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

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FIRE NOTE

TOPICS IN THIS EDITION
- TECHNOLOGY
- RISK
- STANDARDS AND REGULATIONS

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USING FIRE SIMULATIONS TO ASSESS HOUSE VULNERABILITY AT THE URBAN INTERFACE

SUMMARY

The majority of losses resulting from bushfires occur when fires burn into urban areas. Despite being the focus of much management attention, there is no universal way to consider bushfire risk at the urban interface. In Australia, the dominant approach to evaluating building vulnerability is to assess assets based on their relative proximity to potential fuel. But this method does not consider many of the elements that contribute to fire behaviour, including likely weather and short-term variations in fuel properties.

An alternative approach has been developed using a dynamic bushfire simulator to create sets of fire predictions, which can then be used to create maps of potential fire behaviour. Simulation approaches allow a much wider range of factors to be considered, including location specific effects of vegetation, weather and terrain. Potential fire behaviour maps can provide a more detailed indication of the likely impacts to buildings, allowing 'Wildfire Interface Zones' (see definition box, above right) to be mapped based on specific criteria of interest.

This research has demonstrated that dynamic fire characterisation models are likely to be a valuable tool for improving the way risk at the rural/urban interface is characterised. Management activities, such as prescribed burning, fuel modification, the application of building construction guidelines and the construction of firebreaks can then be objectively assessed in terms of their cost and benefits.

DEFINITION: WILDFIRE INTERFACE ZONE

The area where an asset, or flammable material in contact with an asset, has the potential to be ignited by exposure to any combination of flame, radiation, embers, firebrands or hot gases from a bushfire. This excludes areas only exposed to smoke, ash or charred material from a bushfire.

The extent of the actual 'Wildfire Interface Zone' will depend on the nature of the fuels, weather, topography, seasonal conditions and scale of bushfires in that geographic location at a given point in time, but for planning purposes the extent of the potential 'Wildfire Interface Zone' can be determined for a stated set of conditions.

ABOUT THIS PROJECT

This *Fire Note* reports on the *Enhancement of fire behaviour models* (PHOENIX) subproject conducted within the *Risk assessment and decision making* project. An overview of the *Risk assessment and decision making* project is provided in *Fire Note 109*.

AUTHORS

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MAPPING THE WILDFIRE INTERFACE ZONE

CONTEXT

The effective management of bushfire risk requires that mitigation activities are prioritised to areas of greatest threat. This research has improved the characterisation of fire risk at the rural/urban interface using a fire simulation modelling approach.

BACKGROUND

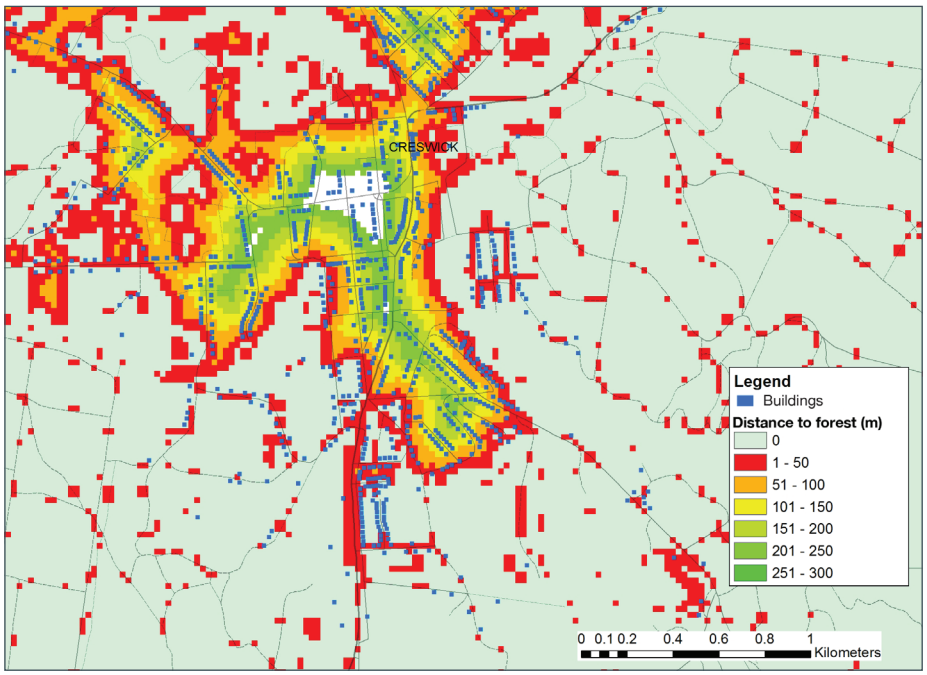
Due to the high potential for asset loss from bushfire, the rural/urban interface has been the focus of a great deal of research and management attention. However, what constitutes this area has not been consistently defined; definitions vary based on the context of evaluation. For example, different definitions may be used when assessing for insurable loss or urban planning. In Australia, Australian Standard AS3959 provides guidance on managing bushfire threat to buildings. The standard considers risk in terms of proximity to vegetation (as potential fuel) qualified to account for the effect of hillslope. In effect, a buffer approach is used to define bushfire threat zones at specified distances around vegetation. However, there are a range of other factors that contribute to fire exposure, including:

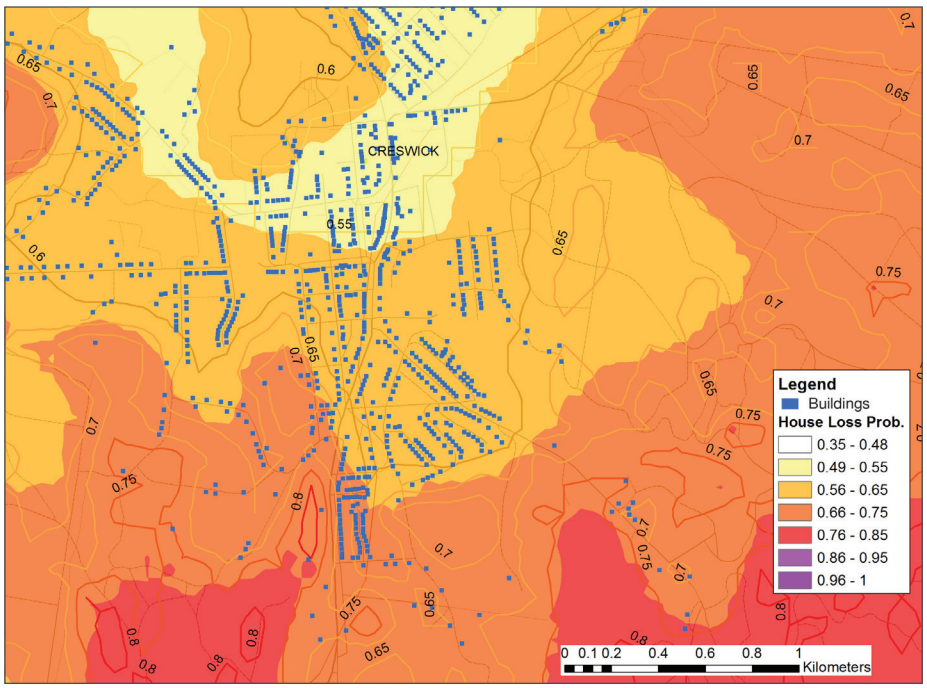
- Likely weather patterns.
- Probable ignition time and location.
- Other terrain effects (such as aspect and effect on wind).
- The scale and position of fuel in the landscape.
- Variation in fuel due to vegetation type.
- Changes through time of fuels.

By considering risk only in terms of vegetation and slope there is the potential

Top, figure 1: An example of the application of the AS3959 approach to assessing house risk, where risk is mapped based on the proximity to forested areas.

Below, figure 2: A map of house loss probability developed by using a simulation approach with PHOENIX RapidFire for a Forest Fire Danger Index of 150. Blue dots are houses, while the shading indicates chance of house loss as a percentage.





for outcomes that misrepresent true risk. For example, larger fires have the potential to reach higher levels of intensity, while a house near a narrow strip of coastal vegetation is unlikely to be as vulnerable as a house adjacent a large area of forest.

BUSHFIRE CRC RESEARCH

Dynamic bushfire simulators such as PHOENIX RapidFire (Tolhurst *et al.*, 2008) have the potential to be valuable tools for defining risk, as they are able to rapidly analyse large amounts of information to produce realistic predictions of fire behaviour. They produce predictions based on a complex consideration of fuel, weather, topography and the properties of the fire itself (such as likely ember production or convection driven wind). Such models can produce outputs that can be related directly to building loss, including flame intensity, ember production and convection wind strength (Tolhurst *et al.* 2011).

While the dominant use of bushfire simulators is for predicting the spread of fires for fire agencies, by simulating numerous hypothetical fires they can be used to develop maps of relative fire risk. This research has developed a new dynamic approach to mapping risk in the rural/urban interface; the 'Wildfire Interface Zone' (see definition box, page 1). These zones can be mapped based on the vulnerability of specific assets (such as houses or infrastructure) and are a function of expected fire behaviour. As the natural landscape is dynamic, with vegetation (which acts as fuel) constantly changing, the 'Wildfire Interface Zones' can be recomputed as the landscape changes.

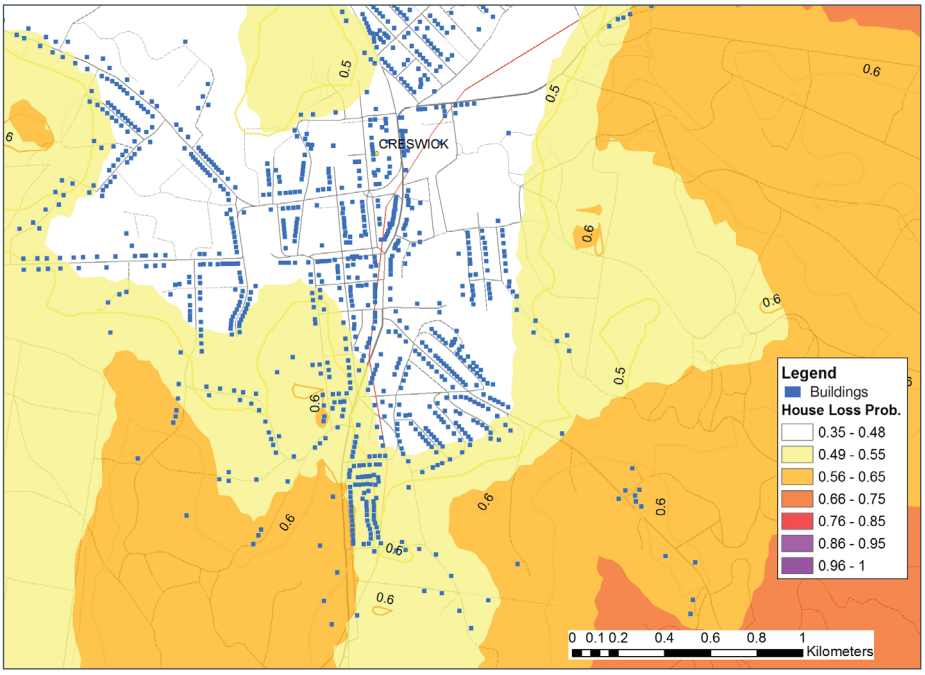
This approach was demonstrated with a case study of Creswick in Victoria, using PHOENIX RapidFire. Within PHOENIX RapidFire virtual fires were ignited in a grid pattern (2km square) starting at 1pm and burning until 11pm the same day. The vegetation data used as fuel inputs was that as used by the Department of Environment and Primary Industries, Victoria. The threat to buildings from fire is highly dependent on the weather conditions under which fires burn. To gauge this further, three different historic weather scenarios were used: Ash Wednesday (16 February 1983), Black Saturday (7 February 2009) and the Muskvale fire (23 February 2009). Observations from these days were modified by adjusting temperature, humidity and wind speed to be aligned with maximum Forest Fire Danger Indices (FFDI) of 25, 50, 100 and 150. These days were chosen as they exhibited the typical Victorian fire weather pattern of a strong north westerly wind followed by a southerly change. Each ignition was simulated with each weather stream. The fire impact maps were cross-referenced with maps of house locations to provide a realistic estimate of the vulnerabilities of actual houses.

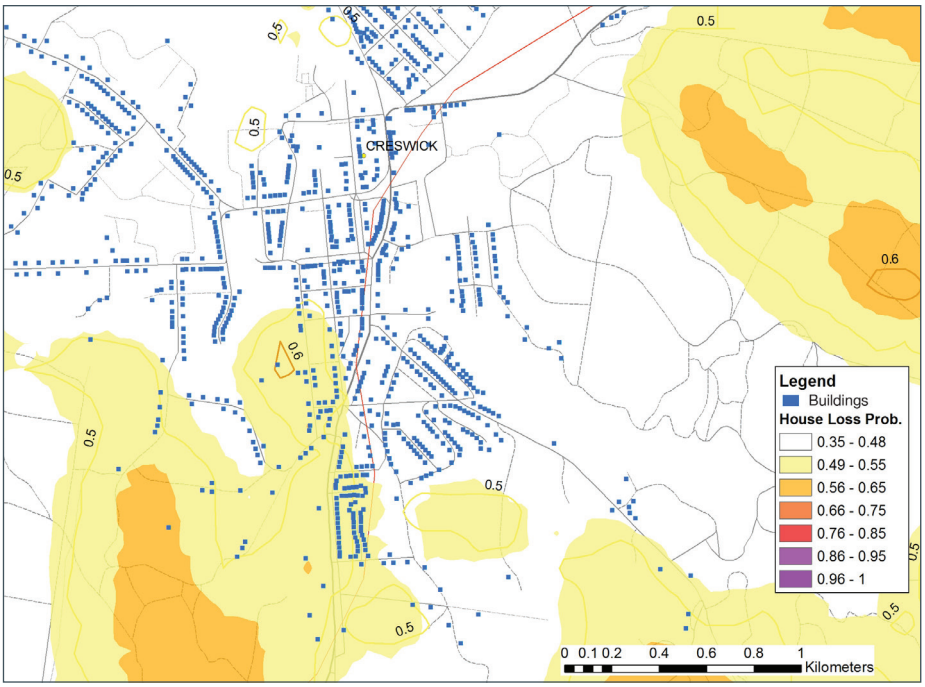
An analysis of the predicted burned areas provided an indication for each point in the landscape of a number of fire related values including:

- The number of times it had been burned.
- The expected intensity of burning.
- The expected number of embers to fall into a specified area.
- The probability of house loss.

RESEARCH OUTCOMES

The research found that estimating the impacts of bushfires at the rural/urban interface using a simulation approach achieved very different results to those achieved following Australian Standard AS3959. The AS3959 approach results in maps of risk category that





Top, figure 3: As per figure 2, but with a Forest Fire Danger Index of 100. Blue dots are houses, while the shading indicates chance of house loss as a percentage.

Below, figure 4: As per figure 2 and 3, but with a Forest Fire Danger Index of 50. Blue dots are houses, while the shading indicates chance of house loss as a percentage.

END USER STATEMENT

Right across Australia and in other fire prone places, the shortcomings in existing risk analyses are a brake on improving community safety. As a planner and a regulator I currently have to rely on static analyses of risk to provide advice on where people should live and work and how they might go about it safely. The existing simplistic risk models tend to generalise across the 'firescape', overestimating in places and underestimating elsewhere. It is difficult to show the relative efficacy of broad area strategies and mitigation options and the subjectivity in decision making is greater than it should be.

This research shows there is a better way. It incorporates fire simulation in four dimensions to produce realistic detail about the nature of the bushfires which will be experienced across wide areas. This can be used for strategic land use planning to address where development should occur and to some extent how that development might respond to bushfire risk. It can also provide more detailed information so that mitigation can both be targeted and tuned for the site. We should pick up these techniques and start incorporating these more nuanced analyses into our fire management decision making, preventively, as well as during fires.

– Mark Chladil, Fire Management Planning Officer, Tasmania Fire Service

consist of zones that enclose mapped areas of vegetation (see figure one, page 2). The width of these zones is not affected by the size of vegetation patches (once a threshold has been reached) and the zones are applied consistently outwards in all directions. While the approach recognises broad vegetation types, there is no consideration of the current status of the vegetation (e.g. species composition or whether fuel reduction has occurred) or the typical fire patterns for the area.

The maps generated by PHOENIX RapidFire show a much more nuanced indication of the patterns of fire risk. Figures two, three and four cover the same location as figure one, and show the probability of house loss at FFDI's of 50, 100 and 150.

There was a strong element of directionality in the simulated maps, with substantially elevated risk to the east of areas of heavy vegetation and reduced risk to the west. This is due to the simulations being based on the typical Victorian fire weather pattern (strong north westerly wind, followed by a southerly change). This pattern is typical for the majority of severe fires that occur in south eastern Australia.

In addition, while the AS3959 approaches maintain consistent mapped risk zones for all conditions, when using a simulation approach, the extent and patterns of mapped risk zones was found to vary with the severity of the weather conditions. This can be considered in the context of fire return period; less severe fire conditions occur more frequently, but may require different preparation activities in comparison to activities in anticipation of rarer, catastrophic conditions.

In addition to the variation in directionality, the simulated risk areas also reduce the weight given to small areas of vegetation. The AS3959 approach assumes fires behave consistently in each fuel type regardless of scale and context. However, PHOENIX RapidFire simulates each fire as a coherent landscape event. It looks at the relationships between the factors that contribute to fire behaviour through time and space (fuel, weather, topography and the fire itself). This provides a more realistic representation of fire behaviour, and allows properties such as embers produced elsewhere and the scale-driven momentum of a fire to be a consideration at a

particular point. These influences enhance fire spread; consequently in small areas of vegetation there is little opportunity for fires to accelerate to their full potential. As a result, simulations that incorporate these effects can capture the real exposure to a hazard as experienced by a dwelling in terms of multiple impact mechanisms (embers, flame contact, wind damage etc.).

Analyses has shown that it is not just the fuel within a set distance of a house that affects the probability of loss by fire, it is a combination of all the factors that contribute to bushfire behaviour. Fire behaviour can be evaluated in terms of values of interest, such as potential house loss, including the likely ember density, radiation load, and convective wind strength. PHOENIX RapidFire can be used to define the 'Wildfire Interface Zones' based on local fuels, terrain and climate. The research team proposes the 'Wildfire Interface Zone' be adopted to replace the concept of the rural/urban interface for fire management.

To do this operationally, further research is required to better understand the mechanisms of house loss, fire return intervals and to standardise expectations of the kind of risks emergency managers are focused on reducing.

HOW COULD THE RESEARCH BE USED?

Understanding the risks to landscape values due to bushfires is critical to successful management. Effectively understanding risk can allow priorities to be determined, activities to be planned and alternatives to be evaluated. This research contributes to the development of a landscape level understanding of the probable and possible consequences of bushfires. The value of the concept of the 'Wildfire Interface Zone' is that it takes a fire-centric view of the landscape; maps represent what a fire is likely to do based on a broad range of dynamic inputs. This is in contrast to the static fuel-centric view that is typically applied. 'Wildfire Interface Zones' have been demonstrated to provide useful indications of likely fire properties in the landscape. However; while the methods of constructing them are still being developed, there is clear potential for improving landscape planning in a range of ways. This includes:

- Accurate indications of the parts of the landscape that have values at risk can help with the prioritisation of interventions. This can include activities such as planning fuel reduction operations or establishing building construction recommendations.
- While the protection of dwellings has been a key focus of fire risk planning, there is also the potential to establish relationships between the outputs of dynamic fire characterisation models and other values. This could include recognising the potential impacts of fires on water catchments, critical infrastructure and biodiversity.
- As the 'Wildfire Interface Zone' method of assessment involves burning hypothetical fires in real landscapes, there is the ability to test the viability and efficacy of various fuel management strategies, in particular different levels and spatial configurations of prescribed burning. This can enable benefit/cost analysis for each strategy in the face of various weather scenarios, enabling each to be evaluated objectively.
- While the initial focus on simulation derived risk maps will focus on current risks, there is also the potential to evaluate future risk in the context of changing climatic and vegetation conditions.

FUTURE DIRECTIONS

The concept of using 'Wildfire Interface Zones' has been demonstrated as a proof of concept, however further work is required before related methodologies can be adopted for operational use and risk zones can be systematically mapped. In particular, additional research is required to improve the understanding of fire impacts, to develop standardised protocols for evaluating risk scenarios and to better understand the uncertainty of model outputs.

REFERENCES /FURTHER READING

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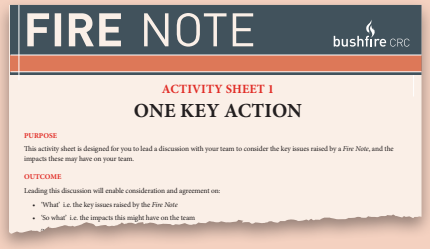
NOW WHAT?

What three things stand out for you about the research covered in this *Fire Note*? What information can you actively use, and how? Tools are available at www.bushfirecrc.com/firenotes to help, along with activities you can run within your team.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ACTIVITY SHEET 1

ONE KEY ACTION

PURPOSE

This activity sheet is designed for you to lead a discussion with your team to consider the key issues raised by a *Fire Note*, and the impacts these may have on your team.

OUTCOME

Leading this discussion will enable consideration and agreement on:

- 'What' i.e. the key issues raised by the *Fire Note*
- 'So what' i.e. the impacts this might have on the team

Fire Note is published jointly by the Bushfire Cooperative Research Centre (Bushfire CRC) and the Australasian Fire and Emergency Service Authorities Council (AFAC). This Fire Note is prepared from available research at the time of publication to encourage discussion and debate. The contents of the Fire Note do not necessarily represent the views, policies, practices or positions of any of the individual agencies or organisations who are stakeholders of the Bushfire CRC.

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