PROGRAM B

The Forest Flammability Model

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ABSRACT
The Forest Flammability Model (FFM) is a complex systems model of forest fire behaviour developed for the NSW Dept. Environment & Climate Change. Fire behaviour is calculated as a physical process determined by the flammability of individual fuel components and the transfer of heat between them. Model outputs for two forest structures are compared with those of the McArthur Meter, Project Vesta and BEHAVE to outline where the differences between the models lie. Implications for land management are discussed.

Model description

The FFM is not an equation, but a model structure composed of sub-models for the component aspects of fire behaviour such as leaf flammability[1], flame angle[2] and the temperature profile of the plume[3]. Because of this, the model can be readily updated as new research becomes available.

Unlike an empirical model, the FFM does not assume that fire behaviour will follow a particular pattern but looks for a physical mechanism to cause the behaviour.

For example, the McArthur Meter predicts that crown fire will occur on flat ground at an FFDI of 40 if there is 20 t/Ha of surface fuel available. It does not consider whether the FFDI was caused by strong winds or by hot dry conditions and takes no account of forest structure; the expected fire behaviour is identical in all forest types.

By contrast, the FFM calculates the availability of all fuels from the surface litter to the canopy by modelling the ability of flame to cross the spaces between the individual fuel elements at the different scales from leaves and plants to fuel strata.

Comparison to other models

The fuel parameters of *Eucalyptus niphophila* forest were surveyed at Guthega in Kosciuszko National Park (elev. 1600m) for 2 different fuel ages – site 1 had no recorded fire in the past 50 years (Fig. 1) and site 2 had 6 year old regrowth (Fig. 2). Figs. 3 & 4 show the forest structure derived from the surveys and used by the FFM for calculations. In the older site, trees were larger with canopies further above the ground, and the dense fire germinated *Bossiaea foliosa* had senesced and left a more open and slightly shorter shrub layer of less flammable species.

Fig. 1. Site 1 - 50 year old *E. niphophila* forest

Fig. 2. Site 2 - 6 year old *E. niphophila* forest

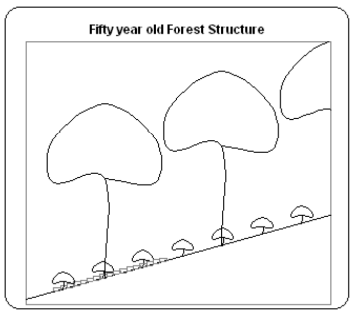

Fig. 3. 50 yo forest structure

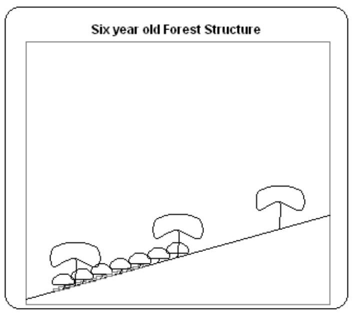

Fig. 4. 6 yo forest structure

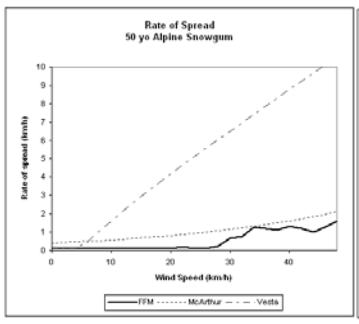

Fig. 5. 50 yo rate of spread

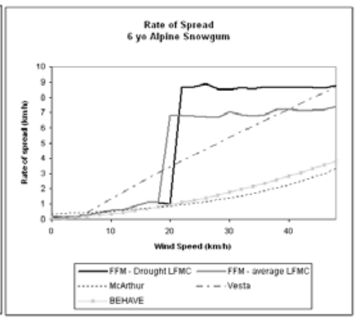

Fig. 6. 6 yo rate of spread

Fig. 5 shows the modelled rate of spread at 26°C, 20% RH, Drought Factor of 6 and increasing wind speed for the 50 year old site compared with the McArthur equations[4] and Project Vesta[5]. Modelling shows fire spread only in surface litter until wind speed reaches approximately 30 km/h. At this point, sufficient ground-level wind is available to tilt the flame and enable fire to spread between grass tussocks and shrubs, increasing the rate of spread.

A much sharper increase is apparent in the rate of spread when the 6 year old fuels are examined (fig. 6). In this case, the increase is made possible because the wind has sufficient strength to hold the flame of a crown fire parallel to the slope. This was not possible in the mature forest because the wind speeds required to do it also tilted the flames of the surface fire so far that they were unable to ignite canopy foliage across the large space between strata. This is consistent with McArthur's observations of crown fire[6].

Note that the drought stressed plants produce a faster fire than those in a normal season. The role of live fuel moisture in the canopy is compared in this instance to predictions from BEHAVE[7], which in this case shows no difference between drought and average scenarios.

Implications for land management

The model provides a physical explanation for the way changing structure and species composition affect the flammability of a forest. By understanding these processes, land managers are able to plan effective fire regimes for fuel management based upon the ecology of the site and its effect on fire behaviour. The model will enable fuel management effectiveness to be measured by its contribution to suppression success rather than by generalisations such as fuel age that may not be relevant to that forest.

The model is currently being validated in preparation for publication.

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