PROGRAM B

FOREST FLAMMABILITY: MODELLING AND MANAGING FIRE AND FUELS

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ABSTRACT. The Forest Flammability Model (FFM) is an approach to fire behaviour modelling that calculates the way that the structure of an entire plant community affects fuel availability, air movement and fuel moisture. The size and spacing of plants along with their moisture content, chemistry and internal structure all affect the capacity for fire to spread through the fuel ladder and the overall rate of spread and flame dimensions. Due to its semi-physical approach, the model is not bound by fuel type and has to date been tested against experimental and unplanned fires in communities ranging from coastal heathland to sub-alpine Snowgum forest and Mountain Ash forest. Results suggest large statistically significant improvements in accuracy when compared to the relevant empirical models, and provide far greater capacity for planning effective fuel management operations.

Introduction

The FFM is an operational fire behaviour model developed as a PhD project through the Australian Defence Force Academy for the NSW Dept. of Environment, Climate Change and Water. The model calculates fire behaviour based upon the physical characteristics of the plants involved rather than using empirical generalisations.

Fuels – Friend or Foe?

Fuel consists of anything that is burning at the fire front and thereby affecting the fire behaviour; however there are no simple ways of determining whether highly influential potential fuels such as tree canopies are actual fuel without first knowing whether the fire will ignite them. In effect, the larger the flame, the more fuel it will ignite and the more fuel ignited, the larger the flame. To complicate this even further, when potential fuels such as shrubs or trees are not burning, they are shading the surface fuels and keeping them moist as well as reducing the wind speed and thereby slowing the fire. As a result, it cannot simply be assumed that some component of a forest will accelerate a fire or slow it down; this must be calculated for every different set of conditions. By doing this, the FFM provides superior insights into effective fuel management.

End User Statement

"Most firefighters are aware that sudden 'unexplained' changes in fire behaviour often occur, particularly when certain thresholds are reached in both weather and fuel variables. These threshold values often involve the interaction of slight changes in wind speed or direction, or subtle changes in fuel structure and composition with the flame zone and heat plume of a fire. The Forest Flammability model is an innovative approach that propagates fire through a fuel array using routines for the various elements driving the ignition process, such as fuel ladders and wind strength. The model will allow agencies to more accurately predict fire behaviour in different plant communities and age classes, and facilitate more informed and effective measures of fuel management."

Bob Conroy,
Executive director, Park Management,
NSW Department of Environment,
Climate Change and Water

Model Validation

Model validation is ongoing, but to date the model has been measured against a series of experimental fires in montane forest and coastal heathland as well as unplanned fires in mature and regrowth Snowgum forest, and extreme intensity fire in Mountain Ash forest.

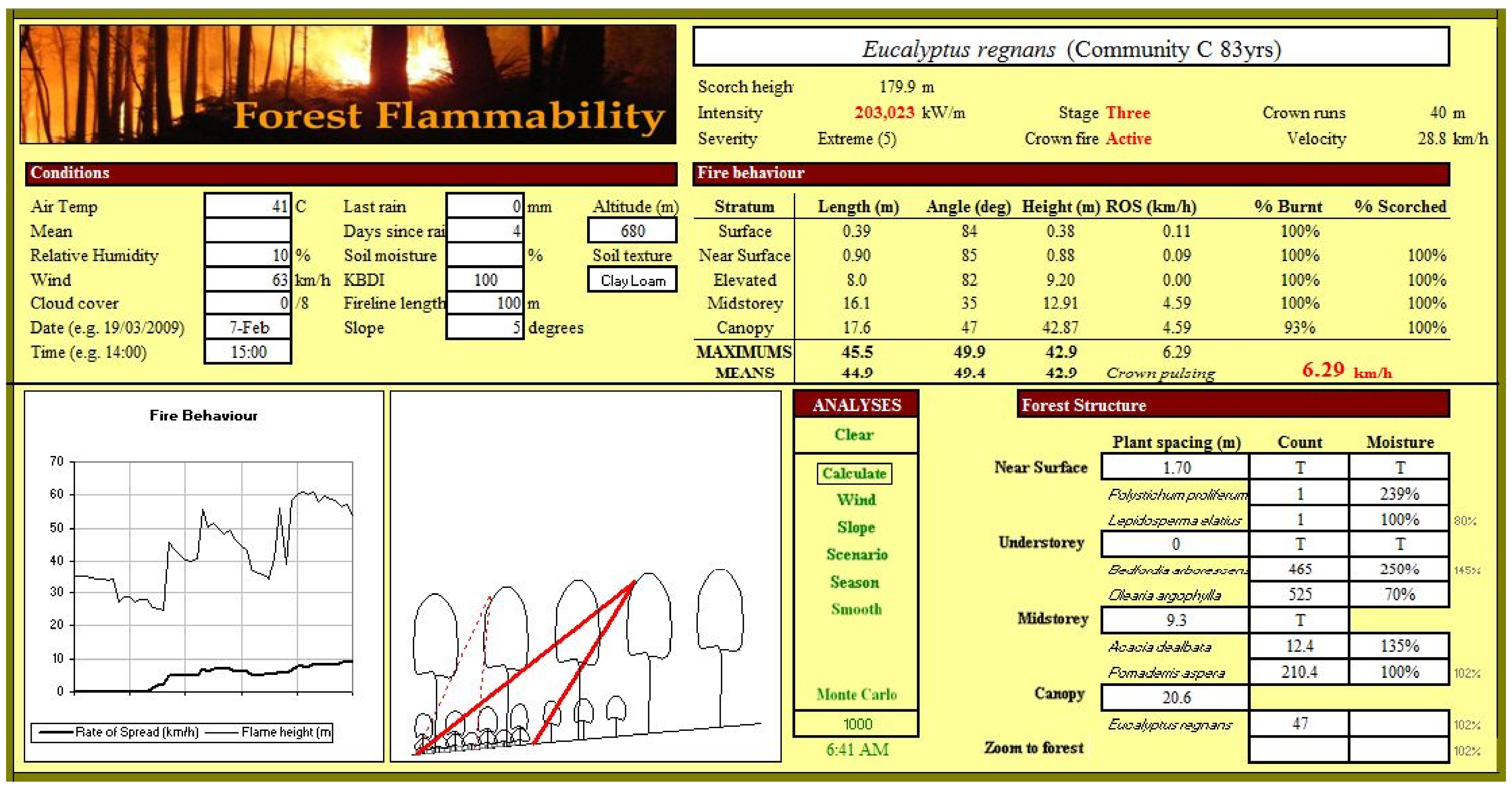

Figure 1. Main interface of the model showing a mountain Ash Community burnt in the February 7 2009 Kilmore fire. Weather and terrain conditions are entered at the top left and forest structure at the bottom right. Fire behaviour details are shown at the top right and in the centre graph in relation to the forest structure. The left hand graph shows modelled ROS and flame height with wind speed varied from 0 to 100 km/h.

These tests have provided large, statistically significant improvements in accuracy for predicted rates of spread when compared to the relevant empirical models (*figure 2*).

Empirical models, often relying on exponential functions tend toward unrealistic over-predictions under extreme conditions; however Extreme Condition Tests have demonstrated that the FFM imposes natural limits on fire rates of spread.

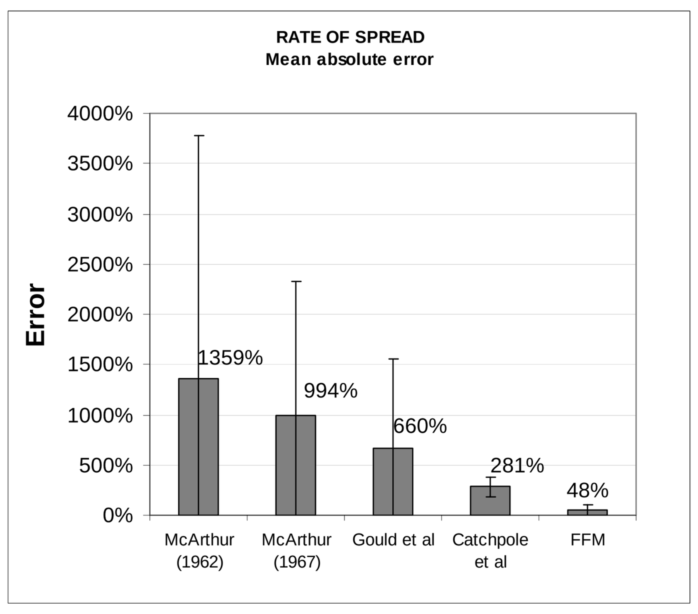

Figure 2. Mean absolute error comparison of the FFM with empirical alternatives to date.

Application to Bushfire Risk Management

By considering the full role of plants in fire behaviour both as fuel and as structural elements hindering fire spread, the FFM is able to assess the significance that ecological changes may have to potential fire behaviour, and can therefore be used in conjunction with such knowledge to calculate the optimal fire management for a site.

Although the effects of climate change on fire have been studied in the context of changing Forest Fire Danger Indices, specific changes such as altered rainfall patterns, heatwaves, influences on plant morphology or ecological changes can now be studied in detail. Preliminary trials of the model in fire incident management have also demonstrated that it provides marked improvements for decision making.

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