Fire Management Strategies for a South West Australian Biodiversity Hotspot

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Introduction

Australia is an island continent of extraordinary biological diversity, predominantly shaped by diversity of climate and geomorphology. Within this relatively stable patterning of biodiversity, bushfire is an ecological process that impinges on almost all ecosystems, providing a finer grained and dynamic diversity overlay to that established by climate and geomorphology. Over millions of years, fire has played an important role in shaping the structure, composition and functioning of ecosystems. The Australian biota displays an array of fire adaptations that enables organisms to persist, and in many cases, depend upon fire.

Anthropogenic fire has been part of the Australian environment for tens of thousands of years. Following European settlement in 1788, the Australian landscape changed dramatically, including the perceptions about fire, its role and use. To Aboriginal people, fire was a friendly force fundamental to survival on this dry, nutrient depleted continent. To most Europeans, fire was a terrifying agent of destruction, to be fought and suppressed at every opportunity. The challenge for Australian conservation agencies is to develop and implement fire management programs that conserve biodiversity and which provide an acceptable level of protection to human life, property and industry. The key to success is to maintain prescribed fire in the landscape at appropriate temporal and spatial scales. This summary outlines how altered fire regimes pose a threat to biodiversity and presents broad strategies being developed and implemented to conserve biodiversity in a south-west Australian biodiversity hotspot.

The scenario of altered fire regimes lends itself to analysis and resolution using the OECD pressure-state-response model. The pressure on the environment in this context is human-induced altered fire regimes, the state refers to the condition of the environment that results from the pressure of altered fire regimes and the response component relates to the actions taken by managers that are designed to ease the pressure or prevent further adverse environmental impacts.

The Pressure: Altered Fire Regimes

Prior to European settlement in 1788, fires were started by lightning and deliberately set by Aboriginal people for a myriad of reasons. There is mounting evidence that in many ecosystems, Aboriginal burning over thousands of years was frequent, widespread and fundamental to resource acquisition. Since European settlement, fire regimes across most of the continent have changed from what is believed to have been the pre-1788 regimes. These changes have occurred due to a number of fundamental factors including cessation of traditional Aboriginal burning practices over most of the continent, the changed natural and built environment, bushfire legislation, changed land ownership/use, and different and often opposing philosophies and beliefs about the role of fire in maintaining natural ecosystems.

In the vast semi-arid and arid regions of the continent, there is evidence that the fire regime has changed from one of frequent patch-burning by Aboriginal people to one of infrequent but large scale and intense wildfires with the cessation of traditional Aboriginal burning following European settlement and usurpation. Frequent patch-burning created a fine-grained mosaic of interlocking patches of vegetation at different seral stages, providing habitat diversity, resources for Aboriginal people and reduced opportunity for large wildfires and subsequent habitat homogenisation. Similarly, altered fire regimes in the tropical savannas of northern Australia have been attributed to declines in biodiversity in the region. Here, the regime has changed from one of predominantly early dry season patchy burning by Aborigines, to very large and intense late dry season fires, started either by lightning or people.

Today, the many forest, woodland and shrubland ecosystems of south-east Australia commonly experience a regime of large, intense and often damaging wildfires. While the "natural" or pre-1788 regime is arguable, from all accounts it is most likely that in many of the drier ecosystems, the regime has changed since European settlement from one of frequent patch-burning to infrequent wildfires.

While altered fire regimes in the sparsely populated and remote semi-arid, arid and tropical savannas of the continent are impacting on biodiversity values, the contemporary regime of large wildfires has but a small impact on human life, property and industry, so generally receives little attention by the media and

by land management agencies. However, this is not the case in the more densely populated regions of the south-west and south-east of the country where bushfires in forests, woodlands and shrublands pose a serious threat to life and property. South-east Australia in particular has a recent history of severe bushfires with consequent tragic loss of human life and property, and disruption to industry. In most cases, bushfire disasters have occurred at the urban-rural interface, where fire-vulnerable settlements interdigitate with fire-prone natural environments. This combined with often extreme weather conditions and heavy fuel accumulations results in intense wildfires that are unstoppable at the peak of their activity. Bushfire disasters are usually followed by high level inquiries, few of which have been particularly effective in preventing a re-occurrence.

The State: Changes to Biodiversity

While there is evidence of altered fire regimes over the last 200 years or so, there is some anecdotal evidence but little scientific evidence of the impact of these changes on biodiversity. Fire ecology research has tendered to be taxon or ecosystem specific and generally short term, rather than landscape scale and long term. There are ongoing debates about the fire regimes imposed by Aboriginal burning, the condition of the natural environment prior to 1788 and changes to the fire regime and consequently to the environment since then.

There is growing scientific evidence that this altered fire regime has contributed to a decline in fire sensitive plant communities and, together with introduced predators and herbivores, declines in medium sized native mammals. Although relatively pristine, the Australian arid zone stands out globally as having experienced the greatest rate of decline and extinction of mammals in recent times.

Aside from general observations of the acute impacts of these wildfires, there have been few published studies on the environmental impacts of a regime of infrequent but large and intense wildfires. There is now ample scientific evidence that for many ecosystems, no single fire regime benefits all organisms and that a diverse fire regime at appropriate scales will promote biodiversity. Therefore, a regime of infrequent large and intense fires is not only socially and economically undesirable, but is environmentally unsustainable. Large-scale incineration of ecosystems and organisms, homogenisation of seral stages and habitats, and disruption and damage to hydrological systems and soils present threats to biodiversity, especially in fragmented landscapes and in the presence of invasive exotic species. It could also be argued that the pre-fire condition of many landscapes, that being of large contiguous tracts of vegetation at the same or similar advanced seral or post-fire stage, does not provide habitat diversity, therefore diminishes biodiversity at the landscape scale.

The Response: Towards a Solution

The pattern of altered fire regimes, from frequent patch-burning under Aboriginal management, to fire exclusion and large wildfires following European settlement, is common to parts of North America, South America and Africa. For a given bioregion (combination of climate, landform and vegetation), the predominant fire regime will be ultimately determined by the role of people in fire management. There are broadly two choices; attempted fire exclusion or the introduction of managed fire (anthropogenic burning - prescribed fire). Globally, where attempts have been made to exclude and suppress fire, including prescribed fire, then the fire regime is inevitably one of large, intense and destructive wildfires at some frequency determined by the productivity of the vegetation and frequency of severe fire weather events.

A critical part of the solution to the threat that wildfires pose to people and to biodiversity conservation, is to work with nature and maintain and manage anthropogenic fire in landscapes that have developed with anthropogenic fire over thousands of years. However, and in the absence of complete knowledge, using fire as a management tool (prescribed burning) is controversial. Opinions range from excluding other than natural (lightning) fire from the landscape to frequent prescribed burning to maintain fuel accumulations at "safe" levels. While many observers recognise the importance of fire in maintaining natural processes, there is often debate about the effects of various fire regimes (frequency, season, intensity and scale) on biodiversity. There is concern that regular fuel reduction burning will be environmentally damaging and threaten biodiversity. While Indigenous knowledge can contribute to fire management decision making, mimicking Aboriginal burning may not be appropriate in changed natural and cultural environments. Ecosystems and organisms vary in their response to fire so developing appropriate (ecologically sustainable) and practical fire regimes that do not pose an unacceptable threat to human life and property, remains the challenge for conservation and land management agencies.

The south-west region of Western Australia is recognised as a global biodiversity hot spot. Fire management is integral to protecting biodiversity and human life and property. Over the last 4 decades, much of the forested region of the south west has been regularly prescribed burnt to manage fuel

accumulation. This has been affective in reducing the severity (size and intensity) of wildfires. Fire management in the region continues to evolve in the light of accumulated knowledge of fire science and management experience. Today, four broad fire management strategies are being applied at various scales to achieve conservation and protection objectives. These strategies are guided by the following twelve principles drawn from a recent review of fire science in south-west ecosystems.

1. The vegetation and climate of south-west Australia make it highly prone to bushfires. Fire is an important natural disturbance factor that has and will continue to influence the nature of south-west landscapes and is integral to conservation management.
2. Species and communities vary in their response to fire. Knowledge of the temporal and spatial scales of fire in relation to life histories of organisms and communities underpins the use of fire.
3. Following fire, environmental factors such as landform, topography, species' life history attributes, exotic invasive species and random events such as climatic events, often drive ecosystems towards a new transient state, masking the effects of fire.
4. Fire management is required for 2 primary reasons, which are not necessarily mutually exclusive: a) to conserve biodiversity and b) to reduce the occurrence of damaging wildfires.
5. Fire management should be both precautionary and adaptive, considering ecological and protection objectives in order to optimise outcomes.
6. Diverse fire regimes at appropriate scales will enhance biodiversity. At the landscape scale a mosaic of patches at different seral stages will provide habitat diversity and choice for mobile organisms. At the local scale, fire regimes based on biological attributes are necessary to ensure persistence of sessile organisms and structures.
7. Avoid applying the same fire regime over large areas for long periods.
8. The scale of the mosaic should a) enable natal dispersal, b) optimise habitat edges and c) optimise connectivity.
9. All available knowledge, including scientific, indigenous and local knowledge should be used to develop ecologically-based fire regimes.
10. Fire history, vegetation complexes and landscape units should be used to develop known and ideal fire age class distributions, or mosaic phases.
11. Wildfire can damage conservation and other societal values hence risk analysis must be based on a systematic and structured approach to identifying and managing the consequences of such an event.
12. Fire management should adapt to new knowledge gained from research, monitoring and experience, and in response to community expectations.

Broad Fire Management Strategies

Managing ecosystems based on vital attributes: Knowledge of vital attributes of key fire sensitive (fire regime specific) taxa within ecosystems is being used to derive appropriate fire regimes. Fire regime specific plants are those that depend on seed for regeneration, have long juvenile periods and which store seed in the canopy (serotinous). The juvenile period, longevity and regeneration and establishment requirements of these taxa are used to establish minimum and maximum fire intervals and the regeneration requirements are used to determine season and intensity of fire. Fire regime specific animals are those that have specialised post-fire habitat requirements, low dispersal capacity (perhaps behaving as metapopulations) and low fecundity. Knowledge of the habitat requirements (seral stage) and dispersal capacity of these taxa assists with determining fire interval and scale or patchiness.

Fire-induced fine-grain habitat mosaics: Prescribed burning to create a fine-grained mosaic of habitat patches at different post-fire stages will enhance biodiversity and provide protection against large fires by creating a fuel pattern that will reduce the scale and intensity of fires. The frequent and targeted introduction of fire into the landscape should, in time, result in a fine-grained shifting mosaic of patches at different post-fire stages ranging from recently and frequently burnt to long unburnt. Consistent with adaptive management, a large scale field trial is being planned in the south-west of Western Australia to investigate this.

Fire regimes for specific rare and endangered taxa: Under Western Australian legislation, threatened flora and fauna, or species that are rare or in danger of extinction, may receive special management attention. In some cases, this may include devising and implementing fire regimes specific to these taxa to ensure their persistence. The mainland quokka (*Setonix brachyurus*) is an example. The quokka behaves as a metapopulation and has specific habitat requirements, occupying riparian zones that are in the mid to late seral post-fire stages. Fire is important for both protecting these habitat patches from wildfires and for regenerating these habitats when they senesce some 25-30 years after fire. Low intensity fires in spring when riparian systems are too moist to burn are important for protecting these

habitats from wildfires, and infrequent summer/autumn burns are important for regenerating senescing habitat. The scale of fire and the spatial patterning of habitat patches are important for allowing effective operation of habitat sources and sinks to ensure the persistence of subpopulations in the landscape. Inappropriate fire regimes, including long periods of fire exclusion followed by large intense wildfires, risks local extinction of subpopulations, the breakdown of metapopulation behaviour and regional extinctions.

Fire regimes for fuel management: The killing power and suppression difficulty of a wildfire is directly proportional to the quantity and nature of the fuel (live and dead vegetation) that burns. In strategic areas, such as around high values assets and fire sensitive species and communities, frequent prescribed burning is necessary to reduce the risk of damage to assets by intense wildfires and to facilitate suppression activities. A regional risk analysis is undertaken to systematically determine values at risk of damage or destruction by wildfire. The frequency of prescribed burning to maintain fuel loads below acceptable levels is determined from a knowledge of the rate of fuel accumulation, the nature of the fuel, the climate of the region and the fire detection and suppression capability.

Critical Knowledge Gaps for Fire Maintained Ecosystems in South-west Australia (Global 200 Ecoregion 119)

- Understanding the long term effects of various fire regimes on biodiversity. This can be achieved by establishing well designed longitudinal experiments in representative ecosystems, sound monitoring as part of management systems and space-for-time studies where there exists a good knowledge of fire history.
- Developing predictive models of species responses to fire regimes in the context of climate change.
- Understanding the impacts of large intense wildfires on biotic and abiotic elements and ecosystem processes.
- Understanding the effects of prolonged fire exclusion on biodiversity and ecosystem health.
- Increased research effort on responses to fire of frogs, reptiles, invertebrates, fungi and cryptogams and fire regime specific ecosystems.
- Describing and understanding spatial pattern/patchiness including, fire mosaics, at the landscape scale.
- Appropriate temporal and spatial distribution of seral stages within landscapes to optimise biodiversity conservation and minimise damaging wildfires.
- Creating fire-induced mosaics/patchiness using managed fire.
- Testing mammal metapopulation theory and linking it with landscape fire ecology.
- Protecting organic substrates from fires that burn deep into the substrates.
- Managing fire in fragmented landscapes.

Partnerships

The Australian Bushfire Cooperative Research Centre (www.bushfirecrc.com) is the logical point of entry for partnerships between the GFP and Australasian fire community.