



# Mapping bushfire hazard and impacts

Research advisory forum / 2019

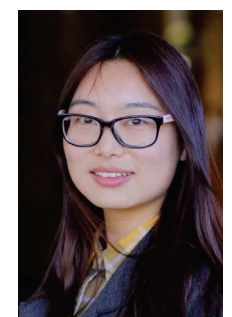
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@Li\_Zhao



bushfire&natural  
**HAZARDS**CRC



Australian Government  
Department of Industry,  
Innovation and Science

**Business**  
Cooperative Research  
Centres Programme

# AFMS: Agreed developments priorities

Order the following future developments by priority

Dry/transition/wet maps based on empirical FMC threshold values that explain fire occurrence

Yes and no 1st

Deciles maps

2nd Y

Times series plumes showing max/min/median instead of 3 previous years

3rd Y

Include information on forest cover

4th Y

Include the uncertainty in the pop-up for a pixel

5th Y

Download Grid as GeoTIFF

6th Y

Distribution of values within a polygon

7th Y

Include incident feed

8th Y



Live Fuel Moisture Co ▾    << < 2019-10-10 > >>    States and Territories ▾    Grid ▾    Entire area ▾

- Live Fuel Moisture Content
- Flammability
- Flammability (Deciles)
- FMC (Deciles)**
- LFMC Uncertainty
- Soil Moisture 0-10cm
- Soil Moisture 10-35cm

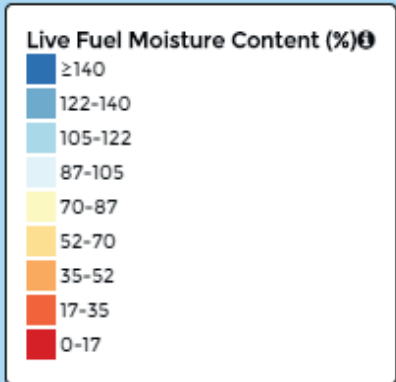
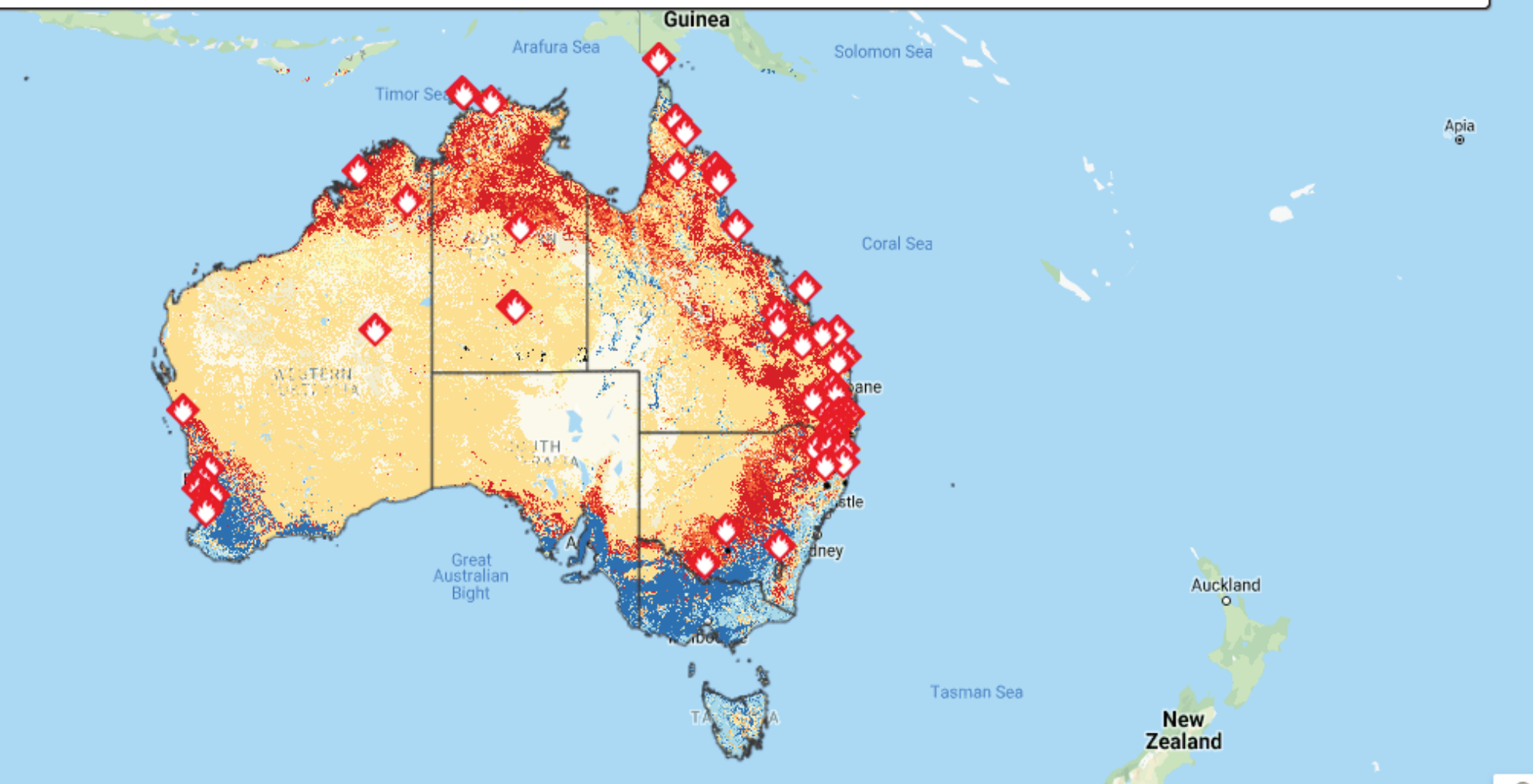
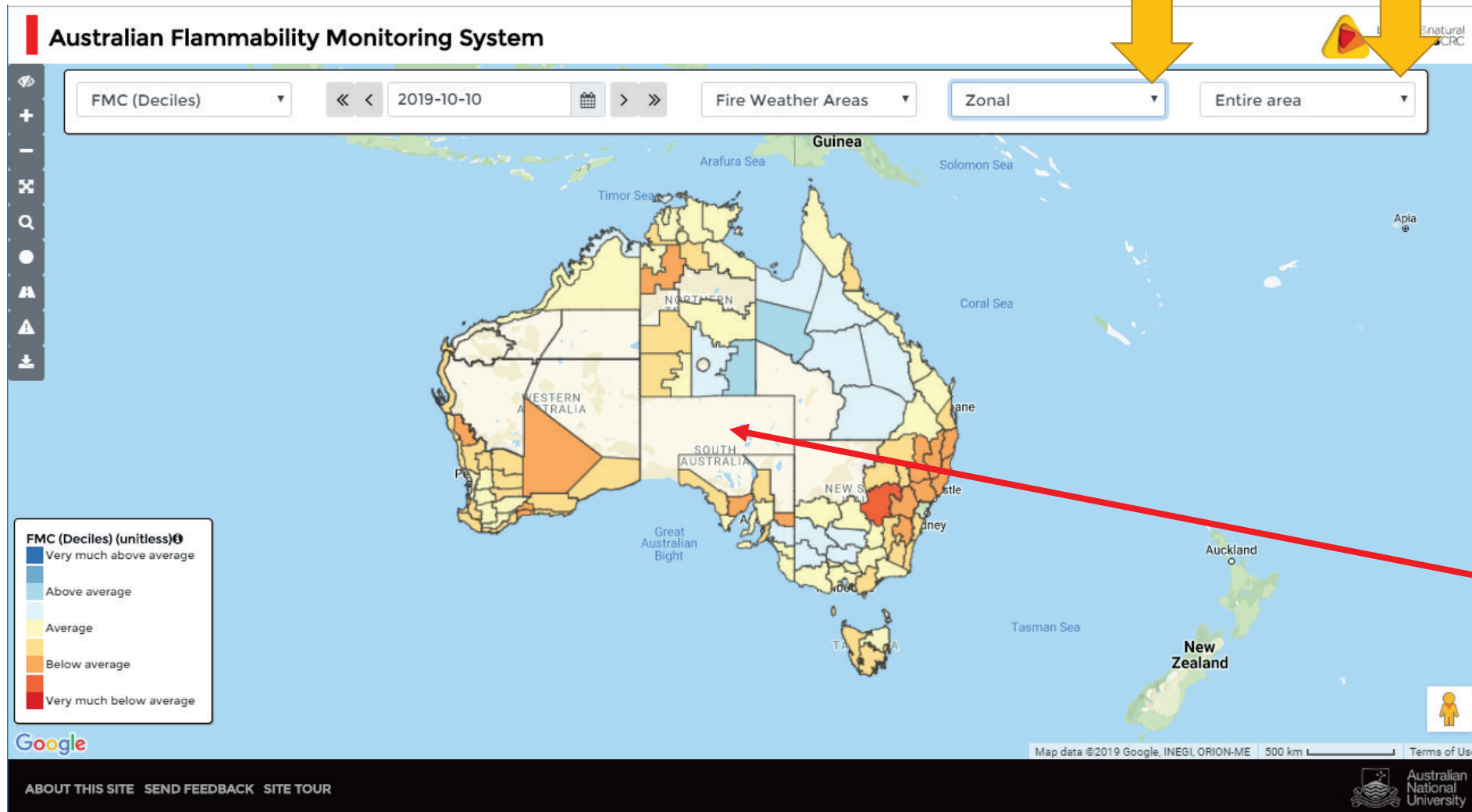


Chart ⌵



# Deciles maps:

will tell you whether FMC or FI is above average, average or below average in comparison to the observations for a given month in the previous years (2001-year before current) and for a given pixel ("Grid" view) or region ("Zonal" view, e.g. fire weather areas)



Gaps ~ 85% of valid pixels in the polygon




# How can deciles maps be used?

NSW RFS @NSWRFS · Oct 8

Hot and dry weather will continue across northern NSW today (Tues 8/10/19), with total fire bans declared for the Far North Coast, North Coast, New England and Northern Slopes. If you're travelling, know the fire danger for your area by checking [rfs.nsw.gov.au/fdr](https://rfs.nsw.gov.au/fdr) #nswrfs

**A TOTAL FIRE BAN MEANS NO FIRES IN THE OPEN**



1 Far North Coast	12 Northern Slopes
2 North Coast	13 North Western
3 Greater Hunter	14 Upper Central West Plains
4 Greater Sydney Region	15 Lower Central West Plains
5 Illawarra/Shoalhaven	16 Southern Slopes
6 Far South Coast	17 Eastern Riverina
7 Monaro Alpine	18 Southern Riverina
8 ACT	19 Northern Riverina
9 Southern Ranges	20 South Western
10 Central Ranges	21 Far Western
11 New England	

**FIRE DANGER RATING**

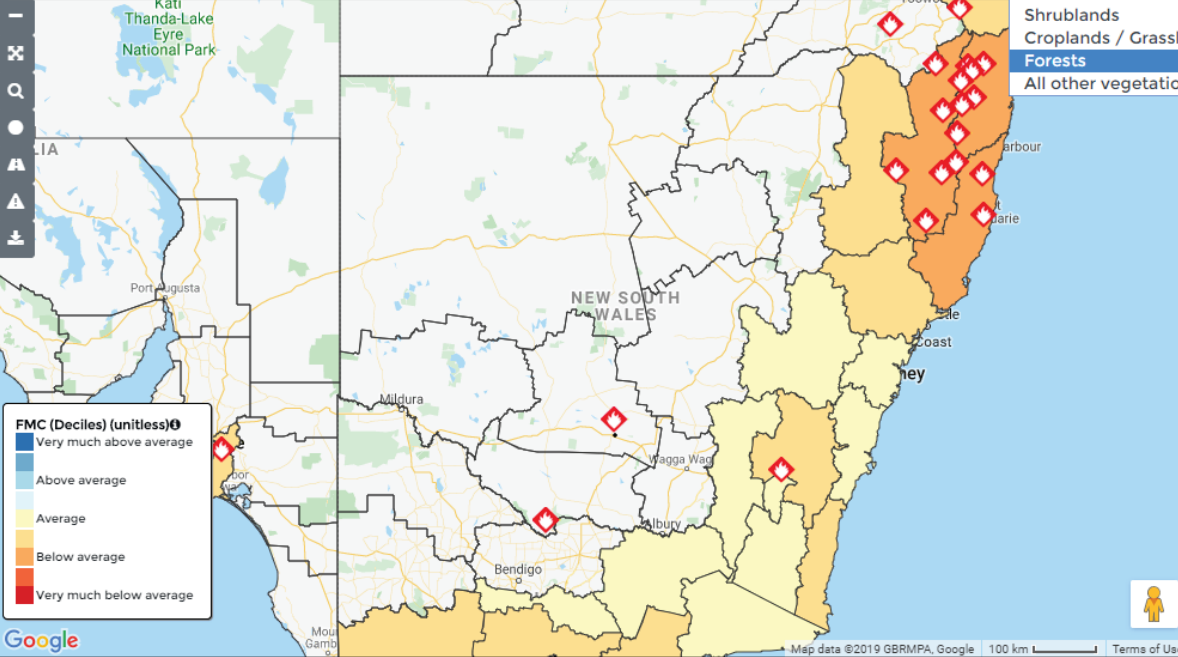
Low - Moderate	High	Very High
Severe	Extreme	Catastrophic

**DON'T BE THE FIRE RISK TO YOUR COMMUNITY.**

[www.rfs.nsw.gov.au](https://www.rfs.nsw.gov.au) | 1800 679 737

**Australian Flammability Monitoring System**

FMC (Deciles) 2019-10-08 Fire Weather Zonal Forests



**FMC (Deciles) (unitless)**

- Very much above average
- Above average
- Average
- Below average
- Very much below average

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Australian National University

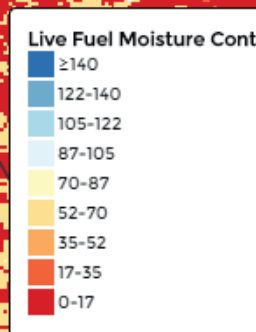
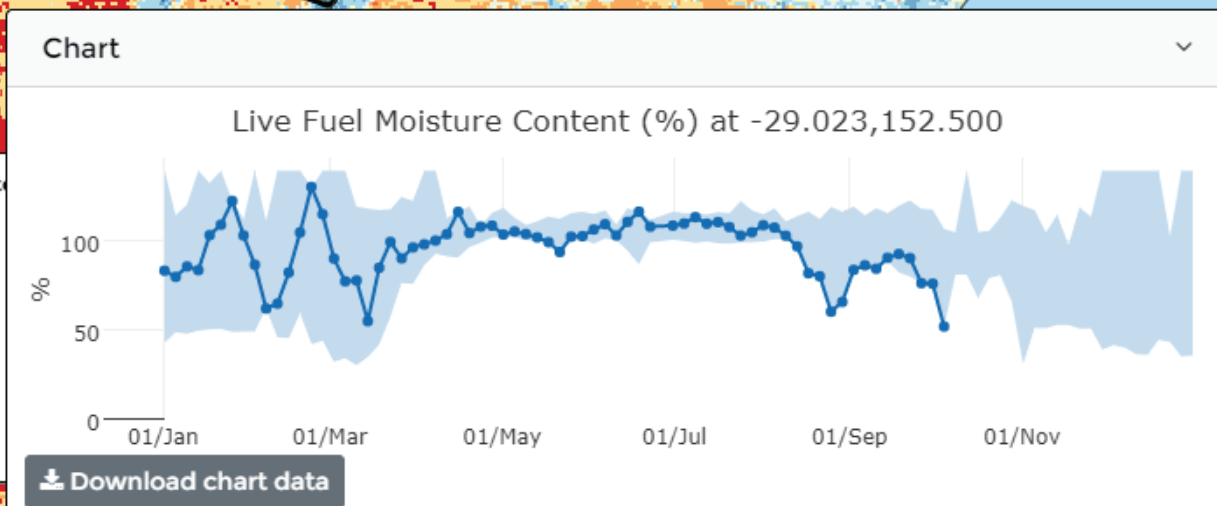
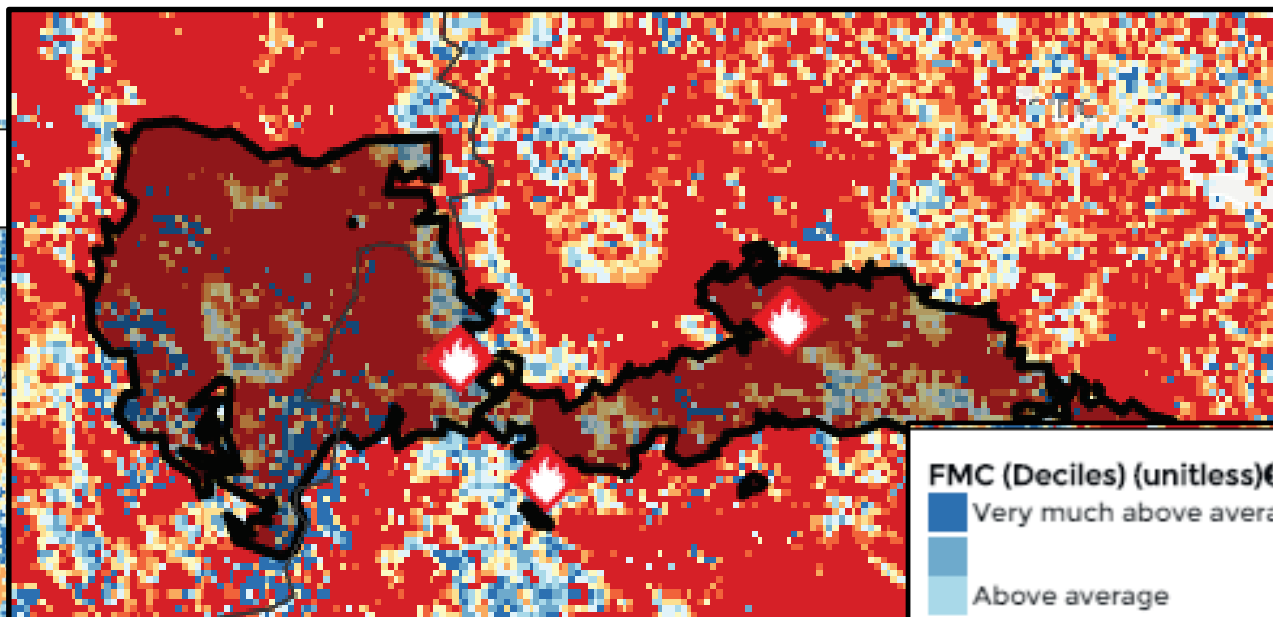
# Other new features

## Australian Flammability Monitoring System

Live Fuel Moi: ▼    << < 2019-10-08 > >>    Fire Weather: ▼

ALERT LEVEL: Advice  
LOCATION: Long Gully Rd, Drake, NSW  
COUNCIL AREA: Tenterfield  
STATUS: Under control  
TYPE: Bush Fire  
FIRE: Yes  
SIZE: 74111 ha  
MAJOR FIRE UPDATE AS AT 15 Oct 2019 5:43PM: [More information](#)  
RESPONSIBLE AGENCY: Rural Fire Service  
UPDATED: 15 Oct 2019 16:22

**Toggle current incidents**



Flammability

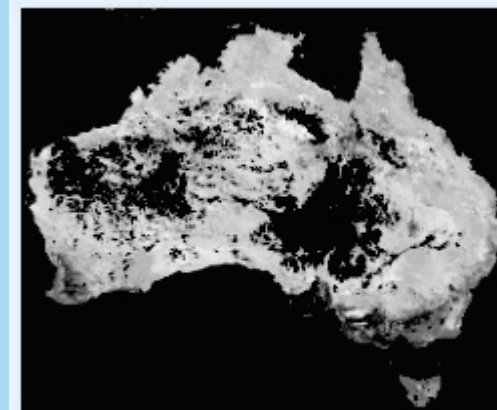
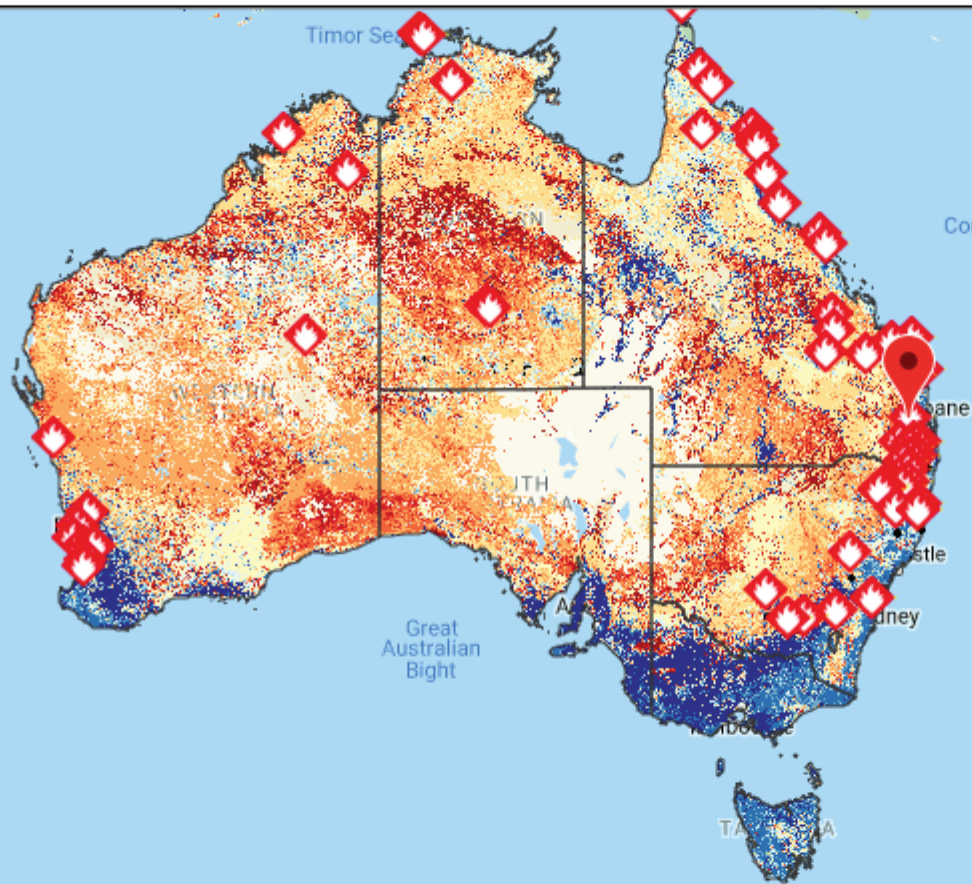


2019-10-16



States and Territories

Entire area



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Apia

Auckland

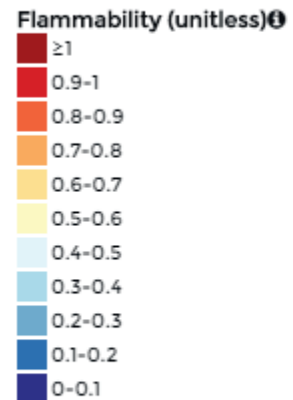
New Zealand



Chart

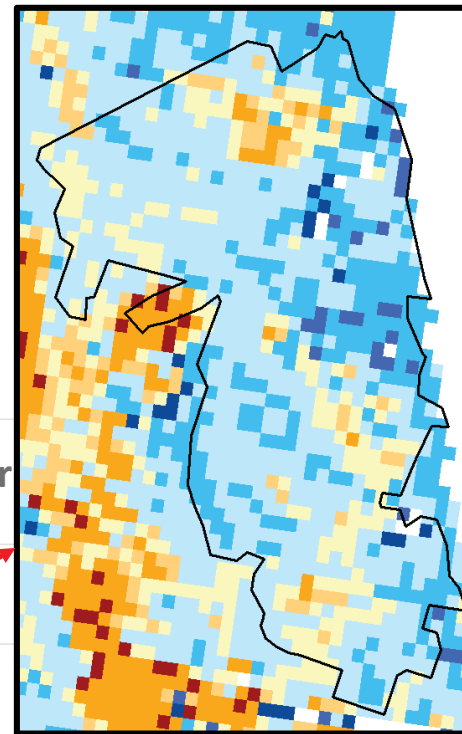
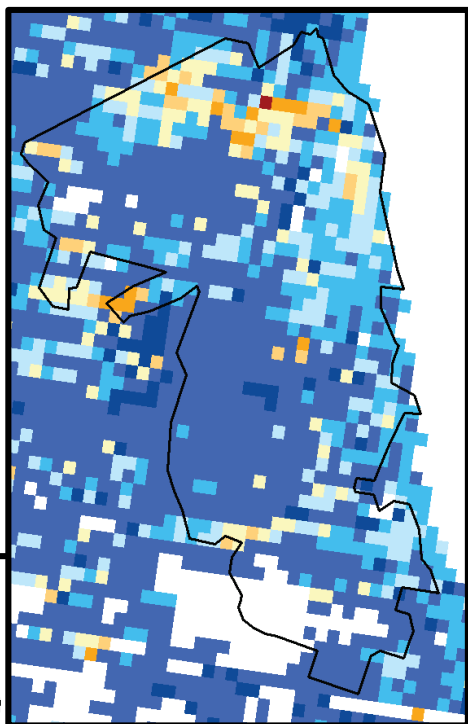
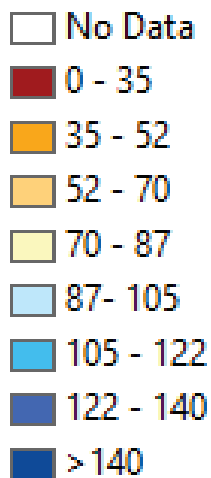


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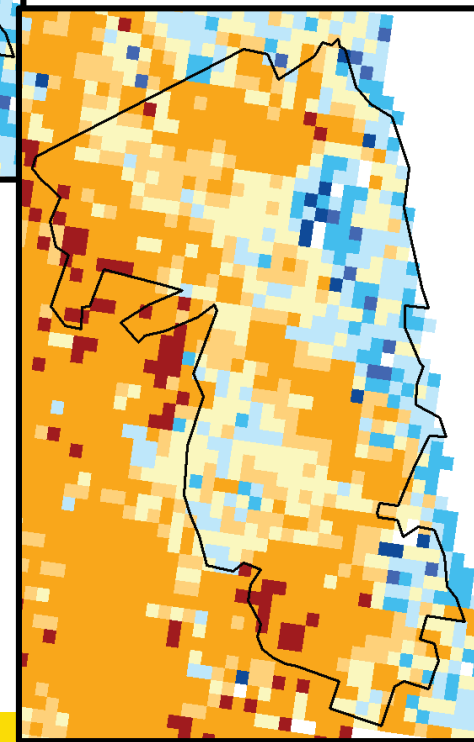
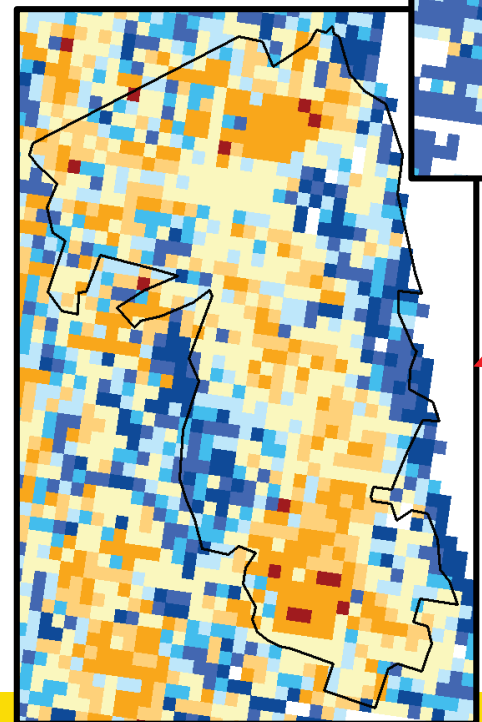
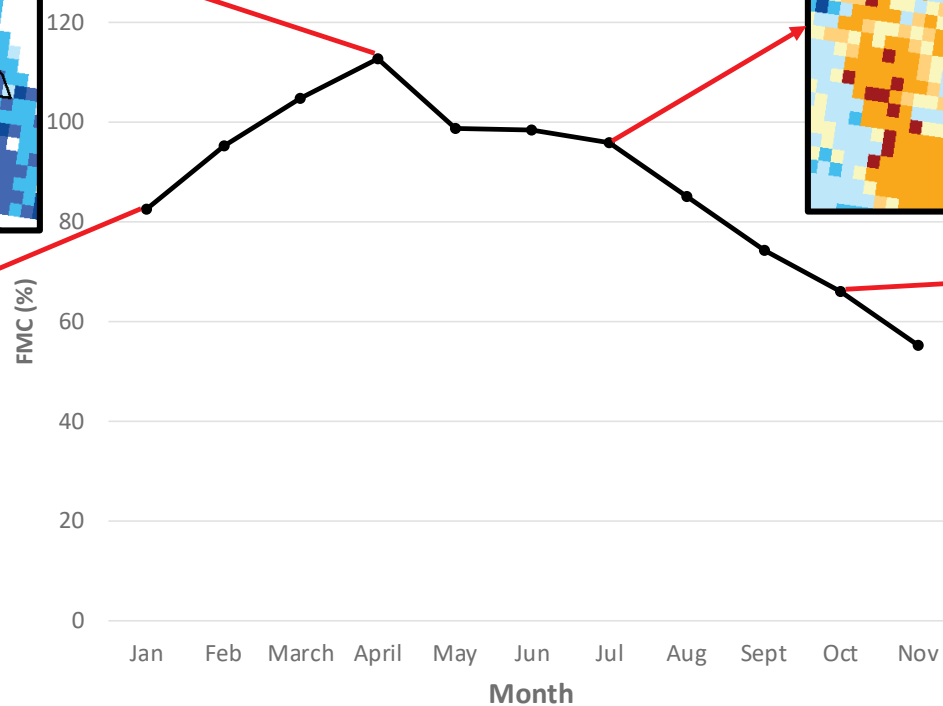


# Temporal FMC dynamics: Deepwater fire 2018

FMC (%)

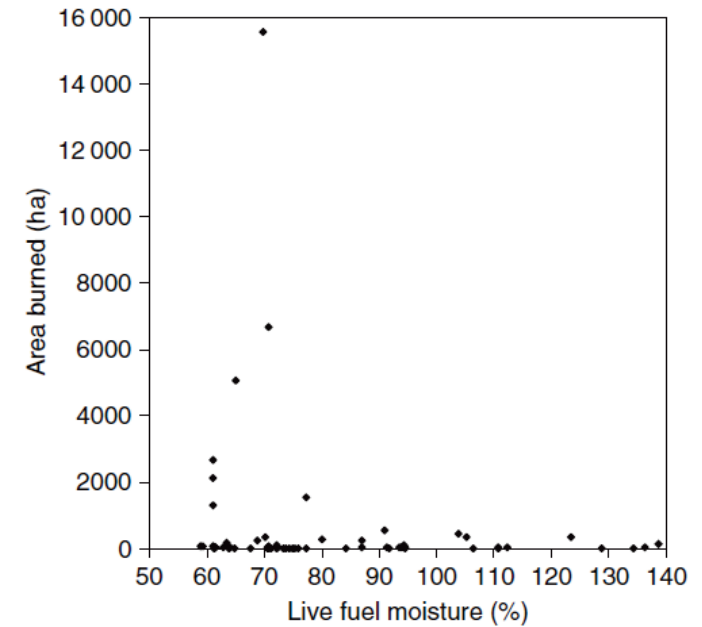
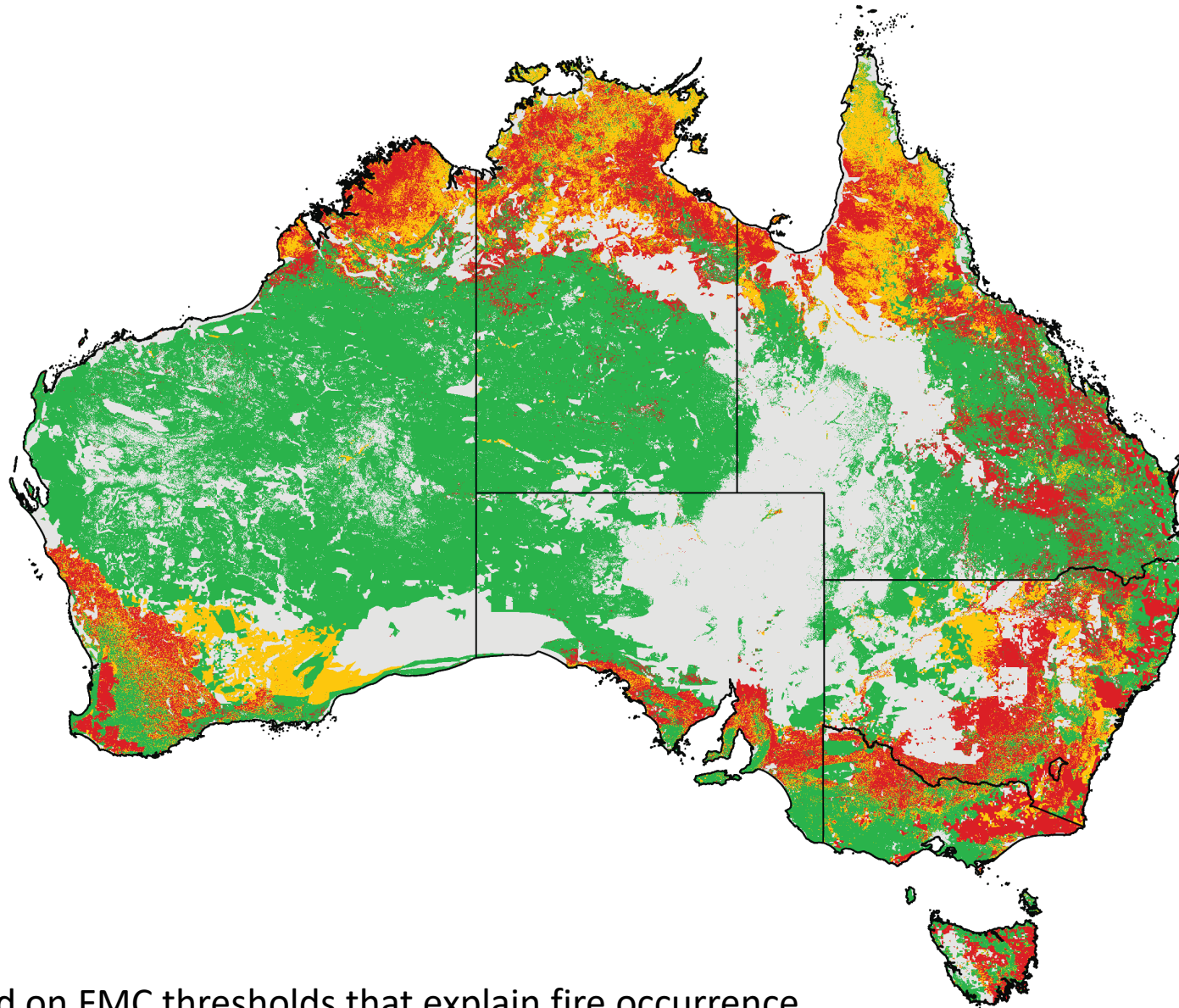


Mean for Deepwater fire perimeter





# FMC map for Australia

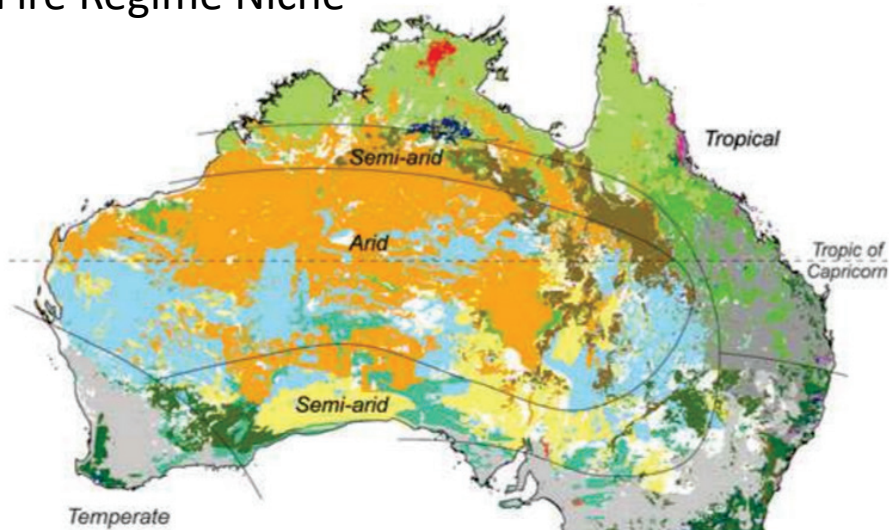


Based on FMC thresholds that explain fire occurrence

Dennison *et al.* 2008, IJWF

# FMC empirical thresholds

## Fire Regime Niche



**Table 1: Approximate LFMC threshold values indicating marked increases in burnt area, and the proportion of each studied niche burnt during the studied time period (2002-2014).**

Fire Regime Niche	Threshold LMFC (%)	% Area Burnt
Temperate Eucalypt forest	160, 135	1.6
Tall Temperate Eucalypt Forest	160, 130	6.5
Temperate heath	55, 20	6.4
Tropical and subtropical pasture	20	10.7
Cropland pasture	65, 20	14.49
Temperate Eucalypt woodland	130, 45	2.5
Tropical Eucalypt forest and woodland	45, 15	26.9
Tropical Heath	95, 50, 20	158.2
Eucalypt savanna woodland	90, 55, 20	19.7
Temperate mallee	45	3.1
Acacia shrubland (mulga)	45	9.2
Hummock grassland	45, 20	43.5

- Rain forest (tropical): Rare low-intensity litter fires in spring
- Tall eucalypt forest (temperate): Very infrequent high-intensity crown fires in summer
- Eucalypt forest (temperate): Infrequent low-intensity litter fires in spring and medium-intensity shrub fires in spring and summer
- Rain forest (temperate): Rare low-intensity litter fires in autumn
- Heath (temperate): Infrequent medium-intensity shrub fires in spring and summer
- Pasture (tropical and subtropical): Infrequent low-intensity grass fires in spring and summer
- Pasture, cropland (temperate): Infrequent low-intensity grass fires in autumn
- Eucalypt woodland (temperate): Infrequent low-intensity litter fires in spring and medium-intensity grass fires in summer
- Eucalypt forest and woodland (tropical): Infrequent low-intensity grass fires in winter and medium-intensity shrub fires in spring
- Acacia woodland (brigalow) (tropical semi-arid): Rare medium-intensity crown fires in spring and summer
- Tussock grassland (temperate semi-arid): Very infrequent low-intensity fires in autumn or medium-intensity grass fires in spring and summer
- Heath (tropical): Infrequent medium-intensity shrub fires in winter and spring
- Eucalypt savanna woodland (monsoon tropical): Very frequent low-intensity grass fires in winter and spring
- Mallee (temperate): Infrequent medium-intensity shrub fires in spring and summer
- Acacia woodland (lancewood) (tropical semi-arid): Very infrequent medium-intensity shrub fires in spring
- Acacia shrubland (mulga) (semi-arid/arid): Rare low-intensity grass or medium-intensity shrub fires in spring and summer
- Eucalypt woodland (tropical semi-arid): Frequent to infrequent low-intensity grass fires in spring and summer
- Chenopod shrubland (semi-arid/arid): Rare low-intensity litter fires in spring and summer
- Hummock grassland (semi-arid/arid): Infrequent medium-intensity grass fires in spring
- Tussock grassland (tropical semi-arid/arid): Very infrequent low-intensity grass fires in spring and summer
- No data

Murphy et al (2013)

Gale et al., 2017



# Some examples of current use

David Taylor (Tasmania) “tools for out Fire Duty Officer → Bushfire Operational Hazard Model(BOHM) “... if you were to drop a match how hot a fire would get, **we use that in prepositioning fire crews and patrols**”

Simeon Telfer (WA) “we are using it in the western part of South Australia for **planning our burning** this spring, as some areas are well below average rainfall and are experiencing more dramatic fire behaviour, while other areas are more like average.”

Stuart Matthews (NSW) “this (new realise AFMS) is a huge advance in making the data useful for operations!

A couple of things that stand out for me:

- Area averaged moisture deciles (which capture current incidents in NSW very well)
- Being able to see the seasonal state of grasses compared to their usual and range of values.”





# Towards a comprehensive Fire Danger Index

**Dependent variable:** Fire ignitions (date+intensity)

**Drivers:**

Fuel condition

- MODIS-derived **LFMC** (%) – 500m (Yebra *et al.* 2018)

Bureau of Meteorology Landscape water balance model predictions (~5km) (van Dijk, 2010)

- Top soil moisture (**w0**, fraction of plant available water capacity)
- Shallow soil moisture (**ws**)
- Deep soil moisture (**wd**)

Fire weather

Bureau of Meteorology daily gridded climate data (~5km):

- Maximum temperature (**Tmax**, °C)
- Daily mean wind speed (**Uavg**, m/s)

Calculated from *Tmax* and Vapour pressure at 3pm

- Relative Humidity (**RH**, %)
- Vapour pressure deficit (**VPD**, Pa)

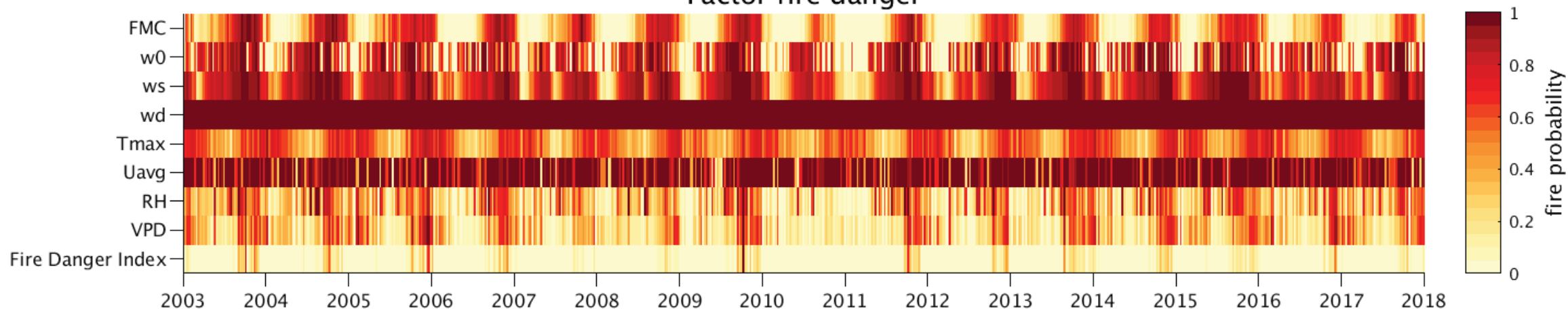
All data available for 2003-2017 and resampled (from 500-m to 5-km) to 2.5 km and daily time step.



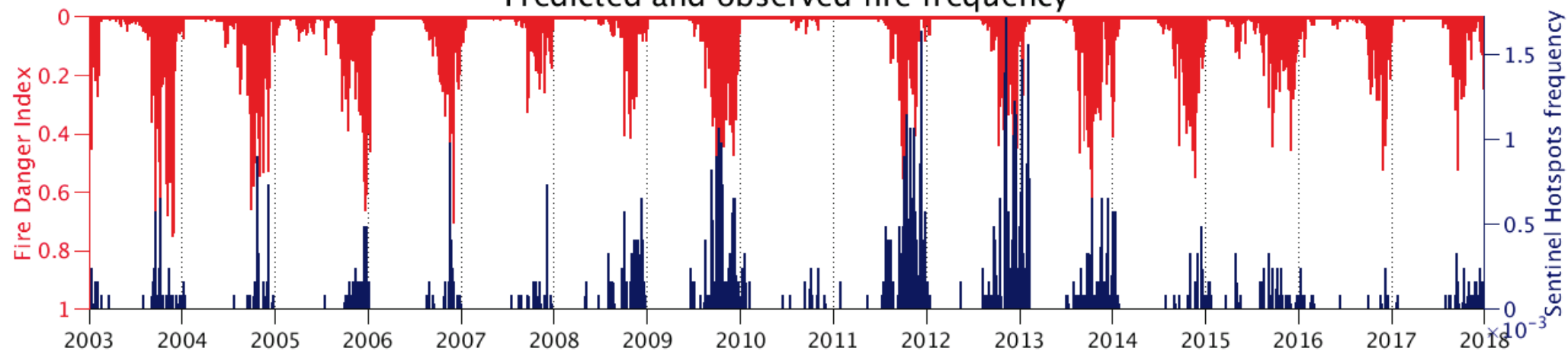
# Evaluation example

Herbert and Lower Burdekin (QLD) – grassland (  $N=293$  )

Factor fire danger

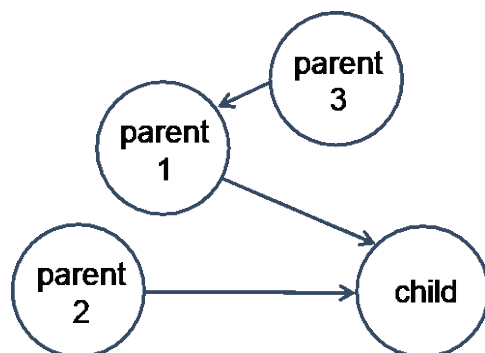


Predicted and observed fire frequency



# Future work: Bayesian Learning Networks

- **Data driven** approach to avoid subjective combining of fire drivers
- Derive **causal relationship** between variables

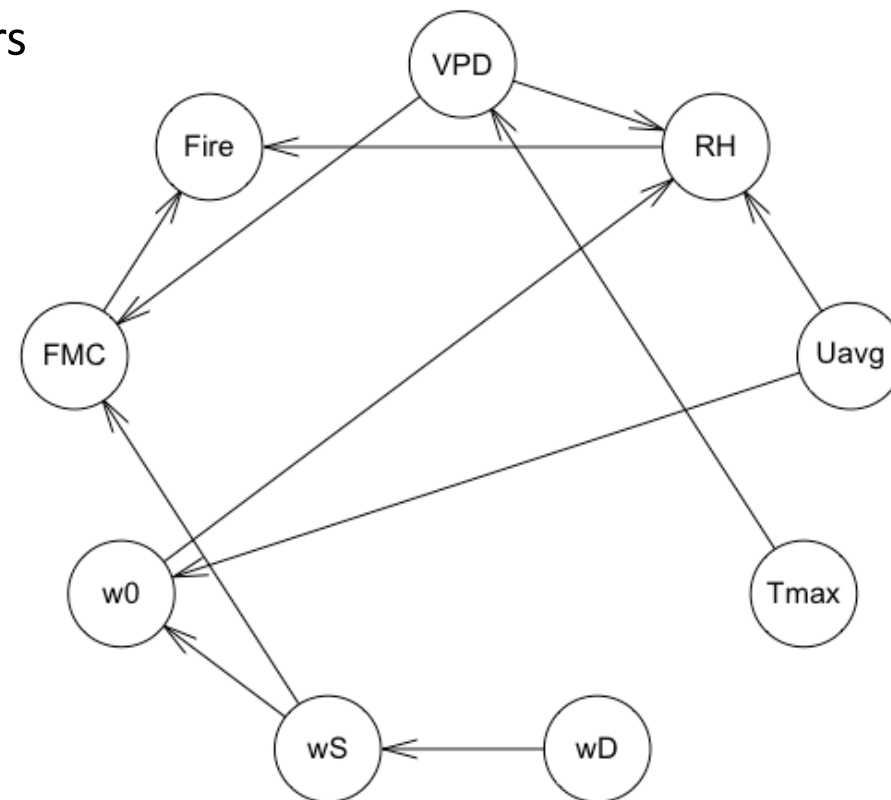


Joint distribution

$$p(\text{child}|\text{par. 1, par. 2})p(\text{par. 1}|\text{par. 3})$$

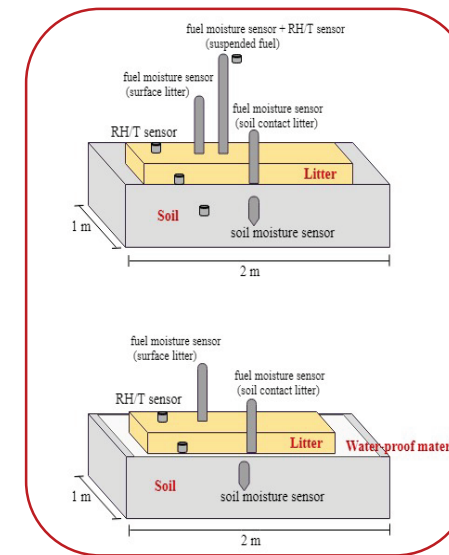
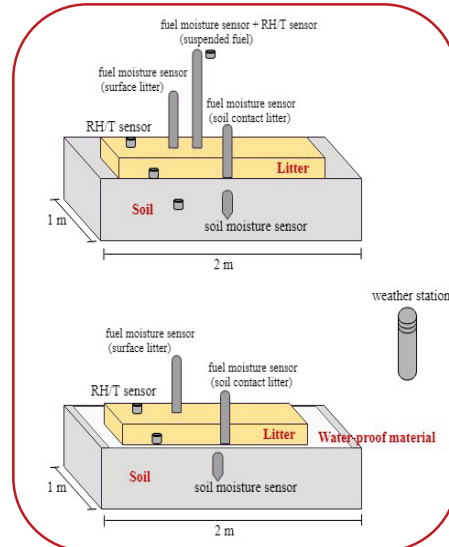
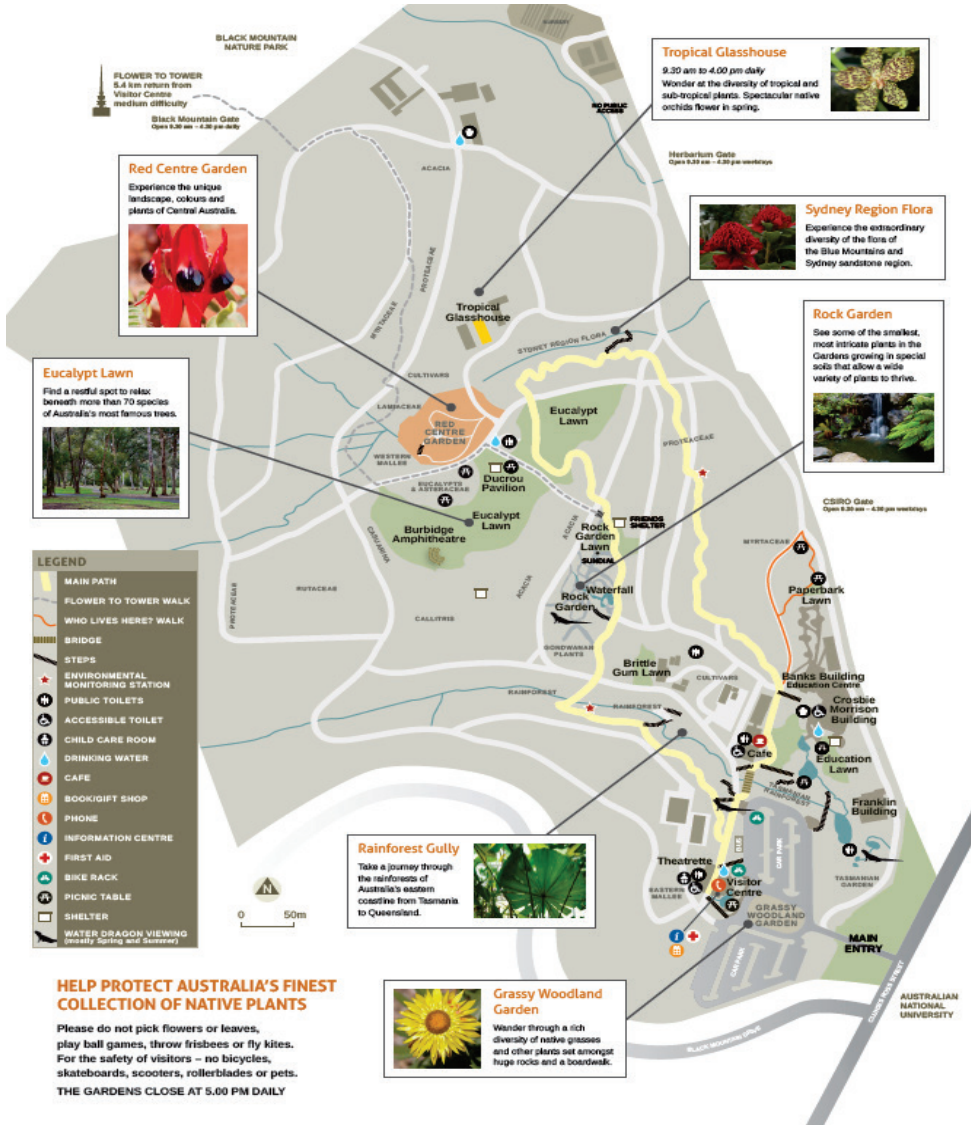
- Provides **joint probability distribution** as inferred from the data

$$\text{Joint pd} = p(wD) p(Tmax) p(Uavg) p(wS|wD) p(VPD|Tmax) p(FMC|wS,VPD) \\ p(w0|wS,Uavg) p(RH|w0, Uavg, VPD) p(\text{Fire}|FMC,RH)$$



e.g. Region 42

# Coupling Litter and soil moisture dynamics for dead FMC





# AFMS: Future developments:

**High-resolution AFMS (<30m)** Using satellite imagery from the Geoscience Australia Digital Earth Australia (GA-DEA) database  
→ pilot areas in the ACT and the Sydney Basin Region.

- Open more opportunities for use (e.g. schedule and plan prescribed burns in topographic terrain)
- Facilitate the sustainability of the AFMS in the longer term, as we transition the current service to GAInclude

**Include our new FDI**

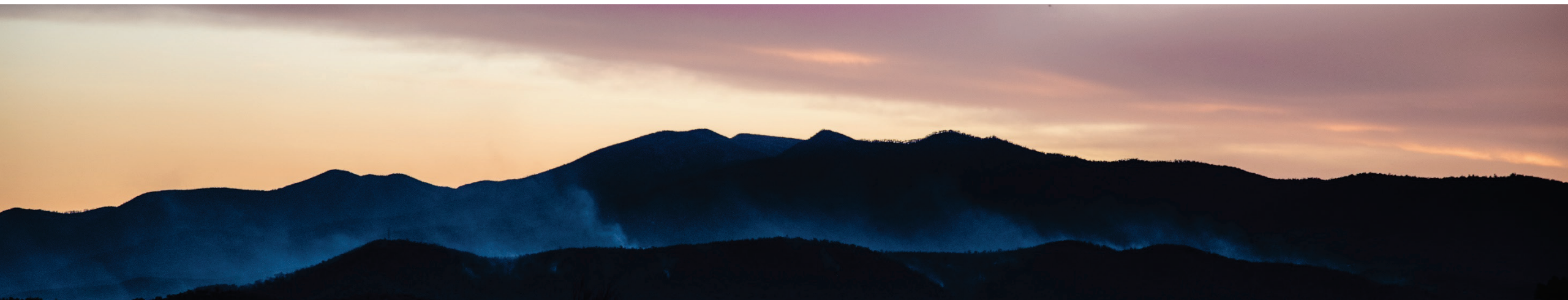
**Fire Danger forecast** (using BoM ACCESS weather forecast)







# Thanks



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