Towards New Information Tools for Understanding Bushfire Risk at the Urban Interface

A Bushfire Cooperative Research Centre Project

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Abstract

The ever-increasing bush/urban interface as a result of not only urban expansion, but also a desire to be close to nature, has increased the potential for serious bushfire consequences. In order to study bushfires in urban fringe areas, we need to better understand the complex interactions between the mechanisms of bushfire attack, human behaviour and urban design. To increase knowledge in these fields, several surveys following large fire events have been conducted. The information gathered is currently being developed into a new spatially navigable database to assist in the analysis of the data, and may potentially become a tool to allow the broader community to better understand these fire events. This paper details the methodologies used and also discusses some of the interesting observations made using this new approach.

Bushfire at the Urban Interface

A bush/urban interface can be defined as the boundary line or separation zone between vegetation (bushland, managed forestry, etc.) and human structures and other human development (United States Department of the Interior 1995; Jappiot 2001).

Bushfires constitute a major natural risk and can have important repercussions from a socio-economic point of view. This situation is of particular concern in urban and peri-urban areas, as recent regrettable examples have shown. The 2003 bushfires in Canberra and the recent wildland fire in California in October 2003 destroyed thousands of houses and were responsible for fatalities, including fire-fighters.

Recent research into bushfires has led to the conclusion that the costs to human lives, property and natural resources are increasing (Leonard 2003).
The causes of house destruction are complex and involve several aspects linked to bushfire propagation in urban areas such as environmental conditions, mechanisms of bushfire attack, human behaviour (before, during and after the fire) and building design.

Environmental conditions play an important role, the high degree of damage within urban areas is related in part to unusual severity of the fire generated by the extreme weather conditions (combination of particularly strong winds and drought conditions). Low rainfall, low humidity and water restrictions can leave the vegetation around buildings and building elements themselves in a very dry and flammable state.

The principle mechanisms of bushfire attack can be categorised into direct flame, radiant heat and embers. Previous CSIRO research has shown that the majority of houses destroyed in bushfires usually survived the passage of a fire front, but burnt down during the following few hours due to fire spreading from ignition caused by burning debris (Leonard 2003). Embers are the major cause of ignition, as they can attack a building for some time before a fire front arrives, during the passage of the fire front and for several hours after the fire has passed. Two types of windborne debris need to be considered: burning debris that could enter into or directly ignite part of a building or its surroundings, and unburnt or partly burnt debris that could facilitate ignition when it accumulates in or on specific parts of a house.

Despite the ever-increasing desire to be close to nature, many people are unaware of the risks and responsibilities associated with living in bushfire-prone areas. Research has shown that human activity plays an important role in mitigating the risks (prevention and suppression activities, before, during and after ember attack) (Ramsay 1996).

Building design also plays an important part in the survivability of a structure. Any part of a building where burning debris can accumulate (or enter) is susceptible to ignition. The accumulation of burning and non-burning debris can occur before, during and after a fire front has passed. Some researchers have already studied the mechanisms of bushfire attack on houses, and their findings have been integrated into AS 3959 *Construction of Buildings in Bushfire Prone Areas,* to improve the performance of buildings (Ramsay & McArthur 1995).

In order to study bushfire in urban fringe areas, we need to better understand the complex interaction between the mechanisms of bushfire attack, human behaviour and urban design. To increase knowledge in these fields, several surveys have been conducted following large bushfire events resulting in significant house loss, from the Ash Wednesday fires in Victoria and South Australia in February 1983 (McArthur 1997) to recent bushfires investigations (Leonard 1999).

The last survey was carried out after the Canberra bushfires in January 2003. The objectives, contents and results of that survey are briefly presented to show the extent of data recorded and the difficulties encountered displaying the result and the information in an accessible way. In this paper, we concentrate on the data collected in the suburb of Duffy.

Survey of Duffy after the 2003 bushfires

Preliminary studies of the damage in Duffy showed unusually high levels of house loss deep into the urban environment. It appeared that most houses were ignited by either ember attack or house-to-house ignition (Leonard, 2003). Housing stock was of the order of 30 years old and thus houses were not specifically designed to be resistant to bushfire attack.

In order to understand the unusual aspects of this major bushfire event, an investigation was performed with the intent to identify the mechanisms of ignition and propagation of the fire in this urban area.

The investigation involved data collection on the following:

- house design and placement,
- ground and aerial photos,
- weather conditions,
- types location of vegetation,
- human behaviour (not comprehensive).

Data collection on houses exposed in Duffy

A survey was carried out over six days at the end of January 2003, ten days after the Duffy bushfire. Six CSIRO-MIT scientists and volunteers visited the scene to examine the remains of destroyed houses, to study the damage sustained by surviving houses and to talk with residents.

Duffy was selected after a familiarisation tour, as it presented the highest density of damage and destruction following the Canberra fires (see Figure 1). Over 229 Duffy houses were surveyed being classified as untouched, damaged and destroyed houses (on-ground survey of each house, and interviews with some occupants who were on site).

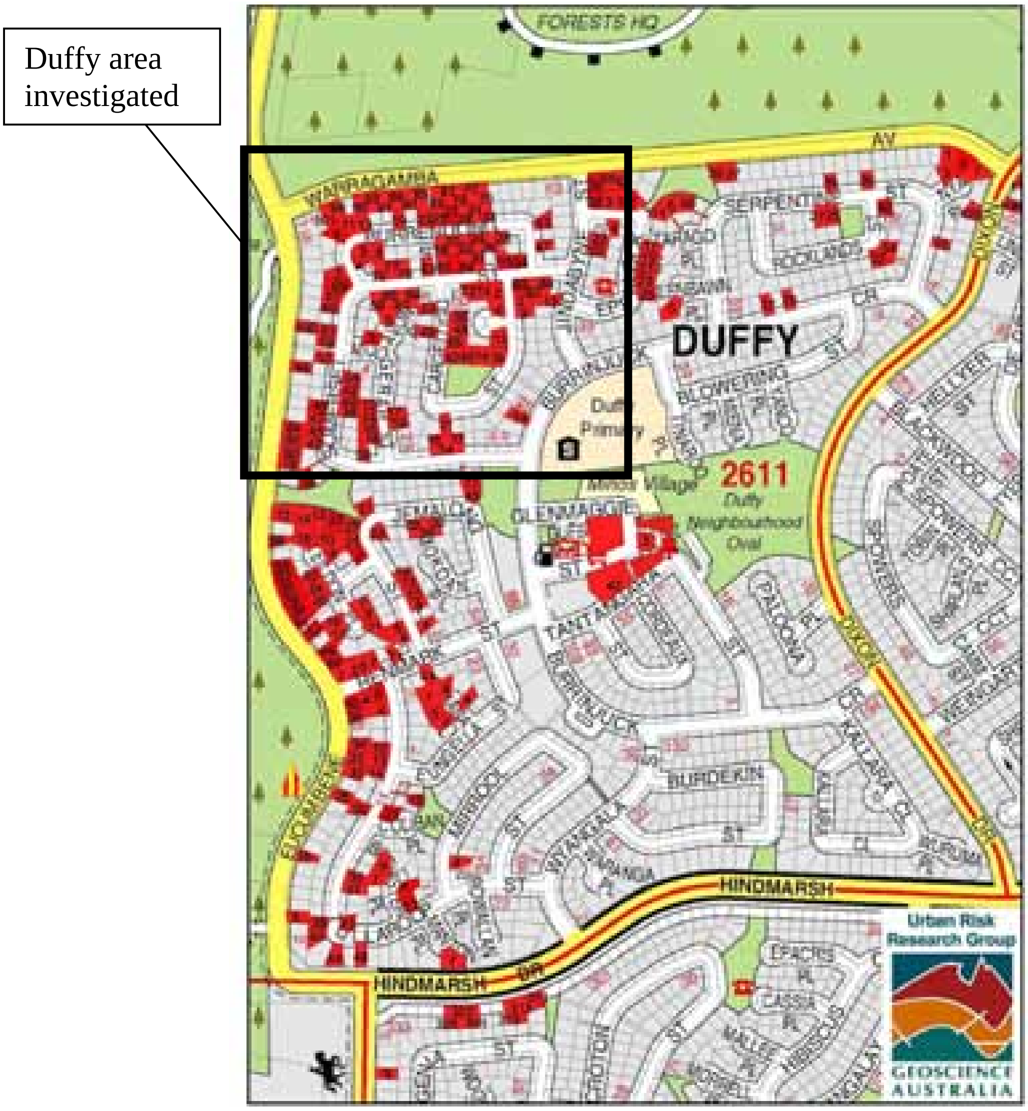

Figure 1. Houses destroyed (in red) in Duffy

Different factors were considered in assessing the impacts and consequences of the bushfire attack on a house, with the survey consisting of over 70 questions. Preliminary questions dealt with the identification, location and ownership details of a house. The questionnaire covered the degree of damage sustained (see Figure 2) and the causes of damage to each house, and closely recorded its design and the materials used in construction. Details of outbuildings and the surrounding environment were also recorded. The final questions looked at the activities of occupants, neighbours and fire-fighters around the house before, during and after the passage of the fire front.

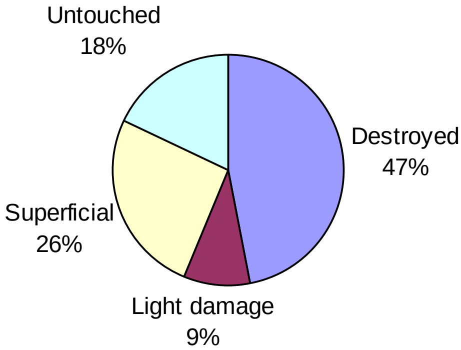

Figure 2. Degree of house damage in Duffy

The investigation of damaged houses provided a large amount of information on the mechanisms of the Duffy bushfire attack, and increased our knowledge of the parameters that could have influenced house survivability. The characteristics of a house design and materials used in construction also influenced house survivability. The houses that survived included all those superficially or lightly damaged, and those that were untouched (Superficial damage is caused by ignitions that were usually extinguished before they entered the structure, while light damage involves some penetration before extinguishment). In 50% of cases, the bushfire attack mechanism was via embers only, and in 35% it was via embers and some radiant heat from surrounding vegetation or other structures.

The data recorded on house design and materials of construction provided information on:

- The flooring system and external walls – to ascertain whether these areas of a house could have resisted ember entry and/or accumulation.
- Openings – windows, external doors and vents present the main possibility of penetration and/or accumulation of burning debris (beneath, in corners). The parameters of these openings were studied in detail in this investigation (frame, kind of material, type of protection, type of damage, etc.).
- Roof – the design of the roof is a vital element in a building's resistance to bushfire attack; certain roof profiles are susceptible to debris built-up and ignition. And virtually all roofs were not tightly sealed from ember entry.
- Decks and verandahs. Showing similar design and materials selection to previous fire investigations, hence presenting a common attack point leading to house destruction.

Details of outbuildings (type, degree of damage, materials of construction) and the surrounding environment (type of vegetation, etc.) was also obtained during the survey. This information was used when ascertaining the progression of the fire across a property. Outbuildings such as garages and sheds usually present more apertures and are therefore more susceptible to ignition. The presence of dry vegetation could increase the risk of attack by embers, flame contact and radiant heat. Certain types of vegetation are particularly susceptible to fire, for example cypress trees, which produce large quantities of dead material, and the intensity at which they burn may adversely affect their surroundings (see Figure 3).

Figure 3. Cypress tree structure

Much of the information collected is of a spatial event nature eg:

- time of fire front passage,
- position the house from the fire front,
- time of occupant intervention.

The logging of this Geospatial information into an appropriate database allows it to be easily related to other information types such as weather. An example of spatial analysis is the study of occupant behaviour, where the theory of whether people who stay with their house tended to be those furthest from the fire front. The analysis of the first two rows of houses does not support this proposition (see table 1).

Table 1 Occupant behaviour

	First line		Second line	
	surviving houses (20)	destroyed houses (22)	surviving houses (15)	destroyed houses (19)
Stayed with the house (before during and after fire front passed)	14		7	2
Left after fire front passed and return after 12 hours		1	1	
Left after fire front passed	1	1	2	
Left before fire front passed and returned after 3 hours	1			2
Left before fire front passed and returned after 6 hours	1		1	
Left before fire front passed and returned after 12 hours	2	3	2	2
Left before fire front passed		1		
Away - Left early		2	1	2
Unknown	1	14	1	11

The activities of occupants, neighbours and firefighters were also recorded during the survey, as it is known that human activity can significantly influence the survivability of structures (see Figure 4).

Information on occupant behaviour was obtained for 50% of the cases, but the information should be used with caution as data recorded for urban design, most of the information is unknown in house destroyed. However, the interviews of people who had stayed with their house have broadened our understanding of the mechanisms of bushfire attack.

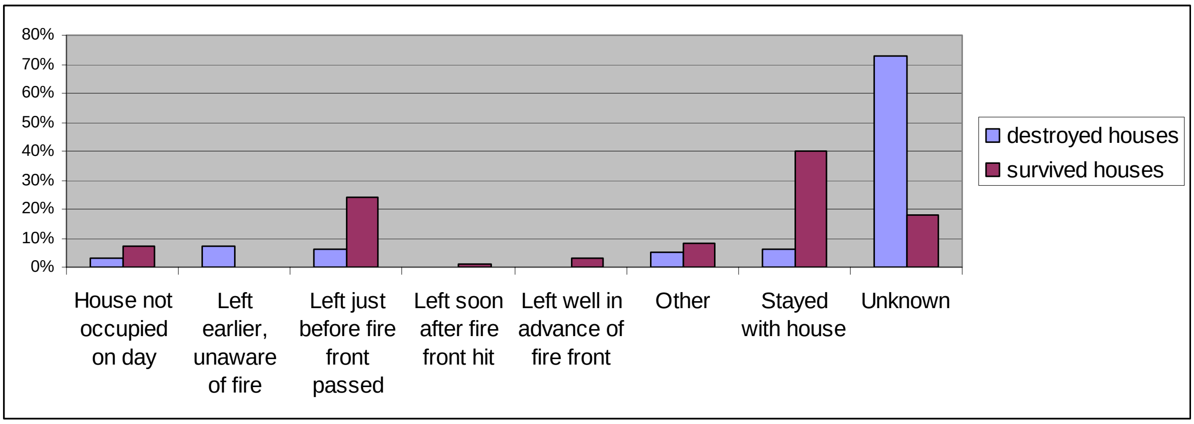

Figure 4. Occupant action

Ground and aerial photography

Additional information was obtained from photographs taken both on the ground (see Figure 5) and via high-resolution aerial photography of the affected area (see Figure 6). The photos are a vital method of recording and storing additional information on each surveyed house for later analysis. The photos reveal information on each house's characteristics (the entire house and its surroundings), the ignition point(s), profile of burnt area, and the damage sustained by the house. They also provide information on the nature of the bushfire attack and house-to-house fire spread.

Figure 5. Examples of ember attack on houses in Duffy

Figure 6. Example of aerial photography of Duffy

Additional information

Additional information on weather conditions, vegetation, slopes, prevention and suppression activities etc. are important to complete the picture to gain a better understanding of the behaviour of the Duffy bushfire.

The different types of data obtained needs to be compared and integrated in order to improve our understanding of bushfires in urban areas. At present, however, the volume and complexity of the information gathered makes comparisons difficult, and there is a need to develop a specific tool to assist in the analysis of the data.

New Information Tools

The development of prevention tools for bushfire-prone areas requires a knowledge of the bushfire phenomenon and its consequences, which involves the storage and analysis of a large amount of data (Blanchi 2001).

The nature of bushfire attack is inherently a spatial problem, hence the most effective method of information collation and navigation is through the use of a spatially navigable database. Thus spatial representation associated with database is an easy and practical tool for the researchers (risk manager) who deal with many problems of organisation and manipulation of the data. Storage in a database, the management, the treatment, the description of located data, and their cartographic representation are tools of simplification, synthesis and communication.

All the information collected during the Duffy survey is currently being developed into a new spatially navigable database. The aim is to eliminate the need to search through large amounts of information located in different areas and in different formats (paper, digital, etc.), and to allow real-time querying and analysis of the database.

The functionalities of the application will enable the generation of a general map of the region studied with active clickable regions for moving down to more detailed data layers. Examples of the next lowest layer are:

- local more detailed maps
- cadastral map
- vegetation overlays
- aerial photo

Each house in the database will be linked to a large amount of information (general information on the data recorded, expert opinion of the data, ground based photos, etc.). The database will be searchable by a variety of parameters such as locality (suburb, house) and kind of damage. The use of GIS in association with the database will enable the geocoding of individual incidents on a house or group of houses, which could be displayed on maps (institutional, informational or jurisdictional base maps). This would make it possible to rationalise the collection and the data processing spatially and to develop logical and topological relations between the data (studies of fire at the urban interface, houses reached by fire, understanding of house-to-house spread, etc.).

At the moment, the database only includes information on the Canberra fires, however it is proposed that survey data of past fires will be addressed using these methods The database will provide a valuable source of data that will support access by a number of applications, including spatial, statistical and text-based applications.

Conclusions

In an effort to coordinate research into bushfires at the urban interface, CSIRO is developing an application that will allow researchers more effective access to a wide range of information on past bushfires. The objective is to set up a tool that aims to increase our knowledge of the mechanisms that influence risk of bushfire damage to houses at the urban interface. Beyond this research initiative lays the more significant task of utilising the body of knowledge to effect real outcomes in relation to building protection in bushfires.

It is envisaged that this application will become web enabled and potentially accessed by the broader a range of organisations (including members of the general community) committed to understanding bushfire issues. All these people could at different levels of interest and understanding further their understanding and ability to deal with bushfire related risks.

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