THEME 1.2- HISTORICAL AND SEASONAL CONTEXT ANALYSES

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Subproject: Fuel hazard

Subproject lead: Rachael Nolan

OVERVIEW

1. Theme

Historical and seasonal context of the 2019/20 NSW bushfires

2. Project question or problem statement

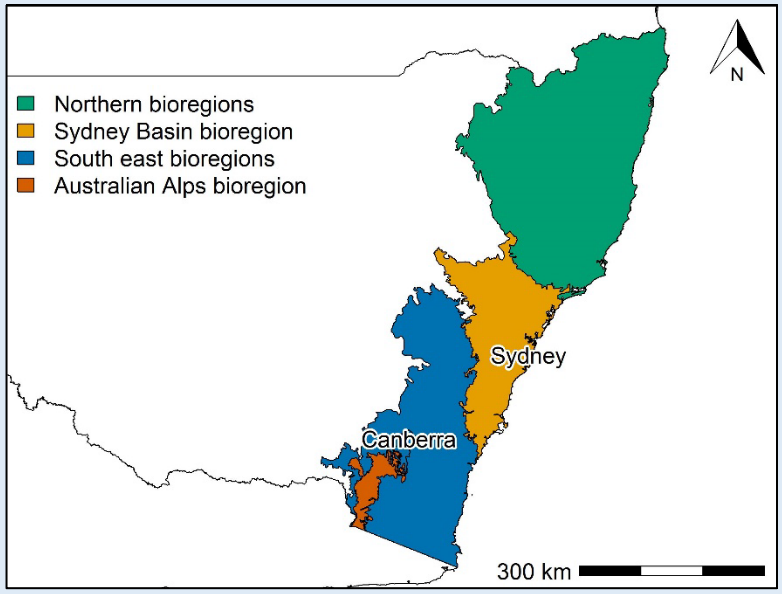
Were fuel loads during the 2019/20 fire season on average higher than previous seasons?

3. Background

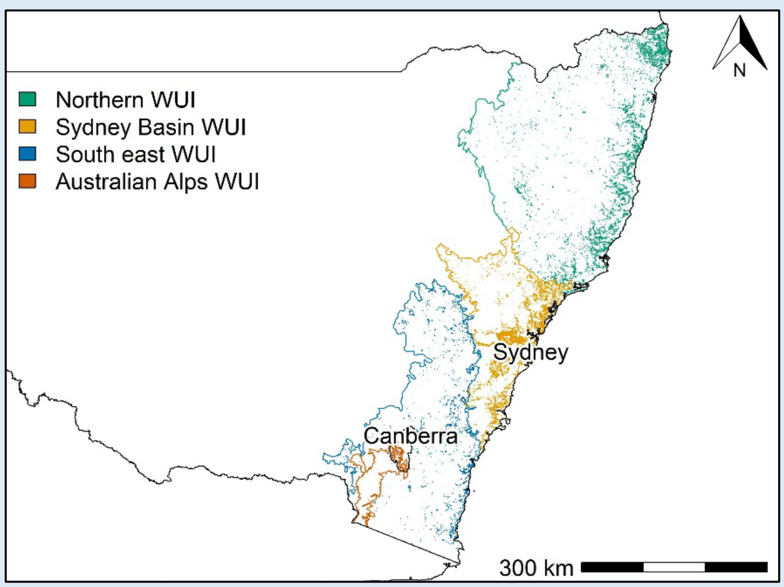
Fuels are routinely characterised into different fuel layers. We examined surface, elevated and bark fuels in forest and woodland vegetation types. We used fire history datasets and fuel accumulation curves, provided by the NSW Rural Fire Service, to estimate fuel loads.

4. Geographic location

The study area incorporated the NSW bioregions which were most affected by bushfires during the 2019/20 fire season. The study area is divided into four main regions for analyses.



Additional analyses were also undertaken within wildland urban interface (WUI) zones, which represent transitional zones between native vegetation and human development. The state of fuel in these zones will potentially have direct influences on risk to lives and property in adjacent developed areas. These WUI zones generally encompass Asset Protection Zones and Strategic Fire Advantage Zones used in risk planning.



5. Key findings

- Across the study area there was large spatial variation in fuel age at the start of the 2019/20 fire season (Fig. 1).
- The proportion of young fuels, i.e. fuels that had burnt in the previous 5 years, exhibited little inter-annual variation over 1990 – 2019 (Fig. 2). The exception is the Australian Alps bioregion, where large bushfires in 2003 transitioned large amounts of fuels to a young fuel age class.
- Estimated fuel loads at the start of the 2019/20 fire season exhibited large spatial variation, reflecting the variation in fuel age (Fig. 3).
- Fuel loads at the start of the 2019/20 fire season were within the range of historical values and generally similar to mean fuel loads since 1990 (Fig. 4 and Table 1). The exception was the Australian Alps bioregion, where the large bushfires in 2003 reduced fuel loads across the majority of the region, with fuel loads increasing over time since 2003.
- Fuel loads within the wildland urban interface (WUI) zones exhibited similar trends to fuels across the different study regions more broadly (Fig. 5). For each region, fuel loads within the WUI zones were similar, or slightly higher, than those estimated across the larger region (Table 1).
- In NSW fuel loads are often classified into five categories of fuel hazard, ranging from low to extreme (Hines et al. 2010). At the start of the 2019/20 fire season surface fuel hazards were on average categorized as ‘high’ to ‘very high’; elevated fuel hazards were on average categorized as ‘moderate’ to ‘high’; and bark fuel hazard ratings were on average categorized as ‘moderate’ to ‘very high’ (Table 1, Appendix 1). Similar fuel hazard categories applied to fuel loads within the WUI zones.
- Following the 2019/20 fires the proportion of young fuels (i.e. fuels burnt in the previous 5 years) increased across all regions (Fig. 2). This resulted in estimated mean fuel loads declining to levels lower than recorded since 1990 for most of the regions examined, except the Australian Alps bioregion (Fig. 4, Table 1). These reductions in mean fuel loads correspond to all fuel types across all regions being classified as either ‘moderate’ or ‘high’ (Table 1, Appendix 1).

6. Significance of findings in context of previous studies

Fuel loads determine rate of spread of fires in forests and woodlands, in association with weather and fuel dryness (Sullivan et al. 2012). Thus, fuel loads are a key co-determinant of area burned and fire intensity, though fire behavior models tend to under predict rate of spread under adverse weather (e.g. high FFDI, Cruz et al. 2012). This may indicate a non-linear influence of weather conditions, including dryness, on rate of spread as indicated in analyses of fire severity patterns (e.g. Bradstock et al. 2010, Price and Bradstock 2012). The findings presented here demonstrate that estimated fuel loads for the start of the 2019/20 season were, on average, no higher than previous seasons. However, we note that the interaction of average fuel loads with widespread record fuel dryness has likely increased fuel availability to burn to exceptionally high levels (Boer et al. 2020). Nonetheless, fuel levels are likely to have been influential in determining fire behavior, and resultant area burned, intensity and effects on human and biotic communities. Determination of such influences and the degree to which they could have been altered via manipulation of fuel loads requires specific analyses at local, landscape and individual fire scales.

7. Limitations and remaining knowledge gaps

These analyses provide insight into fuel loads across large spatial scales, and therefore do not examine the specific role of fuel loads on fire behavior for any particular fire. Further, these results do not address the associated role of fuel loads on the execution and outcome of fire suppression activities in any particular location.

8. Implications for fire management

We have produced the first, comprehensive chronology of estimated fuels across the most fire prone regions of NSW. This now provides a platform for more informed discussion of fuel loads and their role in determining bushfire risks. Such discussion will be improved by ongoing refinement of the basic methodologies used to compile this chronology. This new approach allows us to see that fuel loads in mid-2019 were, on average, no higher compared to previous seasons, since 1990. Given that fuel loads were, on average, comparable to previous seasons, we infer that the exceptional burned area of the 2019/20 season has likely been determined by other biophysical constraints on burned area, in particular fuel dryness and fire weather.

Following the 2019/20 fire season the large declines in estimated mean fuel loads across much of the study area will likely lead to lower bushfire risks.

9. Figures

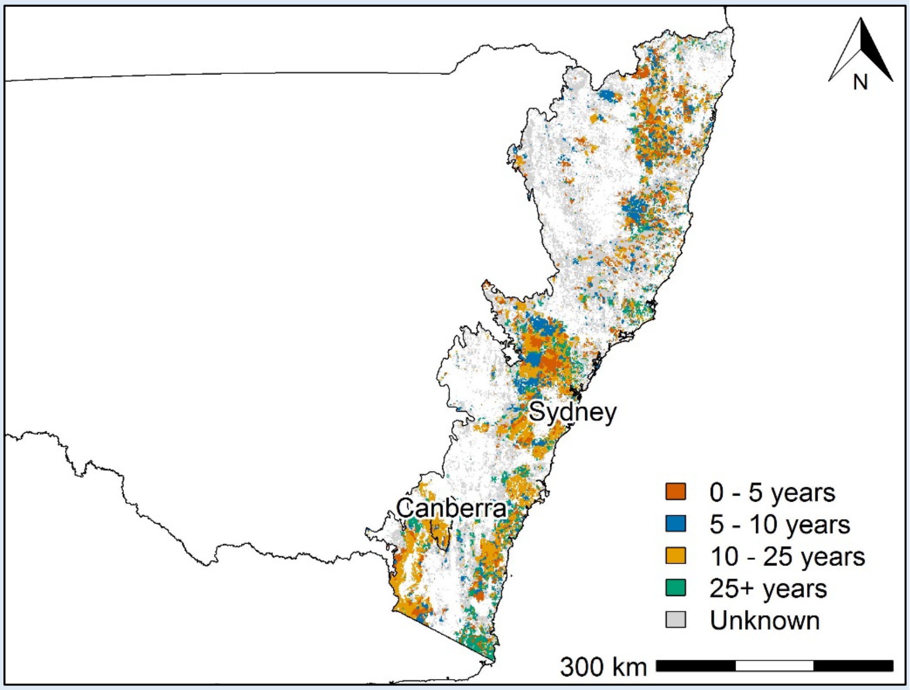


Figure 1. Map of the time since last fire (in years) for forest and woodland fuel types in the study area on July 1, 2019. Both bushfires and planned fires are included in this map.

Enlarged maps of each study region are provided in Appendix 2.

Figure 2. Percentage of forests and woodlands burnt within the previous 5 years (by bushfires or planned fires). Dashed lines represent mean values over 1990 – 2019.

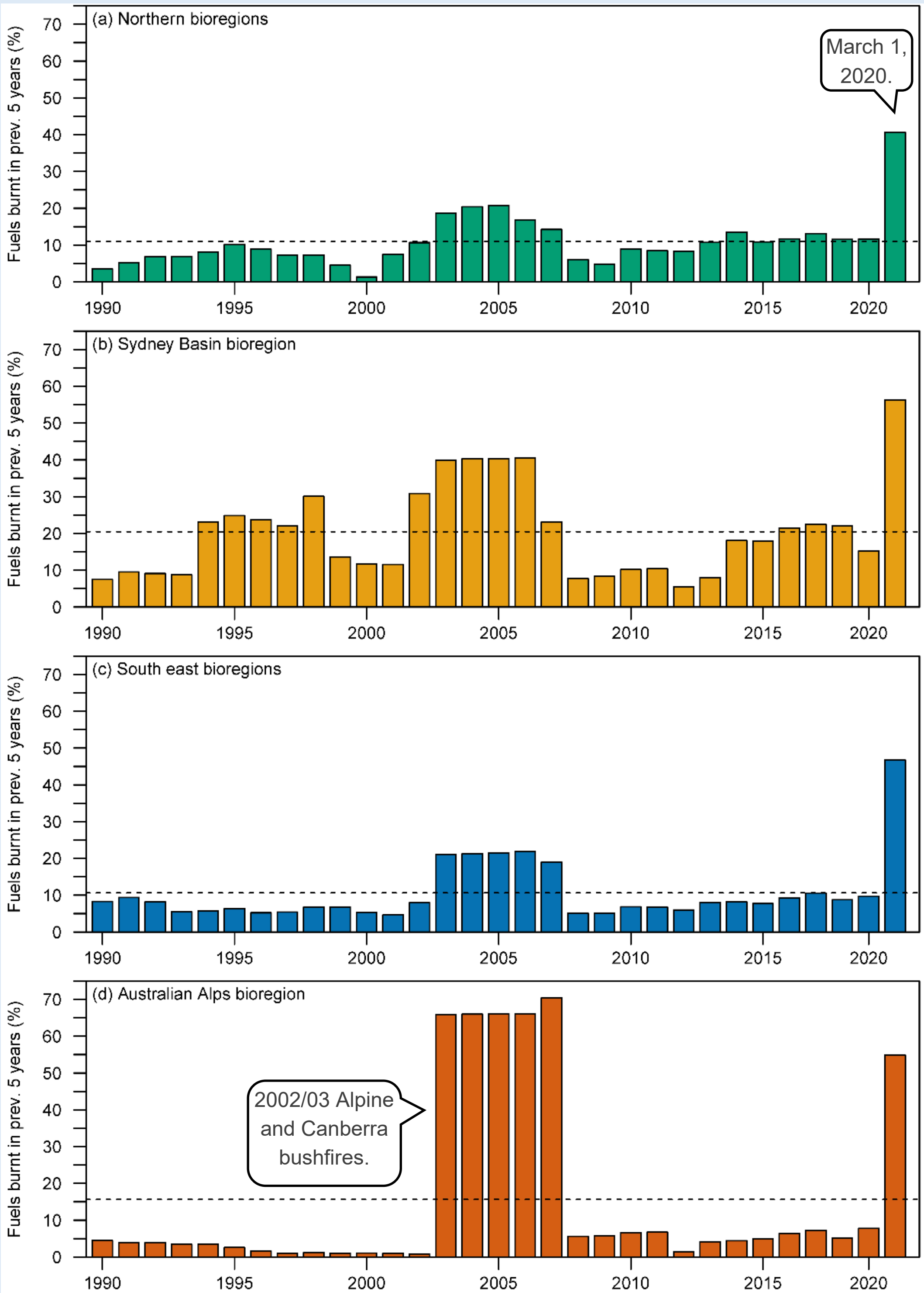


Figure 3. Estimated fuel loads for (a) surface fuels, (b) elevated fuels, and (c) bark fuels, on July 1, 2019.

Enlarged maps of each study region are provided in Appendices 3-5.

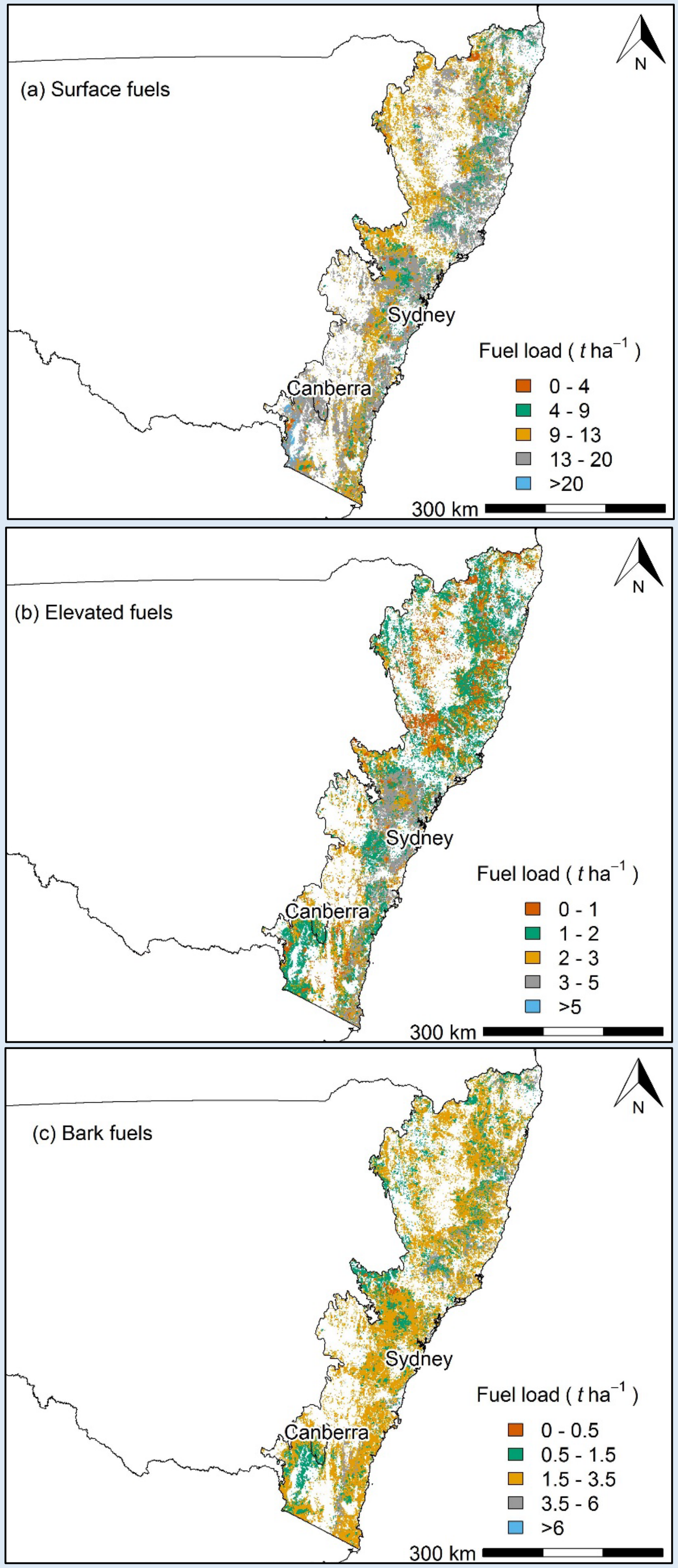


Figure 4. Mean estimated (a) surface fuels, (b) elevated fuels and (c) bark fuels for July 1 of each year for each of the study regions.

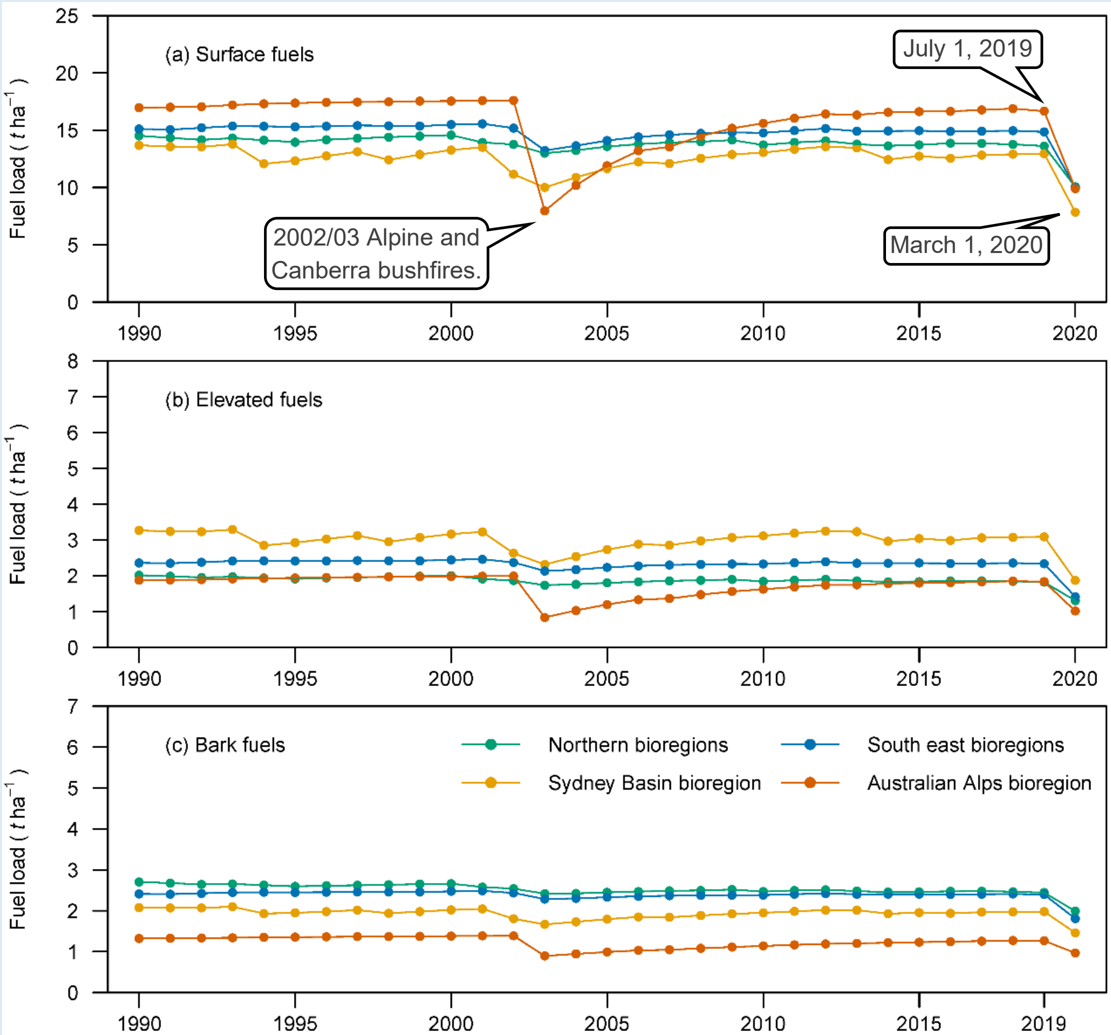


Figure. 5. Mean estimated fuel loads for July 1 of each year, from 1990 – 2019, for the wildland urban interface zones within each of the study regions. Estimated fuel loads are (a) surface fuels, (b) elevated fuels and (c) bark fuels.

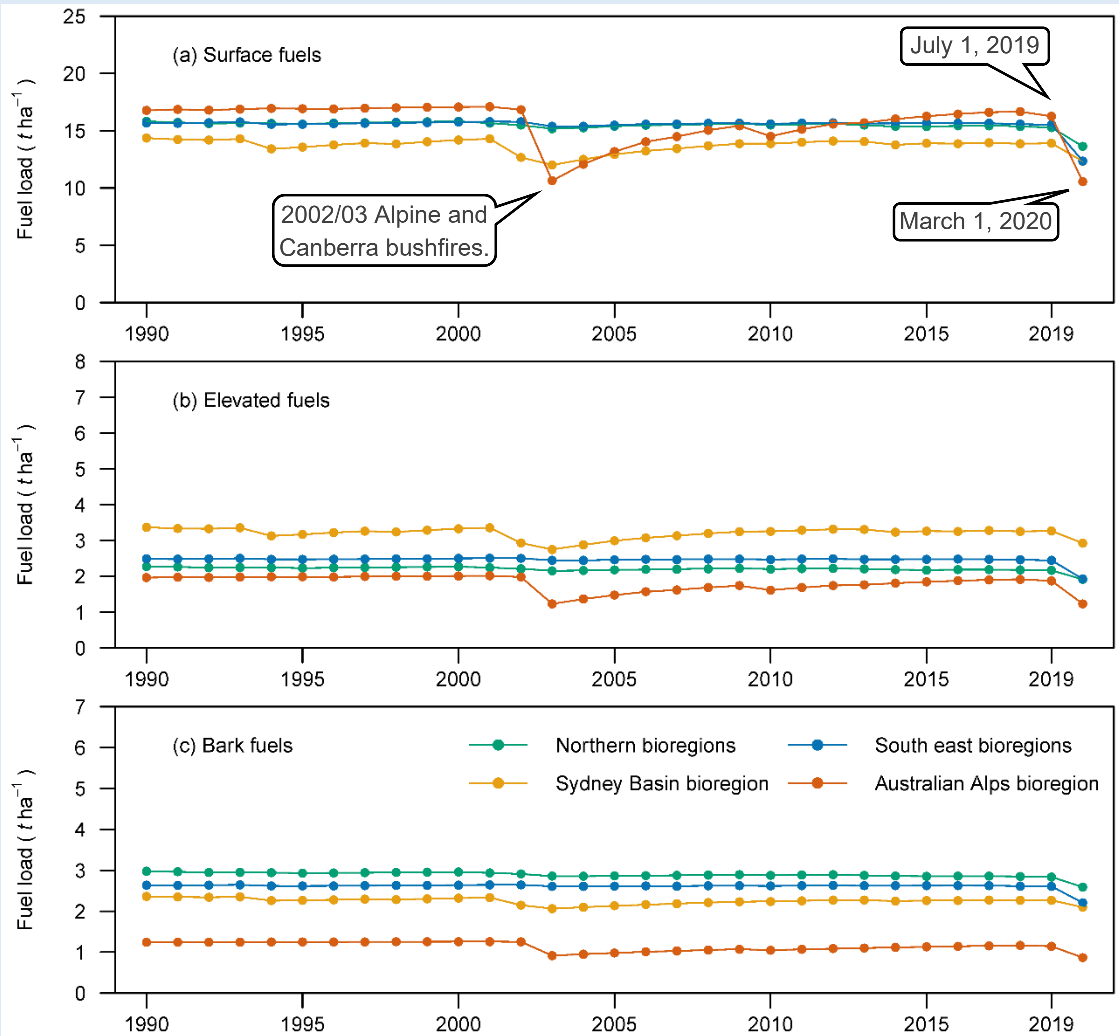


Table 1. Mean fuel loads within forests and woodlands for each study region. Minimum, maximum and mean values are calculated over 1990 – 2019 (i.e. excluding 2020).

Fuel type	Mean fuel loads (t ha^{-1}), Northern bioregions				
	Minimum	**Maximum**	**Mean**	**July 1, 2019**	**March 1, 2020**
All forests and woodlands in region					
Surface	13.0	14.6	14.0	13.6	10.1
Elevated	1.7	2.0	1.9	1.8	1.3
Bark	2.4	2.7	2.5	2.4	2.0
Forests and woodlands within wildland urban interface within study region					
Surface	15.2	15.8	15.5	15.3	13.6
Elevated	2.2	2.3	2.2	2.2	1.9
Bark	2.8	3.0	2.9	3.0	2.6
Fuel type	**Mean fuel loads (t ha^{-1}), Sydney Basin bioregion**				
	Minimum	**Maximum**	**Mean**	**July 1, 2019**	**March 1, 2020**
All forests and woodlands in region					
Surface	10.0	13.8	12.7	13.0	7.8
Elevated	2.3	3.3	3.0	3.1	1.9
Bark	1.7	2.1	1.9	2.0	1.5
Forests and woodlands within wildland urban interface within study region					
Surface	12.0	14.4	13.9	13.7	12.3
Elevated	2.8	3.4	3.2	3.3	2.9
Bark	2.1	2.4	2.3	2.3	2.1
Fuel type	**Mean fuel loads (t ha^{-1}), South east bioregion**				
	Minimum	**Maximum**	**Mean**	**July 1, 2019**	**March 1, 2020**
All forests and woodlands in region					
Surface	13.2	15.6	14.9	14.8	10.0
Elevated	2.1	2.5	2.4	2.3	1.4
Bark	2.3	2.5	2.4	2.4	1.8
Forests and woodlands within wildland urban interface within study region					
Surface	15.4	15.8	15.6	15.5	12.4
Elevated	2.4	2.5	2.5	2.4	1.9
Bark	2.6	2.6	2.6	2.6	2.2
Fuel type	**Mean fuel loads (t ha^{-1}), Australian Alps bioregion**				
	Minimum	**Maximum**	**Mean**	**July 1, 2019**	**March 1, 2020**
All forests and woodlands in region					
Surface	8.0	17.6	15.9	16.7	9.9
Elevated	0.8	2.0	1.7	1.8	1.0
Bark	0.9	1.4	1.2	1.3	1.0
Forests and woodlands within wildland urban interface within study region					
Surface	10.6	17.1	15.5	15.3	10.6
Elevated	1.2	2.0	1.8	1.9	1.2
Bark	0.9	1.3	1.1	1.1	0.7

10. Key reference list

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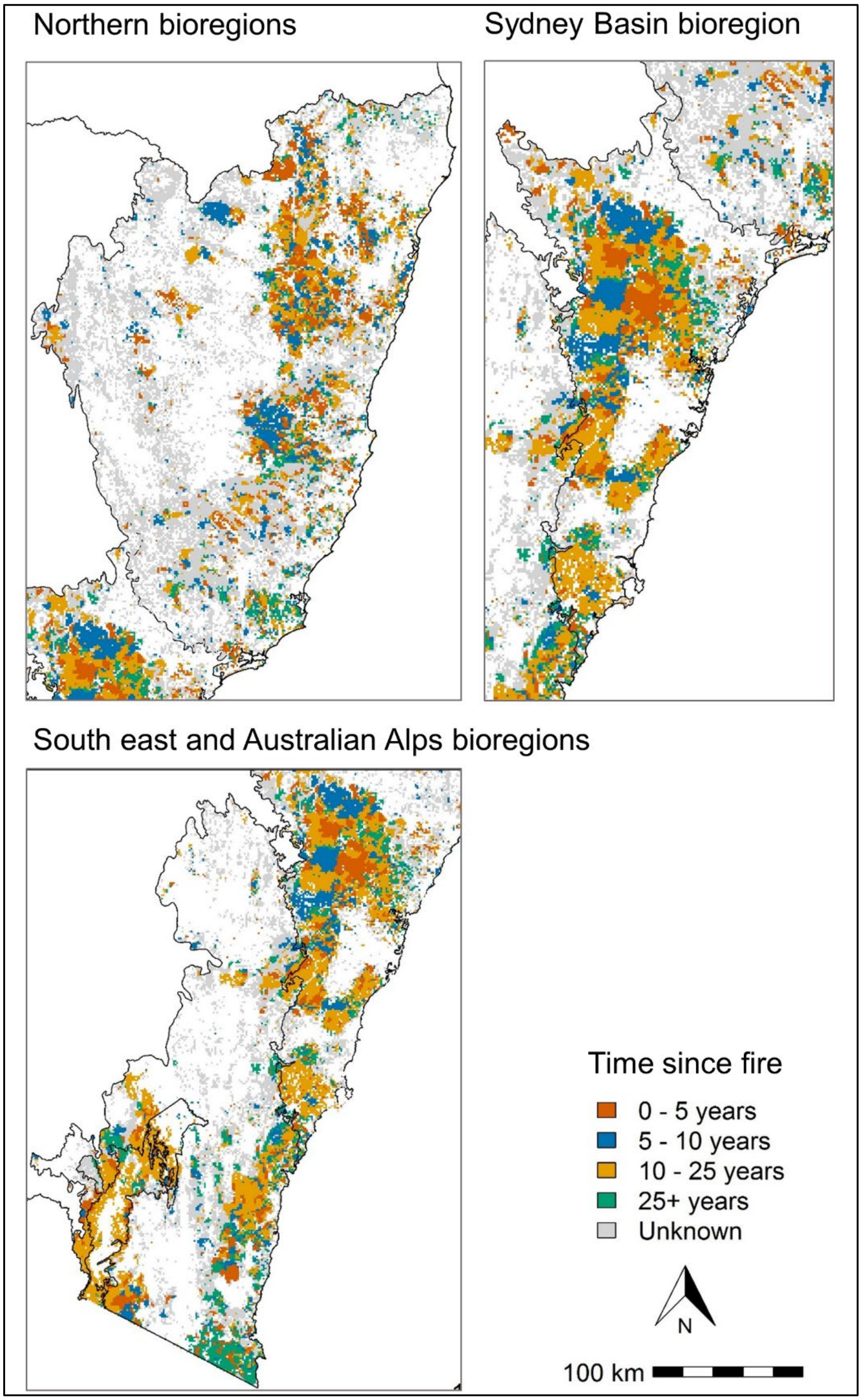
Appendix 1: Indicative relationship between fuel loads (t ha^{-1}) and fuel hazard rating.

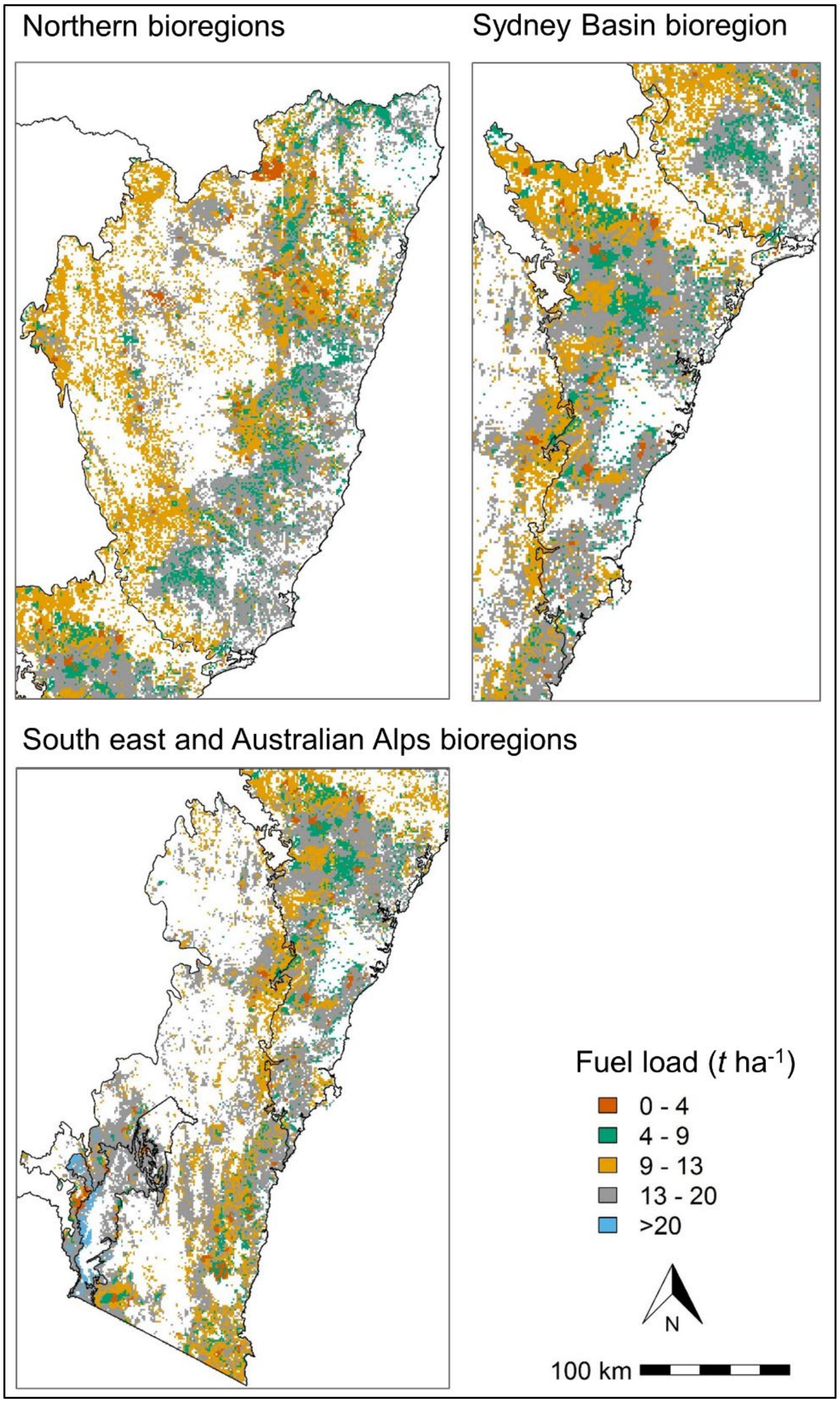
Fuel	Fuel hazard rating				
	Low	Moderate	High	Very High	Extreme
Surface	2–4	4–10	8–14	12–20	16-20+
Elevated	0–1	1–2	2–3	3–5	5–8
Bark	0	1	2	5	7

Table sourced from Hines et al. (2010, p. 36).

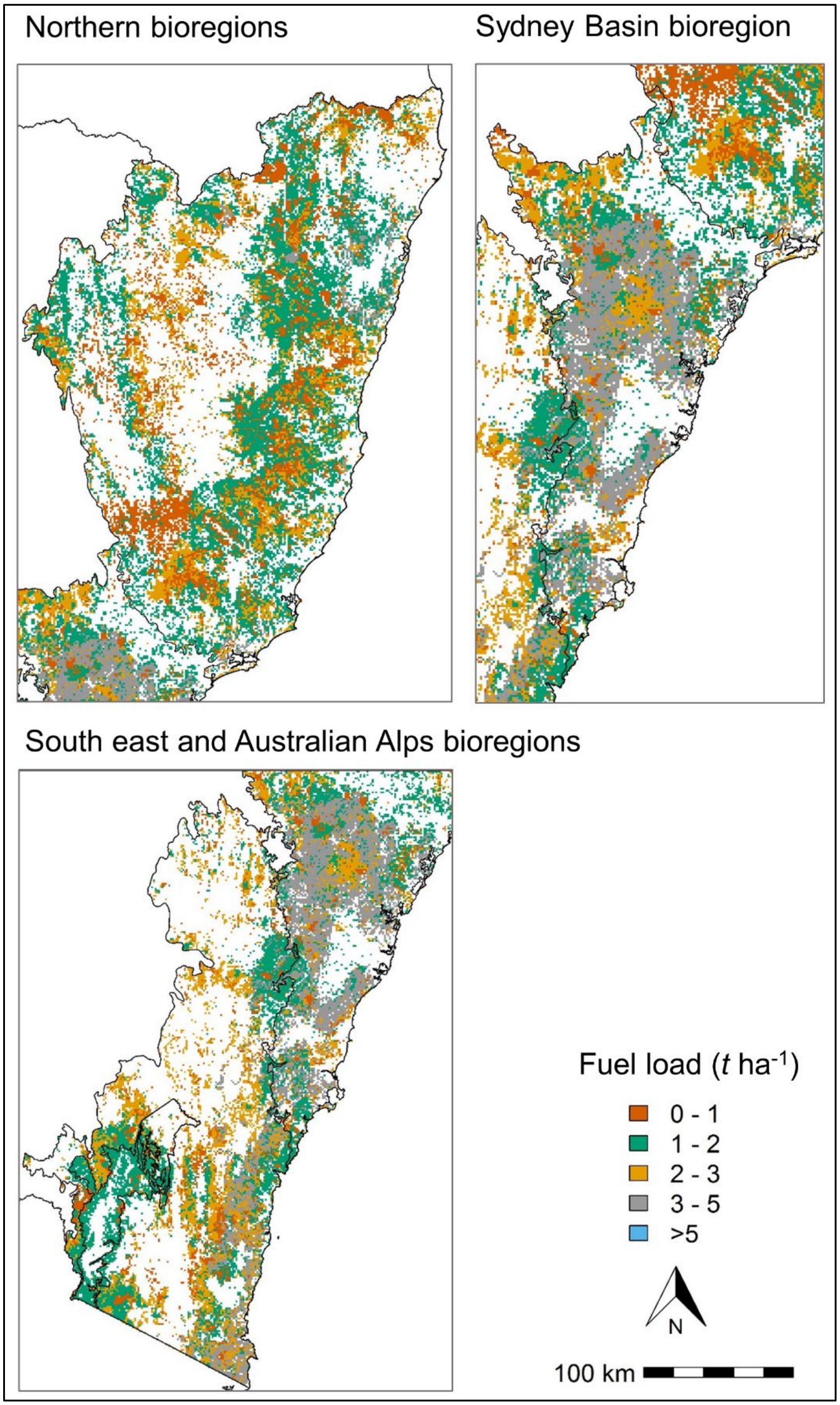
Appendix 2: Enlarged maps of the time since last fire (in years) for forest and woodland fuel types in each study region on July 1, 2019.



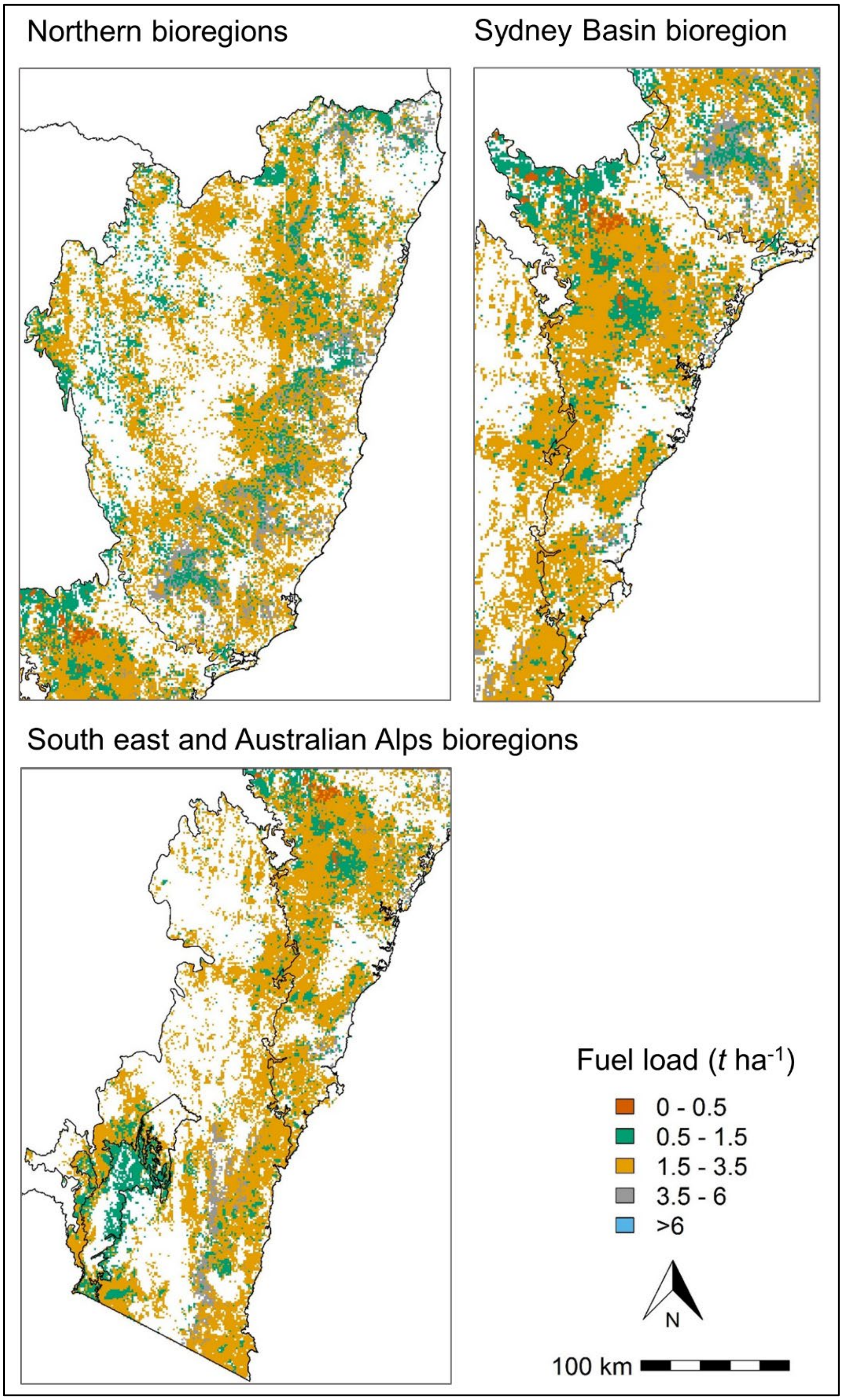
Appendix 3: Enlarged maps of surface fuel loads (t ha^{-1}) for forest and woodland fuel types in each study region on July 1, 2019.



Appendix 4: Enlarged maps of elevated fuel loads (t ha^{-1}) for forest and woodland fuel types in each study region on July 1, 2019.



Appendix 5: Enlarged maps of bark fuel loads (t ha^{-1}) for forest and woodland fuel types in each study region on July 1, 2019.



Appendix 6: Methods

Time since fire

The number of years since fire (either bushfires or planned fires), was calculated across the study area for forest and woodland fuel types (see Kenny and Roberts, 2016, for fuel type classification). Time-since-fire was calculated on the 1st of July for each year since 1990. 1990 was chosen as the baseline study year since fuel loads often take 20-25 years to reach steady states following fire (Watson 2012). Thus, reliable fire history records are required for at least 25 years prior to the date fuel loads are estimated for. Fire history data was obtained from the NSW Rural Fire Service (RFS).

Fuel loads

Fuel loads were classified into the following three strata: surface fuels, elevated fuels and bark fuels. See Hines et al. (2010) for details of strata classification. Fuel loads were calculated by applying fuel accumulation curves, which model fuel loads as a function of time since fire (Olson, 1963). We applied fuel accumulation curves provided by the RFS, which were mostly based on Watson (2012).

Fuel loads were examined for forest and woodland fuel types across each of the study regions. We focused on forest and woodland fuel types since (i) these fuel types were the dominant fuel type burnt in the 2019/20 fire season; and (ii) these fuel types are less dynamic on an intra-annual basis compared to other fuel types, such as grassy fuels.

Fuel loads were additionally examined within wildland urban interface (WUI) zones, which represent transitional zones between native vegetation and human development. WUI zones are defined as areas where there are intermediate levels of buildings and vegetation fuel, modified from Radeloff et al (2005). For this analysis, the spatial units were ~1 km^2 hexagons, the building points were from the Geoscape buildings database, data courtesy of the RFS. The fuels were estimated from the Maximum Overall Fuel Hazard (OFH, Hines 2010) as supplied by the RFS.

References

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