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AUSTRALIAN FLAMMABILITY MONITORING SYSTEM VERSION 1.0

User feedback and priorities for further development

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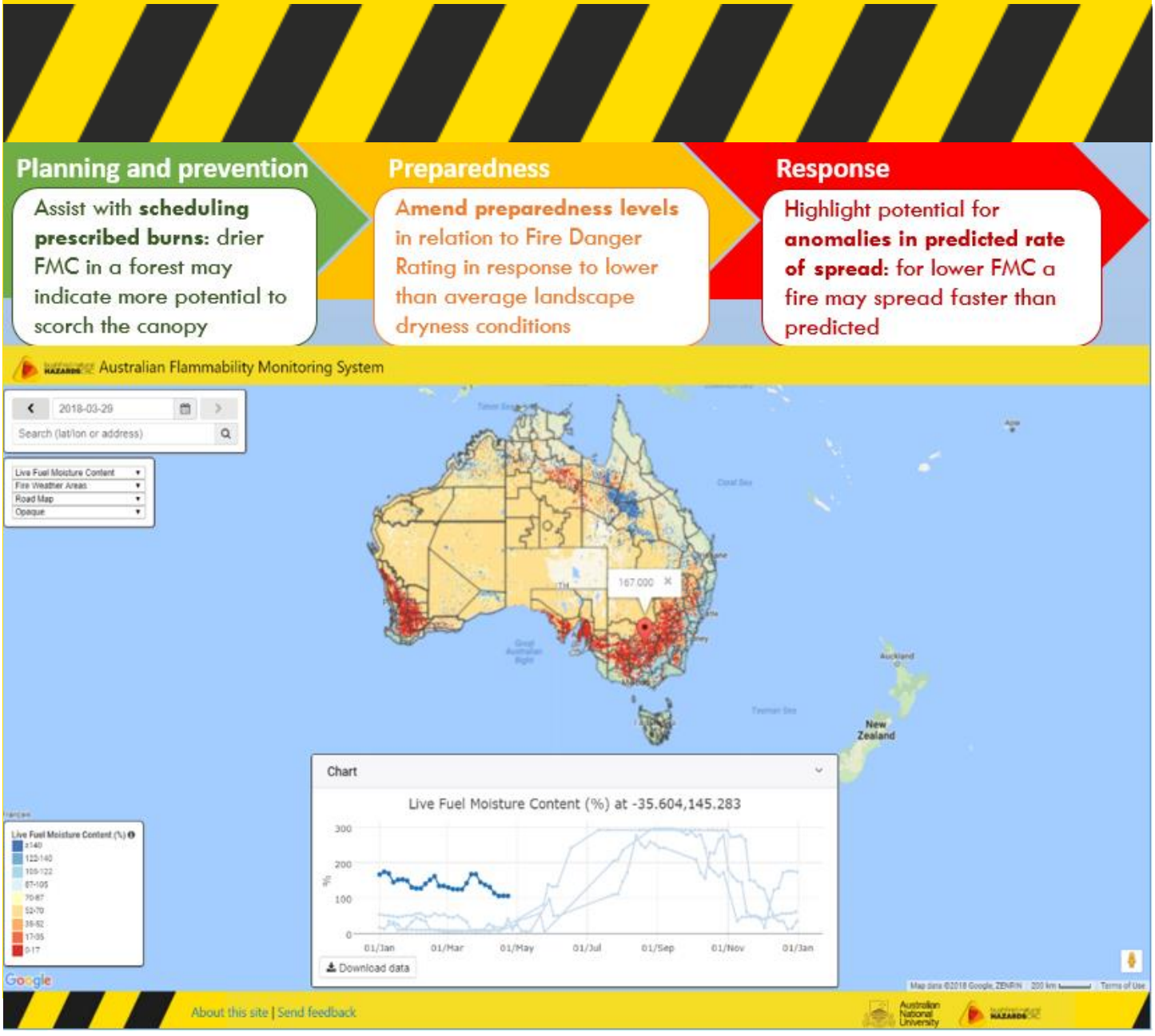

Version	Release history	Date
1.0	Initial release of document	5/12/2018

Publisher:
Bushfire and Natural Hazards CRC

December 2018

Citation: Yebra, M., van Dijk, A. & Cary, G. (2018) Australian Flammability Monitoring System Version 1.0: User feedback and priorities for further development. Melbourne: Bushfire and Natural Hazards CRC.

Cover: Screenshot of the Australian Flammability System website and diagram illustrating the main uses of the AFMS in fire management

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ABSTRACT

In response to the information requirements expressed by end users, the Bushfire & Natural Hazards CRC project 'Mapping Bushfire Hazards and Impacts' (Project A1) developed the Australian Flammability Monitoring System (AFMS) website (version 1.0). The AFMS makes spatial information on fuel condition and flammability easier and faster to access.

This report summarises feedback received from end users and discusses priorities for future development that may potentially be addressed by the BNHCRC and the project team in future.

All end users involved in the project, and participating in several seminars and presentations featuring the AFMS, recognised the value of the system to improve fire management in Australia. However, they also identified some significant barriers to adoption by the Australian bushfire sector. Firstly, neither FMC nor FI are presently used in any models or systems. This means that the sector needs to explore the information and develop work processes for using it. Another key barrier is the timeliness of the system. It presently takes 15 days to acquire the satellite data, process and publish. This delay is too long to allow practitioners to trial the system during operations.

Consequently, future priorities for further development should focus on activities that will contribute to strengthening the usability of the AFMS and adoption. As a first step, we need to invest more time working with end users to develop specific operational applications and integrate the information displayed in the AFMS into current decision processes and tools (e.g. the ACT Parks and Conservation Service's Prescribe Burn Decision Tool). Meanwhile, we also need to improve timeliness, robustness, visual presentation and explanation of the information displayed on the AFMS website to make it easier for users to extract the important details.

The implementation of the AFMS into daily fire management operations will take fire management in Australia to a new level.

END USER STATEMENT

Adam Leavesley, *ACT Parks and Conservation Service, ACT.*

"The Australian Flammability Monitoring System has enormous potential to improve the efficiency of bushfire operations across Australia and drive the expansion of our capability. The provision of accurate, spatially explicit, near real-time estimates of FMC and flammability at a range of spatial resolutions would permit more accurate targeting of scarce bushfire fighting resources in time and space. It would no longer be necessary to estimate jurisdiction-wide readiness based on anecdotal extrapolation of conditions at a few locations".

INTRODUCTION

The Bushfire & Natural Hazards CRC project 'Mapping Bushfire Hazards and Impacts' (Project A1) uses satellite observations and high-performance computing technology to produce up to date spatial information on fuel condition and fire hazard. This information can support the new National Fire Danger Rating System (NFDRS) as well as assist a range of agencies with responsibilities for fire and land management.

The first phase of this project conducted an investigation of promising data sources and methods at national and local scales and was followed by a critical appraisal of the potential benefits and challenges associated with each, along with a recommendation on a narrower set of objectives to be pursued in subsequent years.

Among the options investigated, information on fuel moisture content (FMC) and flammability at a national-scale was judged to represent the best return on investment and generated the greatest interest among end users. Consequently, it was recommended, and subsequently agreed by the BNHCRC, that development of that type of information, to be provided through a web service called the Australian Flammability Monitoring System (AFMS) would be the major focus for R&D over the next years (2017-2020).

The project team was granted support from utilisation funds from the BNHCRC to develop the AFMS, and the released the website version 1.0 in March 2018 as an experimental information service undergoing active research. The AFMS version 1.0 is a web-based spatial data explorer (Fig. 1) that provides easier and faster access to spatial information on:

- Live FMC, in kg water per kg dry matter, expressed as a percentage.
- Uncertainty in the FMC values, in the same units.
- A Flammability Index (FI), providing a relative measure of fuel flammability between 0 and 1.
- Soil moisture content near the surface (0-10 cm), in m^3 water per m^3 of soil volume).
- Soil moisture content in the shallow soil (10-35 cm), in the same units.

The AFMS allows users to visualise and interpret information on the above information as maps or graphs for any part of Australia. Data can be compared to preceding years or downloaded for further analysis.

The FMC and Flammability are derived from MODIS observations available at a resolution of 500 m and a 4-day time step (Yebra *et al*. 2018). Flammability is an index that is calculated using empirical relationships between historical FMC and the occurrence and spread of bushfires. At each time step, the values are derived from observations during the previous eight days (Yebra *et al.* 2018).

The soil moisture data are produced by the Bureau of Meteorology's JASMIN modelling system (Dharssi and Vinodkumar, 2017), also developed as part of the BNHCRC research program. They are available at 5 km resolution and daily time step.

GIS layers showing the outlines of Fire Weather Areas, Local Government Areas, States and Territories, National Parks, and Natural Resources Management regions can be selected to combine with the map and assist in spatial orientation. The map can also be made semitransparent to discern underlying a road map or satellite imagery.

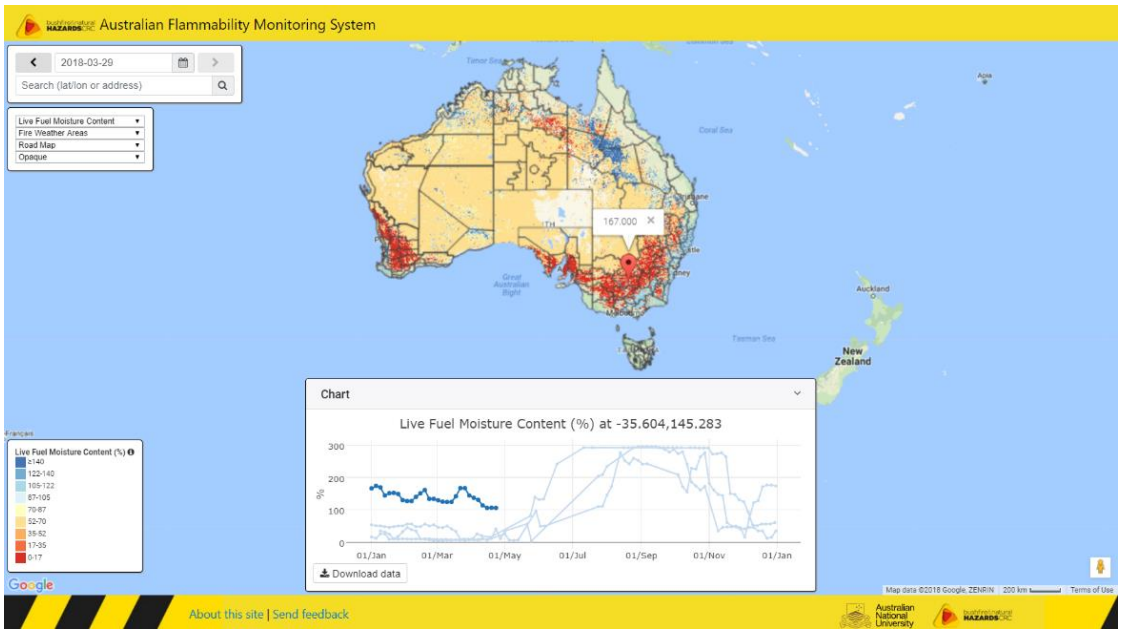

Figure 1. Screenshot of the Australian Flammability Monitoring System website.

Since we released the AFMS version 1.0, we have invited end users to provide comments and suggestions through seminars and workshops as to the website design and features, or on what might be required to improve and make the website optimally useful. For example, on 23 March 2018, the AFAC Predictive Services Systems Working Group sponsored a webinar where the AFMS was demonstrated and followed by a facilitated discussion on priorities for further development. The webinar remains available online[1]. The system was also presented in a Fire Management Workshop organised by the Fire and Incident Management Branch of NSW National Parks and Wildlife Service on the 15th of May 2018 in Sydney. These types of educational events are helping to inform fire and land managers of the benefits of using the AFMS in their organisation to assist them with resource allocation for fire protection and response, improved awareness of fire hazard to people and property, as well as to assist on scheduling planning and prevention activities (Fig. 2). At the same time, the feedback received during these events is helping us to meet the end user requirements better and guide developments for the beta release of version 1.1, planned for September 2018.

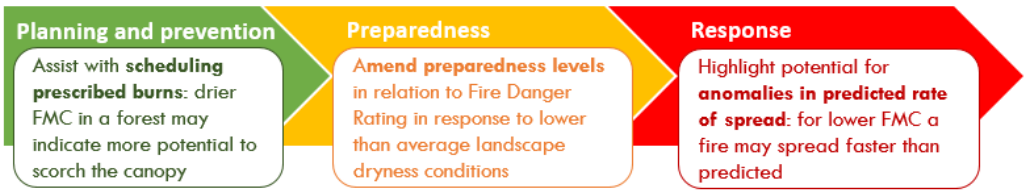

FIGURE 2. CURRENT AND POTENTIAL USES OF THE AUSTRALIAN FLAMMABILITY MONITORING SYSTEM IN FIRE MANAGEMENT.

[1] https://www.youtube.com/watch?v=mfFjmulS3RQ

OBJECTIVE

This report aims to provide a summary of feedback received from users of the AFMS and develop priorities for future development that may be addressed by the BNHCRC and the project team in future.

FEEDBACK RECEIVED AND PRIORITIES FOR FURTHER DEVELOPMENT

A summary of the feedback received, and potential solutions and priorities for further development follows. We have organised the feedback into three categories, as summarised in Table 1.

WEB SERVICE ENHANCEMENT

All feedback received and included in this category is related to improving timeliness, robustness, visual presentation and explanation of the information displayed in the AFMS.

More than one of the users expressed mild confusion by the diamond-shaped pixels and expressed a preference for rectangular pixels. The diamond-shaped pixels are a result from reprojection of the original MODIS data in sinusoidal projection, to geographic coordinates. Based on the early feedback, we implemented resampling to geographic coordinates at 5% degree resolution using the nearest neighbour. This resampling produces rectangular pixels, although it also results in a slight loss of positional accuracy.

One end user pointed out that the AFMS needs to make the FMC signal easier to detect. The vastly different range of FMC values across grass and forest are a major drawback and need to be better represented by the legend. We recognise that the different range in FMC values in grass, shrub and forest is a limitation when it comes to assign a colour category to the map and interpret the FMC values regarding potential fire danger. We will explore two potential solutions

- Map the different fuels (grass, shrub and forest) separately. This implementation will allow us to select more suitable colour scales for each map, while, at the same time will make it easier to find out what fuel type corresponds to each pixel (in the map and the chart)
- Display decile maps in addition to absolute values.

Several end users were confused about what the FMC and FI products indicate in a multilayer forest in relation to what the satellite senses. In a closed forest, FMC will represent mainly the canopy moisture, but in an open forest, the FMC may be an integrated value of several forest layers. They wanted to know more explicitly the fuel layer whose FMC values correspond. To provide that information we will need to investigate ways to make it easy to identify from what layer the FMC is being calculated (e.g. Canopy or grasses) for each pixel (e.g. based on a land cover map and a satellite-based forest cover product). To address this, we will consider adding additional contextual or fire danger factor data layers that are already available online as web mapping services (WMS). Examples include vegetation and land cover information available from Commonwealth and State agencies, biomass estimates available from the Terrestrial Ecosystem Research Network, and weather forecast data available from the Bureau of Meteorology. One approach is to offer a fixed selection of contextual and fire weather layers, though agencies are likely to

have their own preferences in terms of spatial information sources. An alternative approach to explore is to allow the user to add such layers. This could be achieved by making use of WMS import functions similar to those available 'National Map' (https://nationalmap.gov.au/), built on Data61's open source TerriaJS platform. While more flexible, this would require redevelopment of the AFMS website platform. In-depth consultation with end users will help us better understand their use of online and GIS tools in decision making and establish how to best connect into those.

End users indicated that they would like to be able to download the different layers of the AFMS so they can integrate them into their GIS system and overlay with other layers of information they may have (e.g. prescribe burn planning polygons). We will investigate the best options to allow direct data downloads for a region of interest as GeoTIFF for example in an emergency Common Operating Picture setting.

Finally, end users expressed their concerns about the delay on the data stream and latency in the display of the data in the website. We are working on automating this process, and we should be able to provide updates with four days latency soon.

UNDERSTANDING AND USABILITY

While end users recognise the importance of the information displayed in the AFMS for fire danger and behaviour, they also identified some barriers to adoption by the Australian bushfire sector, mainly due to the fact that FMC/FI is not presently used in any models or systems.

One end user highlighted the opportunity of converting grass FMC to curing for a direct application of the FMC product to the grass fire spread model. This relationship could be established by using longtime series of satellite-based FMC and curing (Martin *et al*. 2015; Newnham *et al*. 2011).

Nevertheless, there is more potentially significant value in knowing live FMC and FI anomalies for fire behaviour forecasting (Fig. 2) and the sector needs to familiarise itself with this. For example, a Fire Behaviour Analyst might further revise a fire behaviour prediction based on dead fuel moisture content if all or some of the landscape projected to be burned is anomalously dry or moist with respect to live FMC. Even a textual note indicating that a fire behaviour prediction might be an underestimate given very dry live FMC could prompt alternative fire-ground operations aimed at reducing the likelihood of adverse outcomes for people, constructed- and natural-values in the vicinity of a bushfire or prescribed burn.

The research team needs to enhance understandability and usability and therefore enable adoption of the AFMS into business processes by investing more time working with the end users to study their relevant business processes and develop specific operational applications and integrate the information displayed in the AFMS into decision processes and tools (e.g. the ACT Parks and Conservation Service's Prescribe Burn Decision Tool).

FURTHER ALGORITHM DEVELOPMENT

End users highlighted that the emphasis for further algorithm development should be on ensuring the data service continuity as well as improving the spatial and temporal resolution of the products displayed. It is part of our research plan 2017-2020 to explore other satellite data sources to allow finer spatial and temporal resolution.

TABLE 1. SUMMARIZES THE USER FEEDBACK AND PRIORITIES FOR FURTHER DEVELOPMENT

THEME	FEEDBACK	SOLUTION	STATUS
Web Service Enhancement	Pixels are not square	Change in the projection	Done
	The system needs to better represent the interaction between vegetation types with vastly different FMC dynamics and the scale of the coloured classification	Map the different fuels (grass, shrub and forest) separately	Utilisation Funding under request
		Display decile maps in addition to absolute values	Utilisation Funding under request
	It is confusing to know what the FMC and FI products inform in a multilayer forest in relation to what the satellite senses	Make it easy to identify from what layer the FMC is being calculated by adding additional contextual or fire danger factor data layers that are already available online.	Utilisation Funding under request
	Data needs to be integrated into the users' GIS systems	Allowing direct data downloads for a region of interest as GeoTIFF	Utilisation Funding under request
	More regular updates of data displayed are needed	Automate this process	Utilisation Funding under request
Understanding and usability	Users want to make more use of the information displayed on the AFMS	Invest more time working with the end users and develop specific, operational applications and integrate the information displayed in the AFMS into current decision processes and tool.	Utilisation Funding under request
	Users want to learn more about integrating AFMS products into their current systems	Develop use examples or instruction videos for new website users that explain the strengths and limitations of the data (based on our conversation with end users)	
	Users would like to use FMC in the current grass fire spread model	Relate grass moisture content to curing	Utilisation Funding under request
Algorithm development	Explore other satellite data sources to allow finer spatial and temporal resolution.	Suitability study of different satellite data sources	Planned by June

CONCLUSIONS

In response to the information requirements expressed by end users, we developed the Australian Flammability Monitoring System (AFMS) prototype website to make spatial information on fuel condition and flammability easier and faster to access to end-users.

After conversations and seminars with end users, we have identified some priorities for further development. The main priority to facilitate adoption in the Australian bushfire sector is to invest more time working with the end users to develop specific, operational applications and integrate the information displayed in the AFMS into agencies' current and future decision processes and tools. We also need to improve timeliness, robustness, visual presentation and explanation of the information displayed on the AFMS website. In this report, we list some detailed activities required to achieve those objectives. A limited number of these can be incorporated into the next beta release of the AFMS, planned for September 2018 without further funding. However, a majority of the activities would require further investment, and we are applying for utilisation contingency funds to the BNHCRC.

ACKNOWLEDGEMENTS

This report was made possible through funding from the Bushfire and Natural Hazards CRC through a utilization fund granted to the project 'Mapping bushfire hazard and impacts'.

We thank AFAC Predictive Services Systems Working Group for sponsoring a webinar to demonstrate the Australian Flammability Monitoring System and facilitate discussion on priorities for further development. We also thanks end users across different jurisdictions that have provided invaluable feedback as well as the team of the AFMS web developers.

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