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Uniting fire behaviour science and practitioner experience to improve fire spread prediction

A reliable fire spread prediction requires a sound understanding of the current scientific knowledge of fire behaviour and the prudent application of expert judgement. Scientific knowledge is embedded in fire behaviour models. Expert judgement compensates for deficiencies in scientific knowledge and input data, allowing adaptation of a prediction to specific situations. A recent paper outlines the important aspects of fire behaviour knowledge that help improve the reliability of operational fire spread predictions.

Prediction methods

Timely and accurate fire behaviour predictions are vital for planning effective suppression strategies and issuing public warnings during wildfires, and are essential to support other fire management decision making such as planning and implementing prescribed fires. These predictions are either prepared manually, with fire spread calculations plotted onto maps by hand, or automatically using computer-based fire spread simulators.

The traditional hands-on approach necessitates user decisions for all prediction steps, from model selection to perimeter representation (Figure 1). As a result they require a high level of practitioner knowledge and experience of fire behaviour, can be time consuming to produce and do not easily provide capacity for considering alternate scenarios.

Fire spread projections generated using a fire spread simulator can be produced quickly with a minimum of fire behaviour knowledge or experience. As a result, predictions can be run more often, on more fires, and can easily consider alternate scenarios. However, trade-offs in comparison with manual predictions potentially include accuracy, robustness and flexibility. The large number of embedded processes and implicit assumptions within fire spread simulators are generally not known or appreciated by many practitioners and can reduce prediction reliability. Implicit assumptions built into the simulator cannot be easily adjusted to suit specific conditions or their effects on predictions readily conveyed.

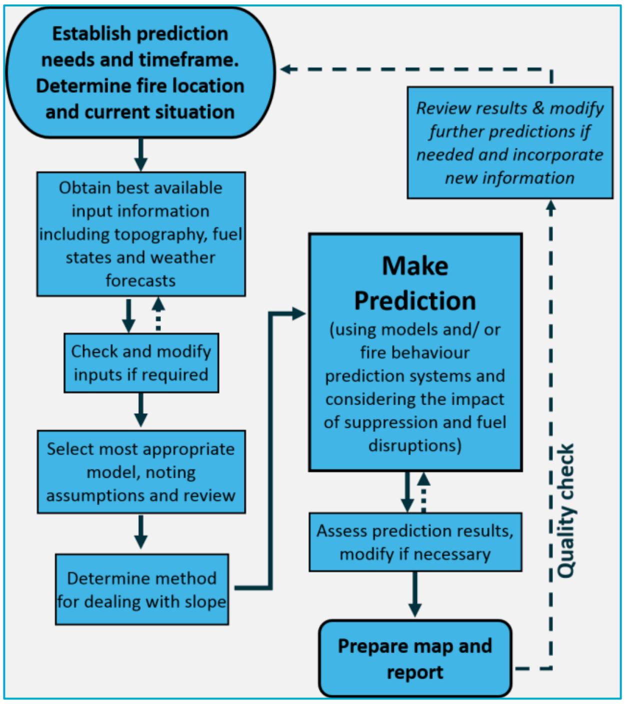

Figure 1. Outline of the workflow for preparing a fire spread prediction.

A recent evaluation of fire spread simulators (Faggian *et al.* 2017) found that the results of a single deterministic simulation can be poor and recommended that multiple predictions in an ensemble be used to account for variability in weather, fuel and ignition inputs. While such an approach may improve the quantification and communication of input uncertainty, it does not deal with the embedded assumptions or the deficiencies in the underlying fire science in the simulator.

The roles of knowledge and judgement

Useful and robust predictions of fire spread draw from a broad range of knowledge and data sources and are processed using fire science and expert judgement. Scientific knowledge is incorporated through the application of well accepted and validated fire behaviour models, whether manually or in a simulator, with an appreciation of each model's limitations and suitability. However, there are many gaps in the current scientific understanding of bushfire behaviour captured in such models which can reduce the reliability of predictions and affect the quality of subsequent decisions.

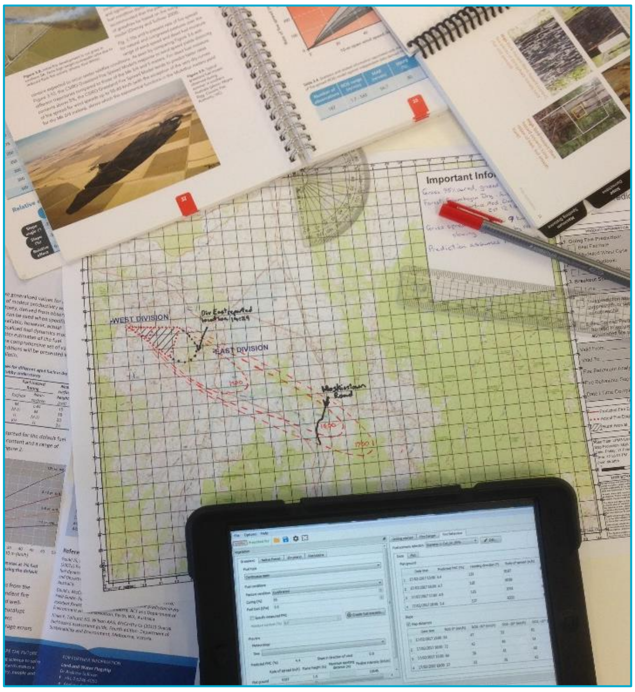

Figure 2. Fire spread predictions draw from many information and data sources and require a high level of skill to produce.

Expert judgement is incorporated into fire spread predictions through the selection of appropriate models for fuel types and conditions. It also provides quality assurance in the application of the science by asking questions about the veracity and validity of predictions. In manual predictions, expert judgement can also be employed to overcome deficiencies in fire behaviour knowledge, such as fire spread in fuel types for which specific models do not exist, and to assimilate local knowledge and field intelligence.

Dealing with fire behaviour knowledge gaps is best done manually on a case by case basis, with a range of strategies available (see Table 3 in Plucinski et al. 2017). Direct observations of fuel, weather and fire behaviour should be used to test the adequacy of assumptions, the accuracy of model predictions and to refine input variables to reduce uncertainty.

Combining knowledge and judgement

The process of preparing predictions, whether manual or automated, requires fire behaviour specialists to have a sound understanding of fire behaviour principles and to understand all model assumptions and simulation choices as well as the natural dynamics of the input variables. Prediction results can then be meaningfully interpreted, and limitations and implications easily communicated.

While methods for overcoming gaps in fire behaviour knowledge are difficult to define for automated systems, software such as the Amicus fire behaviour decision support system (available here) provides a way to combine the expertise and knowledge of a well-trained and experienced fire behaviour specialist with the best fire science.

Amicus enables the best quality information to be incorporated into manual fire spread predictions and also allows the adequacy of automatically generated fire spread projections to be assessed.

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.

References

Faggian N, Bridge C, Fox-Hughes P, Jolly C, Jacobs H, Ebert B, Bally J (2017) Final Report: An evaluation of fire spread simulators used in Australia. Bureau of Meteorology, Melbourne, Victoria.

Link to Amicus software: http://research.csiro.au/amicus

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