Living in a land of fire

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Fire: a fundamental force

Fire is an integral part of Australia's natural environment, and of our cultural and social fabric. The first people on the continent learned to live in a fire-prone environment and to manage fire as part of everyday life. Fire was their principal land management tool, and the early European explorers frequently commented on the presence of smoke and recently burned country. European colonists feared bushfires and used fire to help clear native vegetation for agriculture; they sought to prevent and suppress bushfire to protect life and property. Contemporary Australian land managers are using fire in primary production, for biodiversity conservation, and for the protection of life, property and other assets.

Bushfires will occur at some time in most parts of the Australian continent, although they might be very infrequent in some climatic zones, such as those dominated by rainforest or wet eucalypt forest. The average interval between fires in southern rainforests could be hundreds of years. Between four per cent and ten per cent of the continent (about 32–80 million hectares) might be burnt in a typical year, thereby suggesting an average interval between fires for the continent of about 15 years: in the severe fire season of 1974–75, about 15 per cent of the land area of Australia was burnt (Luke and McArthur 1978), and in 2002–03, a severe fire year in south-eastern Australia, seven per cent (54 million hectares) was burnt. Years in which bushfires cause the most serious threats to lives and property in Australia are typically serious drought years in southern Australia.

The greatest extent of bushfires in any one year is almost invariably in the savannas of northern Australia. Fires at any one point can occur every second year in some places. In some seasons, fires extend into the semi-arid and arid interior, especially following the rare years of significant arid-zone rainfall. For example, rainfall in Central Australia was well above average in 2001, and consequently abundant grass growth in 2002 fuelled the most extensive burning there for 25 years. The greater the average extent of fires, the shorter the average interval between them.

Given the extent and significance of bushfires in Australia, fire features in most themes in any assessment of the state of the Australian environment. For example:

- fires affect the atmosphere through the local and regional impacts of smoke on air quality, and through the global effects of carbon being released from biomass burning
- fires affect biodiversity both in the short term through impacts on individual organisms and the populations of which they are part, and over the longer term through effects on species, ecosystems and habitat
- the effects of fires on human settlements, through threats to human life and property, can be very significant, but can also be substantially mitigated through good planning and preparedness, and effective suppression
- fires affect inland waters by altering catchment hydrology and water quality in rivers and dams, and because they are integral to the ecology of wetlands.
- Fires affect land through both the landscape- and local-scale impacts of uncontrolled fire, and the managed use of fire for fuel reduction and as a tool in farming and forest management systems
- Fire has shaped much of Australia's natural and cultural heritage: Indigenous Australians cared for their country with fire, and the cultural heritage of graziers depends in part on the use of fire; but fire can also threaten sites and structures of cultural significance to both Indigenous and non-Indigenous Australians
- The links between fire and coasts and oceans and between fire and Antarctica are not so obvious, but are nevertheless real. Fires in coastal zone vegetation can impact on coastal and near-shore marine environments, and global climate change, to which carbon release by bushfires contributes, is affecting Antarctica

Fire in Australian environments

Every fire is different, because its behaviour and impacts depend on particular weather conditions, topography, fuel loads and distribution, and on suppression activities. The impacts of successive fires on the environment depend on their frequency (or ‘between-fire interval’), intensity, seasonality and type (namely ‘peat’ or ‘above-ground’). Together these characteristics are known as the fire regime. The concept of the fire regime is now recognised as central to understanding the ecological impacts of fire. Understanding the fire regime is also important for defining risks to people and property, and for mitigation and management decisions (Bradstock et al. 2002).

A particular species or ecosystem is likely to respond differently to a regime of high-intensity canopy fires than it would to a regime of low-intensity surface fires, to fires in milder winter or spring conditions than to fires in drier late summer or autumn conditions, or to a series of fires in successive years than to infrequent fires many decades apart. If the fire regime is altered to one outside the bounds under which species and ecosystems evolved, there are likely to be detrimental effects on those species and ecosystems.

Fire regimes have varied over time in any one location on the Australian continent. The wetter, rainforest-clad continent of 45 million years ago dried out as it moved northwards following the break-up of Gondwanaland; vegetation changed to a sclerophyll-dominated flora in many areas, and the extent and frequency of fires increased (White 1998). Periodic climatic oscillations produce drier periods with recurrent large-scale fires, and contraction of the extent of vulnerable plant communities (Bowman 2003, Lindesay 2003).

Indigenous occupation of Australia altered the fire regime, but detailed evidence of specific impacts is not yet conclusive. The extent of Indigenous burning undoubtedly varied from place to place (see, for example, chapters by Bowman, Hill and Liddle in Cary et al. 2003), depending on climate and vegetation; we might expect that Indigenous peoples living on the coast or on rivers influenced fire regimes differently to those living in rainforests, or in regions with little surface water. Climatic variations such as El-Niño would have interacted with anthropogenic fire regimes, as they do now.

European settlement altered prevailing fire regimes, with effects such as increased fire frequency associated with land clearing, decreased fire frequency due to suppression in settled areas and, more recently, changed fire frequencies, intensities and seasons of burning associated with large-scale fuel-reduction burning in forests, woodlands and heathlands. The removal of Indigenous people from their country as a result of European settlement in much of Australia, and subsequent changes to Indigenous peoples’ way of life, has also profoundly altered fire regimes across Australia. For example, the breakdown of traditional burning practices in northern Australia has led to a far higher incidence of large-scale, wildfires late in the dry season (Russell-Smith et al. 2003).

The seasons in which fires typically occur vary across the Australian continent; fires in northern Australia occur during the dry season in ‘winter’ and ‘spring’, while in the southeast and southwest the fire season is in summer and autumn. Fire regimes vary across Australia. Fires are absent or exceptionally infrequent in rainforests, and of low intensity when they do occur unless the forest has been disturbed by cyclones, logging or frost. Fires in wet sclerophyll forests are infrequent but are often of spectacularly high intensity when they do occur; the average interval between any two fires in Mountain Ash (*Eucalyptus regnans*) forests in Victoria was estimated to be 37–75 years, and that of intense, tree-killing fires to be 75–150 years (McCarthy et al. 1999). Fires in temperate heathlands may typically occur at intervals of between seven and 30 years, whereas fires in tropical savanna woodlands and grasslands may occur every other year on average (see Table 1 for further examples). Without strong human interference, the intervals between fires vary widely in relation to the average. This variation can be important to the persistence of some species such as Leadbeater’s Possum (Mackey et al. 2002).

Contemporary Australian fire science and management use the concept of fire regime as the framework for understanding the complex relationships between fire and the Australian environment (Bradstock et al. 2002, Cary et al. 2003). The framework allows the development of both principles for managing fire to achieve conservation goals and of operational guidelines for ecologically sustainable fire management, informed by appropriate research studies (for example, the Jervis Bay Fire Response Study, or the Kapalga Experiment).

Environmental effects of fire

The environmental effects of fire regimes are determined by the life-history and demography of organisms, the landscape context of the fire, the fuel environment, and fire risk reduction and suppression activities.

Life-history and demography

Not all plants respond the same way when burned by a bushfire. Some die, others resprout, and others still appear little affected. Some of these differences are due to the individual species, some are due to the characteristics of the fire, and some may be due to the particular environmental conditions before and after the fire.

Some species (such as some *Xanthorrhoea* species) flower abundantly soon after fire, while others (such as *Eucalyptus delegatensis*) may take more than a decade to produce their first seed. Some plant species appear on burnt ground as if from nowhere because they were not obvious before the fire. They have regenerated from the germination of seed buried in the ground, stimulated by heat or smoke or the reduced competition following fire. This phenomenon is particularly evident in the sandy deserts of Australia.

Some woody plants of heaths and forests are killed by fires even if they are only just intense enough to scorch the foliage, let alone defoliate the canopy. Many of these species bear canopy-borne cones or capsules, which open and release their seeds after fire. Such species include the common *Banksia ericifolia* around Sydney, *Banksia ornata* in South Australia, *Eucalyptus regnans* in Victoria and Tasmania, and *Callitris* species in many parts of the country. Species such as these are of special management interest because they are vulnerable to short intervals between fires, and can be easily driven to local extinction.

Animal species also behave differently in the face of fires. Koalas are an example of a species that is inevitably exposed to fire, but which can survive if fires are of insufficient intensity to kill foliage. More mobile species may find refuge in burrows. Some, like the iconic Frill-necked Lizard of the tropics may have high mortality rates in a high intensity fire, but nevertheless sustain higher populations after fire because of rapid reproduction or migration from adjacent areas (see Corbett et al. 2003), perhaps because habitat quality improves as a result of fire. Indeed, the effects of fires on mammalian habitats may generally be more important for the survival of the species than the direct effects on the animals themselves (Friend and Wayne 2003).

Fires occur at various scales and with variable patchiness (Gill et al. 2003) and different plants and animals may respond to these differently. Such topics are complex and much is to be learned about the effects of patchiness in single fire events and its flow-on effects through fire regimes.

Table 1: Suggested fire intervals for vegetation types in Southeast Queensland

Vegetation type	Fire intervals in years
Rainforest	Fire exclusion
Wet sclerophyll forest	20–100+
Grassy dry sclerophyll forest and woodlands	3–6
Shrubby dry sclerophyll forest and woodlands	7–25
Coastal heathlands	7–20
Inland (rocky) heathlands	15–50
Paperbark (*Melaleuca quinquenervia*) woodlands	15–30

Source: Fisk et al (2003, Table 7.5)

Landscape

The landscape context for fire is important at a range of scales, from the broad gradients in fire seasonality and occurrence, such as those from north to south across Australia, to the much finer-scale variation of topography, vegetation and fire histories in particular landscapes (for example, Allan and Southgate 2002).

The character and composition of landscapes—particularly their topography, their ecosystems and the extent to which they are fragmented and modified, and the forms of land use and management—have significant implications for fire occurrence, behaviour and impacts. Conversely, the same fire can have differential impacts on different parts of the landscape. These effects may be benign for biodiversity in conservation reserves, adverse for primary production systems, and problematic for water quality.

Fuel environment

Each of Australia's thousands of ecosystems has particular fuel characteristics, in terms of quantity, distribution, persistence and flammability. Because fuel and ignition are the significant determinants of fire behaviour that people can modify (the others are weather and topography), fuel management—for example, through fuel reduction burning or physical removal—is a central activity in fire management by both Indigenous and non-Indigenous Australians.

The introduction of exotic plants and animals, and changes in populations of native herbivores, can have major consequences for the fuel environment. For example, when a highly productive grass such as Gamba Grass is introduced in northern Australia, higher fuel loads result. This is in part because previously disconnected or poorly connected fuels become more contiguous if the new species fills a habitat gap; this is also the case with Buffel Grass in the arid and semi-arid zones, and with some Mediterranean-climate grasses (such as Veld Grass) in southern Australia. Conversely, the introduction of domestic livestock and of browsing pests such as rabbits, or the increased populations of native herbivores such as kangaroos associated with particular land management practices, may diminish fuel loads in some environments through grazing pressure.

Fire risk reduction and suppression activities

Fire risk reduction and suppression activities have the potential to change the environment directly, and indirectly through altering fire regimes. Fuel modification is fundamental component of fire risk reduction, as discussed above and by Ellis et al. (2004). Because fuel reduction burning is the only feasible means of fuel reduction on a landscape scale, it is widely used throughout Australia. Understanding the implications of fuel reduction burning for biodiversity, and developing burning regimes that strike the appropriate balance between fire risk reduction and biodiversity conservation, is a major challenge for land managers (see, for example, Luke and McArthur 1978, Whelan 1995, McCarthy et al. 1999, Bradstock et al. 2002, Abbott and Burrows 2003, Andersen et al. 2003, Cary et al. 2003, Esplin et al. 2003, Ellis et al. 2004).

Fire suppression activities may involve backburning, construction and use of fire trails, and the use of chemical retardants. Each of these can have adverse environmental impacts, although these can be minimised with good planning and management (see, for example, Esplin et al. 2003).

In conclusion, the impact of a particular fire event on the environment depends principally on its context within the fire regime under which a particular ecosystem has evolved. Research will help all Australians better understand how to better manage fire to achieve positive environmental outcomes with minimal impacts on life, health, property and other private and community assets.

Effects of fire on life, health, property, infrastructure and primary production

In addition to their impacts on the environment, fires have significant impacts on life, health, property, infrastructure and primary production systems. Over the past 40 years, fires have claimed more than 250 lives, making them the most hazardous form of natural event in Australia. Their financial cost, around $2.5 billion over the same period, represents about ten per cent of the costs of natural disasters in Australia (Ellis et al. 2004). Low-intensity cool-season fires and intense uncontrollable fires can affect human health through reducing air quality.

The majority of the impacts on life, property and infrastructure occur in southern Australia, where human settlement is greatest and where extreme fire weather conditions occur in most summers. Better community knowledge and understanding of how to prepare for and respond to fire, better planning of developments, and better building design and maintenance are all necessary complements to effective bushfire readiness and response in minimising the risks from bushfire to people, their health, property, infrastructure and production systems.

Fires may be used on grazing properties to remove low palatability material, kill woody plants and promote grass regeneration. The Tropical Savannas CRC has done extensive work on fires in pastoral lands.

Living in a land of fire: achieving better outcomes for people and the environment

Fires have played an important role in shaping Australia's environment, and particular fire regimes are necessary to maintain most Australian ecosystems and much of Australia's biodiversity. It is also the case that fires threaten lives and health, property, infrastructure and primary production systems. An individual fire, and a particular fire regime, can have both favourable and adverse effects on different sorts of assets across the landscape. For these reasons, managing fire and fire-prone landscapes presents significant challenges to Australians. Developing knowledge and understanding in the Australian community, policies and institutional arrangements that foster both best practice and best use of resources, and the most appropriate and adaptive management practices, are key elements of meeting these challenges.

Responses to these challenges need to account for changing demographics, such as the increase in number of rural residential properties, and the migration of Australians to the coastal zone, and for climate change; under probable climate change scenarios, changes to vegetation growth will change fuel types and loads and, under the influence of changing ignition patterns, change fire regimes. For example, the report of the inquiry into the 2002–03 Victorian bushfires discussed 'The changing Victorian environment', which included:

- changing population distributions (reducing in some fire risk areas, such as rural communities, and increasing in others, such as urban fringes)
- changing distribution of land uses across the landscape (for example, the size of the Victorian national parks estate has increased from four to 15 per cent of the state since the early 1970s)
- changing attitudes to the use of fire and technologies for fire suppression
- changing climate, causing an increased bushfire risk.

There is increasing interest in improving the engagement of Indigenous people in contemporary fire management, especially in northern Australia where Indigenous people are major landowners and much traditional ecological knowledge persists (Horstman and Wightman 2001; Hill and Nowakowski 2003; Russell-Smith 2002. This issue remains contentious because of uncertainty over the ecological impacts of traditional fire management and its relevance to contemporary conservation values. The case seems compelling, given that fire is currently unmanaged throughout many remote regions, and local Indigenous communities wish to play a more active role in land management as part of a broader agenda of sustainable livelihoods for Indigenous people living in outback Australia. Moreover, although Indigenous people have fundamentally different value systems in terms of people's place in nature and the value of biodiversity, there is a lot of common ground with mainstream Australians in wanting to 'look after country'.

Policies and institutional arrangements

There are two key elements of improving the policies and institutional arrangements that are related to fire. The first is better coordination between the Australian, state and territory governments, and between agencies in each jurisdiction (Ellis et al. 2004), about all aspects of fire mitigation and management. The second is the adoption of a structured risk-management process to provide the most appropriate framework for effective planning in relation to fires, and for preparedness and response to them. A risk management approach focuses attention on the context in which fires occur—the local community and its assets, the environment, and the available resources for mitigation and response—as well as on the threats bushfires can pose.

The starting point for a risk management approach to the complex challenges of fire management is to establish the context; this necessitates the identification of all the assets that might be threatened by, or might require, particular fire regimes. These assets include life and property, biodiversity, cultural heritage, ecosystem components such as air and water quality, infrastructure, and production systems such as agriculture and planted forests. As Kanowski et al. (2005) commented:

> One of the greatest challenges to bushfire mitigation and management is the development of a broad-based agreement within the community about the nature and relative importance of assets that are potentially threatened by fire, and about the appropriate forms and processes of risk modification. For example, significant tensions may exist between development interests and bushfire risk avoidance strategies that focus on limiting new development in high-risk areas. Similarly, the debate between proponents and opponents of broad-scale fuel-reduction burning strategies has as one of its bases the different relative values ascribed to the protection of property and other human assets, on the one hand, and environmental assets such as biodiversity or air quality, on the other.

Reaching general agreement about priorities in fire risk reduction, and management practices to deliver them, will often demand community and scientific debate, such as that about prescribed burning for property protection and biodiversity conservation, or about land management practices such as cattle grazing in alpine areas.

Building the knowledge and information base

Better knowledge and information are fundamental to better management of fire in the Australian environment. The Ellis et al. (2004) identified knowledge and information priorities for Australian bushfire mitigation and management:

- establishing and maintaining a national program of fire regime mapping, which draws on new technologies such as that provided by the Sentinel satellite-based fire mapping system and the Western Australian Department of Land Information AVHRR imagery
- establishment of a network of long-term ecological research sites and studies, such as at Jervis Bay; or Kapalga, to monitor the impacts of fire regimes and fire events
- better characterisation of fire behaviour and ecological responses to fire, to inform land and fire management options
- better understanding of climate and climate change consequences for fire regimes and impacts
- establishment and maintenance of a suite of nationally-consistent databases and data products relevant to bushfire and the integration of this information into adaptive-management processes

- better knowledge of how building design and materials can minimise risks to life and property
- enhanced understanding of individual and community psychology and social processes relevant to bushfire preparedness and response
- better understanding of Indigenous Australians' knowledge and use of fire, and how traditional and modern knowledge and practices might be best integrated to enhance fire management
- development of a national strategy to build and sustain research capacity, and to share individual and organisational learning.

Implementing strategic planning and management to minimise risks to assets

The size of Australia, its relatively small population and land management agencies, the fragmented landscape resulting from European settlement, the fire prone nature of most Australian ecosystems, and the inevitable occurrence of severe fire conditions, mean that it will never be feasible—even were it desirable—to maintain fuels at a sufficiently low level to prevent fires, nor to suppress all fires in Australia (Kanowski et al. 2005). Rather, land managers and fire agencies need to use their resources strategically to minimise the risk that fires pose to life and to assets of all forms.

In most Australian states and territories, this is now being achieved through the development of various forms of landscape and fuel management planning and zoning. Interface zones—between rural and urban land uses, and between primary production and conservation reserves—are usually the parts of the landscape in which fire poses the greatest risks to lives, property and economic values. Such interface zones are a high priority for fuel management as well as for other preparedness activities, especially where land uses and management objectives preclude wide-scale fuel reduction across the landscape.

Maximising the effectiveness of this strategic approach to fire risk minimisation depends also on much better evaluation by land managers and fire agencies of the effectiveness of fuel reduction and other risk minimisation measures. Drawing on the work of the COAG Report, Kanowski et al. (2005) suggested that this would require:

> … implementation of systematic monitoring and evaluation processes [across all land tenures] that allow (i) accurate measurement and mapping of fuel-reduction activities and fuel loads, (ii) accurate mapping of unplanned fires across a landscape, (iii) detailed analysis of the behaviour of the unplanned fires against the 'fuel-landscape', and (iv) detailed analysis of the pattern of damage to the various assets in the landscape.

This approach to bushfire risk minimisation and to bushfire management offers the best prospects for resolving tensions between different land and fire management objectives, and for protecting life and property whilst also protecting environmental assets. It is embodied in the principles, which the COAG Report (Ellis et al. 2004) argued should guide how Australians live with fire in the future.

Conclusions: living in a land of fire

Fires are an inherent part of the Australian environment. They cannot be prevented, but the risks they pose—to life, health, property and infrastructure, production systems, and to environment values—can be minimised through systematic evaluation and strategic planning and management.

Fires have a fundamental and irreplaceable role in sustaining many of Australia's natural ecosystems and ecological processes, and they are a valuable tool for achieving many land management objectives. However, if they are too frequent or too infrequent, too severe or too mild, or mistimed, they can erode ecosystem 'health' and biodiversity and compromise other land management goals—just as uncontrolled fires can threaten life, property, infrastructure, and production systems.

Australians have been learning to live with fire since Indigenous Australian's migration to the continent. The COAG Report envisaged a future in which Australians continued this learning process, to better understand the nature of fire in Australia, and to better achieve both protection of life and property and conservation of Australia's unique environment.

Case-study 1: Air quality

Emissions from bushfires can affect human health through increasing the levels of smoke particles, carbon monoxide, air toxics and volatile organic carbons in the air, and they can raise the concentration of ground-level ozone. The nationally-agreed standards for air quality, the National Environment Protection (Ambient Air Quality) Measures, specify threshold levels for pollutant emissions; for example, for particles of 10 microns or less in diameter (PM_{10}) is a maximum mean atmospheric concentration of 50 $\mu g/m^3$ over a 24-hour period.

Major bushfire events typically generate particulate concentrations well beyond the threshold National Environment Protection Measures level. For example, in the 1994 Sydney bushfires, the peak was 210 $\mu g/m^3$ (compared with a background level from non-bushfire sources of 30 $\mu g/m^3$); during Sydney's Christmas 2001 bushfires, levels above 150 $\mu g/m^3$ were sustained for ten days; in Canberra on 18 January 2003, the maximum level was 192 $\mu g/m^3$. Fuel reduction burning can also prejudice air quality, especially because the weather conditions under which it is carried out can mean that emissions are retained in urban air sheds for extended periods.

Although studies in the 1990s failed to find statistically significant correlations between bushfire smoke and asthma, a study in Darwin from April to October 2000 did reveal a relationship. Darwin experiences bushfires throughout the dry season: planned fuel reduction burning occurs mostly from April to June, and unplanned bushfires occur mostly late in the dry season. The study examined the concentration of respirable particles arising from all bushfires (both planned and unplanned) with attendance at hospital. The PM_{10} levels ranged from only two to 70 $\mu g/m^3$, with peak fire activity in September, when the National Environment Protection Measures standard was exceeded on five days. There was a significant increase in asthma presentations to hospital with each 10 $\mu g/m^3$ increase in PM_{10}, especially when the PM_{10} level exceeded 40 $\mu g/m^3$. The study concluded that airborne particulates from bushfires should be regarded as just as injurious to human health as airborne particulates from other sources.

The challenge to land and bushfire managers is to manage fuel loads without exceeding threshold air quality standards. An example of how this challenge is being approached is that from south-west Western Australia, where a regular program of fuel reduction is undertaken, mainly in spring. In response to concerns about impacts on air quality in Perth and other urban centres, the Western Australian Government has developed an Air Quality Management Plan. The public land manager, the Department of Conservation and Land Management, is required to plan its fuel reduction activities to minimise urban air quality impacts. It has been largely successful in doing so, with national standard thresholds now exceeded only rarely.

Land and bushfire managers in other Australian states and territories are responding similarly to minimise the adverse impacts of emissions from bushfires on air quality and human health. These mitigation strategies are being informed by research coordinated by the Bushfire Cooperative Research Centre.

Case study 2: Weeds compromise fire management: Gamba grass in northern Australia

Introduced invasive plants pose a major threat to biodiversity and ecological function throughout the world, and their ecological impacts can include significant changes to fire regimes. The management of such invasive plants is extremely challenging even when there is widespread support for their control. However, management is especially problematic when negative impacts in some situations need to be traded off against benefits in others. This is the challenge presented by the African Gamba Grass (*Andropogon gayanus*) in northern Australia.

Gamba Grass was introduced into northern Australia in the 1930s as a pasture grass, and it is highly valued by the northern pastoral industry. This introduced grass is now well-established outside pastoral systems, and its rate of expansion seems to be accelerating. Its success as an invader is due to exceptionally high seed production combined with an ability to colonise a wide range of habitats, regardless of canopy cover or ground disturbance.

Gamba Grass is an extremely tall (up to five metres) perennial grass that produces fuel loads that are on average four times higher than the native species it replaces (mostly annual species of sorghum). It cures later than annual sorghum, and remains erect for longer into the dry season. The higher fuel loads combined with changed fuel architecture results in fires almost an order of magnitude higher in intensity than those fuelled by native grasses. Furthermore, Gamba Grass rapidly re-sprouts following fire and can attain sufficient biomass to support another fire within the same dry season. It therefore has the potential to cause a dramatic alteration of regional fire regimes.

There is widespread concern that the high fire intensities fuelled by Gamba Grass are causing extensive tree death, precipitating what savanna ecologists refer to as a grass–fire cycle. Under this scenario, a decline in tree cover facilitates further grass invasion, leading to more severe fire and further tree decline. Such a self-perpetuating cycle has the potential to transform open forests and woodlands to treeless grasslands, as has indeed occurred following grass invasion elsewhere in the world. There is evidence that this is already happening in the Darwin region following Gamba Grass invasion.

The high fire intensities generated by Gamba Grass pose a threat not only to biodiversity and ecological function, but also to human life and property. Historically, the need to protect lives and property has not been a major driver of fire management in northern Australia because fires are of relatively low intensity and occur in landscapes sparsely populated by people. Invasion by Gamba Grass has now brought high intensity fire to where people live, introducing an unprecedented fire risk.

Case Study 3: Integrating Indigenous and western knowledge systems for land management

Landscape fire is fundamental to traditional Indigenous society as it has played a key role in natural resource management, as well as serving a variety of cultural and spiritual needs. In the north, where Indigenous people are major landowners, fire management remains an integral part of Indigenous life. Although Indigenous fire management had been severely disrupted, much of the traditional knowledge has been retained, and can be re-applied to landscape management (Horstman and Wightman 2001).

This opportunity is being realised by a family of traditional owners in Kakadu National Park, who are re-applying Indigenous fire management at Boggy Plain, a Ramsar-listed wetland on the floodplain of the South Alligator River. Boggy Plain is a site of outstanding biodiversity and it is also an important place for hunting and harvesting by Indigenous people. It is habitat for species including the Magpie Goose (historically, up to 85 per cent of the total Northern Territory's magpie geese have gathered there to feed) and the Long-necked Turtle.

These species, along with a range of water plants such as water chestnuts (*Eleocharis* species), Wild Rice (*Oryza rufipogon*) and Red Lily (*Nelumbo nucifera*), are important food resources for local Indigenous people. Following removal of the Asian water buffalo from Kakadu in the late 1980s, the wetland became overgrown with a grass, *Hymenachne acutangula*, reducing both biodiversity and food availability for Indigenous people.

To senior traditional owner Violet Lawson, the solution was clear—fire needed to be reintroduced to Boggy Plain. Since 2001, Violet's family have set about burning Boggy Plain, based on traditional knowledge handed down from Violet's mother and father. This knowledge has been passed on to Violet's children, and in turn it is being passed on to their children.

The family has implemented a pattern of repeated burning over November and December when the wetland has little standing water, and few birds are in residence. The Hymenachne is still green, so the first fires just burn the drier bases, causing the grass to fall over and die. This provides fuel for subsequent fires. The fires are all relatively low intensity, and the surrounding woodland margins are burnt early in the dry season (April and May) to prevent the flames escaping into the broader landscape.

Using fire, the family has transformed the wetlands of Boggy Plain from a dense thicket of grass into a mosaic of habitats that is rich in biodiversity and of greatly enhanced cultural value to Indigenous people. With support from Parks Australia and the Environmental Research Institute of the Supervising Scientist, Violet's family have been monitoring the changes in vegetation since they began burning. Vegetation change is being assessed using a combination of historical aerial photographs (from 1950 to 1991), Landsat satellite imagery, real-time, high resolution Quickbird satellite images, and ground-based surveys.

More recently, CSIRO has joined the partnership and the project is institutionalised under the national Bushfire Cooperative Research Centre. As employees of CSIRO Sustainable Ecosystems, Violet's daughter Sandra McGregor and son-in-law Peter Christophersen are now quantifying the extent to which fire has enhanced hunting and plant harvesting efficiency, and are assessing the contribution this makes to the regional Indigenous economy.

The project has achieved a range of beneficial ecological, social and economic outcomes, including:

- enhanced biodiversity in Ramsar-listed wetlands within a World Heritage National Park
- enhanced cultural value of the wetlands in terms of increased availability of important food resources for Indigenous people
- intergenerational transfer of traditional ecological knowledge, from old people to children
- demonstration of the value of combining two knowledge systems, traditional ecological knowledge and Western science.

The Boggy Plain project serves as an internationally significant model for integrating Indigenous and Western knowledge systems to achieve positive outcomes for both traditional resource use and the conservation of biodiversity. It has received formal recognition as such through its achievement as a finalist in the inaugural Northern Territory Research and Innovation Awards. The lessons learnt are now being applied to enhance biodiversity and the tourist experience at Kakadu's most iconic wetland, the internationally acclaimed Yellow Waters.

Case Study 4: Biodiversity conservation and life-and-property protection

Bushfires hit the headlines in southern summers, emphasising death and destruction. The media often report 'destruction' of the bush as well. The bush is not destroyed; fires have occurred before, over many millennia, and the bush has recovered. Plants regenerate and animals survive, even when no one could imagine that this could be the case, such as when fires burn through the crowns of woody plants and a completely blackened scene is created. Recolonisation starts occurring after the bush has been burned (not 'destroyed'). Burning can certainly cause changes to the bush—population sizes of plant and animal species will change and it is possible that some species may be lost from a burned area, temporarily or even permanently.

Bushfires focus our attention on individual people and individual structures as priceless assets, and as a society we face a complex challenge of finding ways to protect these human assets. The lower the intensity of a fire, the easier it will be to protect adjacent property. Fuel is the one factor determining fire intensity that humans can manipulate readily. If fuel is limited, then fires cannot reach the same potential that they could if fuel was allowed to accumulate without restriction. This principle underlies fuel-reduction burning as an approach to bushfire mitigation. Fires that are prescribed to achieve fuel-reduction need to be repeated frequently enough to keep the fuel below certain critical levels.

The persistence of plants and animals is influenced by their inherent characteristics and by fire intensity, interval between fires, seasonality, and type of fire over a period of time—this is referred to as the *fire regime*. Not all species respond the same way, so there is a variety of responses to each individual fire as well as to the fire regime. Species may be favoured by one fire regime but be threatened by another. Thus, 'inappropriate fire regimes' are quite often listed as threatening processes in legislation. An inappropriate fire regime for some species may be frequent fires, whereas lack of fire, or high intensity fires, or low intensity fires may be inappropriate for others.

Biodiversity is a convenient term that is used to describe aggregates of species, which, in turn, are aggregates of populations and individuals. Conservation of biodiversity is about avoiding the extinction of local native species. A common misconception is that all Australian species are unaffected by fires. Research clearly shows that the flora and fauna may be adapted to certain fire regimes but not to others.

In many environments where human assets abut bushland in which conservation of biodiversity is a key management objective, achieving a fire regime that facilitates protection of property will compromise conservation of some species. This situation is at the core of many heated arguments about bushfire mitigation strategies—protection of properties *versus* conservation of biodiversity.

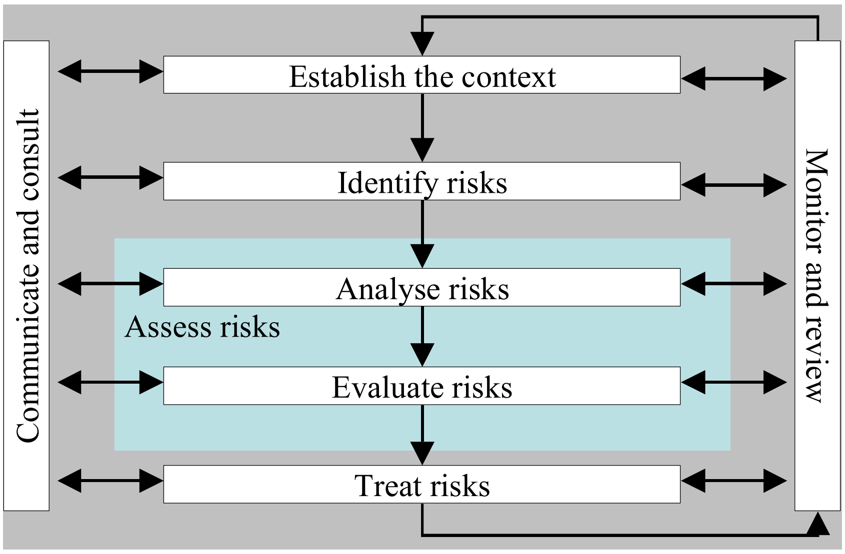
This is a very complex issue that is often treated simplistically; a simple response for property protection (reduce fuel over the whole landscape) will compromise biodiversity conservation, and a simple conservation response (avoid fire regimes that are inappropriate for the local biodiversity) will compromise property protection. Even recent suggestions that using fuel-reduction burning to create 'mosaics' of different fire ages will provide fire protection for houses without damage to the environment are simplistic. Mosaics come in many forms and create their own arrays of fuel patterns and fire regimes that will have as yet untested effects on the potential for protection of property and biodiversity change.

Effective responses to this 'land use conflict' will require a more sophisticated understanding of the locations of biodiversity assets in the landscape, the responses of organisms to particular fire regimes, and bushfire behaviour in particular situations of fuel load, fuel distribution, topography and climate.

A risk management approach to bushfires

A risk-management process provides an appropriate framework for effective management of bushfires in a complex and changing landscape; especially because risk management focuses our attention both on threats and emergencies and also on the context in which these are set—the local community, the environment and available resources. The main elements of this framework are illustrated in this Figure 4.1 from the COAG Inquiry into Bushfire Mitigation and Management.

Figure 4.1 The risk management process



Source: Standards Association of Australia 1999, AS/NZS 4360:1999 Risk Management.

- *Establish the context*. This requires the identification of all assets, the determining of their locations in the landscape, and the articulation of the particular objectives relating to each asset from the perspectives of those groups that value (or benefit from) from the asset. Assets encompass all ecological, social, cultural and economic values.
- *Identify the risks*. In this stage, factors contributing to the likelihood of adverse effects in the event of fire are identified. Key characteristics of the environment (built, natural and social) within the landscape are investigated to determine the vulnerability of each asset.
- *Analyse the risks*. The likelihood of a bushfire occurring is assessed, using historical information and past experience. The probable impacts of a fire are identified for the set of identified assets and values within the landscape or region.
- *Evaluate the risks*. The levels of risks determined during the analysis phase are compared and priorities for further action are developed. This includes evaluating tradeoffs between different assets and values, especially ecological *versus* economic. As part of the comparison, some assessment is made of how particular treatment options will alter the levels of risk.

- *Treat the risks*. This is the implementation phase. Treatments are applied to (i) avoid the risk (for example, land use regulations), (ii) reduce the risk (for example, building regulations, fuel-reduction), (iii) spread the risk (for example, sharing responsibility for readiness between fire agencies and residents), and (iv) manage the residual risk (for example, effective fire suppression plans, community and agency readiness, emergency response).
- *Monitor and review*. Risks and risk-treatment strategies need to be monitored to ensure that they remain relevant and effective.
- *Communicate and consult*. Communication and consultation are critically important at each stage of the process. Those responsible for implementing risk management and those with a vested interest must understand the basis on which decisions are made and why particular actions are required. Creating ownership of the plan is critical to successful implementation.

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