# Technical information supporting the 2023 Fire danger weather environmental trend and condition report card

Department for Environment and Water
August, 2023

DEW Technical note 2023/50

Government of South Australia
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August 2023

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*Preferred way to cite this publication*

Department for Environment and Water (2023). *Technical information supporting the 2023 Fire danger weather environmental trend and condition report card*, DEW Technical report 2023/50, Government of South Australia, Department for Environment and Water, Adelaide.

*Download this document at* https://data.environment.sa.gov.au

# Acknowledgement of Country

We acknowledge and respect the Traditional Custodians whose ancestral lands we live and work upon and we pay our respects to their Elders past and present. We acknowledge and respect their deep spiritual connection and the relationship that Aboriginal and Torres Strait Islanders people have to Country. We also pay our respects to the cultural authority of Aboriginal and Torres Strait Islander people and their nations in South Australia, as well as those across Australia.

# Acknowledgements

This document was prepared by Graham Green (DEW) and Susan Sweeney (DEW) and technically reviewed by David McKenna (DEW). Improvements were made to this report and associated report card based on reviews by Simon Grainger (Bureau of Meteorology), Kirstin Abley (DEW), Amy Ide (DEW) and Fi Taylor (DEW).

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# Summary

The 2023 release of South Australia's environmental trend and condition report cards summarises our understanding of the current condition of the South Australian environment, and how it is changing over time.

This document describes the indicators, information sources, analysis methods and results used to develop this report and the associated 2023 Fire danger weather report card. The reliability of information sources used in the report card is also described.

The Fire danger weather report card sits within the report card Climate theme. Report cards are published by the Department for Environment and Water and can be accessed at www.environment.sa.gov.au.

# 1 Introduction

## 1.1 Environmental trend and condition reporting in SA

The Minister for Climate, Environment and Water under the Landscape South Australia Act 2019 is required to 'monitor, evaluate and audit the state and condition of the State's natural resources, coasts and seas; and to report on the state and condition of the State's natural resources, coasts and seas' (9(1(a-b)). Environmental trend and condition report cards are produced as the primary means for the Minister to undertake this reporting. Trend and condition report cards are also a key input into the State of the Environment Report for South Australia, which must be prepared under the Environment Protection Act 1993. This Act states that the State of the Environment Report must:

- include an assessment of the condition of the major environmental resources of South Australia (112(3(a))), and
- include a specific assessment of the state of the River Murray, especially taking into account the Objectives for a Healthy River Murray under the River Murray Act 2003 (112(3(ab))), and
- identify significant trends in environmental quality based on an analysis of indicators of environmental quality (112(3(b))).

## 1.2 Purpose and benefits of SA's trend and condition report cards

South Australia's environmental trend and condition report cards focus on the state's priority environmental assets and the pressures that impact on these assets. The report cards present information on trend, condition, and information reliability in a succinct visual summary.

The full suite of report cards captures patterns in trend and condition, generally at a state scale, and gives insight to changes in a particular asset over time. They also highlight gaps in our knowledge on priority assets that prevent us from assessing trend and condition and might impede our ability to make evidence-based decisions.

Although both trend and condition are considered important, the report cards give particular emphasis to trend. Trend shows how the environment has responded to past drivers, decisions, and actions, and is what we seek to influence through future decisions and actions.

The benefits of trend and condition report cards include to:

- provide insight into our environment by tracking its change over time
- interpret complex information in a simple and accessible format
- provide a transparent and open evidence base for decision-making
- provide consistent messages on the trend and condition of the environment in South Australia
- highlight critical knowledge gaps in our understanding of South Australia's environment
- support alignment of environmental reporting, ensuring we 'do once, use many times'.

Environmental trend and condition report cards are designed to align with and inform state of the environment reporting at both the South Australian and national level. The format, design and accessibly of the report cards has been reviewed and improved with each release.

## 1.3 Climate change in Australia

Climate affects almost every part of our lives. Communities, industries, landscapes and ecosystems all develop with a tolerance for a range of climate variation. If the climate changes beyond that range of tolerance, then they must either adapt, migrate, transform or decline.

According to the Australian Academy of Science (2015), "Earth's climate has changed over the past century. The atmosphere and oceans have warmed, sea levels have risen, and glaciers and ice sheets have decreased in size. The best available evidence indicates that greenhouse gas emissions from human activities are the main cause. Continuing increases in greenhouse gases will produce further warming and other changes in Earth's physical environment and ecosystems."

The Bureau of Meteorology (the Bureau) and other science agencies employ a range of air, land and marine sensors to track climatic trends across Australia. The Bureau's biennial State of the Climate report draws on the latest monitoring, science and projection information to describe variability and changes in Australia's climate (including temperature) and how it is likely to change in the future (Bureau of Meteorology 2022).

## 1.4 Fire danger weather

The Climate: Fire danger weather report card reports on the trend of change in the accumulated annual and December Forest Fire Danger Index (FFDI) in South Australia over recent decades.

The FFDI is a measure of fire weather conditions and fuel availability which is influenced by recent rainfall. In addition to the weather, bushfire events in Australia are also influenced by factors such as vegetation conditions, terrain and ignition sources (Bureau of Meteorology 2023).

The report card provides textual comments on the trends illustrated in a colour-coded map of the decadal timescale trend in annual accumulated FFDI (Figure 3.1) and a graph of accumulated annual FFDI for the whole of South Australia (Figure 3.2).

In 2022, the use of FFDI for fire danger ratings was replaced by the Australian Fire Danger Rating System (AFDRS) (AFAC 2023). Future reporting will assess trends using the AFDRS Fire Behaviour Index when a sufficient time series length of data is available.

# 2 Methods

## 2.1 Indicator

The indicators considered in the Fire danger weather report card are: 1) the accumulated annual forest fire danger index (FFDI) trend for the whole of South Australia from 1978 to 2022, and 2) the accumulated annual FFDI for each year from 1950 to 2022.

The FFDI is calculated from a formula based on temperature, relative humidity and wind speed on a given day, as well as a dimensionless number representing fuel availability, termed the 'drought factor' (Griffiths 1999). The drought factor is based on a temporally accumulated soil moisture deficit, calculated using the Keetch-Byram Drought Index, KBDI (Keetch and Byram 1968), which uses antecedent temperature and rainfall data to provide an estimate of the soil moisture content compared to field capacity.

Note, FFDI is not typically used to assess fire danger ratings for the whole of South Australia. As the majority of South Australia has mostly sparse vegetation with large areas of low scrub, open woodland and grass cover, the closely related grass fire danger index (GFDI) has commonly been used to assess fire danger ratings across the majority of the state. FFDI is used as an indicator in the fire danger weather report card because 1) historic data records of FFDI are more readily available than for GFDI, and 2) the formula to calculate FFDI uses the same weather variables as the GFDI and serves as an effective indicator of trends in the occurrence of weather conditions of high temperature, low humidity, low rainfall and high winds, that combine to create high fire danger conditions.

## 2.2 Data sources, collection and analysis

Information on the spatial and temporal variation in accumulated annual and December FFDI from 1950 to 2022 was obtained directly from the Business Solutions Group of the Bureau of Meteorology (the Bureau), which is the lead agency for weather monitoring nationally and maintains records of the daily FFDI for locations across Australia.

Information for the trend in annual accumulated FFDI was provided by the Bureau as a colour-coded map, showing a statewide interpolation of the trend in annual FFDI, represented by the change per decade in total accumulated FFDI units per year (Figure 3.1).

Data on the annual accumulated FFDI for the years 1950 to 2022 was provided by the Bureau as a text file with a single accumulated FFDI figure for each year. This dataset was used to construct a simple column graph, illustrating the total annual accumulated FFDI from 1950 to 2022 (Figure 3.2). The annual accumulated FFDI is presented as a comparative indicator of the condition of fire danger weather in South Australia as it provides an indication of how high FFDI values have been in recent years compared with previous years.

## 2.3 Methods to assign trend, condition and reliablity

### 2.3.1 Trend

**Table 2.1. Definition of trend classes used**

| Trend | Description |
|---|---|
| Getting better | Over a scale relevant to tracking change in the indicator it is improving in status with good confidence |
| Stable | Over a scale relevant to tracking change in the indicator it is neither improving nor declining in status |
| Getting worse | Over a scale relevant to tracking change in the indicator it is declining in status with good confidence |
| Unknown | Data are not available, or are not available at relevant temporal scales, to determine any trend in the status of this resource |
| Not applicable | This indicator of the natural resource does not lend itself to being classified into one of the above trend classes |

### 2.3.2 Condition

**Table 2.2. Definition of condition classes used**

| Condition | Description |
|---|---|
| Very good | The natural resource is in a state that meets all environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for all processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought) |
| Good | The natural resource is in a state that meets most environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for only some processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought) |
| Fair | The natural resource is in a state that does not meet some environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from many processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought) |
| Poor | The natural resource is in a state that does not meet most environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from most processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought) |
| Unknown | Data are not available to determine the state of this natural resource, based on this indicator |
| Not applicable | This indicator of the natural resource does not lend itself to being classified into one of the above condition classes |

### 2.3.3 Reliability

Information is scored for reliability based on the minimum of subjective scores (1 [worst] to 5 [best]) given for information currency, applicability, level of spatial representation and accuracy. Definitions guiding the application of these scores are provided in Table 2.3 for currency, Table 2.4 for applicability, Table 2.5 for spatial representation and Table 2.6.

for accuracy.

**Table 2.3. Guides for applying information currency**

| Currency score | Criteria |
|---|---|
| 1 | Most recent information >10 years old |
| 2 | Most recent information up to 10 years old |
| 3 | Most recent information up to 7 years old |
| 4 | Most recent information up to 5 years old |
| 5 | Most recent information up to 3 years old |

**Table 2.4. Guides for applying information applicability**

| Applicability score | Criteria |
|---|---|
| 1 | Data are based on expert opinion of the measure |
| 2 | All data based on indirect indicators of the measure |
| 3 | Most data based on indirect indicators of the measure |
| 4 | Most data based on direct indicators of the measure |
| 5 | All data based on direct indicators of the measure |

**Table 2.5. Guides for applying spatial representation of information (sampling design)**

| Spatial score | Criteria |
|---|---|
| 1 | From an area that represents less than 5% the spatial distribution of the asset within the region/state or spatial representation unknown |
| 2 | From an area that represents less than 25% the spatial distribution of the asset within the region/state |
| 3 | From an area that represents less than half the spatial distribution of the asset within the region/state |
| 4 | From across the whole region/state (or whole distribution of asset within the region/state) using a sampling design that is not stratified |
| 5 | From across the whole region/state (or whole distribution of asset within the region/state) using a stratified sampling design |

**Table 2.6. Guides for applying accuracy information**

| Accuracy score | Criteria |
|---|---|
| 1 | Better than could be expected by chance |
| 2 | > 60% better than could be expected by chance |
| 3 | > 70 % better than could be expected by chance |
| 4 | > 80 % better than could be expected by chance |
| 5 | > 90 % better than could be expected by chance |

## 2.4 Data transparency

Data transparency for this report card is represented in Appendix A.

# 3 Results

## 3.1 Trend

The trend rating for fire danger weather was determined to be 'Getting worse'. This trend rating is defined in Table 2.1 as: "Over a scale relevant to tracking change in the indicator it is declining in status with good confidence". The statewide rising trend in annual accumulated FFDI over more than four decades is assessed to be a trend that is getting worse due to the increased occurrence of fire weather conditions and consequently higher likelihood of bushfires occurring and impacting on communities, agriculture and ecosystems.

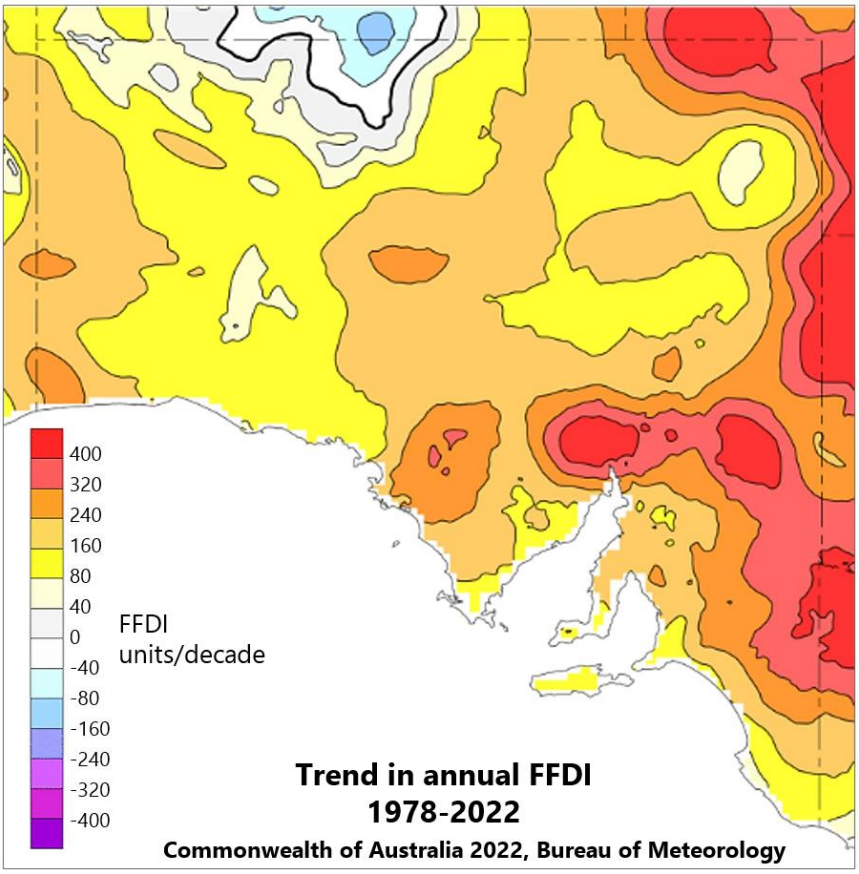



Figure 3.1 presents the spatial variation in the trends in annual accumulated FFDI for the time period 1978–2022, interpolated from weather monitoring stations distributed across South Australia.

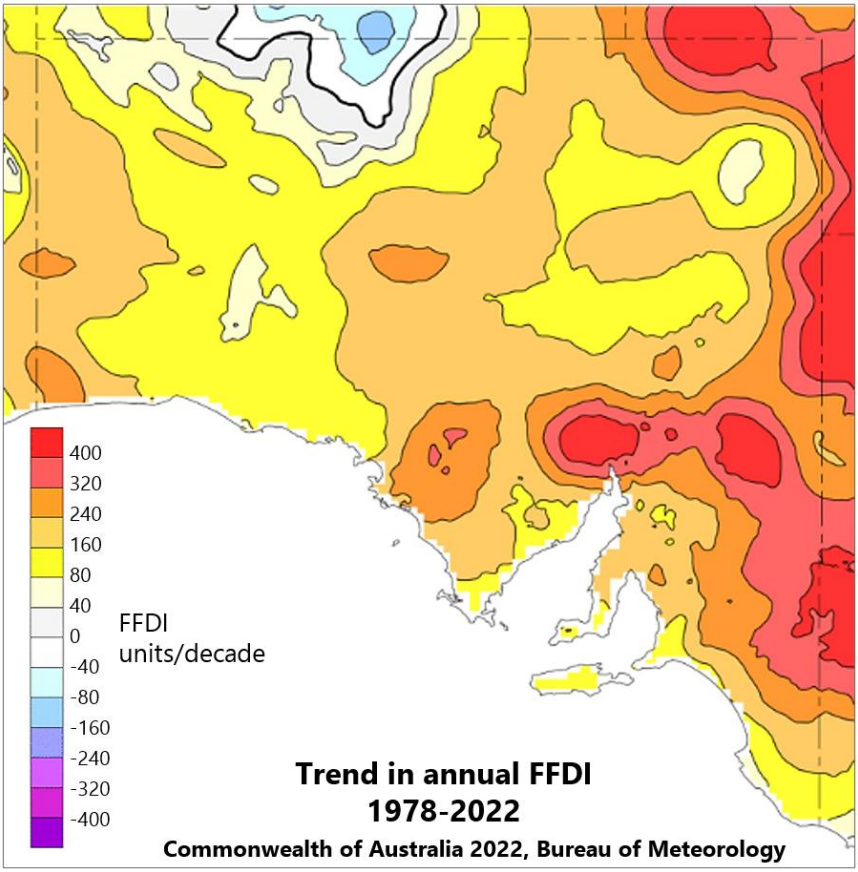



**Figure 3.1. Trend in annual accumulated FFDI per decade 1978–2022**

## 3.2 Condition

The condition rating for fire danger weather was determined to be 'Fair'. Although there is a rising trend in fire danger weather over a decadal timescale, higher rainfall and less extreme temperatures since early in 2020 have resulted in a return to more typical fire danger ratings over the past 3 years (Figure 3.2). However, the inter-annual variations in rainfall and temperatures are highly dynamic. In view of observed longer-term trends in temperatures and rainfall, the long-term trend in the accumulated FFDI is expected to continue to increase with increasing temperature and decreasing rainfall. This aligns with the condition definition of 'Fair' (Table 2.2), i.e. "The natural resource is in a state that does not meet some environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from many processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought)".

Figure 3.**2** presents the total accumulated FFDI in South Australia for each year from 1950 to 2022.

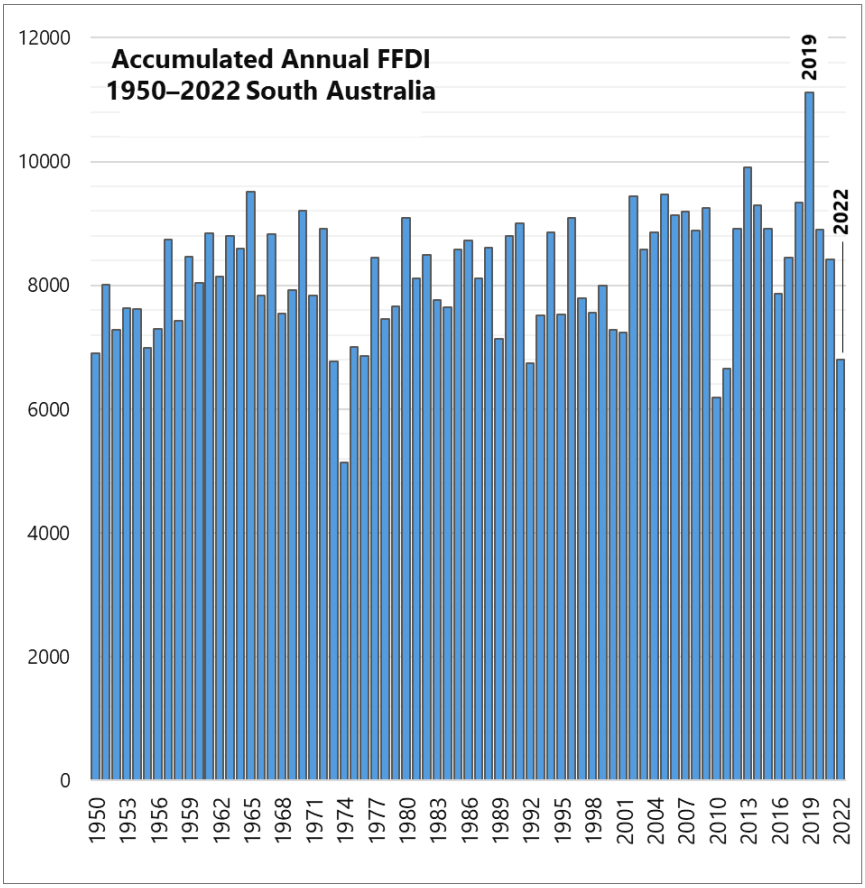



**Figure 3.2. Accumulated annual FFDI in South Australia for the years 1950–2022**

## 3.3 Reliability

The overall reliability score for this report card is 3 out of 5 based on Table 3.1. A reliability rating of 'Good' has been assigned.

**Table 3.1. Information reliability scores for fire danger weather (FFDI)**

| Indicator | Applicability | Currency | Spatial | Accuracy | Reliability |
|---|---|---|---|---|---|
| Fire danger weather | 3 | 5 | 3 | 3 | 3 |

### 3.3.1 Notes on reliability

The information has a currency score of 5 as measured FFDI data up to 2019 have been used in the map of the annual FFDI trend and the graph of accumulated December FFDI.

The information has an applicability rating score of 3 because the FFDI data are based on weather measurements that are direct indicators of the weather variables used in the calculation of FFDI, however the measure of accumulated FFDI uses only the FFDI rating at a particular time each day and hence does not represent the FFDI at all times.

A spatial representation score of 3 has been assigned because the data are from weather stations that are distributed across the state, however, each one is representative of weather conditions over a limited area within the vicinity of the station. Hence, the whole extent of the state is represented by the weather station network, however the measurements represent less than half the spatial variation of the weather conditions within the state.

The FFDI figures are calculated from direct measurements of weather variables at calibrated rainfall gauging stations distributed across South Australia. However, the coverage of these gauging stations is variable across the state, with the more remote areas having a sparse distribution of stations. Furthermore, the measure of accumulated FFDI uses only the FFDI rating at a particular time each day and hence does not represent the FFDI at all times. As a result, the accuracy of the data, for the purpose of the report card, has been ascribed a score of 3.

# 4 Discussion

## 4.1 Trend

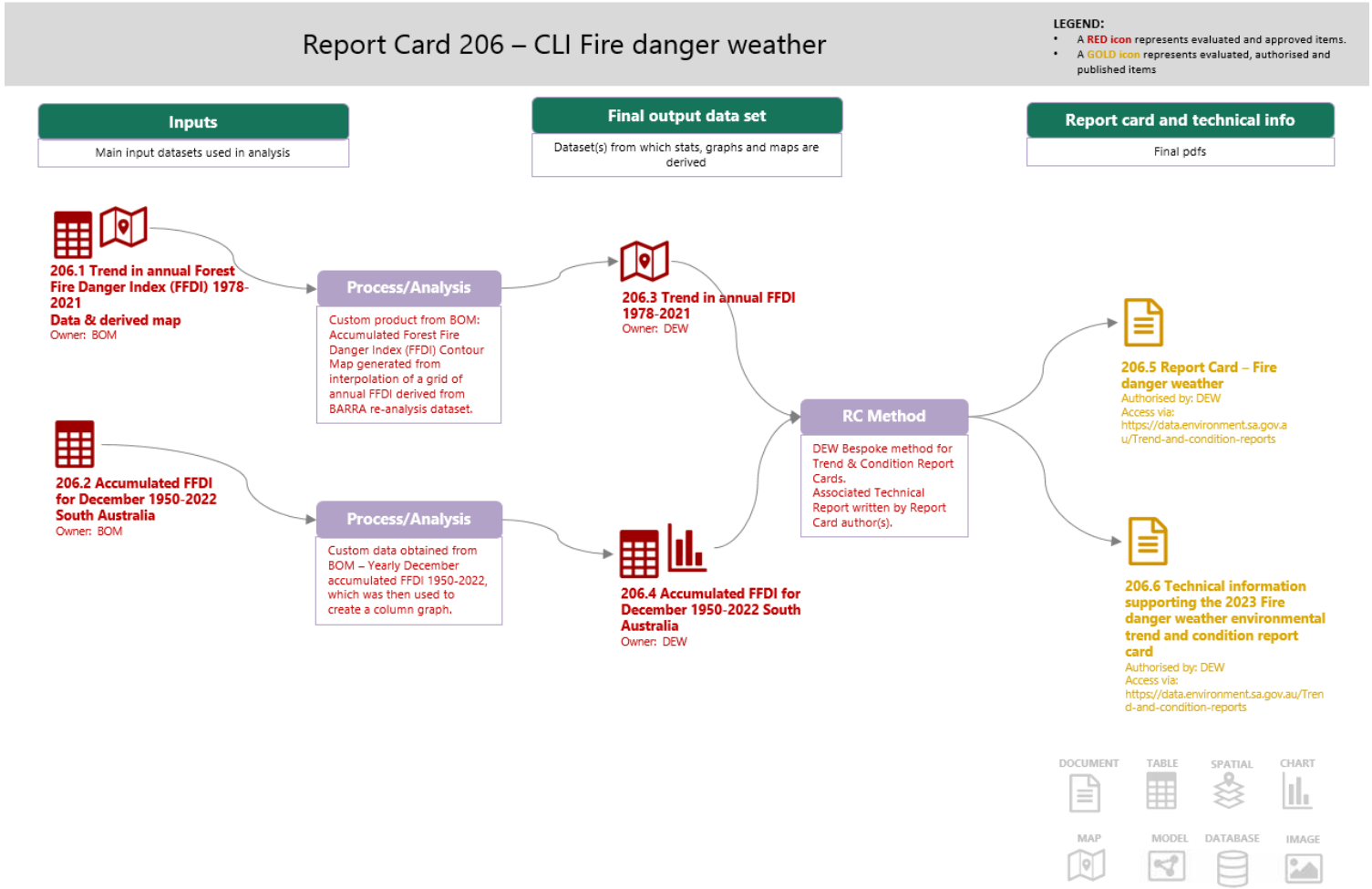
The trend rating for fire danger weather was determined to be 'Getting worse'. A trend of increase in annual accumulated FFDI has been observed over much of South Australia over the past 44 years. A small part of the northern edge of the state has a stable trend (i.e. FFDI is neither improving nor declining) and there is even a small area where the annual accumulated FFDI has been declining, however the rest of the state shows an increasing trend, with the greatest increase occurring in the east and mid-north of the state.

## 4.2 Condition

The condition rating for fire danger weather was determined to be 'Fair'. Although there is a rising trend in fire danger weather over a decadal timescale, higher rainfall and less extreme temperatures since early in 2020 have resulted in a return to more typical fire danger ratings over the past 3 years. However, this is a highly dynamic state. In view of observed longer-term trends in temperatures and rainfall, the long-term trend in the accumulated FFDI is expected to continue to increase with increasing temperature and decreasing rainfall.

In 2022 the use of FFDI for fire danger ratings was replaced by the Australian Fire Danger Rating System (AFDRS) (AFAC 2023). However, at the time of writing the 2023 updates to the Environmental trend and condition report cards, there was insufficient longitudinal data to report any trends in the AFDRS fire behaviour indices. Future updates of this report card will report on trends of change in the AFDRS Fire Behaviour Index when a sufficient time series length of data is available.

# 5 Appendix A: Managing environmental knowledge chart for Fire danger weather



# 6 References

Australian Academy of Science (2015). "The science of climate change: Questions and answers", Australian Academy of Science, Canberra, www.science.org.au/climatechange.

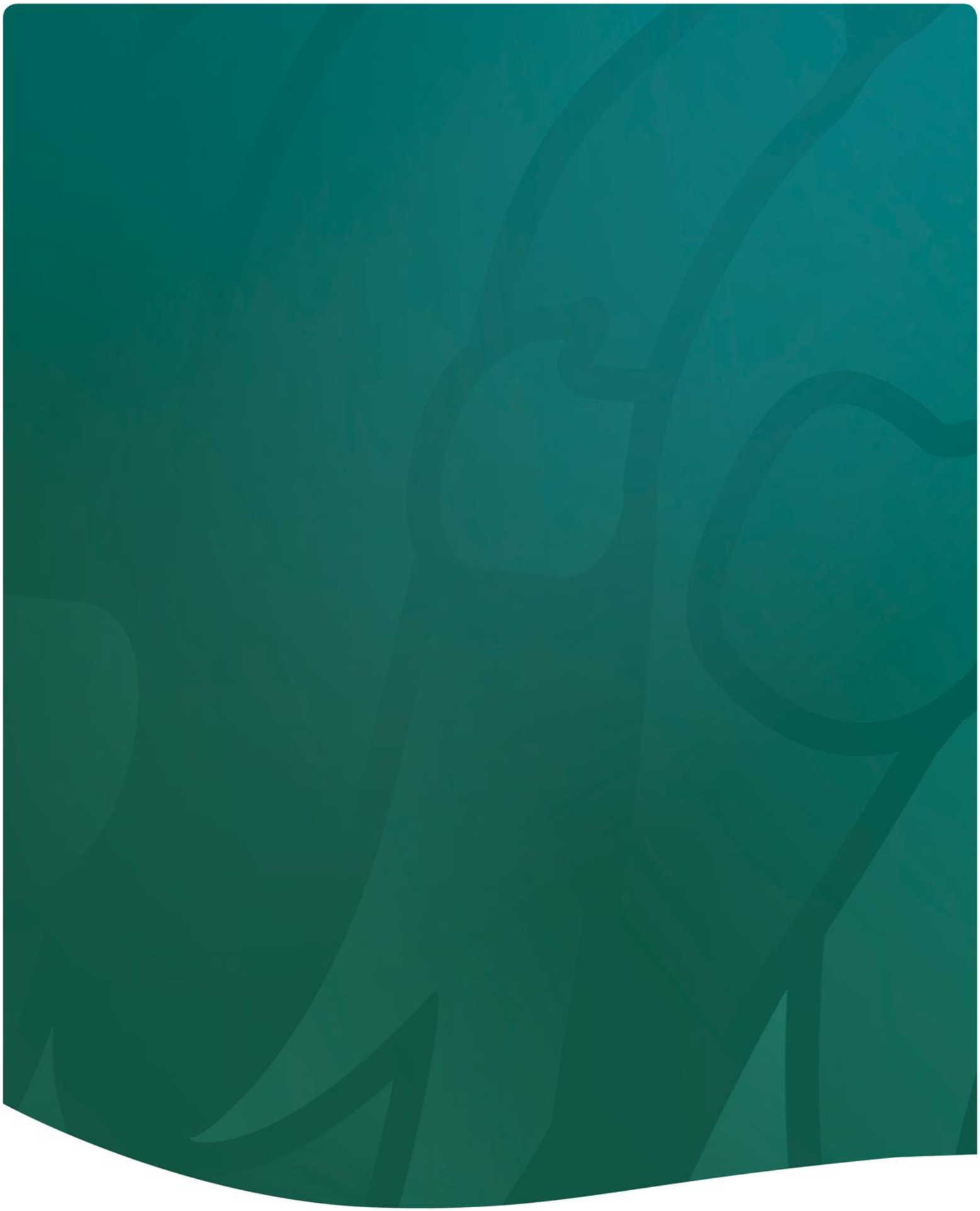
AFAC (2023). Australian Fire Danger Rating System, Australian and New Zealand National Council for fire and emergency services, www.afac.com.au/initiative/afdrs/afdrs-overview.

Bureau of Meteorology (2022). State of the Climate 2022 website, www.bom.gov.au/state-of-the-climate/.

Bureau of Meteorology (2023). Climate average maps - Forest Fire Danger Index (FFDI) website, www.bom.gov.au/climate/maps/averages/ffdi/.

Griffiths D (1999). Improved formula for the drought factor in McArthur's forest fire danger meter. Australian Forestry, 62(2), 202-206.

Keetch JJ & Byram GM (1968). A drought index for forest fire control. Res. Pap. SE-38. Asheville, NC: US Department of Agriculture, Forest Service, Southeastern Forest Experiment Station.



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