Approaches to simulation of prescribed burns in forests of southern Australia

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Abstract: The simulation of wildfires has received significant worldwide attention, and a number of useful models have been developed to predict fire propagation and the risk of damage to infrastructure. In contrast, few models have been developed for low intensity prescribed burns, which are used extensively by land managers in southern Australia for fuel and ecosystem management. Such burns require careful control to reduce unintended environmental, economic and social impacts. Particular issues of concern to communities are smoke exposure and the risk of burns escaping their prescribed boundaries.

We considered the problem of forecasting the behaviour and outcomes of a prescribed burn scheduled to be undertaken in the next 7 days, given a burn boundary, a weather forecast, the intended burn date and a burn prescription. We looked for models capable of predicting the total amount of fuel consumed, the rate of fuel consumption (which can be used to derive smoke emission rates), the spatial pattern of burnt and unburnt areas, and fire behaviour parameters such as average fire intensity.

Prescribed burn simulation presents a number of challenges. In particular, the burn prescription often specifies that fire should only be applied to a fraction of the land area within the burn boundary; in Victoria these target fractions can be as low as 30%. As fuel loads are spatially variable, the amount of fuel consumed can only be estimated if we can predict the spatial pattern of burnt areas within the boundary.

Several modelling approaches were considered including direct simulation of fire propagation, simplified simulation of typical burning strategies, and generic non-spatial methods using average fuel loads. Each approach was evaluated in terms of the level of input required, numerical stability, and potential value for predicting burn outcomes. Model results were also evaluated against observations at an experimental site burnt in March 2012 (Henderson Creek, Otway Ranges, Victoria). Ground surveys and satellite data were used to accurately determine the spatial pattern of fire and the level of canopy scorch at this site. Measurements were also made of pre- and post-burn fuel loads, allowing total fuel consumption to be estimated.

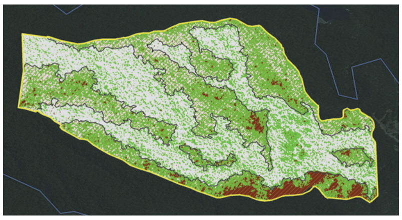

Fig. 1: Observations: Ground survey of burnt area (black line), overlaid on a burn severity assessment derived from RapidEye 5m satellite imagery (grey=unburnt, green=surface burnt, brown=surface burnt and canopy scorched).

We found that using a burning strategy, plus McArthur's Leaflet 80 to predict fire intensity, results in good agreement with observations with only moderate input data requirements. In contrast, fire propagation methods require a detailed ignition pattern as input, which is typically not available before a burn is conducted. Generic methods were found to be useful for providing a first approximation to the total fuel consumption, but did not allow prediction of fire behaviour parameters or the spatio-temporal pattern of fire.

This study has shown that prediction of prescribed burn outcomes may be achievable with inputs typically available several days before the burn, by using a burn strategy simulator. With further development and verification, this type of model may assist land managers in achieving safe and effective prescribed burns.

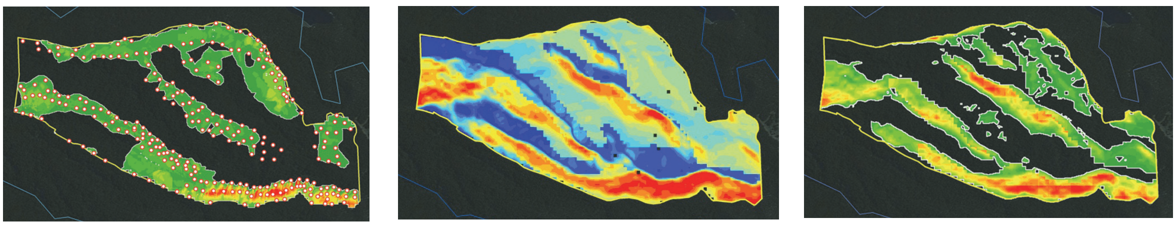

Fig. 2: Model predictions: Left: Full fire simulation using PHOENIX RapidFire with a modified extinction threshold (ignition points marked, colors indicate fireline intensity). Middle: Predicted fuel moisture (Matthews 2010) at the start of the burn (red=dry, blue=wet). Right: Leaflet 80 burn simulation making use of the fuel moisture prediction, burning from dry areas to wet areas until the target area coverage is achieved, without requiring an ignition pattern.

Keywords: *Fire simulation, fuel moisture, prescribed burning, smoke emissions*