THEME 2.1- FIRE SEVERITY AND BEHAVIOUR

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Subproject: Fire spread

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OVERVIEW

1. Theme

Fire Severity and Behaviour

2. Project question or problem statement

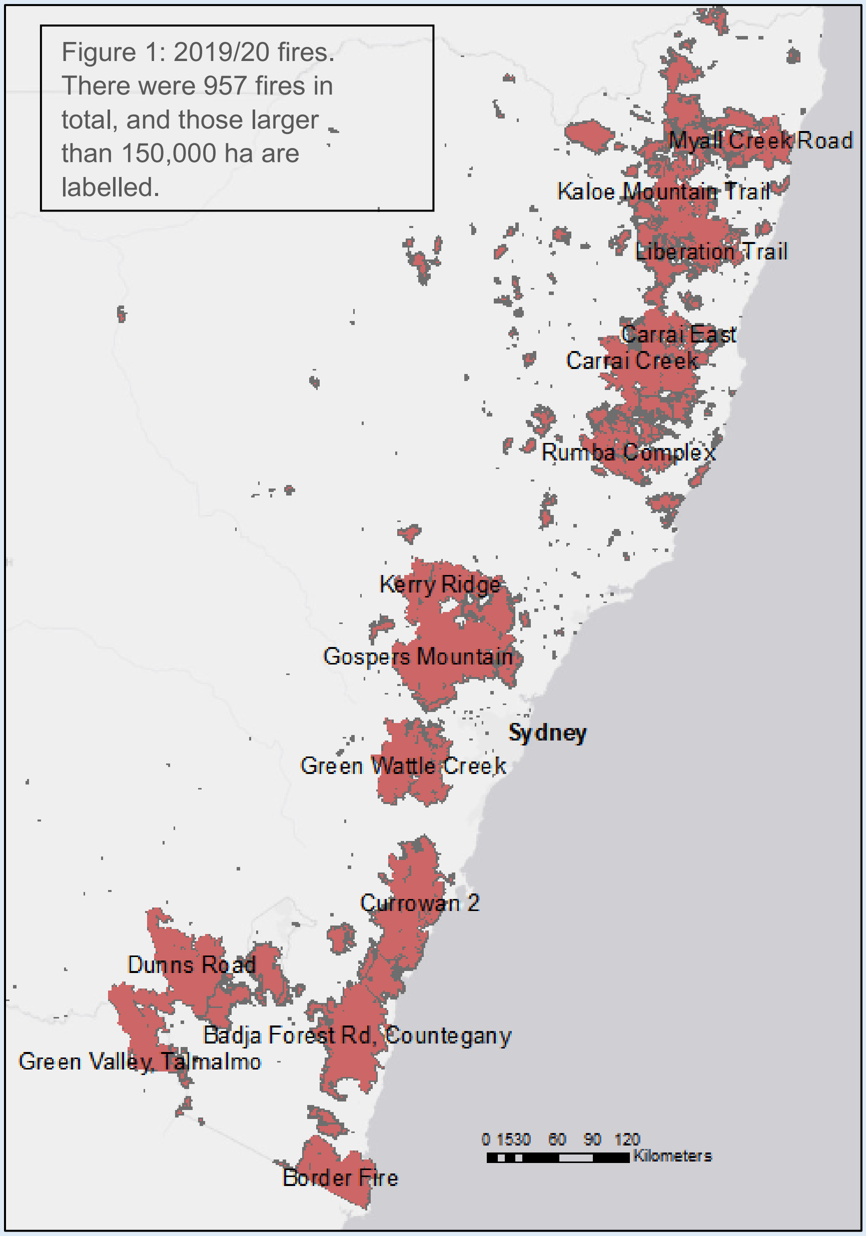
Where and when did the fires occur, what were the patterns of their progression and what were the associated weather conditions?

3. Background

This report describes the context and nature of the fires: where and when they burnt, their progression characteristics and the weather conditions associated with their spread. This provides the context and some of the data for analyses in other reports: e.g. determinants of fire severity and house loss

4. Geographic location

This study encompasses the entire fire-affected parts of NSW.



5. Key Findings

- The first fire recorded in the 2019/20 fire season ignited on 9^{th} August 2019 and the last spread was recorded on March 2^{nd} 2020, with >5 million hectares burnt in total. An animated sequence of the progression for each of the northern, central and southern fires is available here.
- The fires were confined to the northern parts of NSW until the end of October when the first fires in the central region started. By December, the focus had shifted to the southern region and remained there until the end of the season (Figure 2).
- 5.5 million hectares were burnt, more than twice as much as any previous year since records began (fire history data courtesy of Department of Planning Industry and Environment, Figure 3).
- As many as 39,000 houses were exposed to the fires (within ~500m of the fires, see methods). Several towns were impacted including Tenterfield (2019-09-07), Port Macquarie (2019-11-2019), Taree (2019-11-09), Bell (2019-12-19), Balmoral (2019-12-19), Batemans Bay (2019-12-31), Cobargo (2019-12-31), Lake Conjola (2020-01-01), Cabramurra (2020-01-04), and Womboyn (2020-01-11). Dozens of smaller communities were also affected (Figure 4).
- Fire weather varied greatly during the season, but Extreme weather (FFDI>75) in November was associated with major fire spread in the north and Catastrophic weather (FFDI >100) in January with major spread in the Southern Tablelands (Figure 5). The largest fire (Gosper's, central) burnt predominantly under milder weather conditions (Very High or lower, FFDI < 50).
- Breaking the FFDI into some of its component variables revealed subtle geographic patterns (Figure 6). The Southern Tablelands fires included areas burnt under very hot and windy conditions (temperature > 35o and wind > 80 km/h). In the central region the fires burned under relatively still but hot conditions, whereas fires across much of the northern region burned under windy but relatively cool conditions.
- Fire spread occurred under a wide range of wind directions though more so under north westerly than other directions (Figure 7). It is

notable that major fire spread occurred under south-westerly winds (between 180-270o), even though these winds were uncommon.

- Major surges of fire growth tended to occur during higher FFDI, but many days of high FFDI did not cause a surge in fire growth (Figure 8a).This difference is reflected in a divergence in the pattern of cumulative area growth and cumulative FFDI (Figure 8b).

6. Significance of findings in context of previous studies

The 2019/20 fires were the largest in recorded history in the predominantly forested regions of eastern NSW (by a factor of two for forests in NSW).

Unlike previous major bushfire seasons, the 2019/20 season lasted uninterrupted for many months and was associated with a record drought before the season, low rainfall during the season and many temperature records (Nolan, 2020; Clarke, 2020). Nevertheless, fires burned under a wide range of weather conditions (temperature, wind speed and direction).

7. Limitations and remaining knowledge gaps

The main limitation in reconstructing the progression of the fires is the time interval between progression polygons. The median interval was 17 hours, but 25% of progressions had intervals > 2 days (range 6 minutes to 129 days). This limitation makes it difficult to estimate when fires reached certain locations and the conditions associated with burning at specific times and places. More than 90% of the progressions were sourced from aerial line-scan images (n=4700), which give a precise fire boundary and time, but the accuracy of digitization from line-scan to polygon was highly variable in the original data (Michael Storey, Stephanie Samson, James Barker, personal observation). We corrected digitization errors down to a level of 100 m precision where possible by cross-reference with the line-scans, though some errors remained.

Distance between the fire and weather stations posed another problem for analysis. In these data the median distance was 24 km but 25% of the polygons were more than 46 km from the nearest station. The RFS portable stations were very useful in this regard, with 64% of the progressions being closest to one of these stations rather than a BOM station. Weather often varied among stations, and the differences were most pronounced between coastal and inland stations. The median difference between the highest and lowest observed maximum daily FFDI among the stations within 100 km of each progression was 40. Gridded FFDI estimates provided an interpolation between stations, but only one value per day at a resolution of 6 km (Dowdy 2018) was available.

8. Implications for fire management

- While we have not examined this specifically in this report, the magnitude of the fires compared to previous years will pose an extra-ordinary challenge in recovery and rebuilding communities, infrastructure and affected biota.
- These fires set a new standard for how much destruction bushfires can cause, and as such they should trigger a re-assessment of risk management strategies.
- This is especially true given that climate change modelling predicts higher likelihood of these kind of events in the future.

9. Figures

Figure 2. Timing of the fires across eastern NSW through the 2019/20 season

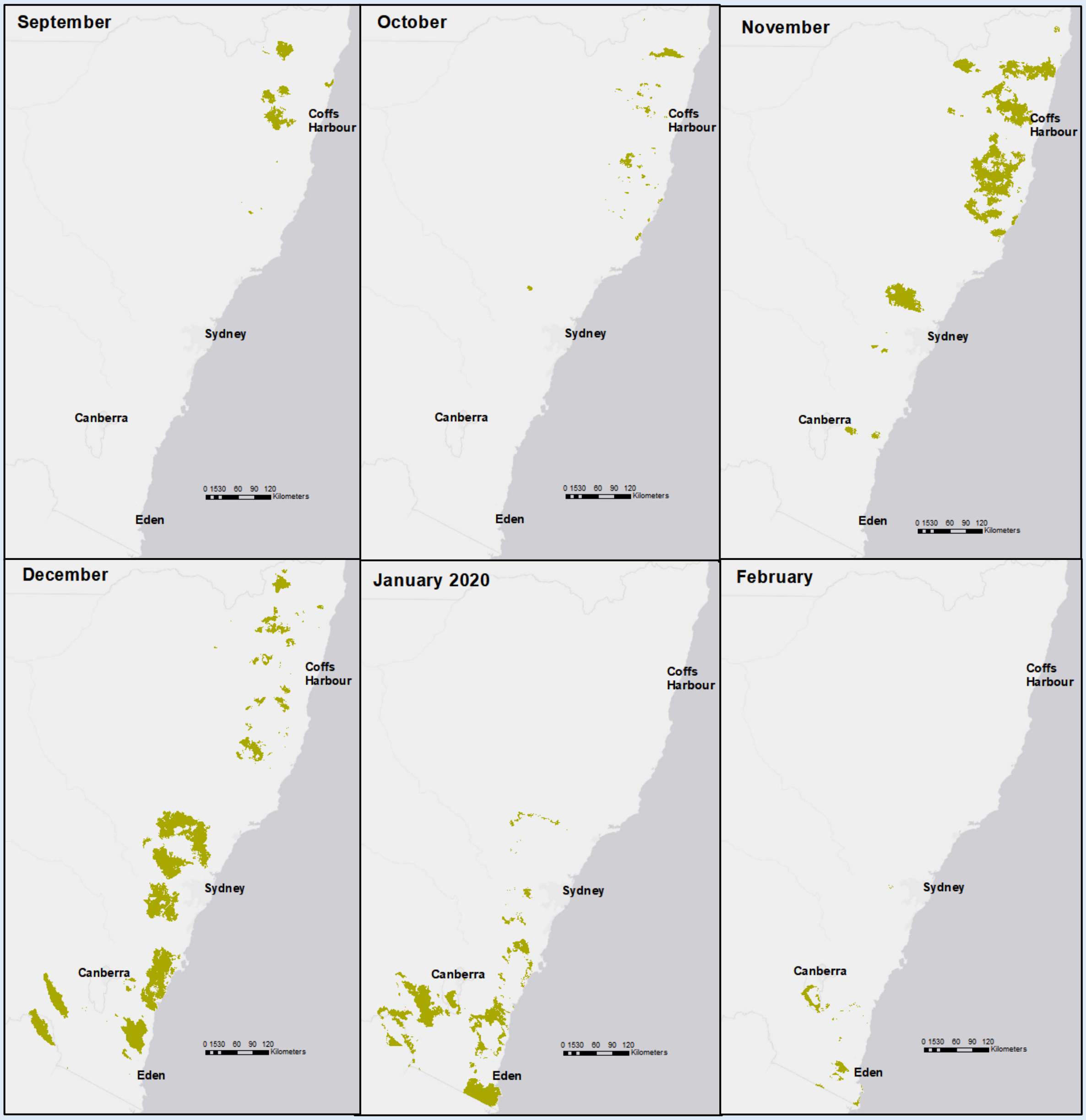
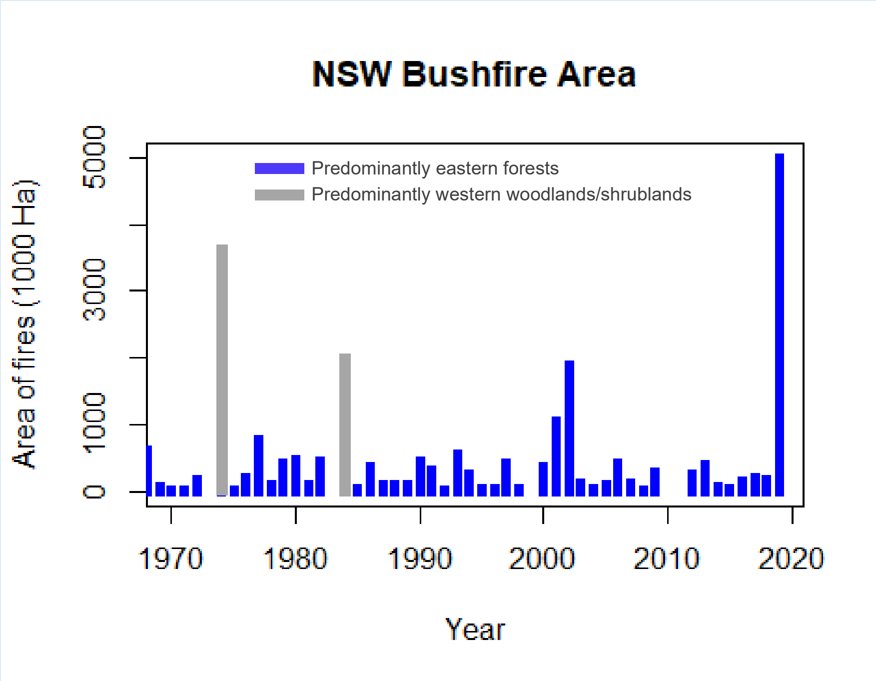


Figure 3. Historical area burnt per year in NSW. Data courtesy of NSW Department of Planning, Industry and Environment. Note the large fires in 1975 (grey) were not forest but semi-arid shrublands and woodlands in western NSW.



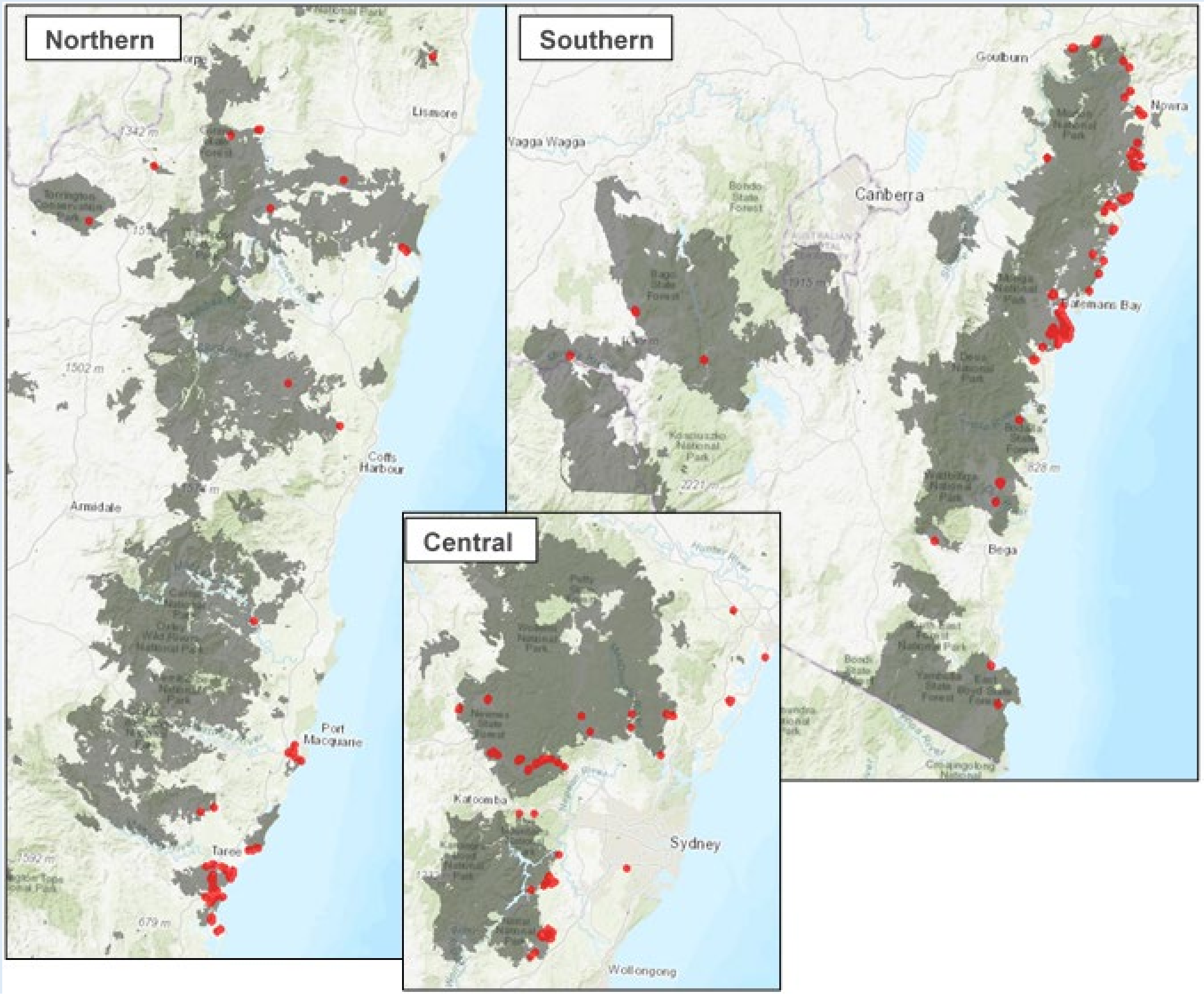


Figure 4. Communities affected by the 2019/20 fires. The areas in red are those 100 ha hexagons with >25% area burnt and >20 houses.

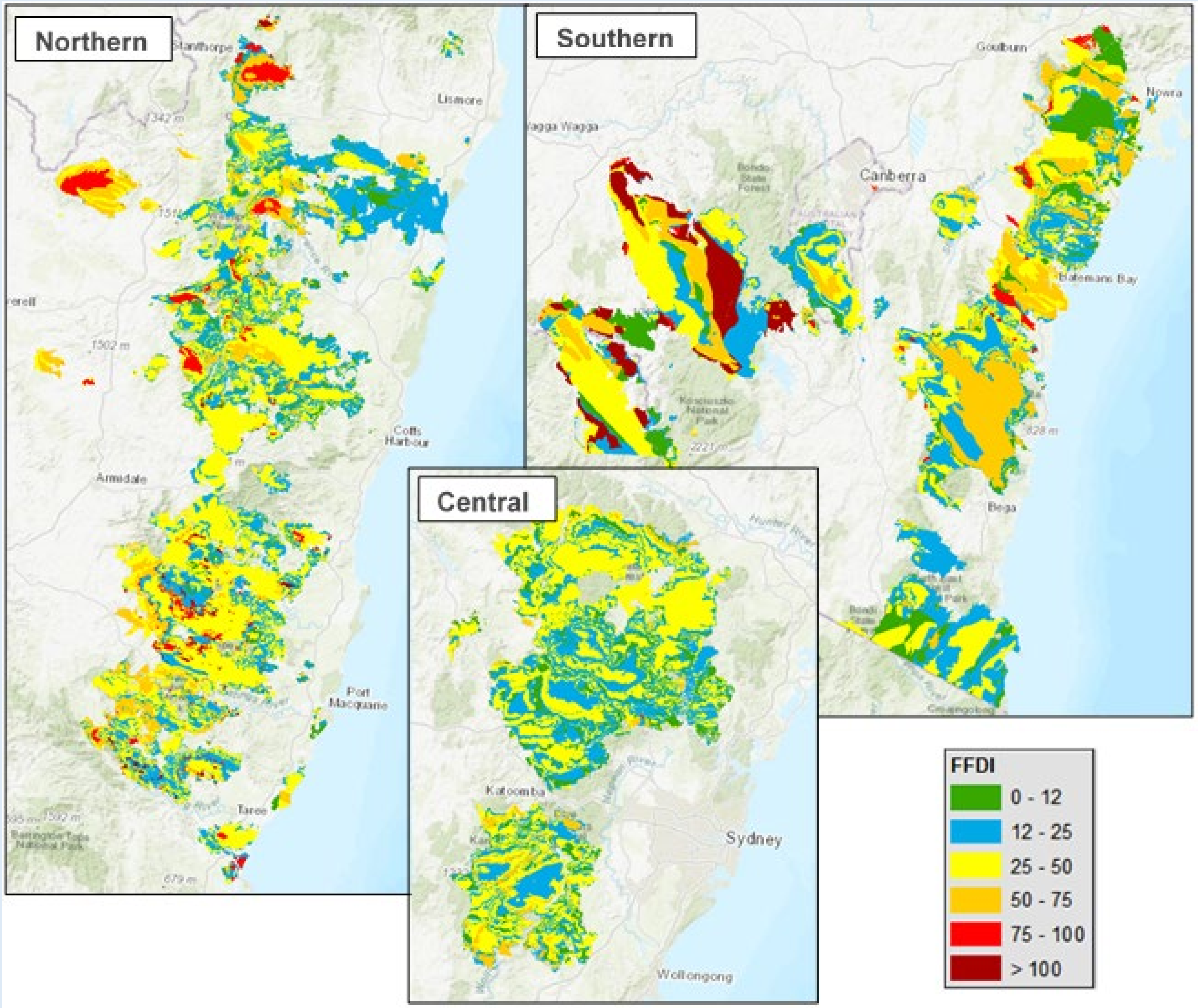


Figure 5. FFDI experienced across the fire-grounds. See method for details of the attribution.

Figure 6: Estimated temperature, wind speed and wind direction experienced during the fire. The method is explained in the methods section.

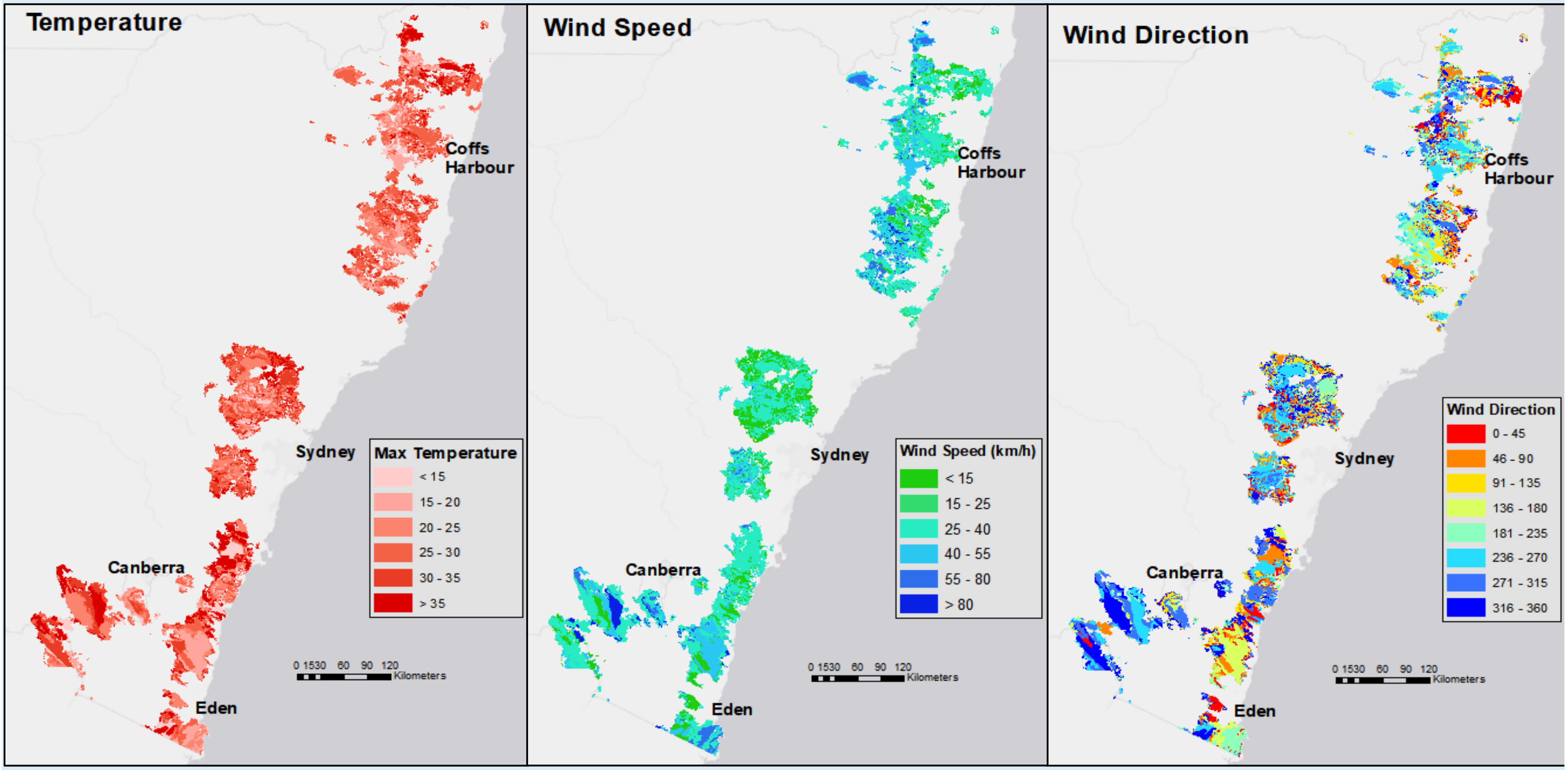


Figure 7: Area burnt in different levels of five weather variables across the whole season.

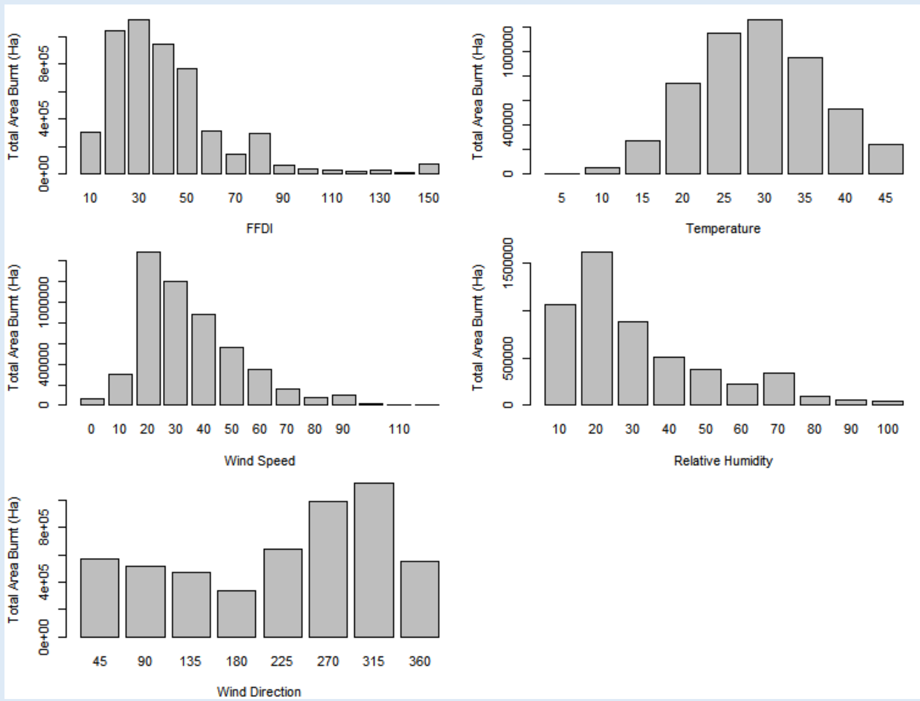
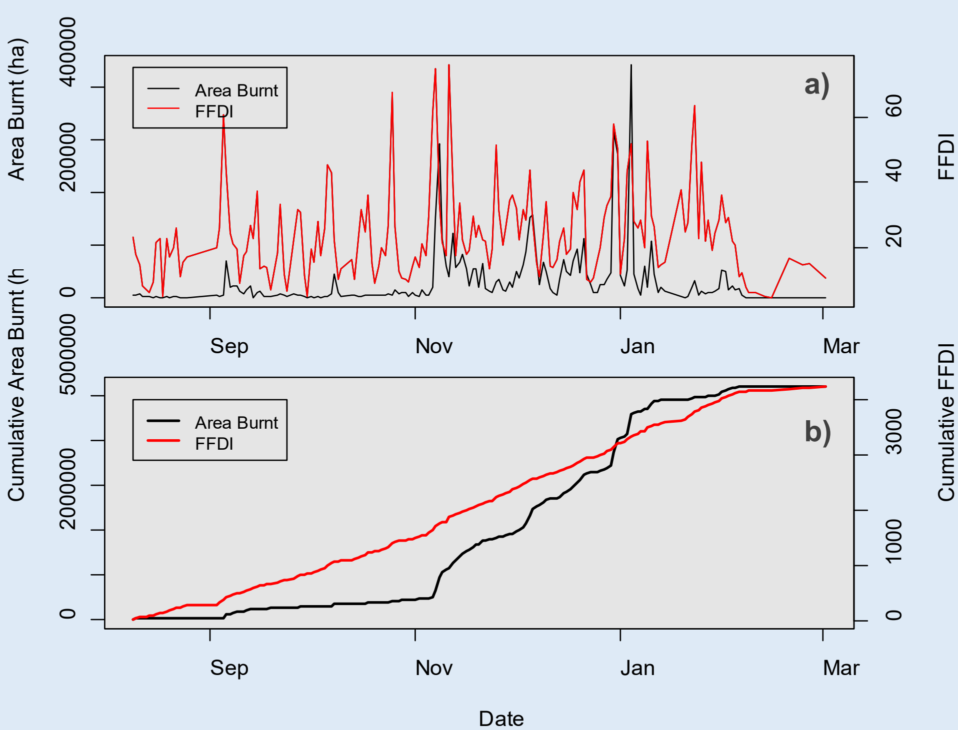


Figure 8: Comparison of daily area burnt and FFDI: a) raw values; b) cumulative.



10. Key reference list

Clarke, H. 2020. Fire Weather. NSW Bushfire Risk Management Research Hub Reports to the NSW Bushfire Inquiry1.3

Dowdy, AJ (2018) Climatological Variability of Fire Weather in Australia. *Journal of Applied Meteorology and Climatology* **57**, 221-234.

Nolan, R. 2020. Fuel Dryness. NSW Bushfire Risk Management Research Hub Reports to the NSW Bushfire Inquiry1.1

Storey, M, Price, O, Sharples, J, Bradstock, R (in press) Drivers of long-distance spotting during wildfires in south eastern Australia. International Journal of Wildland Fire

11. Appendix

Methods

This report was based on combination of fire progression mapping and weather data. There were five sources of data and several steps involved.

- Progressions were reconstructed from the NSW Rural Fire Service fire polygons database recorded in ICON (the online, real-time operational reporting system), which were edited to ensure the lines were mapped accurately and the times were correct by reference to 4700 aerial linescan images (used operationally to track the fire front and also supplied by NSW RFS) and to fire hotspot data (points observed by the MODIS and VIIRS satellites and downloaded from NASA). Where these data were able to infill the RFS progressions, extra polygons were added. The resultant progression dataset had 5000 polygons.
- Weather data was obtained from the Bureau of Meteorology (BOM) automatic weather station network (half hourly observations) for all stations within 50 km of the fire boundaries and from 17 portable weather stations operated near to the fires by RFS (10 minute observations).
- The progression polygons were processed to calculate the time of the previous known progression to set the time window for calculating weather. Also, they were split into non-contiguous parcels and each of these were assigned their centroid coordinates (121,000 final polygons).
- Each progression polygon was assigned weather according to two parameters: the time window between the progression and the previous one; and the set of nearby operational weather stations. The maximum FFDI was estimated as the distance-weighted mean of the maximum FFDI in all of the stations within 100km from the centroid of the progression polygon (i.e. mean(maxffdi/distance)/mean(1/dist)). This averaging approach has been used for assigning weather to fire progressions in previous studies (Storey et al., in press). Meanwhile, wind-speed, wind direction, temperature and relative humidity were extracted from the closest station at the time of maximum FFDI.
- The map of affected communities and estimates for the number of houses exposed was created by counting the number of houses (buildings with a footprint between 80 and 700 m^2) from the Geoscape building layer (supplied by RFS) in arbitrary 1 km^2 hexagonal polygons across NSW. These were filtered to hexagons with >25% of their area burnt.