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# Australian Fire Danger Rating System Research Prototype: National fuel map

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## Introduction

The Australian Fire Danger Rating System (AFDRS) Program is building a new fire danger rating system for Australia. The first part of the system to be built (the AFDRS Research Prototype) is a Fire Behaviour Index based on calculations from operationally ready fire spread models.

The AFDRS Research Prototype is a spatially explicit system that calculates fire behaviour and fire danger outputs within a forecast grid system. This requires multiple spatial data inputs, including:

- a fuel type grid with a nationally consistent classification, linked to detailed fuel attribute data;
- grids representing the current state of fuel (time since last fire, grass curing, grass fuel load); and
- standard and additional weather forecast grids from the Bureau of Meteorology.

This paper will focus on the fuel type classification, which resulted in the production of a nationally consistent fuel map. Other papers in this session will present the design of the ratings, implementation of the forecast system, the results of a live trial and remote sensing data analysis, and a climatology of ratings.

## Methods

Fuel classification and mapping in Australia is generally based around vegetation maps as the fire behaviour models used operationally in Australia are empirical models developed through observation of fire in particular vegetation types (Cruz *et al.* 2015, Hollis *et al.* 2015). While vegetation maps are a convenient base layer from which to develop fuel type mapping, this requires substantial interpretation.

From a fire behaviour perspective the vegetation stratum that will carry the fire is the most important (Sullivan *et al.* 2012), and hence structural vegetation classification is the most useful for fuel type classification. Climatic and bioregional variation influence ecosystem productivity, and hence fuel condition and dynamics (Watson 2009), while floristic information can provide data on some specific fuel attributes, e.g. bark type (Horsey & Watson 2012).

For the purpose of the AFDRS Research Prototype, fuel type classification was driven by the need to select an appropriate fire behaviour model, and to capture the range of variation in the fuel attributes that feed the inputs to the fire behaviour modes. A hierarchy of classification describes the use of increasingly detailed fuel information within the Research Prototype, with direct links to the other elements of the system:

- Broad fuel types = standard fire behaviour models (n = 8);
- AFDRS fuel types = standard and modified fire behaviour models (n = 22);
- State fuel types = regionally defined fuel types with fuel attribute information (n = 430).

Broad fuel types are defined by the operationally available fire behaviour models (Cruz *et al.* 2015). At this level, the fuel types reflect broad vegetation structure in a way that indicates the primary fuel strata for fire propagation. However, many vegetation types don't have a fire behaviour model specifically developed (e.g. rainforests, arid shrublands, wetlands, rural and urban areas). These vegetation types have been allocated to the model with the most similar fuel structure (as per Gould and Cruz 2015). However, there are often factors (broadly represented by climatic variation or human management) limiting the flammability, fuel availability or fuel connectivity in these vegetation types. Thus some modifications are required to the fire behaviour calculations to reflect these limitations (as per Plucinski *et al.* 2017). The broad fuel types divided into these additional fuel types make up the full list of AFDRS fuel types.

At the most detailed level, definition of State fuel types accounts for spatial variation in fuel attributes (e.g. bioregional and floristic influences) and allows for the use/adaptation of existing jurisdictional fuel type classification and fuel attribute data sets. The fuel attributes collated were those necessary as inputs to calculation of rate of spread, flame height, and intensity in the various fire behaviour models. Estimation of current fuel levels was made by overlaying temporal fuel state data (e.g. grass curing, reported grass fuel load, and time since last fire).

Fuel maps and fuel attribute tables were developed in consultation with representatives from each jurisdiction. The best available spatial and attribute data (generally currently used operational fuel type) was sourced for each jurisdiction and classification was based primarily on this.

Work has been conducted through the Australasian Fire and Emergency Services Authorities Council (AFAC) to develop a national Bushfire Fuel Classification (BFC) system (Hollis *et al.* 2015, Gould and Cruz 2015, AFAC 2018, Cruz *et al.* 2018). Principles from this system were used to inform fuel classification for the AFDRS. However, implementation of the BFC was only in initial stages during the Research Prototype development, so no BFC data was available to use. Work is continuing through AFAC to encourage the jurisdictions to conduct fuel classification in the BFC system. The AFDRS project team are involved in this work, and will look to integrate the BFC into the AFDRS in the future when sufficient data is available. A high level comparison has been made between the two classifications. While many fuel types are directly equivalent, closer examination is necessary for the fuel types that require fire behaviour model modifications.

## Results and Discussion

The current operational Fire Danger Ratings (FDR) within Australia use the Forest and Grass Fire Danger Indices (FFDI and GFDI) (McArthur 1958, 1960), hence all vegetation is classified into either forest or grass. Ratings are calculated at a weather forecast grid scale (c. 6km), but reported within fire weather areas (FWA). In forecast grids with a combination of grass and forest fuel both GFDI and FFDI are calculated, with the higher value being used. Within a fire weather area the highest rating with at least 10% coverage is used to set the FWA rating. Note that fire weather areas are variable in size, generally reflecting population density.

While forest only covers a small portion of Australia (c. 7% area coverage), it coincides with the areas of greatest population, and is the fuel type most likely to impact on residential areas. The mapping of forest fuels between the current and AFDRS classifications is equivalent in most jurisdictions, with the exception of Western Australia and Tasmania (Figures 1-4). Nationally, forest dominates 20% of FWAs (18% under AFDRS) and is significant (i.e. at least 10% area coverage) in 39% (38% under AFDRS), predominantly within the south-eastern states.

While grass-like fuels cover the largest area of Australia, descriptions of 75% of Australia being grass fuel (Cheney & Sullivan 2008; Sullivan *et al.* 2012) include a variety of fuel types: tussock grassland, pasture and crop land (all included in AFDRS 'grassland' broad fuel type), tropical grasslands (AFDRS 'woodland') and hummock grass (AFDRS 'spinifex').

The classification of grass fuels is where the difference between the current FDR and the AFDRS becomes apparent (Figures 1-4). Current fire danger ratings are primarily set by GFDI, with 89% area coverage and 77% of fire weather areas dominated by fuel classified as grass.

Under the AFDRS classification grass covers the greatest area nationally (61% of area, dominates 66% of FWAs), however half of this is in the woodland broad fuel type (which uses the northern Australia grassland model that allows for a tree canopy over a grassy understorey). Between grassland and woodland, woodland covers a greater physical area but in less populated areas, hence grassland influences more fire weather areas.

The other fire behaviour models, which are not currently considered when calculating fire danger ratings, collectively cover a significant portion (32% of area, dominate 16% of FWAs) of Australia. Of these, spinifex is the most prevalent, followed by mallee heath and shrubland.

Spinifex covers a large area of inland Australia, but coincides with the most arid, remote and sparsely populated areas. In the current FDR system this is all treated as grass. Fire behaviour in spinifex hummock grasslands is very different to that in continuous grasslands, due to the different structure, continuity and life cycle of spinifex (Cruz et al. 2015).

The assignment of the other broad fuel types (mallee heath, shrubland, buttongrass, and pine) between FFDI and GFDI in the current FDR is variable. Spatially these fuel types have a small national area coverage (Figure 4), and do not influence a lot of fire weather areas. However, these fuel types all have unique characteristics influencing their fire behaviour, which become apparent when fire danger is calculated at the forecast grid scale.

The fuel type and fuel attribute data sets developed for the Research Prototype represent an important step in the development of nationally consistent data with a direct operational application. There is a wide range of applications for this data beyond the AFDRS including operational agency use, inter-operability between jurisdictions, input to fire spread simulators, integration with the national Bushfire Fuel Classification, and input to research projects.

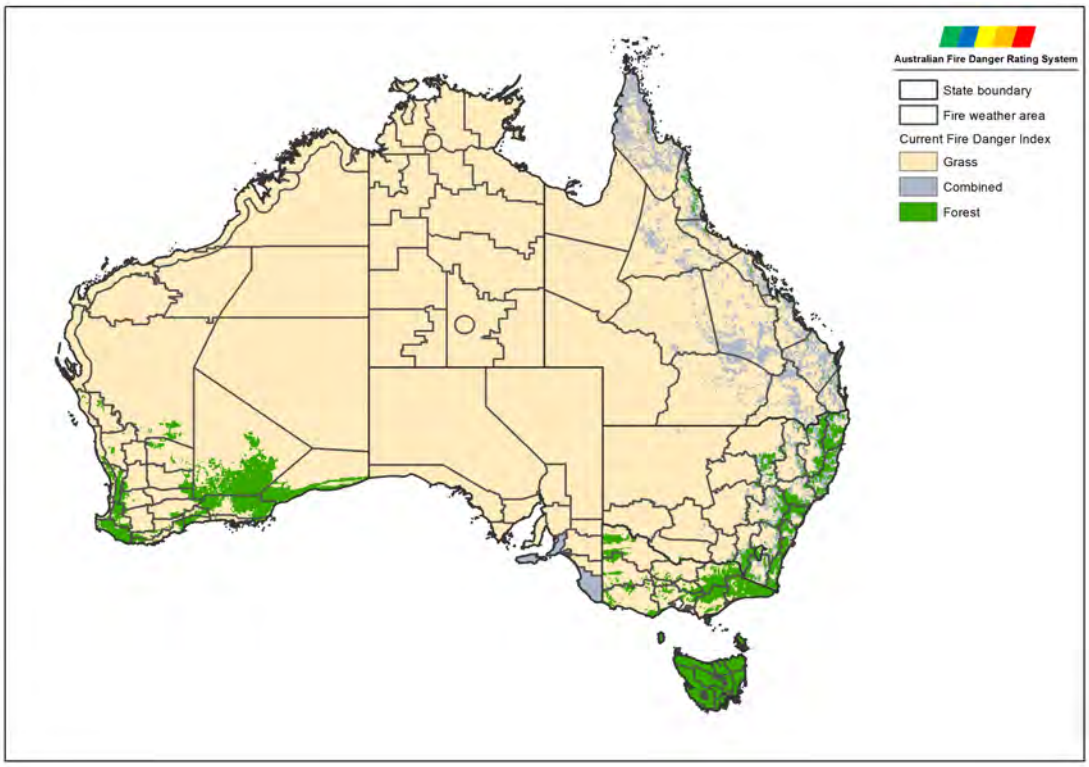


Figure 1. Current fire danger ratings application in Australia

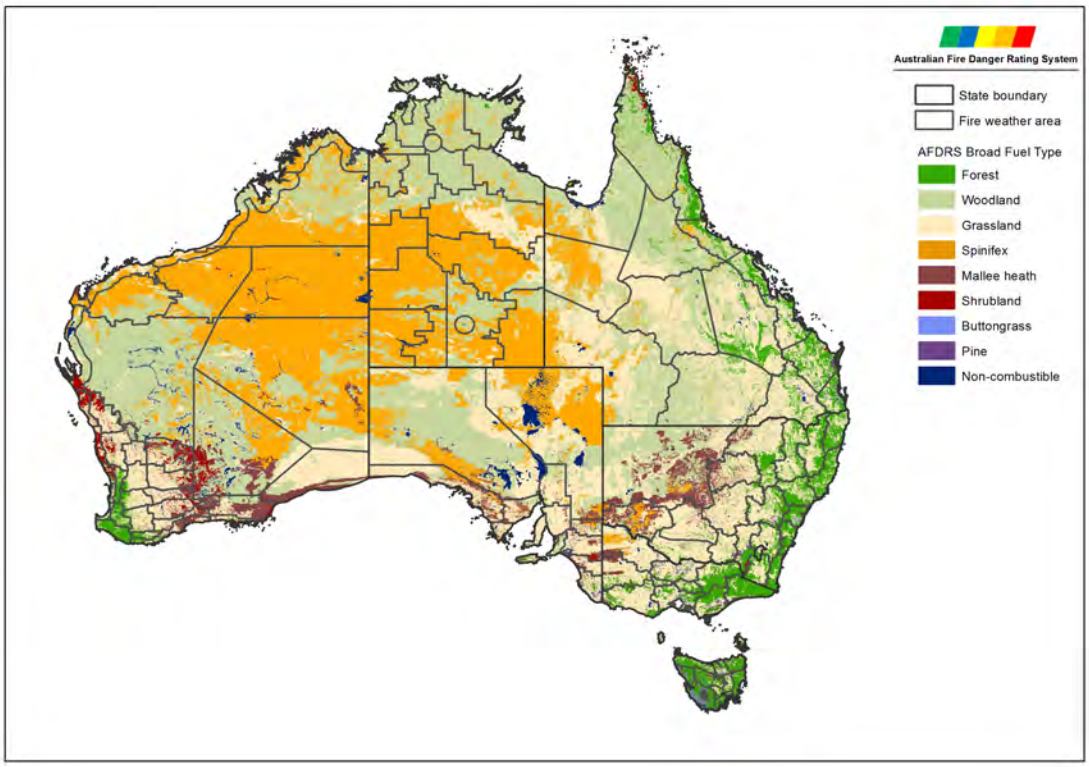


Figure 2. AFDRS Broad fuel type classification representing fire behaviour models

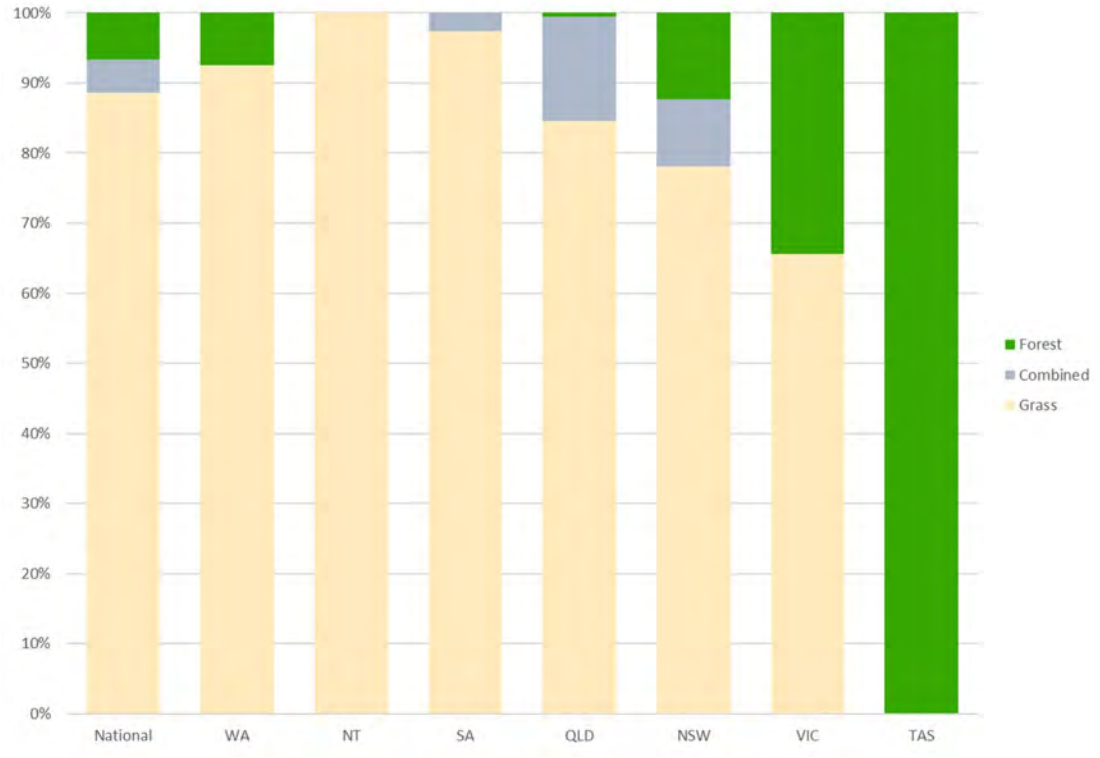


Figure 3. Coverage of fuel types per jurisdiction in the current Fire Danger Ratings system

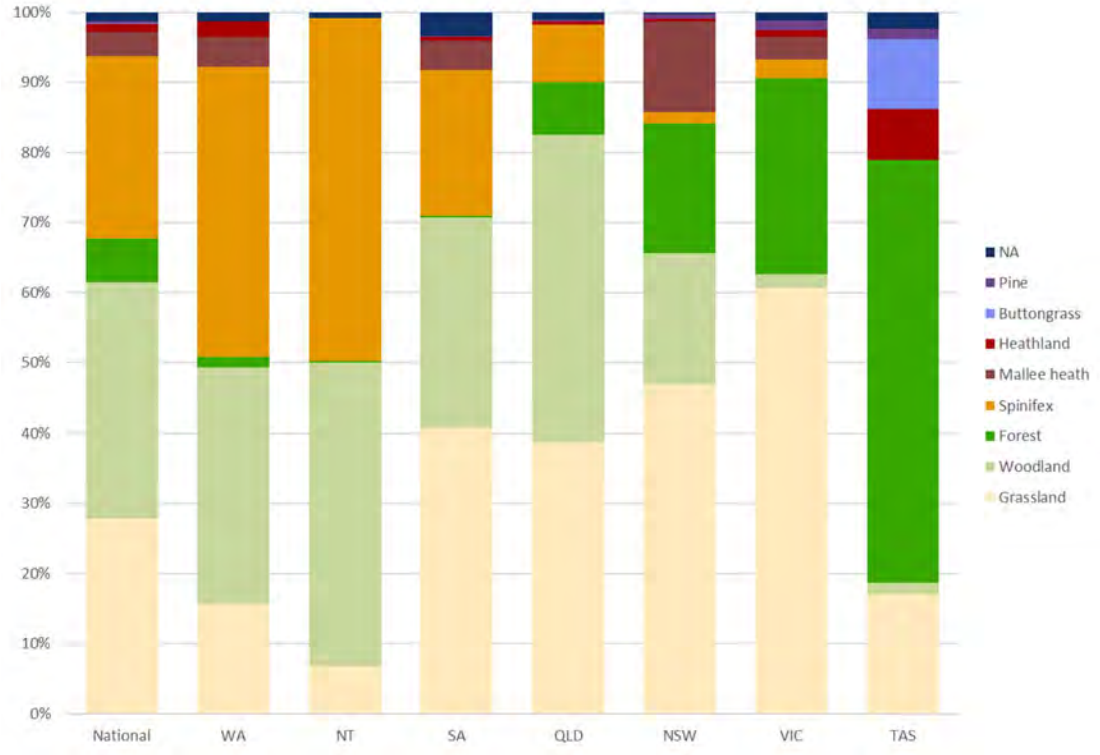


Figure 4. Coverage of broad fuel types per jurisdiction in the AFDRS Research Prototype

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