THEME 2.2- FIRE SEVERITY AND BEHAVIOUR

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Subproject: Fire severity and past fire impact

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OVERVIEW

1. Theme

Fire Severity and Behaviour

2. Project question or problem statement

What were the patterns of fire severity across the Gospers Mtn, Bees Nest and South Coast fire complexes? How was fire severity driven by weather conditions, and what was the impact of recent past fire on severity?

3. Key findings

- Fire severity is a measure of the ecological and structural impact of a fire on vegetation. High-resolution satellite imagery captured before and after the fire can be used to calculate an index of fire severity – here the FESM algorithm is applied (Gibson *et al.* 2020). Severity categories presented are **unburnt**, representing an unburnt surface with green canopy, **low** indicating an understorey fire that did not impact the canopy, **moderate** indicating partial canopy scorch**, high** indicating full canopy scorch and partial canopy consumption, and **severe** indicating full canopy consumption. Across the entire state, 800,600 hectares were burnt in high or severe categories, indicating partial or complete canopy consumption.
- In the 2019/2020 fires, the complete range of fire severity classes occurred within the three case-study fires (Gospers Mtn, Bees Nest and the South Coast complex). Taken across the whole fire area, there was a greater area burnt under lower severity classes inside the areas burnt by recent (less than 3 years ago) past prescribed or

unplanned fires than in the comparison recently unburnt area, but in all three case-study fires, large areas were nonetheless burnt in the high or severe categories in recently burnt areas (Figures 1,2,3). This indicates that while past fire, including prescribed fire, can sometimes have an impact in reducing fire severity, it does not consistently reduce severity, and areas can reburn at a high or severe class despite recent fire.

- In the case of all three case-study fires, examination of fire severity patterns within the boundaries of recent fires shows a range of responses. For the Gospers Mtn (Figure 4), South Coast (Figure 5) and Bees Nest (Figure 6) fires, some post-2017 fires appeared to act as a barrier to fire spread in 2019/2020, some showed reduced severity inside the past boundaries, and some appeared to have no impact on severity in this year's fires. Details of individual fire impacts are provided in the figure captions of figures 4, 5 and 6. Broadly, recent unplanned bushfires fires appeared to have a greater impact than prescribed fires in acting as a barrier to spread. Prescribed fires tended to reduce severity without completely stopping fire spread, though many prescribed fires had no detectable impact on severity.
- In the Gospers Mtn fire, dry sclerophyll forest is the dominant vegetation formation, and fire severity was dominated by the moderate and high classes, indicating extensive, consistent canopy damage across the entire area (Figure 7). Unburnt areas were largely confined to the valley regions, dominated by wet sclerophyll forest. Areas in the southern portion of the fire ground did experience the severe category, indicating complete canopy consumption, primarily in dry sclerophyll forest.
- Vegetation within the South Coast fire complex, which for the purposes of this analysis includes the entire region from Bega through to Nowra, is more diverse in vegetation, with most vegetation formations experiencing high and severe fire severities (Figure 8). Significantly, large areas of wet sclerophyll forests, which maintain long fire intervals and are expected only to burn under prolonged drought and extreme weather conditions, experienced canopy-consuming severe fire severity. Areas of fire-sensitive rainforest also burnt in high or severe classes.

- In the Bees Nest fire in the north of the state, both wet and dry sclerophyll vegetation formations experienced significant areas high severity fire, and canopy-consuming severe fire (Figure 9).
- Fire weather, as represented by the McArthur Forest Fire Danger Index (FFDI) is assumed to be a major driver of severity. However, this was not clear in all fires. For the Gospers Mtn fire (Figure 10), there appears to be little tendency towards higher severity categories during elevated fire weather conditions, with areas burning in the high or severe categories even during more moderate fire weather. The South Coast complex (Figure 11) also shows a spread of severities across the range of FFDI, although with large areas burnt in the high or severe classes during elevated fire weather. The Bees Nest fire (Figure 12) shows a clearer relationship between severity and FFDI, with most of the high and severe burning occurring during elevated FFDI, although fire weather for much of the area of this fire was more moderate, with few areas burnt when the FFDI was above 50 (Very High).
- FESM severity was also calculated for all prescribed burns from mid-2017 intersecting with the case study areas. This mapping shows that severity in prescribed burns is highly variable and patchy (Figure 13), with large areas of the nominal prescribed burn areas classified as unburnt. Satellite severity mapping can fail to detect low severity fires under dense canopies, which may explain the large area classified as unburnt. However, the patchy nature and low severity of these prescribed burns suggests they may have low utility in acting as barriers to bushfires.

4. Significance of findings in context of previous studies

An analysis of the effect of prescribed burning on the severity of the 2003 Alpine fire in eastern Victoria (Tolhurst & McCarthy 2016) showed that past prescribed burning did reduce fire severity and assist in suppression, but this effect was strongest during more moderate weather conditions, and that prescribed burning had little impact when the Forest Fire Danger Index (FFDI) was above 50. This study also found that prescribed burns less than 3 years old had the greatest impact on severity. Our analysis was limited to fires from mid-2017 with this in mind, as well as due to the lack of consistent Sentinel-2 satellite imagery for the FESM severity algorithm prior to this date.

Despite this, we found varying effects of prescribed burns on fire severity, with some reducing severity while others appearing to have no impact, despite their recency. A review of the effectiveness of prescribed burning globally (Fernandes & Botelho 2003) concluded that the effectiveness of prescribed burning is strongly limited by fuel accumulation rates, with forests rapidly accumulating fuels within the first 2-4 years post-treatment, and with prescribed burning most effective in heterogenous landscapes with low likelihood of extreme fire weather conditions. In these case-study fires, the extreme fire weather experienced, along with the homogenous vegetation that limited suppression ability and allowed for long fire-runs, likely limited the effectiveness of prescribed burning in affecting severity in many cases.

5. Limitations and remaining knowledge gaps

- The satellite-based severity classification has an inherent limitation in detecting fire effects through dense canopies. There is also a lower limit to the sensitivity and resolution of satellite-based estimation in mapping patchy low severity ground fires, which may appear as unburnt. The FESM algorithm does not currently include any training data from the 2019/2020 fire season, but there are plans revise and improve the severity classification using additional high-resolution aerial photography of this season's fires.
- This is a preliminary, primarily qualitative analysis. A statistical analysis of fire severity in the Gospers Mountain fire showed some limitations in the ability to detect an effect of weather, as represented by FFDI, on reducing fire severity, but this may be reflective of the overall lack of association between FFDI and severity across this fire. This analysis plus further statistical analysis of the South Coast and Bees Nest fires, that will additionally gauge the effect of logging practices, will be forthcoming in a revised report.

6. Implications for fire management

- Areas within mapped prescribed burn boundaries are commonly very low severity with mosaics of unburnt patches, so the entire area may not be adequately treated. This needs to be considered when calculating state-wide treatment area. Satellite severity mapping cannot always detect low-severity prescribed burns, although the

detection of canopy-level effects may be sufficient to understand fire behavior. Additional research utilizing satellite severity mapping to understand prescribed burn severity patterns would be beneficial for managers to understand and account for fire severity metrics in assessing the utility of prescribed burning operations.

- Prescribed burns do appear to have some impact on severity in some cases, but not necessarily in preventing fire spread, and not all the time. Prescribed burning may be most effective in reducing fire severity and aiding in suppression when applied frequently to targeted areas close to assets, and prescribed burning in remote areas for ecological management, while necessary, cannot necessarily be relied upon to act as a barrier to fire spread.
- Both time since fire, and the severity of past fire, affect the utility of past burns to reduce fire severity. These constraints on the effectiveness of prescribed burning need to be acknowledged and accounted for.

7. Figures

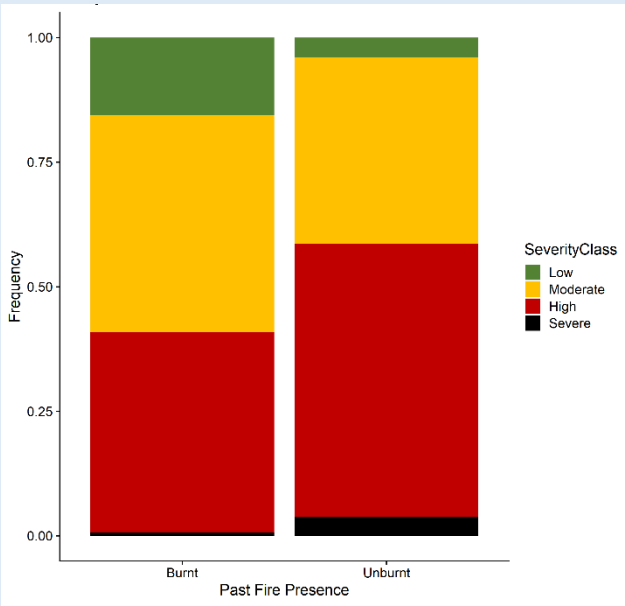

Figure 1. Fire severity class inside the Gospers Mountain fire boundary inside and outside post-2017 burnt areas.

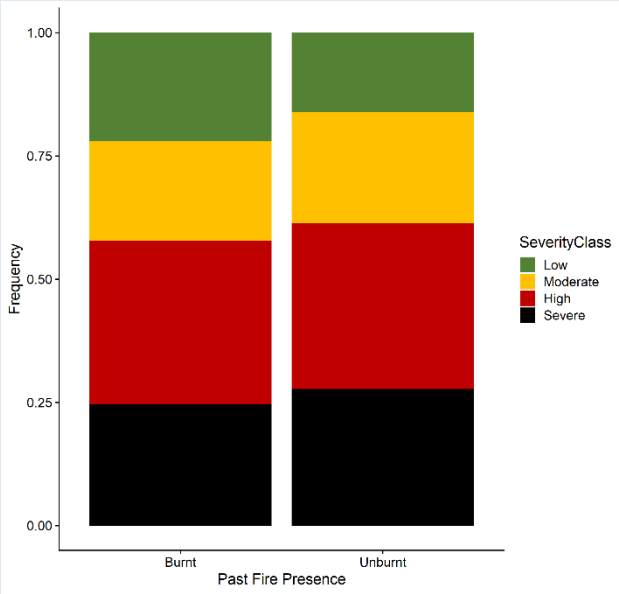

Figure 2. Fire severity class inside the South Coast complex fire boundary inside and outside post-2017 burnt areas.

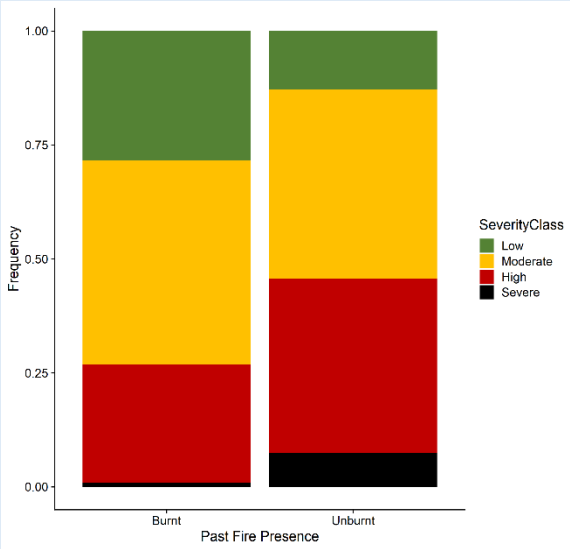

Figure 3. Fire severity class inside the Bees Nest fire boundary inside and outside post-2017 burnt areas.

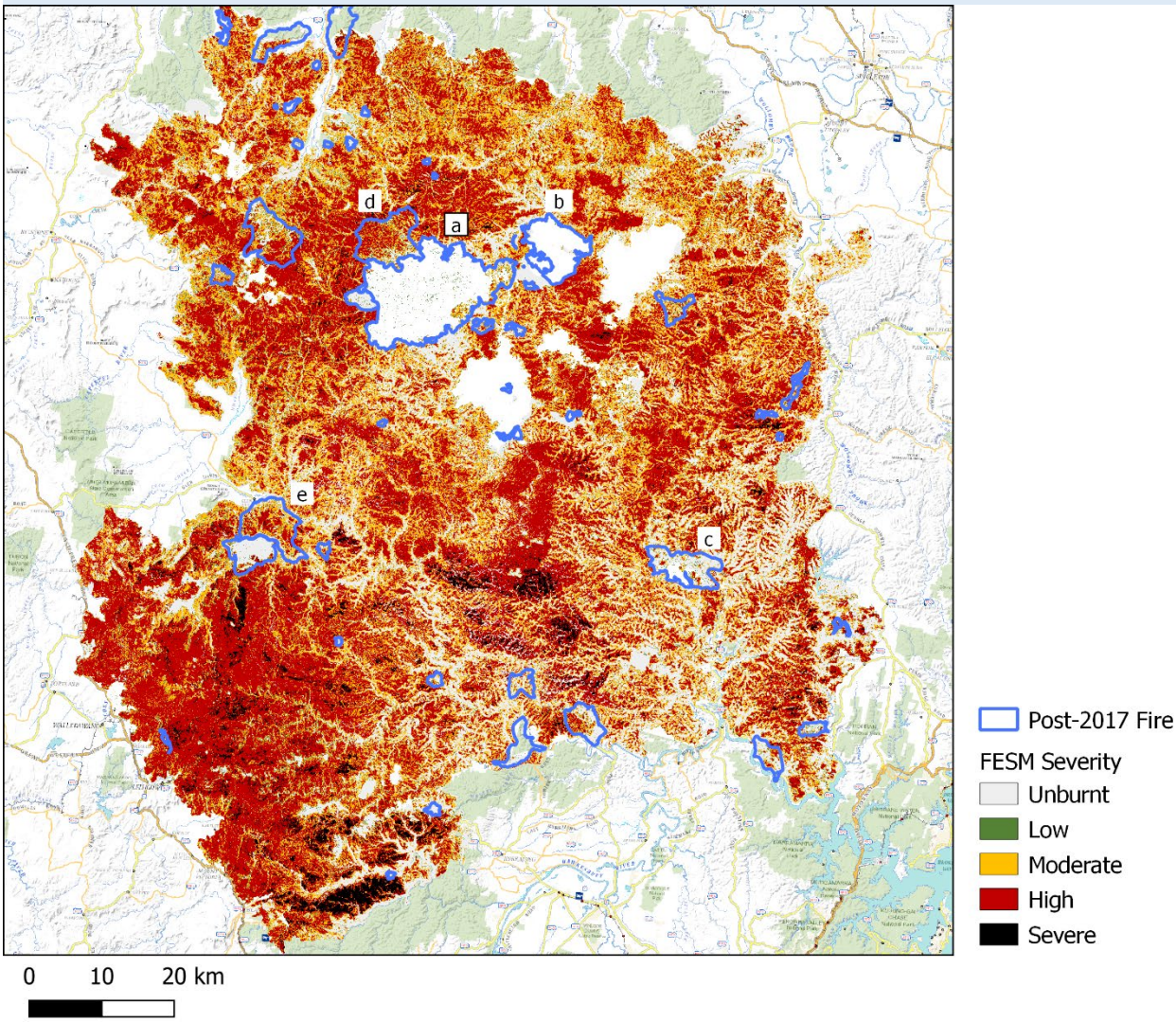

Figure 4. Gospers Mountain fire severity, with post-2017 wildfires and prescribed burns indicated. Fires **a** and **b,** which were wildfires that occurred in early 2018, served to act as a barrier to or significantly reduce severity. Fire **c**, a 2017 prescribed burn, reduced severity overall but areas of high severity remained, while fires **d,** a 2019 prescribed burn and **e,** a 2017 prescribed burn appear to have little impact on severity in the 2019/2020 fire.

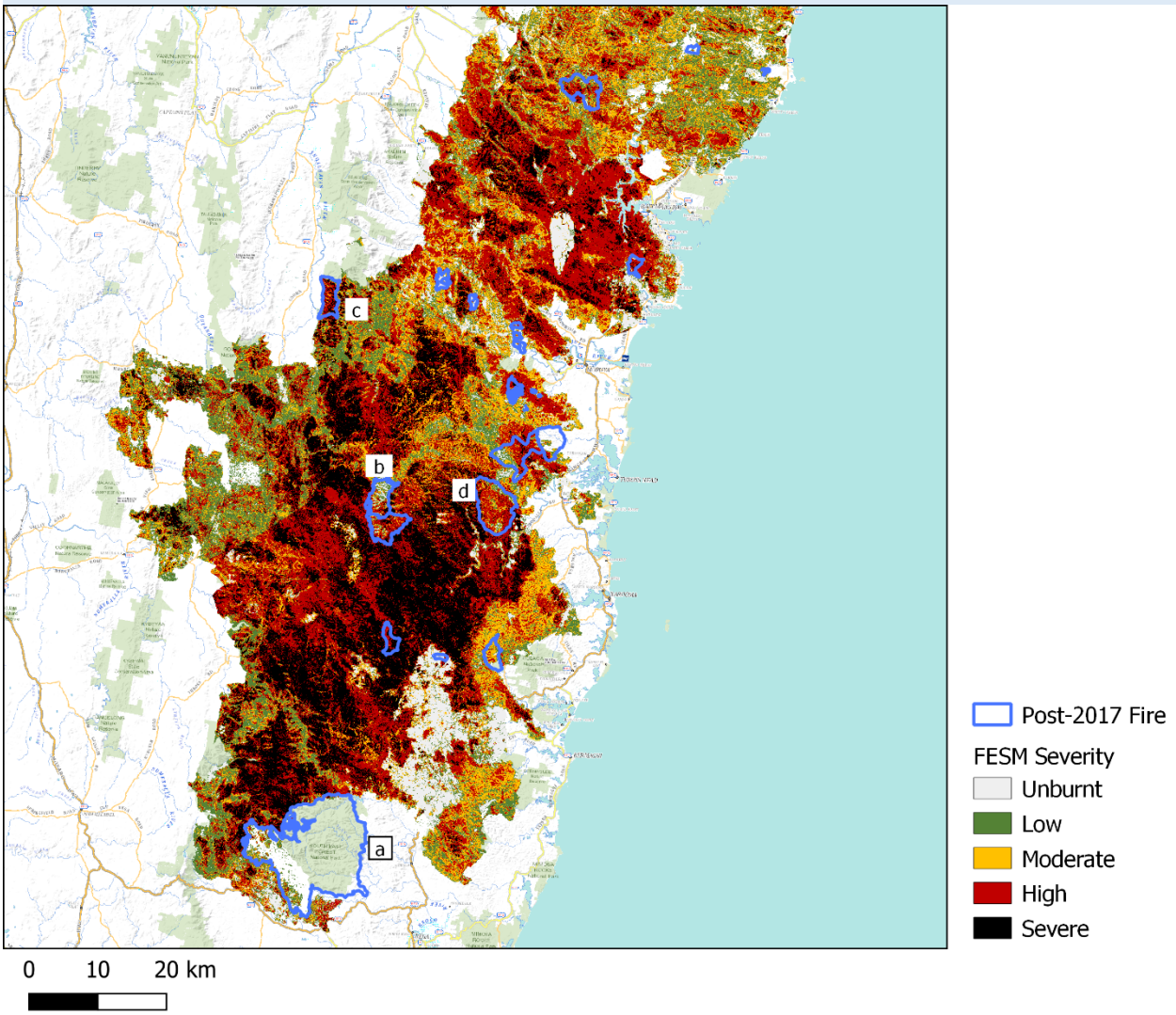

Figure 5. Southern portion of South Coast fire complex fire severity, with post-2017 wildfires and prescribed burns indicated. Fire **a**, a wildfire from 2018, appears to act as a barrier to fire spread, with some patchy areas of low severity burnt within it. Fire **b**, a prescribed burn from May 2019, also appeared to reduce severity, while fires **c,** a 2017 prescribed burn, and **d**, a 2018 prescribed burn, did little to reduce the severity of the 2019/2020 fire.

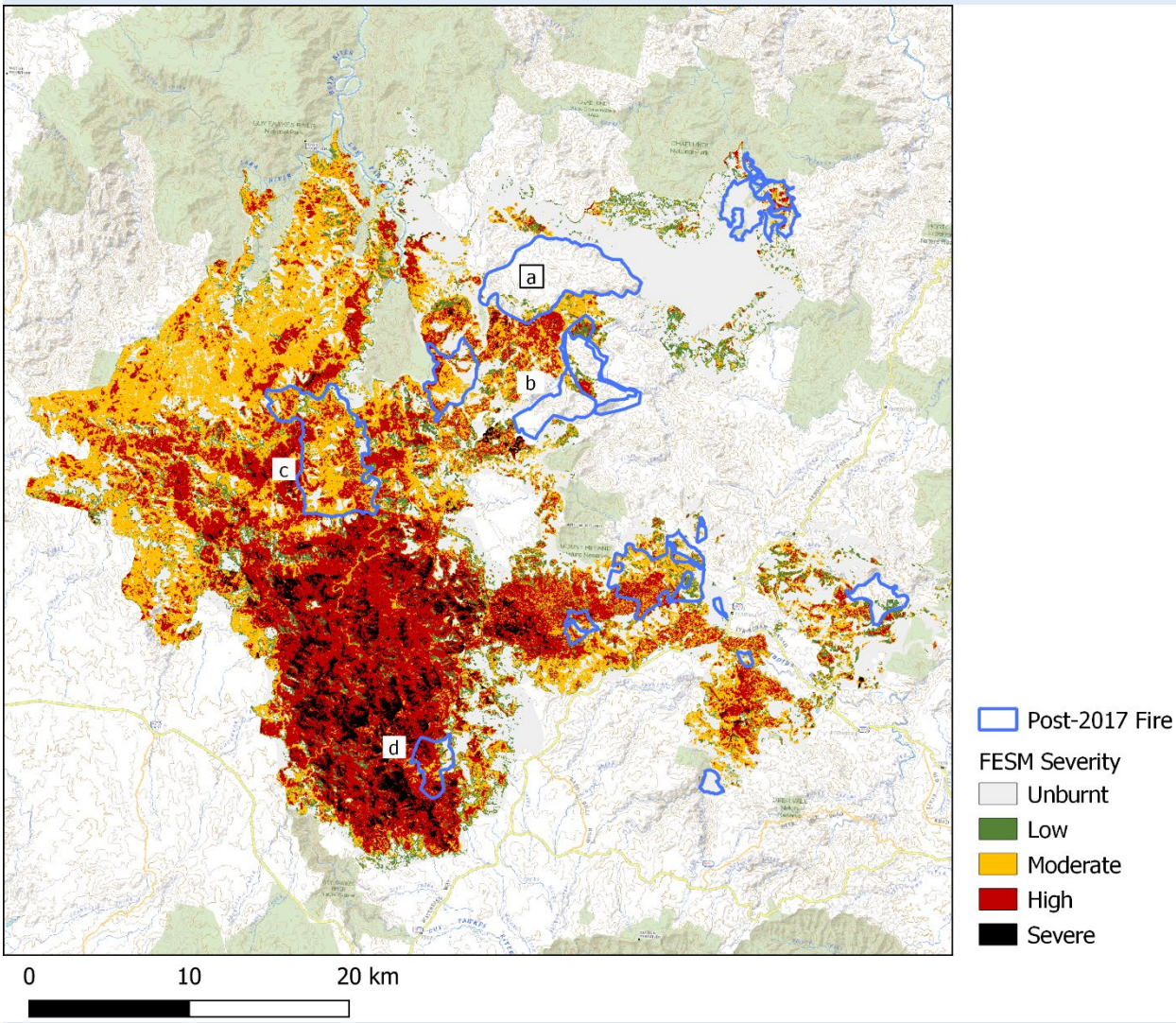

Figure 6. Bees Nest fire ground fire severity, with post-2017 wildfires and prescribed burns indicated. Fires **a** and **b**, both wildfires from 2018, appear to act as barrier to fire spread. By comparison fire **c**, a wildfire from 2017, and fire **d,** a 2017 prescribed burn, did not appear to act as a barrier or reduce the severity of the 2019/2020 fire.

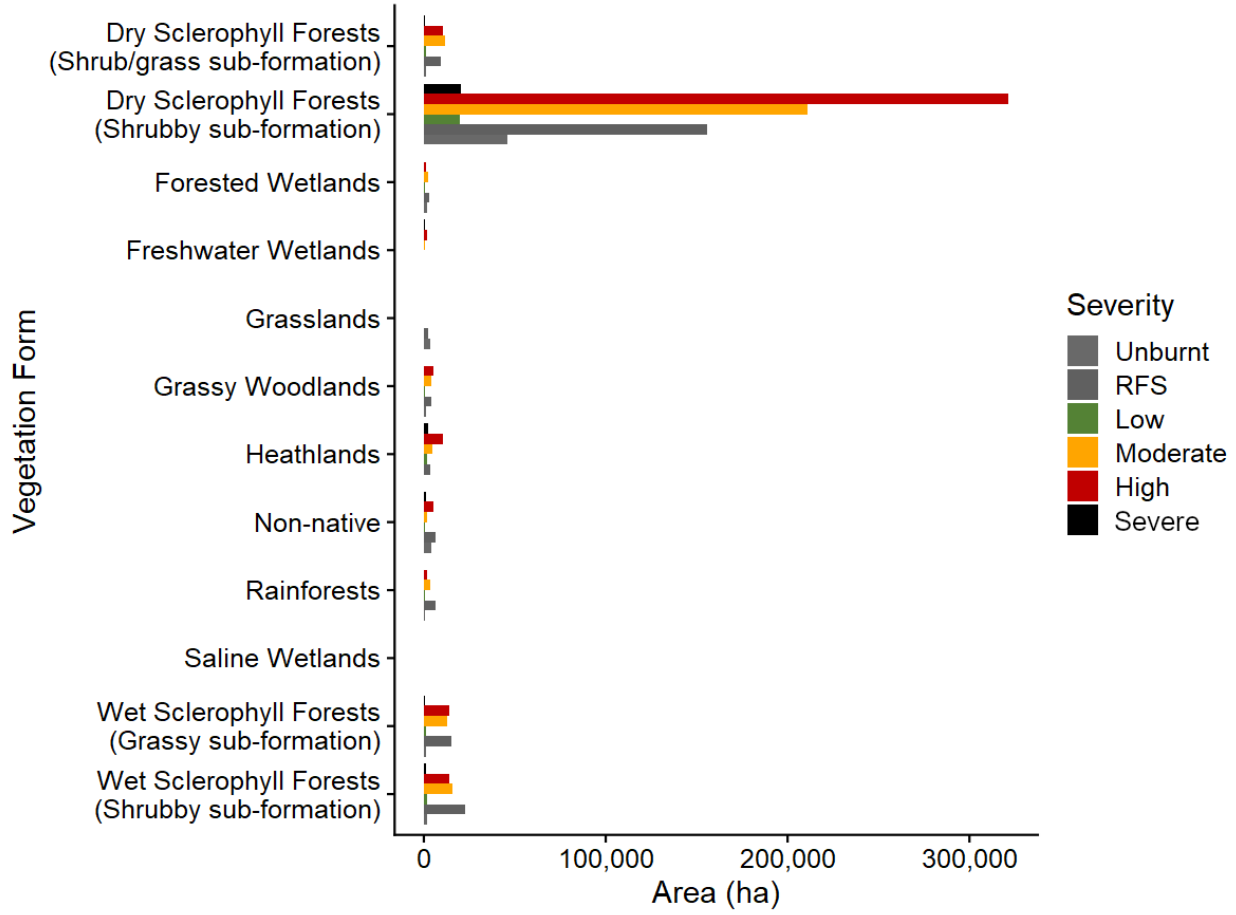

Figure 7. Summary of 2019/2020 fire severity classes by vegetation formation within the Gospers Mountain fire.

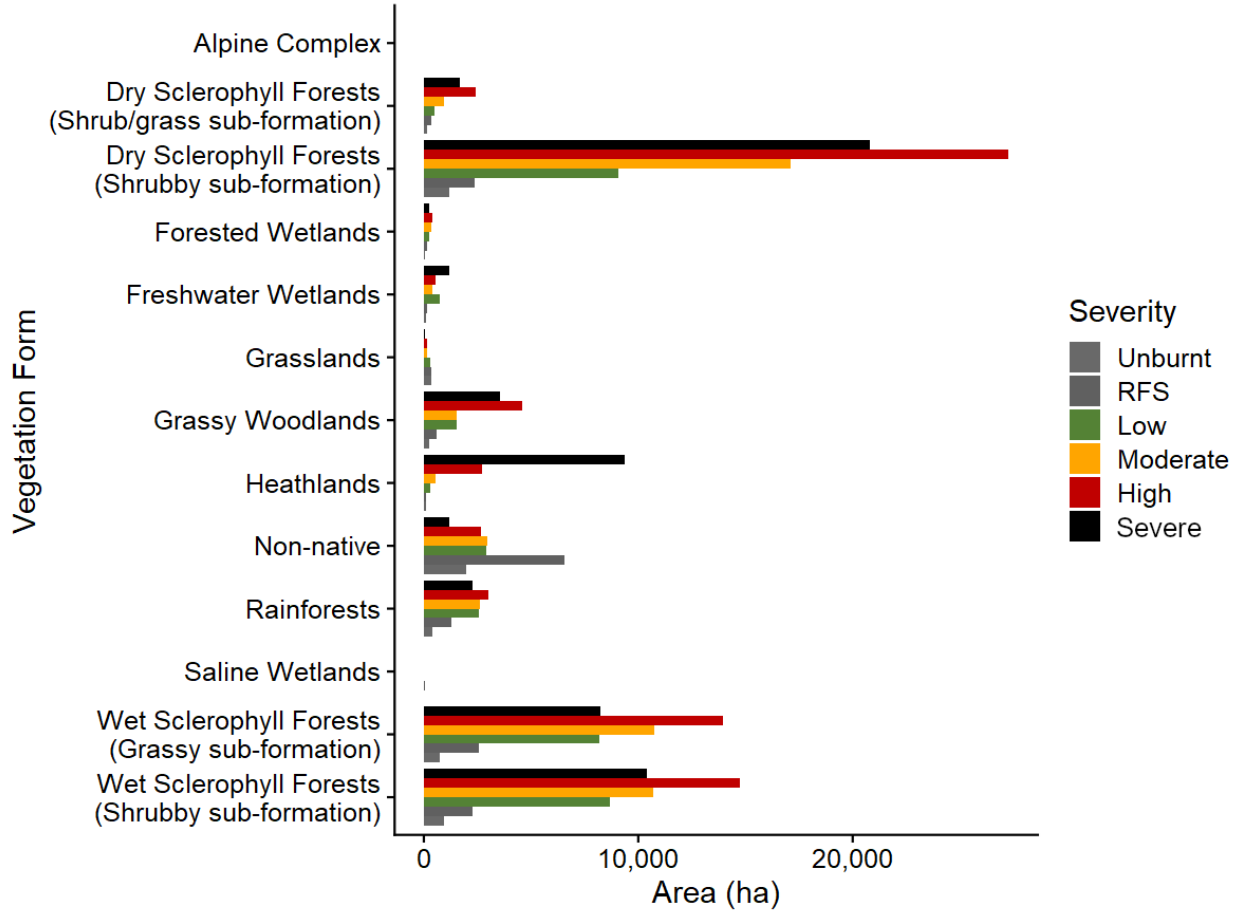

Figure 8. Summary of 2019/2020 fire severity classes by vegetation formation within the South Coast fire complex.

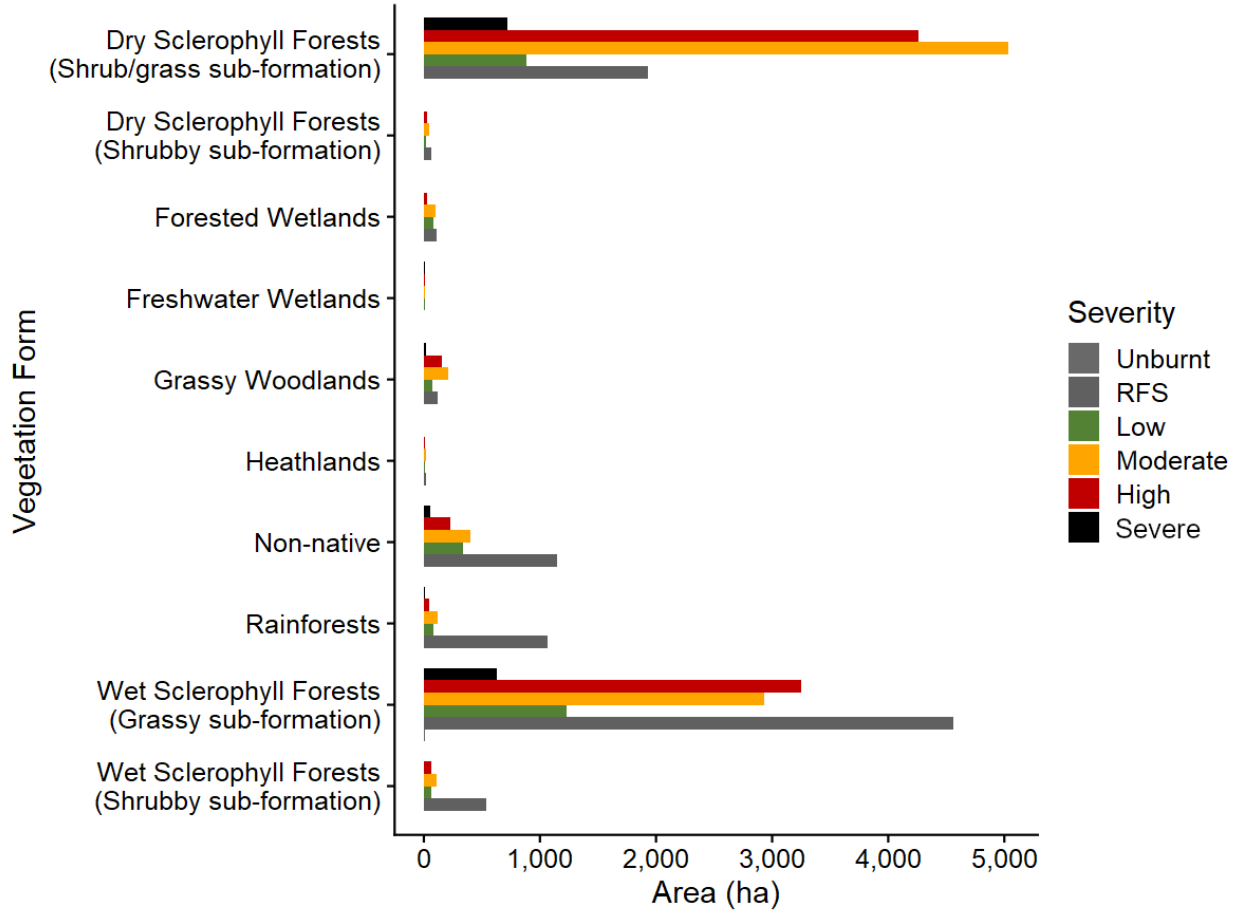

Figure 9. Summary of 2019/2020 fire severity classes by vegetation formation within the Bees Nest fire complex.

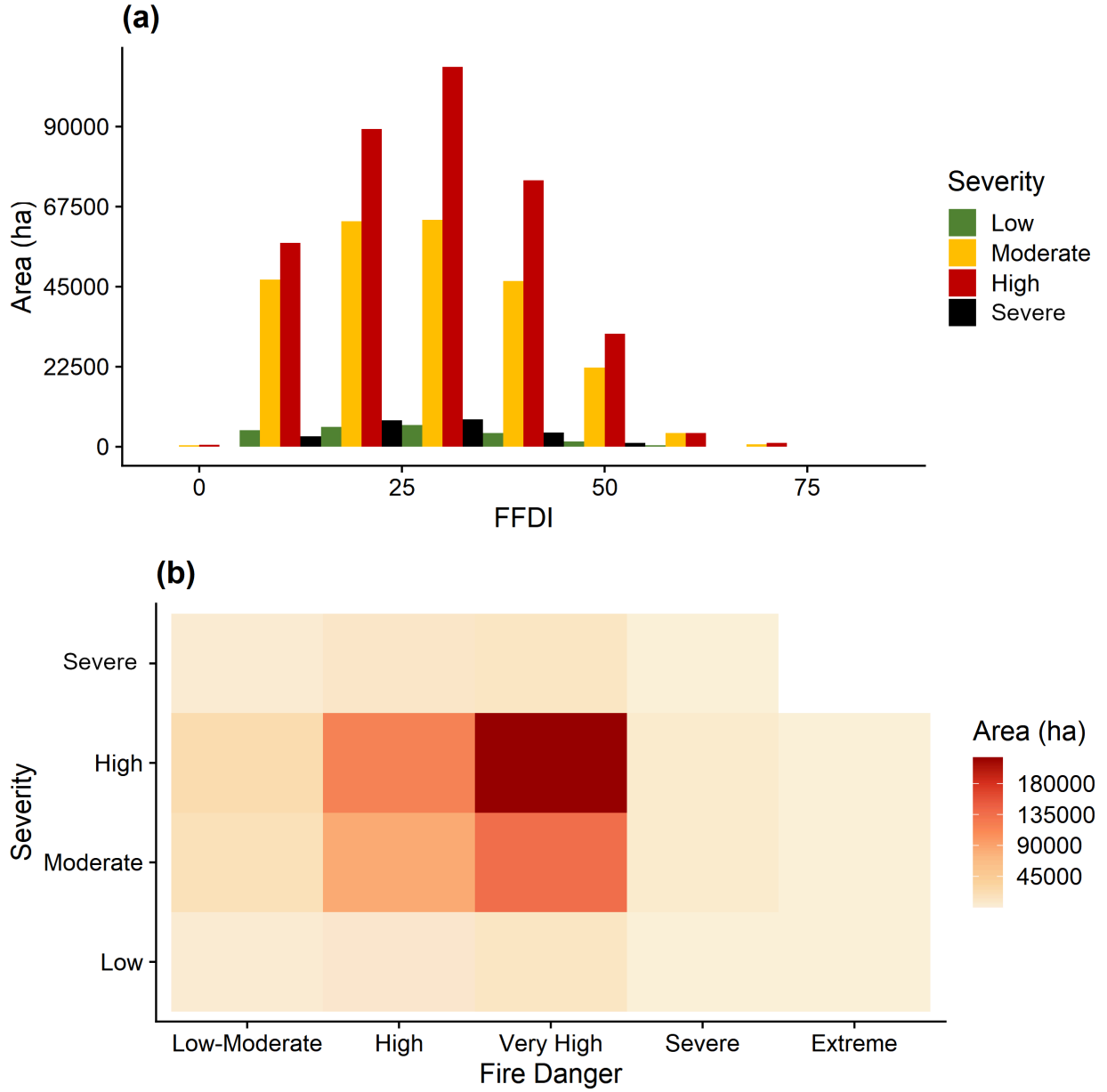

Figure 10. Gospers Mountan fire area burnt at diferent severities across the FFDI range (a) and cross-tabulated with fire danger classes (b).

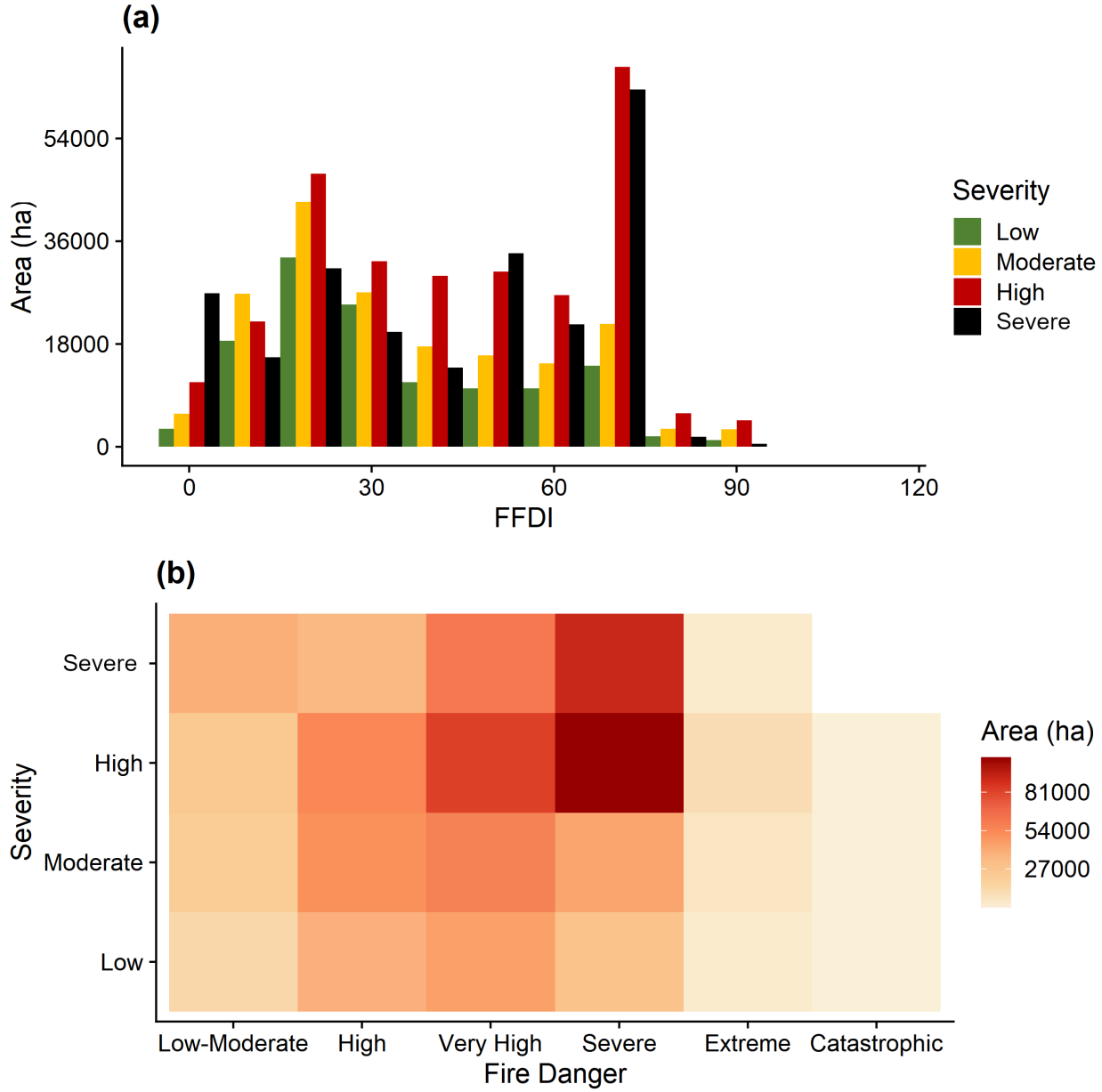

Figure 11. South Coast fire complex area burnt at diferent severities across the FFDI range (a) and cross-tabulated with fire danger classes (b).

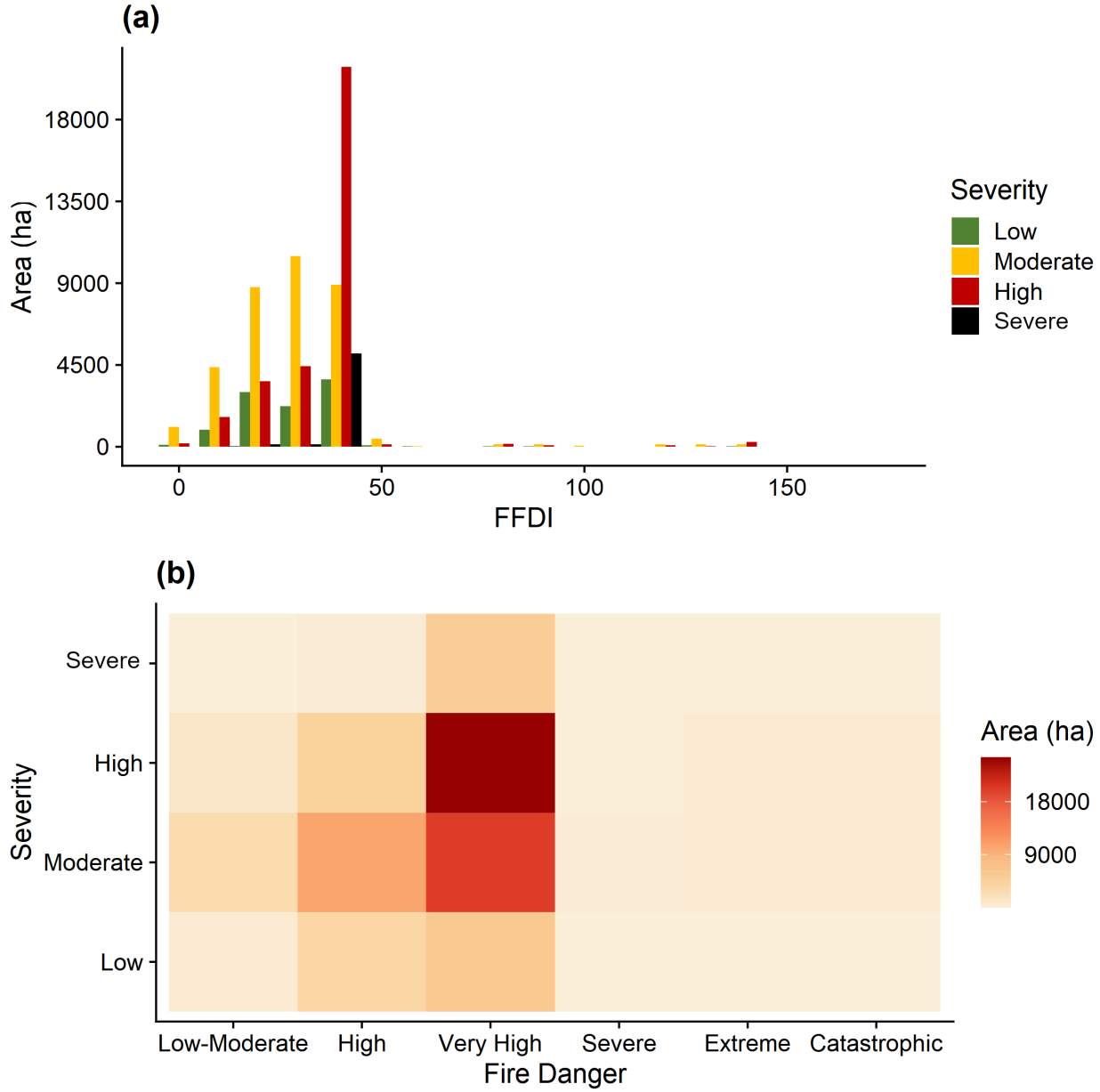

Figure 12. Bees Nest fire area burnt at diferent severities across the FFDI range (a) and cross-tabulated with fire danger classes (b).

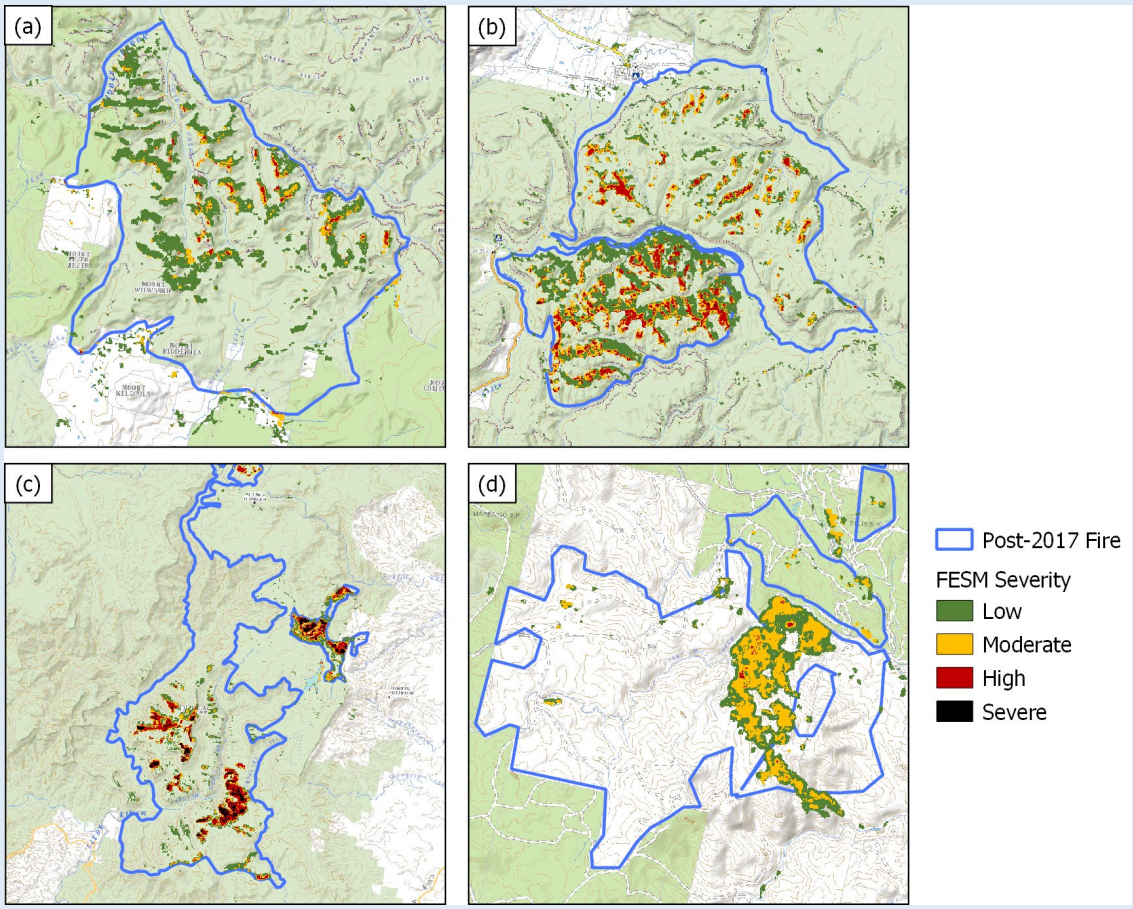

Figure 13. Severity measures within a range of past prescribed burns. (a) A prescribed burn conducted in 2019, in the Gospers Mtn fire boundary. (b) Two prescribed burns, the northern one conducted in 2017 and the southern one in 2018, in the Gospers Mtn fire boundary. (c) Two prescribed burns, the western one conducted in 2017 and the smaller eastern one in 2018 in the South Coast complex fire boundary. (d) The southern polygon indicates a prescribed burn conducted in 2017 in the Bees Nest fire boundary; the polygons to the north east are wildfires.

8. Key reference list

Fernandes, P. M., & Botelho, H. S. (2003). A review of prescribed burning effectiveness in fire hazard reduction. *International Journal of wildland fire*, *12*(2), 117-128.

Gibson, R., Danaher, T., Hehir, W., & Collins, L. (2020). A remote sensing approach to mapping fire severity in south-eastern Australia using Sentinel 2 and random forest. *Remote Sensing of Environment*, *240*, 111702.

Tolhurst, K. G., & McCarthy, G. (2016). Effect of prescribed burning on wildfire severity: a landscape-scale case study from the 2003 fires in Victoria. *Australian Forestry*, *79*(1), 1-14.

9. Appendix

Methods

- Past fire boundaries for New South Wales were obtained from the NSW RFS, for determining the location and time of previous prescribed and unplanned fires.
- The FESM fire severity mapping algorithm (Gibson *et al. 2020)* was applied across all fire grounds in New South Wales. In addition, the algorithm was applied within past prescribed burn and unplanned fire boundaries for previous years going back to 2017, the year in which the Sentinel-2 satellite imagery required for the algorithm became available.
- Vegetation formation mapping was obtained from the NSW State Vegetation Type Map, current to January 2019. FESM severity for each cell was attributed with the vegetation formation is fell within, in order to summarize severity category by FFDI.
- Fire progression polygons were obtained from the NSW RFS, and were assigned distance-weighted mean FFDI values derived from Bureau of Meteorology weather stations within 100km for each timestep. FESM severity for each cell was attributed with the FFDI of the isochron it fell within, in order to summarize severity category by FFDI.