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Australian Forestry

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tfor20

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To cite this article: R. J. Keenan, P. Kanowski, P. J. Baker, C. Brack, T. Bartlett & K. Tolhurst (2021): No evidence that timber harvesting increased the scale or severity of the 2019/20 bushfires in south-eastern Australia, Australian Forestry, DOI: 10.1080/00049158.2021.1953741

To link to this article: https://doi.org/10.1080/00049158.2021.1953741

Published online: 27 Jul 2021.

AUSTRALIAN FORESTRY
https://doi.org/10.1080/00049158.2021.1953741

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No evidence that timber harvesting increased the scale or severity of the 2019/20 bushfires in south-eastern Australia

R. J. Keenan[a], P. Kanowski[b], P. J. Baker[a], C. Brack[b], T. Bartlett[b] and K. Tolhurst[a]

[a]School of Ecosystem and Forest Sciences, University of Melbourne, Melbourne, Australia; [b]Fenner School of Environment and Society, Australian National University, Canberra, Australia

ABSTRACT

In the summer of 2019/20, bushfires of unprecedented scale in south-eastern Australia focused attention on how forest management might have affected their risks and impacts. Some argued that the severity and extent of these fires were made worse by timber harvesting and associated forest management and that harvesting in native forests should cease as a means for reducing fire risk. Little evidence has been presented to support these contentions. This article reviews evidence for the relationship between harvesting and fire extent and severity from these fires. The proportion of forested conservation reserves burnt in these fires was similar to that for public forests where timber harvesting is permitted, and the proportion of forest burnt with different levels of fire severity was similar across tenures and over time since timber harvest. Recent analysis of the areas burnt in 2019/20 indicated that the extent and severity of the fires was determined almost entirely by three years of well-below-average rainfall (leading to dry fuels across all vegetation types), extreme fire weather conditions and local topography and that past timber harvesting had negligible or no impact on fire severity. Three major inquiries into the fires made no recommendations regarding the impact of timber harvesting on fire risk. We argue that policy proposals to mitigate fire risk and impacts should be evidence-based and, to avoid the cognitive bias associated with expert opinions, should integrate the multiple perspectives of traditional Indigenous knowledge, the experience of local and professional fire managers, and the breadth of evidence from bushfire research. Together, these perspectives should inform strategies for reducing bushfire impacts and increasing forest resilience and community safety.

ARTICLE HISTORY
Received 3 May 2021
Accepted 15 June 2021

KEYWORDS
forest; fire; severity; logging; management; Black Summer

Introduction

In the summer of 2019/20, bushfires of unprecedented scale (colloquially known as the 'Black Summer' bushfires, Davey & Sarre 2020) burnt across the forests of south-eastern Australia. Between September 2019 and early January 2020, fires burnt around 5.8 million ha of forest in New South Wales (NSW) and Victoria, and some individual fires exceeded 100 000 ha in area (Boer et al. 2020). Thirty-three people died in these fires and over 3000 homes were destroyed (Filkov et al. 2020). Fire burnt mainly in eucalypt forests, although other vegetation types were also affected. The area that burnt with high severity (approx. 1.8 million ha) was larger than that of any fires since 1988; however, the ratio of proportion burnt with high severity to total fire extent was similar to previous fires (Collins et al. 2021). Smoke from fires had major impacts on human health (Johnston et al. 2021), and the fires had direct and indirect impacts on wildlife (Dickman & McDonald 2020) and wildlife habitats (Ward et al. 2020). An estimated 0.67 Mt of carbon dioxide was emitted, which may or may not be sequestered in future years by forest regrowth (Bowman, Williamson, Price, et al. 2021).

The drivers of these fires have been the subject of debate. Antecedent climate conditions were major factors—particularly the well-below-average rainfall over the preceding three years (Nolan et al. 2020). Long-term, human-induced trends in climate across the region contributed to these climate extremes, increasing the chances of large-scale forest fires and supporting past projections that climate change would drive increases in fire risk across the region (Abram et al. 2021). Near-surface air temperatures during the summer were about 1°C higher than the 20-year mean, increasing evaporative demand, which, combined with drought, reduced soil moisture and produced extensive areas with dry fuels (Ehsani et al. 2020). 'Dynamic propagation', in which fire–atmosphere interactions increase fire intensity and rate of spread, was a more prominent feature of these fires than in previous events (Sharples 2020). Adams et al. (2020) identified climate conditions as a primary driver but pointed to high fuel loads as a significant contributing factor. Bradstock et al. (2020) contested some claims about fuel loads. Recent fuel-reduction burns significantly reduced the severity of the Black Summer fires in some locations, but they were generally less effective under extreme fire weather conditions (Hislop et al. 2020).

The scale and impact of the fires focused attention on the influence of past timber harvesting in contributing to fire extent and severity. Lindenmayer et al. (2020), in a commentary article, contended that the bushfires were 'made worse' by logging and associated forest management and that 'logging of forests has had profound effects on these fires' severity and frequency'. No evidence from the 2019/20 bushfires was presented to support these contentions. The authors, and their academic institutions, went on to promote this commentary paper in the media (see, for example, Cox 2020; Perkins 2020; Science Daily 2020; UQ News 2020). Subsequently, that article, and related academic studies, have been used to call for the cessation of harvesting in

CONTACT R. J. Keenan rkeenan@unimelb.edu.au School of Ecosystem and Forest Sciences, University of Melbourne, Melbourne, Victoria, Australia

native forests on the basis that it increases fire risk. Given the potential impact of these claims on forest and fire management, and on communities who live near or work in forests, it is important to assess their veracity.

Drivers of bushfire behaviour

The risks posed by bushfires are a function of the likelihood of their occurrence and their consequences. Bushfire behaviour, extent and impacts are determined by multiple complex and interacting factors, of which past disturbance is one. Landscape-scale bushfires require spatially continuous fuel that is dry enough to burn, an ignition source, and conducive weather conditions. In temperate Australian forests, sufficient fuel is generally available for fires to spread except in the first few years immediately after a fire, when fuels are not necessarily sufficiently dry to burn. The ignition sources for the 2019/20 fires were primarily lightning strikes in remote areas. Commentary on bushfires often confuses descriptors of fire and fire impacts. Important parameters include vegetation flammability, fire extent, fire intensity and fire severity. Other important elements of fire behaviour are rate of spread and the length of time that fires continue to burn after the initial front passes through. These different aspects of fire need to be considered separately in assessing the potential impacts of timber harvesting on fire behaviour and the potential risks to human communities and ecosystems.

Vegetation flammability is the ability of vegetation to burn. It is a complex concept (Gill & Zylstra 2005), and it is difficult to predict from vegetation composition, in part because the flammability of individual plant parts is not a good predictor of the flammability of whole plants or other fuels such as leaf litter and woody debris (Schwilk 2015). Laboratory flammability studies seldom replicate the heat transfer mechanisms and combustion processes that drive fire propagation, and they offer limited insight into vegetation–fire interactions (Fernandes & Cruz 2012).

Fire intensity is a measure of the energy released in a fire. More intense fires consume greater quantities of live and dead foliage, spread more rapidly and are more difficult to suppress. Fire severity is typically a measure of the impact of a fire on the forest canopy, assessed by the degree of crown combustion or scorch. Fire severity can also be considered in terms of the overall ecological impact of a fire on trees, understorey plants, biota, soils and water quality, but it is more often assessed in terms of change to aboveground and belowground organic matter and, even more frequently, by the effect of the fire on the forest canopy, as assessed using remote sensing imagery (Collins et al. 2020). The relationship between fire intensity and severity is not linear. For example, a fire of lower intensity may cause high canopy combustion or scorch in low forest, whereas a fire of substantially greater intensity is required to cause combustion or scorch in a tall forest.

Evidence for a relationship between timber harvesting and fire behaviour

A relationship between timber harvesting and fire behaviour has been suggested for some time, but evidence from Australian forests is limited. Lindenmayer et al. (2020) cited two studies as 'compelling evidence that … logging regimes have made many Australian forests more fire prone and contribute to increased fire severity and flammability'. In the first of these studies, Taylor et al. (2014) found that, in extreme fire weather conditions in the Black Saturday fires in Victoria in 2009, the probability of canopy consumption was higher in regrowth forests than in long-undisturbed tall wet forests. The model predictor in that study was time since fire, but young stands originated after timber harvesting while old stands were of fire origin, which confounded the study design, making it difficult to draw inferences about the influence of past timber harvesting versus past fire on the probability of fire severity. In addition, the study showed that the probability of canopy consumption *plus* canopy scorch was high (>80%) across all ages in the sampled forests. In these montane ash forests, full crown scorch typically kills trees. So, many more trees die in all ages than indicated by crown consumption alone. The results of Taylor et al. (2014) suggest that old forests are as susceptible to potentially lethal crown damage as young and middle-aged stands. It is also important to note that wet eucalypt forests have tall (>60 m) trees at maturity, with dense broadleaf shrub or tree understories and abundant fuels. Fuel moisture limits the occurrence and extent of fire in these forests (Cawson et al. 2018). The conditions in which fuels become dry enough to burn occur infrequently, but, with high live fuel loads, fires, once started, often have high-severity impacts. These low-frequency, high-impact fire events make it hard to draw inferences about the general, landscape-level implications of fire because many conditions will vary between events.

In addition, Tall, wet eucalypt forests comprise a relatively small proportion (16%) of native eucalypt forests in south-eastern Australia (MPIG and NFISC 2018) and less than 3% of the forest area burnt in Victoria in the 2019/20 fires. Dry eucalypt forests are much more extensive in south-eastern Australia, accounting for nearly 80% of the forest area. They are lower in height (20–40 m), with open understories of low (<4 m) sclerophyllous shrubs or grasses. Conditions are dry enough in these forests for the understorey and forest floor to burn every year. Following ignition, fire extent and severity are limited by the amount of fuel, and dry eucalypt forests generally experience more-frequent low-severity surface fires (Cawson et al. 2020), although intense crown fires can occur under extreme fire weather conditions (Murphy et al. 2013). Fire behaviour, and interactions with past harvesting, are therefore likely to be different in dry eucalypt forests compared with wet eucalypt forests. For example, Lindenmayer et al. (2009) reported that 'evidence from a range of forest types around the world … suggested that strategic forms of timber harvesting in dry forests can reduce fire severity'.

In the second study presented by Lindenmayer et al. (2020) as evidence for their contention that timber harvesting has made many Australian forests more fire-prone, Zylstra (2018) analysed fire frequency in the Australian Alps national parks in forests in which there is either little, or no, recent history of timber harvesting. Lindenmayer et al. (2020) also asserted, citing Kooyman et al. (2014), that 'fires spreading from logged areas have burnt into adjacent old-growth eucalypts and rainforests'. The single source cited by Kooyman et al. (2014) was a review by Laurance et al. (2014) of the impacts of converting tropical rainforests to agriculture outside Australia.

In other studies, Price and Bradstock (2012) and Bradstock and Price (2014) found evidence that some eucalypt forests subject to timber harvesting had a higher probability of

burning with higher severity than older, unlogged forests. However, in a study of areas burnt in the extensive 2003 alpine fires in Victoria, Tolhurst and McCarthy (2016) found no link between timber harvesting and bushfire extent or severity, with these fires driven almost entirely by weather conditions, slope, aspect, fuel levels, atmospheric stability and the scale of the fire. Bowman et al. (2016) found disturbance history (timber harvesting or fire) to have a relatively small effect on fire severity compared with the influence of fire weather in montane wet *Eucalyptus delegatensis* F.Muell. ex R.T.Baker forests in Victoria. Other research in eucalypt forests showed that the shrub-layer fuel hazard remained relatively constant over time following burning and timber harvesting (Cawson et al. 2018).

Evidence from the 2019/20 bushfires

Analysis of the land management effects on areas burnt in the 2019/20 fires in south-eastern Australia has been limited. Looking simply at land tenure, the area of forests burnt in conservation reserves was nearly double the area burnt in public forests in which timber harvesting is allowed, although the proportions of forest burnt in each tenure were similar (Table 1). This was also the case in an analysis by the NSW Department of Primary Industries (2020) (Figure 1), which indicated that, of the 763 000 ha of state forests burnt in that state, 210 000 ha (27.6%) had had some form of harvesting activity in the last 35 years. A slightly higher proportion of forest harvested in the previous five years burnt at high severity compared with areas with no recent harvesting; however, the proportion burnt at extreme severity was lower in areas harvested in the last five years. In general, there was no indication that a previous history of harvesting affected fire severity at a landscape scale.

Table 1. Area ('000 hectares) and proportion of forest burnt in the 2019/20 bushfires across south-eastern Australia (ACT, NSW and Victoria), by tenure

Tenure	Total forest area	Total forest area burnt in 2019–2020	Proportion burnt in 2019–2020
Conservation reserves	9049	3326	0.37
Multiple-use public forests	4913	1758	0.36
Private forest	8398	1311	0.16
Leasehold forest	4257	22	0.01
Other Crown land	1001	122	0.12
Unresolved tenure	81	2	0.02
Total	27 699	6541	0.24

Data source: ABARES. 2020. Forest fire area data for the 2019/20 summer bushfire season in southern and eastern Australia [accessed 29 June 2020]. Available from: https://www.agriculture.gov.au/abares/forestsaustralia/forest-data-maps-and-tools/fire-data

A recent study assessing 32% (2.35 million ha) of the area burnt across three regions (two in NSW and one in eastern Victoria) (Bowman, Williamson, Gibson, et al. 2021) found that more than 44% of the native forest area burnt suffered severe canopy damage. Analysis indicated an overwhelming dominance of broad spatial factors (mostly topographic), followed by fire weather (expressed as Forest Fire Danger Index), as the factors driving complete scorch or the consumption of forest canopies in natural and plantation forests. The drivers of severe canopy damage were broadly the same across the three study regions. Recent harvest status, in combination with or separate from recent burning, was ranked low in importance as a driver of fire severity in each region. Past timber harvesting and bushfire disturbance in native forests had a very small effect on severe canopy damage, reflecting the limited extent of timber harvesting in the last 25 years (4.5% of the area burnt in Victoria, 5.3% in southern NSW and 7.8% in northern NSW).

Findings from government inquiries

Three government inquiries were held into the 2019/20 fires. These took extensive evidence from different levels of government, land and fire management agencies, academics and the public. A background paper for the Federal Government Royal Commission into National Natural Disaster Arrangements provided a comprehensive literature review indicating conflicting evidence from the scientific literature on the relationship between timber harvesting and fire behaviour (Commonwealth of Australia 2020b). The report of the

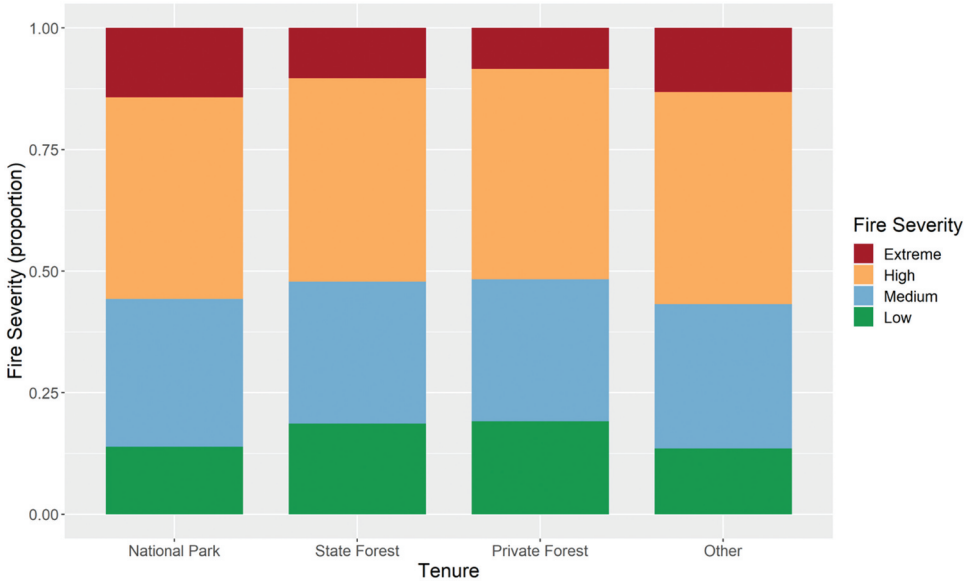

Figure 1. Proportion of forest area burnt in the 2019/20 fires in NSW by land tenure and level of fire severity (supplied by NSW Department of Primary Industries and originally published in NSW Department of Primary Industries 2020)

Royal Commission (Commonwealth of Australia 2020a) made no reference to or recommendations regarding timber harvesting and fire risk. It did present an example of fuel management activities on a private property, including regrowth clearing and stand thinning to restore an open grassy forest stand structure, which subsequently reduced the intensity and rate of spread of fire and the potential impact on the NSW town of Bawley Point.

The NSW Government inquiry (Owens & O'Kane 2020) found no clear evidence of the impact of land management (timber harvesting in state forests or grazing on private land) on fire behaviour, but it found that forest flammability was not influenced by forest management regimes. It noted that variation in these practices might influence these results and that further research was important. Again, no recommendations were made regarding changing timber harvesting practices to reduce fire risk.

The Victorian Government inquiry (Pearce 2020) noted submissions from interest groups and community members about concerns over the relationship between timber harvesting and bushfire risk, but also the potential for harvesting and the presence of personnel to reduce aspects of fire risk. The Inspector-General observed that:

> The timber industry provides an important support capacity to fire management in Victorian forests with a skill set, knowledge base and operational experience in forest landscapes. The cessation of native forest harvesting by 2030 poses challenges for the fuel management program and bushfire response capacity across the state (Observation 4.3).

Much of the attention in the Victorian Inspector-General's report was on the high level of community dissatisfaction with the limited extent of fuel-reduction burning and competing concerns in the community about the wider application of this practice. No observations or recommendations were made about timber harvesting. Community submissions more broadly supported alternatives such as mechanical fuel treatments, cool burning and empowering Traditional Owners to conduct cultural burning. The Inspector-General recommended that 'the Department of Environment, Land, Water and Planning lead the development and distribution of evidence-based land and fuel management tools for use by all legislated fuel management organisations to ensure a common approach to fuel management'. The report concluded that, rather than trying to build an ever-increasing bushfire response capability by marshalling more aircraft, personnel, trucks and equipment, Victoria needs a more sophisticated, adaptive and innovative approach to improve human and environmental outcomes in managing fire risk.

Policy and management responses

Proposed policy changes in response to the 2019/20 bushfires have been wide ranging, including ceasing timber harvesting, the proactive restoration of logged forests, defragmenting forested landscapes and expanding the extent of old-growth forest (Lindenmayer et al. 2020). A reduction in native forest harvesting has been underway in Australia for 30 years (Ajani 2007), but this transition to plantation timber production has had little impact on fire extent or intensity. The volume of timber removals in south-eastern Australian native forests has declined by 50% in the last 20 years, while the average annual area burnt has more than doubled (MPIG and NFISC 2018). Long-undisturbed old-growth forests are also proving highly vulnerable to the impacts of landscape-scale fires. For example, the area of old-growth forest in Victoria has declined by more than 50% since 2000, with 99% of this loss due to bushfires (Australian and Victorian Governments 2019).

Globally, 'mega-fires' are increasing in area, and the time intervals between them are decreasing, across all flammable biomes, including in unmanaged, remote areas (Bowman et al. 2017; World Bank 2020). Simply removing timber harvesting from the landscape is therefore unlikely to be an effective strategy for reducing fire impacts under potentially more frequent extreme fire weather conditions.

On the other hand, more active management of the extensive dry eucalypt forests in south-eastern Australia should help reduce fire risk and impacts, improve forest resilience, and facilitate more active fire suppression under less severe conditions. This is the case elsewhere (Lindenmayer et al. 2009). Such management may include Indigenous cultural burning (Steffensen 2020), other forms of controlled burning (FFMG 2014; Hislop et al. 2020), thinning (Volkova & Weston 2019; Keenan et al. 2021) and mechanical fuel reduction, which is now used widely in the United States of America (Kalies & Yocom Kent 2016) and is being tested in Australia (Ximenes et al. 2017).

Most *Eucalyptus* species have well-developed adaptations to resist and recover from fire, although some (typically wet-forest specialists) are obligate-seeders. More frequent high-severity fires can cause a substantial reduction in tree density in forests dominated by both resprouting and obligate-seeding species. For instance, three fires in quick succession in the early 2000s caused the demographic collapse of an obligate-seeder-dominated *Eucalyptus* forest (Bowman et al. 2016).

Different approaches are required in tall wet forests, where more frequent high-severity fires may result in the loss of obligate-seeder species. To maintain mountain ash forests and species with similar reproduction strategies, fire may need to be no more frequent than 75–150 years (McCarthy et al. 1999).

Strategic management options to reduce the impact of bushfires in tall, wet eucalypt forests include:

- Actively managing dry forests to the north and west of these forests to enable fire suppression and control under severe conditions and thereby reduce the likelihood of fires moving into wet forests
- Maintaining capacity to rapidly suppress and extinguish fires, particularly those starting in drier forests under extreme fire weather conditions that will spread into wet forests, by maintaining roads and access tracks and firefighting capability in or near the forest for rapid early detection and response
- Thinning in even-aged regrowth to accelerate the growth of residual trees and reduce the likelihood that they will be killed by bushfire
- Using alternative silvicultural practices to create more variable stand structures and maintain larger trees as seed sources across the landscape

- Maintaining adequate seed stocks and technical capacity to regenerate severely burnt or reburnt areas by reseeding (Ferguson 2009; Bassett et al. 2015).

Conclusions

The scale and severity of the 2019/20 bushfires in south-eastern Australia were unprecedented, and a harbinger of a more flammable future. Suggestions that past timber harvesting had a significant impact on the extent of severity of these fires are not supported by the emerging evidence from those fires. Proposals that ceasing timber harvesting will reduce future fire risk are unfounded, and this policy option may have impacts on the capacity to prepare for, and respond to, future bushfires. International evidence suggests that appropriate timber harvesting can be part of active management practices to reduce future fire risk. Policies and practices to mitigate fire risk and impacts should be evidence-based, and they should integrate multiple models and different perspectives to avoid the cognitive bias inherent in many expert opinions (Shea et al. 2020). Indigenous, local and professional fire knowledge, and the full breadth of evidence from bushfire research, should inform strategies for reducing fire impacts and making fire-prone Australian forests more resilient and human communities safer.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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