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Fire spread models for Australian vegetation

Models to predict likely fire spread and behaviour are key tools in a fire manager's toolbox. But how well do we know the models we use? A new book and companion scientific paper detail all available models, their performance, and application bounds, to support their informed use.

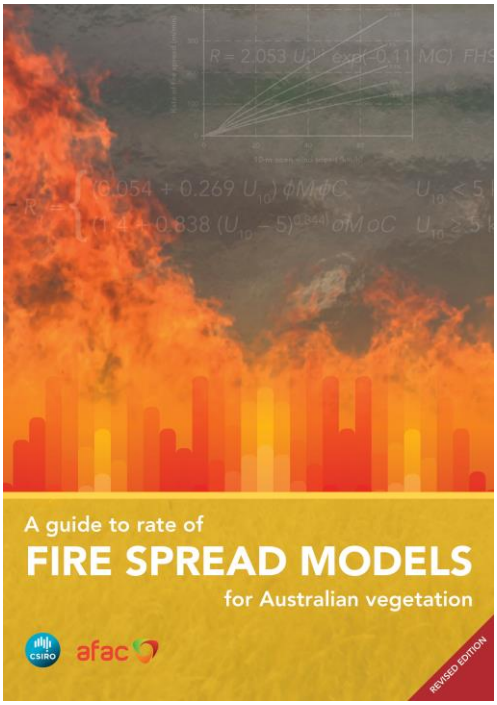
Why do we need this book?

The idea for this work arose from discussions with a number of fire practitioners who felt overwhelmed by the variety of fire behaviour models available and the lack of easily accessible information about their origin, applicability, and predictive performance.

Fire behaviour research in Australia has been a decentralised endeavour, with different research organisations developing fire models for particular applications as needed. They were published in a variety of places including conference proceedings, internal (and, sometimes, unpublished) reports, academic theses, books and articles, many of which are hard to find, particularly in a digital form.

A Guide To Rate Of Fire Spread Models For Australian Vegetation consolidates operationally relevant available Australian rate of fire spread models for the first time into one practical reference guide. It also provides a comprehensive evaluation of the performance and potential applications of the models for wildfire spread prediction or prescribed burning planning.

> *Rates of spread vary in a bewildering way. It would be easy to yield to the temptation to throw up our hands and say that it is useless to try for anything but good guesses at the rate a given fire will spread under given conditions of fuel, weather and topography. The saner attitude is to keep digging away at the effect of this or that factor on rate of spread in the belief that in time the intricate puzzle will be solved by the creation of something that can rightfully be called the science of rate of spread.*
>
> G.M. Jemison (1939)



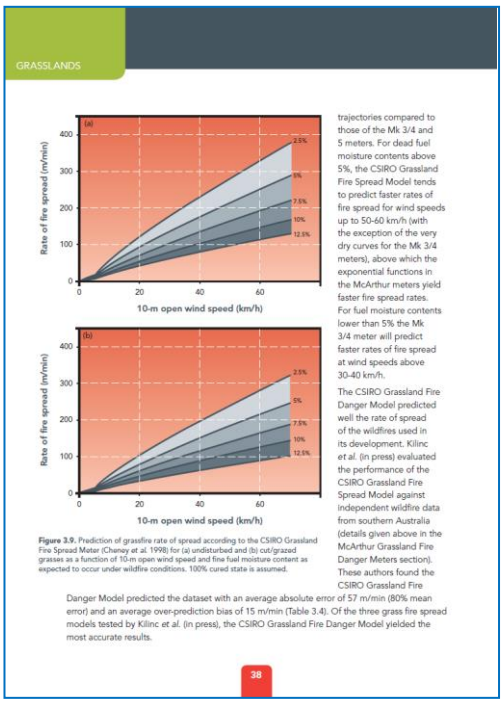
The contents

The book provides an introductory overview on the "art and science" of predicting bushfire behaviour as well as an historical perspective of fire behaviour research in Australia. The book then identifies a total of 22 fire spread models used operationally for wildfire and prescribed burning applications. The models cover fire spread prediction in a wide range of fuel types, including hummock and continuous grasslands, shrublands, dry and wet sclerophyll forests, as well as pine plantations.

Background information and a detailed functional description of each rate of fire spread model are given, including a discussion of experimental design and subsequent data used to develop the model.

Generally it is the range of these data that constitutes the model's application bounds. The mathematical equations that form each model are presented along with a discussion of model form, the main input variables and their influence on model behaviour (i.e. how the model will behave with increasing wind speed, for example), and a summary of known performance evaluation studies undertaken. Fuel type-specific moisture content models and output tables are provided for each model where applicable to enable quick estimation (without the need for computational software) of this variable.

The main objective of the book is to make the science accessible and useful and this is reflected in the structure and design of the publication. Easy to understand graphs, tables and photos are used throughout to illustrate key concepts.


GRASSLANDS

Rate of fire spread (m/min)

10-m open wind speed (km/h)

Figure 3.9. Prediction of grassfire rate of spread according to the CSIRO Grassland Fire Spread Meter (Cheney et al. 1998) for (a) undisturbed and (b) cut/grazed grasses as a function of 10-m open wind speed and fine fuel moisture content as expected to occur under wildfire conditions. 100% cured state is assumed.

trajectories compared to those of the Mk 3/4 and 5 meters. For dead fuel moisture contents above 5%, the CSIRO Grassland Fire Spread Model tends to predict faster rates of fire spread for wind speeds up to 50-60 km/h (with the exception of the very dry curves for the Mk 3/4 meters), above which the exponential functions in the McArthur meters yield faster fire spread rates. For fuel moisture contents lower than 5% the Mk 3/4 meter will predict faster rates of fire spread at wind speeds above 30-40 km/h.

The CSIRO Grassland Fire Danger Model predicted well the rate of spread of the wildfires used in its development. Kilinc et al. (in press) evaluated the performance of the CSIRO Grassland Fire Spread Model against independent wildfire data from southern Australia (details given above in the McArthur Grassland Fire Danger Meters section). These authors found the CSIRO Grassland Fire Danger Model predicted the dataset with an average absolute error of 57 m/min (80% mean error) and an average over-prediction bias of 15 m/min (Table 3.4). Of the three grass fire spread models tested by Kilinc et al. (in press), the CSIRO Grassland Fire Danger Model yielded the most accurate results.

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Most of the major vegetation types in Australia have had more than one rate of fire spread model developed for operational use. This book identifies those models that represent the current state of our knowledge with respect to bushfire behaviour science and those that have been superseded. Recommendations are made on which models should underpin best practices for operational and scientific prediction of rate of fire spread and those that should now not be used.

Where to get it

The book was published by AFAC in January 2015. After the initial print a number of errors were identified. A revised version has now been printed and is available from the AFAC online shop. For those that purchased the first version (prior to September 2015), an errata sheet is now available.

June 2017 UPDATE: A digital version of the book is now available as a PDF from here.

A companion scientific article by the same authors, *Empirical-based models for predicting head-fire rate of spread in Australian fuel types,* has also been recently published in the Australian Forestry journal. This article makes the scientific content of the book available to a wider audience, primarily researchers overseas, who might not be exposed to the book.

The paper provides a stronger focus on the scientific background of the models. Reprints of this paper are available upon request from Miguel.Cruz@csiro.au.

Further reading

Cruz MG, Gould JS, Alexander ME, Sullivan AL, McCaw WL, Matthews S (2015) *A Guide to Rate of Fire Spread Models for Australian Vegetation*. AFAC Publishing, Melbourne. 125 pp.

Cruz MG, Gould JS, Alexander ME, Sullivan AL, McCaw WL, Matthews S (2015) Empirical-based models for predicting head-fire rate of spread in Australian fuel types. *Australian Forestry* 78, 118-158.

Links

AFAC online bookshop:
http://www.afac.com.au/auxiliary/shop/product?ID=1469

Errata for first print run:
http://research.csiro.au/pyropage/fire-spread-guide-errata

Digital download as PDF:
http://research.csiro.au/firemodelsguide

References

Jemison, G.M. (1939) Determination of the rate of spread of fire in the Southern Appalachians. *Fire Control Notes* 3(1): 4–7.

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