CASE STUDY FACT SHEET

ELECTRICITY
SECTOR
CLIMATE
INFORMATION
PROJECT

Bushfire risks for transmission networks

Introduction

Increasing risk from exposure to bushfires associated with climate change may have implications for the safe and efficient operation of Australia's electricity networks. These risks should be assessed, and strategies for mitigation and adaptation should be integrated within ongoing planning and operational decision-making frameworks.

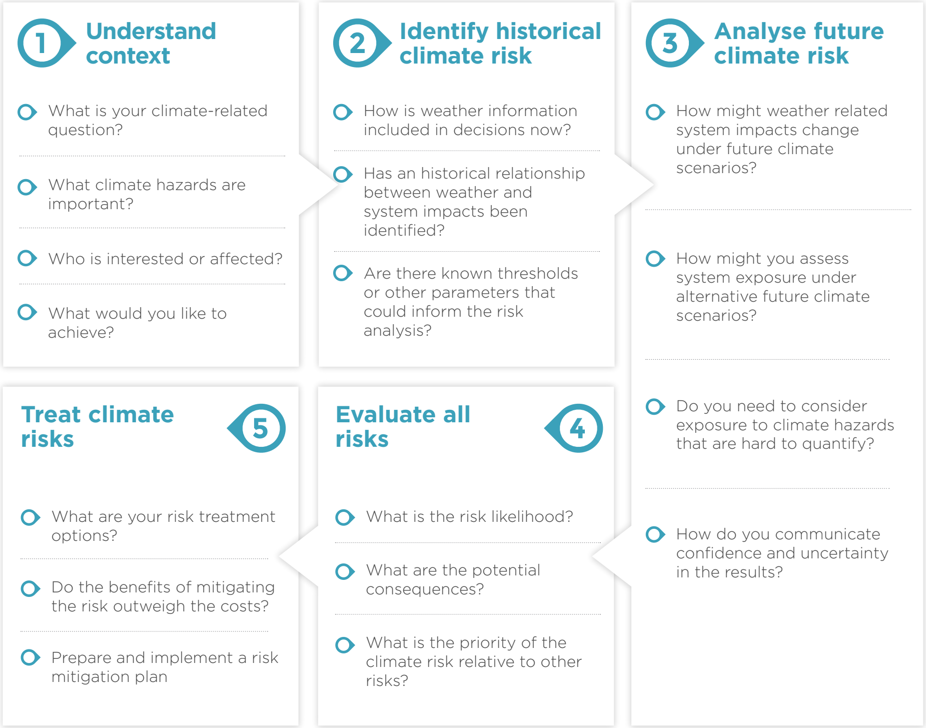
This Electricity Sector Climate Information (ESCI) case study, undertaken in collaboration with ElectraNet and the Bushfire and Natural Hazards Cooperative Research Centre (CRC), explores the projected change in bushfire weather risk and whether it could contribute to the choice of paths for new transmission lines. It also includes discussion on the implication for distribution line design and fuel load management.

The case studies are designed to demonstrate the use of the ESCI Climate Risk Assessment Framework choice and the application of appropriate climate information for long-term risk decision-making for the sector. This case study is also presented as a Summary Case Study Fact Sheet, along with other ESCI case study fact sheets, on the ESCI website.

This case study and other case studies from the project can be found at: www.climatechangeinaustralia.gov.au/en/projects/esci/esci-case-studies

Overview

This case study demonstrates how to apply the ESCI Climate Risk Framework (Figure 1) to assess changes in exposure to bushfire weather for the electricity transmission network. We assess future bushfire weather risk using the Forest Fire Danger Index (FFDI) projections developed for the ESCI project. There are four 'switches' for fire activity: (1) ignition source, (2) fuel load, (3) fuel dryness and (4) suitable weather conditions for fire spread (Bradstock 2010). The FFDI incorporates two of the switches: fire weather and fuel dryness (in the FFDI Drought Factor). The other components would also need to be considered when evaluating the results of the assessment.



1 Understand context

- What is your climate-related question?
- What climate hazards are important?
- Who is interested or affected?
- What would you like to achieve?

2 Identify historical climate risk

- How is weather information included in decisions now?
- Has an historical relationship between weather and system impacts been identified?
- Are there known thresholds or other parameters that could inform the risk analysis?

3 Analyse future climate risk

- How might weather related system impacts change under future climate scenarios?
- How might you assess system exposure under alternative future climate scenarios?
- Do you need to consider exposure to climate hazards that are hard to quantify?
- How do you communicate confidence and uncertainty in the results?

4 Evaluate all risks

- What is the risk likelihood?
- What are the potential consequences?
- What is the priority of the climate risk relative to other risks?

5 Treat climate risks

- What are your risk treatment options?
- Do the benefits of mitigating the risk outweigh the costs?
- Prepare and implement a risk mitigation plan

Figure 1 ESCI Climate Risk Assessment Framework, based on International Standard ISO 31000 'Risk Management' and Australian Standard AS 5334 'Climate change adaptation for settlements and infrastructure'.

The Electricity Sector Climate Information (ESCI) project was funded by the Department of Industry, Science, Energy and Resources (DISER) and was a collaboration between the Bureau of Meteorology (BOM), the Commonwealth Scientific & Industrial Research Organisation (CSIRO) and the Australian Energy Market Operator (AEMO). The ESCI website is at: www.climatechangeinaustralia.gov.au/esci

DISCLAIMER: This case study is intended as a guide for conducting a climate change risk assessment, not to provide information for use in operational decision-making as every organisation, location, and portfolio of risks is different and should be assessed in that context.

Understand context

The National Electricity Market (NEM) operates on one of the world's longest interconnected systems. Its transmission and distribution networks are often exposed to bushfires which can sometimes result in power outages. The outages can be the result of direct physical damage to transmission lines, although this is rare. More often, the outage is due to pre-emptive de-rating or disconnection of supply that is undertaken to avoid the risk of phase-to-phase arcing caused by heat and smoke from nearby bushfires.

When designing new transmission lines, designers consider paths that minimise the risks associated with bushfires by avoiding vegetated areas where possible or, if not, then reducing fuel load under lines. They also diversify the risk associated with bushfires by building geographically diverse line paths, aiming to minimise the probability of losing multiple transmission lines to the same event. Understanding the future risk of bushfire as this varies regionally may inform the routing of transmission lines. If future bushfire risk is lower along a potential path, this could improve the investment case.

This case study focuses on bushfire weather conditions and how these are projected to change in the future. It is important to note that bushfire is a complex hazard so a full risk assessment should also consider factors such as fuel load and type, fuel suppression, and ignition likelihood, noting climate change will also contribute to changes in these additional fire hazards.

The current science indicates that under Australian conditions the FFDI is suitable for rating bushfire weather (McArthur 1967; Luke and McArthur 1978), with the metric being used to define levels of fire danger (Figure 2). The index combines a record of dryness, based on rainfall and evaporation, with meteorological variables for wind speed, temperature and humidity. For this case study FFDI is employed to measure risk, however it should be noted that other fire weather indices are available or in development.[1]

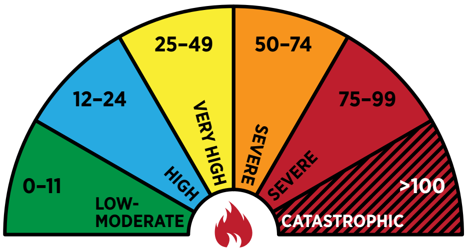


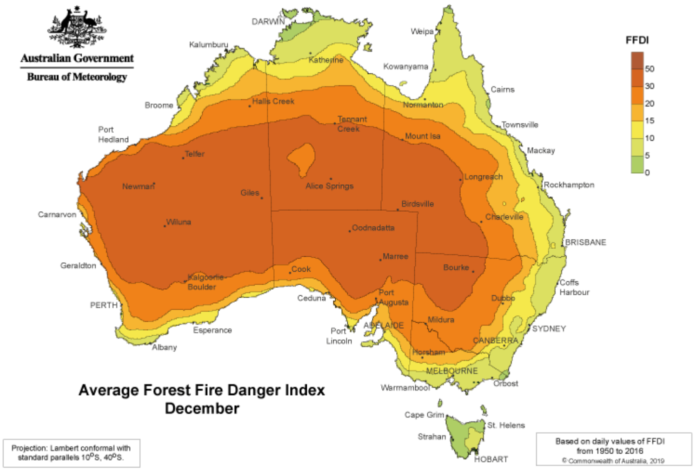
Figure 2 Relationship between FFDI values and bushfire danger ratings for Victoria to show how higher FFDI values are used to indicate more dangerous weather conditions for bushfires (FFDI values in silver boxes). Different States and Territories use FFDI with slightly differing scales to indicate bushfire danger rating. Catastrophic is also referred to as 'Code Red'.

Stakeholders and decision-making criteria

Investment cases for new transmission lines are primarily decided on how well they support the National Electricity Objective in promoting efficient investment in, and efficient operation and use of electricity services for the long-term interests of consumers of electricity.[2] Specifically, this risk assessment is of interest to engineers and asset managers and regulators as it has implications for investment decisions.

Identify historical climate risks

Maps of the average FFDI for December (Figure 3) since 1950 indicate regional variability with lower danger on the east coast of Australia and in Tasmania.



Average Forest Fire Danger Index
December

Projection: Lambert conformal with standard parallels 10°S, 40°S.

Based on daily values of FFDI from 1950 to 2016
© Commonwealth of Australia, 2019

Figure 3 Average FFDI over Australia for December for the period 1950–2016. Higher values represent more dangerous weather conditions for bushfires: for example, FFDI above 50 is classed as 'Severe'. (Source: Dowdy 2018)

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[1] The Australian Fire Danger Rating System (AFDRS; currently in development and testing stages) will replace FFDI in the next couple of years as the primary indicator of fire risk. The AFDRS will include a range of fuel types as well as fire weather indices.

[2] Australian Energy Market Commission (2021). National Energy Objectives. https://www.aemc.gov.au/regulation/regulation

There has been an observed trend towards more dangerous weather conditions for bushfires in Australia over the past 70 years with climate change (Figure 4) (Dowdy 2018; Harris and Lucas 2019).

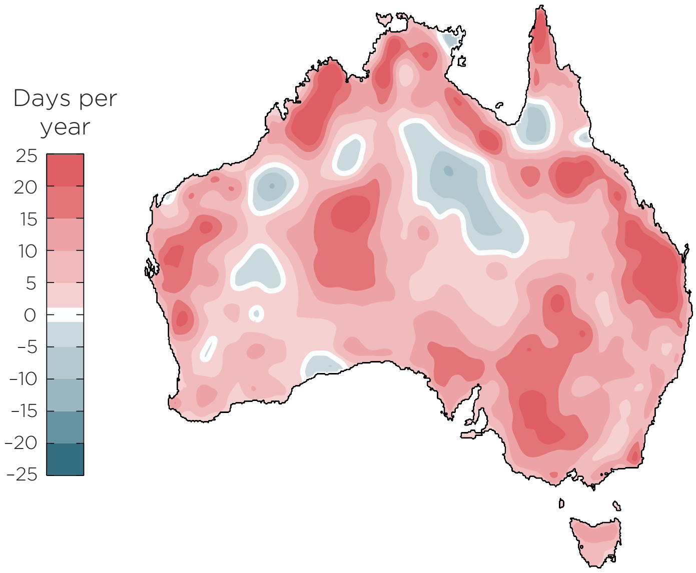

Figure 4 Long-term changes in the number of days with dangerous weather conditions for bushfires. This figure shows the change in the annual (July–June) mean number of days that the FFDI exceeded its 90th percentile for July 1985 to June 2020 compared with July 1950 to June 1985.

Severe rainfall deficiencies leading up to the summer of 2019–2020 exacerbated fire weather conditions (BOM 2020); the accumulated FFDI indices for spring 2019 were the highest on record for Australia as a whole (based on all years since 1950) (Figure 5). In the summer of 2019–2020, known as the 'Black Summer', Australia faced unprecedented bushfires (van Oldenborgh 2021).

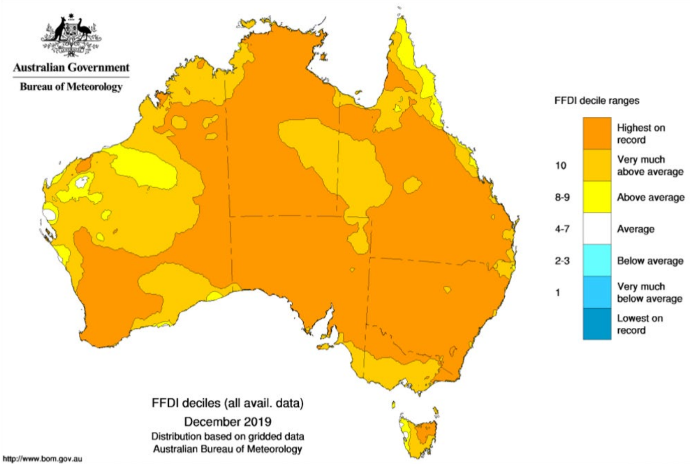

Figure 5 Accumulated FFDI deciles for December 2019 (based on all years since 1950). (Source: BOM, using the data set as described in Dowdy 2018)

Transmission network operators (TNSPs) and AEMO proactively manage bushfire risk through operational processes such as cutting back vegetation near power lines, reducing electricity flows on windy or smoky days, and planning other maintenance so that it does not coincide with high bushfire risk or high temperature (therefore high demand) days. Despite this, a bad bushfire season, such as the 2019–2020 season can have a significant impact on network performance.

For the period from November 2019 to March 2020, the number of unplanned outages was significantly higher than in the previous summer, particularly in New South Wales (NSW) (Figure 6), with the increase mainly due to bushfires between November 2019 and January 2020.

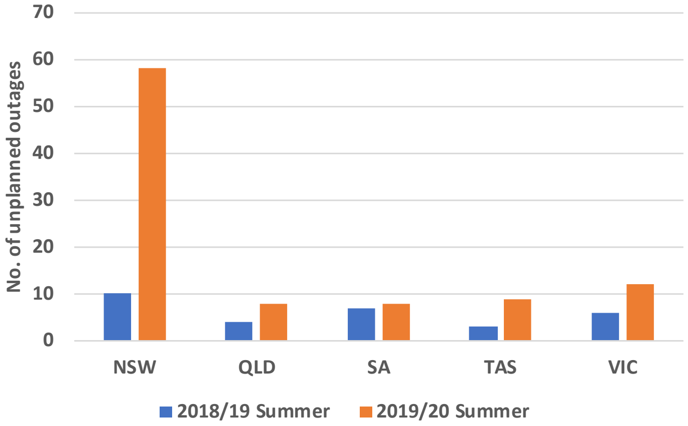

Figure 6 Number of unplanned transmission outages in NEM regions, summer 2019–2020 vs summer 2018–2019. (Data source: AEMO Summer 2019–2020 NEM Operations Review)[3]

The historical relationship between line de-rating on the Dederang–South Morang interconnector in northern Victoria (VIC) (black line shows days of line de-rating events observed) and lagged fire danger days in the historical data set (the fitted values are demonstrated by the brown line) is significant and is illustrated below (Figure 7). The ensemble of climate projections then illustrate the range of possible outcomes for bushfire interactions on this line over time, should this historical relationship persist. The ensemble of climate projections shows an upward trend over time in the median frequency of bushfire impact days on this line.

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[3] Australian Energy Market Operator (2020). 2019–20 NEM Summer Operations Review Report. https://www.aemo.com.au/-/media/files/electricity/nem/system-operations/summer-operations/2019-20/summer-2019-20-nem-operations-review.pdf?la=en

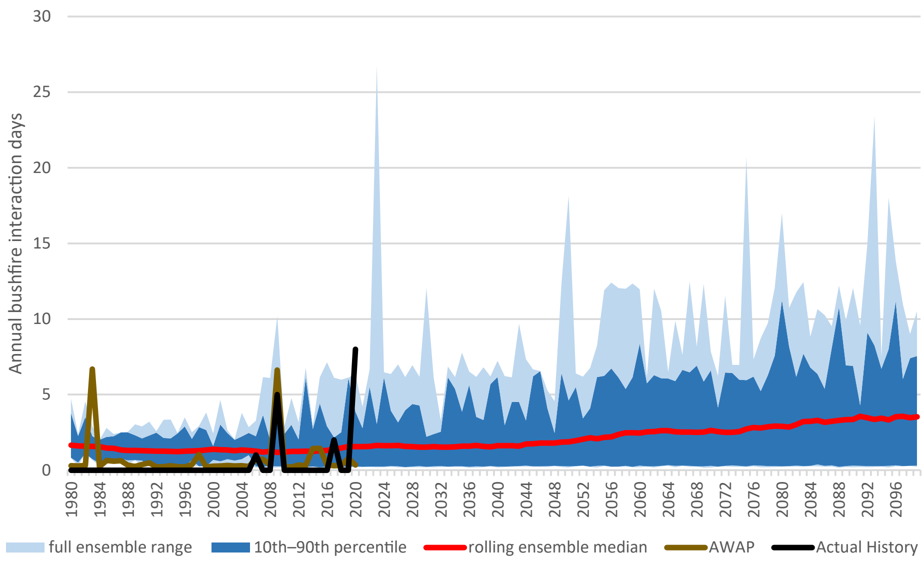

Figure 7 Indicative analysis showing a projection of bushfire interaction for the Dederang–South Morang line (part of the VIC–NSW interconnector) compared with FFDI. The climate model ensemble used in this projection matches that included later in this paper.

Analyse future climate risks

Climate change projections suggest that Australia's fire weather will likely increase in intensity, particularly in the south and east as a result of increasing temperature and reduction in precipitation in some areas and some seasons This may also influence soil moisture content which in turn may result in more intense fires (CSIRO and BOM 2015; Dowdy et al. 2019).

Assessment locations

The case study considers the reliability of existing lines in VIC, eastern South Australia (SA) and southern NSW, illustrated by paths 3 & 6 below. In addition, two new potential transmission line paths are being considered (Figure 8):

- Project Energy Connect is a new transmission line between SA and NSW (an ElectraNet project). The preferred path for this line is marked in the map below as number 1 while line paths 2 and 3 indicate alternative paths considered in project scoping. Line path 3 is the location of an existing line.

- Victoria–New South Wales Interconnector West is a potential new interconnector between VIC and NSW. Currently, paths 4 and 5 are being considered via a regulatory process; and path 6 is the location of an existing line.

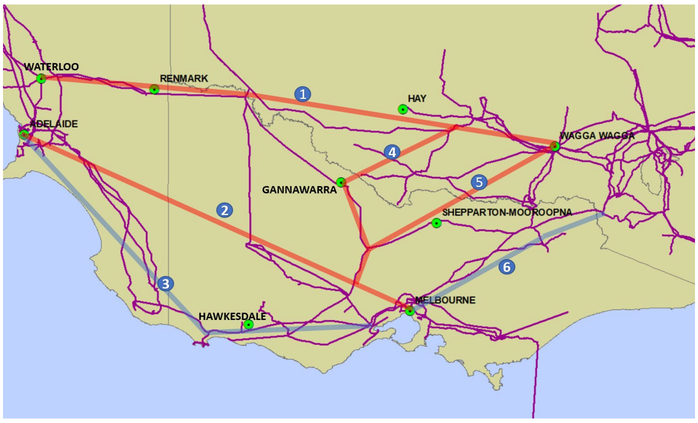

Figure 8 Paths for proposed transmission lines (red) for Project Energy Connect (1 and 2) and VIC–NSW interconnector (4 and 5), and existing line paths indicated in blue (3 and 6) superimposed over transmission line network (purple lines). Identified locations of case study analyses for changes in FFDI (green circle).

Analysis period

Given that transmission lines have an operating lifetime of more than 50 years it was appropriate to consider the contribution of climate change to bushfire risk over the rest of the century, therefore, projected changes in bushfire risk were considered in 20-year increments from 2030 to 2090.

Future climate scenarios

Future climate scenarios are influenced by three main sources of uncertainty:

- Future greenhouse gas emissions scenarios
- Regional climate responses to a given emission scenario
- Natural variability at timescales ranging from hours to decades

It is important to consider a range of greenhouse gas emission pathways and also a range of plausible regional responses simulated by different modelling groups from around the world.

Greenhouse gas concentration pathways

For the transmission line path design case study, a high emissions pathway (RCP8.5) was assessed noting for a more thorough assessment of future fire weather risk, it is strongly recommended that a range of concentration pathways are used to assess potential best and worst cases.[4]

Climate models

Of the 40 global climate models (GCMs) available for assessing projected climate changes, each provides a different simulation of future weather and climate at a given location. Unfortunately, there is not a single 'best' model for all applications so it is important to consider results from a range of models that sample the range of uncertainty.

An ensemble of 21 models (see Appendix A) downscaled using CCAM (McGregor and Dix 2008) and Quantile Matching for Extremes (QME) (Dowdy 2020) was used to provide information on the range of plausible projected changes. These calculations can be used to indicate the change in weather conducive to bushfire in the future projected climate under this high emission pathway, noting the spatial resolution of the modelling may not establish fine-scale details of relative bushfire risk between nearby locations with a high degree of confidence.

Projections of FFDI for the study locations

Projections of the number of days above defined FFDI thresholds (FFDI > 25, FFDI > 50, FFDI > 75, FFDI > 100) were calculated for locations along the different transmission paths (Figure 8). Figure 9 shows a time-series analysis for the Adelaide Hills, with results for other locations presented in the Appendix. An analysis of bushfire-induced de-rating data from the Dederang–South Morang transmission line (Figure 7) suggest that the bushfire season needed to be analysed for the eight months from September to April to cover the relevant fire danger period.[5] For all FFDI

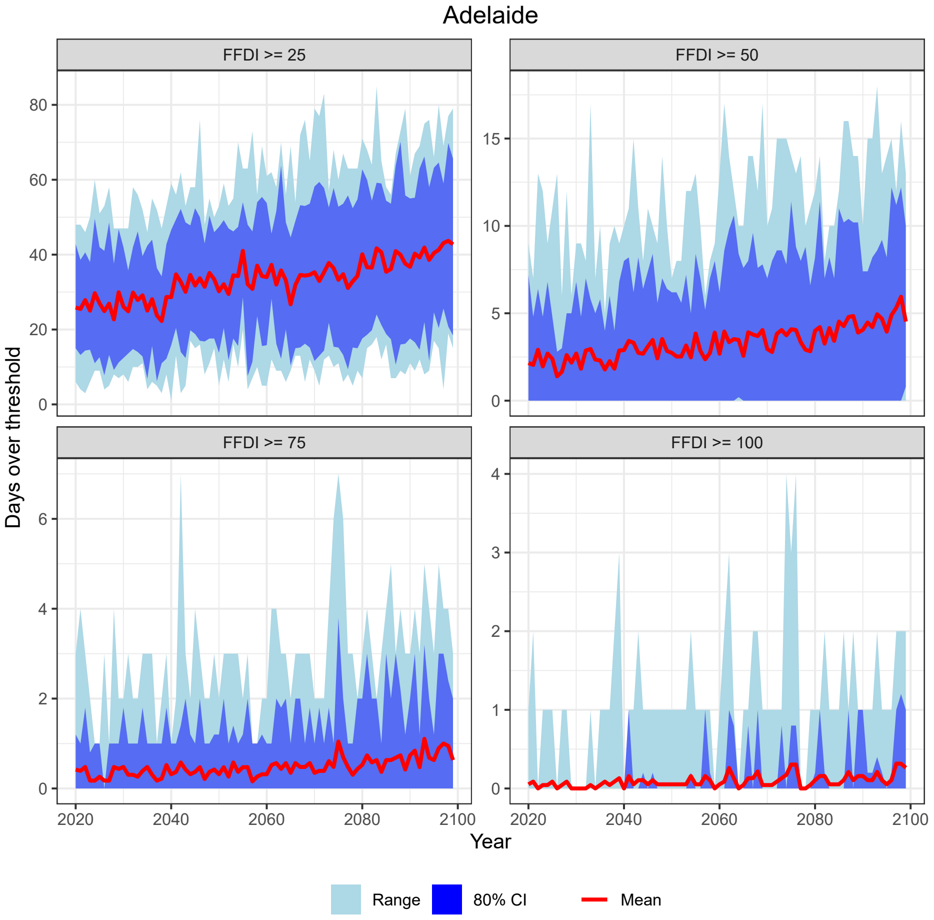

Figure 9 Time-series of projected FFDI (Sept to April period) for Adelaide for four different thresholds, corresponding approximately to 'very high', 'severe', 'extreme' and 'catastrophic' bushfire risk (Figure 4). The analysis shows the projection for RCP 8.5 based on an ensemble of 20 GCMs using CCAM and QME downscaling scaling. The red line denotes the mean of the ensemble, the dark blue band shows values corresponding to the central 80% of the ensemble and the light blue gives the full range.

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[4] See ESCI Key Concept—choosing representative emissions pathways (RCPs).

[5] Note: the bushfire season may extend beyond these months with climate change.

values and all locations there appears an increase in frequency through the century with, for example, the average frequency of FFDI days above 25 for the study locations increased by 10 days over that time. There is also an increase in the more extreme FFDI indices through the assessment period.

This same analysis was conducted at several locations along each of the existing and proposed transmission paths; it showed that bushfire weather varies across the landscape, with inland locations (such as Hay, Gannawarra and Renmark) experiencing more frequent hot and dry weather than coastal locations (see Appendix B). While weather varied across regions, the rate of change of bushfire weather (not shown here) under the high emission scenario was observed to be broadly consistent between the paths.

Evaluate climate risk

Climate projections indicate that periods of extreme bushfire-conducive weather are likely to increase in all regions of interest. The projected changes to fire weather conditions during the September to April period, examined here, including the analysis of extreme daily values as indicated by fire weather indices, provide strong indications that bushfire-related impacts on NEM infrastructure are likely to increase both in frequency and severity in the future. These impacts include:

- Reduced maintenance periods used for cutting back vegetation near power lines
- Smoke from nearby fires triggering de-rating (reduced energy flows) to reduce the risk of arcing
- Direct destructive impact of bushfires on poles and lines

Increases in the frequency and intensity of dangerous bushfire weather are very likely to have an impact on transmission lines in the future with all transmission corridors to expect increasingly hazardous bushfire weather, with dangerous bushfire weather increasing at about the same rate for each corridor.

Bushfire weather risk is higher on the inland path (1) and lower on the two paths closer to the coast (3 and 6) (Figure 8). However, each path also has differing exposure to fuel loads, with inland paths expected to have very low fuel loads, therefore while FFDI projections indicate a significant increase in risk of bushfire weather on this line, other influencing factors may dominate any overall risk for bushfire occurrence. This suggests that for path planning purposes, changes in FFDI are insufficient to differentiate between possible transmission pathways. However, given the projected increases in the severity of fire weather conditions in our warming climate, greater diversity of transmission paths could plausibly help reduce the risk of multiple line failures from large bushfires in the future.

Understanding this increased risk of bushfire weather may contribute to other planning considerations. For example, for sites where suppression is challenging or expensive, changes in bushfire weather may meaningfully change long-term maintenance costs, noting that weather is also responsible for variations in vegetation and bushfire fuel load.

Risk treatment

Despite the inability to include fuel information, the bushfire weather trends can still provide useful information for long-term planning for bushfire risk. The discussion of mitigation options here is based not just on the original case study but on subsequent focus groups with three TNSPs and three distribution network service providers (DNSPs).

Long-term planning of paths or equipment

This case study explored whether the spatial detail in fire weather projections provided useful information for planning of transmission lines, given the finding that the relative risk of fire to different paths did not change. Given plausible future increases in the frequency of bushfires, the potential benefits of improved reliability derived from geographic diversity of transmission lines is likely to be enhanced.

In contrast to large-scale planning for new potential transmission line paths, bushfire weather trends may be unlikely to provide meaningful differentiation for distribution lines. Distribution networks have more intrinsic diversity than transmission networks, and options for routing new transmission lines are often limited to relatively small-scale variations (e.g. 100 m left or right).

Information on the spatial distribution of bushfire weather may help with planning for the location of key infrastructure sites such as terminal stations. Bushfire weather maps and trends over time should be considered as part of infrastructure location decisions, together with current knowledge of fuel conditions and ignition, as well as considering the recorded history of damaging fires. However, unless the potential sites for key infrastructure are very widely separated, regional detail in the future projected changes in bushfire weather is unlikely to be a key differentiator with currently available modelling and scientific understanding.

Fuel load management

Understanding how bushfire weather is changing can also inform long-term fuel-management planning to help increase reliability. Increasing severity of bushfire weather conditions could increase the cost of fire management practices along each line. If bushfire management and suppression costs differ significantly for the different paths, for example, then additional risk to network reliability could be a significant differentiator. This is likely to be more of an issue for DNSPs than for TNSPs as the lower height of distribution lines, and therefore the increased proximity of trees and undergrowth, means that they have a higher risk of starting bushfires, and of being damaged by bushfires, than the TNSPs.

Long-term planning of maintenance

Maps of FFDI with current distribution and trends are very useful, even without fuel information. Combining this daily time-series information with network maps can help inform operational risk assessments by improving, for example, long-term planning of suppression activities and fuel reduction. Useful information to be obtained from these data sets includes changes in start and end dates of fire seasons[6] with an earlier start to the fire season in many parts of southern Australia having been observed (Dowdy 2018; Harris and Lucas 2019; Dowdy et al. 2019). The observed trends and FFDI projections also indicate increased severity of fire weather around the peak of the fire season, noting that these summer months correspond to an important time for NEM management and planning given the high demand associated with summer heatwaves.

Making decisions using climate trends on bushfire weather

Climate data can provide useful guidance for long-term decision-making around bushfire hazard for the sector, but the data need to be considered together with other influencing factors, as described earlier. One important step in sector decision-making for maintenance, insurance and for long-term investments is to calculate the cost and consequence of bushfires. Fire weather projections from the ESCI project can be integrated into impact, cost and consequence models such as:

- **PHOENIX RapidFire**—a model that simulates bushfires. It integrates fuel, terrain, weather conditions and suppression to simulate a fire's development and progression in the landscape. The model is mechanistic, continuous, dynamic and empirically based. It simulates fire characteristics such as fire spread, flame height, intensity, size and ember density. It can also simulate some of the effects of suppression efforts and the impact of fire on various values and assets.

- **SPARK**—a CSIRO-developed toolkit for the simulation and analysis of wildfires. Users can design custom fire propagation models incorporating various input, processing and visualisation components, each tailored for wildfire modelling. SPARK can be used for many applications including planning, warning and response, and research.

- **Project Ignis**—a collaboration between the Bushfire and Natural Hazards CRC and Energy Networks Australia. This project has developed a standardised methodology for networks to assess the cost of a major bushfire event involving powerlines, the benefits that may arise from management actions, and uses the outputs of the PHOENIX RapidFire fire simulation model.

Further information

Maps of changes in FFDI and time-series of FFDI projections for multiple climate models and 168 locations around the NEM are accessible via the ESCI website. The website also provides more general information on how to conduct a climate risk analysis and access to additional support materials. Changes in FFDI in 20-year intervals from 2030 have also been provided by the ESCI project as a visual schematic resembling a map.

The ESCI team would like to thank members of ElectraNet and the Bushfire and Natural Hazards CRC who contributed to this case study.

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[6] See also ESCI case study—bushfire affecting electricity distribution.

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Appendices

Appendix A: Models used in the study

CCAM (6 Models): ACCESS1-0, CAN-ESM2, CNRM-CM5, GFDL-ESM2M, MIROC5, NorESM1-M

QME (15 Models) ACCESS1-0, ACCESS1-3, bcc-csm1-1, bcc-csm1-1-m, BNU-ESM, CCSM4, CNRM-CM5, CSIRO-Mk3-6-0, FGOALS-g2, GFDL-CM3, GFDL-ESM2G, GFDL-ESM2M, MIROC5, NorESM1-M, MRI-CGCM3

Appendix B: Data and charts for different study locations

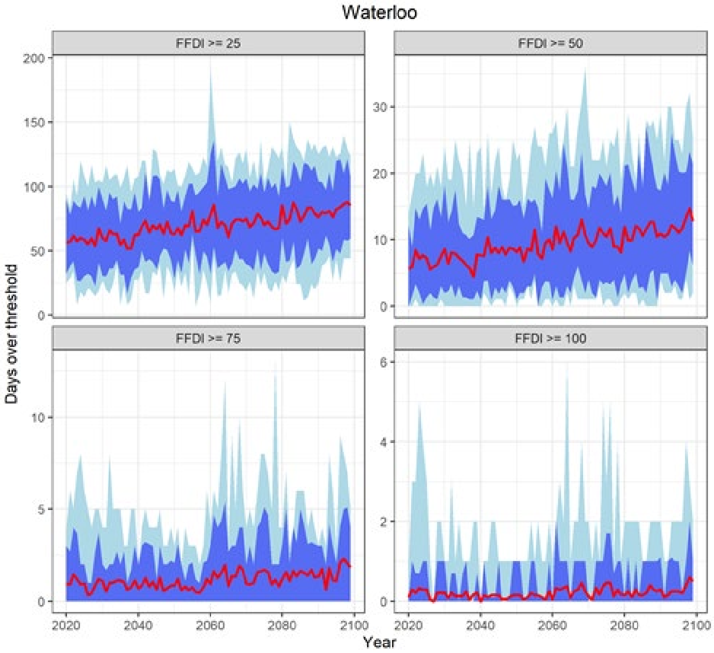
Time-series and violin plots for all locations indicated in this case study (Figure 8). Violin plots are similar to box plots except that they also show the probability density of the data at different values. For example, for Waterloo, the number of days with FFDI above 25 increases on average from around 50 days for the 2010 period to around 80 for the 2090 period. For the 2090 period, the results range from 50 to around 120, with the highest probability of around 80 days.

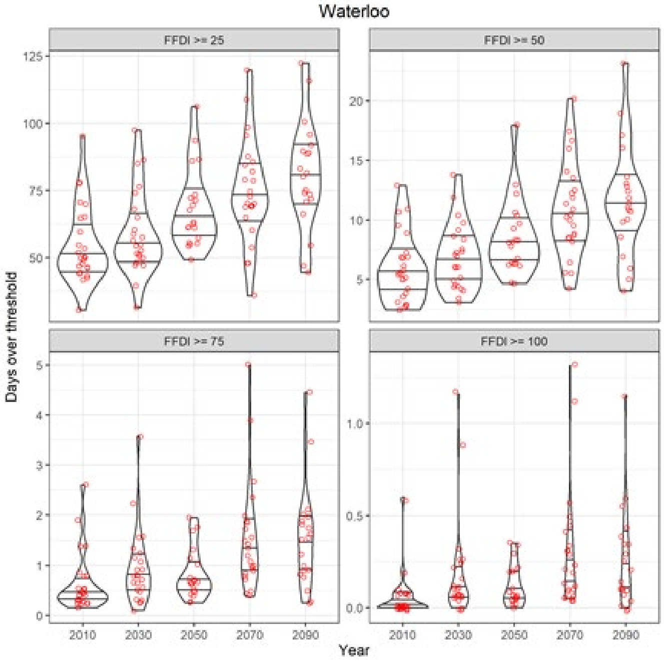
Plots for paths 1 to 5, described in Figure 8, are tabulated below.

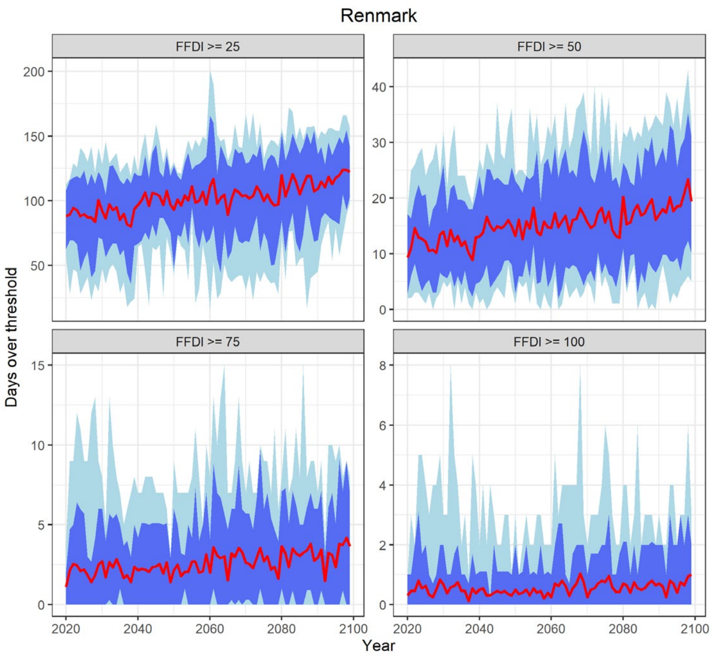
The analyses below are an alternative way of displaying the information shown in Figure 11. The 'violin plots' show the change in frequency in the number of days over the specified FFDI threshold at 20-year intervals. The vertical range of the plots shows the full range of results from the ensemble, the internal bars indicate the 25th, 50th and 75th percentile, and the width of the plot indicates probability density of the data at different values.

Time-series of projected FFDI (September to April period) for Adelaide for four different thresholds, corresponding approximately to 'very high', 'severe', 'extreme' and 'catastrophic' bushfire risk (Figure 4). The analysis shows the projection for RCP8.5 based on an ensemble of 20 Global Climate Models using CCAM and QME downscaling scaling. The red line denotes the mean of the ensemble, the dark blue band shows values corresponding to the central 80% of the ensemble and the light blue gives the full range.

Path 1






Renmark
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
200
150
100
50
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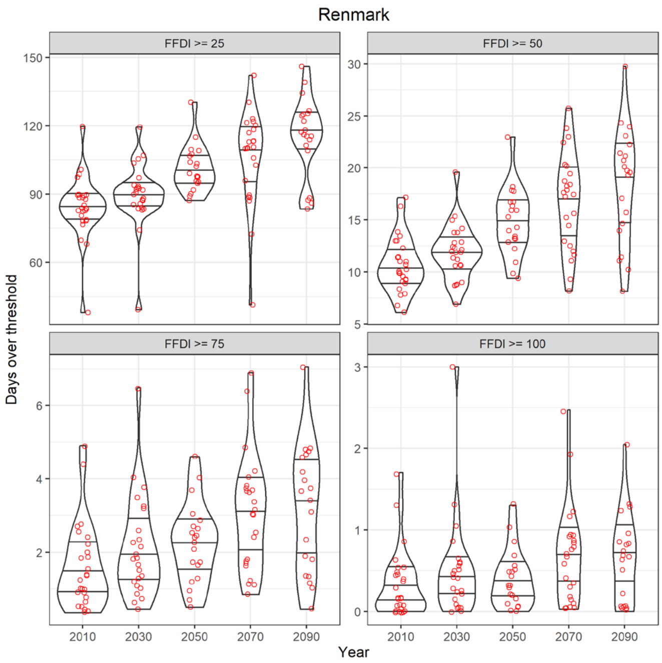
Renmark
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
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120
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60
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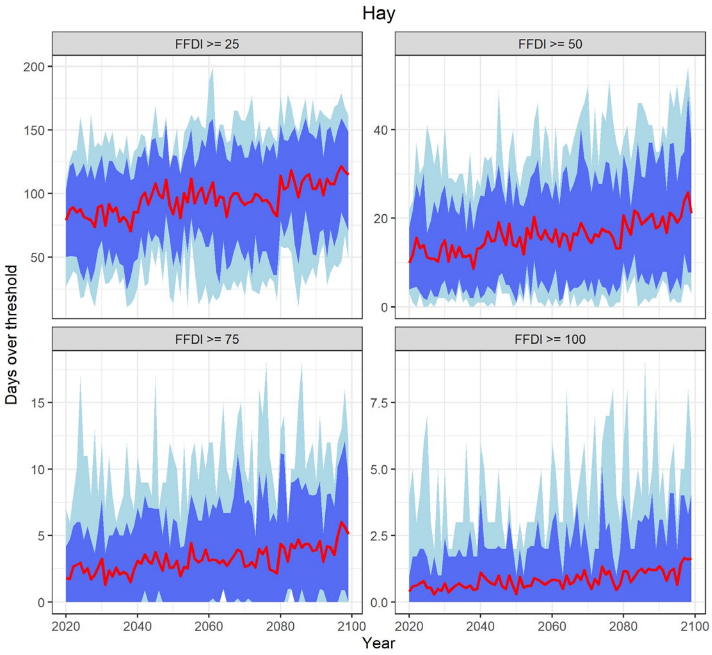
Hay
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
200
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2020
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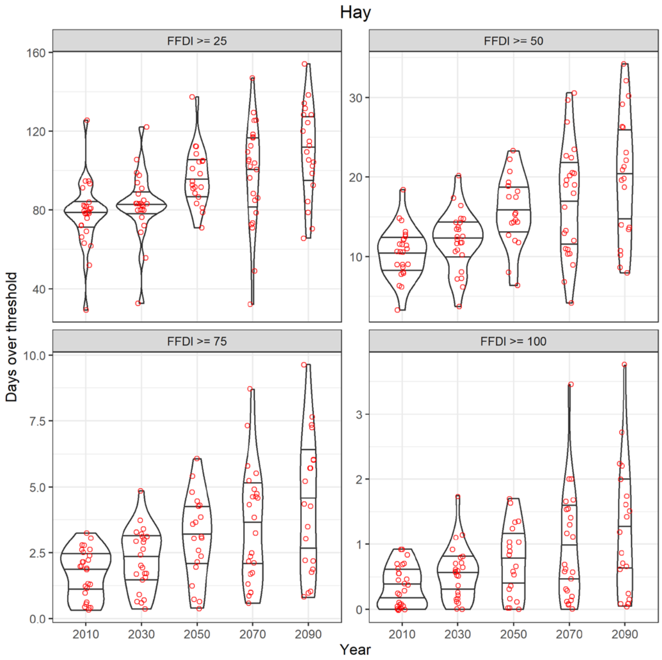
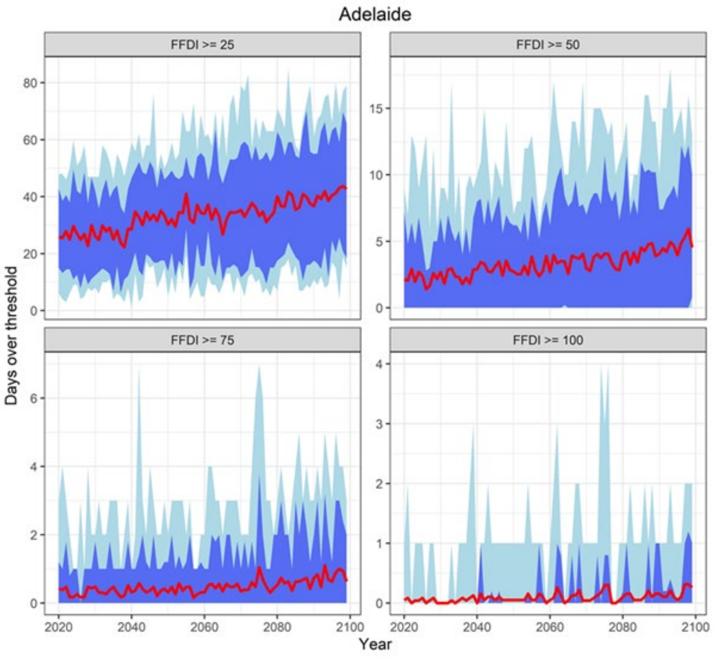
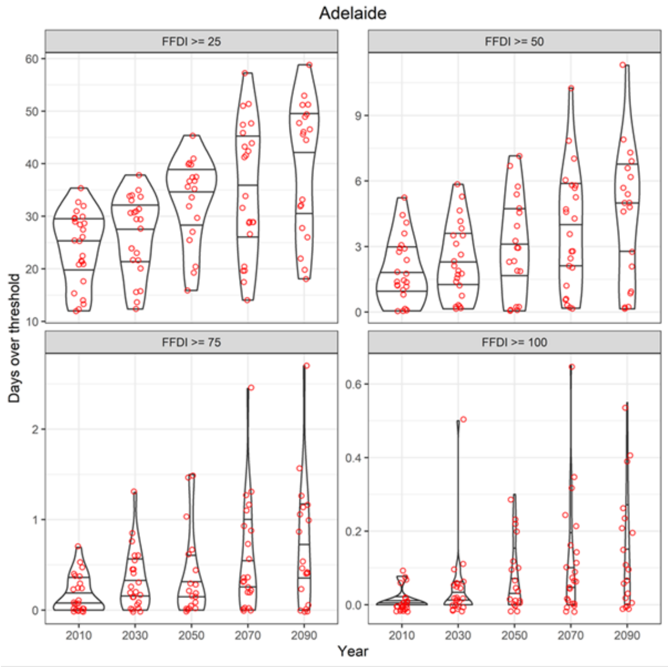
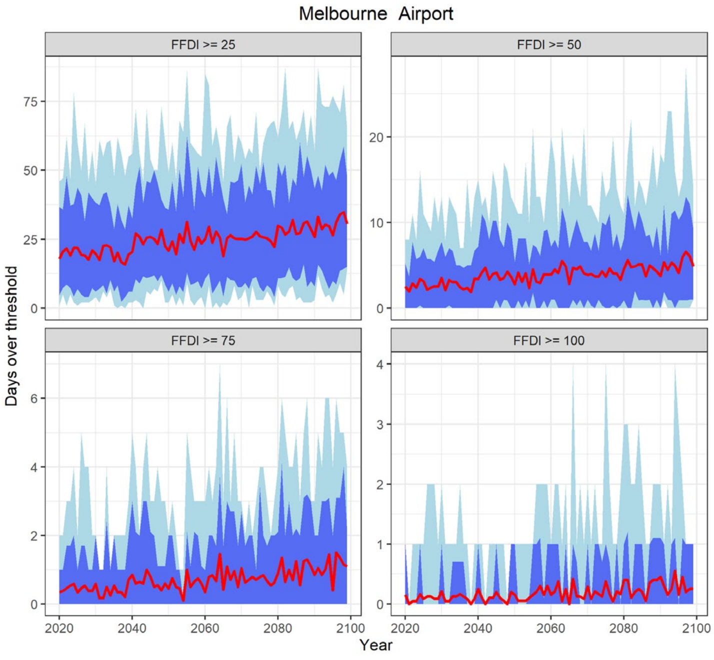
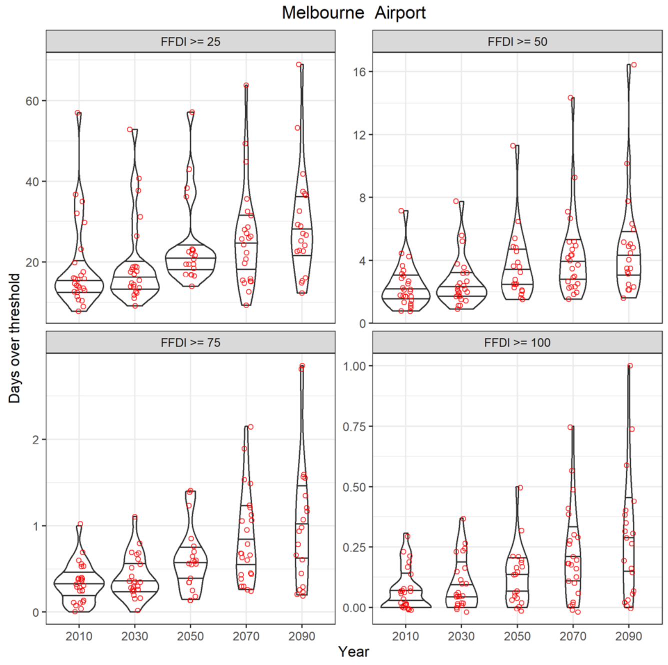

Hay
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
160
120
80
40
30
20
10
10.0
7.5
5.0
2.5
0.0
3
2
1
0
2010
2030
2050
2070
2090

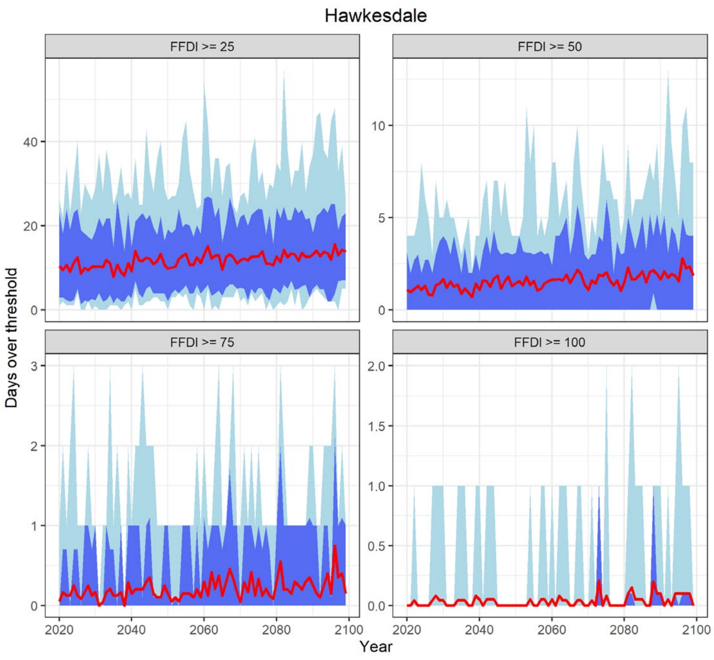
Path 2

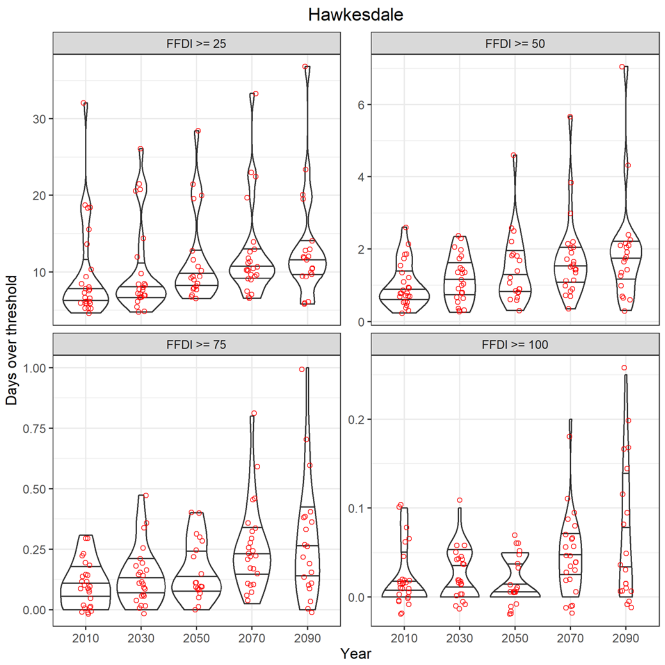

Adelaide
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
0
20
40
60
80
5
10
15
2
4
6
1
3
2020
2040
2060
2080
2100


Adelaide
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
10
20
30
40
50
60
0
3
6
9
1
2
0.0
0.2
0.4
0.6
2010
2030
2050
2070
2090

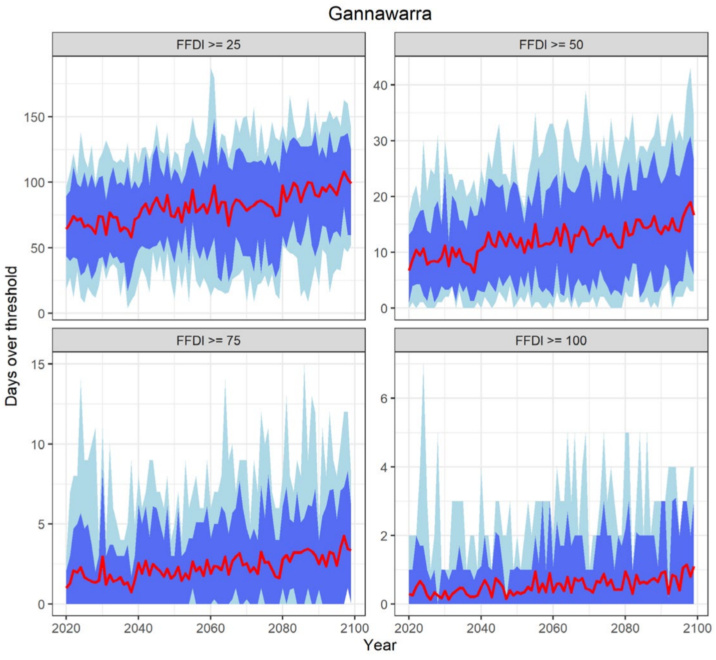

Melbourne Airport
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
0
25
50
75
10
20
2
4
6
1
3
2020
2040
2060
2080
2100

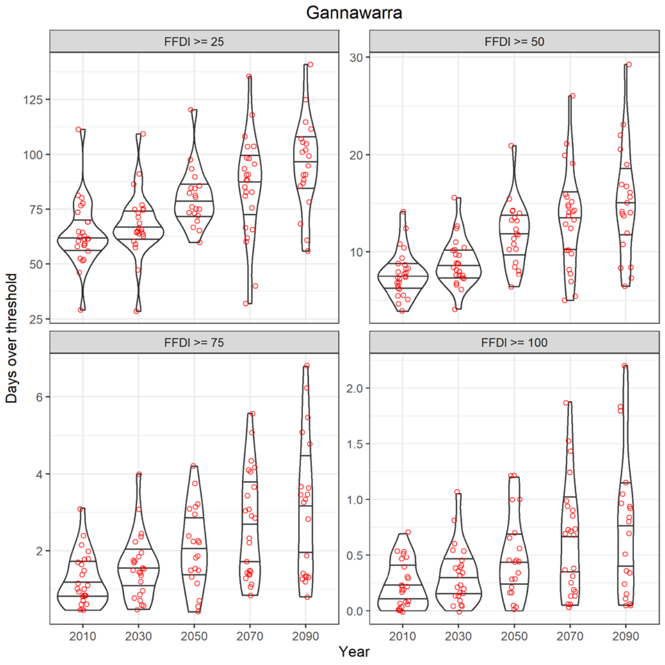

Melbourne Airport
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
20
40
60
0
4
8
12
16
1
2
0.00
0.25
0.50
0.75
1.00
2010
2030
2050
2070
2090


Hawkesdale
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
0
20
40
5
10
1
2
3
0.0
0.5
1.0
1.5
2.0
2020
2040
2060
2080
2100

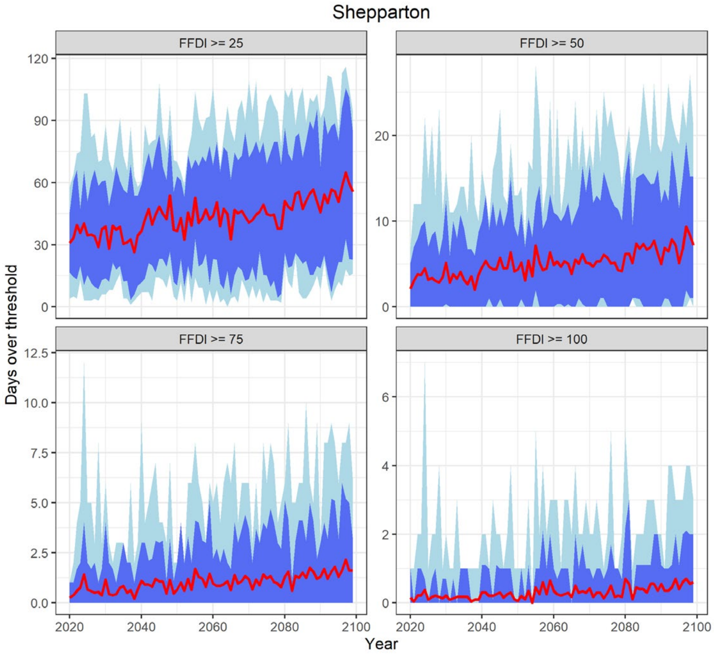

Hawkesdale
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
10
20
30
0
2
4
6
0.00
0.25
0.50
0.75
1.00
0.0
0.1
0.2
2010
2030
2050
2070
2090

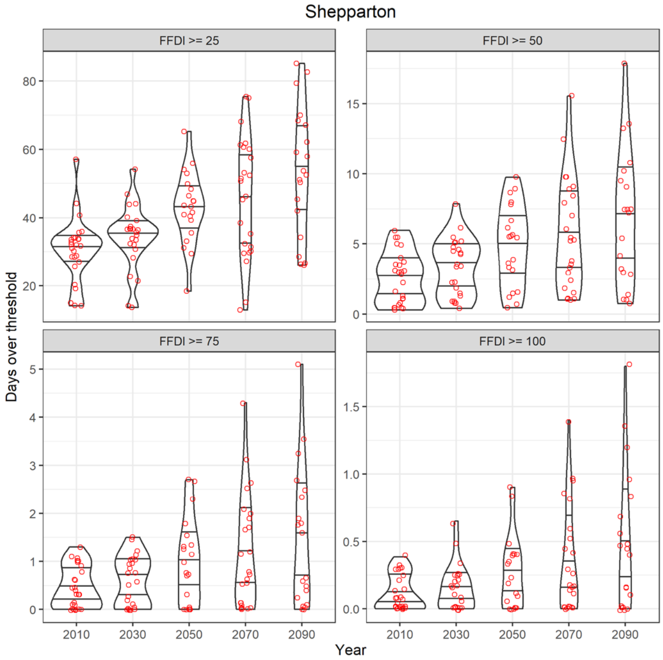
Path 4

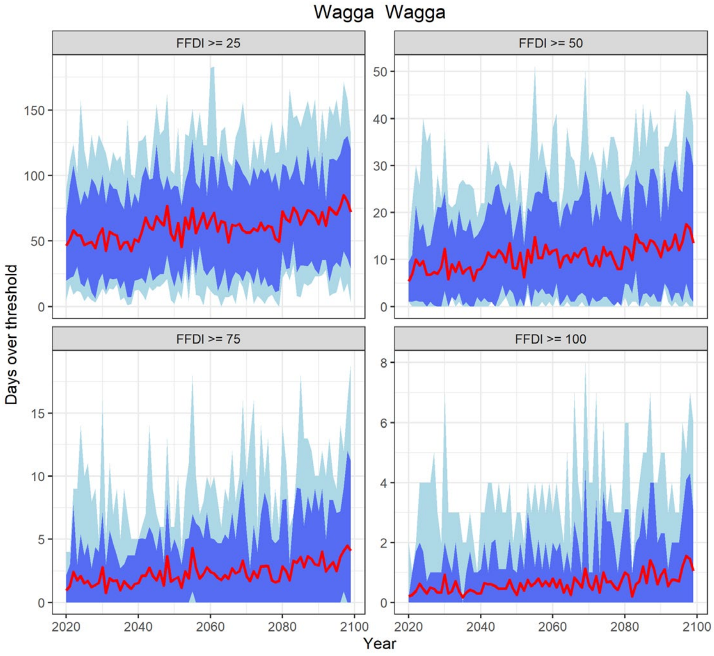

Gannawarra
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
0
50
100
150
10
20
30
40
5
15
2
4
6
2020
2040
2060
2080
2100

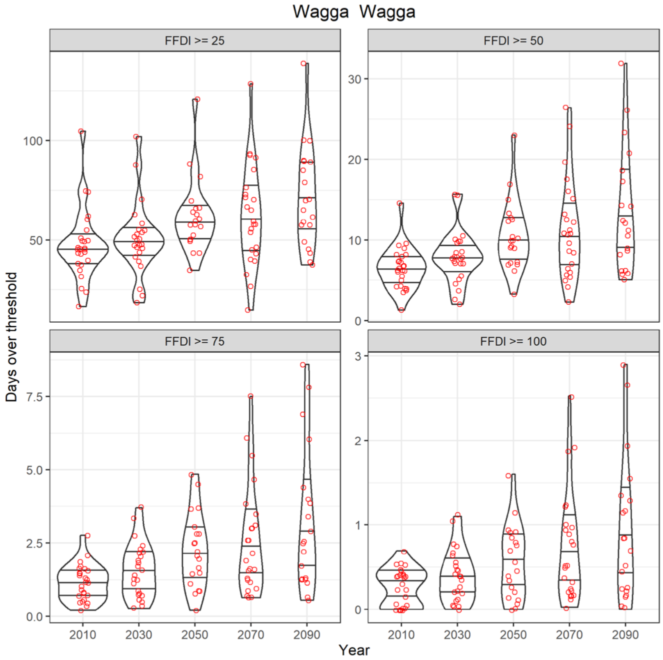

Gannawarra
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
25
50
75
100
125
10
20
30
2
4
6
0.0
0.5
1.0
1.5
2.0
2010
2030
2050
2070
2090

Path 5


Shepparton
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
0
30
60
90
120
0
10
20
0.0
2.5
5.0
7.5
10.0
12.5
0
2
4
6
2020
2040
2060
2080
2100


Shepparton
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
20
40
60
80
0
5
10
15
0
1
2
3
4
5
0.0
0.5
1.0
1.5
2010
2030
2050
2070
2090


Wagga Wagga
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
0
50
100
150
0
10
20
30
40
50
0
5
10
15
0
2
4
6
8
2020
2040
2060
2080
2100


Wagga Wagga
FFDI >= 25
FFDI >= 50
FFDI >= 75
FFDI >= 100
Days over threshold
Year
50
100
0
10
20
30
0.0
2.5
5.0
7.5
0
1
2
3
2010
2030
2050
2070
2090