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Fire weather and prototype fire danger ratings for the Gell River fire, Tasmania

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ABSTRACT

We provide a preliminary analysis of the meteorology of key aspects of the Gell River fire in Tasmania during late December 2018 and early January 2019, including the lightning storm that ignited the fire, and conditions on 4 January 2019, when the fire increased substantially in size. We also briefly assess the performance of the Australian National Fire Danger Rating System (AFDRS) Research Prototype available on 4 January against observations of fire spread and routine McArthur Forest Fire Danger forecasts.

The Gell River fire occurred within a context of declining October – April rainfall in western Tasmania over the last two decades, in comparison to the average rainfall for the period since 1900 (Fig. 1, Bureau of Meteorology and CSIRO (2018)). It was one of several large fires that competed for fire management resources over an extended period during the 2018-2019 Tasmanian fire season. The fire impacted natural values including those of the Tasmanian Wilderness World Heritage Area (TWWHA) and risked spreading into parts of the iconic Mt Field National Park, as well as threatening a number of communities in the Derwent Valley, particularly Maydena. The Gell River fire also threatened major electrical transmission infrastructure connecting the large Gordon-Pedder power generation facility in the west of Tasmania to population centres in the east, and burnt approximately 500 ha of a 5,000 ha pine plantation. On 4 January, thick smoke from the fire crossed over the Greater Hobart area, sparking concern and raising awareness within the wider community about the fire activity (Fig. 2).

Contributing weather factors

Rainfall in the weeks leading to the fire ignition had been sporadic. While December rainfall had been close to average, the three months leading up to the start of January had generally seen below average rainfall in the vicinity of the ignition area (Fig. 3a, b). Rainfall of 10-15 mm had occurred in the 24 hours to 0900 EDST (Eastern Daylight Savings Time) 22 December but there was subsequent no rainfall. Fuel availability calculations indicated that moorland fuels were available to burn when ignition occurred on 27 December. While sufficient antecedent rainfall had occurred to prevent the fire from spreading freely into many wet forest areas at that time, some rainforest areas, particularly about forest margins, were drier than others and available to burn.

On 27 December, widespread lightning occurred over central Tasmania (Fig. 4) including the Gell River region, associated with a trough extending over Tasmania from Victoria (Fig. 5). The atmosphere below the unstable mid-level cloud band within which lightning was generated was dry, with a dewpoint depression of 20 to 35°C between 950 and 700 hPa, resulting in minimal thunderstorm precipitation reaching the ground. This combination of weather factors permitted some lightning ignitions to become established fires. Over ensuing days, the Gell River fire was able to remain alight, before it grew progressively under the influence of dry, warm weather during the first few days of January. The fire made a major run during 4 January, increasing from approximately 5 700 ha to 14 000 ha, in hot, windy conditions ahead of a significant cold front that crossed Tasmania during the day but which did not deliver any rainfall. The atmosphere was dry and unstable ahead of the cold front. The instability, together with mechanical turbulence generated by the movement of the airmass over the Tasmanian topography, allowed the mixing of dry, high-momentum air from the upper atmosphere to the land surface during the day, especially in regions away from the west and north coasts and including the Gell River area. The fire burnt through mostly buttongrass moorland in the Vale of Rasselas on 4 January, but impinged on some forested areas, particularly forest edges. The post-frontal airmass was cooler, but substantially. dry, inhibiting the normal diurnal uptake of moisture by fuels overnight in the wake of the frontal passage and permitting the fire to continue growing, albeit more slowly than on 4 January.

Australian Fire Danger Rating System

The AFDRS has been developed in recent years following agreement by Senior Fire Officers and Ministers that the current system of fire danger ratings, developed in the 1960's, has significant shortcomings, and that a new system was required.

The AFDRS incorporates recent fire science and is designed to be modular and have the capacity for continual improvement.

AFRDS forecasts have been generated daily using this system since October 2017 with the Research Prototype being made available to land managers across Australia for evaluation and testing (Matthews et al., 2018). It was initially planned that prototype fire dangers would be calculated across Australia during the period October 2017 through to March 2018, with an evaluation period to follow. The prototype was felt to be sufficiently useful, however, that the project was extended to include the northern Australian fire season during 2018 and a second southern season 2018-2019, during which period the Gell River fire occurred. This extension has permitted further evaluation and the additional benefit of increased familiarity of the system on the part of fire managers.

With a commitment by Australian fire and government agencies to implement the AFDRS operationally across Australia over the next three years, AFDRS calculations and data continue to be generated daily to allow further increased familiarity and use by fire managers.

As part of the evaluation, over 400 fire danger forecasts were compared against current methods of forecasting fire danger, across eight primary fuel types and around Australia. The evaluations were carried out by fire managers and by the AFRDS project team, with results suggesting that the AFDRS Research Prototype performance was better than that of the current system (Grootemaat et al. 2019). In particular, the prototype was better than the current system in identifying severe fire behaviour conditions, which are relatively uncommon (Matthews et al. 2018).

Key underpinning components of the system include a national, consistent fuel grid together with clearly defined descriptions of expected fire behaviour, suppression and containments implications and potential consequences. The fuel grid is linked to fire behaviour models specific to the eight major fuel types within the AFDRS. This enables a greater discrimination of potential fire activity within the varying vegetation types than the McArthur fire danger rating system.

Fire Danger associated with the Gell River fire on 4 January

Operational fire weather forecasts for 4 January indicated Very High fire danger for eastern parts of the West Coast district and Severe fire danger in adjacent areas of the Upper Derwent Valley for forested areas (Fig. 6a) and Very High fire danger in moorlands. These values were calculated using the McArthur Mark V forest fire danger index and rating system (McArthur, 1967; Noble et al., 1980) and the Buttongrass Moorland fire danger rating system (Marsden-Smedley et al., 1999), and results suggested that fire could run freely through either vegetation type on this day. A map of forecast forest fire danger index is routinely generated by the Bureau of Meteorology, and distributed to fire agencies. However, areas of moorland (or other vegetation types) are not separately identified within those maps.

On the other hand, integrated maps of daily maximum fire danger rating are published daily within the AFDRS that incorporate all vegetation types within the mapped region. Category 5 (extremely rapid fire growth, very difficult to control) fire danger was forecast by the AFDRS within the buttongrass moorland-dominated Vale of Rasselas, identified by the red ellipse in Fig. 6b, but only Category 1 to 2 (very low or self-extinguishing) fire danger was flagged for the bounding wet forests.

Under the prevailing conditions, the fire was observed to run extensively through the moorland fuel types but had limited penetration into the adjacent areas of wet forest

Discussion

As suggested in Fig. 1, western Tasmania has become increasingly vulnerable to fire in recent decades. While fires have regularly occurred in western Tasmania since European settlement (e.g. "Black Friday" 1934, 2 February 1939, Zeehan fires 1981; State Emergency Service (1990), Australian Bureau of Statistics (2000)) and through prehistory (e.g. Bowdler (2010)), in the last twenty years, they have become more widespread and more frequent with drying conditions during the warmer months (Thackway et al. (2008), Marsden-Smedley (2014), Australasian Fire and Emergency Services Authorities Council (2016), French et al. (2016), Press (2016)). Tools to better manage such fires therefore have considerable value not only in Tasmania but across Australia.

The Australian Fire Danger Rating System integrates recent, operationally ready, fire science and presents a way to improve the suitability of fire danger forecasts in an increased number of fuel types using clearly defined descriptions of expected fire behaviour, suppression and containment implications and potential consequences. In environments such as those in western Tasmania which feature a complex mosaic of different vegetation types, the AFDRS promises to be a valuable tool to improve the accuracy of fire danger prediction, while making forecasts more specific and targeted. The Gell River fire provided a good example of such application and broad suitability of the AFDRS forecasts on 4 January 2019.

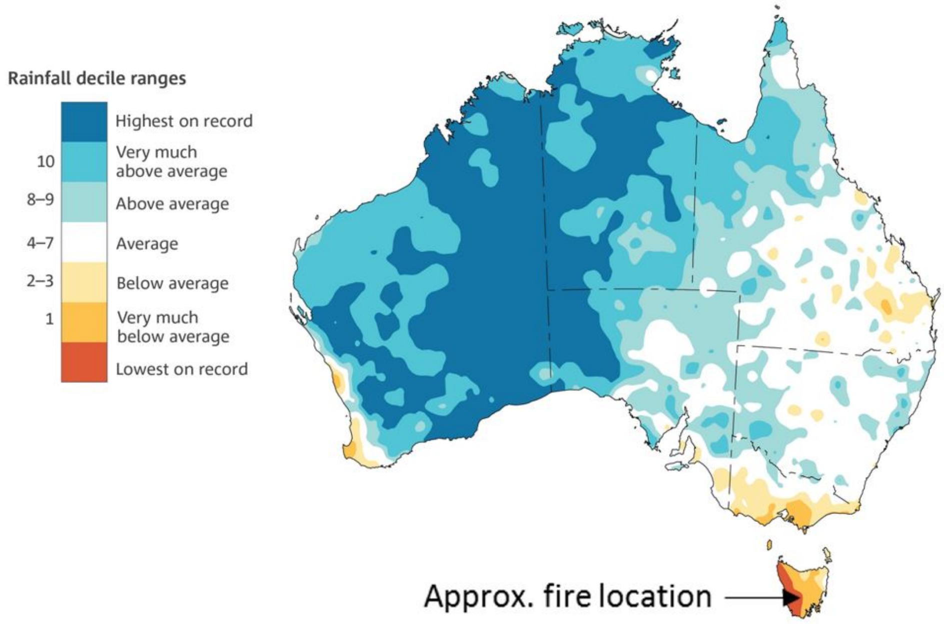


Figure 1: Deciles of Oct-Apr rainfall 1998-2018, cf. the same period since 1900 (from State of the Climate, BoM/CSIRO 2018).

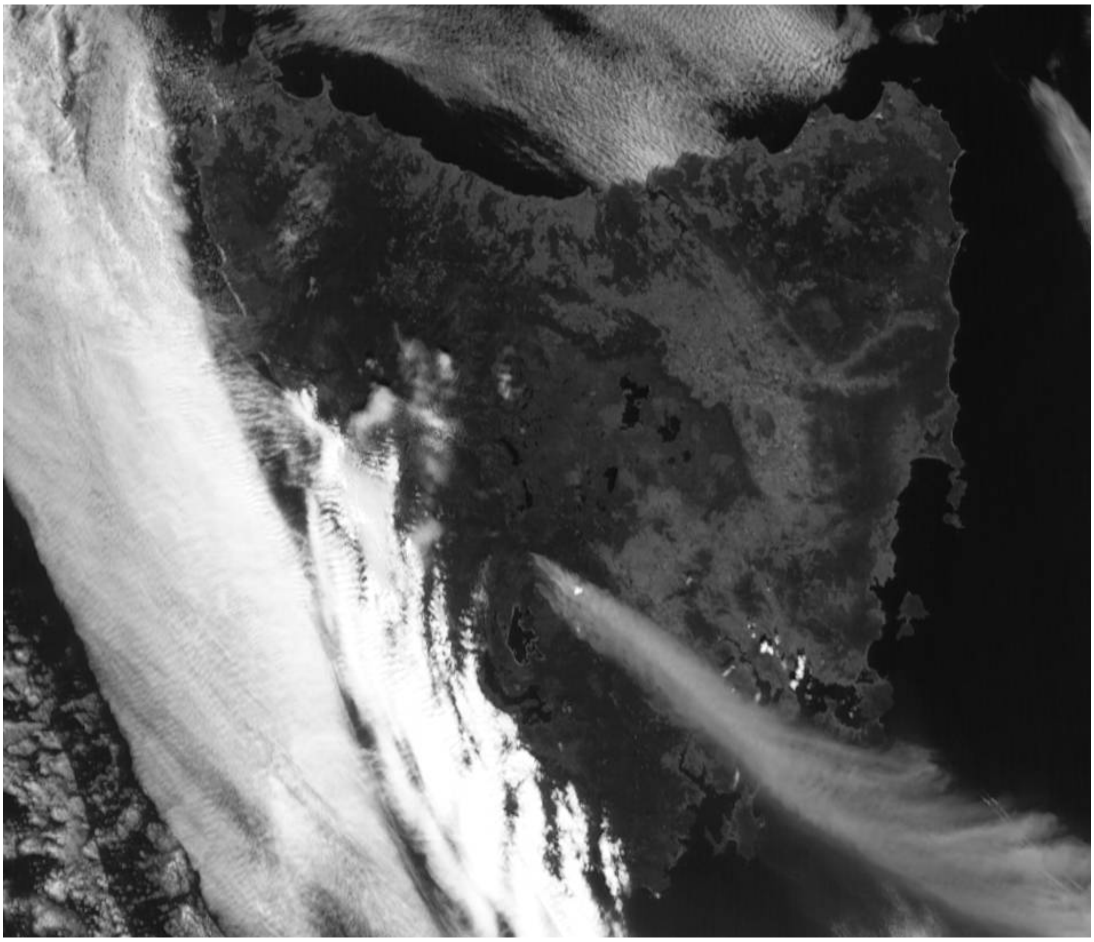


Figure 1: Visible wavelength Himawari-8 image showing the smoke plume from the Gell River fire extending over southeast Tasmania.

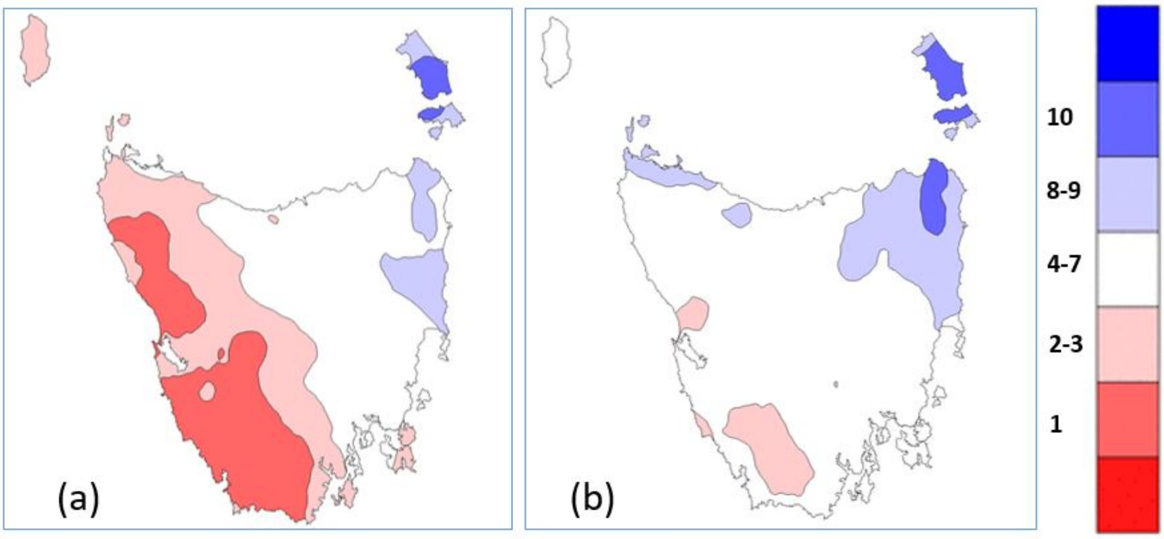


Figure 3: Tasmanian rainfall deciles for (a) Oct-Dec 2018 and (b) Dec 2018. Legend at right indicates decile ranges.

A further consideration is that current operational fire danger forecasts do not distinguish between wet and dry forest types which have different fuel moisture profiles (see e.g. Duff et al. (2018), Cawson et al. (2018) for discussion of the impact of fuel moisture on flammability). The tertiary classification of vegetation in the fuel mapping that underpins the AFDRS permits a substantially greater degree of resolution of fuel characteristics than is possible with fire danger systems currently in use operationally within Australia. On the other hand, models of fuel availability in wet forests require further development to be reliable.

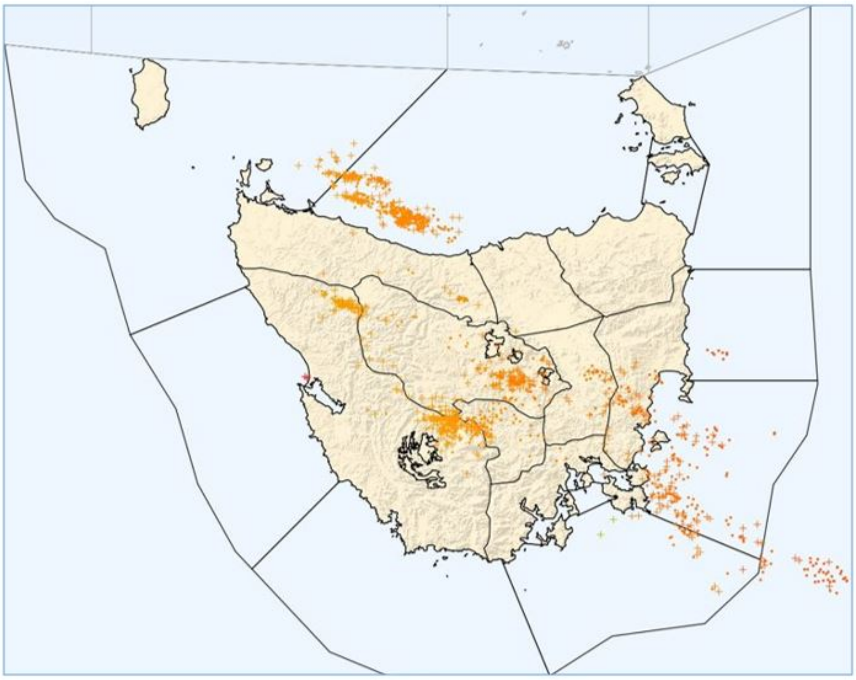


Figure 4: Lightning detections for the 24 hours to midnight Thursday 27 December 2018. Source: Global Position and Tracking Systems, TOA Systems Inc.

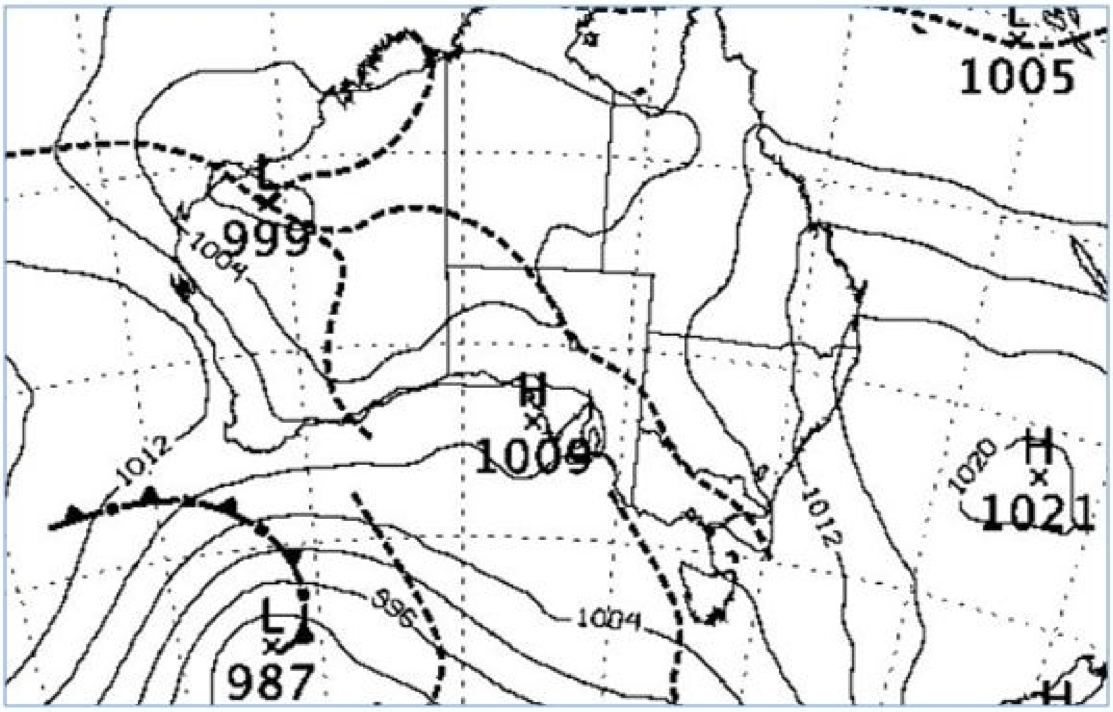
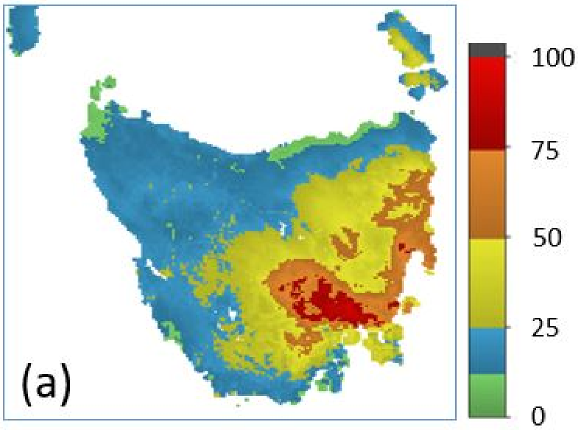


Figure 5: Mean Sea Level Pressure map for 2300 EDST Thursday 27 December 2018. Source: Bureau of Meteorology National Operations Centre.



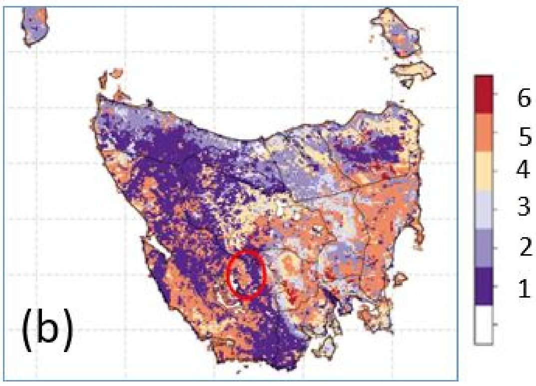


Figure 6: (a) FFDI forecast for Tasmania, based on 0500 EDST 4 January update to weather grids (b) AFDRS forecast for 4 January 2019. Location of Vale of Rasselas highlighted by red ellipse.

Despite the better representation of fuel types within the AFDRS and use of appropriate fire behaviour models for different fuels (Matthews et al. 2018, Grootemaat et al. 2019), there was good evidence that the Gell River fire burnt into some forest (W. Frey, pers. comm., Fig. 7), in spite of the low fire danger ratings assigned to the forest by the forecast system. It is likely that poor resolution of soil moisture, and therefore fuel moisture, played a part here (see e.g. Vinodkumar et al. 2019, Walsh et al. 2017, Merlin et al. 2012). Several factors would have contributed to this uncertainty in soil moisture estimation. The fire started in a remote area with very limited observational infrastructure – the nearest regular rainfall recordings are tens of kilometres away at locations including Scotts Peak, Butlers Gorge and Ouse. In a uniform environment, this may not have been problematic, if still not ideal. In the topographically diverse environment of western Tasmania, it can lead to significant inaccuracies (Walsh et al. 2017). In addition, the fire started in a region where the rainfall gradient, decreasing from over 3000 mm/year in the west to around 500 mm/year on the east coast, is at its greatest. One further difficulty still is that the deep organic soils that are common in western Tasmania are not well-represented by current soil moisture models (Press, 2016).

Some of these problems are likely to be improved with the introduction of tools under development within the Bushfire and Natural Hazards Co-Operative Research Centre, including the Australian Flammability Monitoring System (AFMS, Yebra et al. 2018) and the JASMIN Land Dryness system (Vinodkumar and Dharssi, 2019), which uses numerical weather model output to estimate soil moisture. Both of these tools employ assimilation of remotely sensed data, which helps to address the lack of surface measurements. Cloud cover can be a problem in some areas, however, particularly western Tasmania. With JASMIN in particular, recent research to downscale the system from its current 5 km horizontal resolution to 1 km resolution would be valuable in Tasmania, but this has proven to be a difficult task in forested areas (Vinodkumar et al. 2019). The inclusion of the fluxes of moisture and energy between the surface and atmosphere that are a feature of JASMIN, given its basis in the Bureau of Meteorology's numerical weather prediction system, will nonetheless assist in the refinement of soil moisture characterisation in remote areas such as Gell River.

A proposal is being co-ordinated by the Tasmanian Parks and Wildlife Service to site a soil moisture sensor within the Tasmanian Wilderness World Heritage Area near Scotts Peak, to facilitate better understanding of the flux of moisture through the organic soils of western Tasmania. If this project is implemented, the information from this sensor will also contribute to better soil moisture representation for future fires in this region, and in similar environments.

The AFDRS is designed to be modular, so that as new science is developed and tested it can be implemented within the fire danger rating system. In this way, the potential of tools such as the Australian Flammability Monitoring System and JASMIN can be realised within the AFDRS, and current research into wet forest flammability can be included in updated fuel availability functions for those forest types. At a time when fuels in western Tasmania are increasingly available to burn during the warmer months, the AFDRS will assist fire managers better prepare for and respond to fires in the rugged and fragile landscapes found in western Tasmania. The predictions of the AFDRS on 4 January were unsurprising to fire behaviour analysts tasked with predicting fire progression. The integration of fuel maps and appropriate fire models with an overarching categorisation of fire behaviour across the landscape is nonetheless a helpful tool to assist in the prediction of fire danger in a complex assemblage of vegetation types.

Conclusion

The Australian Fire Danger Rating System is being operationally implemented nationally in coming years, after successful prototyping commencing during the 2017-18 southern Australian fire season. The system draws together much recent fire science and meteorology, including topics as diverse as vegetation typing and fire behaviour models to climatologies derived from new weather reanalyses (Matthews et al. 2018). We have highlighted in a brief overview a single application of the AFDRS, providing background information on the weather and fire event sufficient to set a context for the application of system. The case of the Gell River fire progression during 4 January demonstrates the value of the AFDRS, both in integrating the output of a number of fire behaviour models and in the improvement of forecasted fire danger.

Figure 7: Vale of Rasselas following fire passage on 4 January 2019, showing areas of burnt moorland, and some areas of forest into which fire penetrated. Image courtesy Warren Frey, Tasmania Fire Service.

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