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

FIRE NOTE

ISSUE 109 MAY 2013

FIRE IMPACT AND RISK EVALUATION

SUMMARY

The *Risk assessment and decision making* project has developed a proof of concept simulation system with the aim of providing critical fire planning information to emergency services, government and the public. The Fire Impact and Risk Evaluation Decision Support Tool (FireDST) is an advanced software program that can be used to understand the potential impacts a bushfire may have on community assets, infrastructure and people. FireDST demonstrates the ability to predict the probabilities of both neighbourhood and house loss, as well as the potential health impacts of bushfire smoke and the areas that are likely to be affected by a bushfire.

A short video that details the research has been produced with the assistance of the Metropolitan Fire Brigade. It can be viewed on the Bushfire CRC website.

ABOUT THIS PROJECT

This *Fire Note* reports on the *Risk assessment and decision making* project, conducted under the Bushfire CRC *Understanding risk* program. The project has delivered a proof of concept which has clearly shown the meteorological fire spread, household vulnerability and smoke dispersion models developed during the first phase of the Bushfire CRC (2003-2010) can be integrated and overlaid across the NEXIS database to demonstrate the probable impact of a bushfire. This can provide valuable response and preparedness information for agencies. This proof of concept has been developed using research level computing resources (not currently available operationally) and showcases what could be possible in the future.

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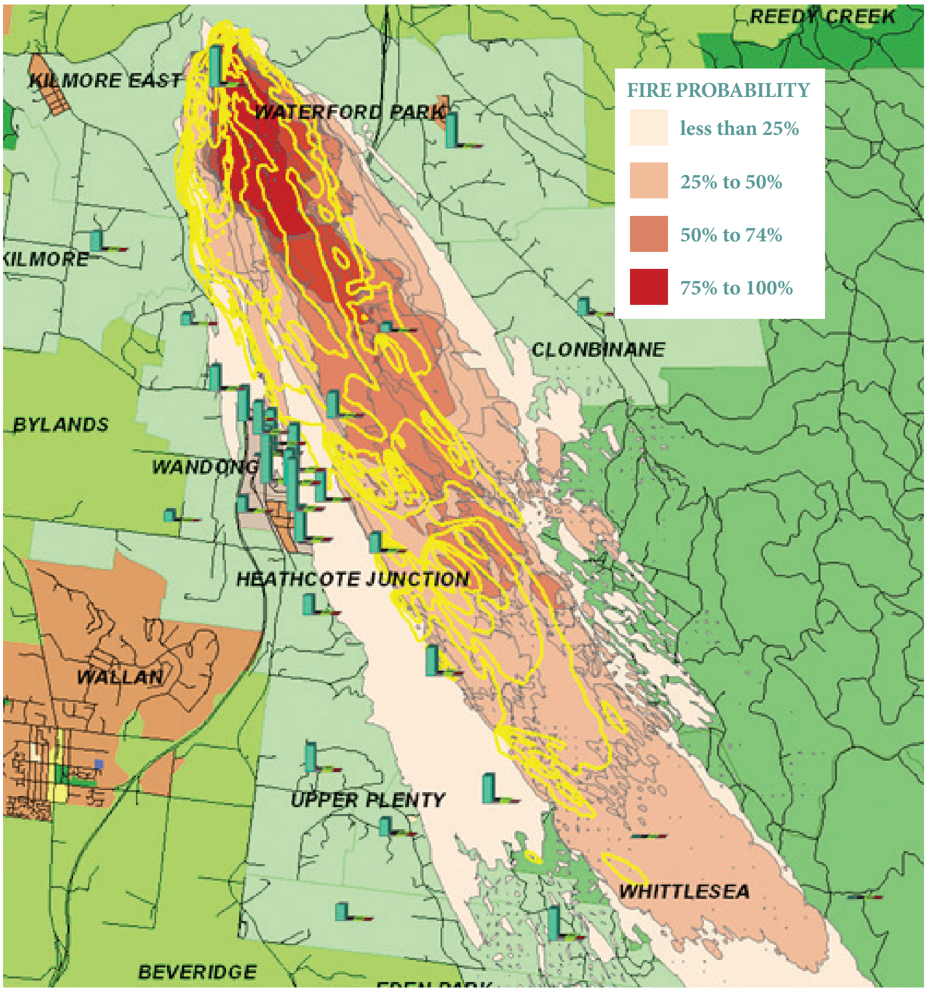

▲ **Figure 1:** FireDST has projected the impact and fire spread simulation until 3.45pm for the Black Saturday Kilmore East fire, using probabilistic meteorology. The cream to red-coloured segments represent areas where there is that probability that the fire will affect that region. The actual fire reconstruction (shown in yellow) is fully contained within the probabilistic fire spread region. The green bars represent population density.

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CONTEXT

Outcomes from the 2009 Victorian Bushfires Royal Commission identified a need to further develop the ability to assess the potential bushfire impacts on rural and urban/rural interface communities, both when responding to an immediate threat and examining possible extreme scenarios that may pose a threat in the future.

BACKGROUND

Fire managers and incident management teams need to make quick decisions in extremely complex situations. They need to know where to direct firefighting resources, and how best to protect the community, buildings and infrastructure. FireDST has been developed with a view to assist fire managers in the future with making these decisions. It predicts the likely path of a bushfire, including which towns may be impacted. It also has the potential to show infrastructure that may be impacted. This is all achieved by processing known information about ignition location, weather (humidity, temperature, wind speed/direction) and vegetation. FireDST can be run under predicted weather conditions, or be modified for a range of different scenarios, such as changing the wind strength/direction, and the time of a wind change.

BUSHFIRE CRC RESEARCH

Development of FireDST

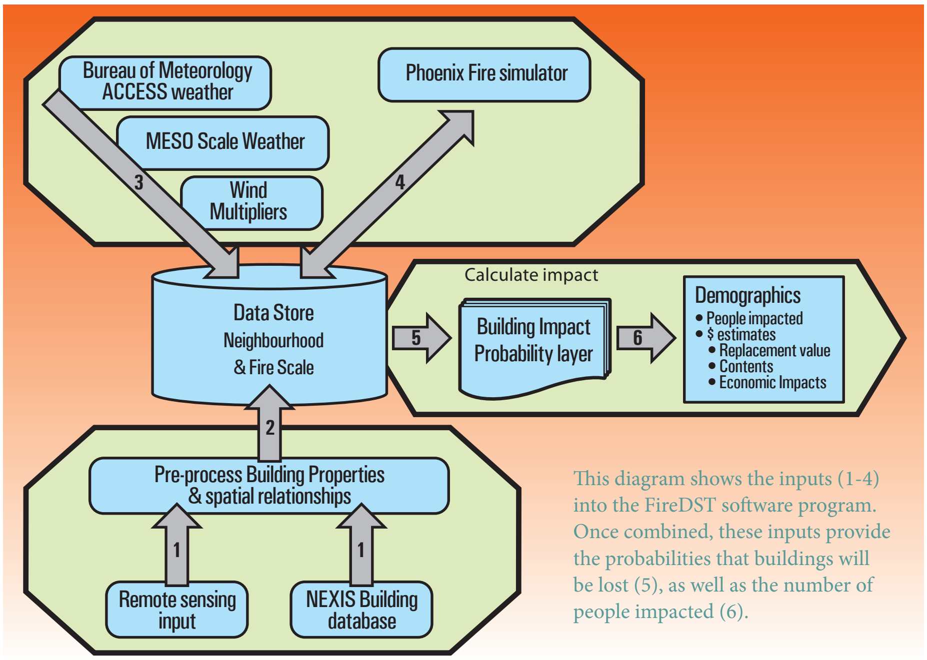
The research and development focus for the project involved the estimation of the impact of extreme fires on a community. This involved developing a probabilistic simulation system within which existing methods were enhanced, and new methods developed and integrated to enable the calculation of fire impact (Figure 2, top right).

FireDST has the potential of producing a large number of simulations (addressing the uncertainty) in only a marginally longer time period than for a single simulation by adopting a parallel computing platform (Roosta, 2000). Parallel computing is a form of accelerated problem solving in which many calculations are carried out simultaneously, operating on the principle that large and complex problems can often be divided into smaller ones, which are then solved concurrently (in parallel).

The project has developed a computational risk assessment framework (Jones *et al.*, 2012), as well as methods and tools to address the impacts associated with the likely ignition and spread of a bushfire. This includes a spatial interface detailing the impacts to communities and assets in the path of a bushfire.

FireDST has been developed and validated using data of the conditions experienced from three significant bushfires: the Warragamba, New South Wales bushfire on Christmas Day 2001; the Wangary bushfire in South Australia in January 2005; and the Kilmore East bushfire on Black Saturday in February 2009. These fires were selected as case studies as they encompass a range of terrain and topography, fire severity and complexity of extreme fire weather. The case studies were utilised to develop, test and validate the components of FireDST, as well as the FireDST simulation system outputs (spatial pattern of house loss and people likely to be affected by smoke inhalation). An outline of the key research areas follows.

FIGURE 2: FIREDST COMPONENTS – INPUTS AND OUTPUTS



This diagram shows the inputs (1-4) into the FireDST software program. Once combined, these inputs provide the probabilities that buildings will be lost (5), as well as the number of people impacted (6).

END USER STATEMENT

The development of FireDST was large and complex, as the project was the first of its kind. It has provided valuable new information to assist the fire and land management community.

Now that the proof of concept has been demonstrated, agencies can commence evaluation and consider their operational needs.

As more people move into urban/rural interface areas, agencies need to continually update the way they approach fire safety. FireDST will assist in this development to keep communities safer.

– David Youssef, Deputy Chief Officer, Metropolitan Fire Brigade, Victoria.

Meteorology of extreme fire events

The atmospheric conditions associated with extreme fire weather have been explored using the new Bureau of Meteorology numerical weather prediction system (known as ACCESS; Australian Community Climate and Earth-System Simulator; see Puri, 2011). ACCESS has been run at horizontal resolutions down to 400 metres and temporal resolution information up to every five minutes, and includes the vertical atmosphere at 3.6 kilometre resolution and 15 minute time steps. This research mode uses computer power more than 10 times faster than is currently used operationally. This gives the ability to see fine details of many small-scale atmospheric structures that are likely to have an impact on fire spread and intensity.

The project demonstrates the potential for such models to be used operationally in the future with the continued advancement of technology, and has informed development of computationally efficient methods that can drive the fire spread model.

Interaction with terrain and topography

The meteorological information has been modified to produce a more realistic understanding of the local wind affecting the fire spread. A simplified model was used to represent the effect of terrain and topography on the local wind speed at very high resolution (25 metres), using digital elevation models and airborne and satellite imagery to characterise the slope, aspect and roughness of the land surface.

The model is an automated computational method developed from the equations within the Australian/New Zealand wind actions standard (AS/NZS 1170.2, 2011). The simplified model does not claim to represent the full complexities of the interaction between the atmosphere and the earth's surface, but nevertheless produces computationally efficient information at the resolution needed to understand the impact these interactions may have on a forest or building. This information was not available previously.

Spatial mapping of fuels

Laser Imaging Detection and Ranging [LIDAR] aerial laser scanning technology was used to map the urban/rural interface areas in the case study bushfires (Newnham *et al.*, in press). This provided a detailed representation of the horizontal and vertical structures of fuels near these communities.

Fire behaviour

PHOENIX Rapidfire (Tolhurst *et al.*, 2008) is a program that simulates the spread of a bushfire (see figure 3, right). A vertical dimension has been included which has provided new fire spotting and ember transport mechanisms. Convective bubbles that vary in volume depending on the intensity of the fire have been used to transport fire embers downwind. Discrete Event Simulation Cellular Automata models have been applied to simulate fire suppression.

The fire simulation validation methodology (Duff, 2012) has been used to measure the accuracy of the simulations with the actual fires.

Spatial mapping of people, housing and infrastructure

The input data for this has been accessed from Geoscience Australia's existing National Exposure Information System (NEXIS) database (Nadimpalli *et al.*, 2007). This database is based on a statistical approach and shows building information around the country, including details such as how many people live in each building. NEXIS was developed from a large number of datasets, including the Australian Bureau of Statistics Census, and in most areas is statistically accurate at the Census collection district level. This enables an assessment to be made of the estimated number of people and buildings that may be at risk of exposure to radiant heat, ember attack and smoke should a fire occur. NEXIS is only available under licensing arrangements with Geoscience Australia.

Vulnerability of buildings to impact from radiant heat and embers

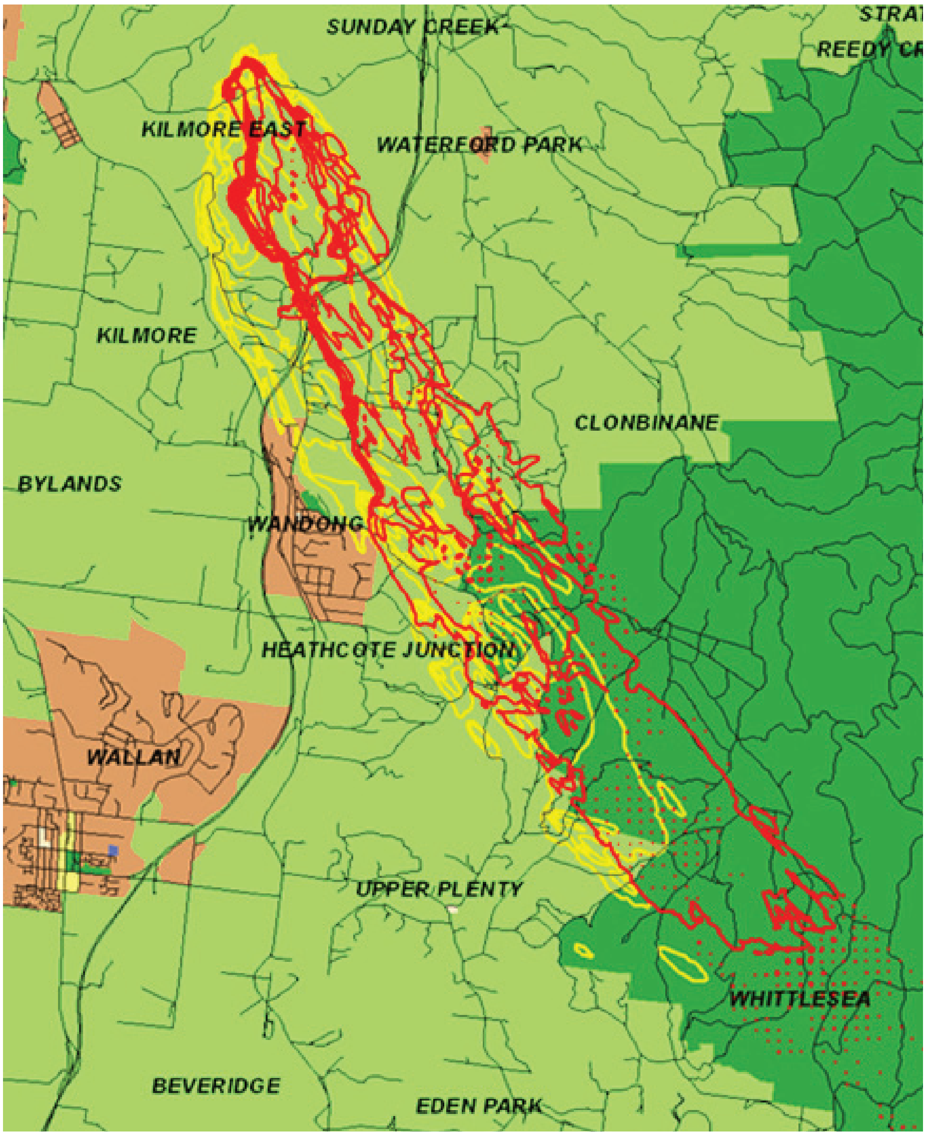
The research of Blanchi *et al.,* 2010 provides an understanding of how buildings and nearby objects (e.g. trees, hedges, fences and sheds) interact during a bushfire. This informs the vulnerability of the house, dependent on the direction of the fire, and informs the prediction of house loss.

Building Fire Impact Model

The development of the Building Fire Impact Model uses a computationally efficient methodology to determine the probability that a building located in a rural/urban interface area is affected by a bushfire, taking into account the role that human intervention may play. The methodology is based on a mathematical technique called Event Tree (also called a probability tree), which is a way of representing the dependency of events (Thomas *et al.*, 2002). Events are described by a list of dependent variables, such as 'person(s) being present', 'fire plan in place', and 'proximity of building to other structures' (following the methodology of Sanabria, 1999, for fires that start within buildings). The ages and family status of any occupants are also taken into account, including whether they are active fire brigade volunteers and if they have independent transport.

Smoke emission and dispersion from bushfires and prescribed burnings

An existing smoke dispersion model (Reisen *et al.*, 2010) has been enhanced, using the vegetation information described previously, coupled with PHOENIX fire spread information. This smoke dispersion model provides an assessment of the impacts on regional air quality. Established epidemiological knowledge predicts the likely impacts of smoke on the health of exposed populations. Local exposure information is provided by the NEXIS database.



▲ **Figure 3:** PHOENIX RapidFire is a fire spread simulator that models the movement of bushfires. It utilises information such as the fuel state and load, as well as the expected weather. PHOENIX can provide limited predictive output (within minutes of a fire being discovered) in the form of an initial assessment of which communities need to be warned and where to send resources to minimise the impact. The PHOENIX fire spread simulation associated with the high-resolution reconstructed meteorology for the Black Saturday Kilmore East fire is shown here. The red line represents the best assessment of the fire spread area for the fire commencing at 11:45am, until 3:45pm. PHOENIX is used operationally by fire and land management agencies in Victoria, New South Wales, Tasmania and South Australia.

RESEARCH OUTCOMES

FireDST has been run using the data from the case study bushfires to model impact. These simulations demonstrate that the proof of concept has provided a research grade simulation system that has the potential to assist fire and land management authorities to develop appropriate fire impact and risk treatment options at local, regional, state and national levels.

Figure 1 (page 1) shows how FireDST has projected the impact and fire spread simulation for the Black Saturday Kilmore East fire, using 'probabilistic' meteorology. The cream to red-coloured segments represent areas where there is that probability that the fire will affect that region. The actual fire reconstruction (shown in yellow) is fully contained within the probabilistic fire spread region. In the future, a user of FireDST could refine this potential area as conditions change or as new information arrives. Also shown are small bars depicting the population potentially impacted. This aggregated statistical information is selectable by the user and the graphs show the population estimate, population over 65, under five years old and those in need of assistance. FireDST can also produce images and information on the simulated impact on residences and communities within the probabilistic fire spread area.

HOW COULD THE RESEARCH BE USED?

FireDST could be used in a number of ways by fire and land management agencies. The most significant advancement made is the ability to simulate the probability of impact of a bushfire. The simulation system provides rich information about the potential losses, and how likely they are to occur given ignition, terrain, weather and fuel conditions/types.

In operational response mode, resource allocation and community warning of a fire and smoke impact can be informed by the risk or likelihood, rather than on simple binary yes or no advice. This might require adaptions to current incident management practice, but it provides a more realistic evidence base of the actual situation.

The components of this system, with minor modifications, could be used for planning applications. Among these are simulating the effects of hardening buildings through construction regulations, including the ability to evaluate beforehand any difference building standards might make. Likewise, 'what if' scenario analysis can be used to assess the potential effect of vegetation modification as well as land use planning.

FireDST can also be used for educational purposes. By using FireDST as part of their incident management training and community safety initiatives, agencies can demonstrate to staff, volunteers and the community which homes would be defendable under different conditions. From this, appropriate bushfire survival plans can be made, and the impacts that preparations such as clearing trees or ember proofing achieve can be demonstrated to the community, taking into account different fire danger ratings.

FUTURE DIRECTIONS

The proof of concept builds on the significant advancements in each of the key areas investigated, indicating a robust future for this research. The project demonstrates what is possible, and the Bushfire CRC is now in discussions with the fire and emergency services industry about the next steps.

The inclusion of this research into operational systems is a priority as end users need to have a reliable simulation system and an operational understanding of uncertainty. Critically, support for FireDST, or similar simulation systems, is needed on a national level to be sustainable. This support should address further development, training, data standards and validation, as well as comprehensive documentation.

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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 35 full and 10 affiliate member organisations.