Anatomy of a perfect storm
Australia's 'Black Summer' forest fires of 2019/20

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with contributions from:
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Photo: Climate Council

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NSW Bushfire Risk Management Research Hub

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Anatomy of a perfect storm

Australia's 'Black Summer' forest fires

- Summary of events and impact
- Global context and significance
- Evaluation of biophysical drivers/constraints

Photo: Climate Council

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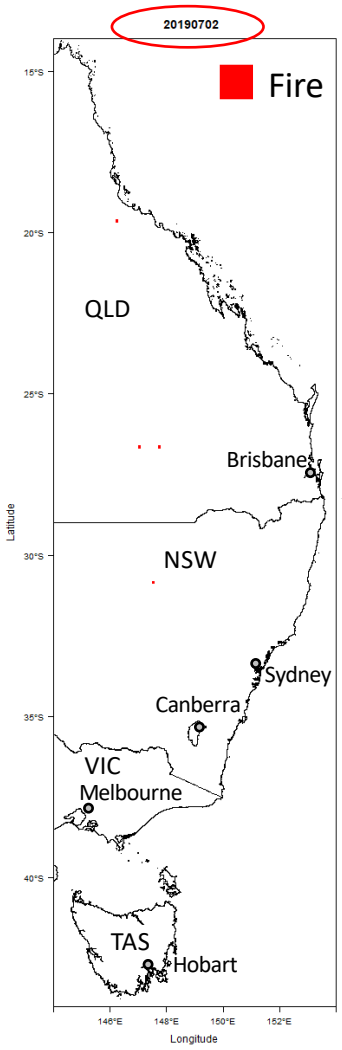
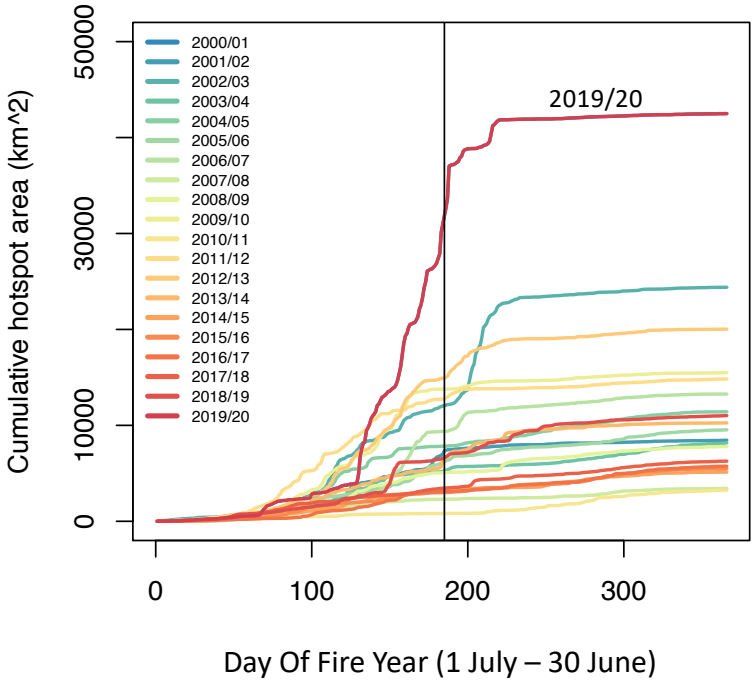
Eastern Australia – unfolding of 2019/20 events


Photo: Lachie Millard (The Australian)





Source: Boer, unpublished data

Eastern Australia – unfolding of 2019/20 events

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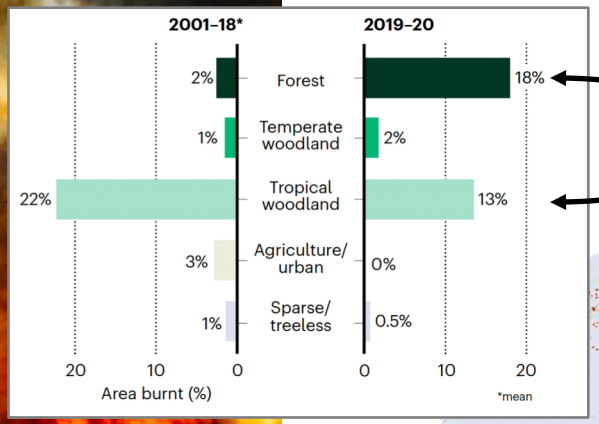
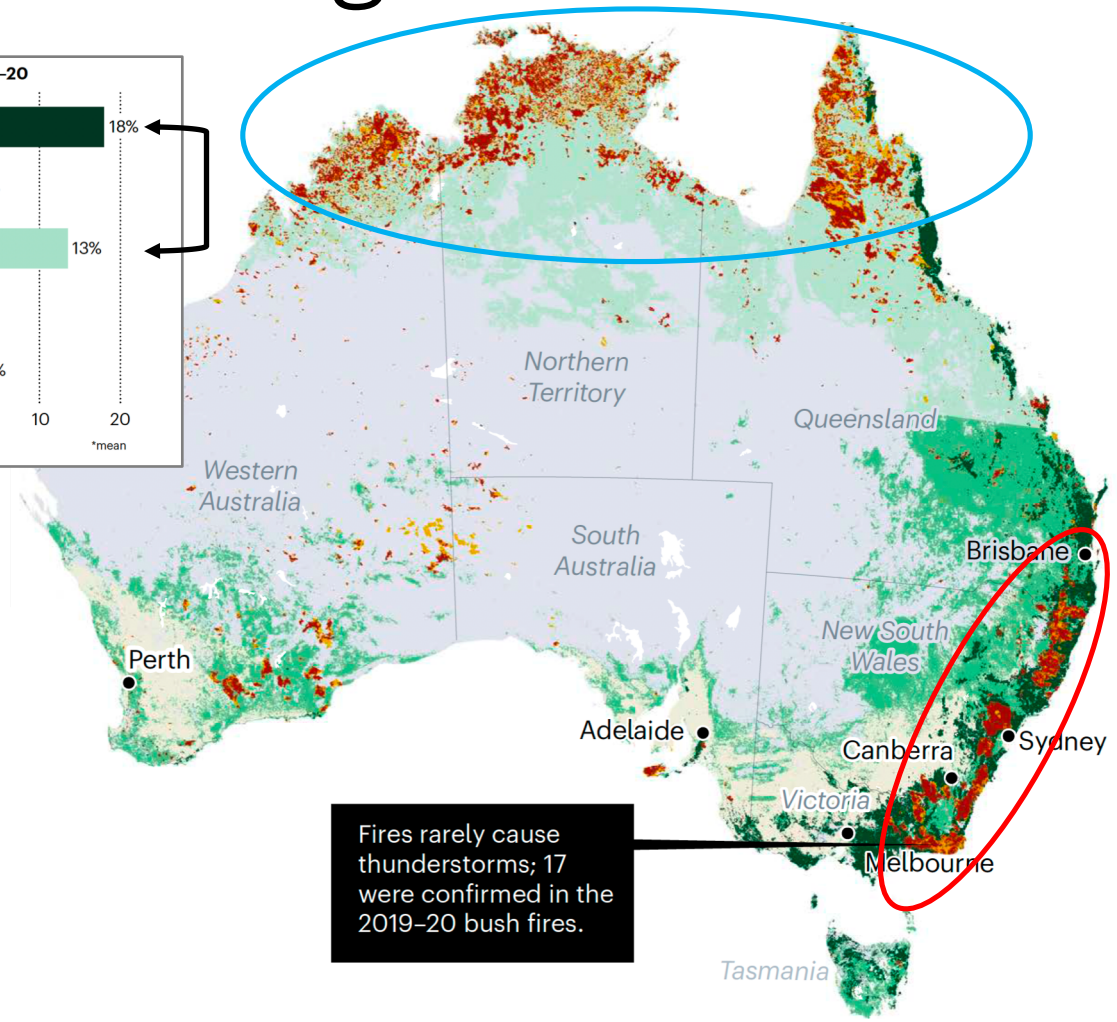
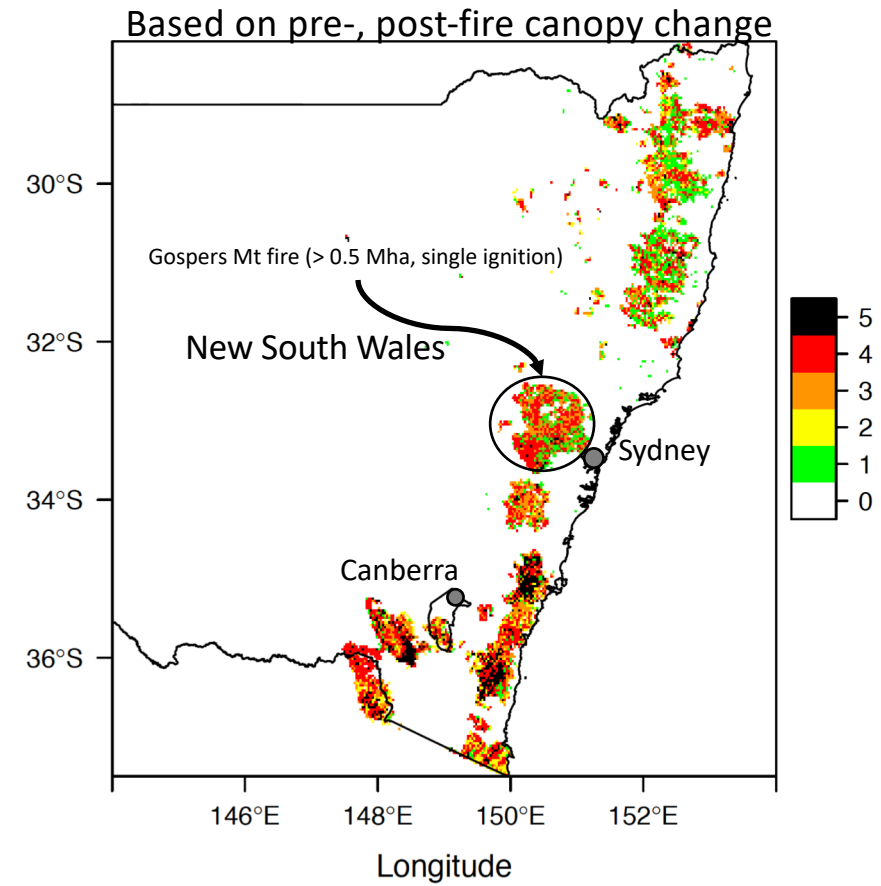




Bowman et al. (2020) Nature

Fire severity

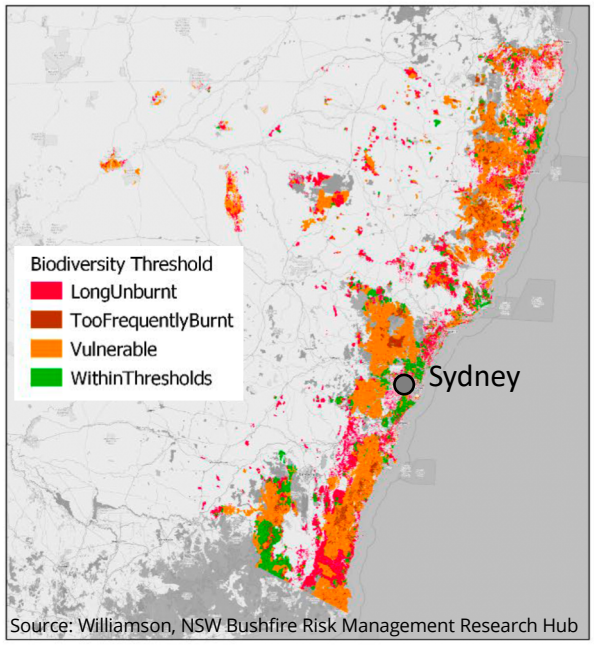


Gibson et al. (2020) RSE

Magnitude of ecological impact

<u>New South Wales + Australian Capital Territory</u>

- 5.4 Mha burned, mainly forest.
- 81 percent of the Blue Mountains World Heritage Area and 54 percent of the Gondwana Rainforests in NSW and QLD burned.
- Significant % of entire range of threatened species (e.g. koala) affected.
- Large fraction of forest area is now vulnerable to "interval squeeze" (i.e. actual fire interval < tolerable fire interval).
- Potentially significant synergistic effects of record drought and fire on tree mortality.



Source: Williamson, NSW Bushfire Risk Management Research Hub


Photo: Darcy Grant

Smoke & Public Health

Research letters

Unprecedented smoke-related health burden associated with the 2019–20 bushfires in eastern Australia

Nicolas Borchers Arriagada[1], Andrew J Palmer[1], David MJS Bowman[2], Geoffrey G Morgan[3,4], Bin B Jalaludin[4,5], Fay H Johnston[1,2]

Weather conditions conducive to extreme bushfires are ... of Planning, Industry and Environment,[5] the Queensland becoming more frequent as a change.[1] Such fires have subst and economic effects, including the effe sociated with smoke, such as premature tion of cardio-respiratory conditions.[2,3] of 2019 and the first of 2020, bushfires b regions of Australia, and smoke affecte ple in New South Wales, Queensland, Territory and Victoria. The scale and du was unprecedented in Australia. We u evaluation of the health burden attribut erated by bushfires during this period.

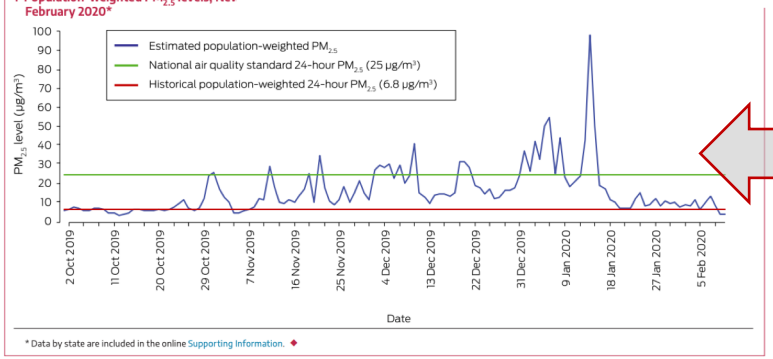
Using standard methods for assessing the lution,[4] we estimated the numbers of ex tions for cardiovascular and respiratory p department presentations with asthma i ACT and Victoria between 1 October 20 that could be attributed to bushfire smok

We estimated population exposure to pa 2.5 μm in diameter ($PM_{2.5}$) for the regio the ACT and Victoria for which publicly a itoring data were available (for about 90 of these states). Data were obtained fro

2 Estimated health burden attributable to bushfire smoke, Queensland, New South Wales, the Australian Capital Territory and Victoria, 1 October 2019 – 10 February 2020

Outcome	Estimated number of cases (95% confidence intervals)				
	Queensland	New South Wales	Australian Capital Territory	Victoria	Total
Excess deaths (any cause)	47 (17–77)	219 (81–357)	31 (12–51)	120 (44–195)	417 (153–680)
Hospital admissions, cardiovascular	135 (25–246)	577 (108–1050)	82 (15–149)	331 (62–602)	1124 (211–2047)
Hospital admissions, respiratory	245 (0–513)	1050 (0–2204)	147 (0–308)	585 (0–1227)	2027 (0–4252)
Emergency department attendances, asthma	113 (61–165)	702 (379–1026)	89 (48–131)	401 (217–586)	1305 (705–1908)

1 Population-weighted $PM_{2.5}$ levels, Nev February 2020*



* Data by state are included in the online Supporting Information.

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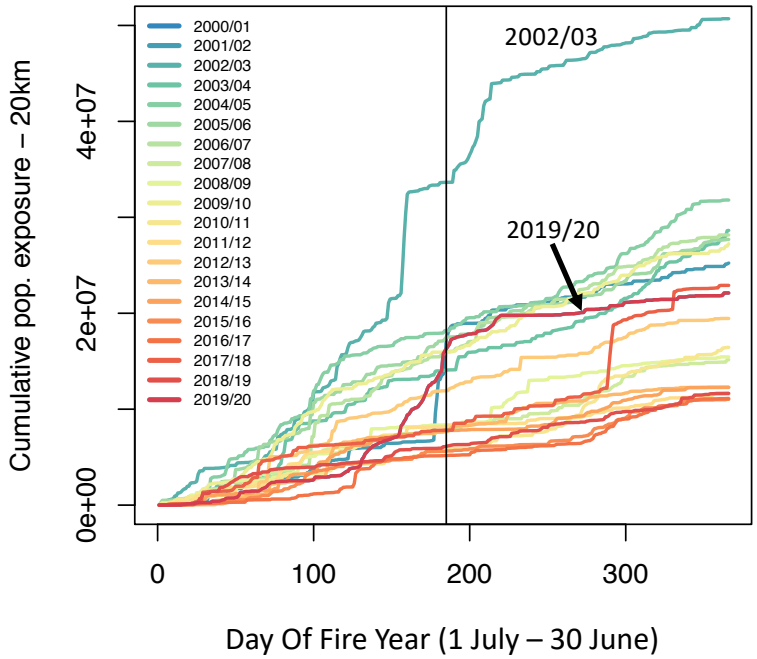
• doi: 10.5694/mja2.50545

Borchers Arriagada et al/ (2020) *Australian Medical Journal*

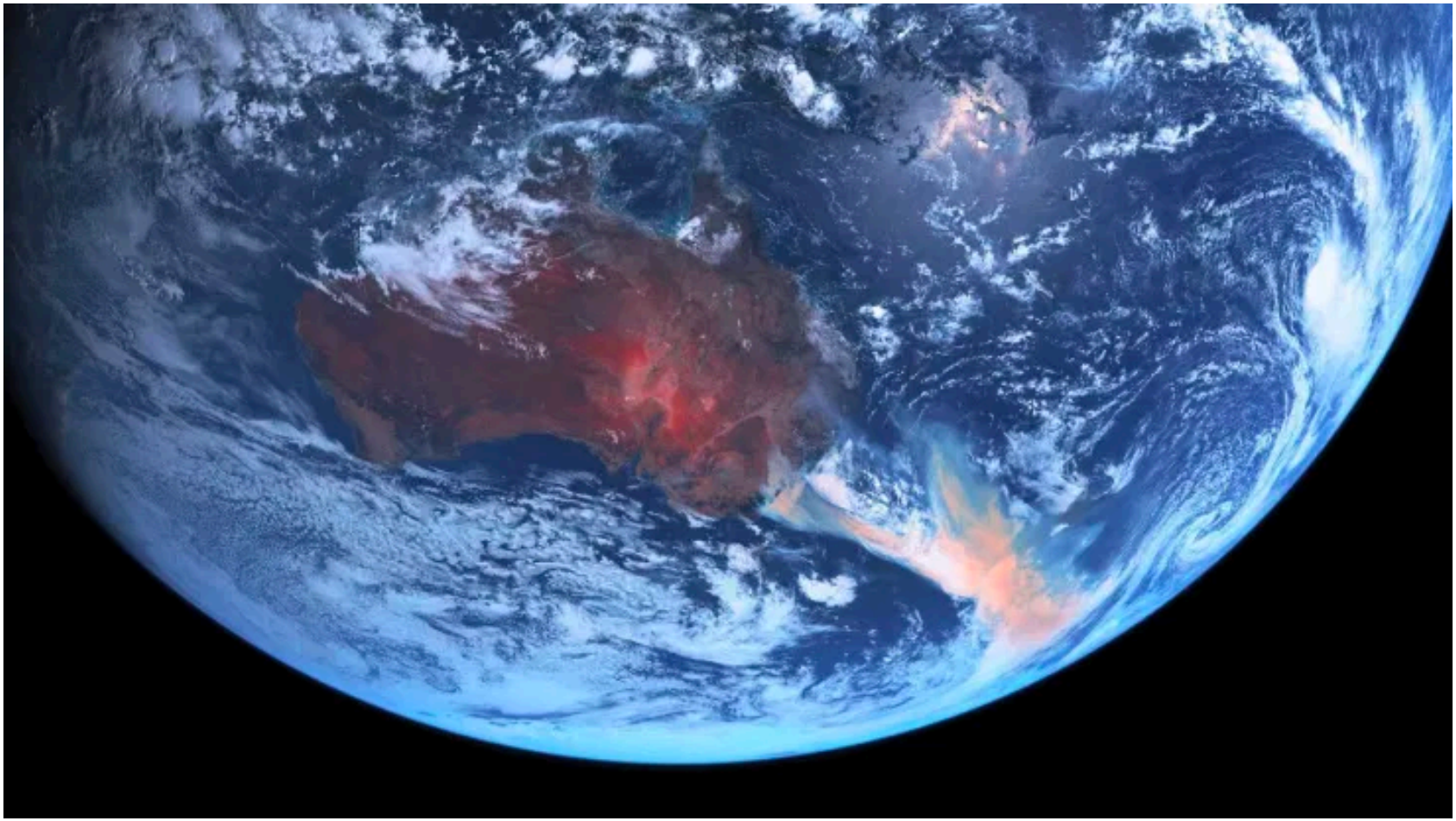
Exposure to active fire



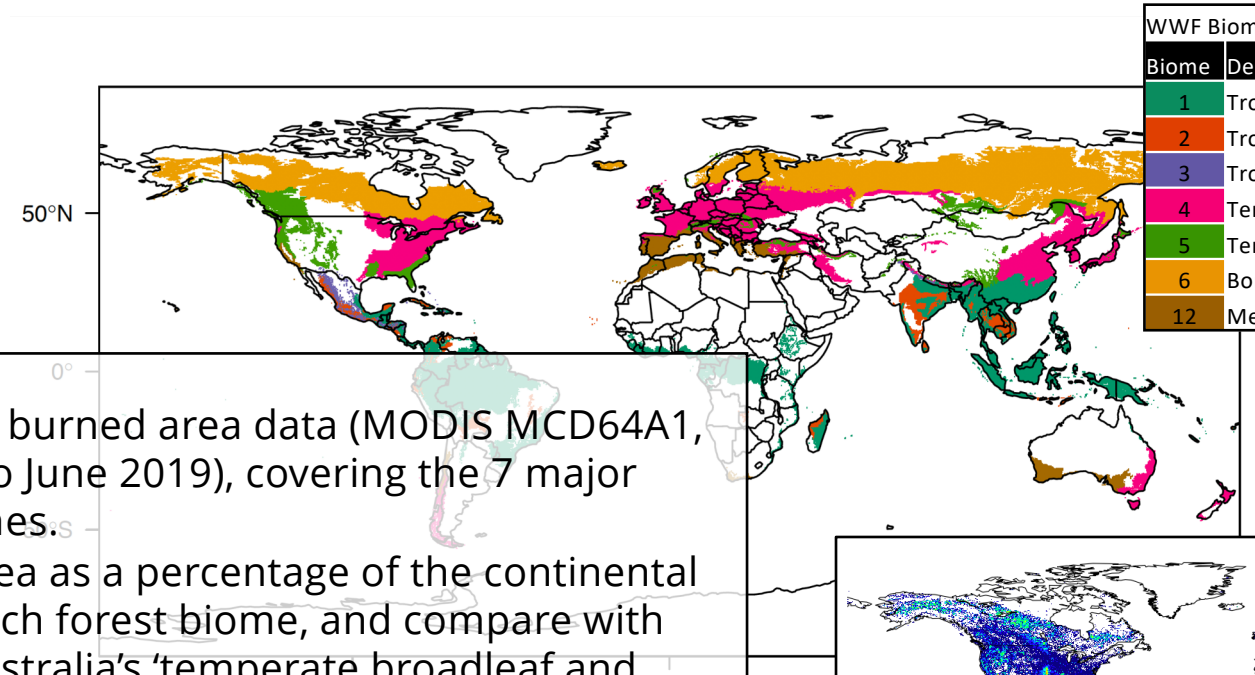
Source: Boer, unpublished data

- Most fires burned in relatively sparsely populated areas, as opposed to e.g. 2002/03 fires
- In 2019/20, exposure of residential population to active fire within 20 km reached ~20 million person days.

Global significance of Black Summer fires



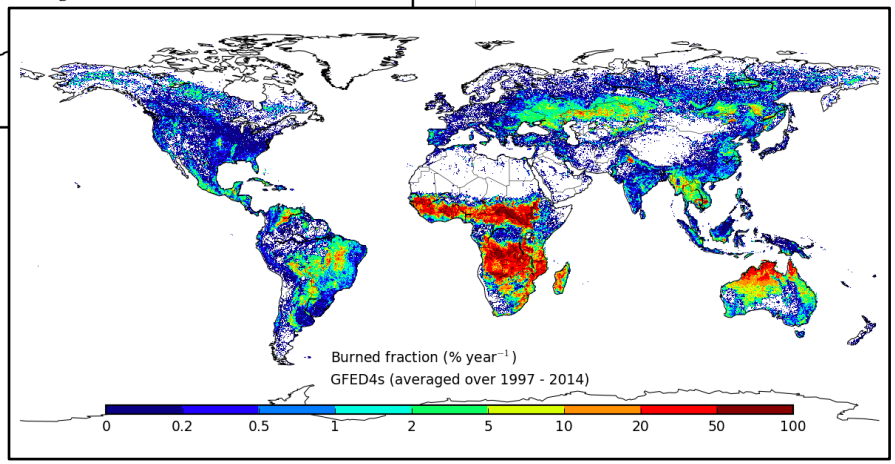
Global significance of Black Summer fires



WWF Biomes (Olson et al. 2001, Bioscience)	
Biome	Description
1	Tropical and subtropical moist broadleaf forests
2	Tropical and subtropical dry broadleaf forests
3	Tropical and subtropical coniferous forests
4	Temperate broadleaf & mixed forests
5	Temperate conifer forests
6	Boreal forests/taiga
12	Mediterranean forests, woodlands and scrub

Analysis:

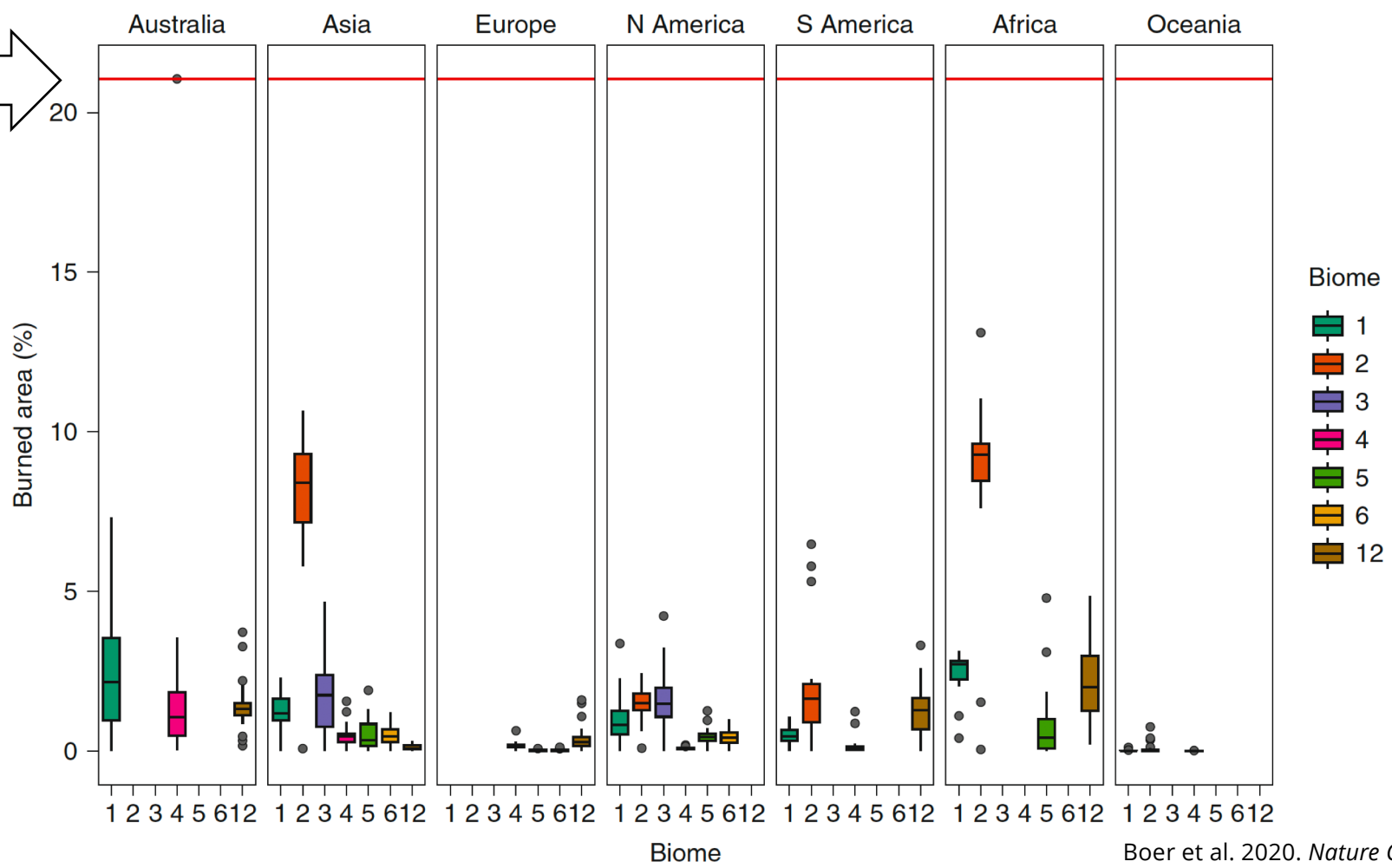
1) 20-years of global burned area data (MODIS MCD64A1, November 2000 to June 2019), covering the 7 major global forest biomes.
2) Annual burned area as a percentage of the continental surface area of each forest biome, and compare with area burned in Australia's 'temperate broadleaf and mixed' (TBLM) forest biome during the 2019/20 forest fires.
3) We show the total surface area of each continental forest biome and the maximum burned area % recorded (excluding 2019/20 eastern Australian forest fires).



source: Globalfiredata.org

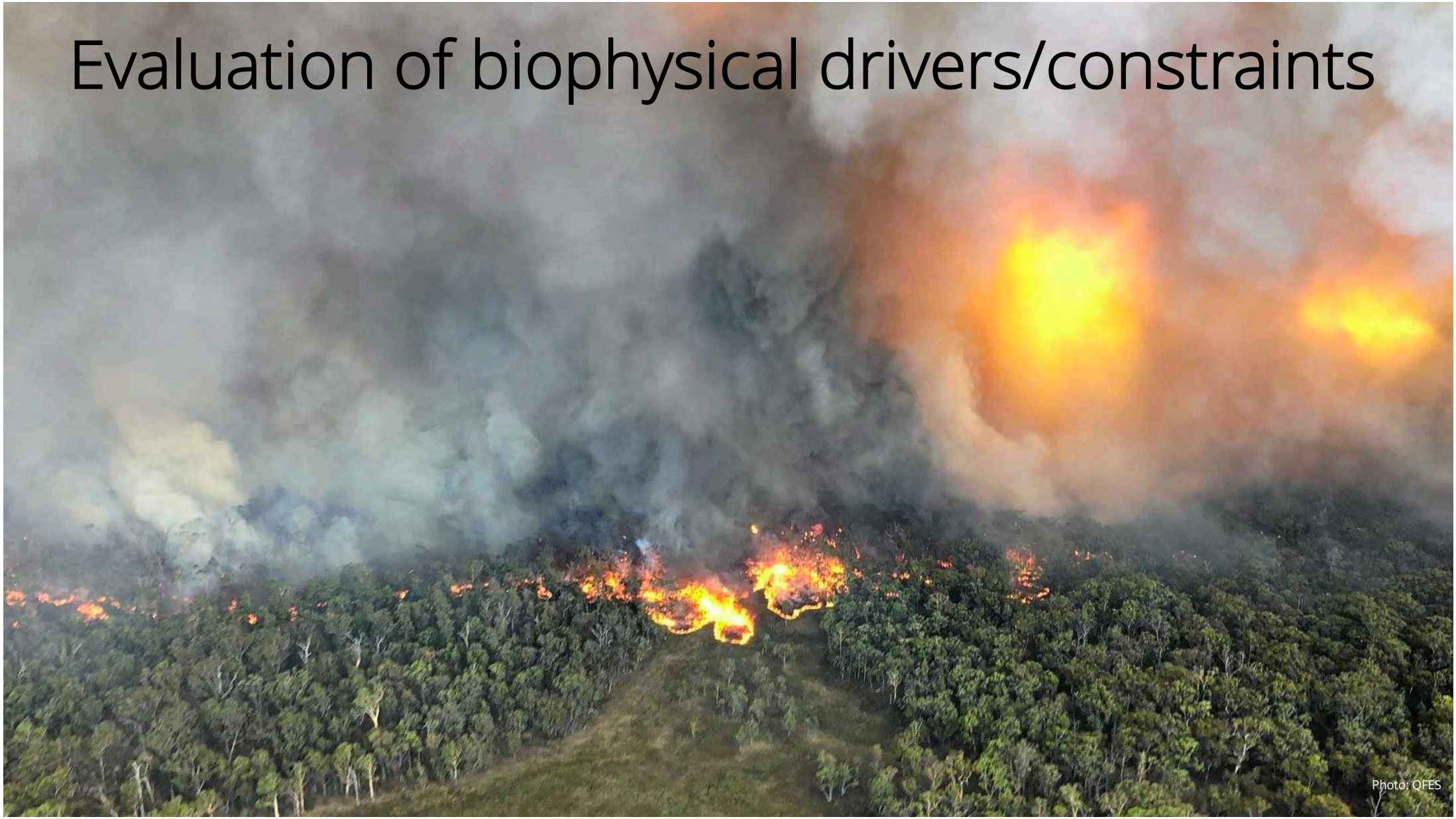
Globally unprecedented burn area %

2019/20 forest fires burn 21% of Australian TBLM forest biome



Boer et al. 2020. *Nature Climate Change* 10

Evaluation of biophysical drivers/constraints



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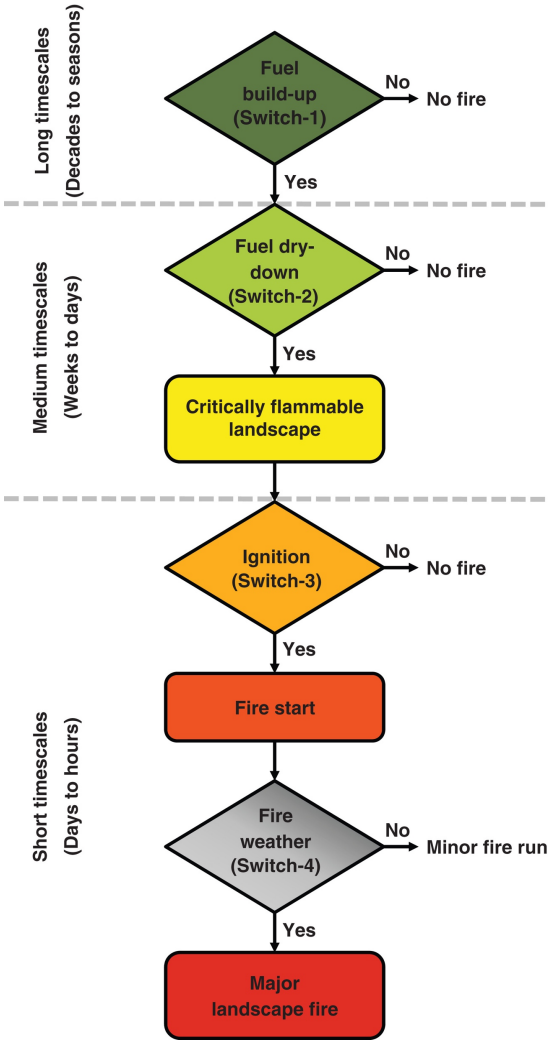
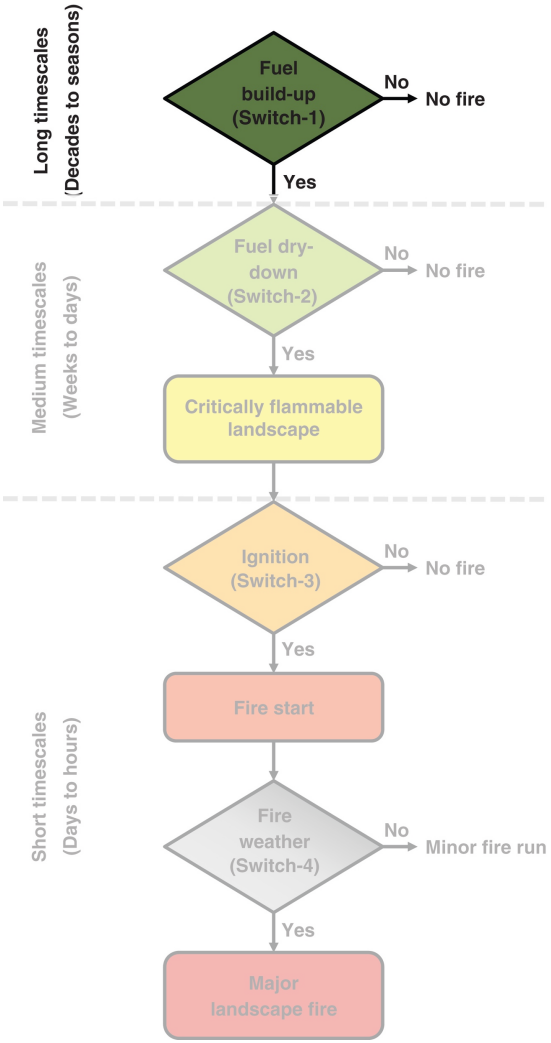
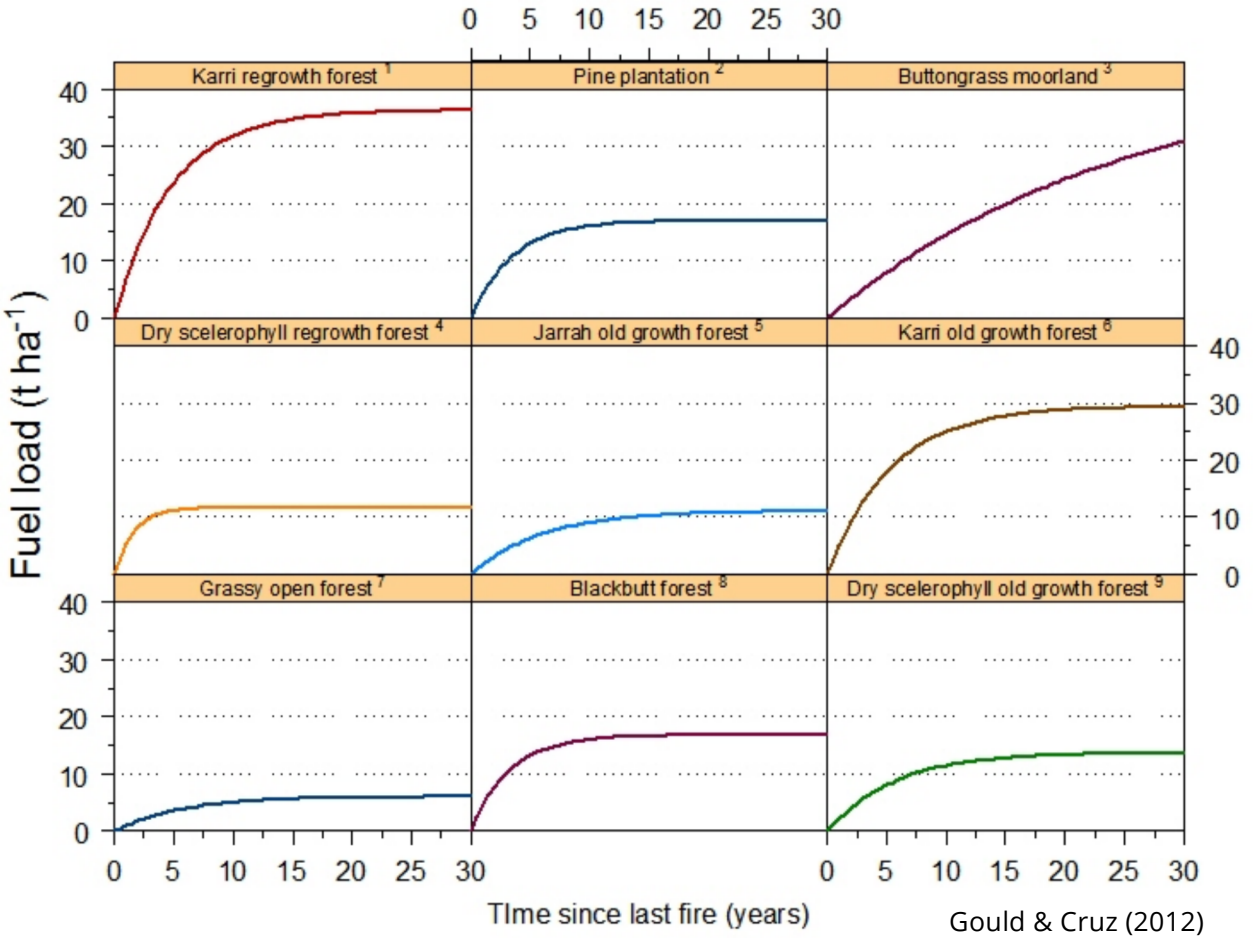


Fuel loads higher than normal?



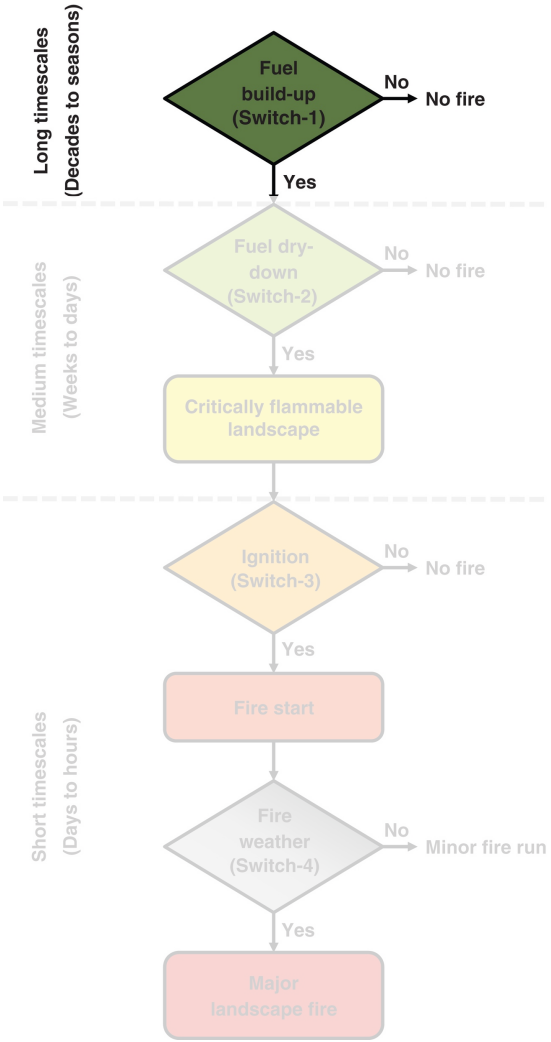
Boer et al. (2017) after Bradstock (2010)



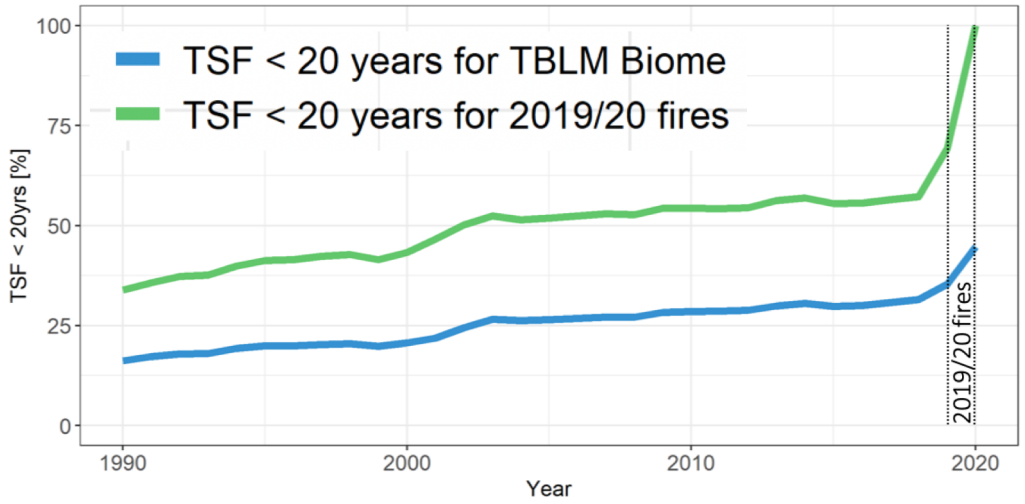
Gould & Cruz (2012)

Fuel loads are typically assumed to increase monotonically with time since fire (TSF)

Fuel loads higher than normal?



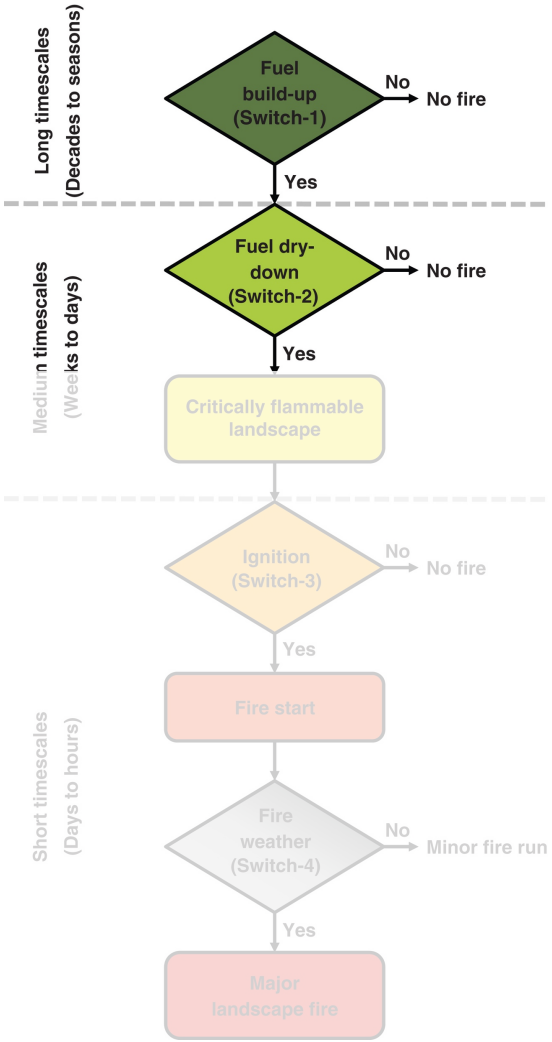
Boer et al. (2017) after Bradstock (2010)



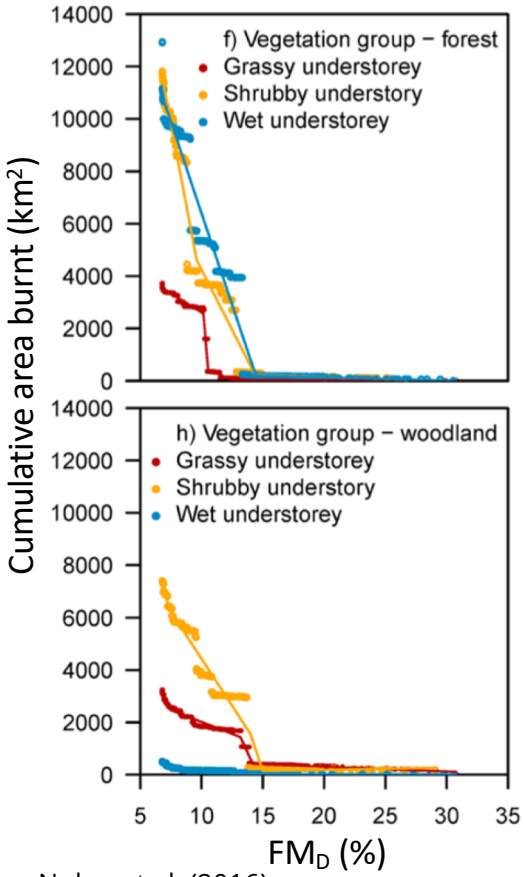
Boer, unpublished data

Forest area of 'young fuels' (TSF<20 years) was similar prior to 2019/20 fires

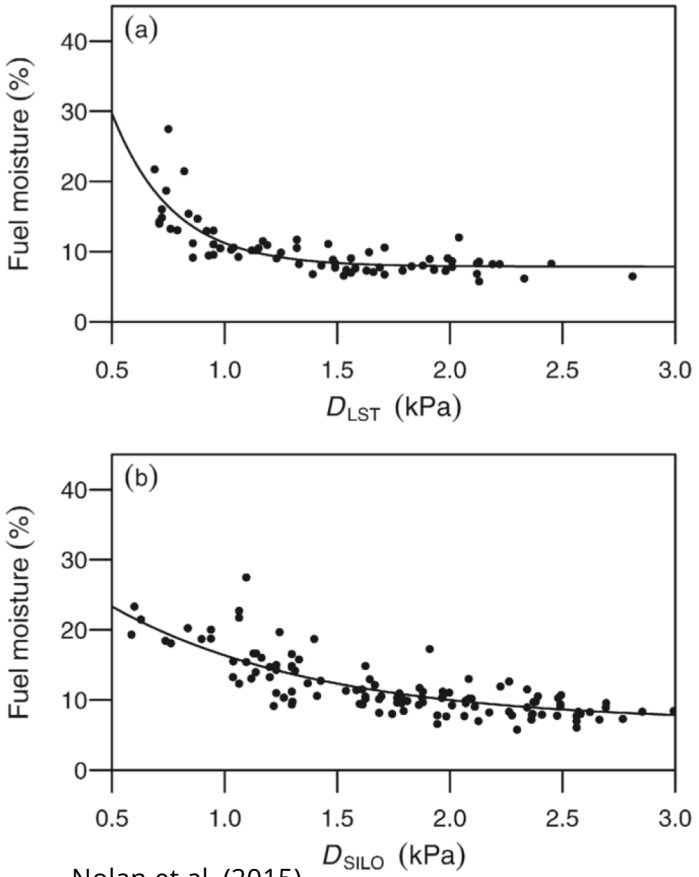
Fuel dryness extreme?



Boer et al. (2017) after Bradstock (2010)



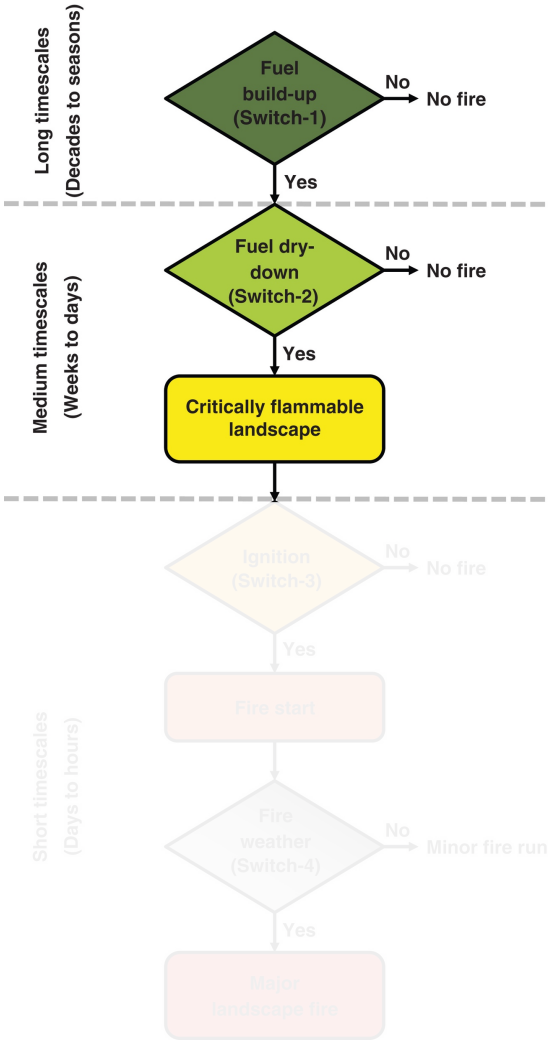
Nolan et al. (2016)



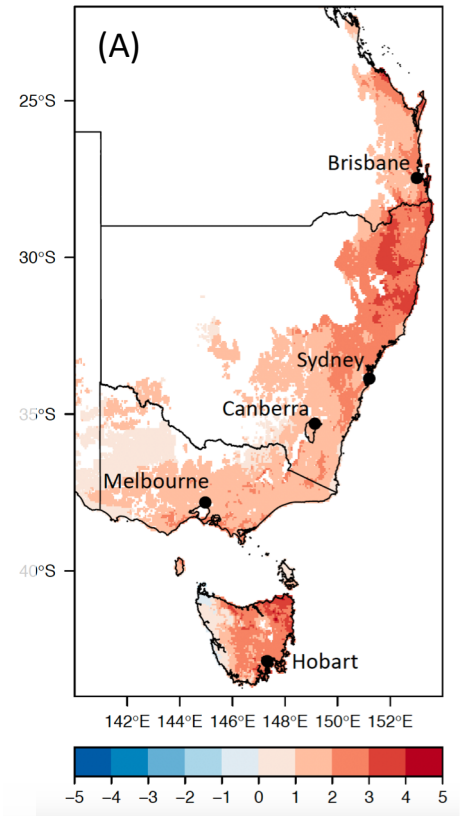
Nolan et al. (2015)

Forest flammability is strongly controlled by fuel moisture content, which can be predicted reliably from vapour pressure deficit (VPD)

Fuel dryness extreme?



Boer et al. (2017) after Bradstock (2010)



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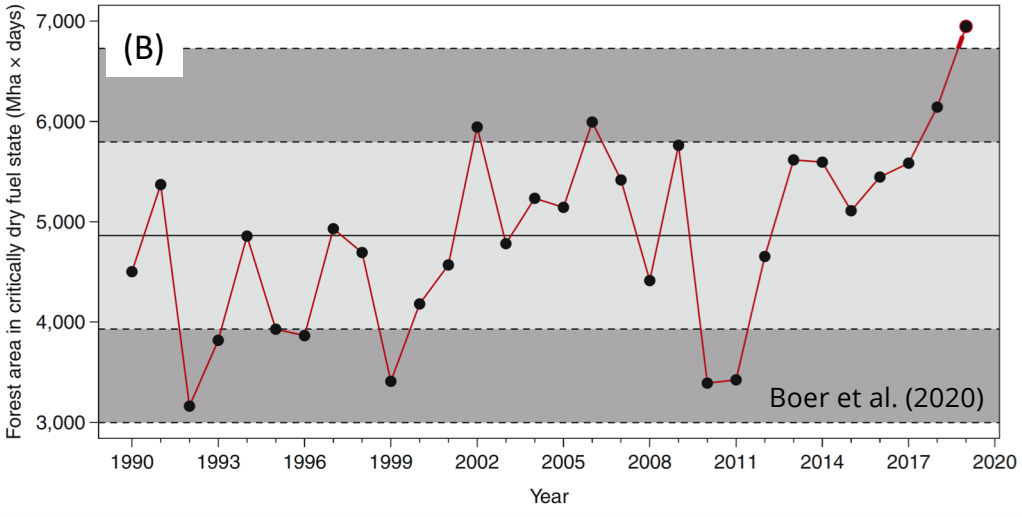
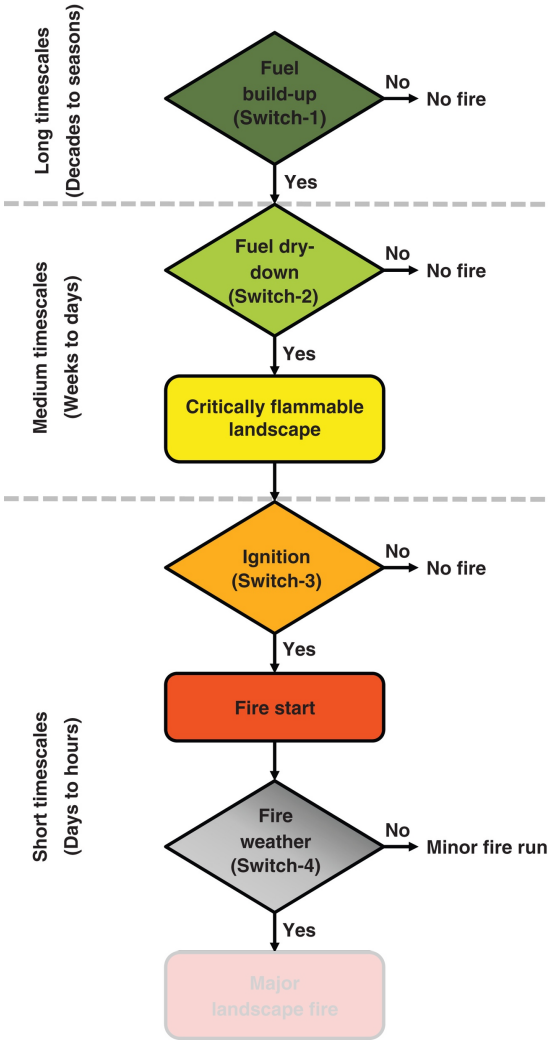


(A) Z-scores of the number of days of predicted dead fuel moisture content <10% in 2019 relative to 1990-2019 reference period; (B) Annual variation in the duration and cumulative area of large forest patches (>100,000 ha) in a critically dry fuel state.

Widespread record fuel dryness set the stage for unconstrained forest fires until heavy rainfall extinguished the fires in February 2020.

More severe fire weather ?



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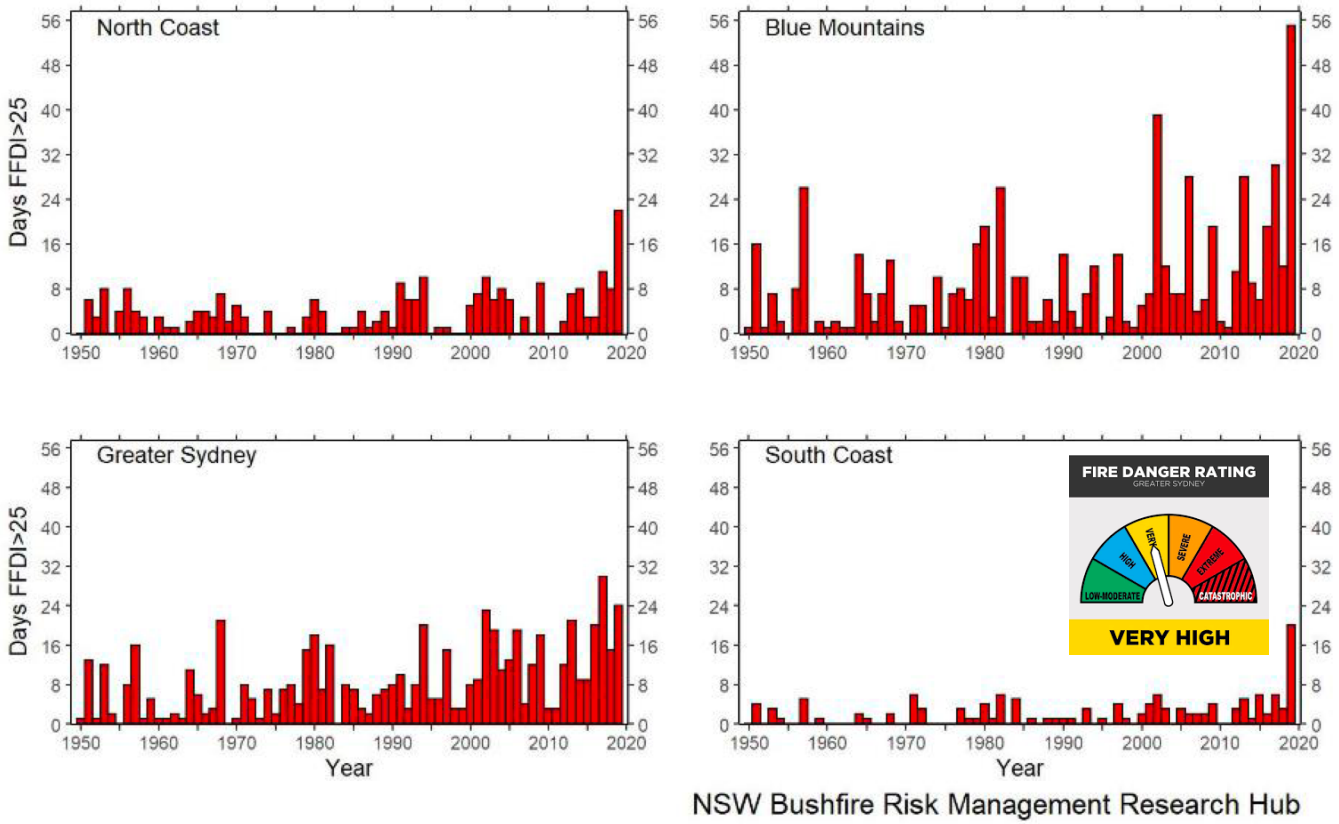
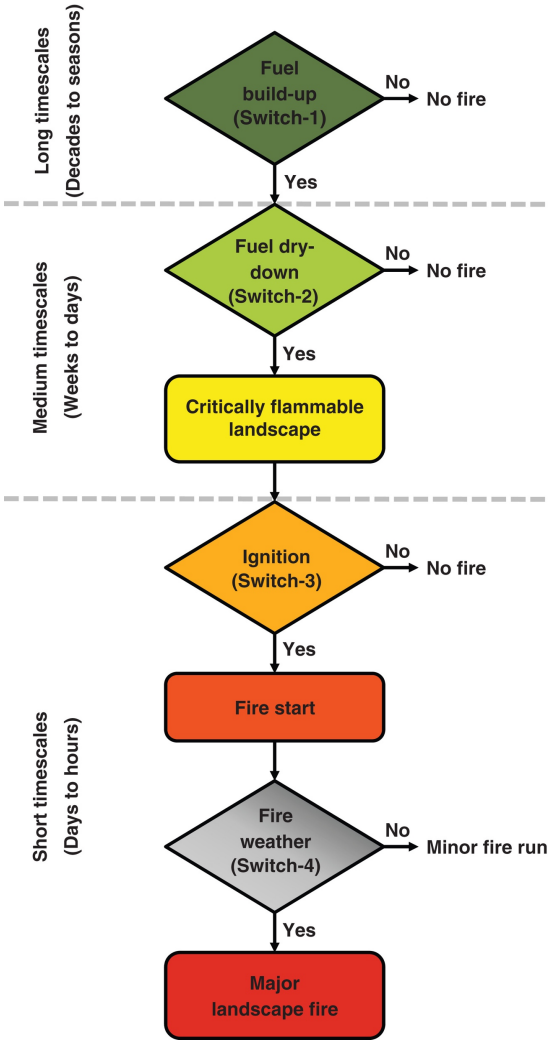


The frequency of 'Very High' fire danger days was extreme throughout NSW

4 switches ‘on’ – no constraints



Boer et al. (2017) after Bradstock (2010)

Conclusions

- The 2019/20 forest fires in eastern Australia were of a globally unprecedented scale.
- Critical biophysical conditions for forest fires were aligned for many months over millions of hectares of forested landscapes.
- There has been a steady increase of areas of ‘young’ fuels over time, indicating that predicted fuel loads were similar to, or below, the long-term mean prior to the 2019/20 fires.
- Record low fuel dryness and extremely high frequencies of severe fire weather in eastern Australia were the key ingredients for unconstrained forest fires.
- The ecological impact of the fires is yet to be fully quantified, but is likely severe, in particular in fire sensitive communities such as rainforests, and for endemic species with restricted ranges.
- Fatality numbers and house loss were relatively low given the scale of burning, but socio-economic impacts (e.g. loss of livelihoods) are very large and exacerbated by COVID-19.
- Fire management policies/practices are challenged by new reality and projected future fire

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