Received: 1 March 2020 | Accepted: 11 March 2020
DOI: 10.1111/gcb.15125

Global Change Biology WILEY

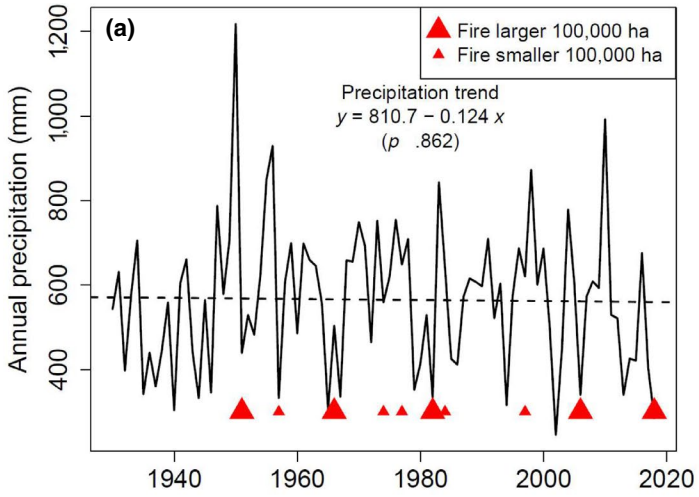
LETTER TO THE EDITOR

Causes and consequences of Eastern Australia's 2019–20 season of mega-fires: A broader perspective

Nolan et al. (2020) give their perspective of the current fire season in Eastern Australia, yet draw attention solely to fuel moisture as a "key constraint on the occurrence of large wildfires in this region." Here we provide a broader view.

Mega-fires were the subject of an international conference held in Tallahassee, Florida in 2011, spawned by increasing awareness that fire suppression was "running out of road." Jerry Williams, the former National Director of Fire & Aviation Management, United States Forest Service, was the keynote speaker and wrote: "protecting people and sustaining natural resources can no longer rely on suppression capabilities, alone; protection will become more dependent on how we manage the forests where high-impact mega-fires incubate" (Williams, 2013). The conference gave rise to discussions about "tipping points," in particular greatly increased risks to ecosystems not previously threatened by fire, and critical ecosystem functions created by the confluence of changing climates and accumulating fuels (Adams, 2013).

More recently, an international group of authors emphasized that an ever-increasing focus by governments on fire suppression was a trap, as it allowed fuels to accumulate to levels that would



(c)

Fuel type (t/ha)	Unburnt National Park	Burnt National Park	Burnt other tenure
Surface litter	12 ± 7	17 ± 12	13 ± 8
Elevated, near surface	3 ± 5	1 ± 2	3 ± 3
Coarse woody debris	20 ± 20	66 ± 98	101 ± 59

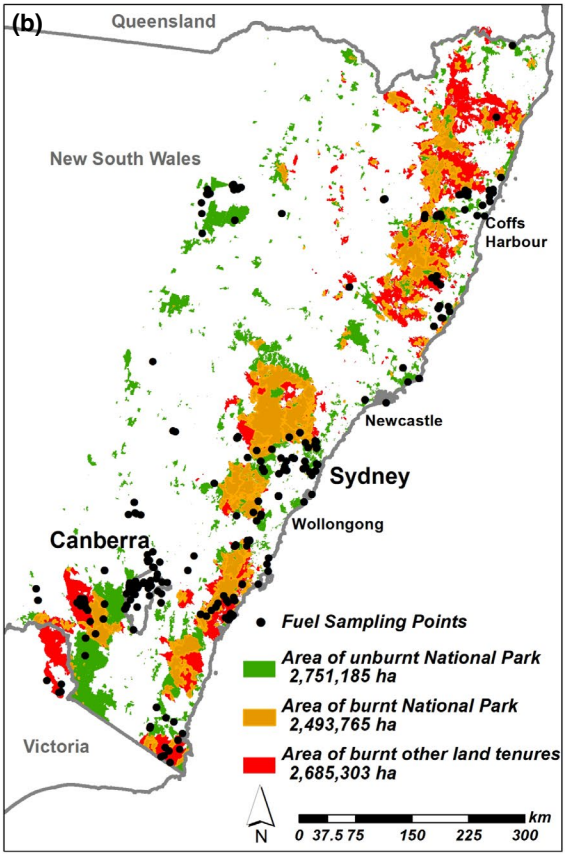


FIGURE 1 (a) An 80-year fire history for the "Pilliga Scrub" forest in north-central New South Wales. This forest of ~5,000 km^2 (S −30.7° W 149.3°) was not burnt in recent fires. The precipitation record is shown along with the annual trend. (b) Map of fires in NSW forests since July 1, 2019. Land areas are identified by tenure, including unburnt and burnt National Park land, and other burnt land (mostly State Forests). Fuel load sampling points are shown. (c) Fuel loads derived from a meta-analysis of published literature. Data for three fuel types are provided: "surface litter" (dead leaves, small twigs and bark fragments); "elevated, near surface fuels" (grass and shrub understory); "coarse woody debris" (woody materials > 26 mm diameter). Mean ± standard deviation are given

This article is a commentary on Nolan et al. 26, 1039 – 1041. See also the response to this letter by Bradstock et al. 26, e8–e9.

eventually burn at intensities well beyond the capabilities of any fire fighting service, anywhere (Moriera et al., 2020).

Sadly, these predictions have proved correct in Australia. Ultimately, it was only rainfall that extinguished the fires. Speculated extraordinary losses of wildlife will be matched by wholesale changes to plant diversity and abundance across much of the forest estate of New South Wales, Victoria and parts of Queensland and South Australia. Losses of soil carbon are unknown, while after an initial increase, water yield will likely take decades to recover to pre-fire condition in key catchments (Brookhouse, Farquhar, & Roderick, 2013; Gharun, Turnbull, & Adams, 2013).

We agree with Nolan et al. (2020) that this fire season is unprecedented in some respects. We also note and support the basic premise that the duration and severity of drought in NSW—which has set many records—is a fundamental driver of the extent and severity of these and other fires in Australia. Drought and fire have had clear, long-term associations in NSW forests, as shown by Figure 1a.

However, this fire season also follows decades of changing land tenure from State Forest to National Park and other conservation tenures. According to Lindenmayer, Hunter, Burton, and Gibbons (2009), logging conducted in State Forest tenures leads to increased fire intensity in some forest types, while others have also argued that high intensity fires are more likely in logged forests (Price & Bradstock, 2012; Taylor, McCarthy, & Lindenmayer, 2014). As shown in Figure 1b, the recent fires—which nearly all burnt at high intensity—did not discriminate among land tenures.

Rapid growth of the conservation estate, including conservation reserves and National Parks are clear features of the past 30 years in all Australian states—none more so than NSW. These changes reflect the values of the >90% of the population who live in urban areas (and >9 million Australians of a total of ~25 million live in either Sydney or Melbourne). Forests are valued by the urban population for their amenity, and perhaps as habitat, rather than for their value as providers of wood, water, and stores of carbon.

A recent analysis for California (e.g., Miller, Field, & Mach, 2020) highlights the worldwide problem that efforts to manage fuels via prescribed burning are poorly regarded by urban populations. Miller et al. additionally identified a range of resource, policy, and legislative obstacles that must be overcome if California is to reduce fuels on the >1 million acres/year that is needed to adequately reduce risks on California's 20 million acres of forest. The 2009 Victorian Bushfires Royal Commission (Parliament of Victoria, 2010)—similar to Presidential Commissions in the USA—made an almost identical (5%–10%) recommendation for Victoria. In New South Wales, fuel reduction efforts across all tenures have scarcely averaged 180,000 ha per annum for decades, in a forest estate of >20 million ha (i.e., <1%).

A consequence of inaction on fuels in NSW is that loads were extreme everywhere. Just the fine, quick-to-burn fuels (e.g., leaves and twigs < 6 mm diameter) were almost universally >>13 tonnes/ha across the NSW forest estate. If the understory vegetation and elevated fuels are included, fuel loads were >15 tonnes/ha, and reached an astronomical 60–100 tonnes/ha if coarse woody debris was included (Figure 1c). It is not surprising that fire intensities and rates of spread—both directly related to fuel loads—caused seasoned fire-fighters to describe fire behavior as "unprecedented."

To suggest that low moisture content of soils and litter and ground-layer vegetation was the cause of the current fires, or their characteristics, is not supported by abundant evidence worldwide—as well as the laws of physics—that mega-fires (including characteristics such as high intensity and fast rates of spread) are a result of changes in climate *and* accumulations of fuel.

Perhaps the most important consequence of current fires in Australia is that rural communities and regions need to be empowered—as they must be in California and elsewhere—to control fuel loads across tenures, free of urban sentiment, as their ability to control climate is negligible. Protections via lines on maps delineating conservation lands, or ecosystems that are "not fire-tolerant," have never been respected by fire, or by climate. They will not be respected in future.

ACKNOWLEDGEMENTS

We thank the Bushfire and Natural Hazard CRC for funding support.

CONFLICT OF INTEREST

The authors declare no known conflict of interests.

Mark A. Adams[1]
Majid Shadmanroodposhti[1]
Mathias Neumann[1,2]

[1]*Swinburne University of Technology, Hawthorn, Vic., Australia*
[2]*Institute of Silviculture, University of Natural Resources and Life Sciences, Vienna, Austria*

Correspondence
Mark A. Adams, Swinburne University of Technology, PO Box 218, Hawthorn, Vic. 3122, Australia.
Email: mark.adams@sydney.edu.au

ORCID

Mark A. Adams https://orcid.org/0000-0002-8154-0097
Mathias Neumann https://orcid.org/0000-0003-2472-943X

REFERENCES

Adams, M. A. (2013). Mega-fires, tipping points and ecosystem services: Managing forests and woodlands in an uncertain future. *Forest Ecology and Management*, *294*, 250–261. https://doi.org/10.1016/j.foreco.2012.11.039

Brookhouse, M. T., Farquhar, G. D., & Roderick, M. L. (2013). The impact of bushfires on water yield from south-east Australia's ash forests. *Water Resources Research*, *49*, 4493–4505. https://doi.org/10.1002/wrcr.20351

Gharun, M., Turnbull, T. L., & Adams, M. A. (2013). Stand water use status in relation to fire in a mixed species eucalypt forest. *Forest Ecology and Management*, *304*, 162–170. https://doi.org/10.1016/j.foreco.2013.05.002

Lindenmayer, D. B., Hunter, M. L., Burton, P. J., & Gibbons, P. (2009). Effects of logging on fire regimes in moist forests. *Conservation Letters*, *2*, 271–277. https://doi.org/10.1111/j.1755-263X.2009.00080.x

Miller, R. K., Field, C. B., & Mach, K. J. (2020). Barriers and enablers for prescribed burns for wildfire management in California. *Nature Sustainability*, *3*, 101–109. https://doi.org/10.1038/s41893-019-0451-7

Moreira, F., Ascoli, D., Safford, H., Adams, M. A., Moreno, J. M., Pereira, J. M. C., … Fernandes, P. M. (2020). Wildfire management in Mediterranean-type regions: Paradigm change needed. *Environmental Research Letters*, *15*, 011001. https://doi.org/10.1088/1748-9326/ab541e

Nolan, R. H., Boer, M. M., de Collins, L., Dios, V. R., Clarke, H., Jenkins, M., … Bradstock, R. A. (2020). Causes and consequences of eastern Australia's 2019–20 season of mega-fires. *Global Change Biology*, *26*(3), 1039–1041. https://doi.org/10.1111/gcb.14987

Parliament of Victoria. (2010). *2009 Victorian Bushfires Royal Commission*. Final report. Melbourne, Australia: Government Printer.

Price, O. F., & Bradstock, R. A. (2012). The efficacy of fuel treatment in mitigating property loss during wildfires: Insights from analysis of the severity of the catastrophic fires in 2009 in Victoria, Australia. *Journal of Environmental Management*, *113*, 146–157.

Taylor, C., McCarythy, M. A., & Lindenmayer, D. B. (2014). Nonlinear effects of stand age on fire severity. *Conservation Letters*, *7*, 355–370. https://doi.org/10.1111/conl.12122

Williams, J. (2013). Exploring the onset of high-impact mega-fires through a forest land management prism. *Forest Ecology and Management*, *294*, 4–10. https://doi.org/10.1016/j.foreco.2012.06.030