Western Australian Bushfire Research Forum 2011

12 and 13 October 2011



Book of Abstracts

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Welcome message

We are pleased to welcome you to The University of Western Australia UWA Club for the inaugural Western Australian Bushfire Research Forum. The two-day forum will showcase local contemporary science that supports bushfire management in Western Australia.

The forum will address a range of bushfire research disciplines including fire behaviour, fire ecology, environmental impacts and social issues.

Our goal is to provide a forum for fire managers and scientists to exchange new knowledge and best practices in fire management for nature conservation and community protection. The forum provides a great opportunity to foster cross-discipline collaboration by bringing together researchers, fire and land managers, and graduate students to strengthen the fire science and research capacity in Western Australia. Building stronger connections and communication among fire managers and science organisations will allow us to meet the challenges of the 21st century fire management.

The organising committee gratefully acknowledges the generous financial and in-kind support the forum has received from:

- Department of Environment and Conservation
- Fire and Emergency Services Authority
- Western Australian Local Government Association
- The University of Western Australia.

We thank you for participating in this forum, and trust you will take full advantage of the information and knowledge that will be shared with you and other attendees so that we can approach the future bushfire challenges with a better understanding and confidence.

The organising committee

- Rick Sneeuwjagt (Chair), Department of Environment and Conservation (DEC)
- Ralph Smith, Fire and Emergency Services Authority (FESA)
- Pauline Grierson , University of Western Australia (UWA)

Program

Wednesday 12 October	Theme	Speaker	Topic
SessionAM1	Moderator	Rick Sneeuwjagt (DEC)	
0900-0910	Welcome to Country	May McGuire (Nyungar Elder)	
0910-0915	Introduction	Rick Sneeuwjagt (DEC)	Role of WA Bushfire Research Committee and purpose of Bushfire Research Forum
0915-0935	Opening address	Gary Morgan (Bushfire CRC)	Value of science in managing fire and fire-prone communities: role of the Bushfire Cooperative Research Centre
0935-1015	Keynote apeaker	Dr Jeremy Russell-Smith (Bushfires NT/Charles Darwin University)	Application of research on Savanna Burning and Greenhouse Gas Abatement to landscape-scale fire management in northern Australia
1015-1040	Morning tea		
SessionAM2	Moderator	Pauline Grierson (UWA)	
1040-1115	Indigenous Fire	Dr Rebecca Bliege Bird, (Stanford University)	Indigenous fire regimes in fire prone landscapes in Australia's Western Desert.
1115-1145	Western Desert	Dr Neil Burrows(DEC)	Managing fire in the Western Desert; what can 40,000 years of human occupation teach us?
1145-1210	Western Desert	Bruce Ward (DEC)	Post Fire Plant Succession and Biodiversity in the Gibson Desert of Western Australia
1210-1250	Lunch		
SessionPM1	Moderator	Ralph Smith (FESA)	
1250-1320	SW Forest Ecosystems	Dr Roy Wittkuhn, Consultant (Eco Logical Australia Pty Ltd)	Impacts of variation in fire interval sequences on species richness and composition.
1320-1350	SW Forest Ecosystems	Paul van Heurck (DEC/Curtin University of Technology)	Mosaic Fires not Wildfires? Logistic Lessons from Beetles in South-West Australia.
1350-1420	SW Forest Ecosystems	Dr Neil Burrows (DEC)	Preliminary findings from studies of mosaic burning in south-west forest ecosystems for biodiversity and community protection.
1420-1450	Mid-west coastal shrub lands	Prof Neal Enright (Murdoch University)	Effects of short-interval fire on woody species biodiversity in kwongan (shrublands) of the Mid West Region
1450-1510	Afternoon tea		
SessionPM2	Moderator	John Lane (WALGA)	
1510-1540	Kimberley	Dr Ian Radford (DEC)	Implications of Kimberley fire ecology research for conservation management.
1540-1610	Kimberley	Dr Sarah Legge (Australian Wildlife Conservancy)	Evaluating the effectiveness and biodiversity impacts of fire management in the Kimberley
1610-1640	Wheatbelt Reserves	Dr Colin Yates (DEC)	Fire, fragmentation, weeds and the conservation of plant diversity in Wheatbelt Nature Reserves.
1640	Close		

Thursday 13 October	Theme	Speaker	Topic
SessionAM1	Moderator	Prof Alistar Robertson (UWA)	
0830-0845	Address by WA Chief Scientist	Prof Lyn Beazley, Chief Scientist of WA (UWA)	
0845-0920	Fire Behaviour	Prof George Milne / Drew Mellor (UWA)	Development and Application of the UWA Wildfire Simulator
0920-0950	Fire Behaviour	Phil Cheney (CSIRO retired)	Fire behaviour during the Pickering Brook bushfire, January 2005
0950-1020	Prescribed fire and fuels	Dr Lachie McCaw (DEC)	Quantifying the effectiveness of fuel management in modifying wildfire behaviour – recent examples from Western Australia and Victoria
1020-1050	Morning tea		
SessionAM2	Moderator	Kelly Gillen (DEC)	
1050-1120	Prescribed fire and fuels	Dr Matthias Boer (UWA/University of West Sydney)	Quantifying long-term regional scale impacts of prescribed burning on wildfire incidence and extent in SW Australian eucalypt forests
1120-1145	Prescribed fire and fuels	Jennifer Hollis (U of NSW/ CSIRO)	Predicting woody fuel consumption in eucalypt forest fires in southern Australia
1145-1210	Fire Behaviour Shrublands	Dr Joe Fontaine (Murdoch University)	Fire behaviour in southwestern Australian shrublands: evaluating the influence of fuel age and fire weather
1210-12500	Lunch		
SessionPM1	Moderator	David Caporn (FESA)	
1250-1320	Fuel Modification in Shrublands	Dr Carl Gosper (DEC)	Effects of the fire management methods of chaining and burning on plant communities
1320-1350	Environmental Impacts	Jaymie Norris (DSE/ UWA)	Impact of variable fire intensity on soil carbon and nitrogen in Jarrah forest soils – Heterogeneity
1350-1420		David Leach (Botanical Gardens, Kings Park)	Summary of fire suppressant impacts on flora of the Swan Coastal Plain
1420- 1450	Social Research	Prof David Morrison (UWA)	Key findings from community surveys following recent WA bushfires
1450-1520	Afternoon tea		
SessionPM2	Moderator	Rick Sneeuwjagt (DEC)	
1520-1550		Dr David Ward (Curtin University)	Mathematical patterns in bushfire mosaics: Does God play dice?
1550-1620	Future Research	Dr Fiona Gibson (UWA) for Prof David Pannell (UWA)	Integrated assessment of the social and environmental outcomes from various prescribed burning strategies
1620-1650	Future Research	Discussion Panel. Moderator Prof Alistar Robertson (UWA)	Future bushfire related research needs for Western Australia
1650	Close		

Oral presentations

Wednesday 12 October 2011

The value of science in managing fire and fire-prone communities: the role of the *Bushfire Cooperative Research Centre*

Gary Morgan – CEO Bushfire CRC

Abstract

Significant areas of southern Australia constitute some of the most fire-prone areas on Earth.

Historically, the role science has played in the management of landscape fire in Australia has varied considerably. Most land management agencies, until relatively recent times, generally incorporated research components into their organisational structures.

The situation within fire and emergency service organisations was more problematic – many agencies tended to focus their practices on experience and technological development.

The *Bushfire CRC* was established in July 2003, with the strong support of the *Australasian Fire and Emergency Service Authorities Council* and its member agencies, the support of COAG - linked *Forest Fire Management Group* and a majority of the park and forest management agencies around Australia. Its formation followed bushfires around Sydney in December/January 2001/02.

The associated research program subsequently established went beyond the traditional (and important) focus on fire behaviour and fire fighter health and safety. Unique to the fire industry, both in Australia and internationally, the *Bushfire CRC* established a focus on community safety as a key component of bushfire management (the involvement of social sciences in Australian bushfire research only seriously commenced with the establishment of the *Bushfire CRC*).

The *Bushfire CRC* also commenced research in virtually all the areas that had been the subject of recommendations made by bushfire-related Inquiries around the country in the previous decade. After seven years of research, carried out through 13 separate organisations, the *Bushfire CRC's* partners are now seeing increasing returns on their investment as the associated research adoption phase gathers pace.

Australia's first, nationally coordinated, multi-disciplinary bushfire research program has had an impact. New decision support tools have been implemented in areas such as smoke management, aerial suppression, prescribed burning, community engagement, fire weather forecasting, volunteerism and fire-fighter health and safety. Important research has been conducted on the role and behaviour of fire in a range of ecosystems including the tropical savannas of northern Australia and of the relationship between eucalypt decline and fire regimes.

In tandem with researchers, fire and land management agencies have gained a significantly improved insight into the way people face the bushfire threat. Central to this research is the need for a better understanding of what drives human behaviour before, during and after a bushfire. And industry now looks to the *Bushfire CRC* for advice on better materials for building houses, fencing, water tanks and other structures.

The period since 1998 has seen an unprecedented level of 'third party' scrutiny of the management of landscape fire in Australia. These Inquiries have frequently involved detailed examination of agency policies and procedures, often involving the cross-examination of witnesses - a process that has helped focus agencies on the importance of their policies being 'evidence based'. At more recent Inquiries, *Bushfire CRC*-linked researchers have increasingly been relied upon.

Critically, one of the key reasons for establishing the *Bushfire CRC* was to address the serious and growing national shortage of bushfire-related researchers. One of the *Bushfire CRC's* most important achievements to date must be the fact that post-doctorate fellows and post-graduate students now number more than 80.

Finally, the presentation will briefly examine the role of researchers in policy formulation and the future of the current national research effort.

Application of research on savanna burning and greenhouse gas abatement to landscape-scale fire management in northern Australia

Jeremy Russell-Smith

Bushfires NT, Northern Territory Government
North Australian Indigenous Land & Sea Management Alliance
Research Institute for the Environment & Livelihoods, Charles Darwin University

An average of ~20% of Australia's 1.9M km^2 tropical savannas is currently burnt each year, mostly in the late dry season under relatively severe fire-weather conditions. While much of northern Australia is nominally allocated for pastoral land-uses, for the most part late dry season wildfires occur in remote, biodiversity-rich, and typically rugged landscapes derived from infertile substrates with little economic pastoral potential. Outside urban centres, tenure parcels typically are very substantial (>>100,000 ha), and associated infrastructure is limited. Most of the non-urban population is Indigenous (i.e. Aboriginal) and much fire-affected land is held by Indigenous people, either as sole title owners or, more commonly, under non-exclusive ('native') title arrangements.

As a means for addressing these landscape-scale fire management and associated Indigenous economic development and biodiversity challenges, over the past fifteen years or so there has been growing development of, and government support for, Indigenous land and associated fire management enterprise opportunities. Of particular relevance here has been R&D support for Kyoto-compliant savanna burning activities, focusing on reducing greenhouse gas emissions from late dry season wildfires through reinstatement of customary, strategically-focused fire regimes.

Operating successfully since 2005, the 28,000 km^2 Western Arnhem Land Fire Abatement (WALFA) project provides the first commercial-scale example of a voluntary savanna burning offset project internationally. A number of other large regional-scale savanna burning projects are now under development across fire-prone northern Australia, including in the Kimberley. Formal recognition of carbon credit offsets derived from savanna burning projects is now possible with (a) recent passing (August 2011) of the Carbon Farming Initiative legislation by the Australian parliament, and (b) the development of an associated savanna burning accounting methodology— undergoing final formal appraisal at the time of abstract preparation. These (and associated biosequestration) benefits derived from savanna burning projects have the potential to transform indigenous rural economies and help address social disadvantage—and provide sustainable economic means for delivering fire management and biodiversity benefits.

Indigenous fire regimes in fire-prone landscapes

Rebecca Bliege Bird, Douglas W Bird, Brian F. Codding, Peter Kauhanen (Stanford University)

Abstract

Although humans have occupied fire-prone ecosystems across the world for millions of years, there is still much debate as to their impact on the fire regime, even in Australia, where indigenous burning accounts for a large proportion of fires. In Australia, fire in woodlands, shrublands, and grasslands, much of it caused by lightning, accounted for 15% of the total global land area burned in 2000. The extent to which lightning accounts for much of the fire in Australia's subtropical arid zone has made it difficult to detect the effect of indigenous burning on fire regimes and has led many researchers to discount the contribution of aboriginal fire to fire regimes in Australia.

This analysis provides empirical data showing the landscape-scale differences between a fire regime dominated by lightning and one dominated primarily by indigenous ignition sources in which nearly all ignitions are linked to particular traditional foraging activities. As such, we provide a proxy for the long history of indigenous application of fire in the arid savannas and xeric woodlands comprising much of central and western Australia.

We focus on testing five major hypotheses about the nature of indigenous fire regimes, looking at differences relative to both the patch and landscape spatial scale, and differences at the seasonal and decadal temporal scale.

1) One of the common hypotheses about indigenous effects at the patch scale is on the time between successive fires: indigenous burning may increase the frequency of fires by reducing fire interval. 2) One of the major effects of anthropogenic burning at the landscape scale is to reduce the scale of habitat patchiness and increase successional diversity at smaller spatial scales. 3) This increased habitat patchiness has been hypothesized to preserve more mature habitat than under a lightning regime. Mature patches of habitat provide important predator refuge for many of the endangered small mammals in the Australian desert. 4) There are two common hypotheses about the temporal patterning in indigenous fire. At short time scales (seasonal), some have suggested that mosaic burning at a small spatial scale creates firebreaks that prevent fires from spreading during seasons when lightning fires are particularly prevalent. 5) At longer time scales (decadal or greater) climatic variability due to ENSO-related shifts in monsoonal activity changes fire regime by shifting ignition frequencies, plant growth, wind, and moisture levels of vegetation, all of which have a strong influence on the frequency and size of lightning fires. Some have suggested that humans amplify this climatic-driven variability in fire size and frequency, or that climate is the major driver of fire size, spatial patterning, and extent regardless of ignition source.

In this paper, we test these hypotheses using a ten-year sequence of Landsat image mosaics at roughly six month intervals covering 46000 sq km of the Western Desert of Australia, hand-digitizing 6100 visible fire scars. This area encompasses two actively burning aboriginal communities (Parnngurr and Punmu), an active mine site (Telfer), a tourist destination (CSR), and a national park (Karlamilyi). We find that indigenous dominated regimes 1) provide 1.5 times more area of mature habitat refugia; 2) increase successional patchiness and diversity at the scale of human activity; 3) reduce mean and median fire size and prevent fires in the largest size classes; 4) lengthen the interval between fires and

reduce fire frequency in habitats where burning is associated with immediate increases in foraging returns, and have no impact on interval in habitats where fire is not used for foraging; and 5) unlike lightning fire regimes, anthropogenic fire extent and size is not significantly correlated with climatic variability: in the lightning regime, 24 months of better than average rainfall induce enormous fires that cover extensive tracts of the landscape. This does not occur under the indigenous regime: fire size and extent is buffered from climatic variability.

References

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Managing fire in the Western Desert; what can 40,000 years of human occupation teach us?

Neil Burrows

Science Division, Department of Environment and Conservation
Faculty of Natural and Agricultural Science, University of Western Australia

Extended Abstract

Highly flammable vegetation and long periods of hot, dry weather have ensured that spinifex-dominated ecosystems of the Western Desert have had a long association with fire. These ecosystems are not only flammable, but they are fire maintained, with plants and animals displaying a variety of physical and behavioural traits that enable them to persist with, and in many cases, depend upon a range of fire regimes. Fires have been caused by lightning and people, but since Aborigines occupied these landscapes some 40,000 years ago people have been by far the greatest source of ignitions.

Fire regimes in much of the Western Desert changed when Aboriginal people discontinued traditional burning practices. It changed from a fine scale mosaic made up of numerous patches of vegetation at different times since fire (seral stages) to a coarse grain mosaic of fewer seral stages. This pattern is consistent with that observed in other flammable landscapes around the world following a reduction in fire frequency – usually due to the departure of people, the abandonment of traditional management practices that shaped these ecosystems or partially effective fire suppression. In almost all situations where this has occurred, there are fewer fires, but the fires are larger, more intense and damaging.

Altered fire regimes have been implicated in the recent decline of arid zone fauna. While predation by introduced predators is likely the primary cause, this will have been exacerbated by highly altered fire regimes, and where it was practiced, pastoralism - processes that have simplified habitats and reduced vegetation cover over large areas, diminishing habitat quality and exposing native fauna to predation.

As has been the case for the past 40,000 years in the Western Desert, people are integral to fire management in these landscapes and today fire management is integral to ecosystem management and biodiversity conservation. Managing fire for the conservation of biodiversity *per se*, is a laudable but nebulous objective. Fire is one of a number of environmental factors acting alone or together with other factors that influences biodiversity and ecosystem condition. While fire can kill and injure plants and animals, it also stimulates regeneration and rejuvenates ecosystem processes such as nutrient cycling. Fire acts on ecosystems and species primarily through its action on the vegetation at a variety of temporal and spatial scales. At both landscape and patch scales, fire, together with rainfall, alters the structure, composition and biomass of vegetation in space and time.

Vegetation is important in its own right and plants are also the primary producers in terrestrial ecosystems, providing food and shelter (habitat) for other organisms. Vegetation provides the energy to drive ecosystems and to drive fire. The approach to fire management in spinifex-dominated ecosystems is to focus on the role of fire in managing the vegetation, which is crucial as habitat, and to emulate practices that sustained these ecosystems for thousands of years. Good fire management will maintain a variety of seral (post-fire) stages, hence diverse habitats, at appropriate scales based on the growing knowledge that diverse habitats benefit biodiversity.

Title: "Post fire plant succession and biodiversity in the Gibson Desert of Western Australia"

Thomas B. Bragg[a] and Bruce G. Ward[b]

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[b]*Department of Environment and Conservation, Manjimup, W.A. 6258.*

Abstract

A site in the Gibson Desert was selected to test if a shift in the burning regime from one of small human caused fires to broad scale lightning fires has had a detrimental effect on the plant communities. There are a number of recognized landform units in the Gibson Desert but three dominant units were utilized to test vegetation performance in this study. One in a mulga (Acacia aneura) wooded belt, another in Triodia basedowii spinifex complex and a third in Triodia schinzii spinifex association. Measurements of species richness, cover and abundance were taken before and for 5 years after fire.

Species richness increased from an average of 21 species preburn to 54 species in the first year post fire declining to 33 species 2 years after burning. The mulga community had almost double the species richness (76) of either spinifex complex, which were similar (44). Landform units were well separated in ordination space before burning, which separated into burnt and unburnt clusters the year after. These clusters began to coalesce by year four. Species composition of the three landforms is compared over time and with each other.

As a key species the mulga populations are central to sustaining both ecosystem biodiversity and ecosystem function. Mulga can be self-replacing in a fire environment if given sufficient time to establish a soil seed bank [3 & 4]. In this study the mulga sites had a fire return interval of 16 years and > 45years and in both cases high levels of mulga regeneration occur (888 and 1392 seedlings per hectare respectively) suggesting that fire free interval of at least 15years may be required [6].

Soft grasses and ephemeral herbs increased in both abundance and ground cover forming a more continuous fuel once cured. This has the potential to make the country vulnerable to re-ignition in the early post fire period (1-2 years), which presents a significant challenge for management [1 &2]. Additional fire at this time would have damaging results on emerging seedlings and re-sprouting plants. Fires in such close succession would in all probability deplete the seed bank and cause a localized reduction or loss of some species.

The fire utilised in this study killed all above ground parts of living plants except for small patches that were not burnt, however, four years after fire the abundance of woody plants were either higher or had maintained their pre-burn levels. The exception was T. shinzii where two resprouter species (*Rulingia lutieflora and Dicrastylis tomentosa)* has not yet recovered from fire. The Gibson Desert vegetation appears to be quite resilient and recovery from fire is rapid although speed of recovery is most likely rainfall dependent [5].

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Impacts of variation in fire interval sequences on species richness and composition

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We examined the influence that past fire interval sequences have had on biota of the southern jarrah forest and shrubland mosaic in the extensive landscape north of Walpole, Western Australia [1]. We compared species richness and composition of plants, ants, beetles, vertebrates and macrofungi among sites with consecutive short (≤ 5 yr) fire intervals (SS-regime), consecutive long (≥ 11 yr) fire intervals (LL-regime), moderate (6–9 yr) or mixed fire intervals (M-regime) or very long (30 yr) intervals (VL-regime). We hypothesised that sites with predominantly shorter (SS) and longer (LL and VL) fire interval regimes would be least similar in their species composition.

Sites were not clustered according to their corresponding fire regime groups for either forest or shrubland when data for all taxonomic groups were analysed by non-metric multidimensional scaling (nMDS). However, PERMANOVA results for macrofungi suggested a different species composition due to fire regimes ($P = 0.039$), and results for plants ($P = 0.039$), ants ($P = 0.085$) and beetles ($P = 0.089$) suggested a different species composition between SS sites and LL/VL sites, providing some support for our hypothesis. Canonical analysis of principal co-ordinates (CAP) suggested the strongest difference between SS and LL/VL sites was found for beetle taxa (Fig. 1).

Our results suggest that the biota of SWA demonstrates a high degree of resilience to a range of fire interval sequences in both shrubland and open eucalypt forest. However, the maintenance of short or long fire interval regimes has the potential to alter species composition, whereas a mixed or moderate fire interval regime appears to maintain a composition of species that can persist when subject to a range of fire intervals. This lends support to the intermediate disturbance hypothesis [2] and the importance of a variable fire interval regime for biodiversity conservation [3]. We suggest that the variability in fire intervals that has occurred in our sites makes an important contribution to observed resilience, whereas the maintenance of an invariant short or long interval regime over the longer term would likely lead to substantial ecological change.

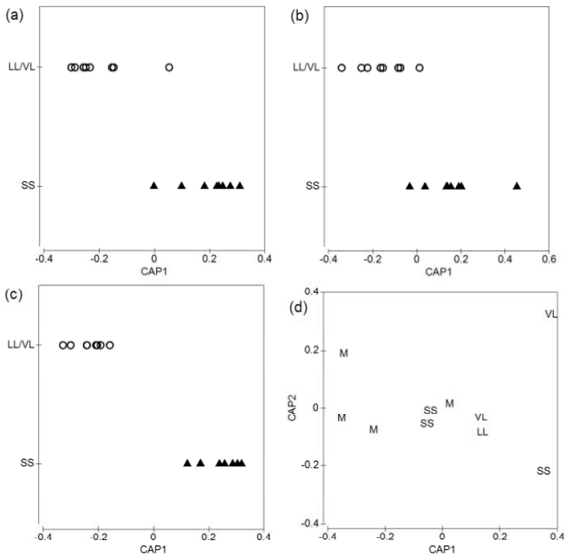


Fig. 1. CAP analysis of sites based on the composition and transformed abundance of (a) plants, (b) ants, (c) beetles, and (d) macrofungi in sites with contrasting fire interval sequences. The compositions of plants, ants and beetles were compared between sites with short-short (SS) fire interval sequences and the combination of sites with long-long (LL) and very long (VL) sequences. The composition of macrofungi was compared between SS, mixed/moderate (M) and a combined LL and VL group.

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Mosaic Fires not Wildfires? Logistic Lessons from Beetles in South-West Australia.

Paul Van Heurck [1, 2]

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Abstract

The south-west of Western Australia is one of the Earth's 20 most diverse centres of vascular plants. This globally renowned biodiversity of the south-west's flora and fauna is hypothesized to have resulted due to the long period of geologic stability following the last major glaciation in the Permian (c. 245 million years before present time) when the south-west landscapes were ground down by ice-sheets to their present low-relief. Since then landscape stability together with gradual climate change, plus the steep east-west geographic gradients of both the annual rainfall and highly eroded infertile soil complexes have favoured the evolution of a patchy landscape mosaic of highly diverse flora and fauna communities.

This mosaic of south-west communities has been burnt by lightning-ignited fires for a very long time. Around 30 million years ago the seasonal Mediterranean climate, with dry summers and lightning-storms, was well established in south-west Australia. Fire therefore imposed another mosaic gradient of temporal interactions between the fluctuating aridity of the climate, the mosaic of diverse plant communities and their vegetation age since fire. From around 50,000 years ago aboriginal "fire-stick farming" may have become another frequent source of fire spread across southern Australia.

Globally arthropod species are estimated to makeup at least 70% of all living species, of which one-in-five have been scientifically named. The highly diverse and endemic south-west arthropod fauna has evolved species with contrasting fire tolerances; including both ancient relict species and pyrophilic arthropod species which have long evolved to favour or tolerate either very old long unburnt patches containing moist habitats such as deep litter or old rotting logs, in contrast to very recently burnt habitat patches of still smoldering ashbeds and recently heat-killed trees. The co-evolution of these arthropods with contrasting fire tolerances supports the hypothesis of a per-historic fire and vegetation mosaic of relict and pyrophilic habitat patches long persisting in the south-west landscape.

However this past mosaic of relict and pyrophilic habitats is threatened by the increasing number and size of wildfires in southern Australia forests, as a result of both changed fire regimes since European settlement, and declining rainfall due to climate change causing dryer, hotter and longer summer fire seasons. On the 20th March 2003 an intense wildfire burnt approximately 20,000 ha of southern jarrah forest and heathland plains, near the south coast of Western Australia. The rapid southward spread of the fire was largely halted at the northern boundary of London forest block, patchily prescribed burnt in the previous spring of 2002. In 2004 the Walpole Fine-grain Mosaic study was established to compare the fire impacts of this wildfire and nearby mosaic burns on the biodiversity of invertebrate assemblages and also perfect the operational logistics of mosaic burning.

In the Walpole Mosaic project area, I found that beetle (Coleoptera) species represented roughly 10 - 20% of study invertebrate richness, and occurred in all trophic guilds. My PhD project tested a standardized set of metrics for monitoring changes in beetle biodiversity. Total study richness of 445 beetle species is partitioned amongst 225 more common species and 220 singleton or rare species, of which 97 only occurred in patchily, mosaic burnt sites, while 64 species were exclusive to wildfire burnt sites. This lesson of habitat complementarity within the rare beetle fauna teaches us the long-term logistics, for reducing wildfire impacts, by creating mosaic fire regimes at landscape scales, to establish heterogeneity of post-fire ages at a fine-grained scale within individual forest and vegetation patches in southern Western Australia. A fine grain mosaic of relict and pyrophilic habitats is the best insurance against the total loss of diverse refuge habitats of invertebrates, in future south-west wildfires.

Mosaic burning in south-west forest ecosystems for biodiversity and community protection

Neil Burrows

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Faculty of Natural and Agricultural Science, University of Western Australia

Extended Abstract

Fire management based on sound science is fundamental to the conservation of biodiversity in south-west W.A., and there is a substantial body of scientific evidence that fire diversity benefits biodiversity. At the landscape scale, a fine-grained mosaic of patches of vegetation representing a range of fire frequencies, seasons and intensities should provide diverse habitat opportunities and reduce the risk of large, damaging and homogenizing wildfires.

The Walpole Fire Mosaic Project which commenced in 2003 in forests north of Walpole is an example of science-based adaptive management to improve fire management and biodiversity outcomes. It is a landscape-scale operational trial to determine whether a fine-grained fire-induced mosaic can be created by the frequent and targeted introduction of fire into the landscape (patch-burning). This does not equate to frequently burning out the landscape, but rather, attempting to create a mosaic of patches of vegetation at different times since last fire (seral stages) by regularly burning relatively small patches across the landscape. Because of the variable nature of vegetation at the landscape scale, some patches will burn frequently, others will burn infrequently; some patches will be small, others relatively large. The resulting dynamic mosaic is being mapped through time and the responses by elements of the biota are being monitored. Monitoring is also being carried out at sites from which fire is excluded and sites experiencing fire regimes in accordance with existing management plans.

After some 8 years, and following the introduction of targeted aerial patch-burning every 3 years or so, a finer scale fire mosaic is beginning to emerge in forested parts of the landscape. Over the 4,800 ha study area, there exists a variety of seral stages, ranging from recently burnt patches to long unburnt patches. Greatest diversity of seral stages exists in forested ecosystems, with non-forested heathlands showing least seral diversity. This reflects the different characteristics of forests and heath vegetation as fuel, and the variety of topographic and edaphic conditions associated with forests compared with heaths.

As the fine scale mosaic establishes, it will become self-regulating as the nature of future fires will be determined not only by surface burning conditions (weather, topography and fuel moisture), but by the spatial and temporal distribution of past fires. Increasing the frequency of patch burning in the landscape to establish a complex mosaic of different fuel ages, will increase the landscape's resilience to severe wildfires. As the mosaic structure establishes, this proposition will be tested by simulating wildfire events.

This is a long term trial, so the patch and landscape-scale influences of mosaic burning on biodiversity are still being assessed. However, some early trends are emerging, especially for fungi and invertebrates. Many species within these groups show strong seral stage preferences, with some species only present (or present at detectable levels) in either the early, intermediate or late seral stages. Therefore, at the landscape scale and at any point in time, there exists a greater diversity of fungi and invertebrates within landscapes comprising a fine scale diversity of seral stages compared with homogenous landscapes, or landscapes of the same time since last fire.

Effects of short interval fire on woody species biodiversity in kwongan (shrublands) of the Mid-West Region, SW Australia

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Mean fire interval in Mediterranean-type shrublands of the Mid-West region, SW Australia has variously been estimated at 7 – 11 years under increased human ignitions (Bell et al. 1987), 13-17 years based on estimated optimum population growth rate for co-occurring *Banksia* species (Enright et al. 1996, 1998a,b), 3-5 years for the pre- and early-European period based on grasstree stem band analyses (Ward et al. 2001), and 13 years based on satellite image analysis of fires since the 1970's (Miller et al. 2007). Disagreement about past (natural, pre-European and early settlement) fire regimes leads to contested interpretations of the circumstances facilitating species co-existence in this high biodiversity vegetation type, and so also to its conservation management and the use of planned fire. Recent large fires (1980's to present) in calcareous shrublands of the near coastal zone at intervals of 7 – 9 years, and projections of increased fire hazard under a hotter and drier future climate, add to the need for more information on the effects of short interval fire on kwongan floristic composition and structure.

This study, conducted in collaboration with the Mid-West Regional Office of DEC, used data for 33 experimental fires (over the period 2006 – 2009) lit under moderate to very high fire danger (FFDI range 9 - 27) conditions to create a sample of fire intervals from 3 – 24 years, to explore the effects of fire interval on plant species composition, richness and structure. Shrublands on acid sand and calcareous substrates (with contrasting species richness, soil nutrient availability, and relative proportions of non-sprouters and resprouters) were compared in order to determine the extent to which rates of biomass accumulation and fire hazard varied between them. For each site, pre-fire vegetation data for all individuals >20 cm height (identity, density, height, width, fruit counts) were collected early in autumn in eight 4 x 4 m plots within a 40 x 40 m sample area, and ground layer vegetation data (all species) and litter layer estimates in five 0.5 m^2 quadrats per plot (n = 40 per site). Sample areas were then burned late in the same autumn and quadrats remeasured at 6 months and 1 year after fire, and 4 x 4 m plots at 2 – 3 years after fire. Samples (n = 30 – 90) of the three most common woody resprouter species were tagged at each site and their response to fire (interval) followed.

Overall, very short interval fires (≤5 years) led to local loss of woody non-sprouter species and to increased mortality for resprouter species. Short fire intervals (6-9 years) led to smaller species losses, with loss/decline potentially higher when drought years follow fire (due to reduced recruitment rates). There was no evidence for adverse fire interval effects on species richness or composition once fire interval was >10 years. Current fire management uses a fire return interval of 12 – 20 years and is appropriate for conservation management. However, the interactive effects of fire interval and drought are of concern in relation to potential future climate change. Slower growth (onset of reproduction) and lower seed set under a hotter, drier climate may require an adaptive response approach from managers with fire intervals lengthened, and planned fires not carried out in drought years unless seed stores have been assessed as adequate and BoM models for the following winter predict at least average rainfall.

Implications of Kimberley fire ecology research for conservation management

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Abstract

Fire regimes dominated by frequent fires late in the dry season are implicated in critical weight range (CWR; 35g-5.5kg) mammal declines across savannas of northern Australia. However in highly flammable environments such as tropical savannas how can we manage fire for conservation? Savanna habitats burn irrespective of our management, so what can fire managers therefore do to benefit biodiversity in a highly flammable environment? Application of extensive early season prescribed burning in Kakadu and Litchfield NPs in the Northern Territory has failed to arrest biodiversity declines there. This has direct relevance to the Kimberley region in northern WA where similar flammable savanna landscapes to those in the Northern Territory dominate the region. We studied the fire responses of threatened CWR mammals and associated vegetation and fauna in the Mitchell River area of the North Kimberley where mammal communities are largely intact. CWR mammal abundance, mammal diet, vegetation structure and non-mammal fauna dynamics were documented over a 5 year period and related to the occurrence of fire events, site fire frequency and larger scale fire regime context. A model species, the north quoll, was radio-tracked to document the effects of fire events on home range and habitat use by this key species. Mammal abundance was documented across management compartments defined by differing fire frequency and number of cattle culling events to identify whether particular management regimes were conducive to maintenance of mammal communities. Observations in fire edge habitats (<200 m from edge of fire scar) showed that small scale prescribed fires had very few detectable negative impacts on mammal populations or associated ecosystems. CWR mammals showed no fire-effects in terms of habitat use or home range size following fire events, and quolls were observed to operate only in burnt habitats in some instances. Negative impacts of fire (e.g. on rodents, skinks and invertebrates) were only observed when fire events covered large areas (>10 km^2), when survey sites were situated >500 m from the nearest unburnt vegetation. This suggests that large-scale fire landscape context is more important in determining mammal habitat use and abundance than local-scale fire impacts or vegetation status. Quolls and bandicoots responded to fires by taking higher proportions of large prey items. This suggests that reduced abundance of some fauna groups after large fires may be due to increased predator impacts, or due to emigration to avoid predators. At the larger scale, mammals were most abundant in management compartments which had relatively low fire frequency (<0.57 fires per year) and had been protected from damaging late season large-scale fires through active management. There was no evidence of reduced mammal abundance relative to historical surveys, though some species have become extremely rare since 1980's surveys. This warrants particular attention for future fire management in the region as habitats such as those on laterite geology historically had high CWR mammal diversity. These data overall suggest that a strategy of applying multiple ignitions to achieve a fine-grain fire mosaic is compatible with conservation management objectives as long as the grain size is kept to a minimum compatible with mammal home range size (10 ha-100 ha). The substantial impact of large unplanned fires illustrates the vital importance of retaining small patch sizes (<1 km^2) in the majority of conservation areas. In order to achieve control over fire size, it is recommended that sandstone habitat should only be burnt during the wet season when fires will self extinguish. Similarly savanna habitats should only be burnt very early in the dry season to avoid large scale fires (>10 km^2) in this key habitat type.

Evaluating the effectiveness and biodiversity impacts of fire management in the Kimberley

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EcoFire is a strategic regional prescribed burning program based on a collaboration between a group of neighbouring landholders, Federal (through Caring For Our Country) and State governments, various regional bodies, and a non-profit conservation organisation. The latter, Australian Wildlife Conservancy, manages the project from its base at Mornington Wildlife Sanctuary in the central Kimberley.

By the early 2000s, fire patterns in the Kimberley region were characterised by extensive wildfires, with adverse impacts on biodiversity, pastoral and cultural values. The region covers over 30 million ha (twice the area of the state of Victoria), with a total population of less than 40,000 people, mostly concentrated in a few small regional towns, making any sort of landscape-scale fire management challenging. In particular, one of the impediments to improved fire management was the lack of coordinated on-ground action across multiple tenures.

EcoFire began in 2007, and now covers about 4.5 million hectares, comprised of 13 contiguous conservation, pastoral and Aboriginal pastoral properties (involving four Indigenous communities) and some intervening areas of Unallocated Crown Land. The project relies on a prescribed burning program to force a shift in fire patterns.

Specifically, we wanted to increase the heterogeneity of vegetation age and structure across the landscape, thus catering for a wider variety of 'pyro-niches' at a smaller scale. We also wanted to increase the amount of old-growth vegetation (three years or older), because some plants and animals are particularly sensitive to high fire frequencies. To achieve this, we aimed to shift the seasonality of fires from the late to the early dry season. In so doing, we would reduce the average size and intensity of fires, create fire scars with many more internal unburnt patches, and increase the 'graininess' of burnt and unburnt patches across the project area.

The impact of the project has been measured in two ways: remote sensing is used to determine if the fire patterns are meeting empirical targets, and the response of biodiversity is measured via a selection of ecological indicators that are known to be sensitive to fire.

Empirical spatial targets include increasing the proportion of each year's annual firescar that occurs in the early dry season, reducing the average distance between unburnt patches, and shifting the age class distribution of vegetation to include more long-unburnt vegetation.

Examples of ecological indicators include tracking the population health of Gouldian Finches (a seed-eating specialist), estimating the density of Brown Quail (a ground layer inhabitant), mapping the distribution and density of Purple-crowned Fairy-wrens (a riparian specialist), monitoring the species richness and abundance of small mammals (ground-dwellers and some seed-eaters), and measuring changes in the characteristics of the soil surface (which is simplified by frequent intense fire).

By the end of 2010, the fire pattern metrics have clearly demonstrated a substantial shift in fire patterns, and the suite of ecological indicators has collectively indicated an improvement in condition.

Fire, fragmentation, weeds and conservation of plant diversity in Wheatbelt Nature Reserves

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The widespread clearing of native vegetation has disrupted patterns of fire ignition and spread in South West Western Australia's (SWWA) highly fragmented agricultural landscapes. Recent analysis of satellite imagery shows that in wheatbelt remnants, fires have become less frequent compared to analogous continually vegetated landscapes and that occurrence declines as remnants become smaller [1].

What could this mean for biodiversity? We know that in fire-prone ecosystems, including SWWA, many plant species recruit predominately in the first years following fire and others may have limited longevity and senesce in long-unburnt vegetation. Atypically long fire intervals may be detrimental for these species, but empirical evidence is sparse [2]. Atypically long fire intervals may also affect vegetation composition and structure and reserve values [3]. Alternatively, some fauna species require habitat features that only develop in long-unburnt vegetation, and many plants require a minimum fire-free period to accumulate a large enough seed bank to replace themselves.

These apparently disparate responses to fire indicate that a single fire regime applied widely across space and time, as is the present trend for many wheatbelt reserves, may not support existing biodiversity, and that variability in the fire regime within ecologically defined bounds may be more desirable. Identifying the range of appropriate fire intervals is thus crucial for management of wheatbelt reserves. Yet this information is lacking for most species.

Fire management in wheatbelt nature reserves must also take into account the landscape context. Introduction of fire in some circumstances could reduce the resistance of native vegetation to invasion by weeds which are abundant in the surrounding agricultural landscape. This creates a conundrum for conservation managers. Should fire be excluded in wheatbelt nature reserves because of the potential threat of weeds, even if atypically long periods without fire are undesirable for biodiversity, and if fire is introduced, how long should it be before an area is burnt again?

To address these questions we measured changes to mallee and mallee-heath vegetation across a time since fire gradient in the Lake Magenta region. We predicted fire interval bounds from assessment of vital attributes for key species and vegetation structural and compositional change. In addition, we experimentally investigated the effect of fire and fragmentation on resistance of mallee vegetation to weed invasion.

Species diversity declined with time since fire in mallee-heath but not in mallee. Mallee-heath exhibited senescence when > ~45-55 years since fire, with increasing standing dead vegetation, bare ground, and declining vigour in sprouting *Eucalyptus* spp. Mallee showed no such evidence of senescence, and continued to increase in stature at the upper end of our time since fire gradient [4].

Serotinous non-sprouters were more effective for predicting fire interval bounds than serotinous sprouters. Consistent with this mallee-heath, dominated by non-sprouters, is more vulnerable to variation in fire interval than mallee, dominated by sprouters. We propose that fire-return intervals of ~35-80 yrs are acceptable in mallee-heath and ~30 years to beyond the range of vegetation ages sampled in mallee at c. 350mm mean annual rainfall [Gosper, Prober, Yates unpubl. data].

Landscape position had a greater impact than fire on weed invasion. Weeds grew well at reserve edges with paddocks independent of fire. In contrast, fire did not exacerbate weed growth in intact mallee where soil nutrients were low, and consequently could be used in reserve interiors. Managers should avoid burning reserve edges if resources are not available for weed control [5].

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Oral presentations

Thursday 13 October 2011

Development and Application of the UWA Wildfire Simulator

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The facility to forecast the spread of fire at the landscape level has application as a predictive tool to aid wildfire incident management, as a planning utility that determines outcomes to hypothetical "what if?" scenarios, and as a cost-effective complement to conducting experiments with real fires. Although there is an incomplete understanding of the physical processes governing fire spread, empirical models, such as the well-known McArthur meters [1], have been developed that estimate the head rate-of-spread from weather and fuel variables. The McArthur forest fire meter Mk 5, for example, accepts five variables, air temperature, relative humidity, fuel load, wind speed and drought factor. However, a fire spread simulator that utilises these rate-of-spread models faces a number of challenges: first, it must convert the one dimensional head rate-of-spread to fire spread over a 3D landscape; second, it must employ a computationally efficient method to be able to simulate wildfire at landscape scales; finally, the simulator must interface to accurate geo-referenced data if it is to make realistic forecasts. Our presentation will describe how these challenges are met by the UWA Wildfire Simulator.

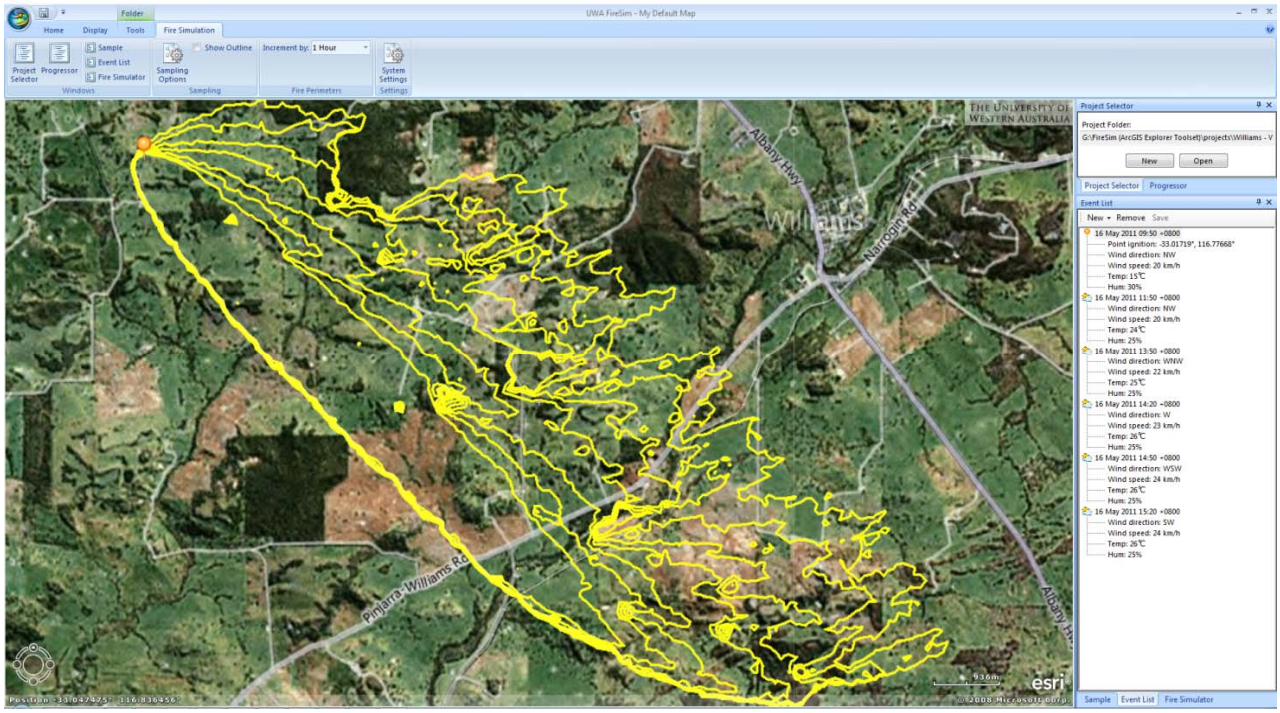
The UWA Wildfire Simulator consists of two key components, the first being the core, a cell-based, discrete event wildfire spread simulator. Cell-based, discrete event methods are more efficient than fire front propagation techniques, but previous systems used regular shaped cells and suffered from distortion because fire spread was constrained to a limited number of directions; for example, rectangular cells, which were typical, constrain spread to the direction of the four or eight immediate neighbours. The UWA simulator minimises distortion by employing a randomised, irregular cell grid that eliminates the directional constraints imposed by regularity [2]. Distortion can be further minimised by increasing cell connectivity, so that cells up to k "links" apart are considered neighbours, where k is a parameter set by the user.

The second key component is a geographic information system (GIS) that facilitates the entry, sampling and display of input data layers, including topography, vegetation maps, previous fire history and ignition points or current fire line. It also post-processes the simulator's output, producing a geo-referenced spread prediction map showing fire perimeters at regular time intervals and illustrating the progression of the wildfire across the landscape.

On current generation PCs, the UWA Wildfire Simulator takes less than 1 min to simulate a wildfire across a 25 km × 15 km area sampled at 100 m resolution (approximately 42,000 cells). Rapid simulation such as this supports real-time operation and facilitates planning for multiple scenarios – simulating the fire's response to expected and worst-case weather conditions, for example. The system is currently data-configured for south-western Australia, with a WA-wide extension planned for completion by the start of 2012, to be followed afterwards by a total WA, QLD, NT and SA package.

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UWA FireSim - My Default Map
Home
Display
Tools
Fire Simulation
Project Selector
Progressor
Sample
Event List
Fire Simulator
Windows
Sampling Options
Show Outline
Sampling
Increment by: 1 Hour
Fire Perimeters
System Settings
Settings
THE UNIVERSITY OF WESTERN AUSTRALIA
Albany Hwy
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Project Selector
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Project Selector
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Event List
New
Remove
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16 May 2011 09:50 +0800
Point ignition: -33.01719°, 116.77668°
Wind direction: NW
Wind speed: 20 km/h
Temp: 15°C
Hum: 30%
16 May 2011 11:50 +0800
Wind direction: NW
Wind speed: 20 km/h
Temp: 24°C
Hum: 25%
16 May 2011 13:50 +0800
Wind direction: WNW
Wind speed: 22 km/h
Temp: 25°C
Hum: 25%
16 May 2011 14:20 +0800
Wind direction: W
Wind speed: 23 km/h
Temp: 26°C
Hum: 25%
16 May 2011 14:50 +0800
Wind direction: WSW
Wind speed: 24 km/h
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16 May 2011 15:20 +0800
Wind direction: SW
Wind speed: 24 km/h
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Sample
Event List
Fire Simulator

Fire behaviour during the Pickering Brook wildfire, January 2005

N P Cheney

Abstract.

Wildfire during January, 2005 burnt through Jarrah forest east of Perth, Western Australia. Fuels in the area ranged from 1 year-old to 22 year-old in a broad mosaic. A detailed reconstruction of the spread over two days allowed the testing of fire-spread prediction models and the examination of the effects of prescribed burning on fire behaviour.

The WA Forest Fire Behaviour Tables grossly under-predicted fire spread using a wind ratio of 5:1 to convert open wind speed to in-forest wind speed. At a wind ratio of 3:1 the tables predicted reasonably well at low to moderate wind speeds but over-predicted at high wind speeds.

New fire spread equations based on experiments with moderate-intensity fires in Jarrah forest (Project Vesta) predicted fire spread reasonably well over the full range of fuel loads and windspeeds. However, the data suggested the need for better models to predict fuel moisture content, particularly after a day of low humidity

A comparison of predicted and observed rate of spread indicated that reducing fuel load by prescribed burning reduced the rate of spread below the rate predicted 20 year-old fuel loads for at least 8 years. Fire in 3 year-old fuel spread 6 times slower and was 20 times less intense than fire in 20 year old fuel

In the absence of a prescribed burning program and assuming the area had not been burnt for 20 years it was estimated the fire would have burnt into the suburban area with the potential for extensive property damage. The final area could have exceeded 100 000 ha or more than 3 times the area actually burnt.

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Quantifying the effectiveness of fuel management in modifying wildfire behaviour – recent examples from Western Australia and Victoria

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Abstract

Prescribed fire has been used extensively for fuel hazard management in the eucalypt forests of southern Australia since the 1960s. Implementation of prescribed fire programs has been closely linked with, and dependent upon, the development of burning guides for particular forest types through empirical field research. The effectiveness of prescribed fire programs in reducing the overall impact of wildfires has been examined using a variety of methods, and at a range of scales. At the local scale, case studies have proved useful in illustrating the effects of different fuel conditions on fire behaviour, the resulting impacts on natural resource values and fire suppression difficulty. Remote sensing is increasingly being used to monitor the effects of fuel management at the landscape scale with promising advances in the ability to detect fires under a dense forest canopy. Assessment of program effectiveness at the regional scale is generally based on statistical trends in fire occurrence and size. The effect of fuel conditions on fire behaviour has also been studied experimentally, most recently by Project Vesta. In this paper examples of these different approaches are presented, and the strengths and limitations of each discussed. Recent case studies from south-west Western Australia and the Victorian bushfires of Black Saturday 7 February 2009 are examined. Fuels management can have important benefits to fire suppression that are subtle and difficult to quantify, such as increasing the safety, efficiency and effectiveness of suppression strategies. In this situation the lack of fuel management decreases the probability of first attack success under increasing fire weather conditions. An integrated approach that draws on a broad range of information offers the best way of quantifying the effectiveness of fuels management programs.

Quantifying long-term regional scale impacts of prescribed burning on wildfire incidence and extent in SW Australian eucalypt forests

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Prescribed burning is being advocated both for its capacity to reduce fuel loads, and thereby mitigating large high-intensity wildfires, and as a means to re-introduce a natural disturbance to inherently fire-prone ecosystems. However, for many such environments the field evidence or ecological understanding to predict the benefits of prescribed burning is lacking, for either wildfire hazard reduction or conservation. This study analyses a 52-year fire history from the Warren Region in south-western Australia[1]; one of the few regions in the world where prescribed burning has been practised at adequate spatiotemporal scales for assessing long-term impacts on regional fire regimes and ecosystem functioning.

Quantile regression identified the longevity of the influence of prescribed fire treatments on wildfire incidence and extent. Anomalies in the frequency-size distribution of unplanned fires were identified through a relative risk mapping using kernel density estimates. Changes in the spatial distribution of fuel age were quantified using patch metrics, while generalized additive models were applied to estimate effects of fuel age patterns on the incidence and extent of unplanned fire.

Widespread prescribed burning, introduced in the 1960s, has profoundly changed the spatial patterning of fuel age across the landscape while reducing the incidence and extent of unplanned fires. Increases in total annual area treated by prescribed burning are in general weakly correlated with a decreasing number and extent of unplanned fires in the same or subsequent years, decaying to insignificance for time lags greater than six years. However, when summed over six-year periods, the fraction of the area treated by prescribed burning explained 24% and 71% of the variation in the mean annual frequency and extent of unplanned fires, respectively. From the results we estimate that every unit area reduction in the mean annual extent of unplanned fire required about four area units of prescription fire. The incidence of large unplanned fires was significantly less than the long-term average for the region when the annual extent of prescribed fire was at a maximum and significantly more when the annual extent of prescribed fire was at a minimum. The spatial patterning of fuel age alone explained 21% and 64% of the variation in the annual frequency and extent of unplanned fires, respectively. Since the 1960s, the length of time that sites remain unburned by wildfire has increased from ~5 to ~10 years, independent of the previous fire being planned or unplanned fire.

Our findings provide strong empirical evidence of the effectiveness of prescribed burning for mitigating wildfire hazard in SW Australian forests. However, ongoing research and development is needed to implement managed fire regimes that integrate wildfire mitigation with conservation of biodiversity and other environmental values.

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Predicting woody fuel consumption in eucalypt forest fires in southern Australia

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Abstract

Consumption of woody fuel (diameter > 0.6 cm) during forest fires has important implications for fire suppression and firefighter safety, fire behaviour, ecological effects of fire and emissions of carbon and smoke. The ability to accurately predict woody fuel consumption is therefore important to support both forest and fire management decision making. However, information on woody fuel consumption in eucalypt forest fires in southern Australia is scant and the predictive capacity of existing models unknown.

In this Forum, the findings of the Woody Fuel Consumption Project (WFCP) are presented. This project aimed to (1) evaluate the predictive capacity of existing woody fuel consumption models and to assess their potential for application in Australia using woody fuel consumption data collected throughout southern Australian eucalypt forests, (2) investigate potential variables affecting woody fuel consumption across different Australian eucalypt forests including fuel, weather, season and fire behaviour characteristics, and (3) develop an empirically based model of woody fuel consumption for southern Australian eucalypt forest fires using data collected under a wide range of burning conditions.

Pre-fire woody fuel structure and its consumption by fire was measured in eucalypt forests at experimental/prescribed fires and high intensity wildfires as part of the WFCP in south-western Western Australia and northern-central Victoria. Three additional datasets were also sourced to increase variation in forest type, fuel complex and fire characteristics. These comprised data from south-western Western Australia collected as part of Project Aquarius, the Warra Long Term Ecological Research site in Tasmania and Tumbarumba in south-eastern New South Wales. Data were combined to better understand and model the dynamics of woody fuel consumption and evaluate five existing models for the consumption of woody fuels for potential application in southern Australian eucalypt forest fires.

The proportion of woody fuel consumed by forest fires was highly variable, ranging from 9 to 100%. Evaluation statistics for existing models were best for the Australian National Carbon Accounting System model which assumes 50% woody fuel consumption, however this assumption failed to capture large deviations where woody fuel consumption has been

particularly high or low. CONSUME Activity and CONSUME Southern Woody models under-predicted observations while the CONSUME Western Woody model had very little bias and a better proportion of predictions within ±10% of the observed woody fuel consumption. The BURNUP model showed the greatest overall level of error when used with natural fuels; however its performance improved when applied to heavy, modified fuel loads resulting from timber harvesting operations.

A generalised linear model (GLM) approach to model development identified the Forest Fire Danger Index (FFDI) as the best predictor of the proportion of woody fuel consumed, with an R^2 of 0.58 and mean absolute error of 10% (Figure 1). Fireline intensity also had a statistically significant, positive relationship with the proportion of woody fuel consumed. Analysis of combustion stages did not improve the ability of models to predict ignition, partial and full consumption of woody fuels. However, analysis showed that variation in fire behaviour potentially has a greater impact on woody fuel consumption, than variation in fuel characteristics.

The FFDI GLM provides forest and fire managers with a tool to manage woody fuel consumption objectives and may assist fire managers with forecasting post-frontal fire behaviour. The FFDI GLM may also assist forest and fire managers to better meet land management goals and to comply with air quality and emission targets.

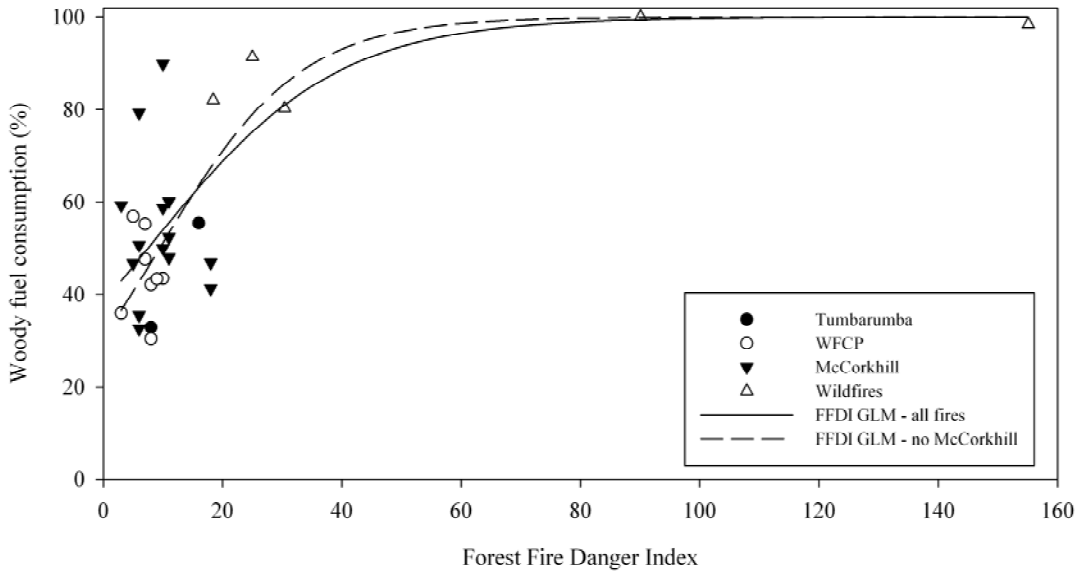


Figure 1. Woody fuel consumption versus Forest Fire Danger Index for all fires, including wildfires.

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Fire behaviour in southwestern Australian shrublands: evaluating the influence of fuel age and fire weather.

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Extended Abstract

Fire regimes and their management in fire-prone Mediterranean shrublands are of ecological and applied interest due to the high biodiversity values of these ecosystems, their association with densely settled areas worldwide, and the propensity for frequent fire at high intensities which often lead to loss of human property and sometimes human life. Fuel age (time since last fire) is often used to approximate fire hazard and informs decisions on placement of shrubland management burns. However, uncertainty remains concerning the relative importance of fuel age and weather conditions as predictors of fire hazard and behaviour. Working with the Department of Environment and Conservations, we obtained data from 35 experimental burns across three types of shrublands (calcareous, tall heath on acid sand, short heath on acid sand) located in the Jurien Bay to Eneabba region 300 km north of Perth. Using these datat, we evaluated the importance of fuel age and fire weather on probability of fire propagation (hazard) and four metrics of fire behaviour (rate of spread, fireline intensity, residence time, surface temperature) under moderate to high fire danger weather conditions (FFDI 8-27). We found significant support for a threshold effect of fuel age for fire propagation but limited evidence for an effect of fuel age or fire weather on rates of spread or fireline intensity, although surface heating and heating duration were significantly related to fuel age and shrubland type. Forward rate of spread was not predicted by either fuel age or fire danger index. Further analysis suggested that dead fuel mass and accumulation rate rather than live fuels was responsible for this relationship. Using BEHAVE, predicted spread rates and intensities were consistently lower than observed values, suggesting further refinement is needed in modeling shrubland fire behaviour. These data provide important insight into fire behaviour in globally significant, fire-adapted shrublands, informing fire management and relationships between fire frequency and fire intensity.

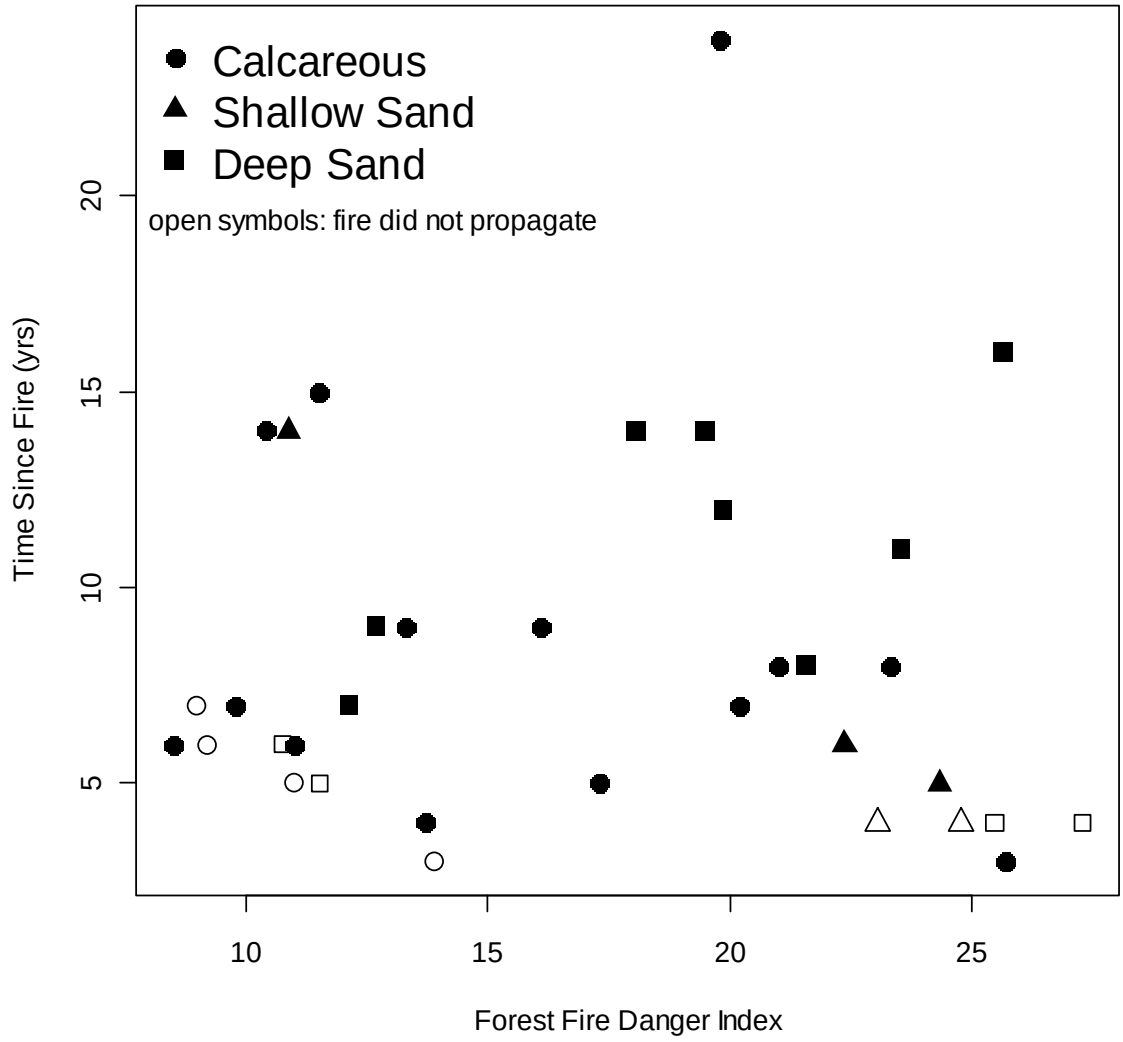


Fig 1. Fuel age (time since fire) and weather conditions as measured by the Forest Fire Danger Index under which 35 experimental burns were ignited in Western Australian kwongan (shrubland) vegetation. Fires that did not carry across a range of weather conditions were of younger fuel ages.

Effects of the fire management method of chaining and burning on plant communities

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Managing fire regimes is increasingly recognized as important for biodiversity conservation in fire-prone regions. In the global biodiversity hotspot of south-west Western Australia, chaining and burning (also known as fuel modification or scrub rolling) is a novel technique used to assist in fire management, for both biodiversity conservation and protection of community assets.

Chaining and burning aims to create a strip, typically 40-100 m wide, with a reduced fuel load to: (i) reduce the likelihood of wildfires crossing the strip; and (ii) facilitate the safe and effective application of prescribed fire [1]. Vegetation is first dislodged using a chain dragged between two machines, then after a period of curing, the vegetation is burnt. Chaining and burning is applied predominantly in shrubland and mallee vegetation, where the vertical distribution of fuel is such that unmodified vegetation usually burns only under severe fire weather [1] and where flattening and drying allows for prescribed fire application under less dangerous conditions. To date, most strips have been single-application, but because the effectiveness of the strips declines over time as plant communities recover, consideration is being given to the re-treatment of existing areas [1].

The effects of chaining and burning on plant communities have been poorly understood until recently, despite the potential consequences of combining two disturbance events: physical damage and fire. To address this, we compared recruitment, resprouting and vegetation structure in mallee-heath subject to chaining and burning and burning only in the Lake Magenta area of the eastern wheatbelt. We hypothesised that outcomes would vary depending on plant functional types defined by disturbance response.

We recorded 90% fewer recruits of obligate seeders (plants killed by complete scorching) with a canopy seed store in chained and burnt compared to only burnt plots, and a 44% decrease in their species richness [2]. Their seeds are likely to have been destroyed in the fire after being shed from protective fruits between chaining and burning [3]. By contrast, recruits of obligate seeding shrubs and fire ephemeral herbs with persistent soil-stored seed banks increased [2], possibly responding to enhanced germination stimuli. Sprouters showed little difference. Chaining and burning significantly alters vegetation composition, and potentially poses a localised threat to threatened, conservation priority or narrow-range endemic obligate seeders with canopy-stored seeds.

Both chained and burnt and only burnt vegetation had less leaf litter and tall vegetation (> 25 cm) than long-unburnt vegetation, indicating a fire management benefit. The stem number of mallee *Eucalyptus* spp. was 20% less in chained and burnt strips compared to where only burnt [4], indicating that consecutive disturbances reduces resilience and may render sprouters vulnerable to subsequent disturbances.

As the probability of fire occurrence is not equal across the landscape, this indicates the value of strategic approaches to fire management. Average fire return intervals decrease from ~340 yrs in small (100-500 ha) wheatbelt remnants, to ~70 yrs in large (> 500 ha) remnants to ~40 yrs in the continuously vegetated Great Western Woodlands [5].

The utility of single-application chained and burnt strips may therefore depend on landscape context. In remnants, where fires are infrequent, the probability of unplanned fires intersecting effective single-application chained and burnt strips is low. Multiple applications will be needed for strips to be effective in fire management over the medium term. The biodiversity conservation consequences of this will need to be assessed against the potential broader benefits of the practice in managing landscape fire regimes.

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Impact of variable fire intensity on soil carbon and nitrogen in Jarrah forest soils – Heterogeneity

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Fire is a major driver of both landscape-scale and fine-scale patterns in forests (Christensen and Kimber 1975). Forest landscapes tend to become more or less heterogeneous in the distribution of biomass and nutrients after fire. Heterogeneity depends on the complexity and structure of biomass/fuel that is a component of determining the uniformity of the impact and the other drivers of fire behaviour (slope/weather). At relatively fine-scales, such as around individual trees, the impact of fire intensity on Carbon (C) and Nitrogen (N) pools is largely unknown. However, fine-scale variation in C and N is likely to be important because of strong links between forest productivity and therefore fuel development in seasonally nutrient-limited forests, such as the Jarrah forest.

Fire impacts on soil C and N availability through a range of processes, many of which are highly dependent on the intensity of the fire. For example, if intensity during a fire remains relatively low (i.e., < 3,000 kW m-1), some soil C will convert from relatively labile organic forms to charcoal (Knicker 2007). Carbon will also be lost at higher temperatures as COx, but charcoal will continue to be formed at the expense of organic matter (OM) (Bennett, Angove et al. 2004). Similarly, the amounts and availability of N after fire is largely determined by fire intensity with continued re-deposition up to ~300 °C; above 300 °C volatilisation occurs and N is lost from the soil into the atmosphere (DeBell and Ralston 1970). After fire, N often accumulates in Australian forest soils in inorganic forms, particularly as ammonium (NH4), thereby decreasing the C to N ratio of the soil and increasing the quality of organic matter (OM) after fire. We sought to assess the impact of increasing fire intensity on C and N fractions in soil, as well as the spatial pattern of microbial biomass as a result of fire.

Mineralization of soil organic matter (SOM) plays an important role in release and supply of plant nutrients and maintenance of soil quality. In many ecosystems that are nutrient-limited, N is stored as organic complexes in soil because decomposition rates are slow (Peet 1971) and litter accumulates (Wallace 1966). Fire thus plays a key role in many forest ecosystems releasing nitrogen from organic matter through both direct and indirect processes, making it available for plant growth (Attiwill and Adams 1993). The microbial community plays a vital role in mediating ecosystem response to fire disturbance, such as making nitrogen available for plant uptake. Soil biodiversity is intrinsically linked to ecosystem function of some processes, particularly nutrient (Schimel, Bennett et al. 2005) and subsequent energy flow (Giffiths, Ritz et al. 2000).

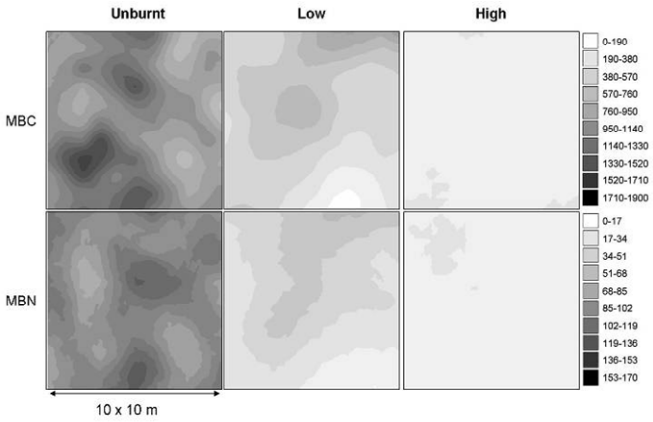


Figure 1- Interpolated patterns of microbial biomass, MBC (mg kg^{-1} soil) and MBN (mg kg^{-1}

soil) for the 10 m x 10 m field plots representing, from left to right, unburnt, low burn severity and high burn severity.

The reduction in microbial biomass due to fire noted in this study followed similar patterns previously described for a range of forest types (Pietikäinen and Fritze 1993; Wilson, Mitchell et al. 2002; Mabuhay, Isagi et al. 2006). Microbial biomass was, unsurprisingly, less affected at low versus high burn severity. How this reduction influences broadrer processes is not well established. Yet it is well known that fire can affect forest soil biogeochemistry both directly and indirectly. Increasing fire severity impacts upon the microbial community by directly reducing microbial biomass and simplifying the pattern of distribution, essentially creating a smaller, coarser distributed community. The complex interaction of impacts on the different C and N fractions means that some pools are influenced by burn severity and some are not, and interactions between fractions makes it difficult to access. Yet as a combined resource (the C and N status) the influence of increasing fire intensity is not a universally simplifying process. The combination of the development of a coarser pattern of microbial biomass and the development of finer pattern in C and N status with increasing burn severity suggest that there is at least a temporary decoupling between the microbial community and the resources as a result of a direct impact of fire.

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Summary of fire suppressant impacts on flora of the Swan Coastal Plain

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Abstract

Fire suppressants are now accepted in Australia and worldwide as a useful tool in the control of wildfires. However, the impacts of fire suppressant chemicals on flora are poorly understood. Based on the biodiverse flora of Banksia woodland, here I present the first comprehensive study for understanding the impact of fire suppressants on plant growth and populations. A summary of major findings will be presented with the aim to facilitate best environmental practice during fire suppression activities.

Experimental trials investigated impacts of ten fire suppressant products on; 1) soil nutrient content, 2) seeds and seedling emergence, 3) seedling mortality and growth, and 4) biodiversity and plant populations within Banksia woodland. The fire suppressants comprised of seven short-term foams (Chemguard First Class, Hydrex AR FFFP, Jet-X Foam, FireAde 2000, Silv-Ex Foam, Ansul3% Fluoroprotein Foam, and Virtual Training Foam), two polymer gels (Barricade Fire Blocking Gel and ClearETI Fire Gel), and one long-term retardant (Phos-Chek G75F).

Content analysis revealed suppressants varied widely in concentration of plant-available nutrients. Sulphur (S) was common to short-term foams (ranging from 45 to 912 mg/kg). While ammonium (NH_4^+), S, and phosphorus (P) were very high within the retardant (28775, 21180, 8586 mg/kg, respectively). Field trials demonstrate suppressants can significantly elevate soil nutrient concentrations, with persistence of up to 12 months for some products.

Effects of fire suppressants on seedling emergence were both species-specific and product-specific, correlating strongly with S and P concentration. Suppressants often delayed germination and significantly reduced final emergence. In contrast, weed seedling emergence was often significantly enhanced.

Response of seedlings to application of fire suppressant was also species-specific and product-specific. Seedling mortality was strongly correlated with S and sodium (Na) concentration. A fertiliser effect in the growth of surviving seedlings was evident for suppressants with higher nutrient content.

Two field trials found that native species' biodiversity remained unchanged by fire suppressants. However, some suppressants affected populations of individual species, resulting in altered species composition. Though some native species were affected, the greatest changes occurred for weed species 12-months after application, indicating fire suppressant are altering soil seed bank composition.

Overall, experimental trials demonstrate that fire suppressants can affect flora and alter Banksia woodland communities. The operational effectiveness and cost benefits of fire suppressants may therefore need to be weighed alongside the potential for negative ecological impacts.

The Perth Hills Fires 2011 : Key Findings from Community Survey

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Abstract

Background

On the weekend of 5 and 6 February 2011, two major bushfires devastated separate areas of the natural and built environments in the Perth metropolitan area. One of the fires took place across the suburbs of Red Hill, Herne Hill, Millendon, Baskerville and Gidgegannup (hereafter Red Hill–Brigadoon fire) (City of Swan), the other occurred in Roleystone and Kelmscott (hereafter Kelmscott–Roleystone fire) (City of Armadale). The Bureau of Meteorology had issued a Fire Weather Warning (FWW) and a Total Fire Ban (TFB) had been declared for all the fire-affected areas prior to the commencement of the fires.

Methodology

After analysis of the fire scars from the Kelmscott–Roleystone fire and Red Hill–Brigadoon fire, interviews were conducted with residents of 425 households in, around or near the fires, with all residents of interviewed households asked to take part in a household member survey. Following the interview process, an extensive questionnaire was mailed out to a random selection of 3000 residents of the affected suburbs, producing a response rate of over 30%.

Findings

Preparatory Measures

Residents reported engaging in a range of preparatory actions in prior to and during fire with no clear pattern emerging. From the mail out survey, the most cited source of information used by residents for their bushfire preparation was the 'Prepare. Act. Survive' pamphlet sent out by the Fire and Emergency Services Authority (FESA). During the interviews, using 'common sense' and relying on experience from living in the community were very common responses by residents.

The data revealed residents living on larger block sizes engaged in more preparatory measures than those on smaller block sizes perhaps reflecting varying perceptions of risk. Perception of degree of threat to life and property was associated with the number of preparatory actions; a high level of threat perception was associated with a greater number of preparatory actions per household. Perception of the likelihood of a bushfire to a resident's town or suburb did not have any association with the number of preparatory actions per household. Those involved with a Bushfire Ready Group (BRG) were the most proactive in property preparation but no link between preparedness and property damage was evident from the data.

Barriers to Preparation

A number of barriers to preparation were reported. Monetary constraints were seen as significant but additionally the following were reported: perceived complexity of regulations; difficulties with bureaucracy; lack of time; complacency; lack of experience; age and health-related difficulties; frustration over other residents' lack of preparation; and being in a rental situation moderated a sense of responsibility.

Total Fire Ban (TFB) and Fire Expectations

Sixty seven percent of those surveyed thought a TFB was in place on the day of the fires although there was no clear understanding of what a TFB might actually mean in practise. Residents reported applying a 'common sense' mentality (variously defined) due to prevailing weather conditions or from not knowing the difference between a fire ban and a total fire ban. Interestingly, over 60% of respondents expected to receive an official warning if required to evacuate

Learning, Information and Warnings about the Fire

The majority of residents became aware of the fire through either seeing or smelling smoke, with the next most important source of information being contact from family, friends or neighbours. When seeking or receiving further information from official sources about the fire, the most accessed sources were StateAlert, ABC Radio, the FESA website, emergency services personnel and other radio stations. Ten of the residents responded that the StateAlert was the most important source of information upon which they relied.

Implications

Managing community perceptions of risk and expectations remains a significant problem. This in part seems to be a consequence of the information that is available to residents and perhaps feelings of efficacy. The implications of the findings with respect to promoting proactive preparation will be discussed.

Does God Play Dice?

Mathematical Patterns in Bushfire Mosaics

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Abstract

Using a mathematical approach based on Graph Theory and the Four Colour Map Theorem, this presentation demonstrates the existence of a self-organizing tendency in bushfire mosaics, and suggests that we will do better to take note of that tendency, rather than ignore, or deny it.

Not everybody has a mathematical background, so this presentation makes an approach to mathematics through history. Four mathematicians, spanning four hundred years, are introduced, and their contributions discussed. They are René Descartes (1596-1650), Leonhard Euler (1707-1783), Francis Guthrie (1831-1899), and Paul Erdös (1913-1996). Simple coloured graphs are used to show the relevance of their ideas, and a graphic model of the jarrah forest in Wungong Catchment, near Perth, is developed. Equations relating the number of patches in a mosaic to the frequency of burning are presented (Ward 2010). The effects of some potential bushfire management scenarios are tested.

From the model it becomes clear that burning as frequently as the litter will just carry a light, patchy fire, will lead to a stable mosaic, within which large fires cannot grow (Loehle 2004). Upland jarrah forest will just carry fire at 3-4 year intervals.

Excluding fire for longer periods will lead, inevitably, to an unstable mosaic, due to a 'connectivity avalanche' of flammable patches. Broad fuel connectivity can happen very suddenly. In summer weather, broad areas of heavy, connected fuels can lead to large, uncontrollable bushfires, with danger to human life and property, and potential damage to natural ecosystems, for example by killing mature trees, and native animals. This outcome has been demonstrated a number of times in south-western Australia, most recently in the Roleystone-Kelmscott bushfire of February 2011 (Keelty 2011).

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Integrated assessment of prescribed burning

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Team members: Dr Fiona Gibson, Dr James Fogarty, Dr Graeme Doole, Geoff Park
Associated PhD Student: Veronique Florec

Abstract

Prescribed burning is the controlled application of fire to an area at a specific time and intensity required to meet specific management objectives. As such, a prescribed burn is likely to have both positive and negative impacts. For example, there can be benefits for life and property by reducing the risk of catastrophic fires, potential health and safety risks to surrounding communities, and potential adverse outcomes to local biodiversity. As such the uptake of prescribed burning by land managers throughout various regions in Australia has been limited and sometimes controversial.

The aim of this project is to provide an integrated assessment of various prescribed burning strategies, and to quantify trade-offs between social and environmental outcomes from various prescribed burning strategies. The challenge is to quantify the impacts appropriately for different strategies, to weigh them up, and measure trade-offs.

A variety of methods will be used to achieve the aims. First, relevant information will be collected and reviewed, such as existing reports, publications and data sets. Workshops will be conducted with researchers, land managers and officers from responsible organisations to identify and understand the decision options to be studied and the impacts of the decision options on fire risks and outcomes. The options may include different frequencies, timings, and scales of burning, and different on-ground fire management options. Second, through workshops with researchers and land managers, existing information about the impacts of various prescribed burning regimes on bushfire risks, environmental condition, and communities will be collated and evaluated, together with information about the costs of implementation. Third, we will develop a quantitative decision framework that integrates the information gathered through the workshops, and uses optimisation algorithms to identify the best possible packages of management options to meet specific objectives, such as minimising catastrophic fire events. In recognising the uncertainty surrounding the impact on risk, and social and environmental outcomes, differing expert opinions on the outcomes from prescribed burning will be investigated within the decision framework.

The benefits from using this integrated approach include the following: a high level of engagement with relevant organisation and experts; integration of diverse information types into one framework; provides a synthesis of current knowledge in a management context, including both published information and expert judgements; identifies and deals with knowledge gaps and uncertainties; a strong focus on decision making; transparency of assumptions and their impacts on outcomes; indications about future research priorities.

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