Background briefings on emerging issues for fire managers from AFAC and Bushfire CRC.

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AUSTRALASIAN FIRE AUTHORITIES COUNCIL

FIRE NOTE

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FUEL MOISTURE AND FUEL DYNAMICS IN WOODLAND AND HEATHLAND VEGETATION OF THE SYDNEY BASIN

In a comprehensive study of dead and live fuel moisture and fuel dynamics in the Sydney Basin this Bushfire CRC PhD thesis by Brendan Pippen offers valuable information for fire managers and operational field staff in the Sydney Basin.

BACKGROUND

The vegetation of the Sydney Basin, Australia, is highly flammable and subject to a wide range of fire regimes. Sclerophyllous shrubs and sedges are common and in some vegetation types up to 70 % of fuel consumed during a fire can be live.

The principal factor affecting the ease of ignition and rate of combustion of individual fuel particles and fuel beds in bushfires is the dead fine fuel moisture content (FFMC). FFMC refers to the amount of moisture in a fuel particle or array for which the maximum particle diameter is less than 6 mm. It is expressed as a percentage of the fuels' oven dry weight (ODW). Fuels never become fully dry in the field; the driest recorded fuel moisture contents in Australia being between 2 and 3 %. In saturated litter beds FFMC may be > 200 %. A FFMC of 20 % to 25 % is generally sufficient to prevent ignition or halt combustion in fine eucalypt fuels. FFMC is a complex interaction of many factors and many models have been developed to predict FFMC using readily measured variables. To predict fire rate of spread to within +/- 50 % these models need to predict FFMC with a 1 to 2 % accuracy in the range of FFMCs in which fires will burn.

In some vegetation communities live fine fuel also contribute to fine fuel loads of ground fires. In these communities, while fire behaviour has a greater dependence on FFMC, the fuel moisture content of live fuel < 3 mm (LFMC) has been determined to be a significant influence on fire behaviour. The interaction between LFMC and fire behaviour for Australian species is poorly understood. In Australia in general, and specifically in the Sydney Basin, very little is known about the seasonal variations in LFMC.

In low open vegetation types such as grasslands, sedgelands and heathy fuels the percentage dead fuel is probably the most important aspect of the fuel array influencing fire rate of spread after fuel structure and continuity. Because of its influence on fuel moisture, this effect is more important than fuel load. Sedges are the most abundant fine near-surface fuel in Sydney Basin heathlands and considered to be the most influential fuel on fire behaviour. Worldwide the dynamics of the percentage dead fuel in sedges has received minimal attention when compared to grasses.

The current operational fire behaviour models used in the Sydney Basin are empirical models that have been developed in other vegetation types and have not been evaluated in the fuel types of the Sydney Basin. There has been limited research into fire behaviour and fuel dynamics in this bioregion.

RESEARCH ADOPTION

"This PhD's research combines and integrates field observations, laboratory experiments and previously developed models to advance fuel moisture modelling and knowledge in Australia. It directly addresses deficiencies in the understanding of bushfire fuels behaviour in the Sydney Basin and forms the basis for future development of prescribed burning guidelines specific to the vegetation communities of the Sydney Basin. By sponsoring the research adoption from this Bushfire CRC project NSW National Parks and Wildlife Service has created an opportunity for fire managers and operational field staff to implement these research findings in an appropriate manner."

Bob Conroy
Executive Director Park Management
Parks and Wildlife Group
Department of Environment and Climate Change

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BUSHFIRE CRC RESEARCH

To address deficiencies in the understanding of bushfire fuels behaviour in the Sydney Basin this Bushfire CRC PhD thesis investigated FFMC, LFMC and percentage dead sedge in common fuel types with a history of problematic fire management.

- A laboratory study was undertaken to investigate the FFMC responses of common Sydney Basin eucalypt woodland and heathland fuels to changes in relative humidity and temperature.
- Targeting prescribed burning conditions, drying after rain and diurnal variation of FFMC was studied in the field simultaneously in flat areas of adjacent woodland and heathland. During 6 sampling events over 16 days the FFMC of woodland eucalypt surface fuel, eucalypt near-surface fuel and sedge, and heathland sedge were sampled hourly. Duff moisture content in each vegetation type was sampled every two hours.
- The LFMC of 4 common shrubs and one sedge species was measured fortnightly over two years. Weather conditions on site were also monitored with a 10m Automatic Weather Station and this data was used to calculate soil dryness indices (SDI and KBDI).
- The percentage dead sedge in three heathland types was measured at the end of each season for two years.

Field sampling was undertaken on Little Forest Plateau in the Moreton National Park. Experiments were designed to test available FFMC models and provide information that will assist with implementing prescribed burns.

RESEARCH OUTCOMES

Dead fine fuel moisture content

Under conditions similar to when prescribed burns are conducted the fuel types studied here had significant dead fine fuel moisture content (FFMC) variations within the diurnal cycle. At times the fuel changed from conditions where ignition was not possible, to a condition supporting a fire of at least moderate behaviour in as little as three hours.

The FFMC components of current operational fire behaviour models were found to be inadequate for predictions of FFMC under these conditions. For the Controlled Burning in Eucalypt Forests (CBEF) of McArthur ("Control Burning in Eucalypt Forests", Forestry and Timber Bureau, Australia, Leaflet No 80, 1962) the under predictions of FFMC are as high as 4 %, while for the Forest Fire Danger Meter (FFDM) of McArthur (1967) underestimates by as much as 6 % and overestimates of as much as 10 % are not uncommon. If it is assumed that the influence of FFMC on fire behaviour is accurately described the FFDM may underestimate or overestimate fire behaviour, while the CBEF is likely to overestimate fire behaviour, however its potential to do this appears to be less than the FFDM.

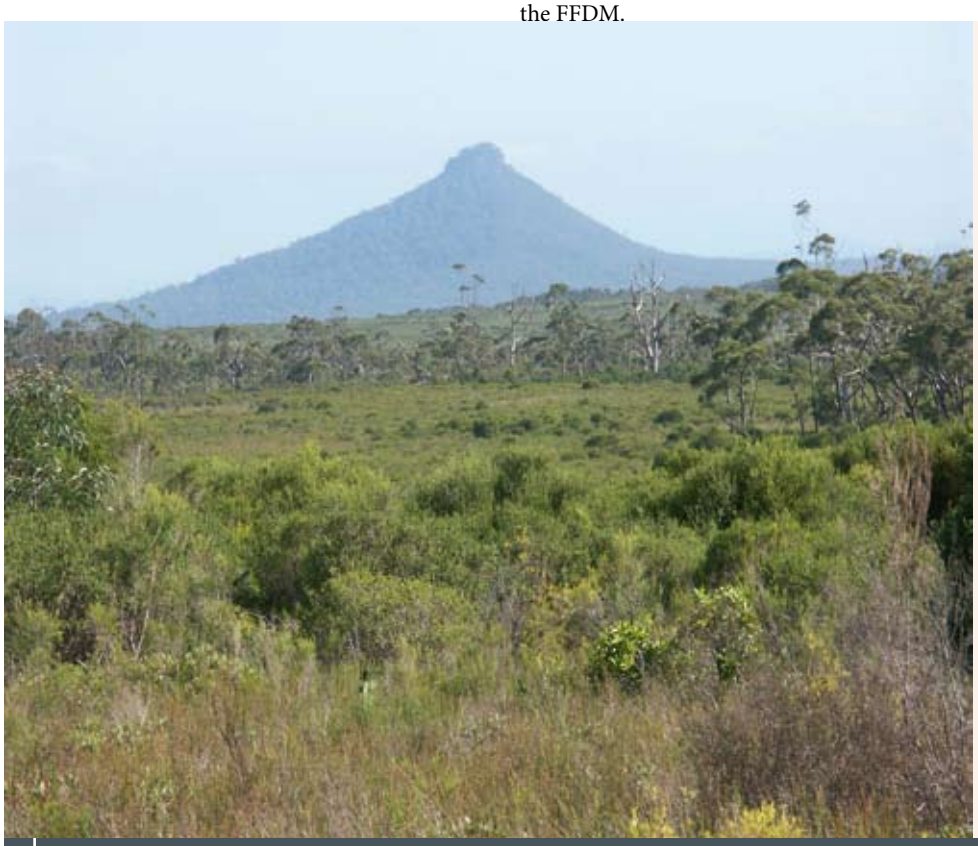
Two other models tested offered some improvements in FFMC predictions, but practical complexities with their implementation means further development is required before they are an operationally viable alternative.

Measuring the FFMC at the time of interest and altering the timing of ignition and lighting patterns accordingly is the most powerful tool available for prescribed burn planning.

Basic generalisations regarding the relative FFMC behaviour in these communities are:

- When dew was formed eucalypt fuels obtained higher FFMC than sedge fuels, with eucalypt surface litter being wetter than near-surface litter.
- On days where dew was recorded, eucalypt fuels took longer to reach their minima than either of the sedge fuels. In eucalypt fuels this delay in reaching the minima was in the order of one to three hours.
- Microclimate effects and fuel dynamics resulted in heath sedge being more responsive to adsorption conditions, with more pronounced increases in FFMC occuring earlier than woodland fuels.

Due to the resource intensive nature of the sampling gathering additional information on the influence of aspect on FFMC was not possible. Phil Cheney offers some guidance on the issue (see text box below).



ASPECT AND FINE FUEL MOISTURE

"The main factor that influences the drying rate of moist fuel is the amount of solar radiation received at the fuel. Thus changes in the sun's angle of intercept to the fuel caused by aspect and slope means that fuel moisture variability on different aspects is much more pronounced during times of year that prescribed burning is undertaken than it is during summer. At times of seemingly benign conditions when attempts to ignite a fire have limited success the suns angle of intercept can create conditions where the fuel moisture potential on northerly aspects that is similar to summer conditions. At these times a fire that is only trickling earlier in the day can develop an intensity in the afternoon that may be life threatening to the unwary. Most examples of unexpected fire behaviour have resulted from people who have tried to burn moist fuel in undulating terrain. Individual's need to be aware of their location relative to north and its effect on fuel moisture, then adjust lighting patterns accordingly."

Phil Cheney
Honorary Fellow CSIRO Forest Bioscience

Live fine fuel moisture content

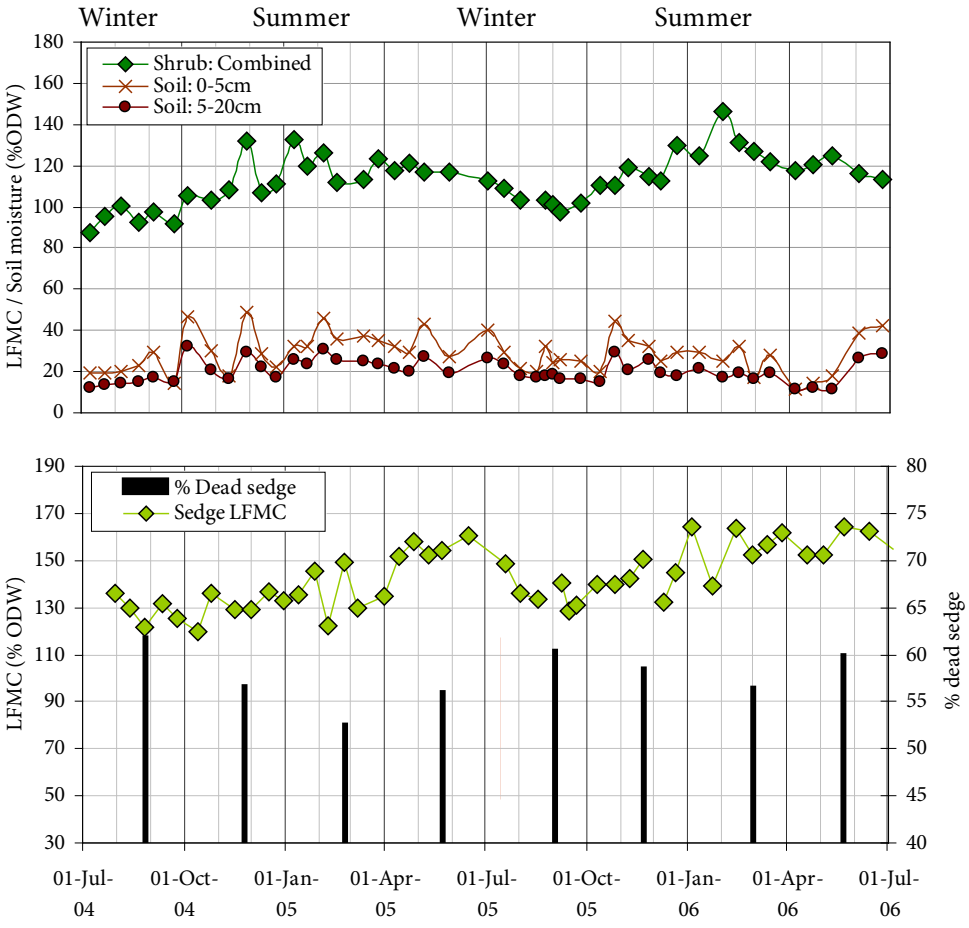
Live fine fuel moisture content (LFMC) of common heathland shrubs and sedge was investigated over two years and found to be both seasonal and influenced by phenology. In contrast to fire prone shrublands of the northern hemisphere the minimum LFMC's for all shrubs occurred in late winter and spring (August to October), and the maximum LFMC's were in summer (December to February). LFMC for each shrub species was highest when new shoots had been growing for about one month. All of the 4 shrub species had a similar temporal pattern of variation in LFMC. This allowed for a logical averaging of the moisture contents and avoiding the complexity of accounting for an individual species LFMC variations.

Near-surface fuel dynamics

The dominant near-surface fuel in mature heath, sedge, was found to have little seasonal variation in its' percentage dead but the percentage dead maxima occurred at the same time as the LFMC minima of shrubs and sedge in both years.

It is hypothesized that the minimum percentage value of dead sedge recorded in this study of 52.6 % represents the minimum percentage of dead sedge that would be measured for mature heathland communities in the Sydney Basin under the most favourable growing conditions. It is unknown whether sedges behave in the same way as grasslands and sustain combustion only when curing is greater than 50 %. If they do then the minimum percentage dead sedge suggested here would be above this threshold. Importantly for operational planning this would mean that mature heathland communities would be capable of burning under any seasonal conditions if the dead fuel moisture content was favourable. Thus the time since fire, and the associated accumulation of dead fuel in the near-surface component, would be the most influential factor affecting fuel availability, with annual seasonal variation having relatively little influence.

A comparison between the percentage dead sedge and the measured sedge LFMC showed that the annual LFMC minima coincided with the percentage dead sedge maxima during spring (September and October) in both years. This suggests that in communities with a continuous cover of sedges during normal years (when severe soil moisture deficits are not recorded), these factors combine to produce a fuel hazard in the Sydney Basin that is at its highest during spring.



FUTURE DIRECTIONS

This research is now being adopted by NSW National Parks and Wildlife Service by sponsoring the delivery of presentations, research notes and the publication of scientific literature.

The next step in formulating a burn guide specific to the Sydney Basin is to model fire behaviour against weather and fuel characteristics such as wind, FFM and fuel structural attributes.

MORE INFORMATION

Pippen, Brendan. G. (2007). Fuel moisture and fuel dynamics in woodland and heathland vegetation of the Sydney Basin. PhD thesis, University of New South Wales (Australian Defence Force Academy). 410 pg.

Brendan Pippen's research was part of Bushfire CRC Program A - Safe Prevention, Preparation and Suppression and A1.1 Fire Behaviour Modelling. The thesis was supervised by Wendy Anderson (University of New South Wales - Australian Defence Force Academy) and Jim Gould (CSIRO Forest Biosciences - Bushfire Dynamics and Applications).

This project was assisted by significant in-kind contributions to the Bushfire CRC by CSIRO Forest Biosciences - Bushfire Dynamics and Applications and the University of New South Wales - Australian Defence Force Academy. Assistance was in the form of personnel for field data collection and access to equipment and vehicles. Other in-kind contributions were also made by the ACT Urban Services and the NSW Fire Brigades (Natural Hazards).

Photos on pages 1 and 4 courtesy of Donald Macdonald, Department of Environment and Climate Change.

PROJECT VESTA - FFM MODEL

Following the submission of the thesis the Interim Edition Fuel Assessment and Fire Behaviour Prediction System in Dry Eucalypt Forests was published from the work of Project Vesta. As part of the NSW National Parks and Wildlife Service research adoption, the fine fuel moisture content (FFMC) model of the guide was evaluated against the eucalypt surface and near-surface fuel observations recorded for this study.

- The model provides much better predictions of FFMC than the Forest Fire Danger Meter.
- The model provides a similar level of accuracy as McArthur's Controlled Burning in Eucalypt Forests (CBEF), however the predictions of the minimum FFMC each day had errors of around 1.5 %, which was 0.5 % better than the CBEF.

Measuring the FFMC at the time of interest and altering the timing of ignition and lighting patterns accordingly is the most powerful tool available for prescribed burn planning.

Fire Note is published jointly by the Bushfire Cooperative Research Centre (Bushfire CRC) and the Australasian Fire Authorities Council (AFAC).

Bushfire Cooperative Research Centre
Level 5/340 Albert Street
East Melbourne VIC 3002

Telephone: 03 9412 9600
www.bushfirecrc.com

Bushfire CRC is a national research centre in the Cooperative Research Centre (CRC) program, formed in partnership with fire and land management agencies in 2003 to undertake end-user focused research.

Australasian Fire Authorities Council
Level 5/340 Albert Street
East Melbourne VIC 3002

Telephone: 03 9418 2388
www.afac.com.au

AFAC is the peak representative body for fire, emergency services and land management agencies in the Australasia region. It was established in 1993 and has 26 full and 10 affiliate members.