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Overcoming knowledge gaps for bushfire predictions

There are many aspects of the behaviour of bushfires for which we do not have a complete understanding. These gaps in knowledge need to be overcome when undertaking operational fire behaviour predictions to ensure meaningful results. Compensation strategies for a number of critical knowledge gaps are provided.

Making useful fire spread predictions

Effective fire behaviour specialists have a deep understanding of fire behaviour that they have acquired through first-hand fireground experience and extensive training. They apply their personal judgement and feel for a situation to overcome gaps in the formal understanding of how a fire will behave in order to make meaningful predictions.

Gaps in fire behaviour knowledge are best dealt with case by case to enable local conditions to be considered. However, it is important that appropriate compensation strategies are implemented in a way that facilitates reliable and repeatable predictions. Where possible these should be validated against fireground intelligence, well documented and effectively communicated.

Examples of some of the most prominent fire behaviour knowledge gaps affecting fire behaviour predictions and possible compensation strategies are given below. Addressing these gaps must be a priority for future research.

Further reading

Plucinski MP, Sullivan AL, Rucinski CJ, Prakash M (2017) Improving the reliability and utility of operational bushfire behaviour predictions in Australian vegetation. *Environmental Modelling & Software* 91, 1–12.

Critical knowledge gaps affecting fire behaviour predictions and possible compensation strategies

KNOWLEDGE GAP DESCRIPTION	COMPENSATION STRATEGY
Duration of the initial fire growth phase Current fire spread models predict the quasi-steady rate of spread of fully developed fires. There is limited knowledge of the rate of development of fires commencing from point ignitions, including the amount of time required for a fire to reach the quasi-steady rate of spread. This means that the spread rate may be over-predicted for fires that are still developing.	Recognise that predictions will over estimate spread rates for initiating fires for the first 15-120 minutes depending on fuel type, especially during low wind or high fuel moisture conditions. Seek verification from the fireground.
Fire spread on slopes, in complex terrain and extreme conditions The influence of slope steepness is not limited to its direct mechanical effects on flame propagation. Other topographic effects such as the changes in wind and vegetation make it difficult to isolate this effect. Complex topography, particularly that introducing turbulent wind flows such as lee-slope eddies, confounds the heterogeneity of environmental variables making the predictability of fire spread in such conditions highly complex. The effects of interactions of fuel, weather and topography under extreme conditions are not well understood.	Select an appropriate spatial and temporal scales for predictions where uncertain input variables can be either be better estimated or their effects are less pronounced. Prepare predictions for a range of alternate scenarios that consider different effects such as lee-slope turbulence on fire spread and spot fire development.

KNOWLEDGE GAP DESCRIPTION	COMPENSATION STRATEGY
Fuel types without specific fire spread models There are a range of fuel types across Australia for which specific spread models do not exist. These include wet eucalypt forests, rainforests, semi-arid woodlands and shrublands with ephemeral grass understories, young regrowth forests, native cypress forests, short rotation eucalypt plantations and urban vegetation.	Apply a model designed for a similar vegetation structure and make manual adjustments to compensate for known differences such as fuel arrangement, fuel dryness and wind exposure.
Fire spread around the entire perimeter Existing operational fire spread models have been developed for predicting the spread of head fires. Knowledge of the spread of other parts of the fire perimeter and the overall shape of fires is limited. Geometric approximations (e.g. length-to-breadth ratio) used to estimate perimeter growth are not based on physical mechanisms and have not been validated against observations. The sustainability of fire spread under marginal conditions, in particular self-extinguishment, is not well understood.	Apply approximations but adjust them to fit with expectations from previously experienced scenarios in similar conditions. Manual adjustments are most important when fires are burning in complex terrain, particularly of flanks.
Short-distance (wind-driven) spotting Short-range spotting involving embers blown up to 500 m by the wind occurs in a broad range of fuels and conditions and is an important mechanism for breaches of containment lines. There are currently no models for predicting short range spotting or the relative effects that such phenomena may have on the overall behaviour and spread of a bushfire.	Annotate maps with warnings for areas downwind of hazardous locations such as heavy fuels and steep inclines. Prepare predictions for a range of alternate scenarios that consider ignitions in these locations.
Characteristics of flames in different fuel types Flame characteristics (height, length, depth, residence time, radiative output, etc.) are poorly understood for many fuel types but are important for estimating impact and determining viable suppression options. Existing models only apply to head fires in a few fuel types. There is a need for a more fundamentally-based generic model describing the three-dimensional structure of flame as determined by the energy released and associated buoyancy forces, fuel structure and wind speed for surface and crown fires.	A model for a similar fuel type could be applied with consideration of differences in the dryness, wind exposure and vertical continuity of fuels. Understanding the influence of the height of the fuel layer through which the fire is propagating is essential.
Models to support prescribed burning Most prescribed burn guides and models used in Australia pre-date many recent advances in fire science. They contain simple relations with few inputs and do not consider more complex interactions such as the role of fuel structure in fire propagation. They also lack models quantifying fire sustainability. Improved models would help ensure that prescribed burns are effectively scheduled and achieve their objectives. They would also help with determination of post-burn control and patrol requirements, as well as predict the likelihood of escapes and subsequent suppression requirements.	Measure fuel moisture content in the field and apply existing models with consideration for the impact of ignition patterns and timing, and fuel structure (including near-surface, elevated and bark fuels), noting that the influence of these factors will be different to wildfire conditions. Compare predictions with field observations.

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