the wealth of resources at our disposal, we can rise to the challenge and face this together. We can build a future where we all thrive.



David Pocock
Former Wallabies rugby union player,
Co-founder, FrontRunners

1. Introduction

Sport is a major part of Australian culture. Every weekend, millions of Australians participate in, watch or discuss sport. Sporting legends are idolised and our national teams and clubs are revered. Australia punches above its weight, often topping the tables and podium on the international stage. Mega sporting events such as the AFL and NRL grand finals and the women's T20 World Cup final are watched by millions and the Australian Tennis Open Final, one of the world's four 'Grand Slam' tournaments, is a major event on the global sporting calendar. Our elite and community sports infrastructure is world class.

Sport encompasses many different activities from casual participation, through community clubs and organised activities, to professional sports. In Australia, at all levels we both participate and watch, and one third of all volunteering (1.8 million people) is sports-related (BCG 2017). It is estimated that the full spectrum of Australian sports-related activities is worth at least \$39 billion, or about 2% of GDP, and employs more than 220,000 people (BCG 2017). However, the full value of sport goes well beyond its economic contribution, supporting physical and mental health and associated higher productivity, as well as improved educational outcomes and social capital. Boston Consulting Group (BCG) estimates that these additional outcomes increase the total value of sport to around \$50 billion each year, or closer to 3% of GDP.

In towns and cities and in rural and regional areas across Australia, sport is the social fabric of communities, nurturing social networks and forging long-lasting friendships. Six out of ten Australian adults participate in sport three times a week. In 2019, three-quarters of Australian children (0-14 years old) participated in organised outside-of-school sport or physical activity at least once per year, with most of this participation being through sports clubs (62.1%) (SportAus 2020).

The Australian Sports Commission report, 'Intergenerational Review of Australian Sport' (BCG 2017), found that several emerging trends put Australia's sporting future at risk. Schools are devoting fewer hours to sport and physical education and there are fewer trained sports teachers. This is despite inactivity and obesity being major

health risks, with eight out of ten Australian children not meeting the recommended activity guidelines, and two-thirds of adults and one-quarter of children being overweight or obese. Prior to the COVID-19 pandemic, some sports – particularly AFL, NRL, and cricket – were successfully growing and commercialising, although many others struggled to gain prominence or were unable to attract sponsorship, resulting in a widening wealth gap between the commercial, largely male, sports and the broader sports community.

Many sports are highly dependent on favourable climatic conditions (Dingle and Mallen 2020). For example, skiing and snowboarding rely on the availability of sufficient and reliable snow, enough (but not too much) rainfall is required for good playing surfaces for cricket, football and golf, and athletes must avoid extreme heat for their safety. Climate change thus represents a significant long-term challenge facing sport in Australia. Despite this, the 'Intergenerational Review of Australian Sport' (BCG 2017), 'Sport 2030' – the Federal Government's first national sports plan (Commonwealth of Australia 2018) and 'The Future of Australian Sport' (CSIRO 2013) all fail to consider climate change and its implications.

Australia's climate has warmed on average by 1.44°C since 1910, with most warming occurring since 1950 and every decade since then being warmer than the preceding ones (BoM and CSIRO 2020). The frequency of extreme heat events is also increasing. 2019 was Australia's warmest year on record, with 33 days that exceeded 39°C – more than the total number observed in the entire

1960-2018 period (BoM and CSIRO 2020). Cool season rainfall (April – October) has declined by 10-20 percent across mainland southern Australia over recent decades (BoM 2021). 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 (BoM and CSIRO 2020; Abram et al 2021). On the other hand, the intensity of short duration (hourly) extreme rainfall events, often leading to flash flooding, has increased by around 10% (BoM and CSIRO 2020).

Climate change – driven mainly by burning fossil fuels and land clearing – is worsening extreme weather in Australia, playing havoc with both elite and grassroots-level sport. Australia's beloved summer sports calendar, which includes Big Bash League (BBL) cricket, AFLW games, the Tour Down Under cycling race, the Australian Open tennis, A and W-League football and community sports is under threat from climate change.

"Australia's "summer of sport" is no longer cause for celebration – it serves as a warning. Extreme weather periods will become more common and more dangerous as the new decade unfolds, prompting questions over whether football [and other sports] continues with a summer calendar" (Samantha Lewis, freelance women's football journalist, The Guardian 2020a, online quote).

While sport is a significant contributor to climate change, it can also be an influential part of the solution. Professional clubs, leagues and international sporting events such as the Olympics and Commonwealth Games, the Australian Tennis Open and World Cup cricket, football and rugby result in significant greenhouse gas emissions, mostly from travel, but also from venue construction, powering events and waste produced. It is estimated that total global emissions from sport are comparable to the total emissions of Spain or Poland, roughly 300–350 million tonnes of greenhouse gases annually and equivalent to around 60 percent of Australia's total emissions (Goldblatt 2020). Although this is likely to be a conservative estimate due to limited carbon emissions data on most sports in most countries, events and leagues. Further, the emissions of spin-off industries such as broadcasting and sportswear are not included in the calculations (Goldblatt 2020). Clearly, there is a need for more data on the carbon footprint of sport.

Sport can become
a powerful force
for climate action.

The good news is that sport can also be a powerful force for change. Using the star appeal and influence of elite athletes, clubs and national teams, as well as global sporting events, sport can call for climate action and embed climate solutions in their operations. Considering that community sports clubs are so deeply embedded in everyday life in Australia, they also provide a powerful focal point for raising local awareness and inspiring community action.

The implications of climate change for sport have provided the impetus for several reports, although considering the importance of the issue, the number is relatively modest. Publications include some sport-specific reports, for example, on cricket, tennis and cycling (ACF and Monash University 2019; 2020a, b) and the British Association for Sustainable Sport's 'Hit for Six: The Impacts of Climate Change on Cricket' (BASIS 2019), studies on the links between climate change, sport and health (see, for example, Townsend et al. 2003), as well as some general reports, notably 'Sport & Climate Impacts: How much heat can sport handle?' (The Climate Institute 2015) and 'Heat, Humanity and The Hockey Stick: Climate Change and Sport in Canberra' (Auty and Roy 2019). Several reports have been published in the UK, including 'Game Changer: How climate change is affecting sports in the UK' (The Climate Coalition 2018) and 'Playing Against the Clock: Global Sport, the Climate Emergency and the Case for Rapid Change' (Goldblatt 2020).

As the intensity and severity of climate change grows, there has been increasing media coverage on the impacts of extreme weather on specific sporting events, such as heatwaves and bushfire smoke on tennis, cricket, cycling and soccer in Australia; drought on cricket in India; wildfire smoke on baseball, soccer and golf in the US; super cyclone Hagibis on World Cup rugby in Japan; and storm Desmond on English

football. Australia-based organisations such as FrontRunners, the Sports Environment Alliance and Surfers for Climate Action and global organisations such as the World Surf League are engaging with athletes on the issue. Yet, as mentioned above, none of Australia's major future-focused sports reports discuss or tackle the implications of climate change. Indeed, a recent review of sports management literature found that only two publications focused on the issue in general (see Orr and Inoue 2018; Dingle and Mallen 2020).

This new report focuses primarily on summer sports and climate change, with a separate report planned for winter sports. A third Climate Council sport report will focus specifically on the 2023 Women's World Cup in Australia and New Zealand.

The report describes the influence of climate change on extreme weather events, with a specific focus on how each type of event can affect specific sports. For example, heatwaves on tennis; drought on cricket; bushfire smoke on soccer/football; intense rainfall on community sport; sea-level rise and shifting storms on surfing. The report looks at climate projections and how summer sport might become unplayable without rapid emissions reductions and significant climate adaptations. Next, we examine how climate affects sport from a health, social, economic and infrastructure perspective. Finally, we examine climate solutions and the positive role that sport can play. We provide case studies describing how professional and community sports are tackling climate change by, for example, powering stadiums and facilities with renewables, encouraging active and public transport to and from venues, adopting carbon neutral strategies, using their platform to demonstrate and call for stronger action on climate change, and switching from fossil fuel-backed corporate sponsorship to renewables and other climate friendly sponsorship.

None of Australia's major future-focused sports reports discuss the growing threat of climate change on the \$50 billion a year industry.

Here we aim to elevate the issue of sport and climate change, showing how climate change is threatening Australian sports and how the sector can become a powerful voice for climate action, supporting groups such as FrontRunners, Sports Environment Alliance, Surfers for Climate and the World Surf League, sports administrators, community sport and all levels of government. By tackling the climate crisis, we can sustain sport for future generations.

We are grateful for the insightful reviews of Professor Matthew England (University of New South Wales) and Professor Ollie Jay (University of Sydney). Thanks also to Councillors and Climate Council staff and research volunteer Lachlan Pickering for their feedback and assistance in the preparation of this report.

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

2. Sport and climate change in Australia

Climate change and extreme weather events threaten the viability of summer sport as it is currently played in Australia (Figure 2). This section describes how climate change is worsening extreme weather events and disrupting sports. Australia's future climate is described, showing how some summer sports could become unplayable if climate change continues unabated, depriving future generations of the many benefits of an active and healthy sporting life.








Figure 1: Climate change could deprive future generations the enjoyment and many benefits of playing summer sport.



Figure 2: Australian sport and climate disruption.



FAST CLIMATE FACTS

-  All extreme weather events are influenced by climate change.
-  Since 2013, every year has been amongst the ten warmest on record for Australia.
-  Since 1950 the annual number of record hot days across Australia has more than doubled.
-  Heatwaves are becoming hotter, lasting longer and occurring more often.
-  Bushfire seasons are starting earlier and lasting longer and there has been an increase in the number of days of Very High fire danger and above over the last 30 years across southeast Australia.
-  Cool season rainfall has been declining across mainland southern Australia over recent decades, with April - October rainfall reduced by 10-20 percent.
-  The intensity of short duration (hourly) extreme rainfall events, often leading to flash flooding, has increased by around 10%.


For more information, please access 'State of the Climate 2020' (BoM and CSIRO 2020).

QUEENSLAND

Brisbane: Soccer / NRL / Rugby Union


-  Intense rainfall led to Lang Park (Suncorp Stadium) being submerged in 1.5m of water in January 2011 forcing the Maroons (rugby league State-of-Origin), the Reds (rugby union) and the Roar (soccer) to play away from home.

Tropical Queensland - Community Sports

-  Grassroots sport badly affected by intense rainfall in early 2019, with three clubs each estimating +\$250,000 damage bill.

NEW SOUTH WALES


New South Wales: Professional and Junior Football

-  Record-breaking heat on 11 February 2017 (NSW state-wide average temperature of 44°C) resulted in Newcastle's A-League soccer match vs Melbourne Victory and all under-18s NSW football trial games being cancelled.

Sydney: Cricket Ashes Test

-  England's captain Joe Root was hospitalised suffering from dehydration and viral gastroenteritis after the air temperature hit 41.9°C during Australia vs England test match in January 2018.

Sydney: Sailing

-  The SOLAS Big Boat Challenge, a warmup for the Sydney to Hobart race, was cancelled in December 2019, because of poor visibility on Sydney Harbour from thick bushfire smoke.

ACT

Canberra: Big Bash Cricket

-  Bushfire smoke resulted in the BBL match in Canberra being abandoned on 21 December 2019; denying Sydney Thunder victory over Adelaide Strikers.


NORTHERN TERRITORY

Darwin: AFL


-  In November 2020, AFL Northern Territory league implements extreme heat policy with mid-30°C temperatures forecast for weekend games. "When the sun is beating down and it's 35 degrees with 80 per cent humidity during a 2:00pm game, there's only one word to describe it – brutal" (Daniel Fitzgerald, NTFL player, Darwin Buffaloes, ABC 2020, online quote).

WESTERN AUSTRALIA

Perth: A-League


-  Severe electrical and thunderstorms in Perth postponed an A-League match at Campbelltown Stadium between Sydney FC and Perth Glory (schedule for 7 Dec 2011) because the Perth Glory team was unable to travel.

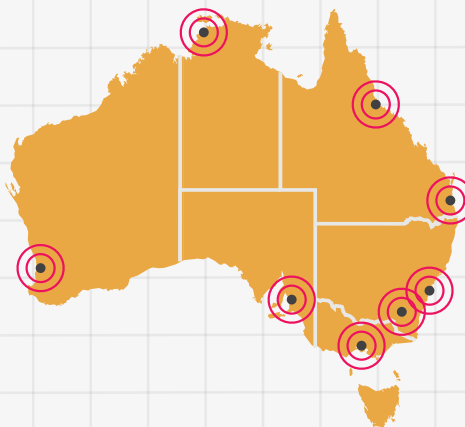
Perth: Horseracing

-  Ascot horse race was abandoned due to extreme heat in December 2019.

SOUTH AUSTRALIA


SA: Tour Down Under Cycle Race

-  Heatwaves forced organisers to shorten the route in 2018 and 2019.




VICTORIA


Melbourne: Australian Open Tennis

-  Extreme heat (+40°C) over two days in January 2018 caused player heat stress and a review of the tournament's extreme heat policy.

Victoria: Community Sport

-  More than half of the community sporting leagues in rural Victoria delayed or cut short their 2007 season because of drought.

Victoria: Disability Sport

-  Extreme weather forced the cancellation of the 2017 Victorian Disability Sport and Recreation Festival.

2.1 Climate change and extreme weather events

The term 'extreme weather event' refers to "an occurrence of a value of a weather or climate variable beyond a threshold that lies near the end of the range of observations for the variable" (IPCC 2012, p. 5). In general, extreme events occur only rarely and are usually short-lived, lasting only several hours or up to several days. Examples include extremely hot days and heatwaves (three or more consecutive days of unusually high maximum and minimum temperatures), very heavy rainfall, hail storms, and tropical cyclones. A few extreme events can last for much longer periods of time and are usually termed extreme climate events. An example is drought, which is a significant lack of rainfall over a period of months to years.

All extreme weather events are being influenced by climate change due to increasing global emissions of greenhouse gases (Trenberth 2012). This is leading to a marked increase in the frequency and/or severity of destructive weather events: extreme heat, intense downpours, powerful cyclones, crippling droughts, and dangerous fire weather (BoM and CSIRO 2020).

Sport is continually being cancelled, postponed or cut short due to worsening extreme weather as the climate changes.

2.2 Extreme heat

The burning of coal, oil and gas is driving up greenhouse gas emissions, causing global heating. The seven hottest years on record globally all occurred in the past seven years (NOAA 2021). In decadal terms, the 2010s were warmer than any preceding decade, a full 0.2°C warmer than 2000-2009, representing a sharp acceleration in the rate of temperature increase. Today the world is 1.1°C warmer compared to pre-industrial times (NOAA 2021, Figure 3). This warming is not distributed evenly, and many land areas are already significantly hotter than the global average. For example, Australia has warmed by 1.44°C since national records began in 1910 (CSIRO and BoM 2020).¹ The mean temperature for the 10 years from 2011 to 2020 was the highest on record, and 0.33°C warmer than the 10 years from (2001–2010). All years since 2013 have been amongst the ten warmest on record for Australia. Of the ten warmest years, only one – 1998 – occurred before 2005 (BoM 2021).

¹ If using a pre-industrial baseline rather than 1910, then by 2019 Australia had warmed by more than 1.5°C.

Figure 3: Global time series of annual land and ocean temperature anomalies from 1880 to 2020 (1981 to 2010 average) with iconic sporting moments running along the 20th century global average temperature trend line (black solid line).

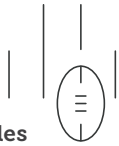


WORLD TIME SERIES:

ICONIC SPORTING MOMENTS AND A FOSSIL FUELLED LONG-TERM GLOBAL HEATING RUN

1858

First organised game of Australian Rules Football (Scotch College and Melbourne Grammar).



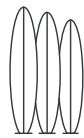
1877

First cricket test match played in Australia (Australia vs. England at MCG).



1915

Surfing brought to Australia (Hawaiian Duke Kahanamoku demonstrated ancient Hawaiian board riding technique at Freshwater).



1960

Rod Laver wins his first Australian Tennis Open singles final.



1960

Kevin Richard Coombs OAM becomes Australia's first Indigenous sports person to compete at the Paralympic Games (Rome, wheelchair basketball).



1962

Perth Commonwealth Games.



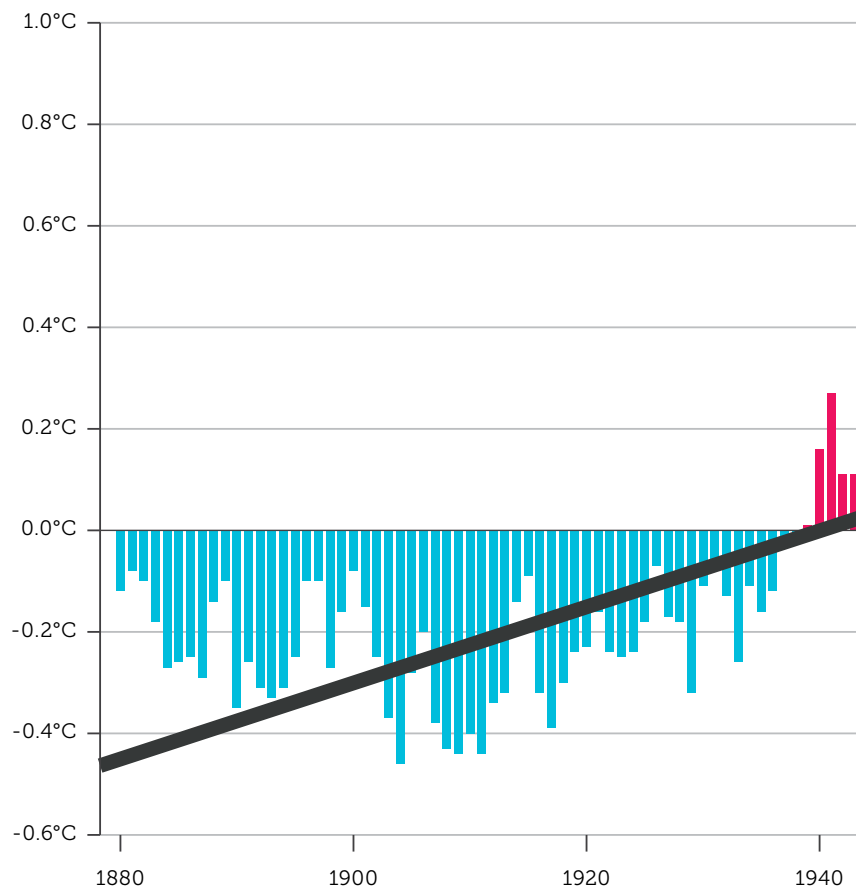
1971

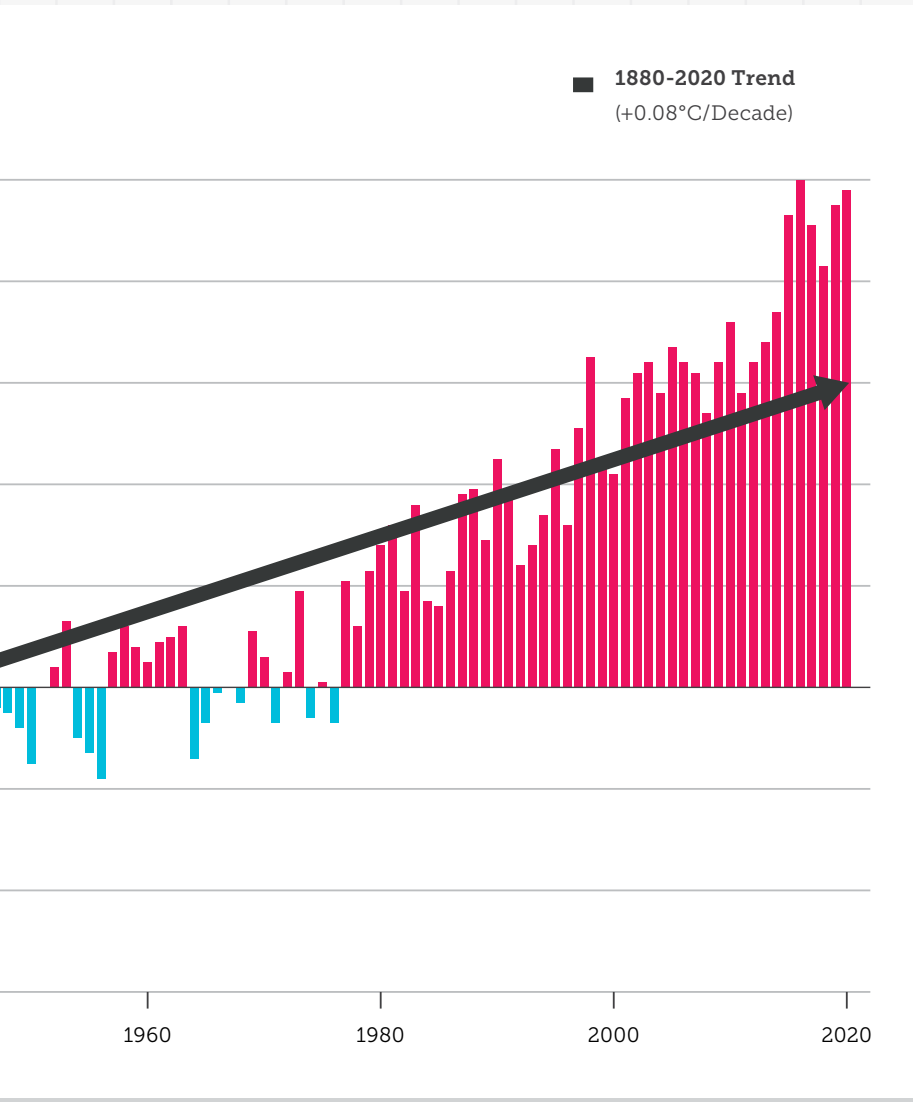
Evonne Goolagong Cawley number one tennis player in the world.



GLOBAL LAND AND OCEAN

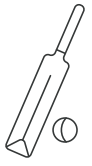
January - December Temperature Anomalies





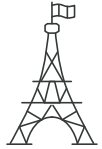
2020

Australian women win T20 World Cup cricket.



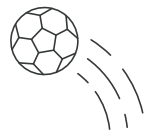
2011

Cadel Evans wins the Tour de France.



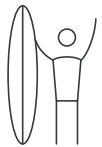
2010

Matildas win football Asia Cup.



2006

Layne Beachley AO becomes the most successful female surfer winning a 7th World Title.



2000

Sydney summer Olympics and Paralympics.



1999

First Tour Down Under Cycle race in South Australia.



1974

Socceroos qualify for their first world cup.



1976

World Surf League established and Australian surfer Peter Townend becomes the first WSL Champion.



1991

Wallabies win their first rugby world cup.



As illustrated by Figure 4, an increase in global average temperatures means a marked increase in the probability of extreme and record-breaking hot weather, and a decrease in the probability of extreme cold weather. The annual number of hot days (above 35°C) and very hot days (above 40°C) has also increased strongly over most areas since 1950.

Since 1900, heatwaves have killed more Australians than bushfires, cyclones, earthquakes, floods, and severe storms combined (Coates et al. 2014). The link between climate change and more extreme heatwaves is clear, both in Australia and

globally. Heatwaves are lasting longer, reaching higher maximum temperatures and are occurring more frequently over many regions of Australia (for the time period 1971-2008) (Perkins and Alexander 2013; Perkins-Kirkpatrick et al. 2016; Figure 5). Climate change has increased the risk of experiencing severe heatwaves by two and three-fold in terms of their frequency and intensity (Perkins et al. 2014). During the 2018-19 summer, exceptionally severe heatwaves occurred in Australia, notable for their continental-wide scale as well as for breaking records for both duration and individual daily extremes (BoM 2019a).

Figure 4: When average temperatures increase and the curve showing the distribution of temperatures moves to the right, there is a significantly greater probability of experiencing very hot, potentially dangerous conditions for sporting events and athletes. **Source:** Climate Council 2021.

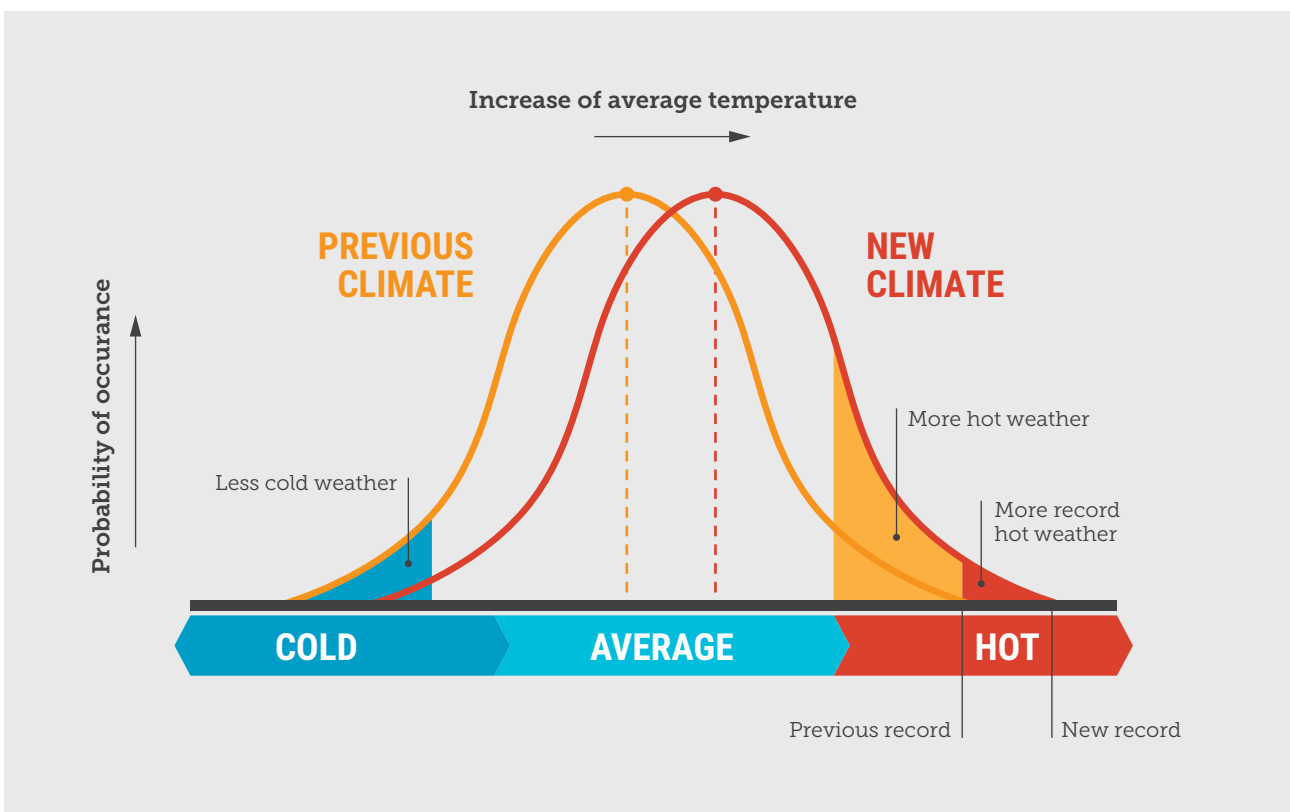
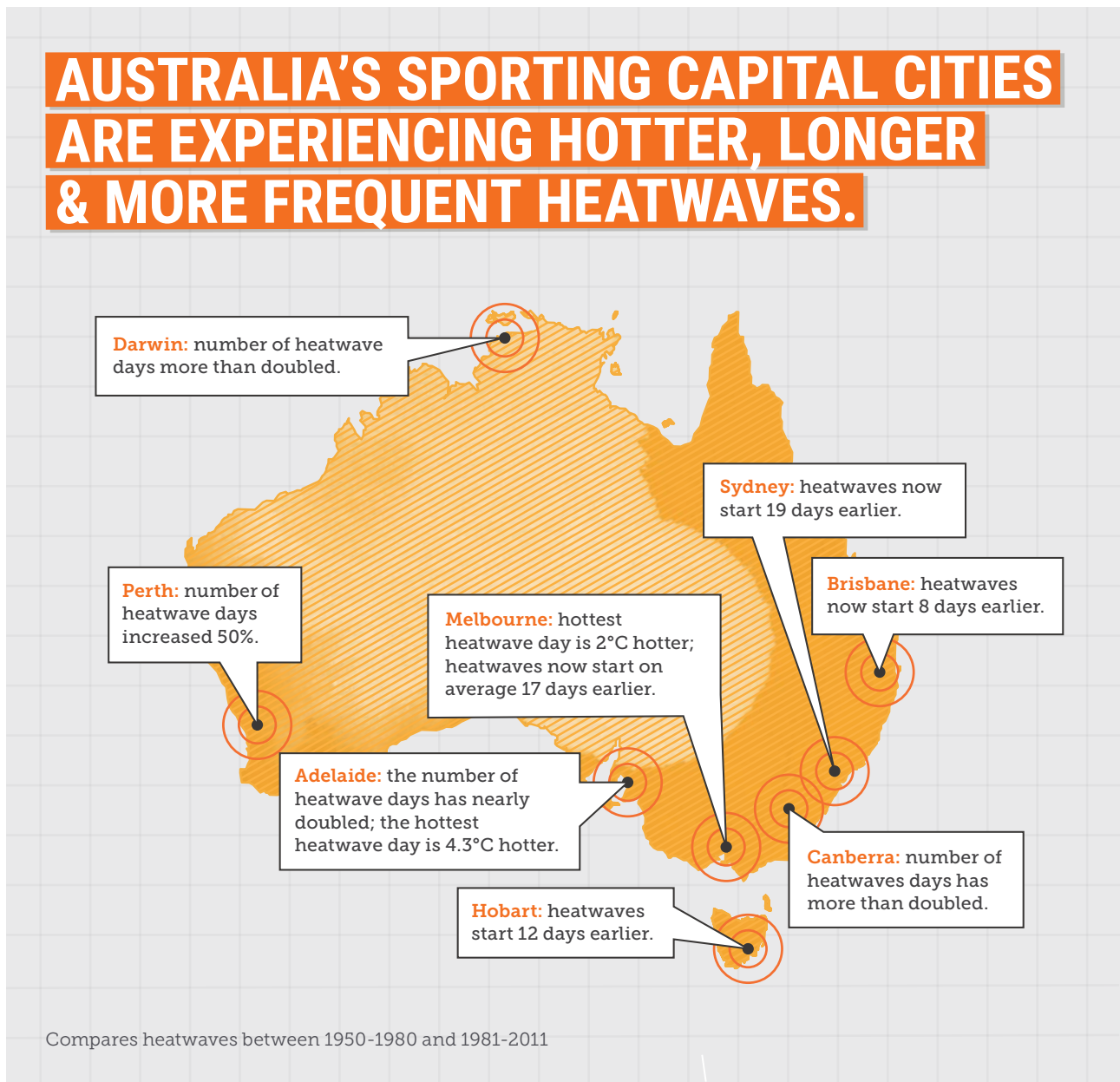


Figure 5: Major cities where summer sports such as A and W-League soccer, BBL cricket and major tennis tournaments are played are all experiencing hotter, longer or more frequent heatwaves, based on a comparison by Perkins and Alexander (2013) of heatwaves during the 1950-1980 period with those during the 1980-2011 period.



Climate change is increasing the intensity and frequency of severe heatwaves in Australia, putting athletes and spectators in increasing danger.

EXTREME HEAT AND AUSTRALIAN SPORT

Increasingly, heatwaves are playing havoc with major summer sporting events here in Australia and overseas. Extreme heat can have significant impacts on the health of competitors and spectators as well as sporting infrastructure (Chalmers and Jay 2018; Section 4.1).

Figure 6: Camila Giorgi of Italy attempts to cool down in a break during her match against Alize Cornet of France in round two of the Australian Open in January 2014.



Tennis

Heatwaves coinciding with the Australian Open Tennis have been a recurring issue in Melbourne. In 2009, temperatures peaked at 41°C and play was suspended for 45 minutes during the women's singles quarter-final between Serena Williams and Vera Zvonareva (ABC 2009). During the 2014 Australian Open tournament, play was halted for the afternoon of 16 January after the temperature exceeded 43°C (Climate Council 2014; SMH 2014a). Canadian player Frank Dancevic described the 2014 tournament as "inhumane" because players competed in temperatures that surpassed 40°C for several days in a row (SMH 2014a). While players sweltered in extreme temperatures (Figure 6), off-court ambulances treated almost 1,000 tennis fans in the first few days of the tournament for heat exhaustion (Climate Council 2014; SMH 2014b).

Extreme heat was again oppressive at the Australia Open in 2018, when matches were played in temperatures reaching the high 30°Cs and low 40°Cs and the on-court ground surface temperature reportedly reached 69°C (The Guardian 2018a; Climate Council 2019). In particular, two days of extreme heat with temperatures above 40°C led to players suffering health effects and prompted the Australian Open officials to review the tournament's extreme heat policy (see Section 4.1). During this tournament, Novak Djokovic described his 2018 match against Gael Monfils as "brutal" while Monfils reported to court doctors with fears of fainting due to dizziness and shortness of breath (ABC 2018a). Simona Halep spent four hours in a Melbourne hospital after the roof remained off Rod Laver Arena during the women's final (The Guardian 2019a).

Cycling

The Tour Down Under in South Australia, held in January, is Australia's premier cycling event and the largest cycling race in the southern hemisphere (ACF and MCCRHR 2020b). In 2020 the event attracted 48,000 international and interstate visitors, generated \$66.4 million in economic impact, and created the equivalent of 742 full-time jobs (Santos 2021). This event has also been feeling the impacts of extreme heat. In 2006, four days of temperatures over 40°C melted bitumen on the course, and in 2016 Stage 1 was cut by 26.5km because of extreme conditions (ACF and MCCRHR 2020b; Figure 7). Heatwaves during the event in 2018 affected crowd numbers and resulted in organisers making changes to key stages, cancelling side events, and ensuring tour doctors were on alert for signs of heat stress (Cycling News 2018; Climate Council 2019). In 2019, the route of the Tour was shortened again due to a severe heatwave being forecast (The Guardian 2019b).

Figure 7: Extreme heat takes its toll on Tour Down Under cyclists in Adelaide on 22 January 2006.



Extreme heatwaves are playing havoc with major summer sports events and can create “inhumane” conditions for competitors.

Football/Soccer

Nine of the 10 hottest years on record in Australia have occurred since A-League soccer began in 2005 and eight of the 10 hottest years on record have occurred since the W-League kicked off in 2008 (BoM 2021). With summer temperatures rising, A- and W-League soccer games are being played in increasingly difficult conditions and match schedules are being changed because of extreme heat. On 11 February 2017, New South Wales experienced a record breaking state-wide average temperature of 44°C (BoM 2017a), resulting in the postponement of Newcastle's A-League soccer match against Melbourne Victory, while Football NSW cancelled all trial games for the under-18s and below and shifted under-20s and

first grade trials to evening start times (The Guardian 2017). Football was feeling the heat again on 30 December 2018, when forecast high temperatures in Newcastle resulted in Football Federation Australia (FFA) postponing the W-League football match between the Newcastle Jets and Adelaide United, and delaying the kick-off of the A-League match between Newcastle Jets and Adelaide United in line with the FFA Heat Policy (Westfield W-League 2018). In December 2019, A- and W-League fixtures were rescheduled due to extreme heat forecasts. The challenges for the W-League and National Youth League are even more stark, and W-League players have long complained of being forced to play in the heat of the day to avoid clashes with A-League games (The Weekend Australian 2019).

Almost all of Australia's top 10 hottest years on record have occurred since the A- and W-Leagues were established almost two decades ago.

Cricket

Cricket is arguably the quintessential Australian summer sport with the iconic Ashes Test series, the Big Bash League, Women's National Cricket League and community cricket. Like many sports, cricket is facing testing times due to extreme heat. Since 1910, when national climate records began and Australia won the test match cricket series against South Africa, Australia has warmed on average by 1.44°C (BoM 2021). Since the 1980s, Boxing Day cricket has become a summer staple for sports fans in Australia but record-breaking heat has also become more frequent. The consequences of our failure to deeply and rapidly reduce greenhouse gases were scorched into the memories of cricket fans during the Sydney Ashes Test in January 2018, when England's captain Joe Root was hospitalised suffering from dehydration and viral gastroenteritis as air temperature hit 41.9°C (ABC 2018b). In December 2019, New Zealand cancelled the opening of the two-day warm up match against Cricket Victoria because of an extreme heat forecast of 45°C for Melbourne (BBC Sport 2019a). In February 2017, for the first time ever, all Sydney grade cricket was called off (Cricket NSW 2017) when the NSW statewide average maximum temperature reached 44°C, the warmest February day on record (BoM 2017b). Grassroots cricket is also feeling the heat. For example, the Red Cliffs Cricket Association, located in the Mildura region, has seen the number of January days of 38°C or above increase more than five-fold since 1980 (ACF and MCCRHR 2019).

Triathlon

On 2 March 2016, temperatures hit 34°C in Penrith during the NSW All Schools Triathlon Championships at the nearby Sydney International Regatta Centre. Paramedics were called following reports of nine people suffering from heat exposure during the event. (ABC 2016).

Lake and river water sports

Lakes and rivers are the playgrounds for many water-based sport and recreational activities, including swimming, fishing, diving, water-skiing, windsurfing, canoeing and rowing (Auty and Roy 2019), all of which require water of a healthy standard. Increased water temperatures provide favourable conditions for blue-green algae (*Cyanobacteria*) blooms that produce harmful toxins when swallowed, inhaled or come into contact with the skin. Common symptoms include irritated skin, flu-like symptoms and gastrointestinal illness (Commonwealth of Australia 2021). Local governments have identified increasing blue-green algae as a climate change risk that is already affecting participation in water sports and recreation (Auty and Roy 2019; The Canberra Times 2020).

2.3 Bushfires

Climate change is escalating bushfire risk. Bushfire seasons are starting earlier and lasting longer, and there has been an increase in the number of days of Very High fire danger and above over the past 30 years across southeast Australia.

In the Black Summer of 2019-20, Australia experienced unprecedented, devastating climate change-driven bushfires that burned over 24 million hectares (Abram et al. 2021; Climate Council 2021). An estimated eight million Australians were affected in some way, with 33 lives lost directly in the fires (Commonwealth of Australia 2020), and over 400 people dying of conditions worsened by toxic smoke inhalation (Johnston et al. 2020). Over 3,000 homes were lost and the national financial cost is estimated to be in excess of \$10 billion (Commonwealth of Australia 2020). An estimated three billion vertebrate animals were either killed or displaced (WWF 2020), 80 percent of the Blue Mountains World Heritage Area and 50 percent of Gondwanan rainforests were burnt (Commonwealth of Australia 2020). Sport is also not immune to the escalating threat of bushfires.

BUSHFIRES AND AUSTRALIAN SPORT

Tennis

As bushfires raged along the east coast in January 2020, Australian Open men’s champion Novak Djokovic expressed concern that smoke might cause health problems for players (ABC 2020b). Despite this, the Kooyong Classic and Australian Open qualifiers commenced on a day when Melbourne’s air quality was rated as the worst in the world (The Guardian 2020b; ACF and MCCRHR 2020a). Slovenian player Dalila Jakupovic abandoned her Australian Open qualifier mid-match after an intense coughing fit, and Australian Bernard Tomic’s chances of qualification for the main draw ended after he struggled in smoky conditions. In a statement, Tennis Australia said conditions were constantly being monitored, with decisions made using onsite data and in close consultation with their medical team, the Bureau of Meteorology, and scientists from Environment Protection Authority Victoria (ABC 2020b).

The Australian Open was not the only tennis event to be affected by bushfire smoke in January 2020. On 3 January when Canberra’s air quality ranked the worst in the world, Tennis Australia moved the Canberra International to Bendigo (The Guardian 2020c).

Figure 8: Smoke haze hangs over Melbourne during an Australian Open practise session at Melbourne Park on 14 January 2020.



Toxic smoke from the unprecedented bushfires in 2019-20 caused havoc for summer sport, putting the health of athletes and spectators at risk.

Figure 9: Bushfire smoke shrouds the Big Bash League (BBL) cricket match between the Sydney Thunder and the Adelaide Strikers at Manuka Oval in Canberra on 21 December 2019. The match was later cut short because of toxic air pollution from climate change-exacerbated bushfires.



Cricket

The BBL match between the Sydney Thunder and Adelaide Strikers was abandoned in Canberra on 21 December 2019 due to bushfire smoke (SMH 2019a; Figure 9). Shortly after this game, the New Year's Test match between Australia and New Zealand was scheduled in Sydney, prompting Cricket Australia to state that it expected bushfire smoke to be an issue for the test. Cricket Australia's head of operations Peter Roach said ICC regulations would allow officials to work around the issue, effectively treating it like a rain delay (The Guardian 2020d).

AFL

Heavy smoke from bushfires forced several AFL clubs to change their training plans on 14 and 15 January 2020. The EPA Victoria warned that Melbourne's air quality had reached 'hazardous' levels. In response to the health warning, the Western Bulldogs, Melbourne, Carlton and Collingwood switched to indoor training sessions (AFL 2020).

Football/Soccer

The Black Summer bushfires also disrupted soccer in Australia. On 3 January 2020, Football Federation Australia postponed the W-League match between Canberra United and Sydney FC because of hazardous air quality and high temperatures in the Hunter region (W-League 2020b). Other postponements included the Y-League fixture between Canberra United and the Newcastle Jets and the W-League game between Newcastle and Adelaide (W-League 2020b).

2.4 Drought

Australia is the driest inhabited continent on Earth, with a water cycle that is highly variable both geographically and seasonally (Climate Council 2018). Climate change has already had a significant impact on rainfall over much of the continent, especially the southeast and southwest during the cool season, with less runoff into streams, rivers, lakes and dams. Since the mid-20th century, the severity of droughts, such as the Millennium Drought and the one that recently gripped eastern Australia, has increased because they are occurring in hotter conditions, leading to declines in soil moisture through evaporation (Climate Council 2018). 2019 was Australia's driest year on record, and 2018-2019 was the driest two-year period on record in the southeast (BoM and CSIRO 2020). Drought has many negative impacts on human physical and mental health (see Section 4.1), agricultural productivity, ecosystems and biodiversity. Drought also affects sport.

DROUGHT AND AUSTRALIAN SPORT

Drought is challenging sport in Australia, affecting the ability to play, increasing the number of injuries, and damaging or making it difficult to maintain playing grounds and facilities (SMH 2004; The Climate Institute 2015; Auty and Roy 2019, Dingle and Mallen 2020). Infrastructure impacts range from increased water and energy use, to higher insurance premiums to cover the increased likelihood of injury due to harder grounds (The Climate Institute 2015).

Climate-exacerbated drought in Australia has badly affected outdoor sports, increased injuries and eroded the social fabric of rural and regional communities.

Community Sport

Sport is an important contributor to the social fabric of many communities, and yet in times of drought and water restrictions, participation can become extremely challenging (Partridge et al. 2009; Heberger 2012). A study on rural families, small business operators and service providers, found that drought has impacts on workloads leaving less time for community activities such as sport. Some survey respondents even spoke of giving up sport altogether (Alston and Kent 2004). During the Millennium Drought (1997 – 2009), Australia’s leading amateur sports insurance underwriter, Sportscover, noted an increase in the number of shoulder injuries due to harder, rain-parched grounds. For example, shoulder injuries increased by 23 percent in 2001, compared to 1994 levels, overtaking ankle injuries as the second most common sports injury in amateur sport (The Age 2001).

While elite professional venues may be able to afford expensive upgrades, local grounds often struggle (The Climate Institute 2015). In 2007, more than half of the community sporting leagues in rural Victoria delayed or cut short their season because of drought. That same year, three quarters of metro and rural AFL leagues delayed or curtailed their season because of temporary and permanent ground closures. Over 100 community cricket clubs in Geelong were forced to end their season three months early, and football pre-seasons were affected by the lack of available training ovals (Municipal Association of Victoria 2007). Water restrictions and soaring water costs laid bare 1,700 water-intensive clay tennis courts throughout the state. Over this period, local communities that could afford extra water had playable fields, while those that could not afford water were more likely to have their sports fields closed (Dingle and Mallen 2020).

Figure 10: A sports oval is dry in September 2007 after failing winter rain in Melbourne. Drought-ravaged Victoria saw widespread cancellations of community sport.

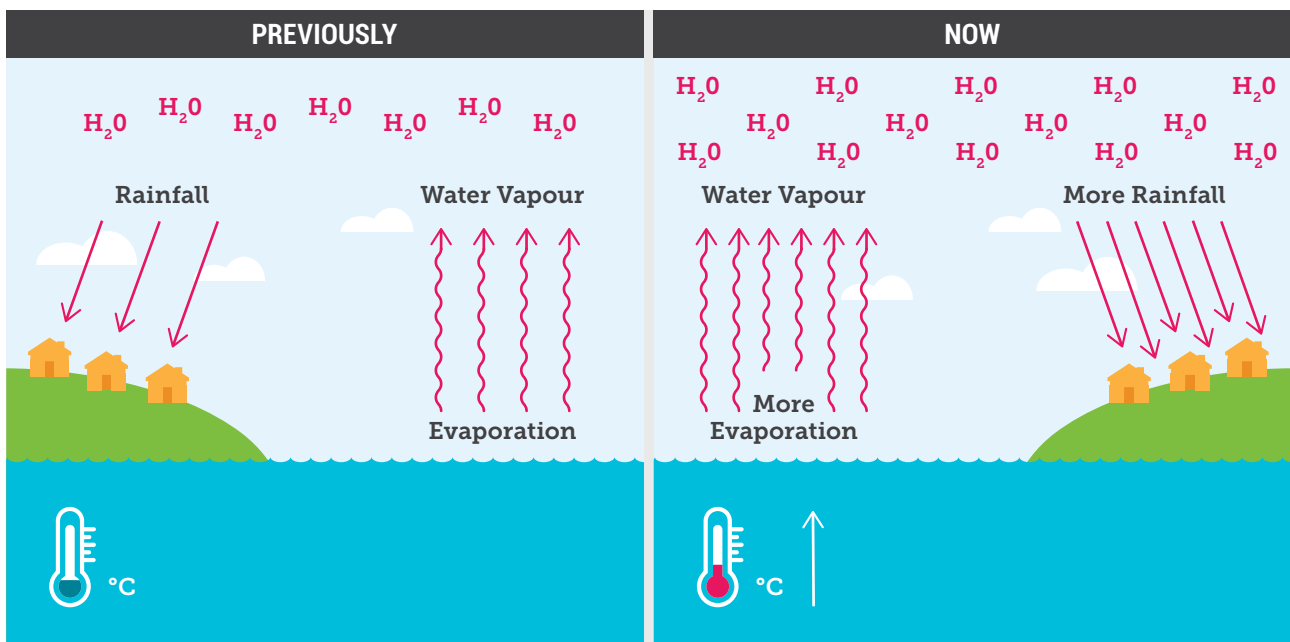


2.5 Intense rainfall

Heavy rainfall events are becoming more intense in Australia. As greenhouse gases increase in the atmosphere, the atmosphere is warming because these gases are trapping more heat. A warmer atmosphere can hold more water vapour. The oceans are also warming², especially at the surface, in turn driving higher evaporation rates that also increases the amount of water vapour in the atmosphere (Figure 11). For each 1°C rise in global average temperature, the atmosphere can hold approximately 7 percent more moisture (Trenberth 2011; Hartmann et al

2013), in turn increasing the probability of more intense rainfall events (BoM and CSIRO 2021). In Australia, the magnitude of extreme daily rainfall (mm/day) is increasing in line with this rate, whilst the magnitude of extreme hourly rainfall (mm/ hour) is increasing at double this rate, and more than triple this rate in the tropical north (Guerreiro et al. 2018). The intensity of short-duration (hourly) extreme rainfall events has increased in Australia by around 10 percent or more in some regions in recent decades (BoM and CSIRO 2021).

Figure 11: The influence of climate change on the water cycle. Left: The pre-climate change water cycle. Right: The water cycle operating under higher air and surface and ocean temperatures, leading to more water vapour (H₂O) in the atmosphere, and in turn, more rainfall. **Source:** Climate Commission (2013).



2 The oceans absorb more than 90% of the excess heat generated by the increase in greenhouse gas concentrations in the atmosphere (IPCC 2019).

INTENSE RAINFALL AND AUSTRALIAN SPORT

Professional and grassroots sport

Queensland experienced a strong La Niña event in 2010-11 with intense rainfall and major flooding. On the 10 January 2011, rainfall totals in Brisbane reached over 112 mm and a further 110 mm fell on the 12 January causing severe flooding (BoM 2011). The city's famed Lang Park (Suncorp

Stadium) became submerged in 1.5 metres of water, damaging operating systems and equipment and resulting in the Maroons (rugby league State-of-Origin), the Reds (rugby union) and the Roar (soccer) all winning national titles away from home (The Climate Institute 2015). More than 30 golf courses as well as countless turf and sports facilities were also badly affected by the floods (Australian Turfgrass 2011).

Intense rainfall affected Lang Park (Suncorp Stadium) again in March 2015, causing the abandonment of an A-League soccer match between the Brisbane Roar and the Wellington Phoenix with 20 minutes left to play. Stadium general manager Alan Graham said that *"On Saturday we had rainfall at the rate of 295 millimetres per hour, that is three times in excess of what not only Suncorp Stadium but any other stadium in the country could handle"* (ABC 2015). In May 2015 the ANZAC match between Tasman rivals Australia and New Zealand was postponed after 100 mm fell in Brisbane (SMH 2015).

Tropical Queensland was badly affected by an exceptional rainfall event from late January 2019 into early February. In and around Townsville, the accumulated totals from consecutive days of heavy rainfall were the city's highest on record since records began in 1888. In the seven days to 4 February 2019, the Bureau of Meteorology's site at Townsville Aero recorded 1052.8 mm, and 1257.0 mm in the ten days to 6 February (BoM 2019b). Prior to this event, the Townsville record for a 7-day period was 886.2 mm (January 1998) and for a 10-day period was 925.5 mm (January 1953). The event meant that by mid-February 2019, Townsville had recorded more than its average annual rainfall of 1128.0 mm (based on all years of data for the site from 1941–2018) (BoM 2019b). Grassroots sport was badly affected by the intense rainfall in early 2019, with three clubs each estimating their damage bill was more than \$250,000 (City of Townsville 2019).

Figure 12: Rain delay during test cricket match between Australia and India at the Gabba in Brisbane, 16 January 2021.



 **BOX 1: CLIMATE CHANGE AND SURFING**

Few activities are as intimately connected with the climate system and the rhythms of the natural world as surfing. The sport is quite literally embedded in the interaction between the ocean and atmosphere – in the transfer of energy between wind and waves – and in the interface between the land and ocean.

Greenhouse gas emissions from the burning of coal, oil and gas are already altering wind and wave patterns, the shape of coastlines, and many other factors that affect surf conditions.

Moreover, the many devastating impacts of climate change on ocean ecosystems – including acidification and deadly marine heatwaves – are of great concern to the surfing community, irrespective of whether they directly affect surf conditions. It is therefore no surprise that surfers are emerging as powerful advocates for stronger action to address the climate crisis.

PIECES OF THE PUZZLE

Surfing is dependent on many different phenomena that are affected by climate change, and we must consider all of these to build a realistic picture of the likely overall impact of climate change on surfing, now and in future. Here we outline the current state of relevant knowledge across each of these factors.

Wind and swells

Day-to-day and seasonal variations in surf conditions are part of what gives surfing its thrill and adventure. However, underlying patterns of wind and swell have remained relatively stable and predictable through human history, understood by early Polynesian surfing pioneers through to today's professional athletes of the World Surf League.

These underlying conditions are changing due to our impact on the climate.

Climate change is creating a warmer and more energetic ocean-atmosphere system. This means more energy for waves. Global wave power – the amount of energy being carried by ocean surface waves – has increased by an average of 0.47% per year since 1948 and by 2.3% per year since 1994, in line with the increase in sea surface temperatures (Reguero et al. 2019).

Consistent with the effect of climate change on rainfall and other weather phenomena, the impact on wind and waves is mostly being felt at the extremes. In other words, while there may only be a modest increase in average wave heights, there could be a pronounced increase in the incidence of very large waves. A recent analysis of over three decades' worth of satellite data (1985-2018) found that globally there has been a small but significant increase in mean wind speeds and significant wave height over that period, along with a larger increase in the most extreme (top 10%) of wind and wave conditions (Young and Ribal 2019). The change has mostly occurred at higher latitudes, in particular in the Southern Ocean.

Taken in isolation, such a trend may seem like a good thing, at least for those set on chasing ever larger waves. Put simply, climate change may mean that the largest waves on the planet get even larger. This may excite the elite group of big wave riders with the skill and nerve to tackle the monster waves of the notorious Praia do Norte in Nazaré (Portugal), or those seeking thrills closer to home at Tasmania's Shipstern Bluff or the aptly-named Cape Fear off the coast of Sydney. However, this misses the bigger picture and the many other changes in wind, waves, coastlines, bathymetry (the shape of the sea floor) and other factors that need to be taken into account.

 **BOX 1: CONTINUED**

As with other impacts of the climate crisis, changes are not felt uniformly around the world but vary considerably from one location to another. While average wave heights may increase in some locations, in other areas, particularly in the Northern Hemisphere, wave heights may decrease (Hemer et al. 2013). An analysis of trends in wave heights at 16 international surfing locations since the 1970s found that almost all had seen a downward trend (Willis 2018). For Australia's East coast, while multiple studies have shown a current or likely future increase in wave heights (Heme et al. 2013, Young and Ribal 2019), others report a downward trend (Willis 2018) or project that increasing greenhouse gas concentrations will lead to fewer days with large waves (Dowdy et al. 2014). This suggests that we need to learn more about the many and complex ways in which waves are affected by climate change.

Other predicted changes in wave characteristics, beyond their size, are also likely to affect surf conditions. Shifts in large-scale wind and swell patterns will also likely drive changes in wave direction and the angle at which waves hit the coast (Hemer et al. 2013, Erikson et al. 2015). For example, shifts in open-ocean storms that build the North Pacific swells and produce Southern California's world class surf could shift further north, sending the swells on a course that runs more parallel to the coast rather than towards it (Erikson et al. 2015). Combined with sea-level rise, such changes could dramatically reshape coastlines, changing some much-loved surf locations.

Beneath the waves

Good surf depends not only on the size of ocean swells but on the shape of the seabed near the coast. Many of the world's best waves, such as Teahupo'o in Tahiti and Peahi in Hawai'i, owe their unique and giant breaks in part to shallow coral reefs.

The combination of ocean acidification and higher ocean temperatures is already proving deadly for the world's tropical coral reefs. Between 1995 and 2017, Australia's Great Barrier Reef (GBR) lost more than half its hard corals (Dietzel et al. 2020). The GBR also experienced three major bleaching events in five years (2016, 2017 and 2020), driven by warmer seas (Corals CoE 2020). In its Special Report on 1.5°C, the Intergovernmental Panel on Climate Change (IPCC) projected that even if the global average temperature rise is held to 1.5°C, coral reefs will decline by a further 70-90 percent. At 2°C, tropical reef-building corals are expected to "mostly disappear", with the loss of more than 99% of corals (IPCC 2018).

Dying reefs, sea-level rise, shifting storms, impacts on sandbars, and other factors linked to climate change will inevitably alter how waves break, and mean that some of the planet's most revered waves are forever changed.

 **BOX 1: CONTINUED**

Rising seas and destructive storms

Sea-level rise is changing where, when and how waves break against the coast. It will continue to alter and even eliminate some existing surf breaks – especially those that break best at low tide, but may also improve others and create entirely new ones.

A study on California’s surf, based on the local knowledge of over a thousand surfers, concluded that by 2100 and as a result of sea-level rise alone, 16% of surf spots would be at risk of disappearing altogether, and a further 18% threatened, while only 5% would be improved (Reineman 2017).

In its 2019 Special Report on the Ocean and the Cryosphere in a Changing Climate, the IPCC projected that sea levels would likely rise, on average, by 0.6-1.1m by 2100 – an increase on

earlier projections – if the world fails to meet the goal enshrined in the *Paris Agreement* of limiting the global average temperature rise to well below 2°C (IPCC 2019). Over longer time spans, the melting of the Greenland and Antarctic ice sheets is likely to lead to considerably greater rises in sea level, up to many metres a few centuries from now (IPCC 2019).

The optimistic projection is that the loss of some breaks to sea-level rise and coastal erosion will be balanced out by the new breaks that will be formed. However, with so much of our coastline rimmed with houses, sea walls and other structures, in many instances beaches will simply disappear and coastal development will create a hard barrier that prevents new surf spots from forming. In other words, the loss of existing surf spots is unlikely to be fully offset by the opening up of new ones.

Figure 13: A surfer heading for wild surf conditions at Snapper Rocks on the Gold Coast in December 2020. Heavy rainfall, high winds and flooding hit the region and into northern NSW.



 **BOX 1: CONTINUED**

Tropical cyclones and other powerful storms, compounded by sea-level rise, can change the character of a shoreline in a single strike. Today there is research linking climate change to many different aspects of cyclone formation and behaviour, including how often they form, maximum windspeed, the speed at which a system intensifies, how long it may retain strength after making landfall, the duration of cyclone seasons, and the geographic range of cyclones. While the science is more nascent in some of these areas than others, the overall picture is of fewer but more intense cyclones becoming significantly more destructive as the world heats up (Climate Council 2021). While cyclones may yield excellent surf at times, they can also be immensely damaging to coastal communities and leave shorelines forever altered.

Healthy oceans

No surfer wishes to paddle out into an ocean that is sick and impoverished of life, even if there may be places on the planet that witness waves of hitherto unknown power.

Climate change is the single greatest threat to healthy oceans that sustain not only surfers but all life on our planet. From coral reefs to mangroves to the deep ocean, marine ecosystems are suffering immense and increasing damage (IPCC 2019). These changes, combined with more powerful storms, sea-level rise, and other impacts of climate change, pose profound challenges to the economic, food and physical security of many coastal communities. The ability of these communities to be able to support surfers during their travels is uncertain. Some of the world's most treasured locations for surfing, including Fiji, Tahiti and other countries of the Pacific, are on the frontline of these impacts.

PUTTING IT ALL TOGETHER

While there is a degree of uncertainty surrounding some of the many ways in which climate change is affecting surf conditions worldwide, and a need for ongoing research, there is little doubt that climate change will profoundly affect the future of surfing, including in many ways that we are only beginning to understand. The one silver lining – the chance of chasing even bigger waves – is likely to be negated by the loss of much-loved breaks, damage to coastal communities and coastal ecosystems, and the heating and acidification of the ocean to which surfers are so intimately bonded.

By the very nature of the sport, there can be few athletes more attuned to changes in the Earth System as surfers. With so much at stake, the surfing community can be a powerful voice for action.

3. Global sport and climate change

It's not just home sport that is increasingly being put to the test by climate change; extreme weather events are disrupting sport globally. Figure 14 illustrates how supercharged climate extremes are disrupting sport across the world.



For a more comprehensive account of global sport and climate change, please refer to the report ['Playing against the clock'](#) commissioned by the Rapid Transition Alliance (see Goldblatt 2020).

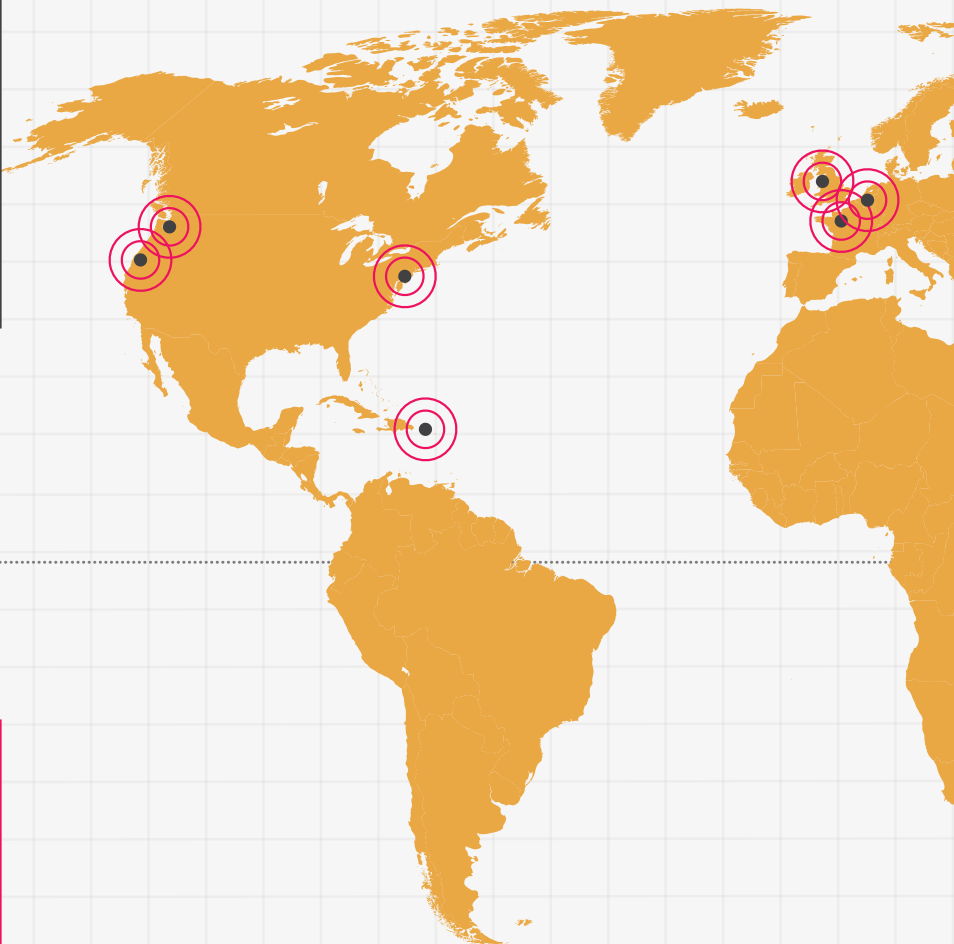
Sport globally is feeling the brunt of climate change exacerbated extreme weather events.

Figure 14: Global sport and climate disruption infographic.

GLOBAL SPORT AND CLIMATE DISRUPTION


Deadly Consequences: Extreme Heat and Young Athletes

The US Centers for Disease Control and Prevention (CDC) deems athletes as a vulnerable group in hot weather, and heatstroke is the main cause of death on the sports field among young athletes (ABC News (US) 2019). Since 1995, 47 high school and 13 college American football players have died from heat stroke, with nearly all of them (90%) occurring during practice (NCCSIR 2019; Climate Central 2019).




NORTH AMERICA


2017 Oregon, USA: Wildfires / Smoke - Cycling

 Cycle Oregon was cancelled because of wildfires. Smoke and air quality levels ranged from 'unhealthy' to 'hazardous'.

2018 New York, USA: Tennis

 At the US Open Tennis tournament, on court temperatures peaked at 49°C. Five players retired from matches for heat-related reasons.

2019 New York, USA: Triathlon


 A forecast high of 37°C forced the cancellation of the New York Triathlon because event organisers were unable to provide either a safe event experience or an alternate race weekend.

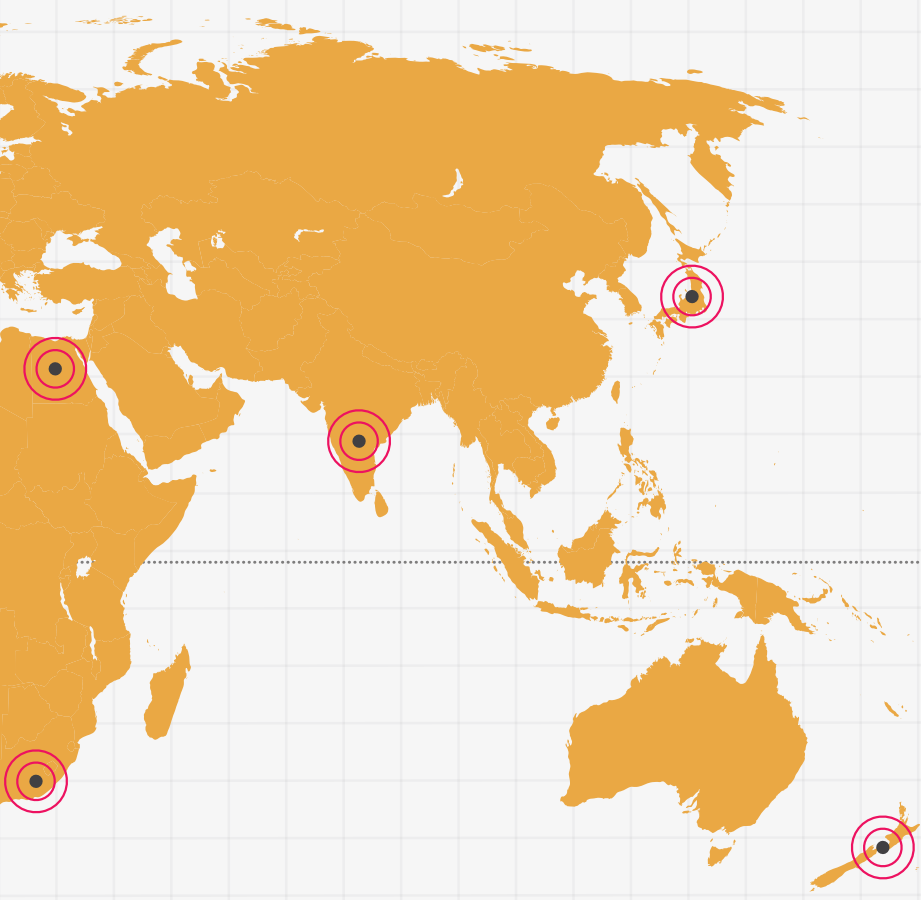
2020 Seattle, USA: Wildfires / Smoke - Baseball

 A Major League Baseball game between the Seattle Mariners and San Francisco Giants was postponed on 15 September because of poor air quality.

CARIBBEAN



2017 Anguilla and Dominica: Hurricane - Cricket

 Cricket ground James Ronald Webster Park in Anguilla was seriously damaged by Hurricane Irma, and just two weeks later Windsor Park cricket stadium in Dominica was devastated by the category 5 Hurricane Maria.



EUROPE



2018 England: Storms - Soccer / Football

  English football team Carlisle United's Brunton Park was unplayable for 49 days, suffering £200,000 (AUD 350,000) damage from Storm Desmond.


2000-16 Wales: Intense rainfall - Cricket

  Glamorgan County Cricket Club grounds were flooded six times. 1,300 hours of play was lost to rain between 2000 and 2016.



2016-17 Scotland: Intense rainfall - Golf

  In 2016-17, over 20 percent of playing time was lost at courses across Greater Glasgow compared to 2006-7.



2019 France: Heatwave - Soccer / Football

  During the 2019 Women's World Cup Football quarterfinals daytime temperatures hit +37°C, with water breaks added in the Italy vs. Netherlands and Germany vs Sweden matches.

2019 France: Hailstorm - Cycling



  Mountain stage of the 2019 Tour de France was cut short for riders' safety when a powerful hailstorm and landslide made passage through the Alps too dangerous.

2020 Belgium and the Netherlands: Storm - Soccer / Football



  Storm Ciara caused widespread postponements in Dutch football and the top two levels of Belgian football.

ASIA

2016 India: Drought and Heatwave - Cricket


  India's Supreme Court ordered the Indian Premier League (IPL) to cancel cricket matches in Delhi and Pune. Thirteen IPL games were moved from the Maharashtra region.

2019 Japan: Typhoon - Rugby Union


  For the first time in Rugby World Cup history, three matches were called off as a result of Typhoon Hagabis, while other games were played in extremely wet conditions.

AFRICA

2018 South Africa: Drought - Cricket



  Club and school cricket was cancelled halfway through the season across Western Cape.

2019 Egypt: Heatwave - Soccer / Football

  At the 2019 Africa Cup of Nations football tournament Nigeria forward Samuel Kalu was hospitalised after training suffering from "severe dehydration" and extreme heat. This caused a dispute on match day between the Moroccan coach and referees over a lack of water breaks.

OCEANIA

2018 New Zealand: Intense rainfall - Rugby

  In April 2018, flooding in northern New Zealand submerged the Tairua Rugby Field and the Paeroa rugby club suffered the worst flooding in years.

4. Climate impacts and sport: health, economic and infrastructure

4.1. Health risks of sport in a supercharged climate


Sport provides opportunities to live an active and healthy life. However, worsening extreme weather events exacerbated by climate change are making participation in summer sports increasingly challenging.

EXTREME HEAT AND ATHLETES' HEALTH


National mortality records in Australia suggest substantial under-reporting of heat-related mortality. Less than 0.1% of 1.7 million deaths between 2006 and 2017 were attributed directly or indirectly to excessive natural heat. However, recent research indicates that official records underestimate the association at least 50-fold, estimating over 36,000 deaths (Longden 2019; Longden

et al. 2020). In 2020, the US-based National Bureau of Economic Research published new projections for the number of people likely to die from climate change-fueled extreme heat. It concluded that if no action is taken, on average there will be 221 additional deaths per 100,000 people globally each year by 2100 – roughly equivalent to all deaths from cardiovascular disease today. Even after factoring in estimated efforts to adapt to a changing climate, the study still projects an extra 73 deaths per 100,000 people annually by 2100, which is greater than the number of people who died from COVID-19 in 2020 (Carleton et al. 2020).












Figure 15: Symptoms of heatstroke.



SYMPTOMS OF HEATSTROKE



Severe heat-related illnesses can be deadly, and the most serious form is heat stroke. The main criteria for diagnosing heat stroke is a deep core temperature of $>40.5^{\circ}\text{C}$ AND central nervous system dysfunction, which can be defined as a combination of some of the following:

<p> Irrational behavior, irritability, emotional instability</p> <hr style="border: 0.5px solid #ccc;"/>	<p> Collapse, staggering or sluggish feeling</p> <hr style="border: 0.5px solid #ccc;"/>
<p> Altered consciousness, coma</p> <hr style="border: 0.5px solid #ccc;"/>	<p> Diarrhoea</p> <hr style="border: 0.5px solid #ccc;"/>
<p> Disorientation</p> <hr style="border: 0.5px solid #ccc;"/>	<p> Profuse sweating</p> <hr style="border: 0.5px solid #ccc;"/>
<p> Headache</p> <hr style="border: 0.5px solid #ccc;"/>	<p> Excessive thirst</p> <hr style="border: 0.5px solid #ccc;"/>
<p> Confusion</p> <hr style="border: 0.5px solid #ccc;"/>	<p> Rapid pulse, quick breathing</p> <hr style="border: 0.5px solid #ccc;"/>
<p> Nausea or vomiting</p> <hr style="border: 0.5px solid #ccc;"/>	

Source: Korey Stringer Institute (Professor Ollie Jay, personal communication, 8 February 2021).
Note: While some groups are more at risk than others, everyone is potentially at risk from severe heat-related illness, especially while playing outdoor summer sport in hot weather.

Scientists expect that by 2100, climate change-fueled extreme heat will kill more people across the globe annually than COVID-19 did in 2020.

Sporting organisations have a responsibility to build resilience and prepare for increasingly destructive extreme weather.

Extreme heat is a major health risk for anyone exposed to increasingly brutal Australian summer conditions, including athletes at their peak fitness (see Box 2). In some notable examples, English cricket captain Joe Root was hospitalised suffering from heat exhaustion after an Ashes test match in Sydney in 2018 and Australian Open tennis players have retired due to illness brought on by exposure to excessive heat. Extreme heat forced the Australian Open tennis to suspend matches and the 2019 Tour Down Under Cycle race cut almost 30km off the original 149km stage 2 route from Norwood to Angaston to cope with extreme heat in South Australia (Cycling News 2019) (see Section 2.2).

The ACT Office of the Commissioner for Sustainability and the Environment report notes a need to recognise that heat exposure is a genuine health threat and risk to summer sports. Reducing exposure is a critical challenge as Australia experiences more frequent and intense heatwaves and more days of extreme heat. Sporting governing bodies and governments at all levels from Federal to local councils play an essential part in building resilience and preparing for the escalating threat of worsening extreme weather (see Auty and Roy 2019). The Victorian Government has issued factsheets to help sports participants avoid heat-related illnesses and the necessary actions to take if symptoms of heat illness occur while playing sport (see VicSport 2021).

EXTREME HEAT POLICIES

Sports Medicine Australia has a national policy that governing bodies of Australia’s major summer sports have used to put their own policies in place (see examples in Table 1). Extreme temperatures play an obvious role in heat stress for athletes, but other factors such as wind conditions, direct solar radiation (which determine temperatures in the sun versus the shade) and humidity levels are also very important (Jay and Chalmers 2018; Figure 16).

Temperature: The weather forecast “temperature” is measured in the shade, but physiological strain (rise in heart rate, sweating, body temperature) differs depending on whether or not an athlete is directly in the sun (“radiant heat”).

Humidity: Sweating is humans’ most important physiological process for keeping cool in the heat. High humidity impairs our ability to sweat, increasing our risk of heat-illness.

Wind: Even the lightest breeze brings a reprieve from high humidity because wind promotes evaporation, i.e. it helps replace air directly above the skin saturated with water vapour with drier air. Therefore, the ability of an athlete to cool down is much higher in breezy conditions.

For more information, see ‘Extreme heat in sport: why using a fixed temperature cut-off isn’t as simple as it seems’ (Jay and Chalmers 2018).

AFL, NRL and A-League coaches and player associations have called for improvements in their respective leagues’ heat policies after extreme heat affected games during the 2013, 2014 and 2015 seasons (The Climate Institute 2015).

Figure 16: Conditions primed for athlete heat stress.

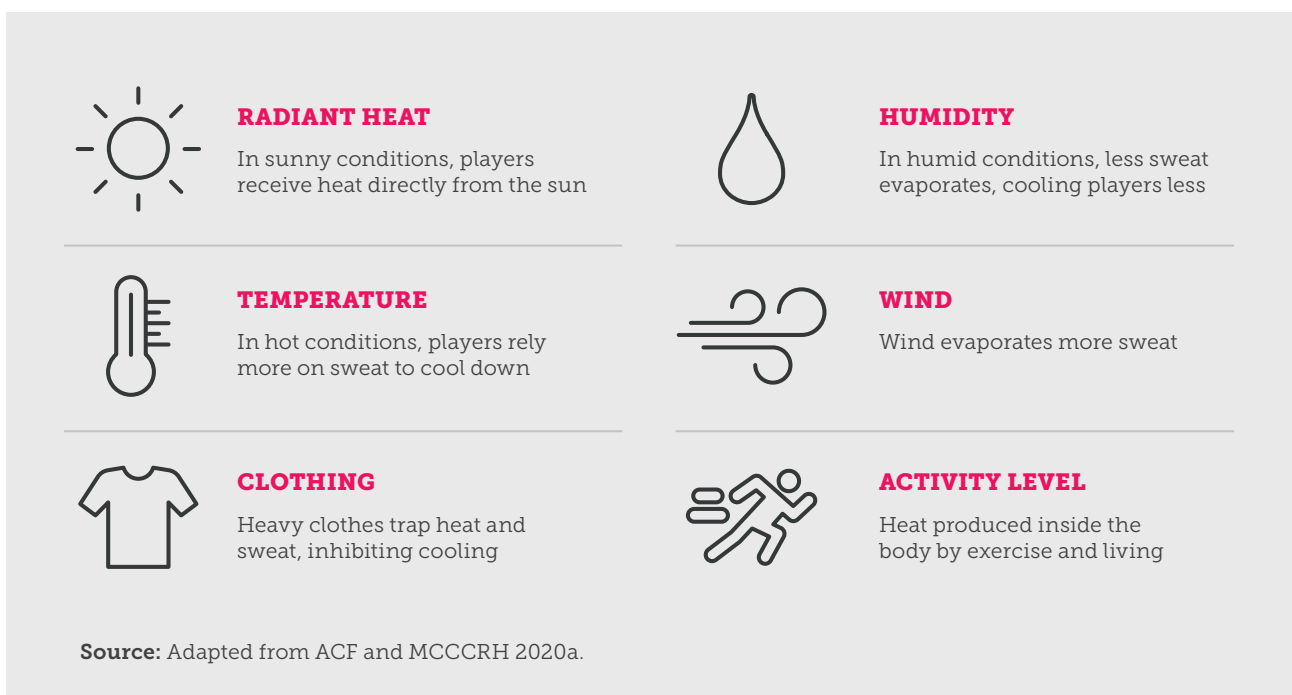







Table 1: Overview of the major Australian summer sporting codes' extreme heat policies.

Sport	Heat Policy
<p>Tennis Australia</p> 	<p>Extreme Weather Policy (effective 25 November 2018) uses a 1-5 Heat Stress Scale that takes a combination of air temperature, humidity, radiant heat and wind speed into account, with a rating of 5 meaning 'stop play'.</p> <p>Open Competitions, leagues of events and over-16 tournaments: If the forecasted WBGT³ reading within 24 hours and up to one (1) hour before play is due to commence, exceeds 32.5°C or ambient temperature exceeds 38°C⁴, play may be cancelled and where, during play the WBGT exceeds 32.5°C or ambient temperature exceeds 38°C⁴, play must be suspended on completion of the current game. After suspension of play, if the WBGT remains greater than 32.5°C or ambient temperature remains 38°C⁴ for more than 90 consecutive minutes, play may be cancelled by the relevant official, administrator, team captain or club representative.</p> <p>The Australian Open Heat Stress Scale is the first heat policy to be introduced by any of the four Grand Slam tennis tournaments (Australian, French, US and Wimbledon in the UK). Key features include: more comprehensive measuring of on-court weather conditions at Melbourne Park with an improved accuracy of measurement devices across the site (Environmental Measurement Units from The University of Sydney); and a 10-minute break for men's singles (to go with the 10-minute break already in place for women's singles and junior singles, and the 15-minute break for wheelchair singles) (Australian Open 2018).</p> <p>Note: In addition to heat, Tennis Australia also has additional extreme weather policies for rain, flood and hail; thunderstorms and lightning; high wind; and sand, dust or smoke (airborne contaminants). See Tennis Australia's 'Extreme Weather Policy' for more details.</p>
<p>Cricket Australia</p> 	<p>Heat Stress Policy Management: Cricket Australia recommends the use of the '<i>Community Cricket Playing in the Heat Guidelines</i>' (last updated 30 June 2020), as it provides cricket organisers and participants a scientific approach to managing extreme heat conditions. The guidelines use a Heat Stress Risk Index (HSRI) tool that is also available through the MyCricket website (Cricket Australia 2021) and includes the following factors: ambient air temperature in the shade (°C); wind speed (in km/h); relative humidity (%); and black globe temperature (°C), (user is asked to rate cloud cover in order to estimate the black globe temperature). Hourly values for air temperature, wind speed and relative humidity should be obtained from a credible weather data source. The recommended weather data source is the Bureau of Meteorology website (http://www.bom.gov.au). For example, by using the HSRI tool, a game played during the summer in clear skies, 35°C, with 50% humidity and no wind has a risk rating in excess of 10 or more. In such conditions the umpire can consider suspending the game (Cricket Australia 2020).</p> <p>The Heat Policy applies to Cricket Australia sanctioned competitions, including community cricket, but not to international test cricket matches, which are governed by the International Cricket Council (ICC) playing regulations, including extreme heat policy, which leaves decisions regarding playing conditions to the umpire. Cricket Australia states that although it will enact its heat policy in relation to players representing Australia in international cricket, the ICC has the final say (ACF and MCCRH 2019).</p>
<p>Football Federation Australia</p> 	<p>Football Federation Australia's Heat Policy (effective October 2016) has been developed with reference to international guidelines, including Sports Medicine Australia, the American College of Sports Medicine and FIFA, among others. The policy attempts to mitigate the risk of heat related injuries when matches are played in extreme heat. Ambient temperature alone is not the sole determining factor in assessing the risk of heat related injury. In addition to the ambient temperature, a range of other key factors such as humidity, cloud cover, solar radiation, wind, shade, and the time of day can interact to determine the heat load on a player. The Wet Bulb Globe Temperature reading is a parameter that provides an indicator of the risk of exertional heat illness for a footballer and takes into account all these factors in providing a temperature reading during training or competition. The Heat Policy states that a match may be delayed or postponed when the WBGT reaches 28°C. In addition, Football Australia's Heat Policy mandates that a 90 seconds drinks break is implemented in each half of a match when the WBGT is measured between 26 and 27.9°C, or the ambient temperature is 31°C or greater. Decisions to implement a drinks break, or to delay or postpone a match are based on the medical advice from the team doctor(s) at the venue (FFA 2016).</p>

3 The Wet Bulb Globe Temperature (WBGT) is an index that, when measured properly, provides a weighted average of the effects of the sun, air temperature, and humidity (Jay and Chalmers 2018).

4 36°C for under 16, senior (over 65) and wheelchair tournaments.

Sport	Heat Policy
<p data-bbox="164 459 279 539">Australian Football League</p> 	<p data-bbox="339 459 1409 591">The AFL's 'Football in Extreme Conditions: Guidelines for Prevention of Heat Injury' expect players to have adequate fluid intake before and during the game and training sessions, and to also utilise pre-game, game and post-game cooling strategies. When a wet-bulb reading reaches 28°C or higher, the AFL said it would contact clubs to ensure there was adequate preparation before games. It can also consider postponing a game in extreme conditions (ABC 2019).</p> <p data-bbox="339 607 1409 712">Notes: AFL Victoria's Extreme Weather Policy (effective January 2017) states that in the case of any other events of extreme weather or environmental conditions, such as extremely strong winds, flood, extreme fire danger, or fires being present in the vicinity of the training session/game, consultation of all parties involved must take place to determine the safest outcome for all involved (AFL Victoria 2017).</p>
<p data-bbox="164 743 264 792">Cycling Australia</p> 	<p data-bbox="339 743 1409 952">Heat Policy (January 2018). The following minimum requirements will determine activation of the Extreme Heat Recommendations. Temperatures are to be deemed at the race venue by the side of the course NOT in direct sunlight. The Chief Commissaire is required to conduct assessments every 30 minutes throughout the day when temperatures are above 30°C. Temperatures between 31°C and 37°C: events should be scheduled for the coolest part of the day; Temperatures between 38°C and 40°C: competition schedule and program may be modified with respect to time of day and the duration of the event; Temperature 41°C and above: all competition will be postponed until the temperature is below 41°C.</p> <p data-bbox="339 967 1409 1048">Note: AUSCYCLING has an extreme weather policy (effective 1 November 2020) with guidelines on heat; rain, flood and hail; thunderstorms and lightning; and air quality (primarily bushfire smoke and dust storms) (AusCycling 2020).</p>

When designing a heat policy, various factors are considered. For example, sports such as AFL, rugby and soccer require vigorous levels of activity that engage large muscle groups (such as running, jumping, squatting, kicking) and this produces a lot of heat. Sports that are less intense, such as walking and light jogging, generate relatively small amounts of heat. A further consideration is that some sports, such as cricket and field hockey, require protective gear that can act as a barrier for heat loss. Sweat rates are also usually the highest on the head, back, and shoulders. Therefore, a cricketer wearing a helmet and padding on the upper body is less likely to be able to keep cool because of limited evaporative cooling (Jay and Chalmers 2019).

Sports Medicine Australia is currently updating its heat policy, which will be delivered through an online tool linked directly to the nearest BoM station, providing 72 hour forecasts (Professor Ollie Jay, personal communication, 8 February 2021).

BOX 2: CLIMATE CHANGE FUELLED EXTREME HEAT FORCED ME TO RETIRE FROM SPORT – AMY STEEL, FORMER AUSTRALIAN NETBALLER

My personal experience has shown me that climate change is already affecting our lives – not a risk we only need to be concerned about in the future.

In 2016 I suffered a heat stroke playing netball in an indoor stadium, during a pre-season tournament at Australia’s highest level. I was physically the fittest and strongest I had ever been and couldn’t have imagined this would be the last game I’d play, and be left with lifelong health consequences, including chronic inflammation and fatigue. I was lucky though, because heat stroke can be fatal.

This is but one example of heat-related illness causing damage, and if this could occur to an elite athlete at peak fitness, then what are the risks for sport at a grassroots level?

Sport is such a pivotal part of Australia’s culture and wellbeing. It is essential that we, as a sporting community, advocate for, and undertake personal change so that we can preserve sport as we know it for ourselves, our kids, and their kids. Organisations such as Sports Environment Alliance, EcoAthletes, FrontRunners and the Climate Council of

Australia are all working on this mission by giving clubs and athletes the voice and tools they need to expedite the transition to a low-carbon economy, and adapt sport to the challenges of a changing climate.

As a former athlete, I know the challenges of speaking out on an issue that was seen as political, particularly when so many sports rely on government funding. Many athletes care about climate change, but are often instructed not to talk about the issue for fear it may tarnish the sport’s relationships with supporters and sponsors. We hope to change this by opening up the conversation, giving athletes the platform to speak confidently about their own stories of connection to the natural environment, what sport means for them, the changes they’re willing to make and inspiring others to start on this journey.

COVID has shown us that sport can and must adapt, and we have the tools to do so. Now is the time for the sporting community to lead the charge and get on with it.

BUSHFIRES AND TOXIC SMOKE

Bushfire smoke contains air pollutants including particulate matter, and carcinogens such as benzene and formaldehyde (Bernstein and Rice 2013). There is emerging evidence that even very low levels of air pollution are harmful and can increase the risk of death (see, for example, Yu et al. 2020). 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 short-term to lifelong.

Bushfire smoke blanketed population centres including Brisbane, Sydney, Melbourne and Canberra during the 2019-20 Black Summer 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. Other parts of Sydney recorded 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 (ABC 2020c). The 2019-20 Black Summer bushfires are estimated to have caused over 400 smoke-related premature deaths in addition to 3,230 hospital admissions for cardiovascular and respiratory disorders and 1,523 emergency attendances for asthma (Johnston et al. 2020), and the associated health costs totalled AU\$1.95 billion (Johnston et al. 2020). Physical exertion causes deeper inhalation and so those playing sport in the smoke will have inhaled dangerous air more deeply into their lungs. It is as yet unknown what the long-term consequences of prolonged exposure to the hazardous smoke will be, for athletes and others.

Figure 17: View from North Sydney Olympic swimming pool as smoke from bushfires in New South Wales blankets Sydney CBD in December 2019 during the Black Summer of devastating climate extremes.



In Melbourne, hazardous air quality disrupted the Australian Open tennis tournament in January 2020, causing one player to retire with breathing problems and other matches to be delayed or abandoned (The Guardian 2020b). In Canberra, a BBL cricket match at Manuka Oval was suspended in mid-over when the umpires deemed it unsafe to continue as a sharp curtain of thick, noxious smoke blew in across the field (ABC 2020d).

Air quality concerns for professional sports have been documented since the 2008 Beijing Olympics, which had the highest levels of air pollution of any measured games (Wang et al. 2009). Polluted air can impede athletic performance and affect athletes' health. As bushfire seasons become longer and more intense, sporting organisations will increasingly be confronted by the problem.

"Because they work so hard and breathe so much, athletes actually turn out to be a sensitive subgroup to pollutants," Professor Ed Avol, clinical preventive medicine and air pollution expert, University of Southern California (The Verge 2020, online quote).

Air pollutants can decrease lung function and reduce blood flow, both of which are essential for optimal athletic performance (Rundell 2012). At the professional level, where athletic performance is separated by very slim margins, any reduction in these physical functions can have a major impact. One study of the topflight German professional football league, the Bundesliga, found that air pollution was linked to poor athlete performance on the field (Lichter et al. 2015).

Hazardous and toxic smoke from the Black Summer bushfires blanketed sports venues and caused the deaths of more than 400 Australians.

MENTAL HEALTH AND SOCIAL BENEFITS OF SPORT

Climate change affects mental health. Recent research links rising temperatures caused by climate change with poor mental health, including self-harm and suicide (see, for example, Zhang et al. 2020). As sport becomes increasingly affected by climate change-driven extreme weather events, participation will foreseeably lessen. Given the mental health benefits of physical activity and sport, reduced participation means that mental health issues will likely increase (ACT Government 2019). Mental health professionals have also reported an increasing number of patients presenting with 'climate-change anxiety', noting feelings of stress, anxiety, dread and uncertainty about the future (ACT Government 2019). As climate change cranks up the intensity of extreme weather, the number of individuals with existing mental illness and those who will develop mental health problems is expected to increase, straining the coping capacity of the mental health care system (Auty and Roy 2019).

Sport is often promoted as an inclusive environment, bringing people of all backgrounds and abilities together to participate and benefit from a range of personal, health and social benefits (Schailée et al 2019). Sport also plays an especially important role in rural, regional, and remote Australia bringing communities together; contributing positively to community identity and a sense of place; promoting social interaction and community inclusion; and playing an important role in providing opportunities for physical activity and improved health outcomes (Spaaij 2009; Tonts and Atherley 2010; Frost et al. 2013).

Figure 18: From towns and cities to rural and remote areas, sport is key to the social fabric of communities and supports health and wellbeing.



Additionally, rural and regional Australian centres are increasingly hosting sporting events that provide economic stimulus and instil a sense of community pride (Blood 2020). However, climate change is already threatening community sports and worsening extreme weather events are set to challenge the viability of many community outdoor summer sports, particularly in rural and regional areas on the frontline of climate change. Government, industry and community all need to work together to respond to this challenge (Auty and Roy 2019).

4.2 Economic impacts

Although it is difficult to quantify the full economic benefits of the sport industry because it is not measured separately by the Australian Bureau of Statistics⁵, it is estimated that the full spectrum of Australian sports-related activities is worth at least \$39 billion, or some 2% of GDP, and employs more than 220,000 people (BCG 2017). However, the full value of sport goes well beyond its economic contribution, supporting physical and mental health and higher productivity associated with these, as well as improved educational outcomes, and social capital. BCG estimates that these additional outcomes increase the total value of sport to around \$50 billion each year, or closer to 3% of GDP. It is estimated that every dollar spent on sport returns \$7 of total benefits to Australia (BCG 2017).

Sport is worth around \$50 billion each year, employing almost a quarter of a million Australians.

The economic value of sport and other associated benefits, such as improved health and social well-being, could diminish if climate change continues unabated. Already, climate change impacts have economic consequences for sport. Increased temperature requires more resources for maintenance of facilities and postponed or cancelled events result in economic losses. Increased rainfall results in ground closures and a loss of revenue while extreme weather events can damage and destroy facilities, cause event cancellations and reduce participation and the number of spectators (Auty and Roy 2019).

In 2020, the Australian Tennis Open injected \$387.7 million into the Victorian economy – up more than 12 percent from \$347.2 million the previous year. Over the past decade, the Australian Open has contributed more than \$2.71 billion in economic benefits to Victoria. In 2020, 48,000 interstate or international visitors travelled specifically for the event and the tournament supported 1,775 jobs in Victoria (Tennis Australia 2020). The Tour Down Under cycling race has major economic value for South Australia, with an economic impact of \$66.4 million generated in 2020, creating the equivalent of 742 full time jobs (Santos 2021). These benefits are increasingly under threat as both the Australian Open and the Tour Down Under have been hit in recent years by climate disruption (Section 2).

⁵ ABS has many industry breakdowns (e.g. agriculture, transport, mining) but sport is not one of them because it crosses over with a range of other sectors including construction, retail, media, manufacturing, etc.

Drought severely affects sport. In 2007, more than half of community sporting leagues in rural Victoria delayed or cut short their season because of drought. In Dandenong, 74 sports grounds were damaged, costing \$1.3 million to rehabilitate (Dingle 2015; The Climate Institute 2015).

Climate disruption of sporting events has also had financial consequences in other countries. For example, in England, extreme weather caused the cancellation of 25 Football League fixtures during the 2015-16 season. In response to this particularly stormy season, the English Football Association spent £48 million (\$86 million) to weather-proof pitches across the country (The Climate Coalition 2018).

Insurance is also becoming a significant cost factor for sport (IOC 2020a). Drought, extreme heat and changed rainfall patterns affect ground surfaces and increase the operating costs of sport, including insurance premiums to cover the increased injury risks of competing in climate extremes (The Climate Institute 2015). During the Millennium Drought (1997 – 2009), insurance premiums rose, and some grounds lost insurability altogether, including nine cricket grounds in the City of Moonee Valley (Dingle 2015; The Climate Institute 2015).

Climate disruption is a growing cost for sport in Australia, including rising infrastructure maintenance and insurance premiums.

4.3 Infrastructure

Climate change is already challenging the use and management of sporting facilities, increasing the damage and destruction of facilities, and increasing maintenance costs (Dingle and Stewart 2018; UNFCCC 2018; Auty and Roy 2019). The UN Sports for Climate Action Framework identifies the following physical impacts of climate change on sports infrastructure:

- › Damage to playing surfaces due to extreme temperatures, extended periods of drought, flooding and/or pest species extending their natural range;
- › Damage to buildings, playing surfaces such as courts and stadiums and other infrastructure due to violent storms and flooding; and
- › Coastal erosion and sea-level rise directly affecting sport properties in coastal locations.

This report documents damage to Australian sports infrastructure from intense rainfall and flooding, for example, the La Niña intense rainfall and flooding in 2011 which resulted in the cancellation of sporting events in Queensland (see Section 2.5). Community sport in Australia is now dealing with more intense rainfall events which are affecting the conditions of sports grounds and their maintenance, while extreme heat is compacting playing surfaces (Dingle and Mallen 2020). For example, community sport in tropical Queensland was washed out after an exceptional rainfall event from late January 2019 into early February 2020. Three clubs reported damage bills of over a quarter of a million dollars each (City of Townsville 2019).

Figure 19: Lang Park (Suncorp Stadium) in Brisbane submerged after intense rainfall and floods in January 2011. For each 1°C rise in global average temperature, the atmosphere can hold approximately 7 percent more moisture, in turn increasing the probability of more intense rainfall events such as occurred in Brisbane in 2011.



If climate change continues unabated, within the next three decades, one quarter (23 of 92) of English league football grounds will face partial or total annual flooding of their stadiums by 2050 (Goldblatt 2020). In the US, if sea levels continue to rise, flooding will affect the Boston TD Garden, current home of the Celtics basketball and Bruins ice hockey teams; Citi Field in New York where the New York Mets baseball team play their home games; MetLife Stadium in New Jersey, the home of the New York Giants and New York Jets National Football League teams; and Petco Park, the home of the San Diego Padres baseball team (The Climate Reality Project 2020). These are just some examples of sports infrastructure under threat from climate change (see, for example, Goldblatt 2020 for a more comprehensive account).

Stadiums and other large sporting facilities should not be constructed or have major works carried out without due care and consideration of climate risks (Govind 2018). To ensure that investments in dealing with extreme weather are sufficient to cope with climate disruption, the management of sports infrastructure and operations should use climate change projections in their planning (Govind 2018). Appropriate future climate scenarios need to be considered, including the internationally agreed goal of keeping global heating to well below 2°C but also, where possible, a 3°C world, the one towards which we are currently heading (UNEP 2020). Tools such as CSIRO and BoM's thresholds calculator (see CSIRO and BoM 2019) are available for sports administrators and BoM to explore possible future operating environments by using information from climate projections. The UN Sports for Climate Action Framework also calls for climate adaptation measures being required in the design of new or refurbished sport venues (UNFCCC 2018).

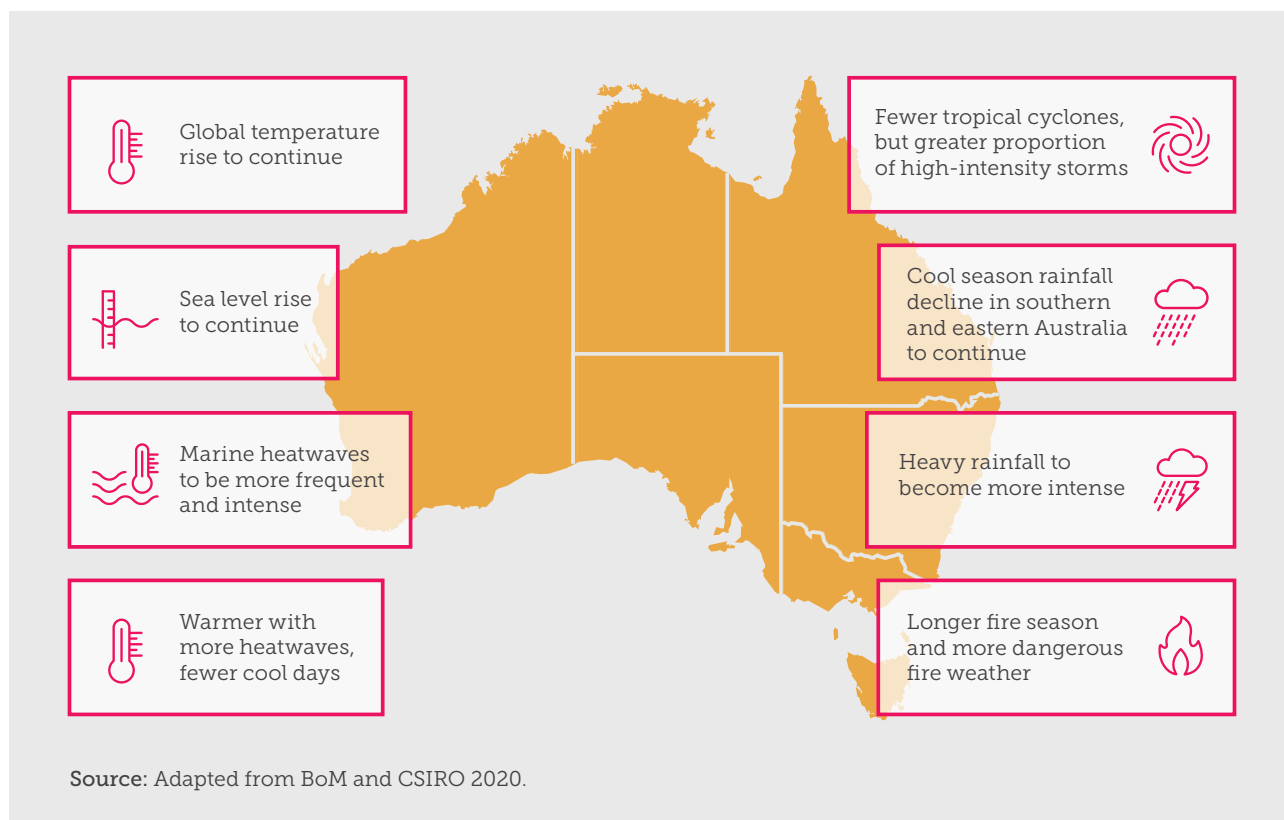
5. Future climate and sport in Australia

The latest State of the Climate report by the Bureau of Meteorology and CSIRO clearly articulates the risks of climate change continuing unabated (BoM and CSIRO 2020; Figure 20).

Australia is projected to experience:

- › Continued increases in air temperatures, more heat extremes, and fewer cold extremes.
- › Continued decrease in cool season rainfall across many regions of southern and eastern Australia, likely leading to more time in drought, and more intense, short duration heavy rainfall events.
- › A consequential increase in the number of dangerous fire weather days and a longer fire season for southern and eastern Australia.
- › Further sea level rise and continued warming of the oceans around the continent.
- › Fewer tropical cyclones, but a greater proportion projected to be of high intensity, with large variations from year to year.

Figure 20: Australia's Future Climate.



While the current decade is warmer than any other decade over the last century, it is also likely to be the coolest decade of the century ahead. The average temperature of the next 20 years is virtually certain to be warmer than the average of the last 20 years (CSIRO and BoM 2020). The amount of climate change expected in the next decade is similar under all plausible global emissions scenarios. However, higher ongoing emissions of greenhouse gases will lead to greater warming and associated impacts by the mid-21st century, while reducing emissions now will lead to less warming and fewer impacts.

Extreme heat is one of the greatest climate challenges Australian summer sport is facing. Cardiovascular-intense sports demand cooler climates and therefore cycling, soccer, tennis, football and any outdoor sport that requires significant cardiovascular effort are under threat in stifling summer conditions. Extreme heat events are projected to continue to increase if greenhouse gas pollution continues along a business-as-usual trajectory. Even if the *Paris Agreement* goal to limit global temperature rise to well below 2°C is met, summer heatwaves in Sydney and Melbourne are likely to reach highs of 50°C by 2040 (Lewis et al. 2017). Major summer sporting events in Australia such as the Australian Tennis Open, the Tour Down Under cycle race, as well as summer sports such as cricket and soccer, will become unplayable in their current format.

Extreme heat is increasing in many of Australia's sporting capital cities, as measured by the number of hot summer days (over 35°C) (Section 2.2) and is expected to increase further through this century (Figure 21). The severity of these rises beyond the next decade or two depends very much on the speed at which Australia and the rest of the world acts to reduce greenhouse gas emissions.

The projections for the future demonstrate the importance of greenhouse gas emission reductions and stabilisation of the climate this century. The number of hot days we experience towards the end of this century is strongly dependent on the emissions trajectory that actually occurs. Continuing on the current high emissions trajectory would result in large increases in hot summer days in all of Australia's sporting capital cities by 2050 and 2090 compared to the current climate (Figure 21).

It is clear that if global emissions continue to increase, Australian sports will have to make significant changes:

"We might need to think about playing [summer] games in the evening or during the transition seasons of spring or autumn to avoid the most intense summer temperatures" Dr Joelle Gergis, Councillor, the Climate Council (Australian Geographic 2018, online quote).

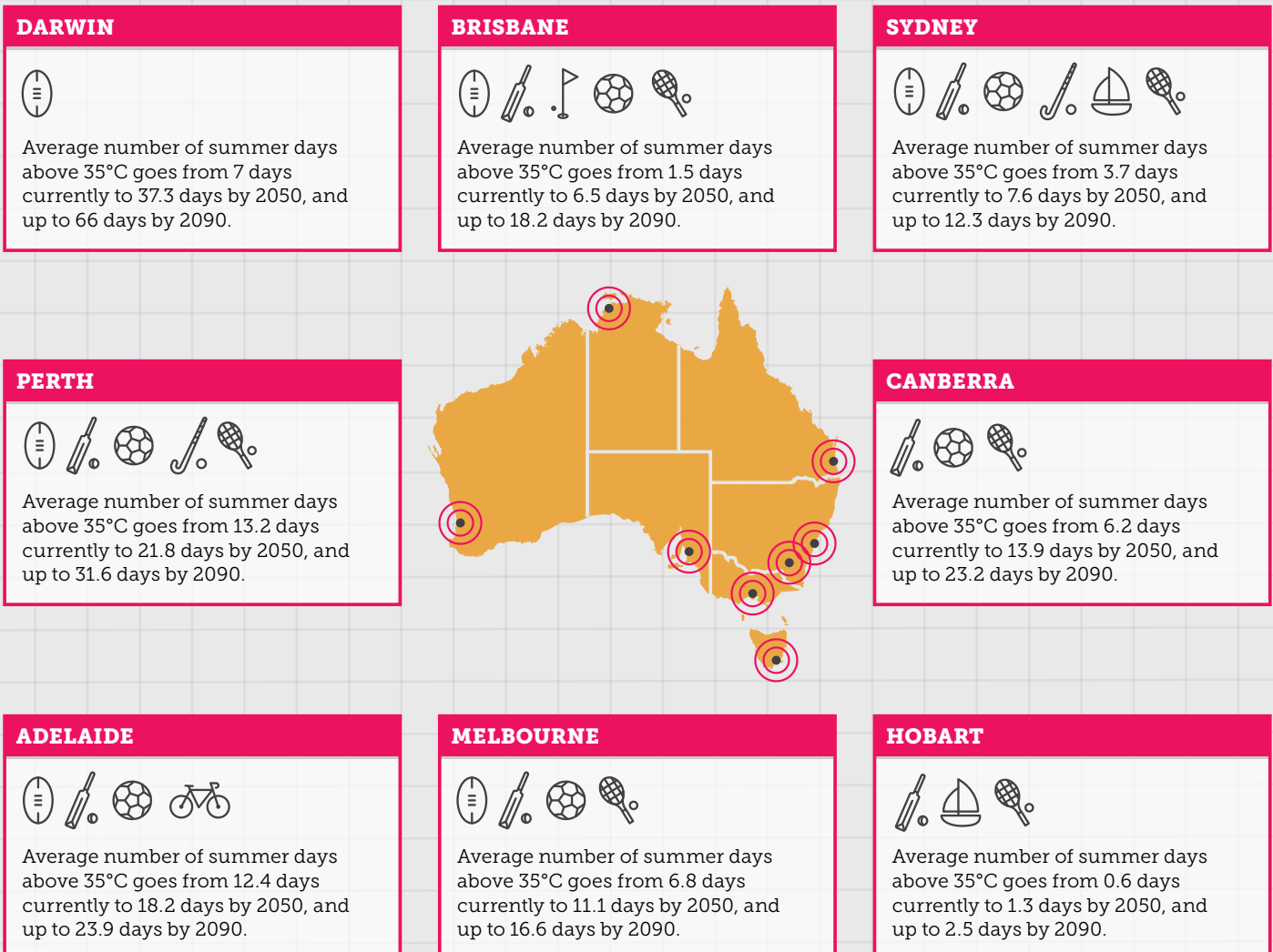
Summer heatwaves in Sydney and Melbourne could reach highs of 50°C by 2040, making outdoor sport unplayable.

Figure 21: Future Climate of Australia's Sporting Capital Cities.

FUTURE CLIMATE OF AUSTRALIA'S SPORTING CAPITAL CITIES

The long-term average number of hot days (above 35°C) in summer (Dec – Feb) compared to the 1981-2010 average (AWAP) and the projected average number of hot days (above 35°C) in summer in 2050 and 2090 for Australian capital cities under high (RCP 8.5) emission scenarios.

Symbols show select major summer sporting events hosted by a capital city. See Appendix 1 for more specific temperature data and information about this infographic, and Figure 20 for a description of how climate change will worsen extreme weather events in Australia, unless we deeply and rapidly reduce emissions.



6. Future climate and global sport

Despite a short-lived drop in carbon dioxide emissions associated with the COVID-19 pandemic (Le Quéré et al. 2020), the world is still heading for a temperature rise of 3°C or more this century, well in excess of the *Paris Agreement* goal of limiting global warming to well below 2°C (UNEP 2020). Under these conditions, extreme weather events would become increasingly destructive, with more intense and frequent heatwaves, worsening wildfires, intensifying storms, and severe droughts (IPCC 2013).

A world where we fail to deeply and rapidly cut greenhouse gas emissions could make summer sports unplayable, denying future generations the privilege of sport as we know it.

“Every community that hosts a professional sports venue, a sports stadium or arena, is going to be affected by global climate disruption, by climate change, whether through storm surges, more precipitation, stronger hurricanes, wildfires, droughts” (Allen Hershkowitz, environmental science advisor to the New York Yankees baseball club, The Climate Reality Project 2020, online quote).



For a more comprehensive account of global sport and climate change, please refer to the report '[Playing against the clock](#)' commissioned by the Rapid Transition Alliance (see Goldblatt 2020).

BOX 3: RISING SEA LEVELS THREATEN THE SOUL OF RUGBY UNION AND HOME OF GOLF

Sea-level rise is driven by climate change through the melting of glaciers and ice sheets, and because the volume of the water in the oceans increases as it warms, a process known as thermal expansion (Bindoff et al. 2013). As described in Box 1, if the world fails to limit global average temperature rise to well below 2°C, sea levels would likely rise on average 0.6-1.1m by 2100 (IPCC 2019). At 3°C of warming, almost 300 million people worldwide will live in areas that will eventually be flooded (Kulp and Strauss 2019).

Any further failure by Australia and the rest of the world to take decisive climate action will result in devastating consequences, and many low-lying regions are particularly vulnerable, including much of the South Pacific, which is often described as the soul of rugby union:

“The Pacific Islands are the soul of our sport, and have produced some of the most dynamic and exciting players on the planet... Yet as this [Climate Reality Project 2020] report underlines, Samoa, Tonga and Fiji are all facing increased risks from rising sea levels and extreme weather” (Jonny Fa’amatuainu, former Samoan international, Climate Reality Project 2020, online quote).

For Fiji, losing its precious lands to the sea cuts to the core of its rugby. The success of Fijian rugby has been attributed to “the way of the land” – that is, learning to play rugby on the beach. The beach is a place for conditioning and strength training, and its beautiful setting stirs a passion for the game that inland fields cannot match. Yet climate change is gradually destroying beaches and has forced play further inland (The Climate Reality Project 2020).

On the other side of the world, the ancient game of golf is also under threat from rising sea levels, with coastal erosion affecting some of the UK’s most iconic courses. The impacts on the coastline are twofold. Firstly, since 1900, sea levels have risen by an average of 15-20cm around the UK (CCC 2016). Secondly, damage from storms and intense rainfall is increasing (Wong et al. 2014). More than one in six of Scotland’s 600 golf courses are located on the coast, including the Old Course at St Andrews, Royal Troon and Montrose Golf Links in Angus. ‘Links’ are the oldest type of golf courses, developed in Scotland, and located on the coast on ‘links land’ characterised by dunes, sandy soil and fine-textured grassland. Montrose is one of the five oldest golf courses in the world and more than 450 years of golfing history is at risk of being washed away by rising seas and coastal erosion. Research published in 2016 by Dundee University showed that over the past three decades, the North Sea has advanced 70 metres towards Montrose (Jeffay 2017). The combination of rising sea levels and reducing sediment is moving the shoreline further inland, effectively reversing the conditions that originally created the beaches and dunes. This poses a costly threat to the iconic Montrose Links (The Climate Coalition 2018).

“We will also see more damaging storm surges which, combined with rising sea levels, are likely to worsen the coastal erosion already being experienced by Montrose and other historic golf courses. Climate change is putting these historic links courses in the birthplace of golf at risk” Kate Sambrook, Priestley International Centre for Climate, UK (The Climate Coalition 2018, p. 8).

7. Sport: a powerful voice and springboard for climate action

"Sport provides some of society's most influential role models. If sport can change how it operates to act at the speed and scale necessary to halt the climate emergency, others will follow."
Andrew Simms, Co-ordinator, [Rapid Transition Alliance](#) (The Guardian 2020f, online quote).

7.1 Sport: a force for climate action

While sport in Australia and around the world is under threat from climate change, sportspeople have an influential role to play in being part of the solution. From the community to the professional and elite level, sports lovers can become a collective and powerful voice for climate action.

Already, many sporting bodies, clubs and athletes are leading the way in calling for strong action on climate change. This section highlights opportunities for sport to be part of the solution with examples of those already leading the way.

From the grassroots to the professional and elite level, sport can be part of the solution.

Figure 22: Cockburn Aquatic and Recreation Centre in Western Australia, which hosts one of the largest rooftop solar systems in the state.



7.2 International institutions as a platform for climate action in sport

International sporting bodies and other international institutions are increasingly acknowledging both the impacts of climate change on sport and the role of sport in addressing climate change. Several international bodies and frameworks have been established to provide resources and encourage action from the community to the professional level, including from clubs, athletes, and fans. Key international bodies such as the International Olympic Committee (IOC), football/soccer's international governing body Fédération Internationale de Football Association (FIFA), and the World Surf League are also beginning to factor climate change considerations into their operations.

The United Nations Sports for Climate Action Framework was launched in December 2018 at the UN Climate Change Conference (COP24) in Katowice, Poland. The objectives of the Framework are to encourage the sports community to reduce emissions in line with the *Paris Agreement* and to use sport as a unifying tool for global climate action. The Framework launched with 17 founding signatories, including the IOC, World Surf League, Tokyo 2020 and Paris 2024 Summer Olympics, as well as individual clubs such as the Forest Green Rovers Football Club and

Kyoto University American Football Club (UNFCCC 2018). The Framework now has over 175 signatories, including Australian bodies such as Bowls Australia, Tennis Australia, and the Australian Olympic Committee (UNFCCC 2021a). Participants commit to five principles, including reducing their impact on the climate and promoting and advocating for climate action (UNFCCC n.d.).

Several other international bodies and networks have been established to drive emissions reductions and climate advocacy in the sports community. For example, the Sport and Sustainability International (SandSI) Network is one of many emerging networks connecting and supporting the sports industry and fans seeking to accelerate action on climate change in and through sport. SandSI's goals include a carbon neutral and zero waste sports sector by 2030 and the Network hosts programs including Football 4 Climate and the Sustainable Development Goals Sport Lab (SandSI 2020). SandSI members include the New York Yankees baseball team, world motorsport governing body Fédération Internationale de l'Automobile (FIA), and sports marketing and consulting firm 5T Sports (SandSI 2020).

The International Olympic Committee (IOC) has adopted sustainability as one of the three pillars of the Olympic Agenda 2020 and requires host cities to develop a 'carbon management plan' to measure and minimise the greenhouse gas emissions in all activities related to the Games (IOC 2018; IOC 2021). In 2020, the IOC announced that from 2030, the host contract will be updated to include a requirement that all Summer and Winter Olympic Games are 'climate positive', requiring host nations to minimise both direct and indirect emissions, and compensate for any remaining emissions that cannot be avoided (IOC 2020b).

Although it is commendable that sporting bodies have started to acknowledge the climate crisis, the response so far is not commensurate with the challenge. Only a small fraction of the world's thousands of sporting bodies, federations, tournaments, leagues and clubs have signed up to the UN Sport for Climate Action Framework, and even fewer have emission reduction targets and plans to meet climate commitments (Goldblatt 2020). The following sections provide examples of shining sustainability lights in the sports industry, in Australia and overseas. These examples will hopefully inspire others to get runs on the climate action scoreboard, and benefit from the many positive outcomes of genuine and sustained climate action.

The International Olympic Committee will require host nations to run 'climate positive' Olympic Games from 2030.

7.3 Athletes and sport using their powerful voice for climate action

Key voices in the sports community are increasingly calling on sporting institutions and international bodies that are not leading on climate change to embrace the role of sport as a powerful platform for action. Athletes, teams and others in the sporting community are using their media and public profile to demand stronger action both from the sports community itself, and from governments and other decisionmakers.

Australian soccer stars have been leading the way in calling for stronger action on climate change. In December 2020, former Socceroo

and commentator Craig Foster wrote to the international governing body of football (FIFA) urging it to make the 2023 Women's World Cup, co-hosted by Australia and New Zealand, the 'climate action World Cup'. This would include raising awareness about the escalating climate crisis and operating as a climate neutral event. Foster's letter was supported by Matildas' player Aivi Luik (Figure 23) and 17 climate and environment groups and drew attention to both the urgency of climate action and the impact of climate change on sport, as well as the role that sport can play in the solution (news.com.au 2020).

As a voice for climate action, leaders in sport can reach new audiences and catalyse action.

Figure 23: Matildas' player Aivi Luik in action during the Women's Olympic Tokyo 2020 Asian Qualifiers match between Australia and Thailand. Luik is a climate champion and a voice for climate action.



David Pocock (Figure 24), former Wallabies rugby union player, has long championed climate action. Former Australian international netballer, Amy Steel (see Box 2), current WSL pro surfer Adrian 'Ace' Buchan (The Guardian 2020g), tennis ace Roger Federer (SBS news 2020) and world champion F1 driver Lewis Hamilton (Reuters 2020) are also powerful proponents of much stronger climate action.

"I think we all have to admit now that climate change is a huge issue. Before I'd seen the [BASIS 2019] report I hadn't really thought about how it would impact the game of cricket. I was really taken aback. I'm more than happy to put my hand up. I have got three children – 22, 20 and just about to turn 18 – it's a different world for them. People want to put their head in the sand, and say I'm not going to be around in 50 years. That's just wrong" (Shane Warne, Australian cricket legend, BASIS 2019, online quote).

Athletes, both professional and non-professional, are also joining forces to form their own organisations to amplify their voices. For example, FrontRunners, co-founded by David and Emma Pocock, is a recently formed movement based in Australia with a mission to ensure athletes are part of the solutions to climate change and other environmental issues (FrontRunners 2021). The Sports Environment Alliance (SEA) has a goal of sharing knowledge and building networks to enhance the industry's engagement in the clean economy (SEA 2021).

Figure 24: David Pocock in action for the Wallabies against New Zealand in 2019. The retired rugby union player is a long-standing advocate for climate action.



Individual sports are also forming their own movements for climate action. For example, the Australian-based Surfers for Climate unites surfers to implement climate solutions in their own community, calling on political leaders to champion climate action (Surfers for Climate 2021). The World Surf League amplifies this call on the world stage, and committed to achieving carbon neutral operations by 2019, including for international events (World Surf League 2019).

7.4 Powering sport with renewable energy

One important way that sport can contribute to reducing greenhouse gas emissions is by using renewable energy to power operations, including stadiums, offices and other facilities, any associated activities, and transport. This is an area where both professional and community sports associations can participate in the solution, and there are already leaders emerging from both domains.

Powering sport with renewable energy can be achieved by installing solar panels on sporting facilities and using the energy directly or by buying 100% renewable energy through an energy provider, such as by choosing a retailer or electricity plan that is 100% renewable, or signing a Power Purchase Agreement (PPA) to source renewable energy. Sporting associations are also increasingly leading the way in using storage technologies such as batteries, which, when combined with renewables

such as onsite solar panels, allow renewable energy to be stored and used whenever needed. Wind and solar are the cheapest source of new electricity generation in Australia and renewable energy is reducing power prices (CSIRO 2020; AEMC 2020). This means that using renewable energy not only reduces greenhouse gas emissions but also reduces power bills, in some cases dramatically, saving money and creating a range of positive outcomes for local and professional sports bodies.

PROFESSIONAL SPORT LEADING ON RENEWABLES AND STORAGE

There are a wide range of professional sports teams and facilities installing solar panels to power some or all operations with renewable energy, both in Australia and around the world. Queensland's Metricon Stadium (Figure 25) is home to the Gold Coast Suns AFL team, as well as hosting cricket, concerts and other events, and was the main stadium for the 2018 Gold Coast Commonwealth Games (Metricon Stadium n.d.). The stadium is also home to a solar rim – a five-metre-wide ring of solar panels around the entire inner roofline of the stadium – installed as part of a redevelopment in 2011, which supplies roughly 20 percent of the stadium's total electricity needs (Metricon Stadium n.d.).

Using renewable energy to light up grounds and run sporting venues cuts emissions and power bills.



Figure 25: Metricon Stadium on the Gold Coast, with a 'solar rim' of solar panels along the inner roofline, supplying roughly 20% of the stadium's electricity.

London-based Arsenal Football Club (FC) set an international example in 2018, when it became the first British football team to install large-scale battery energy storage to reduce emissions and cut power bills. The battery, installed in the basement of the Emirates Stadium, is capable of storing enough energy to power the 60,000-seat stadium for a whole match (The Guardian 2018c). Arsenal buys 100% renewable energy from an electricity retailer, rather than having onsite solar panels. The battery means that the stadium can buy electricity when it is cheap and store it to use for powering the stadium at times when electricity is expensive. The battery not only saves the club money but generates income, supplying spare capacity and helping balance supply and demand for the UK's national grid (Clean Energy World 2019).

Every Arsenal home-game at its 60,000-seat stadium is powered by renewable energy.

There is potential for this to become a model for major sporting venues. Sporting venues are particularly well-placed to contribute to climate action in this way – they require large amounts of electricity to power games, but the venues are unused much of the rest of the time, so the electricity can be supplied to the local grid when it is not needed (Sustainability Report 2019a).

BOX 4: FUTURE PROOFING COMMUNITY SPORT & RECREATION FACILITIES

- Dr. Sheila N Nguyen, Executive Director, Sports and Environment Alliance

The Sports Environment Alliance (SEA) partnered with the Victorian Government in 2018 to deliver the *Future proofing community sport & recreation facilities: A roadmap for climate change management for the sport and recreation facilities sector* project.

This initiative is a response to increasing climate change impacts on sport infrastructure, elevating the need to mitigate the risks of the people who play sport, while tackling climate change.

Because of the urgent need to engage sporting communities in climate action, a major component of the initiative has focused on education and basic tools which can help kick start and track their climate mitigation and adaptation progress. To effectively support as many community sport and recreation facilities as possible, the project focused on two key outcomes: a guidelines document and an online self-assessment tool.

The guidelines document is accessible and user friendly, covering the link between sport and planetary health, climate science, and the climate impacts felt globally, nationally, and in Victoria. At a more operational level, the guidelines document provides case studies of places of play which have engaged in climate strategies. For example, the Wangaratta Indoor Sports and Aquatic Centre (WISAC) and adjacent Eco Living Community Centre form the Eco Living Precinct. This project includes a real time display of energy efficiency, a solar hot water system, building insulation and an education component at the Eco Living Community Centre. As a result, the facility's greenhouse gas emissions have been cut by almost a quarter. It is estimated that energy saving measures will save the sports and recreation complex around \$2,000 a year.

In addition to the case studies, this SEA and Government of Victoria joint initiative provides useful tips on how sports organisations and facilities can help tackle climate change. Examples include switching to renewables, reducing transport emissions, and enhancing biodiversity and conservation efforts, by reducing water, energy, and material use.

The second resource is an online assessment (www.noplanetnoplay.org / 'Take Action') tool designed to provide an indication of an organisation's climate change readiness as well as options for improvement with real time user support. By completing the assessment, the organisation will get a score and the online tool generates a pledge document that can be used internally for strategic and operational purposes and/or publicly to show the sporting organisation's climate leadership efforts.

The *Future proofing community sport & recreation facilities initiative* aims to assist sport and recreation communities to become more climate resilient and protect sport for current and future generations.

LOCAL GOVERNMENTS LEADING FOR COMMUNITIES

Community sporting clubs and local councils around Australia are also leading the way in powering sporting facilities with renewable energy and storage. Nillumbik Shire Council in Victoria recently won a national innovation award for its Hybrid Solar and Battery Off-Grid Community Stadium & Relief Centre (Cities Power Partnership 2020). The council installed rooftop solar panels and a battery system to create an off-grid community sport and recreation facility (Nillumbik Shire Council

2020; Figure 26). The facility can also be used as a community relief centre in the event of an emergency, such as a bushfire, supporting climate action and community resilience. This is an important contribution to a community hard hit by the devastating 2009 Victorian Black Saturday bushfires (Nillumbik Shire Council 2019). The solar and battery system is also used to power the first electric vehicle charging station in the area (Nillumbik Shire Council 2020).

Figure 26: Nillumbik Shire Council's Hybrid Solar and Battery Off-Grid Community Stadium & Relief Centre in Victoria, which features rooftop solar, a battery system and an electric vehicle charging station.



7.5 Setting targets and developing strategies to reduce emissions

Sports teams, stadiums and other facilities are increasingly embracing their role in tackling climate change by setting ambitious targets and developing strategies to reduce their greenhouse gas emissions. Often, these targets and strategies are part of wider sustainability plans that also include efforts to reduce waste, reduce plastic, improve energy efficiency, and/or to conserve or recycle water.

REDUCING GREENHOUSE GAS EMISSIONS

The Melbourne Cricket Club (MCC) signed on to the UN Sports for Climate Action Framework in 2019 and has introduced a range of strategies to reduce emissions, forming a working party with Richmond Football Club and Tennis Australia, both based around the iconic Melbourne Cricket Ground (MCG), the major venue managed by the MCC (The Age 2020b). In 2017, the MCG won a national energy efficiency award for reducing energy consumption by almost one quarter through a range of upgrades including LED lights and a 'smart' air-conditioning system that adjusts output based on occupancy sensors (MCG 2017). More recently, the MCG installed solar panels on some sections of the northern stand to help to run its water recycling facility, with excess electricity transferred to other areas of the venue (The Age 2020b).

The UK MCC (Marylebone Cricket Club) has also been a leader in reducing greenhouse gas emissions. Lord's Cricket Ground, owned by the MCC, was the first sports venue in the UK to employ a full-time Sustainability Manager in 2009. Lord's has been powered by 100% renewable electricity since 2016 (and 100% wind power since 2017) and has a broader sustainability strategy that includes reducing single use plastic and reducing food waste, including by donating unused food (MCC 2021).

The sport sector can respond to the climate challenge with ambitious targets and strategies.

SETTING NET ZERO TARGETS

At the international level, both the Union of European Football Associations (UEFA) and world motor sport governing body FIA have announced they would set science-based emissions reduction targets in alignment with the *Paris Agreement* goal of remaining well below 2°C of global warming (Sustainability Report 2020). While UEFA is yet to announce its specific emissions reduction target, which will be crucial in assessing whether it provides a positive example, the football governing body made the announcement alongside several other climate announcements. This includes UEFA signing on to the European Climate Pact, committing to publicly contribute to and support the EU Green Deal, the EU's plan to create jobs and a strong economy with net-zero greenhouse gas emissions by 2050 (UEFA 2020). UEFA will run a three-year television advertising campaign promoting the Green Deal's call to action during its elite competitions (UEFA 2020). These steps are positive, but UEFA and FIFA should also consider the continued expansion of its major championships. More teams competing in qualifying and major tournament campaigns results in more emissions from travel, which is the climate Achilles heel of global sport (Walters 2020; Goldblatt 2020).

The FIA Formula One, a sport synonymous with petrol guzzling, has a target to achieve a net zero carbon footprint by 2030. This includes developing carbon neutral fuels, improving the efficiency of logistics and travel, and powering operations with 100% renewable electricity (F1 2019). FIA is also the home of Formula E, an all-electric motorsport that has grown significantly from its first season in 2014/15 to gain World Championship status for the 2020/21 season (Formula E 2021; Figure 27). Tackling climate change was one of the key goals of founding Formula E, and it was the first sport to achieve a net zero carbon footprint from inception. Carbon neutrality has been achieved through reducing emissions where possible and offsetting remaining unavoidable emissions, as well as measures such as extending end-of-life options for lithium-ion battery cells (Formula E 2020).

Figure 27: The 2018 Rome e-Prix, a Formula E all-electric car race. Tackling climate change was one of the key goals of founding Formula E.



BOX 5: 'THE WORLD'S GREENEST FOOTBALL CLUB'

The Forest Green Rovers (FGR), a professional football club in England that competes in League Two, is a leading example of a sports club with a strategy for carbon neutrality being implemented through a wide range of emissions reductions and sustainability measures. FIFA has crowned FGR 'the world's greenest football club' and it is the first football club to be certified carbon neutral by the UN, both titles that the club carries with pride (FGR n.d.).

The club has been working towards its goal to become the world's first carbon neutral football club since 2010, including installing solar panels at its home stadium, using a solar-powered lawn mower, improving energy efficiency, adopting an entirely vegan menu for both players and spectators, and encouraging lower

transport emissions by installing electric vehicle charging points and providing a 'park and ride scheme' (UNFCCC 2021b). FGR has also tracked and published its carbon footprint since 2011, providing information on its progress, providing an example for other clubs in England and around the world.

An annual social responsibility index of international football leagues (responsiball) ranks leagues against three criteria, including sustainability and climate action. The Swedish football league, Allsvenskan topped the table in 2019. The A-League in Australia was near the bottom of the table, finishing 21st out of 24 leagues (Responsiball 2019).

7.6 Changing the schedule of matches and events

One way that sports leagues are adapting to climate change is by altering the schedule of matches and events to adapt to deteriorating conditions and introducing policies to protect players and spectators from the impacts of extreme weather. For example, in Australia, W- and A-League soccer fixtures have been rescheduled due to climate change-exacerbated extreme weather, such as postponing matches from evening to morning games to avoid extreme heat (SMH 2018; SMH 2019b; Section 2.2).

PLANNING EVENTS WITH CLIMATE IN MIND

Major sporting competitions are starting to take proactive steps to design fixtures to minimise the effects of extreme weather. For example, the 2022 FIFA World Cup in Qatar has been moved from the traditional summer schedule to be held in November, Qatar's winter. The capital Doha has a November average daily maximum temperature of 29.5°C, compared to around 41°C in the summer months of June, July and August (WMO 2021). In a July 2010 heatwave, the temperature hit a record high of 50.4°C. Such heat extremes have prompted concerns about the impact of the heat on the workers constructing stadiums for the World Cup, with reports of employees, especially migrant workers, dying due to heat stress (The Guardian 2019b). Even with the tournament taking place in November, the (outdoor) stadiums will be air conditioned – an effort to protect those present but raising further concerns about the greenhouse gas emissions released (Washington Post 2019).

Similarly, prior to the postponement of the 2020 Tokyo Olympics, organisers switched the start time of the marathon race to earlier in the day and were applying a reflective layer to the course in an effort to reduce pavement temperatures. They have since moved the marathon and walking events to Japan's northern city of Sapporo (800 km north of Tokyo), which has a much cooler climate. These steps were taken in response to concerns that an extreme heatwave experienced in Tokyo in 2018 might be repeated (World Economic Forum 2019). The 2018 summer heatwave claimed the lives of at least 65 people and resulted in 22,000 people being admitted to hospital with heat stroke (BBC News 2018).

IMPLEMENTING POLICIES TO PROTECT AGAINST CLIMATE CHANGE-FUELLED EXTREME WEATHER

Sporting codes are increasingly introducing policies to protect players and spectators from the impacts of extreme weather, such as specifying the conditions under which games should be cancelled or postponed. These policies are often implemented or updated following criticism received after matches or tournaments that went ahead in dangerous conditions.

Section 2.2 gives more details of how extreme heat has disrupted major summer sporting events in Australia, and Section 4.1 describes the effects of extreme heat on athletes' health and includes a summary of the heat policies of major sporting organisations in Australia.

7.7 Encouraging active and public transport to venues

Another key step that sport, especially professional teams and sports facilities and venues can take towards tackling climate change is through reducing greenhouse gas emissions associated with transport. This can include encouraging fans to use public transport rather than driving, providing free public transport for ticketholders to venues, and encouraging active transport such as cycling and walking by providing safe and adequate footpaths and bike lanes or cycle ways. Venues can also encourage electric vehicle use, such as by installing EV charging stations.

Public and active transport not only reduces greenhouse gas emissions but also brings a range of other benefits, including health benefits from increased physical activity and reduced air pollution, as well as reduced traffic congestion. Indeed, many of the examples below may have started as congestion-busting efforts but have positive co-benefits for reducing transport emissions.

Several Australian sporting venues are already leading the way. SunCorp Stadium, home to a range of sports including Rugby League, Rugby Union, A- and W-League soccer, and the Gabba, which hosts a range of sports including AFL and cricket, are two Brisbane venues that provide free public transport or special event shuttle services with pre-purchased tickets to all events (The Gabba 2018; SunCorp Stadium 2020). The Gabba provides no public parking onsite, and SunCorp Stadium effectively limits parking by implementing 15-minute parking limits on event days, further encouraging fans to find an alternative to driving (The Gabba 2018; SunCorp Stadium 2020).

Public and active transport was also a feature of the 2018 Commonwealth Games hosted on the Gold Coast. Free public transport was provided to all ticketholders, workers, and officials in locations around Queensland, with additional services and new park-and-ride hubs established for the Games (Gold Coast 2018). Active transport was also encouraged, with cycle park locations and bikes available for hire close to competition venues, and signage and journey plans

Sporting events and venues can help reduce transport emissions by offering free public transport.

available to encourage walking to venues (Gold Coast 2018). Similarly, Sydney Olympic Park encourages a range of public and active transport options and has an EV charging station onsite. Many events held at Sydney Olympic Park include free public transport with ticket purchase, and the venue also encourages active transport with a range of bike trails and safe cycleways (Sydney Olympic Park n.d.).

Encouraging public and active transport is also common for major sporting events and sporting venues around the world and can have a significant impact on the way that spectators commute to events. For example, Seattle's 72,000-seat Husky Stadium, home to the Washington Huskies college football team, offers free public transport on game days. After introducing this program in 1984, the share of ticketholders arriving via public transport increased from four to 21 percent, demonstrating the impact and importance of sports venues and teams playing a role in encouraging public transport use (Bloomberg 2020).

7.8 Climate-friendly corporate sponsorship

Ensuring climate-friendly corporate sponsorship is another way that sport can participate in tackling climate change. Professional sports teams and athletes, as well as some community sports, receive significant support through corporate sponsorship. These teams and athletes play an important role by considering climate change in assessing and accepting sponsorship.

FOSSIL FUEL COMPANIES AND SPORT

As discussed in Section 2, burning fossil fuels is driving climate change, but many sports teams and competitions in Australia and internationally are sponsored by fossil fuel companies or companies with significant involvement in fossil fuels. There are countless examples of this in Australia, including oil and gas company Santos sponsoring the Tour Down Under cycling tournament; Adani Australia (now rebranded as Bravus), the company behind the controversial Carmichael coal mine in Queensland, supporting the Queensland

Cowboys rugby league team; and Woodside, Australia's largest gas producer, sponsoring the Western Australian Nippers (the junior surf life-saving program) (SMH 2020). Alinta Energy is a commercial partner of Cricket Australia, and the energy company is a subsidiary of Pioneer Sail, which is Australia's seventh largest greenhouse gas polluter (SMH 2019c; ACF and MCCRHR 2020a). Santos recently entered a multi-year partnership with the Australia Open as its 'Official Natural Gas Partner' (Tennis Australia 2021). More positively, ANZ, a major sponsor of the Australian Open, has recently put policies in place to end financing of thermal coal projects by 2030 (ABC 2020e).

As described in previous sections in this report, accelerating climate change is already having devastating impacts on sport and our communities in Australia and around the world. It is time for sports teams and athletes to consider the climate impacts of their corporate sponsorship deals, and to consider ending partnerships or refusing to partner with companies contributing to the problem rather than the solution.

Burning fossil fuels is driving climate change but many sports teams and athletes are sponsored by fossil fuel companies.

CALLS FOR A BAN ON FOSSIL FUEL SPONSORSHIP

There are several international campaigns calling for particular sports teams to drop corporate sponsorship from the fossil fuel industry or for a total ban on fossil fuel sponsorship of sport. For example, Friends of the Earth have called for a complete ban on fossil fuel sponsorship in sport, drawing parallels to bans on tobacco sponsorship. The Friends of the Earth campaign focuses in particular on petrochemical company Ineos' sponsorship of Team Ineos, a professional cycling team that was previously known as Team Sky (Sustainability Report 2019b). The Insure our Future campaign and advocacy group SumofUs launched the 'AIA Kick Out Coal!' campaign in 2020, targeting life insurance company AIA's sponsorship of Tottenham Hotspur Football Club ('Spurs') in the English Premiership League. The campaign notes that while many large insurers worldwide have divested from fossil fuels, AIA has no policies in place restricting fossil fuel investment (The Guardian 2020h).

In Australia, Hostplus invests around \$50 billion on behalf of over a million Australians, including those working in the sport sector, making it one of the largest super funds in the country. Hostplus' top 100 Australian investments shows the fund has over \$800 million invested in fossil fuels. Market Forces has launched a campaign for workers to call on Hostplus to get their money out of companies undermining climate action (see hostplusdivest.org).

Dropping fossil fuel sponsorship would mean sport is serious about tackling climate.

Sport has started to understand the powerful leverage it has to help tackle humanity's greatest challenge, climate change. But a lot more is needed. The examples described in this section serve as case studies of game changers at professional and grassroots levels, with the aim of inspiring athletes, clubs, sporting organisations, governing bodies, sponsors and fans to take strong and effective climate action to sustain the game for future generations.

8. Conclusion

A major pillar of Australian culture is under threat. Climate change and worsening extreme weather is disrupting sport, and climate inaction has locked in further damaging impacts. Without urgent and decisive action, Australia's summer of outdoor sport could become unplayable. Sporting organisations, all levels of government and all Australians need to be aware of the escalating climate risks to a sector worth \$50 billion, employing almost a quarter of a million Australians. Other immensely important benefits of sport include improved health and wellbeing and social opportunities for communities, particularly in rural and regional areas. These benefits are also at risk from a supercharged climate of intense, and increasingly destructive extreme weather.

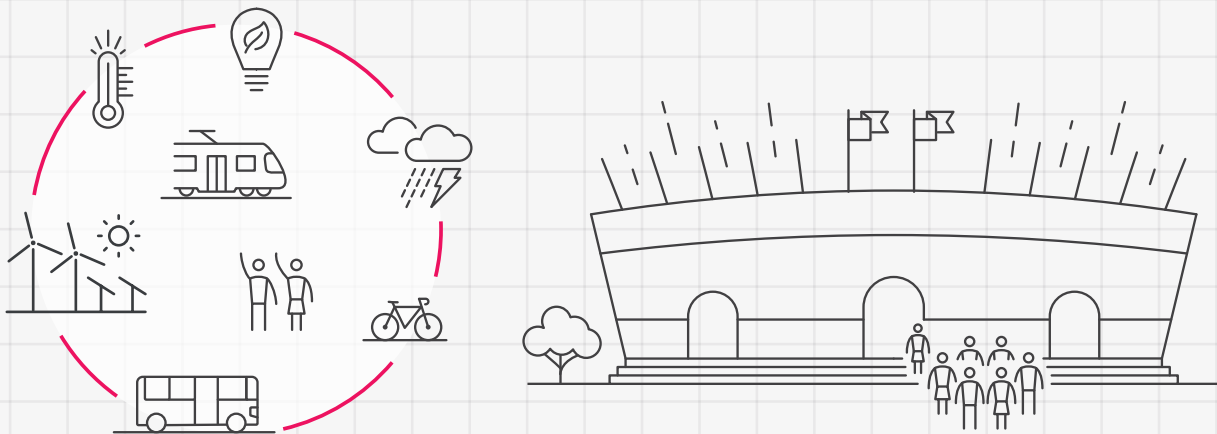
The good news is that sport can be a powerful force for change. Using the star appeal and influence of elite athletes, clubs and national teams, as well as global sporting events, sport can call for stronger action and leadership and embed climate solutions in its operations. This includes professional and community teams powering stadiums and venues with renewable energy and battery storage technologies, applying energy efficiency measures, reducing waste, and promoting sustainable transport to and from sporting events. Professional and community clubs and leagues can switch sponsorship from fossil fuel-backed companies to ones that invest in climate solutions. When it comes to the impacts of climate change that can no longer be avoided, sports can and must work to adapt. Sporting calendars can adapt to a rapidly changing climate by scheduling seasons, matches and events to more favourable times of year or times of day. Science-backed policies on heat, bushfire smoke and other extreme weather events should also be put in place, and regularly updated by all sporting codes and leagues, to protect both athletes and spectators and the role of sport as a critical part of our culture.

The clock is ticking, climate change is accelerating and we must urgently tackle the climate crisis to protect the Australian summer of sport we love, for current and future generations to enjoy.

Figure 29: Going for Gold: The Sports Climate Action Toolkit.

GOING FOR GOLD: THE SPORTS CLIMATE ACTION TOOLKIT

Community and professional sport can be an active part of solutions to climate change - here's how:



PROMOTING ACTIVE & PUBLIC TRANSPORT OPTIONS



Encourage and promote active and public transport to and from venues.

STAYING INFORMED



Read Climate Council and other science-based reports (for example, Bureau of Meteorology and CSIRO's State of the Climate).



Visit the Climate Council website and subscribe to email updates to access science-based reports, videos and factsheets on climate change and solutions.



Follow us on social media for more ways to get involved.

POWERING YOUR SPORT WITH RENEWABLE ENERGY



Power stadiums with solar and battery storage, or purchase 100% renewable energy.



Apply energy efficiency measures, like LED lighting & solar hot water.

USING THE POWERFUL VOICE OF SPORT



Use your influential voice to mobilise and call for strong climate action, including using traditional and social media and your networks.



Athletes/clubs/sport organisations should publicly call for Australia to have science-based climate targets, and be part of the team by pledging that your sport will play its part in getting there.

INVESTING IN CLIMATE ACTION



Actively seek partnering with corporations working on climate solutions and stop accepting money from fossil fuel interests.

KICKING CLIMATE GOALS



Develop strategies to reduce emissions generated by your sport, such as setting science-based targets or developing a sustainability plan.

KEEPING GAME DAY SAFE



Protect players and fans from extreme weather by adopting science-based, regularly updated policies that cover heat, bushfires and other extreme weather events.



Change the schedule of games to adapt to conditions.

JOINING FORCES



Join sport and climate action organisations, e.g. FrontRunners, Sport and Environment Alliance and Surfers for Climate.



Sign up to international efforts such as the United Nations Sports for Climate Action Framework to join forces with likeminded athletes, fans, clubs and sporting organisations.



Ask your local council to join the Cities Power Partnership - Australia's largest network of cities and towns tackling climate change.

Appendix 1: climate future of Australia's sporting capital cities

The long-term average number of hot days (above 35°C) in summer (Dec – Feb) compared to the 1981-2010 average (AWAP) and the projected average number for 2030, 2050, 2070 and 2090 for Australian capital cities under medium (RCP4.5) and high (RCP 8.5) emission scenarios.

City	Select list of major summer sport events hosted by Australian capital cities	Historical (1981-2010)	2030 (medium emission scenario)	2030 (high emission scenario)	2050 (medium emission scenario)	2050 (high emission scenario)	2070 (medium emission scenario)	2070 (high emission scenario)	2090 (medium emission scenario)	2090 (high emission scenario)
Melbourne	Australian Tennis Open; Big Bash Cricket League; International test cricket; Women's National League Cricket; A and W-League Soccer; AFL Women's and AFL pre-season	6.76	9.18 (8.52 – 10.03)	9.31 (8.28 - 10.41)	10.10 (8.93 – 11.66)	11.13 (9.66 – 13.34)	11.18 (10.17 – 12.38)	13.5 (11.31-15.72)	11.65 (10.1-13.17)	16.59 (13.52-20.55)
Sydney	Big Bash Cricket League; International test cricket; Women's National League Cricket; A and W-League Soccer; Sydney International tennis tournament; AFL Women's and AFL pre-season; International Field Hockey Pro League	3.66	5.25 (4.76 – 5.9)	5.60 (4.79 - 6.24)	6.15 (5.21 – 7.79)	7.58 (6.03 – 9.1)	7.15 (5.97 – 8.9)	9.42 (7.79-11.66)	7.60 (6.34 – 8.86)	12.31 (9.86-16.28)
Brisbane	Big Bash Cricket League; International test cricket; Women's National League Cricket; A and W-League Soccer; Brisbane International tennis tournament; Australian PGA (golf) tournament; AFL Women's and AFL pre-season	1.45	2.62 (2.03 – 3.76)	3.32 (2.21 – 5)	3.97 (2.83 – 6.1)	6.45 (3.59 – 10.17)	4.93 (3.17 – 6.97)	10.91 (7.79 – 17.1)	6.06 (4-8.9)	18.21 (10.55-28.31)
Adelaide	Tour Down Under cycling race; Big Bash Cricket League; International test cricket; Women's National League Cricket; A- and W-League soccer; AFL Women's and AFL pre-season	12.38	15.36 (13.69 – 16.59)	15.53 (13.97 – 17.69)	16.41 (15.28 – 18.69)	18.21 (16.14 – 21.34)	17.95 (15.83 – 20.38)	20.95 (18.24 – 25.76)	18.63 (16.59 – 20.72)	23.88 (19.69-30.72)

City	Select list of major summer sport events hosted by Australian capital cities	Historical (1981-2010)	2030 (medium emission scenario)	2030 (high emission scenario)	2050 (medium emission scenario)	2050 (high emission scenario)	2070 (medium emission scenario)	2070 (high emission scenario)	2090 (medium emission scenario)	2090 (high emission scenario)
Perth	Big Bash Cricket League; International test cricket; Women's National League Cricket; A and W-League soccer; Perth Tennis International Tournament; AFL Women's and AFL pre-season; International Field Hockey Pro League	13.24	17.66 (15.62 – 20.14)	17.45 (14.62 – 20.38)	19.45 (15.93 – 21.93)	21.77 (19.41 – 24.41)	21.77 (20.03-24.21)	26.16 (21.52 – 31.38)	21.49 (16.59-25.79)	31.55 (25.14-35.31)
Canberra	Big Bash Cricket League; Women's National League Cricket; A and W-League soccer; Canberra Tennis International	6.17	9.70 (8.03 – 11.72)	10.15 (8.9 – 11.7)	11.14 (8.66 – 12.83)	13.89 (12 – 17.21)	13.55 (10-55-16.52)	17.12 (13.45 – 20.62)	14.28 (12.86-16.24)	23.21 (16.59 – 29)
Darwin	Northern Territory Football League	7.03	18.91 (11.55 – 24.1)	22.71 (12.69 – 34.07)	25.99 (17.9 – 33.97)	37.29 (26.55 – 49.59)	35.76 (25.97-43.66)	52.78 (35.62-63.24)	36.05 (45.21-22.72)	65.97 (56.52-74.83)
Hobart	Big Bash Cricket League; Women's National League Cricket; Hobart International Tennis Tournament	0.59	0.87 (0.69 – 0.97)	0.96 (0.76 – 1.17)	1.16 (0.93 – 1.83)	1.31 (0.97 – 1.86)	1.31 (1-1.62)	1.86 (1.38 – 2.45)	1.42 (1.03-1.86)	2.51 (1.76-3.69)

Source: BoM and CSIRO 2019 (Climate Change Projections in Australia: Projections for Australia's NRM Regions. Thresholds calculator. www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/threshold-calculator/).

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