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HEATHLAND FIRE BEHAVIOUR WORKSHOP

Report and Abstracts

Workshop held
July 21st - July 23rd 1998

Black Dolphin Resort Motel,
Merimbula, NSW

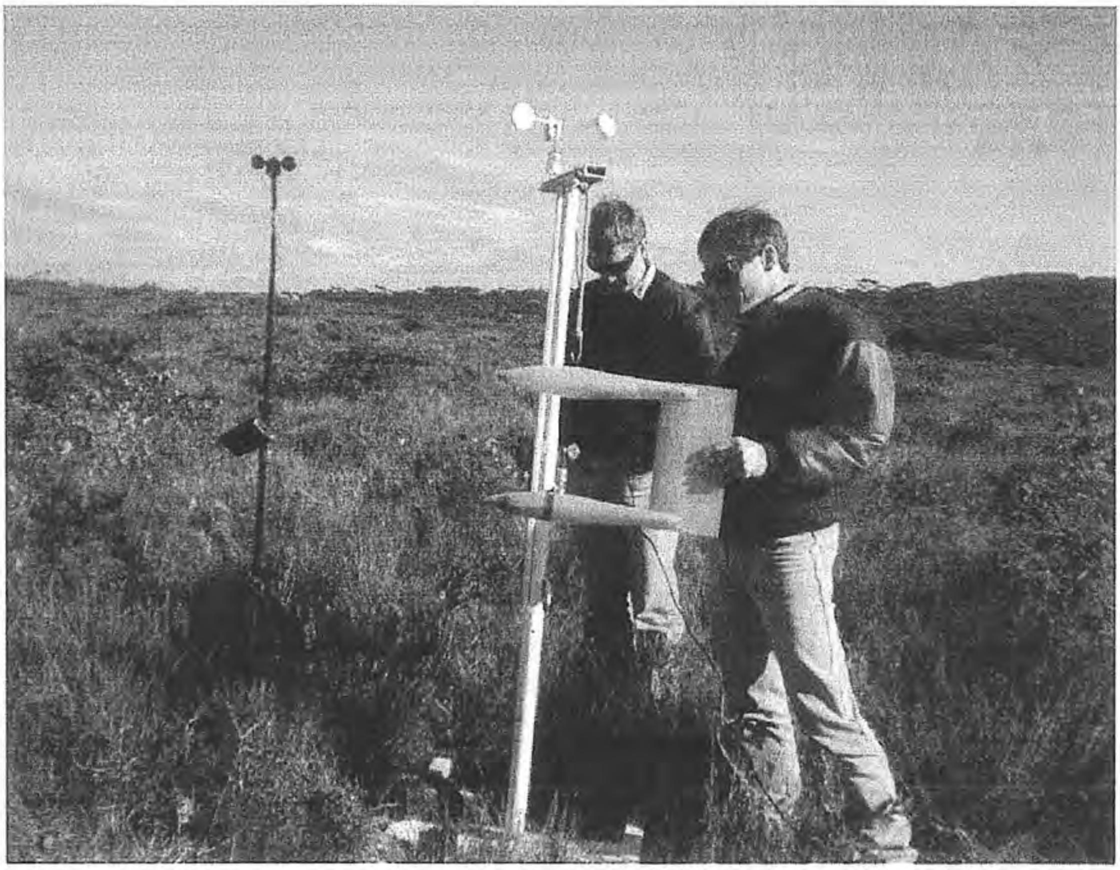
Introduction

This report details the outcomes of a three-day heathland fire research workshop held in late July 1998 to discuss the progress of the Heathland Fire Behaviour Research Group. The Heathland Fire Behaviour Research Group is an inter-agency cooperative project directed towards obtaining a better understanding of the dynamics of heathland fire, and through this knowledge, develop enhanced methods of managing these fires. The fire management methodologies developed by this project are intended to be used for planning fire management regimes, conducting prescribed burning (for both hazard-reduction and habitat-management) and wildfire control. The enhanced understanding of heathland fire which will be an outcome of this research will also provide insights into the dynamics of fire behaviour in heathy woodlands, moorlands and forests.

The Heathland Fire Behaviour Research Group has been running for about five years and has grown out of co-operative research between Dr Wendy Catchpole of the Australian Defence Force Academy in Canberra and fire behaviour researchers in Victoria, Tasmania, New South Wales, South Australia, Western Australia and New Zealand. Recently, links have also been forged with fire researchers in Europe.

The aims of the group are to openly share knowledge for the mutual benefit of all of the group's participants, and to publish the group's findings in appropriate forums. To date, the group has produced one conference paper (Catchpole et al. 1998) which details the results from 117 experimental and 16 wildfires burning over a wide range of conditions and indicates where future work needs to be concentrated. Leading on from the information gained to date, a need was identified for better co-ordination in data collection between the different members of the group. This workshop aimed to address these issues by summarising the current state of knowledge and to implement a standardised data collection methodology.

The workshop was held in Merimbula on the south coast of New South Wales over three days. Current work was presented on the first and last days, and on the middle



day a field trip was made to heathland in the Ben Boyd National Park. The aim of the field trip was to discuss fuel and weather data collection methods and to get different group members to demonstrate the methods they use for collecting data.

Workshop outcomes

Work completed to date

During the workshop, a series of papers was presented which summarised the current state of work being performed in heathland fire behaviour research. The abstracts of these papers are in Appendix 1. A draft fire reporting database has been developed in New Zealand which aims to standardise the types of data recorded and store the data in a consistent format. This fire reporting database is shown in Appendix 2.

Data collection methods

The following discussion of data collection methods has been summarised from the results of the field trip to Ben Boyd National Park and concerns the characterisation of some of the main inputs for fire data collection. These include site characteristics, vegetation type, fuel characteristics, fuel moisture, weather information and data quality. The aim of the discussions and demonstrations made during the field trip was to develop standardised methods for describing the variables used for examining the dynamics of heathland fire.

Site characteristics

The characteristics of the site can have major influences on fire behaviour, especially on slope effects. Therefore, in order to adequately explain fire dynamics, information is required on the slope of the site, its aspect, and the orientation of the fire front to the slope. As a result, the minimum site information that is required is the slope (°), aspect (°), compass direction (°) that the fire is burning in and whether the fire is burning up or down slope. From these four factors, the effective slope that the fire is burning on can be calculated. For example, if a fire is burning in a due east facing site (aspect = 90°) which has a slope of 30° and the fire is burning up and across the slope towards the southeast (compass direction = 135°) then the effective slope in the direction of fire travel is about 21°.

Vegetation type and fuel characteristics

The characteristics of the vegetation being burnt have marked influences on fire behaviour, especially in regard to fuel continuity, fuel height, live to dead ratio and fuel load, although the exact nature of the interactions between these variables are at present poorly understood. For example, in low open vegetation types such as grasslands, sedgelands, and moorlands, the moisture content of the dead fuel and the percentage of dead fuel (normally referred to as the degree of curing in grasslands) are probably the most important aspects of the fuel array influencing the rate of fire spread. In forested vegetation, the equivalent part of the fuel array influencing the rate of fire spread is probably the distribution, height and/or moisture content of the near surface dead fuel.

In heathlands, which are intermediate between grass or sedge dominated vegetation types and forest dominated vegetation types, the situation is less clear, and the spread rate probably depends on a combination of fuel factors. As a result, until a better understanding has been obtained, it is necessary to collect a wide range of data so that we can be sure that we are covering the range of possible predictor variables.

Therefore, it is suggested that for each of the overstorey (if present), intermediate (if present), elevated, near-surface and litter stratums the following be recorded:

- height (metres);
- foliage canopy cover (%);
- continuity (low, medium or high);
- hazard rating (to be developed).

As the presence of a sedge understorey may increase spread rate it is important to indicate the presence of sedge using the Specht classification, eg. Z3G.

Fuel moisture

The aim of the fuel moisture measurement is to sample the fuel stratum which best explains the fire behaviour being examined. For example, when interest centres on fire ecology, the litter moisture is probably the most important factor in determining whether a burn will sustain, and what soil temperature will ensue, while in regard to fire behaviour the most important stratum is probably the near-surface fuel stratum. In some fuel types, information from multiple stratums may be required.

Stratified random sampling should be used to sample fuel moistures. This means that fuel moisture samples should be collected from random locations and in proportion to the composition of the vegetation being sampled. If the vegetation is dominated by one species, then the amount of that species which is collected should reflect its occurrence in the vegetation. For example, if the cover of the vegetation is about 50% tea-tree, then the material collected to sample fuel moisture should comprise about 50% tea-tree.

Live and dead fuels should be collected separately with a minimum of five sub-samples being collected from each of the strata and/or fuel types sampled. Fuel moistures should be determined gravimetrically, and the fuel moisture should be expressed as the percentage of moisture to the dry weight of fuel.

Where the Wiltronics moisture meter is used, then the meter must be calibrated. The calibration used to calculate the fuel moisture should also be recorded with the moisture data.

Weather parameters

The discussion of measuring weather parameters was mainly concerned with the characterisation of the wind speed. Measurement of temperature, relative humidity and cloud cover was also discussed.

The aim of the measurement of weather parameters should be to ensure that data is collected to as high a standard as possible. This means that where possible, data should be to the standards laid down by the Bureau of Meteorology. Where it is not possible to meet these standards, then a statement detailing the methods used to collect the data *must* be made.

When estimating wind speed the following standards are suggested, based on the Bureau of Meteorology Observations Specification No 2013:

Fetch - The wind speed data collection site should be located such that the distance to up-wind obstacles is at least 30 times the height of the up-wind obstacles;

- The distance to down-wind obstacles should be at least ten times the height of the down-wind obstacles;
- Where the wind is variable in direction, the distance to surrounding obstacles in all directions should be at least 30 times the height of the surrounding obstacles.
- Where possible wind speed measurements should be taken on level terrain.

Period - Wind speeds should be measured at a frequency of at least 20 sec, and averaged over the duration of the fire run. Hand-held anemometers are not recommended. If reduced to using a hand-held anemometer when recording wild-fire data, readings should be taken at minute intervals during the fire duration, and averaged.

Height - Where possible, wind speeds should be measured at both ten metres above the ground and at the surface;

- The surface wind speed measurement height must be recorded along with the wind speed data and its measurement height must be at least twice the height of the vegetation in which the anemometer is placed.

A stylised diagram showing how wind speed varies with distance from an upwind obstacle taken from Chen *et al.* 1995 is included as Figure 1.

In addition to the wind speed standards detailed above, the following information is required:

- vegetation height, metres;
- height wind speed is measured at, metres;
- units used to measure wind speed, for example, m sec^{-1}, m min^{-1} or km hr^{-1};
- time period wind speed is measured over, minutes;
- height and distance to up-wind obstacles, metres;
- method used to measure wind speed, for example, automatic weather station, hand held sensors;
- temperature, dry bulb, wet bulb and/or dew point, degrees C;
- relative humidity, %;
- cloud cover and/or solar radiation over the previous hour in eighths or kW m^{-2} as appropriate.

It is important to develop relationships between surface and 10m wind speed for the vegetation complex being studied, so that fire behaviour predictions can be made from forecasts of 10m wind speed. A graph showing the 2m and 10m wind speed measurements taken on the morning of July 22nd at Ben Boyd is included as Figure 2.

Data quality

In order to use the data for fire modelling, an indication of the data reliability is required. Data reliability should be recorded on a three point scale (i.e. low, medium or high). This estimate can be made for either the entire data or for parts of it. For example, if data is being collected for a remote wildfire, then all of the different parts of the data collected may only be best estimates. In contrast, for some fires accurate measurements may be available for some aspects of the data, such as temperature, relative humidity or wind speed, and only approximate figures for fuel characteristics. In the situation of the remote burning wildfire, the data for the fire would be recorded as having a low reliability, while in the second situation, the data for the weather parameters may have a high reliability, and the data for fuel characteristics a low reliability.

Data reporting methods

It is recommended that all data be compiled using the fire reporting database shown in Appendix 2. (The deadline for commenting on the form of the database is October 5th). If using the database is not possible or is inappropriate, then clear notes need to be provided as to how the data was collected and the units used (e.g. state whether the rate of fire spread was measured in m sec^{-1}, m min^{-1}, m hr^{-1} or km hr^{-1}; wind speed in m sec^{-1} or km hr^{-1}, fuel load in kg m^{-2} or t ha^{-1}).

Future directions

In order to address the issues raised in this workshop, additional work is required in the selected areas. These issues will be addressed by the indicated people, and the results communicated to the rest of the group. The issues raised included:

- fuel accumulation models;
- effects of slope on fires;
- effect of variation in fuel type;
- wind field characterisation in woodlands;
- fuel moisture models;

- sustaining versus non-sustaining fires;
- effect of ignition line length, fire size and fire shape;
- links with fire regime models;
- hazard rating systems for heathlands;
- fire reporting data base;
- funding sources;
- next meeting of the Heathland Fire Research Group.

Fuel accumulation models

Work is required to produce a review paper on field survey methods. This may be covered in the heathland chapter of Flammable Australia for which Lachie McCaw is joint author. When the chapter is written Wendy Catchpole and Ross Bradstock will review whether more work needs to be done in developing fuel accumulation models.

Slope effects

The effect of slope on fires in heathland is very poorly understood. To date, it has not been possible to isolate the effect of slope on rate of spread. For example, the very limited data that is available from Tasmania suggests a strong slope effect, similar in strength to McArthur's slope model. Other work from heathlands and shrublands in NSW and New Zealand suggests a much smaller effect. Are these differences because the Tasmanian data used the ambient wind speed while the New Zealand data used the wind speed on the slope? These issues will be further addressed by Grant Pearce, Nic Gellie and Domingos Viegas.

Variation in fuel type

At present it has not been possible to determine how different components of the fuel array influence fire behaviour. There is some evidence that an increased proportion of sedge may increase spread rate. This issue will have to be addressed by collecting additional fuel characteristics data (see above) and then trying to differentiate the effects statistically.

Wind fields in woodlands

In woodlands, there is a reduction in the wind speed below that recorded in the open. Nic Gellie's data suggest that the present heathland fire behaviour model can fairly easily be modified for use in woodlands using a wind-reduction factor. Due to the very extensive areas of heathland that occur in woodlands the effect of tree height and cover on this reduction needs to be determined. This issue will be addressed by Nic Gellie and if the up-coming fire season permits, by the Tasmanians.

Fuel moisture models

Additional fuel moisture modelling is required to better predict fire behaviour and also conditions under which fires will either sustain or self-extinguish (see below). Some of this work has already been published (or is in press) and additional work is currently being performed. For example, Matt Plucinski and Nic Gellie are currently undertaking research degrees containing a component of fuel moisture modelling. Grant Pearce is reviewing NZ moisture information. It may be possible in future to get an honours student to sample litter and aerial dead fuel moisture content hourly over a few days after a rain event to establish drying rates and response times. Wendy Catchpole will co-ordinate these projects.

Sustaining versus non-sustaining fires

The ability to predict whether a fire will sustain or self-extinguish is important for operational fire management, especially in the area of burning for ecological management. This issue has investigated in detail in Tasmanian buttongrass moorlands, and to some extent in Western Australian mallee heath. However, further work is needed to identify the factors critical to sustained fire spread in other heathland types. Therefore, information should be collected not only on running fires, but also the conditions under which fires stop burning. At present we have 10 non-sustaining fires in different fuel types available for analysis.

Effect of ignition line length, fire size and fire shape

Previous research has shown that ignition line length and fire shape have marked effects on fire behaviour. The exact nature of these interactions are poorly understood, so additional information is required which should be recorded in the fire reporting data base (Appendix 2). Also fire shape, including flank and back spread rates are required for fire regime modelling (see below).

Fire regime models

Information on fire behaviour can provide insights into the effect of different fire regimes. By modelling different potential fire regimes, the effects of variation in management practices can be estimated. These issues will be addressed by Ross Bradstock and Geoff Cary.

Heathland hazard rating system

To date, forest hazard assessment systems have been developed by the Victorians and jointly by CALM and CSIRO for use in Project Vesta. The latter system incorporates a number of components from the Victorian system from which it was partially derived. Both rating systems appear to have potential for to heathlands. These systems are very similar, but differ in the number of classes used and the class boundaries. They need some modification for use in heathlands. Greg McCarthy and Lachie McCaw will address these issues.

Fire reporting data base

A draft fire reporting form has been produced by Grant Pearce. Comments on this data base would be appreciated by the end of the first week in October 1998, so the data base can be finalised.

Possible sources of funding

- ARC grants - Ross Bradstock and Wendy Catchpole have applied for a SPIRT grant for research into fire behaviour and fire regimes in coastal and hinterland shubland and heathland
- AFAC - Adrian Pyrke to ask Tony Blanks to bring the work of the Heathland Fire Behaviour Research Group to AFAC's attention with a view to requesting funding in 2000 after the Vesta project has ended.
- Organisational funding
- National Heritage Trust, particularly for remnant vegetation - Ross Bradstock to investigate
- Monash University CRC proposal

Next meetings of the Heathland Fire Research Project

Finally, the next meeting of the Heathland Fire Research Group is to be held one evening during Bushfire '99, to be held in Albury. If possible, those of us who are going to Portugal may have a small meeting in Luso, during the 14th Conference of Forest Fire and Meteorology with our European colleagues.

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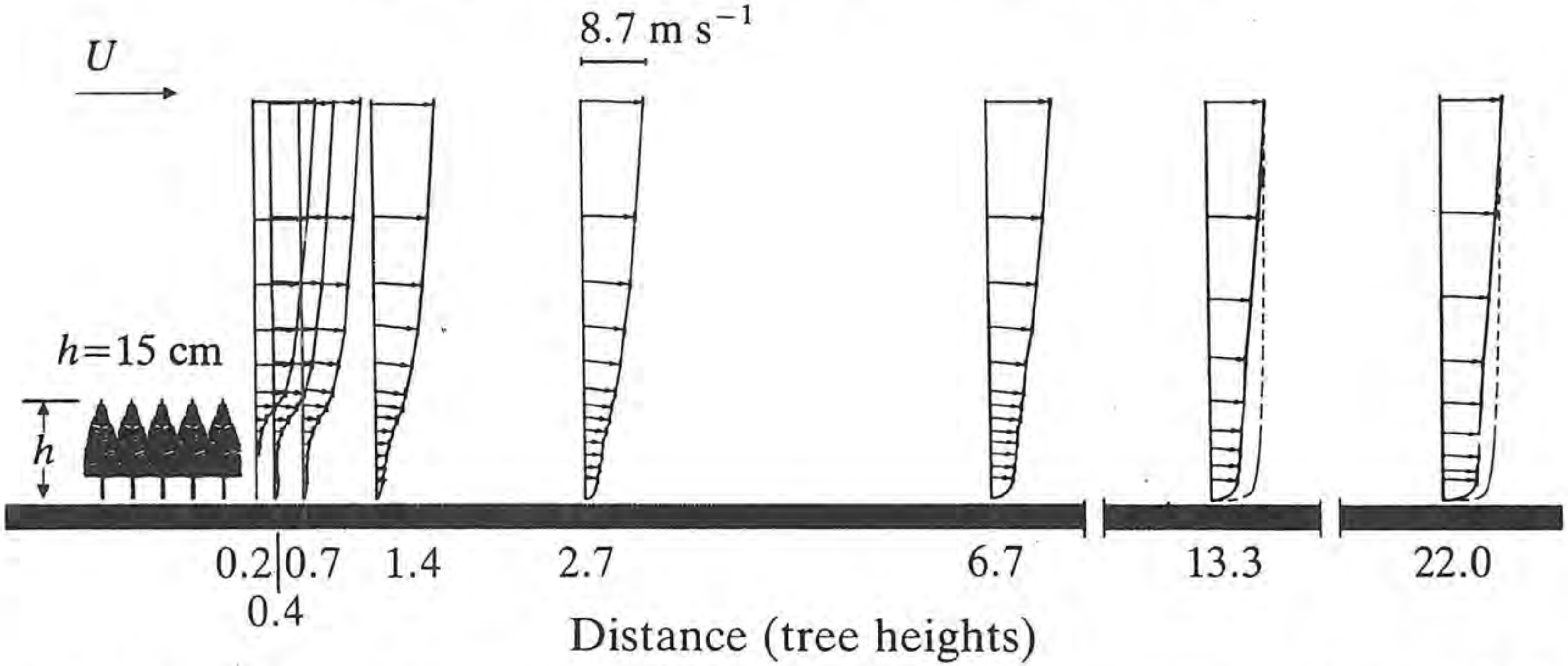
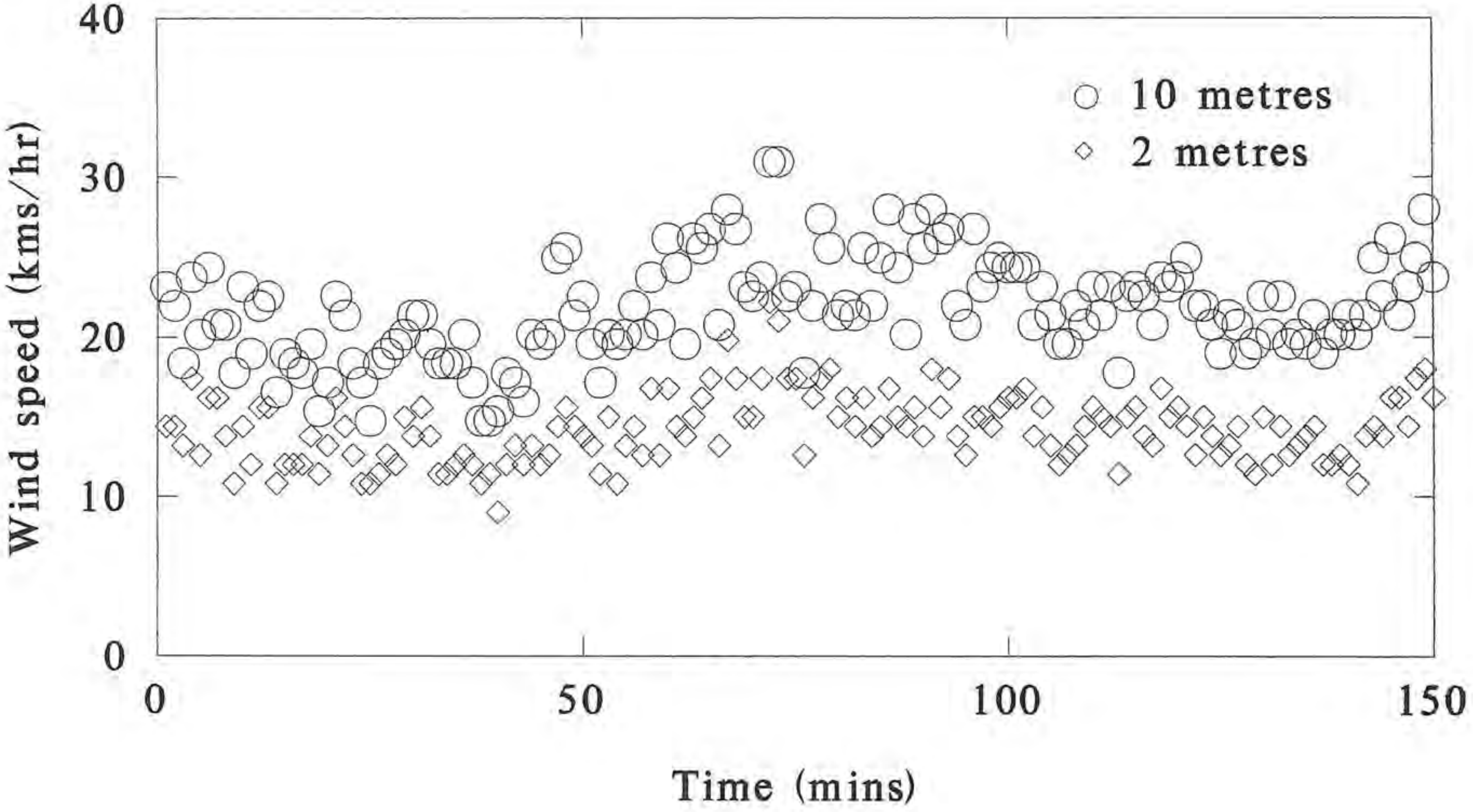


Fig. 1 Velocity vectors measured in an opening with an infinite downwind distance. The free stream velocity was 8.7 m s^{-1}.

Wind Speed at Eden Workshop (NSWNPWS)



APPENDIX 1 : ABSTRACTS

Heathland vegetation and fire effects: old wine in new bottles.

Ross Bradstock, Biodiversity Survey and Research Division, Box 1967 Hurstville NSW 2220.

Heathlands, shrublands, shrubby woodlands and open forests with a heath understorey are comparatively well researched in ecological terms. Variations in structure, composition and accumulation of biomass in heath communities in relation to environmental factors such as soils and drainage will be briefly reviewed. The nature of plant and animal responses to fire regimes will also be briefly reviewed. It is emphasized that vegetation of this kind (within Australia and elsewhere) has benefited from research within the mainstream of the life history/fire regime paradigm. Quantitative insights into plant and animal dynamics in relation to components of fire regimes are now available as a result and a summary of such insights and their use in management will be presented. Major developments in research involve the extrapolation of what is essentially point-based research to the scale of landscapes. Techniques for landscape-scale analysis of fire regimes and modelling are outlined which may aid such developments. An understanding of the size and pattern of individual fires and the factors that control these characteristics is integral to such an approach. Research on fire behaviour in heaths and other shrub dominated communities needs to address practical questions that deal with the contribution of individual fires to the overall development of fire regimes. Demand for knowledge of this kind will grow as the practice of ecological fire management expands.

Research for fire management in mallee-heath shrublands of South-Western Australia.

Lachlan McCaw, CALMScience Division, Department of Conservation and Land Management, Manjimup, Western Australia, 6258.

Shrublands are an important and widespread vegetation type in south-western Australia. This paper provides an overview of recent research which has addressed issues affecting fire behaviour in a shrubland community dominated by short multi-stemmed trees belonging to the genus Eucalyptus. Research has provided important information on: fuel characteristics and rate of fuel accumulation; moisture content dynamics of live and dead fuel particles; conditions required for the initiation of fire spread; and fire behaviour over a wide range of weather conditions. A fire behaviour guide has been developed to assist practitioners with implementation of prescribed burning and wildfire suppression operations. This guide contains a series of curves which illustrate the diurnal trend in litter fuel moisture content under several different weather patterns typical of the fire season. Some of the experimental procedures and findings from this study may be applicable to shrublands in Mediterranean environments elsewhere in Australia and around the world.

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McCaw, L., T. Maher, and K. Gillen. 1992. Wildfires in the Fitzgerald River National Park, Western Australia, December 1989. Western Australian Department of Conservation and Land Management, Technical Report No. 26. 21 pages.

Fuel moisture modelling in buttongrass moorlands

Jon Marsden-Smedley[1], Fire Management Section, Parks and Wildlife Service Tasmania, Department of Environment and Land Management, GPO Box 44a, Hobart, TAS 7001, Australia.

Wendy Catchpole, School of Mathematics and Statistics, University College, Northcott Drive, ACT 2600, Australia.

A series of models intended for predicting dead fuel moisture in Tasmanian buttongrass moorlands have been developed. The problems encountered in developing these models will be discussed, along with the solutions to these problems. These problems ranged from inadequate data, inappropriate site selection, equipment failure and questions as to which predictor variables to use. These problems were mostly overcome using data from a project specifically examining dead fuel moisture content in buttongrass moorlands. The models developed should have wide applicability in predicting dead fuel moisture under operational conditions.

References

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Spatial variation in fine fuel moisture

Matthew Plucinski, Department of Geography & Environmental Science, University of Newcastle, Callagahan, NSW, 2308

The moisture content of fine fuels is governed by the humidity and temperature of the fuel surface and precipitation. Humidity and temperature drive the water vapour transport direction and latent heat exchange (Viney & Hatton 1990). These vary across space, especially on the micro-scale, with regard to aspect, slope and vegetation effects such as shading and wind buffering. Fuel moisture

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also varies with the diffusivity characteristics of the individual fuel particles associated with their species and form.

The variation of fuel moisture has been studied with regard to aspect and vegetation cover. Further work will be aimed toward looking at the effect of vegetation type and density, as well as the diffusivity differences across a range of litter forms. The role of aspect was studied in an open heath (Specht et al. 1974) on Wybung headland in Munmorah State Recreation area on the north central coast of NSW (33° 12'S, 151° 37'E). The effect of vegetation cover has been studied in a closed heath and a low open forest (Specht et al. 1974) at Salt ash, north of Newcastle (32° 54'S, 151° 77'E) as well as Wybung headland.

The methods used for estimating fuel moisture content were sampling and oven drying, use of tray analogues and the Wiltronics TH fine fuel moisture meter. Cantoni atmometers (Livingston 1935) have been used alongside fuel samples to measure the actual evaporation loss. Temperature and relative humidity have been measured at 1.5 metres and wind at 2 metres and at the fuel surface.

Early results indicate that the density of near-ground vegetation has the greatest effect on the near-ground microclimatic factors that affect the fuel moisture content.

References

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Comparison of biomass sampling methods

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Grant Pearce, ***Forest Research***, P.O. Box 29237, Christchurch, NZ.
Liam Fogarty[2], ***Forest Research***, Private Bag 3020, Rotorua, NZ.
Alen Slijepcevic, *Forest Research*, NZ Private Bag 3020, Rotorua, NZ.

Fuel sampling is necessary to provide fire researchers with estimates of fuel loadings for use in fire behaviour modelling, but it also has many applications in other areas of fire management and ecological research. However, random destructive sampling is time consuming and therefore expensive, so that both researchers and fire managers require more efficient and cost effective methods of assessing fuel loads. New Zealand's ***Forest Research*** (formerly FRI) set up experiments to compare fuel loading estimates from random destructive sampling in tussock grasslands with those obtained from stratified samples selected using McIntyre's ranking and height/cover sampling. The practical problems associated with the stratified sampling methods resulted in little gain in efficiency over random sampling.

Using fuel data collected at experimental burns, or in conjunction with other activities such as grassland curing assessment, models predicting biomass and fuel loadings have been produced for a range of vegetation types, including tussock fuels. Typically, these models predict fuel load based on vegetation height, or a combination of height and percent ground cover. The simplicity of double sampling procedures that use easily measured fuel characteristics results in more rapid, non-destructive assessment of fuels, for which there will be many applications including fire hazard assessment, or as inputs into fire danger rating models or wildfire threat analysis systems.

The efficiency of double sampling procedures in predicting (average) fuel load was compared with that of random and stratified sampling. Quadrat samples were initially used to develop a biomass prediction equation for the same site as the transect sampling used to determine the site average height and cover and, secondly, a previously developed regression equation was utilised together with on-site transect sampling. Using a previously developed regression equation tends to give poor efficiency because of the large site effects in the data.

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Sampling methods for Project Vesta.

Lachlan McCaw, CALMScience Division, Department of Conservation and Land Management, Manjimup, Western Australia, 6258.

The cost-efficient biomass sampling methods used for Project Vesta in the Jarrah forest in Western Australia will be described. Possible modifications for use in heathlands will be discussed.

Measuring Wind for Fire Behaviour

Ian Knight and **Peter Hutchings**, CSIRO Forestry and Forest Products, PO Box E4008, Kingston, ACT 2604.

20 anemometers were used to make simultaneous under-canopy measurements at 5m above ground within a Jarrah forest prior to the burning phase of the project Vesta fire behaviour experiment. Wind speed was logged at 5 second intervals and subject to temporal and spatial correlation analysis with the aim of establishing how well an anemometer reflects the wind at an experimental fire up to 400 metres away. The persistence of individual gusts below canopy appears to be limited to about 2 canopy heights. Correlation analysis about a point moving in the direction of the wind produces weak peaks at 2-3 m/sec, a velocity more easily linked to the above canopy wind speed.

Reference

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Identifying some problems

Wendy Catchpole, School of Mathematics and Statistics, University College,
Northcott Drive, ACT 2600, Australia.

In this talk I aim at identifying some problems associated with heathland fire behaviour modelling, discuss some new results, and point out areas in which our knowledge is sparse, and information is needed.

There is a difference in fire behaviour in NZ and E.Australian fires which needs investigation. This may help to remove some of the variability from the model. Some of this effect may be due to measurement differences of fire behaviour variables, which will be investigated at Ben Boyd NP.

Some information is available on fires on slopes which suggests that the slope effect in the McArthur meter is too strong for heathland fires.

It may be possible to include heathy woodland fires in the model with a suitable wind reduction factor, but work is needed on determining a wind reduction factor, predicting dead fuel moisture content in woodland, and investigating the effect of Eucalyptus leaf litter as a suspended or litter fuel.

It is difficult to obtain information on the effects of height, loading, bulk density and percentage dead fuel as these variables are naturally correlated. The effect of moisture content in the available fire behaviour data is examined more closely. There is a suggestion that the effect of moisture content is stronger at low moisture contents.

Flame length is well correlated with Byram's fireline intensity, but there is evidence that estimates of flame length are observer-dependent. Some estimates of the size of fuel consumed in heathland fires are available, but for NSW and Victorian coastal heathland biomass accumulation models are badly needed to determine fire impact.

Models for the probability of burning have been developed for buttongrass moorland and WA mallee heathland, but there is a need for more data on non-sustaining fires to develop similar models for heathland.

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Unbounded Burning in Buttongrass Moorlands and Heathlands

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Wendy Catchpole, School of Mathematics and Statistics, University College, Northcott Drive, ACT 2600, Australia.

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There are situations where prescribed burning is required to achieve specific management objectives, but where boundaries (e.g. roads, slashed fire breaks, streams, non-flammable vegetation types or recently burnt areas) are not available for burning smaller blocks of a desired size within larger blocks of an unvarying fuel type. The creation of boundaries may not be possible for practical reasons (e.g. cost) or because of conflict with other management objectives (e.g. remote area zoning).

A recent study sought a solution to this problem for buttongrass moorlands in Tasmania (Marsden-Smedley *et al.* 1998; Marsden-Smedley *et al.* in press). It has been common practice to burn blocks of buttongrass moorlands, utilising available boundaries, from 500 to 3,000 hectares in size.

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The high burning frequency required to achieve fuel management objectives for such blocks would almost certainly compromise nature conservation values.

The study concluded that fires will self-extinguish under a broad range of conditions, typically associated with clear, still nights and moderate to heavy dew fall. This means that unbounded burning prescriptions can be defined which are practical in terms of available weather opportunities (Marsden-Smedley et al 1998). By applying these prescriptions it is possible to burn smaller areas within larger blocks of buttongrass moorland. This will reduce the ecological impact and may even provide better protection against large scale wildfires at a cheaper price. The practical application of these prescriptions for buttongrass moorlands is still to be tested at the landscape level, particularly in terms of achieving objectives of fuel management, risk reduction and fire regimes suitable for nature conservation.

A similar approach is required for heathlands and heathy woodlands in Tasmania. The conditions for the self-extinguishment of fires within heathlands are probably similar to those for buttongrass moorlands. The management issues and conflicts are also similar.

The problems associated with conducting this research will be discussed along with the solutions to these problems. These problems ranged from misconceptions about the relationships between different factors influencing fire behaviour to logistical constraints during the burning program.

The underlying models behind the burning prescriptions will be described, giving two analyses of the available data using logistic regression and classification trees. These methods can be seen to be complementary.

References

Marsden-Smedley, J. B.; Catchpole, W. R. & Pyrke, A. (in press) Tasmanian buttongrass moorlands: sustaining versus non-sustaining fires. Int. J. Wildland Fire

Marsden-Smedley, J.; Catchpole, W.R. & Pyrke, A. (1998) Unbounded burning in Tasmanian buttongrass moorlands. Report prepared for the Tasmanian Fire Research Fund, Hobart. 41 pp.

New fire behaviour database

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Following cooperative international efforts to develop fire behaviour models for scrub and heath fuels, a combined fire behaviour database was proposed. A prototype database has since been developed as a Microsoft Excel-based spreadsheet. In addition to general information on data sources, the proposed database contains information on fire environment factors, fuels (structural characteristics, fuel moisture contents, fuel loadings), weather (and fire danger conditions), and topography (i.e., slope) as well as fire behaviour observations (ignition line length, head fire width, rate of spread, fuel consumption, flame front characteristics). Wherever possible, quantitative measurements should be used, although qualitative estimates can be incorporated. Reliability estimates for key observations are also included. Notes linked to database column headers provide instructions for entering new data, and it is hoped that the database will be able to incorporate data from a wide variety of sources and vegetation types.

Heathland fire behaviour prescriptions for Victoria

Greg McCarthy and Karen Chatto
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A brief resume of the current findings from Victorian heathlands burning is presented. The emphasis of this work has been to produce a set of readily useable field prescriptions for field staff undertaking prescribed burns in heathlands and shrublands, or fire control staff who may be required to predict fire behaviour for wildfires in heathland fuels. Consequently it has been aimed at developing the simplest possible models for predicting flame height and forward rate of spread, with parameters which are easily measured or estimated in the field.

Two models, one for FROS and one for flame height, have been developed from the relatively limited data set. Both use wind speed at 2m and vegetation height. They are presented in contour graph form. They form the basis for a pocket-sized Heathland Burning Card.

Empirical fire models for heathland and forest with a heath understorey

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Between 1983 and 1997 observations of fire behaviour have been collated from direct observations on-going fires and from fire reports collected by the NP&WS of NSW in the course of fire management operations. These fire observations have been collated onto a fire behaviour database, together with as much direct and indirect estimates of other fire weather and fuel conditions, including fuel types, fuel height, and wind speed.

One of the missing elements in this fire database has been direct measurements of fine fuel moisture content. So far the Macarthur Grassland Fuel moisture equations have been used to determine the fuel moisture content of the dead standing and ground fuels. This approximation to dead fuel moisture has not been validated in heathland fuels in South-eastern Australia.

I am currently undertaking a part-time Masters Thesis to determine the possible relationship between dead fuel moisture content and ambient environmental conditions, as well as produce empirical fire behaviour models for heathlands and for forests with a heathland. I will present some of the proposed methods of fuel moisture and wind analysis for discussion.

I will also present some of the current analyses of the relationship between the draft Heathland Fire Model and the observations for three fuel types in the Sydney Basin. The main fuel types I will compare the model with are: heathland, forest with a heathy understorey, and Open Forest with a sparse heath understorey. The latter type is also found in the Pilliga.

Finally I will present how this fire modelling works fits into a framework of fire and ecosystem management. I developed this framework as part of my recent Churchill fellowship study tour to America and Canada last year.

Fire behaviour modelling in New Zealand

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Since 1993, the Forest and Rural Fire Research programme at Forest Research (formerly FRI) has undertaken a major experimental burning programme to investigate fire behaviour in a range of vegetation types. Burns in native heath and scrub (Leptospermum and Kunzea spp.) and exotic gorse scrub (Ulex europaeus) have been identified as a priority due to the lack of available fire behaviour information in these fuel types. Where possible, data from the burning trials has been supplemented by wildfire observations, so that the database currently consists of some 38 scrub and heath data points.

Efforts at modelling fire behaviour in these and other fuel types have followed the Canadian approach, by correlating observed fire behaviour with components of the Fire Weather Index (FWI) System (which forms one of the major components of the New Zealand Fire Danger Rating System). Attempts to predict rate of fire spread using the Initial Spread Index (ISI), for example, have had only limited success, and more recent efforts have been directed at relating fire spread to variables such as wind speed, elevated dead fuel moisture content and structural characteristics, such as fuel height, loading or bulk density.

Reference

Fogarty, L.G., Pearce, H.G., Catchpole, W.R. and Alexander, M.E. 1998. Adoption versus adaptation: lessons from applying the Canadian Forest Fire Danger Rating System in New Zealand. Paper submitted for the 14th Conference of Forest Fire and Meteorology, Luso, Portugal.

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Instructions for Fire Behaviour Database

APPENDIX 2

General

dbrefno	database reference number	For Wendy's benefi
source	data source	Wendy's reference (e.g., person or country
burnid	burn or wildfire ID number	Name and/or number of fire
site	site label	Location or area name
lat	latitude (deg.min.s)	Latitude of burn site
long	longitude (deg.min.s)	Longitude of burn site
vegnclass	vegetation type classification	Based on Specht (1970)? e.g., manuka/kanuka heath (**mkh**) or scrub (**mks**), gorse scrub (**go**), wetland (**wl**), pakihi (**pk**), tussock (**tu**), pasture (**pa**), tussock/pasture (**tupa**), stubble (**st**)
ustype	understorey description	Also based on Specht (1970)? e.g., sedge (**se**), fern (**fe**), gorse (**go**), tussock (**tu**), rush (**ru**), pasture (**pa**)
treat	fuel treatment descriptor	e.g., crushed/rolled (**cr**), ungrazed (**ng**), grazed (**ga**), baled (**ba**) or unbaled (**ub**) stubble
firetype	source of observations	**EB** for experimental burn, **WF** for wildfire, **PB** for prescribed burn

Weather

temp	temperature (deg C)	Average temperature recorded during fire run
rh	relative humidity (%)	Average relative humidity recorded during fire run
wspdmeas	wind speed measured at other than 10 m (m/s)	Average wind speed recorded during fire run, e.g., from portable station or hand-held anemomete
wspdht	height of wind speed measurement (m)	For above wind speed measurement, if other than 10 m
wspdloc	location of wind speed measurement	Description of measurement location; use **O** for an adequate open clearing, **C** for small clearing, **I** for in-stand, **A** for above canopy
wind10	10 m wind speed (m/s)	If recorded at 10 m, e.g., 10-min average recorded on the hour at a nearby RAWS during a wildfir
wdir	wind direction (deg)	If measured, necessary for determing wind-slope interaction of fires burning on slope
rain24	24-hour rainfall total (mm)	
dslrain	days since last rain (days)	greater than ?? mm
lramt	last rain amount (mm)	
kbdi	Keetch-Byram Drought Index	
sdi	Soil Dryness Index	
cldcover	cloud cover (8ths)	
climreg	climate region	Climate classification (in NZ, based on NZ Met Service 1983)
wxrely	reliability of weather observations	**H** for high, **M** for moderate, or **L** for low

Fire Weather Index (FWI) System components

FFMCd	daily Fine Fuel Moisture Code	Adjusted using data for burn
DMC	Duff Moisture Code	
DC	Drought Code	
ISId	daily Initial Spread Index	Adjusted using data for burn
BUI	Buildup Index	
FWId	daily Fire Weather Index	Adjusted using data for burn
FFMCh	hourly Fine Fuel Moisture Code	Calculated using the hourly FWI routine from WIPPS (Lawson *et al.* 1996)
ISIh	hourly Initial Spread Index	Calculated using the hourly FWI routine from WIPPS (Lawson *et al.* 1996)
fwirely	reliability/applicability of FWI station and data	**H** for high, **M** for moderate, or **L** for low

Fuels

fuelage	age of fuel complex (years)	Where known, otherwise 99 = old (>10) but age unknown
osheight	overstorey average height (m)	
oscover	overstorey cover (%)	
oscont	overstorey horizontal continuity	Continuity descriptor based on cover and curing, etc.; use **H** for high, **M** for moderate, or **L** for low
os%dead	overstorey proportion dead (%)	
os%meth	method of determining overstorey proportion dead	**D** for destructive sampling, **S** for subsample, **V** for visual estimate, **E** for other estimate (e.g., based on other burn data)
usheight	understorey average height (m)	
uscover	understorey cover (%)	
uscont	understorey horizontal continuity	**H** for high, **M** for moderate, or **L** for low
us%dead	understorey proportion dead (%)	
us%meth	method of determining understorey proportion dead	**D** for destructive sampling, **S** for subsample, **V** for visual estimate
litdepth	litter average depth (m)	
litcover	litter horizontal cover (%)	
litcont	litter continuity	**H** for high, **M** for moderate, or **L** for low
soiltype	soil type	Based on local soil classification (e.g., in NZ, from NZLRI)
allheight	average height of whole fuel complex (m)	Use to describe height, cover and continuity of whole fuel complex if not sampled by individual fuel strat
allcover	cover of whole fuel complex (%)	" "
allcont	horizontal continuity of whole fuel complex	**H** for high, **M** for moderate, or **L** for low
all%dead	proportion dead for whole fuel complex (%)	
all%meth	method of determining overall proportion dead	**D** for destructive sampling, **S** for subsample, **V** for visual estimate
treeht	average top height of overstorey trees (m)	Use for heath or scrub understorey where overstorey trees are not included in fuel sampling
treecov	canopy cover of overstorey trees (%)	" "
treecbht	crown base height for trees (m)	" "

Fuel moisture contents

osdfmc	overstorey fine dead fuel moisture content (%)	
osdmcmth	method of determining overstorey fine dead FMC	**A** for actual values from FMC sampling, **M** if modelled
oslfmc	overstorey fine live fuel moisture content (%)	
oscfmc	overstorey fine composite fuel moisture content (%)	If dead and live overstorey not sampled separately
usdfmc	understorey fine dead fuel moisture content (%)	
uslfmc	understorey fine live fuel moisture content (%)	
uscfmc	understorey fine composite fuel moisture content (%)	If dead and live understorey not sampled separately
litfmc	litter fuel moisture content (%)	
litmcmth	method of determining litter FMC	**A** for actual values from FMC sampling, **M** if modelled

Fuel loadings

osdfld	overstorey fine dead fuel load (kg/m2)	Where **fine** is smallest size class sampled (<5 or 6 mm)
oslfld	overstorey fine live fuel load (kg/m2)	" "
ostotld	overstorey total fuel load (kg/m2)	Total overstorey fuel load including other size classes
usdfld	understorey fine dead fuel load (kg/m2)	Where **fine** is smallest size class sampled (<5 or 6 mm)

uslfld	understorey fine live fuel load (kg/m2)	" "
ustotld	understorey total fuel load (kg/m2)	Total understorey fuel load including other size classes
litld	litter fuel load (kg/m2)	Litter (soil L horizon) fuel load
totfld	total fine fuel load (kg/m2)	If estimated and not calculable from individual strata, total fine fuel load including overstorey, understorey and litter components
totagld	total above-ground fuel load (kg/m2)	If estimated and not calculable from individual strata, total above-ground fuel load including overstorey, understorey and litter components
duffld	duff fuel load (kg/m2)	Duff (soil F and H horizons) fuel load, where present
totld	total fuel load of all components (kg/m2)	If estimated and not calculable from individual strata, total fuel load including overstorey, understorey, litter and duff components
ldmeth	method of determining fuel loadings (kg/m2)	**D** for destructive sampling, **M** if modelled, **V** for visual estimation

Fire behaviour

iglength	ignition line length (m)	
hfwidth	effective head fire width (m)	
runlngth	fire run length (m)	
slopeang	slope angle (deg)	
slopedir	slope direction (deg)	For fires burning on slope
sprddir	direction of fire spread (deg)	For fires burning on slope
ros	head fire spread rate (m/s)	
fuelcons	total fuel consumption (kg/m2)	
consmeth	method of determining fuel consumption	**D** if from pre- and post-burn destructive sampling, **A** if from available fuel estimate, or **V** if from visual
flheight	flame height (m)	
fllength	flame length (m)	
fldepth	flame depth (m)	
fobsmeth	method of estimating flame observations	**T** if measured from top of fuel bed, or **G** if measured from the ground (includes depth of fuel bed)
Hcomb	heat of combustion (kJ/kg)	if determined
fbehrely	reliability of fire behaviour observations	**H** for high, **M** for moderate, or **L** for low

NB. Also see notes associated with each column header (i.e., select cell containing header (e.g., A1), and Insert Note to view or alter instructions)

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