

# Chapter Seven: Bushfire



*A bushfire rages as fire crews work close by, near Merimbula, New South Wales, January 2006  
Photo courtesy: Bureau of Meteorology/Stephen Kemp.*

# Bushfire

Bushfires are an intrinsic part of Australia's environment. The natural ecosystems have adapted to bushfire, while the diversity of the landscape has been shaped by fire. Bushfires have been responsible for some of the most unforgettable natural disasters in Australia, such as the Ash Wednesday fires in Victoria and South Australia on 16 February 1983. Fire has also been harnessed to clear land for agricultural purposes and, importantly, to reduce risk to property from intense, uncontrolled bushfires.

Across Australia, major bushfires are estimated to have cost \$2.5 billion in the period from 1967 to 1999, corresponding to average annual cost of \$77 million (BTE 2001). There have been over 700 deaths caused by bushfire since the first recorded death in 1850 (Blong 2005).



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*A fire crew on the Great Alpine Road near Bruthen, Victoria, January 2007*

*Photo courtesy: CFA Public Affairs/Martin Anderson.*

*The charred remains after a bushfire, showing signs of regeneration in the Royal National Park, New South Wales, January 1994*

*Photo courtesy: Emergency Management Australia.*

*A bushfire near Wentworth Falls in the Blue Mountains, New South Wales, January 1994*

*Photo courtesy: Bureau of Meteorology/John Nairn.*

*Devastation resulting from the Black Tuesday bushfires in a small town in Tasmania, February 1967*

*Photo courtesy: National Archives of Australia/NAA: A1200, L60751.*

The impacts of bushfires differ from those of tropical cyclones, earthquakes and severe storms because an individual has a greater ability to mitigate the negative impacts of fire. Fires generally have some scope to be detected and extinguished early, and their subsequent impacts can be greatly reduced by risk reduction strategies. Bushfire is the only hazard considered in this report for which the potential of the hazard itself can be reduced—by reducing human ignitions and through early suppression.

In this chapter, the bushfire hazard and the processes of analysing the risk associated with bushfire, including the gaps in the available information, are described. Several national groups coordinate firefighting activities, such as aerial firefighting, across the country. The roles and responsibilities played by government agencies and the community in bushfire risk management in Australia are also important in minimising bushfire impacts.

## Hazard Identification

In Australian usage, ‘bushfire’ is a general term used to describe a fire in vegetation. Fires lit purposefully for fuel reduction or land management purposes are often more accurately referred to as ‘prescribed fires’ (AFAC 2007). While bushfire activity in Australia is prevalent in most landscapes that carry fuel (e.g. grasslands, forests, scrub and heath lands), the two predominant bushfire types in Australia are grassland fires and forest fires. Common to both are sources of ignition and factors such as weather conditions that affect the intensity of a bushfire.

Bushfires are ignited either naturally by lightning, or by human activity. Across the Australian continent, lightning is the predominant ignition source of fires, being responsible for just over 50% of all ignitions. In the southern states, where most asset loss occurs, natural causes account for approximately 30% of ignitions. Human

causes of bushfire include accidental ignition through carelessness, and deliberate ignition, predominantly through arson or land clearing.

Most areas of Australia experience bushfires. For most of southern Australia, including southern New South Wales, the danger period is summer and autumn (see Figure 7.1). For northern New South Wales and southern Queensland, the peak period of fire activity is usually in spring and early summer. Northern Australia experiences most of its fires in the drier months between May and September.

The level of bushfire hazard is influenced by several factors. Primarily, the weather conditions at the location of the fire dictate the behaviour of the fire. The McArthur grassland and forest fire danger indices (GFDI and FFDI respectively) are used to determine the spread rate and difficulty in fighting fires (McArthur 1958). Both indices require weather parameters of wind speed, relative humidity and temperature. Additionally, estimates of the grass curing percentage (for GFDI), drought index (for FFDI) and fuel load are required.

High winds can contribute to the impact of a fire by increasing the spread rate of the fire, as well as by carrying burning embers further downwind (causing ‘spotting’). Significant and rapid changes in the wind direction associated with cold fronts can result in rapid increases in the size of the fire front, as was the case with bushfires on Ash Wednesday. Local wind effects caused by topography also make it difficult to predict how a fire may progress.

Relative humidity is an indication of the amount of water vapour in the atmosphere. Very low relative humidity levels can rapidly reduce the moisture content of fine fuels (e.g. leaves, grasses and twigs), which are responsible for propagating the main fire front. Sustained high temperatures can increase the curing level of fuels, further adding to the level of hazard.

The dryness of available fuels is measured by two means—the grass curing index and the drought factor (Noble and others 1980; Griffiths 1999). The drought factor is used for estimating the dryness of forests. The dryness of fuels is directly affected by rainfall amounts preceding a bushfire and the atmospheric conditions, such as relative humidity, at the time of the fire.

Fuel load is the other main contributor to bushfire hazard. A region with less available fine fuel will result in a lower intensity fire compared to a region with a higher fine-fuel load, assuming all other factors are equal. As the type and arrangement of available fuel affects the intensity and spread of a fire, specific fuel management practices, such as prescribed burning or mechanical slashing, can have a significant impact on bushfire intensity.

## Grassland Fire

Grassland fires affect pastoral districts and the savannahs of northern Australia. These fires account for the majority of area burnt by bushfires—in the 2002–2003 bushfire season some 38 million hectares were affected by bushfire across northern and central Australia (Ellis and others 2004). However, these fires result in comparatively little economic impact, due to the low exposure of life and property in central and northern Australia.

## Forest Fire

Forest, scrub and heath land fires affect the more densely vegetated regions of southeast Australia (e.g. the Blue Mountains in New South Wales) and the southern part of Western Australia.

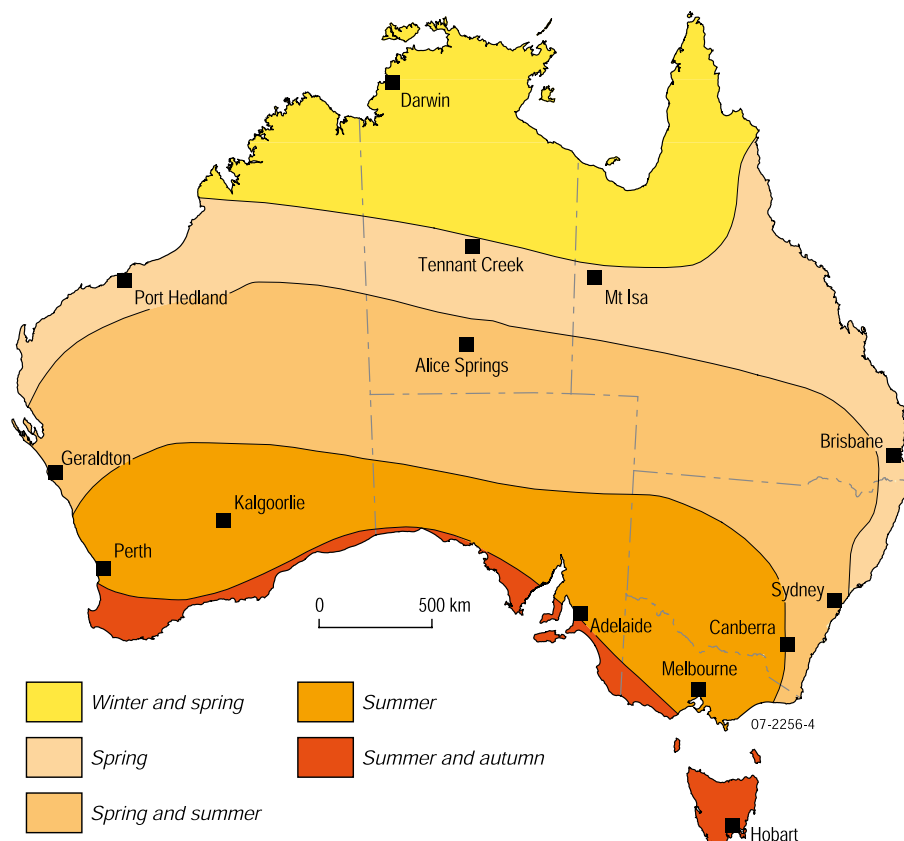


Figure 7.1: Fire seasons across Australia

Source: Bureau of Meteorology, cited in Lindesay (2003), Figure 4.2.

The greatest loss of life and economic impact occurs in the southern states in the urban fringes of cities, where homes and other property are commonly in close proximity to forest, scrub or heath lands. There are, however, cases where bushfires have caused losses deep in suburban areas—for example, the Canberra bushfires of January 2003.

## Cost of Bushfires

The cost of a bushfire is often related to the assets lost or insurance claim value of the event, but real costs include the social and environmental costs as well as the economic losses. The costs of two fires of similar size can vary significantly depending upon the exposure of assets and the population density and socioeconomic profiles of the areas in the paths of the fires.

For the period from 1967 to 1999, the total economic cost of major bushfires has been estimated at \$2.5 billion, contributing about 7% to the annual cost of natural disasters and an

average annual cost of \$77 million (BTE 2001). These values do not (explicitly) include the costs of damage to timber plantations, which would add to the overall costs.

The costs of bushfires vary significantly from year to year, as highlighted in Figure 7.2. The two years with the highest losses correspond to two iconic events—the Ash Wednesday fires in South Australia and Victoria in 1983, and the Black Tuesday fires in Tasmania in 1967. The impact of these events is also reflected in the breakdown of house losses by geographic area, as shown in Figure 7.3.

From 1850 to 2001, 696 lives have been lost in bushfires across Australia (Blong 2005). However, there has been a decline in the number of lives lost in bushfires over the past 20 years (Ellis and others 2004).

The cost of controlling fires may be a major component of the total economic costs, if

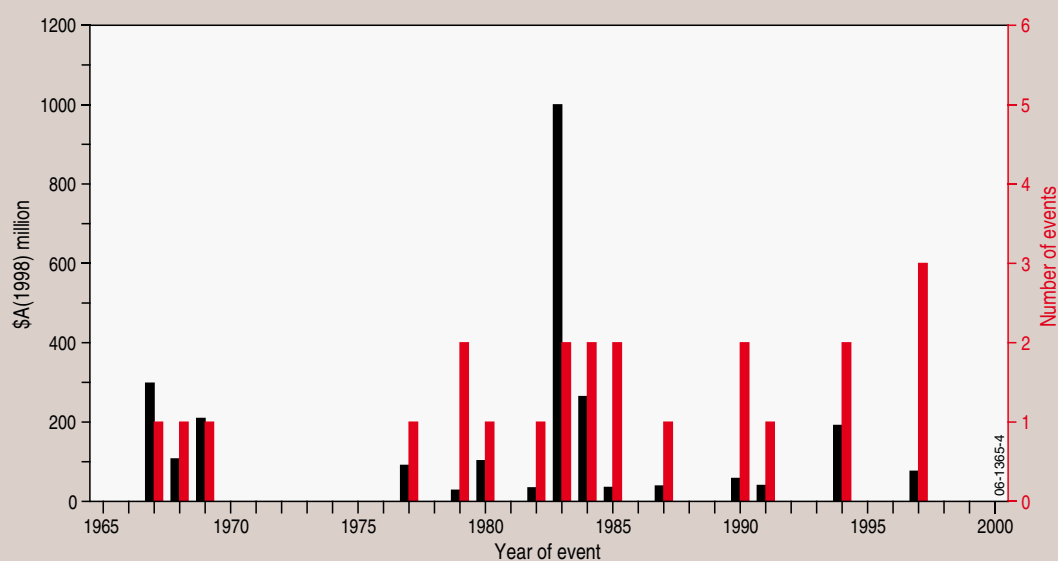


Figure 7.2: Annual cost and number of bushfires in Australia, 1967 to 1999  
Source: Based on BTE (2001), Figures 3.25 and 3.27.



firefighting efforts are successful in protecting assets. Some of these costs are very difficult to estimate. Many loss estimates, particularly for historical fires, cover only the direct physical costs of rebuilding and replacing infrastructure.

There are a wide range of environmental impacts associated with bushfire. These include loss of habitat, changes to biodiversity levels, erosion, effects on water quality and carbon emissions. In many cases, bushfire may also bring environmental benefits, such as regeneration of bushland, particularly in low-intensity fires.

## Potential Influence of Climate Change

Over the past 50 years, Australia has become warmer, with reduced rainfall in the south and east. It is likely this has increased the frequency

of dangerous weather conditions. Given that southern and eastern Australia is projected to become hotter and drier over the coming decades as a result of climate change (Christensen and others 2007), further increases in weather conditions conducive to fire are expected (Hennessy and others 2005).

It is likely that higher fire weather risk in spring, summer and autumn will increase the period in which extensive fire suppression efforts are required. This will also move periods suitable for prescribed burning (i.e. hazard reduction) toward winter, and reduce the opportunity for hazard reduction activities (Hennessy and others 2005).

The occurrence of higher temperatures and reduced rainfall could result in drier forests and lower fuel loadings in grasslands. In turn,

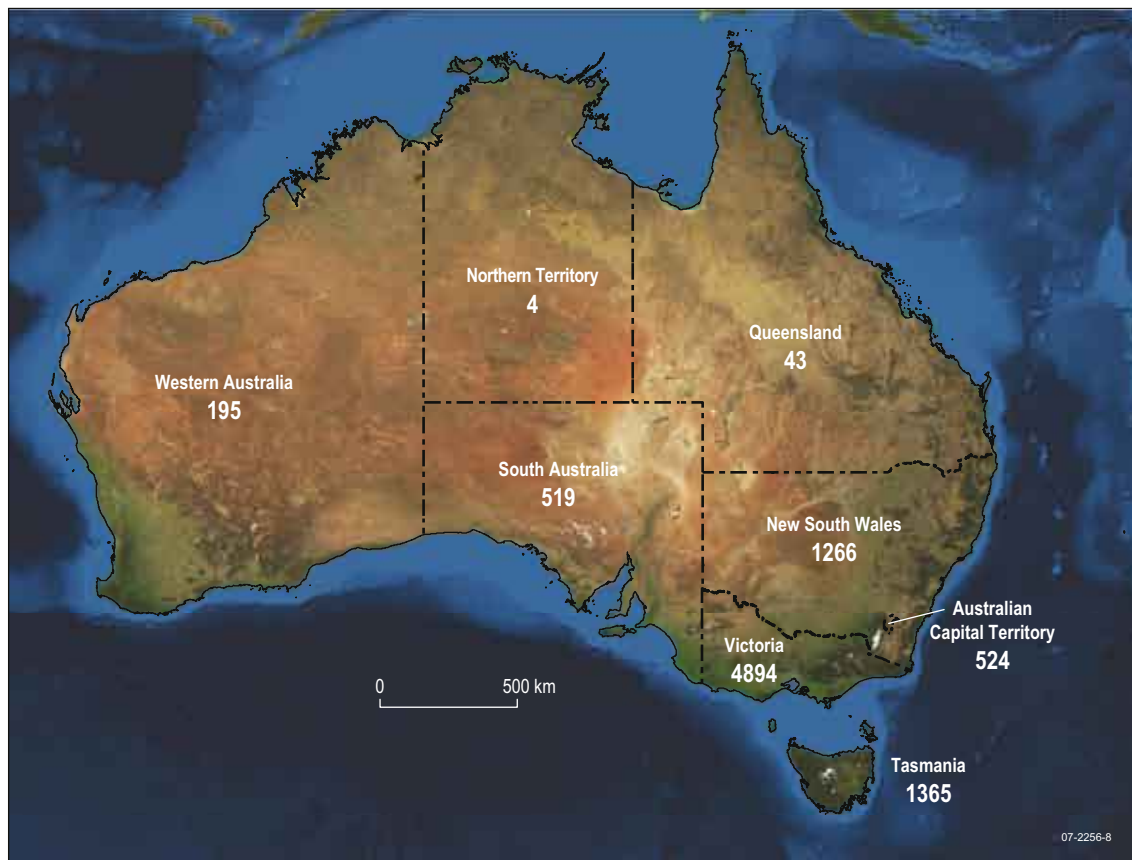


Figure 7.3: House loss from bushfires in Australia by state and territory, 1939 to 2006  
Source: Based on Leonard and others (2006).

this could lead to an increase in the proportion of forest bushfires relative to grassland fires. Conversely, increased rainfall in northwest Australia could result in heavier grassland fuel loadings and more grassland fires (AGO 2005).

## Risk Analysis

The likelihood of bushfire hazard can be summarised in terms of the probability of a fire arriving at a point in the landscape and the intensity of the fire at that point. Consequences of bushfire are highly dependent on the exposure of assets, the landscape immediately surrounding assets, and the nature of each asset—for example, whether it is an occupied structure or a commercial forest plantation. The community's behaviour before, during and after bushfire attack also influences the overall vulnerability of a community.

The lack of a risk assessment framework has been the primary limitation to quantitative risk assessments. Geographic information systems (GIS) have resulted in more accurate inventories

of assets exposed to bushfire. Estimates of asset vulnerability have only recently been undertaken by programmes within the Bushfire Cooperative Research Centre (CRC) (Blanchi and others 2006; Leonard and Blanchi 2005).

## Likelihood Analysis

Likelihood analysis is based on the combination of arrival probability and the intensity of the fire when it arrives. Arrival of a bushfire at a certain point in the landscape is dependent on several factors. Local weather conditions at the time of the fire are important—since the FFDI was introduced, significant house losses have occurred only in cases where the FFDI was observed to be in the extreme range (FFDI >50). The slope and aspect of nearby topography also impacts the intensity of a bushfire. Therefore, to accurately determine the likelihood of arrival requires complex and fine-scale geospatial modelling tools.



*Houses destroyed by the Black Tuesday bushfires in Hobart, Tasmania, February 1967  
Photo courtesy: National Archives of Australia/NAA: A1200, L60753.*



*A bushfire at Moondarra, Victoria, January 2006  
Photo courtesy: CFA Public Affairs.*

Fire spread models such as the *Phoenix* fire model (Clark and Tolhurst undated) can be used to quantify the intensity, size and speed of fires under different weather conditions. Other fire spread models incorporate feedback mechanisms between the fire and the atmosphere, to determine the spread and intensity of bushfires (e.g. Clark and others 2004).

The climatological likelihood of dangerous weather conditions can be determined at regional scales, such as in the work of Hennessy and others (2005). This type of likelihood analysis can be used to inform planning decisions and urban design to minimise exposure to bushfire attack.

Bushfire is one hazard that human action can actively reduce either before or during an event. Through prescribed burns and other fuel reduction activities, the range of weather conditions in which a fire brigade can effectively suppress a fire is increased, reducing the likelihood of arrival at a specific point in the landscape. Further to this, human activity and behaviour are responsible for nearly 50% of bushfire ignitions. Curbing activities that cause ignition—such as burning for land clearing, and arson—can also reduce the likelihood of a bushfire occurring.

### **Data requirements**

The accuracy of fire spread models greatly improves when they utilise high-resolution data on topography, vegetation and meteorology to

predict fire spread patterns for a given scenario. Vegetation and fuel load data are seasonally variable and difficult to determine through spatial means. A combination of aerial photography, predictive models and ground-based validation are the current best practice methods for collecting such information.

Weather conditions such as temperature, humidity and number of days since rain are well-defined inputs, while predictions of localised future weather patterns are highly sensitive inputs for fire spread models. Local-scale influences of topography on wind are challenging to predict, but are important considerations in defining the likelihood of a fire event (Tolhurst and others 2006).

For analysis of possible future events, knowledge of fire-conducive weather frequency is important, preferably at the finest spatial scale possible.

### **Consequence Analysis**

This section focuses primarily on the vulnerability of residential housing. However, it is acknowledged that other assets, including infrastructure (e.g. power utilities), industrial, cultural, environmental and agricultural assets, are also exposed and vulnerable to damage or destruction by bushfire.

The exposure of a structure to bushfire attack can be determined in several ways. The Australian standard for construction in bushfire-prone



areas contains methodologies for assessing the exposure to bushfire attack (AS 3959:1999). Exposure databases can also provide necessary information, such as the proximity of assets to bushland and the construction types of the exposed assets.

Aggregated probability models are often used to determine the impact of bushfire on residential housing (Blanchi and others 2006). The vulnerability of buildings to bushfires varies due to characteristics such as construction material, architectural design, tidiness and proximity to surrounding flammable objects. The Bushfire CRC is conducting research into aspects of vulnerability such as ember attack and ignition, building design, and materials used for windows, facades, water storage tanks and fencing (Bushfire CRC 2007).

Over 90% of all house loss occurs in the absence of direct flame or radiation exposure from the fire front itself. This is directly related to the large influence that human activity (or inactivity) immediately following passage of the fire front has on house loss risk (Blanchi and others 2006). Property owners can greatly reduce the probability of house loss by staying and defending their house from bushfire attack mechanisms such as ember attack and spotting. Often, when a house is lost, it is because of a small construction detail which represents a

weak link in the building design or materials (Leonard and Blanchi 2005).

Studies of past bushfires involving significant loss of houses also provide valuable information on the probability of house loss.

Vulnerability models with broader scope are under development and promise to provide a basis for better overall planning and building provisions.

### *Data requirements*

Broad scale spatial data sets are essential for effective vulnerability analysis at the urban level. A complete exposure database incorporating information on the vulnerability of structures is essential to quantitative risk assessments. High-detail cadastral maps showing property boundaries and building footprints overlaid with high-resolution aerial photography are necessary to determine the spatial relationships between buildings, vegetation and other combustible elements.

At the individual house level, detailed analyses of building design and condition are needed, with close attention given to potential entry points that various fire mechanisms may exploit.

### **Information Gaps**

To develop a comprehensive understanding of bushfire risk, there are areas of knowledge



*Devastation following a bushfire at Seabreeze Avenue in Ferny Creek, Dandenong Ranges, Victoria, January 1997  
Photo courtesy: Emergency Management Australia.*



*A firefighter fighting a blaze from the Great Alpine Road, near Bruthen, Victoria, January 2007  
Photo courtesy: CFA Public Affairs/Martin Anderson.*

where more information is required. Understanding the dynamics of fire behaviour will allow improvements in determining the likelihood of bushfire exposure. Historical fires may provide a wealth of information on the performance of bushfire risk management strategies. The following section outlines some of the information gaps and ways in which they may be resolved.

### Fire Dynamics

Developing more robust theory and models in order to better understand and predict fire behaviour and the ecological impacts of fires, across the range of scales and intensities, is necessary for a number of reasons. One is that fire regimes and ecosystems are very diverse; another is that there are limits to experimentation with high-intensity fires.

### Ecological Impacts

The impact of bushfires on natural ecosystems has been identified as an area requiring improved understanding (Ellis and others 2004). Research in this area is underway, but necessarily requires long-term monitoring of ecosystems and their responses to fires.

### Indigenous Australians' Use of Fire

There is potential for all Australians to benefit substantially from learning from Indigenous

Australians' traditional ways of understanding and using fire. Research into operationally feasible ways of integrating customary and modern practices and technologies will greatly support bushfire mitigation and management.

### Bushfire History

Much of Australia's fire history has not been formally documented, yet history provides a critical insight into the nature and intensity of fires that resulted in loss of life and assets, or had the potential to do so. Recently, individual states have developed methods of recording the spread and extent of fire. Using a nationally consistent methodology and database format would provide an effective basis for verifying and calibrating risk models to underpin future policy decisions.

### Vulnerability Research

The range of assets at risk from bushfire extends well beyond residential buildings—for example, timber plantations and agricultural, cultural and environmental assets are all at risk from destruction from bushfire. Some of these assets, such as power utilities, may be particularly vulnerable to smoke plumes. Exposure data and vulnerability relationships for all assets and people would be a long-term data requirement for any truly comprehensive risk analysis.



## Roles and Responsibilities

As with other hazards, the management of bushfire risk is shared across all levels of government, as well as non-government agencies and groups and the general community. This section outlines the roles and responsibilities of the various stakeholders in the management of bushfire risk across Australia.

### Australian Government

The Australian Government plays a significant role in the management of bushfire risk in Australia. The Australian Government runs the Bushfire Mitigation Programme aimed at identifying and addressing bushfire risk priorities across the country.

The Australian Government also provides weather forecasts and warnings to state fire agencies and the public. This enables fire agencies to prepare for the outbreak of fire on days of extreme fire danger, and to develop strategies for controlling existing fires.

The Australian Government provides national bushfire monitoring services, such as the *Sentinel* mapping system. This delivers information about hotspots to emergency service managers across Australia. The mapping system allows users to

identify fire locations which present a risk to communities and property.

The Australian Government interacts with state agencies in emergency bushfire situations, and acts in a coordinating role between state agencies. In major disasters, the Australian Government provides additional resources such as equipment, medical supplies and Defence personnel, as well as post-disaster relief funds to assist with recovery.

### State and Territory Governments

State and territory fire agencies generally comprise an urban fire agency; a rural fire service covering private property and certain crown lands; and one or more land management agencies covering categories of public lands. State legislation provides for a fire agency to restrict or prohibit the lighting of fires. State agencies with responsibility for issuing total fire bans consult with other agencies, including the Bureau of Meteorology.

State and territory governments have a role in promoting better building design in bushfire-prone areas. State and territory agencies assist in administering the Building Code of Australia, which ensures that buildings in vulnerable areas are built to an acceptable level of bushfire resistance (AS 3959:1999). State fire agencies also



*A destroyed house in the aftermath of the Ash Wednesday bushfires in Macedon, Victoria, February 1983  
Photo courtesy: Emergency Management Australia.*



*A captain on a radio in front of a burning house, Victoria  
Photo courtesy: CFA Public Affairs.*

provide recommendations for town planning to reduce the exposure to bushfire attack.

State and territory fire agencies also interact with other organisations, including local government agencies, across a range of issues, including risk communication and education programmes. Prevention and preparedness strategies to establish community resilience are jointly established by state and territory fire agencies and local government.

State and territory fire agencies assume responsibility for mitigating bushfire hazard by identifying and reducing fuel load (through hazard reduction actions) both in the lead-up to and during the fire season.

State Emergency Services respond to a wide range of bushfire-related incidents, and have important roles in emergency operations. State police and road agencies also are involved, responding to such issues as traffic control, victim identification and asset protection.

### Local Government

Local councils are involved extensively at the prevention and preparation phases of bushfire risk reduction. The issuing of local bylaws and enforcement of building regulations that aim to reduce bushfire risk are important roles for local government. Local government agencies also coordinate community disaster response

plans and facilitate the use of community assets, such as voluntary evacuation centres, in the event of bushfires.

Local government agencies also have a role in developing planning policies that either restrict the spread of residential developments into areas of high bushfire hazard, or prescribe conditions for developments that ensure the provision of buffer zones and design of buildings with high fire safety attributes. These agencies also share in the responsibility for managing fuel loads.

### Industry, Coordinating Groups, Professional Bodies and Research Institutions

The Bushfire CRC brings together researchers from universities, CSIRO and other government organisations, and private industry, to undertake long-term programmes of collaborative research. These programmes aim to achieve real outcomes of national significance in areas such as protecting people and property; preventing, suppressing and managing bushfires; and ensuring community self-sufficiency for fire safety (Bushfire CRC 2007).

The Australasian Fire Authorities Council is a national peak body which provides advice on a range of policies and standards. The Council enables state fire agencies to adopt common practices, resulting in more effective use of interstate resources when required.



The National Aerial Firefighting Centre (NAFC) coordinates a fleet of firefighting aircraft for use by state and territory fire agencies (NAFC 2007). NAFC also assists in developing national protocols for aerial firefighting activities, which assist in minimising the impacts of bushfires.

### Property Developers

There are growing concerns that the spread of urban areas into bushland settings around major cities is creating areas of high bushfire risk. Property developments in these areas need to optimise the desired natural values while minimising fuel loads in the vicinity of buildings. Building design can be adapted to use materials and designs that reduce the risk of embers igniting buildings after the fire front, and provide greater protection to radiant heat.

If requirements for building design, subdivision design and location are considered early in the development process, additional bushfire mitigation costs can be minimised. In most states, development control provisions are in place to provide minimum standards for these requirements.

Forestry plantations are often privately owned, and there is a need to maintain buffer zones

for asset protection around plantations. In some states, regulations exist to provide these minimum requirements.

### Courts and Legal Institutions

Courts are often required to enforce compliance with legislative and local government requirements concerning provisions for minimising bushfire risk. In these situations, courts can be required to decide which piece of legislation should prevail when measures appear to be contradictory: for example, when environmental or heritage protection measures conflict with fuel reduction measures or building codes and regulations.

The decisions of courts in response to litigation associated with bushfire events may result in changes to the legal responsibilities of other groups, primarily state and territory fire agencies and property owners.

### Media

An important role for the media during bushfire events is the transmission of timely warnings and information regarding bushfires. The possibility that power and telecommunications will be disrupted by bushfires makes radio a particularly



*A grassland fire in the Bethungra Hills near Junee, New South Wales, January 2006  
Photo courtesy: Will Barton Photography.*



*Building ruins following a bushfire at Leura in the Blue Mountains, New South Wales, December 1957*  
*Photo courtesy: National Archives of Australia/NAA: A1200, L29036.*

effective delivery mechanism, because people in affected areas can receive information through vehicle or battery-powered radios.

The Australian Broadcasting Corporation has arrangements with state and territory fire and emergency services agencies to transmit urgent safety messages and information during times of bushfire and other emergencies. It is essential that the media report responsibly during these events, and avoid encouraging hysteria through overemphasising the risk or magnitude of an event.

The media also have a role in raising awareness during and ahead of each bushfire season. Involvement includes broadcasting community service announcements encouraging landowners to plan ahead and prepare for the coming fire season, and providing information on fire-related community meetings.

### General Community

Volunteers make up the vast majority of rural fire service members, collectively contributing over 20 million hours annually (Ellis and others 2004). The contribution of these volunteers to minimising the impact of bushfires is invaluable. In addition to actively fighting bushfires, rural fire service volunteers undertake fuel reduction activities and are involved in community education projects to increase awareness of the bushfire hazard.

Residents of bushfire-prone areas need to prepare themselves and their properties ahead of each fire season, in order to increase the likelihood that they and their assets will survive in the event of a bushfire. Activities range from reducing fuel loads around the property (as required by legislation in some states and territories) and performing maintenance on buildings and firefighting equipment, through to planning what actions to take if fire occurs.

Several deaths in recent major bushfires reflected the danger of fleeing a bushfire too late. Occupants are urged to either stay and defend their properties if capable, or to evacuate early before escape routes become affected by fire or smoke. A clear understanding of the nature of bushfire and the specific risks of each situation is paramount to the protection of life and property.

### Conclusion

Bushfires contribute about 7% of the total cost of all major national disasters in Australia at an average annual cost of \$77 million. The records of bushfires in Australia extend back to 1850, with over 700 fatalities recorded since that time.

While large areas of the continent are affected by fire, the greatest losses of property and life occur on the fringes of cities and towns, particularly in southeast Australia. The effects of climate change are likely to result in increased numbers

of days of extreme fire danger in southeast Australia, which will increase the likelihood of destructive bushfires.

A quantitative analysis of bushfire risk is not generally feasible because of the difficulty in spatially defining many of the parameters that affect bushfire likelihood. Probability models of building vulnerability are used in conjunction with exposure catalogues and fire-spread models to provide risk assessments at a regional level.

Improvements in the acquisition of relevant and timely datasets, such as topography and fuel load data, will increase the potential for rigorous, quantitative risk analyses relevant to specific seasonal or even daily weather conditions. Risk assessments will also benefit from ongoing research into the vulnerability of residential housing and other built structures. Across all of Australia, environmental and cultural values must also be considered in assessing the risk from bushfires.

Risk analysis is an important step in justifying and targeting localised actions to minimise bushfire impacts. These actions, which are most often implemented by state or territory fire agencies, are the point where the risk is actually modified. Actions such as fuel reduction by property owners and, importantly, rural fire service volunteers also contribute to minimising the impact of bushfires.



*The fires in Canberra, Australian Capital Territory, January 2003*  
*Photo courtesy: AAP Image/Alan Porritt.*



*A resident battling a blaze from a fire in Farrer, Australian Capital Territory, January 2003*  
*Photo courtesy: The Canberra Times/Andrew Campbell.*

