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

bushfire CRC

AUSTRALASIAN FIRE AUTHORITIES COUNCIL

FIRE NOTE

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AN INTEGRATED APPROACH TO BUSHFIRE MANAGEMENT

BACKGROUND

Bushfires, like droughts, have been part of the Australian environment for thousands of years.

These days, bushfires constitute a major natural and socio-economic hazard, costing Australia, in excess of $M80 per year, and affecting around 3 million hectares of land in southern Australia alone. In some years, such as in 2003 in south-eastern Australia, these figures can rise dramatically. With expanding capital and regional cities, and life-style related choices people are increasingly making, the number of people living on the urban-rural interface in bushfire prone areas is growing considerably each year.

Government agencies in Australia and New Zealand spend hundreds of millions of dollars annually on the management of bushfires. Bushfire related losses occur almost every year. A perennial challenge in the management of fire is to strike a balance between the relative costs of bushfire mitigation, and the related losses incurred by the community.

In bushfire prone parts of the world models of the threat posed under varying fire prevention and suppression regimes have been developing for some years. More recently, these models have sought to combine seasonal and geographic data, with the available fire behaviour science and suppression capability information, in a way that assists both operational and strategic decision making.

Known generically as 'decision support tools' these models can greatly assist bushfire management agencies in a range of tasks including:

- helping to better understand how an individual bushfire will behave;
- better prediction, several months in advance, of the likely level of agency resourcing that will be needed in the forthcoming fire season; and
- achieving a more strategic 'balance', over the longer term, between resources allocated to the suppression of bushfires, and the resources allocated to preparing the bush, the fire fighting and support agencies, and the wider community for the bushfire season.

Because bushfires can move across different landscapes at varying rates of spread under varying conditions, there are many factors to consider in quantifying risk.

Until relatively recently the approach used has involved first determining, and then combining measures of fire risk (chance of ignition), fire hazard (potential fire behaviour) and values at risk. Such approaches result in the production of maps showing variations in risk, hazard and values measured across the landscape.

OVERVIEW

- In an average year around 29 million hectares of Australia are burnt by bushfires. With seasonal fluctuations however, this area can vary to four times greater or less than this average.
- Around 90% of the area of Australia burnt by fire each year is found north of the Tropic of Capricorn, with burning occurring during the 'dry season', generally between April and November. Most of the remaining three million hectares is found in the temperate, southern region of Australia with the highest fire danger generally occurring between December and March.
- On average, bushfires cost Australia and New Zealand over $M90 each year. In some years (2003, 2006/7) this figures can rise dramatically.
- Since the formation of the Bushfire CRC in late 2003 work has been underway on the development of a *bushfire risk management model* that will enable fire and land managers to better understand how the various elements of 'bushfire risk' interact. The model, which is focusing on fires in eucalypt dominated ecosystems, will be a world-first.
- The model will provide both a better understanding of how an individual bushfire will behave and it will allow better prediction, several months in advance, of the likely level of agency resourcing that will be needed in the forthcoming summer. The model will also aid the development of a more strategic 'balance', over the longer term, between resources allocated to the suppression of bushfires and those allocated to preparing the bush, the fire fighting and support agencies and the wider community, for the bushfire season.
- The *bushfire risk management model* will bring together a number of other research projects currently being undertaken by the Bushfire CRC.
- Expectations of the assistance the model will provide are high, both within the fire and land management agencies and in sections of the wider community. Both the Australasian Fire Authorities Council and the Bushfire CRC are strongly supportive of this ambitious research project, seeing it as having the potential to take the management of bushfire in Australia to a new level of sophistication.

Such methodologies are then used to decide what levels of resources are needed to reduce the identified threat. This approach is generally termed 'Models' or 'Standards of Fire Cover' and has been used in many countries (including Australia and New Zealand) since the 1950s. Underlying the approach is that across an agency's area of responsibility, like 'risk' receives like 'cover'.

In more recent years the identification of the spatial distribution of threat has been made easier by the development of Geographic Information Systems. GIS significantly simplify the quantification of the spatial distribution and risk levels of the elements that contribute to 'bushfire risk'. The resultant 'Wildfire Threat Analysis' has been undertaken by most park and forest agencies in Australasia in recent years, with the most advanced approach to date being developed in Western Australia.

Meanwhile in New Zealand, where there are large areas of coniferous forest, strong links have developed with fire and land management agencies in Canada. New Zealand is, for example, currently adapting approaches developed in Canada into its own 'Wildfire Threat Analysis' system. Not only are New Zealand's forests generally quite different to Australia's biologically, but on days of high fire risk Australia generally experiences significantly lower levels of humidity. This situation, when combined with high temperatures, has the ability to dramatically affect bushfire behaviour.

Work has also continued on the development of 'fire spread' models for eucalypt forests. For the reasons set out below however, all the current models have limitations, particular at the extreme end of the fire behaviour range (very dry fuels, high temperatures, low humidity's and strong winds). Current Bushfire CRC related work, which is designed to considerably improve the currently available models, is also described below.

In an evolutionary sense, one of the most important steps in the emergence of currently developing bushfire 'decision support tools' was the appearance in Australia in the 1950s of a *Forest Fire Danger Meter* and a *Grassland Fire Danger Meter*. The grassland meter is the simpler one to use, and both contain limitations, and come with several qualifications in terms of their usefulness. Nonetheless both represented significant bushfire related developments and both remain in widespread use in Australia, having been proven to be robust and relatively simple to use. Currently, South Africa is modifying both for use in that country.

At the very specific level, most bushfire management agencies have developed in recent years a variety of 'decision support tools', and in particular 'fuel hazard guides' (for assisting with the assessment of surface, elevated and bark fuels), 'fire behaviour tables', (for assistance in prescribed burning) and 'resources guides'. These are designed to assist managers in making decisions about the level of resources required for fire suppression and prescribed fire operations.

Currently available 'decision support tools' provide guidance. They are best viewed as complementing the considerable experience, and judgement of the bushfire manager.

THE CHALLENGES

Fire behaviour in eucalypt dominated ecosystems exhibits some very different and as yet imperfectly understood characteristics.

The nature of fires in forests and woodlands is significantly dependant on the dynamics of the available fuels. The chemistry and physics of fuels determine whether fire is possible, and fuel availability determines the nature of fire frequency and intensity. Over time, potential fuels in the forest build up in quantity, they are re-arranged and they show seasonal changes in chemistry and structure. In drier eucalypt forests for example, it takes three to five years for litter to build up sufficiently in quantity and coverage to sustain a fire. Most eucalypts shed up to half their leaves each year, most shedding occurring in late spring and summer. Twigs, branches and bark also contribute to the litter available in the forest.

Eucalypt leaves are flammable in the canopy due to their having a high concentration of volatile oils. They are also flammable in the litter due to their low mineral content. In addition, around 150 species of Eucalypt have fibrous, stringy bark or smooth candle-like bark. Both these bark types add to the forest fuel. During bushfires, this bark allows the fire to run up the trunk of the tree. Critically, these burning strips can, under favourable conditions, break free and ignite new fires up to thirty kilometres away.

One of the more significant developments in terms of the evolution of bushfire 'decision support tools' was the emergence of what can generally be described as 'fire danger indexes'. Fire danger is generally defined as the resultant of both *constant* (such as fuel type characteristics and topography) and *variable* fire danger factors (such as fuel moisture content and weather factors) which affect the chances of a fire starting, spreading, doing damage, and its difficulty of control.

What FDI systems do is to integrate, into a single figure, the effect of the more changeable and hard to estimate items of fire danger. Fire danger measurements taken over a number of years provided an initial, impartial basis, for comparing fire control effectiveness in different regions, or within the same region in successive years.

More recently, efforts have focused on the development of stochastic simulation models that are designed to investigate the relationship between different bushfire prevention and suppression strategies. Inherent in these approaches has been a key question: is the aim of bushfire management to minimise the tangible and intangible cost of fire-related loss or instead, to minimise the total cost of bushfires i.e. fire management costs plus the cost of fire-associated losses.

The challenges confronting researchers attempting to better understand the threat posed by bushfire and its management are considerable. They include:

- The need to separate the place and time of fire ignition, and the potential loss;
- Recognising that 'probabilities' are a key feature of fire threat analysis. Obviously the validity of the probabilities used will depend on the length of the time period studied and the stability of the associated casual factors (e.g. ignition risk or suppression capability);
- Appreciating that the scale at which an analysis of bushfire threat is undertaken, both in terms of geography and time, affects the result. Any fire threat analysis should give careful consideration to issues of scale, and to the likely usage of the results;
- Deciding whether to factor 'fire management actions' (such as fuel reduction burning and asset maintenance) into the analysis/model;
- Adequately accommodating 'boundary' issues (such as a fire crossing land tenures that are subject to differing management philosophies);
- Understanding the relationship between fire severity factors and fire related costs and losses;
- The complexities of the relationship between expected costs and losses and their relationship to assumptions about weather conditions; and
- The numerous weather and fuel variables that are important to fire threat, and the need to simplify the associated complexity in ways that are valid and useful in considering the ability of a fire to spread, to resist control and to cause damage.

RESEARCH

The Bushfire CRC is undertaking two projects that will considerably enhance the capacity of existing bushfire management 'decision support tools'. In addition, most other CRC projects have the capacity to feed directly into the first of these, the *Bushfire Risk Management Model*.

As outlined above, Project A4 *Bushfire Risk Management Model* will produce a single management support system for the managers of fires in eucalypt dominated ecosystems. It will enable fire and land managers to better understand how the various elements of bushfire risk management interact. When completed the model will provide both a better understanding of how an individual bushfire will behave and it will allow better prediction, several months in advance, of the likely level of agency resourcing that will be needed in the forthcoming summer. The model will also aid the development of a more strategic 'balance', over the longer term, between resources allocated to the suppression of bushfires, and the resources allocated to preparing the bush, the fire fighting and support agencies, and the wider community for the bushfire season.

The model being developed incorporates a considerably enhanced simulation program that is capable of showing the spread of fire across the landscape, under different weather and fire suppression scenarios.

The first phase of the project (mitigation) has seen the definition of the **fire management business model** and the development of a set of 'business rules' which indicate how decisions are made to meet management objectives. From these rules has come a mathematical definition of how these factors interact. This allows the testing of various expenditure scenarios against varying levels of risk.

The second phase of the project is developing a conceptual model to describe the likelihood of a fire with particular characteristics occurring in a particular space and time across the landscape. The resultant fire spread simulation model (known as *Phoenix*) contains components that are designed to describe the ignition and spread of fires across the landscape given particular management and weather scenarios. This process provides for the calculation of a probability of a damaging fire emerging from a 'catchment'. Such probabilities will be affected by different management strategies such as prevention, protection, response, recovery and ecologically burning.

As part of this phase of the project, 'fire occurrence modelling' is analysing past fires (their annual, seasonal and diurnal patterns) and producing a model which describes the historical data, with options for changing some of the factors affecting temporal patterns of fire. The model will allow managers to predict the likely occurrence of fires in terms of topography, vegetation type, proximity to roads or urban development and other factors. Managers will also be able to estimate the potential impact on fires of changes in access, level of urban or infra-structure development, public education, fuel management and other elements.

Phoenix has now reached the prototype stage and following a workshop of practitioners from 12 end-user organisations in October 2006, it is currently being tested and evaluated during the current fire season. *Phoenix* is able to be used on individual computers using localized data, and management and suppression scenarios. Phoenix is being used this summer at going fires, enabling testing against actual events.

Following a comprehensive evaluation in the autumn, *Phoenix* should be well placed to incorporate the fire impact models from CRC Programs B, C and D. It should also provide a platform for incorporating the results from the aircraft suppression, fire behaviour, simulation and fuels research from Program A.

The final phase of this project, **fire impact modelling** (consequence) will define the potential impact of a fire. Economic values being calculated include that of houses, timber, water, scenic quality and public utility functions. Social values include human life, trauma, human health and community function. Environmental values include harm to local species and ecosystems, soil erosion, reduced water yield and quality, and atmospheric pollution. Again, several other CRC research projects will soon be well placed to assist with this phase.

Meanwhile, Project A5 *Bushfire Spread Simulation and Modelling* is developing a new type of bushfire spread simulator, using the latest simulation and animation technology, to underpin and support a wide range of fire management activities, including risk analysis, prescribed burning, wildfire suppression and incident control training.

A computer-based environment is being designed to permit rapid and repeatable execution of bushfire simulations under a wide range of conditions. This will facilitate real-time decision-making and the prediction of fire spread for a variety of future weather scenarios and containment strategies. The simulation engine will be based on the fundamental concepts of generation, transport and consumption of heat over the landscape.

This approach is designed to increase the understanding of the non-linear scaling found in extreme fire behaviour, as occurred for example, in the Canberra bushfires in January 2003.

The computer based simulation environment will be a valuable training tool using visualization to consolidate users' understanding of fire behaviour and how it is affected by changes to the fire environment. The interactive nature of the simulation environment will encourage users to explore other aspects of fire such as impacts on firefighter safety and suppression options.

LEFT AND COVER PHOTO: MT BEAUTY FIRE, JANUARY 2007, DEPARTMENT OF SUSTAINABILTY AND ENVIRONMENT

THE FUTURE

in many ways, the *Bushfire Risk Management Model* provides for the bringing together in a 'fire manager-friendly' fashion, much of the current work being undertaken by the Bushfire CRC. The project is clearly ambitious, and will require considerable further resourcing to realise its full potential. This fact and the strong industry support for the project is currently seeing efforts to identify additional resourcing for the project.

Much of the work of the Bushfire CRC is aimed at finding ways of reducing the level of bushfire risk for given levels of investment and resourcing by governments and the wider community. While much has been learnt over the last few decades, about the management of fire in eucalypt dominated ecosystems, and in grasslands, much remains to be understood.

The behaviour of bushfires under extreme conditions (dry fuels, single digit humidity, high temperatures and strong winds), the effects of certain types of atmospheric instability, the impact of climate change, and the behaviour of humans in emergency situations (both fire-fighters, and of affected residents) are just a few of the areas where much remains to be done.

In the meanwhile the work of the CRC continues, and park, forest and rural fire agencies continue to focus on the development of knowledge and experience among their personnel. This will ensure that with the increasingly sophisticated 'decision support tool' being available, bushfire managers will continue to manage the bushfire threat both safely and successfully.

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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.