Managing fire for plant and animal conservation

Putting fire to work for conservation requires local knowledge

Luke Kelly (The University of Melbourne), Angie Haslem (La Trobe University), Brett Murphy (Charles Darwin University)

- Some studies show that more plant and animal species live in landscapes with a high diversity of fire histories, while others show no such relationship.
- The variation in fire regimes that will promote plant and animal conservation depends on the type of ecosystem.
- Fire management will be most effective when it is guided by local knowledge of plants, animals and and the habitats they depend on.

An aerial incendiary line in Kakadu National Park. The creation of fine-grained fire mosaics using prescribed burning is an objective of many fire managers. (Photo: Clay Trauernicht)

Variation in the time between fires, their severity, size and patchiness, and the season in which they occur is called 'pyrodiversity'. Because plants and animals often depend on resources that vary as a result of fire, it is argued that pyrodiversity will produce a diversity of habitats that can support more species. Some studies demonstrate that more plants and animals live in areas with a high diversity of fire histories, while others show no such relationship, challenging the generality of the hypothesis that 'pyrodiversity promotes biodiversity'.

Relationships between fire and biodiversity are context-specific, and vary between species, ecosystems and across spatial scales. For example, pyrodiversity increases bird diversity in eucalypt forests and plant-pollinator diversity in mixed-conifer forests. By contrast, unqualified application of pyrodiversity could reduce diversity of vertebrates in mallee vegetation, and ants and termites in savannas are relatively resilient to variation in fire regimes.

Ecological heterogeneity is important for biodiversity conservation, but not all forms of fire-driven variation are desirable. The ability to identify consistent relationships between pyrodiversity and biodiversity is complicated by feedbacks with other ecological processes. For example, climate, grazing and predation strongly affect fire and biodiversity, as well as relationships between them.

How can scientists and decision makers use the pyrodiversity concept for biodiversity conservation? Foremost, it is essential to recognise that there is no 'one-size-fits-all' approach. Natural ecosystems contain different species, have different fire regimes and present different fire risks to biodiversity and people. Fire management will be more effective when guided by local knowledge and based on the demonstrated requirements of plants and animals, as well as the habitats they depend on.

Ecological Society of Australia
https://www.ecolsoc.org.au

Further information about this topic contact:

Luke Kelly
ltkelly@unimelb.edu.au
(03) 9035 7519

 doi:10.1111/aec.12604

Supporting Evidence

Title	Aim	Key Results
Andersen A. N., Ribbons R. R., Pettit M. & Parr C. L. (2014) Burning for biodiversity: highly resilient ant communities respond only to strongly contrasting fire regimes in Australia's seasonal tropics. Journal of Applied Ecology 51, 1406-13.	To examine the sensitivity of tropical savanna ants to variation in fire regimes using results from a long-term fire experiment.	When treating each of the six fire treatments separately, no significant influence of fire was detected on any ant community response variable. A significant ant responses was only detected when experimental treatments were grouped into two contrasting fire frequency classes, low (burnt at most once over the 5 years) vs. high (burnt every 1 or 2 years). These responses were only evident after 3 years of fire treatment.
Avitabile S. C., Nimmo D. G., Bennett A. F. & Clarke M. F. (2015) Termites are resistant to the effects of fire at multiple spatial scales. PLOS ONE 10, e0140114.	To examine the distribution and occurrence of termites in the fire-prone, semi-arid mallee region of south-eastern Australia.	At the site-scale, there was no evidence of a significant relationship between the occurrence of termite species and time-since-fire. Rather, the occurrence of species was related to habitat features such as the density of trees and logs. At the landscape scale, there was little evidence that the frequency of occurrence of termite species was related to fire, and no evidence that habitat heterogeneity generated by fire influenced termite species richness. The most influential factor at the landscape scale was the environmental gradient represented by average annual rainfall.
Berry L. E., Lindenmayer D. B. & Driscoll D. A. (2015) Large unburnt areas, not small unburnt patches, are needed to conserve avian diversity in fire-prone landscapes. Journal of Applied Ecology 52, 486-95.	To test bird responses to size and isolation of unburnt patches within a large wildfire in southern Australia.	Larger unburnt patches within the wildfire boundary contained more bird species than smaller unburnt patches. However continuous unburnt vegetation outside the wildfire boundary supported the richest bird communities of any site type. Most birds occurred more often in unburnt intact vegetation. The value of unburnt patches within the fire boundary for birds was found to depend on the degree to which species utilise recently burnt vegetation.
Bird R. B., Tayor N., Codding B. F. & Bird D. W. (2013) Niche construction and Dreaming logic: Aboriginal patch mosaic burning and varanid lizards (Varanus gouldii) in Australia. Proceedings of the Royal Society B: Biological Sciences 280.	To investigate the effects of patch mosaic burning and Martu hunting on sand monitor lizard (Varanus gouldii) population density.	Lizard density (% plots present) increased with Martu foraging activity. In burnt plots, lizard densities peaked at intermediate hunting pressure; in unburnt plots, peak densities were recorded at highest hunting pressure. In late succession habitat, plots located close to fire-edges were 1.51 times more likely to have lizard burrows than plots further from fire-edges. Martu foragers had greater lizard hunting returns in landscapes which were more highly modified by human activity (equating to a greater diversity of successional patches).
Bowman D. M. J. S., Perry G. L. W., Higgins S. I., Johnson C. N., Fuhlendorf S. D. & Murphy B. P. (2016) Pyrodiversity is the coupling of biodiversity and fire regimes in food webs. Philosophical Transactions of the Royal Society B: Biological Sciences 37	To develop a novel conceptualisation of pyrodiversity as an emergent property of fire embedded in food webs: (1) considering how this idea relates to the fire regime concept; (2) reviewing the correlative and mechanistic evidence for and against the importance of spatio-temporal fire patterns on biodiversity and how this influences ecological processes; and (3) outlining the implications of our argument for the management of ecosystems.	Rather than merely describing spatio-temporal patterns of fire regimes, pyrodiversity must be understood in terms of feedbacks between fire regimes, biodiversity and ecological processes. Humans shape pyrodiversity both directly, by manipulating the intensity, severity, frequency and extent of fires, and indirectly, by influencing the abundance and distribution of various trophic guilds through hunting and husbandry of animals, and introduction and cultivation of plant species.
Bradstock R. A. & Kenny B. J. (2003) An application of plant functional types to fire management in a conservation reserve in southeastern Australia. Journal of Vegetation Science 14, 345-54.	To describe the application of the vital attributes scheme of Noble & Slatyer (1980) to fire managementin a conservation reserve in SE Australia containing a diverse array of woody species.	Ca. 20% of the species belonged to PFTs defined as sensitive to either frequent or infrequent fire (e.g. obligate seeder types). Varied methods, based on the nature and quality of data were used to estimate juvenile periods and life spans among species in these types, ever the estimates derived in each case were similar. On this basis, a domain of 'acceptable' fire intervals (7 to 30 yr) was derived for the woodland/open-forest vegetation.

doi:10.1111/aec.12604

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Bradstock R. A., Bedward M., Gill A. M. & Cohn J. S. (2005) Which mosaic? A landscape ecological approach for evaluating interactions between fire regimes, habitat and animals. Wildlife Research 32, 409-23.	To explore the link between 'fire mosaics' and the persistence of animal species. Key questions included: are variegated time since fire (i.e. 'visible') mosaics required for species persistence in all types of landscape context?, is the 'visible' mosaic the only form of fire/habitat/ landscape heterogeneity that is needed to adequately understand the requirements of animals resident in areas subject to recurrent fire?, and, are the kinds of mosaics required for persistence of animal populations sensitive to practical management constraints?	Results suggest that persistence of malleefowl Leipoa ocellata populations will be dependent on intervention using small patchy fires but that there is an optimum rate of intervention. Results were sensitive to spatial pattern of prescribed fire, landscape type (topography) and probability of wildfire. Underlying effects of the fire-interval distribution (the 'invisible' mosaic) on plant species and habitat account for these results.
Bradstock R. A., Bedwards M. & Cohn J. S. (2006) The modelled effects of different fire management strategies on the conifer Callitris verrucosa within semi-arid mallee vegetation in Australia. Journal of Applied Ecology 43, 281-292.	To identify a management solution, based on levels and spatial patterns of prescribed fire and unplanned fire, that serves to reduce the size of wildfires while maintaining viable populations of obligate seeder Callitris verrucosa.	Simulations showed that increased levels of prescribed fire resulted in smaller wildfires, and that lowest sizes of C. verrucosa populations resulted from either high (20%/yr) or zero prescribed burning. The latter result being related to the influence of fire interval on C. verrucosa. Results differed between landscape types (dune vs. flat).
Burgess E. E. & Maron M. (2016) Does the response of bird assemblages to fire mosaic properties vary among spatial scales and foraging guilds? Landscape Ecology 31, 687-99.	To compare the influence of fire mosaics and environmental heterogeneity on bird assemblages at two spatial scales, to evaluate the influence of spatial scale on heterogeneity/biodiversity relationships.	Environmental complexity (topographic variation) had strong effects on bird assemblage composition and species richness. Extent of long-unburnt vegetation at the landscape-scale positively affected the richness of multiple foraging guilds, whereas at the site-scale measures of environmental heterogeneity were more influential
Burrows N. D. (2008) Linking fire ecology and fire management in south-west Australian forest landscapes. Forest Ecology and Management 255, 2394-406.	To describe a range of evidence-based practical fire regimes that can be implemented to conserve biodiversity and toprotect human life and property in south-west Australian forests.	Forest ecosystems are fire-maintained, having evolved traits that enable them to persist with, and depend upon a varietyof fire regimes. No single regime is optimal for all organisms and communities, but diverse regimes, within ecological limits, are essential for maintaining biodiversity. Bushfires can also threaten people, property and industry so fire management, including proactive use of fire, is necessaryto both conserve biodiversity and to reduce the negative impacts of bushfires.
Clarke M. F. (2008) Catering for the needs of fauna in fire management: science or just wishful thinking? Wildlife Research 35, 385-94.	To examine how well four common premises that appear to underpin current fire management practices in Australia encompass the needs of fauna.	The scarcity of ecological data on the needs of fauna in relation to fire undermines the confidence managers should place in current popular frameworks for planning ecological burning. Such frameworks are built almost entirely around the goal of maintaining plant community diversity. They provide little guidance to managers regarding the characteristics of desirable 'mosaics' (e.g. patch size, connectivity or composition of age-since-burnt classes) or the timing of fires in relation to faunal population trends linked to other cycles (e.g. El Niño events).

doi:10.1111/aec.12604

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Codding B. F., Bliege Bird R., Kauhanen P. G. & Bird D. W. (2014) Conservation or co-evolution? Intermediate levels of Aboriginal burning and hunting have positive effects on kangaroo populations in Western Australia. Human Ecology 42, 659-69.	To test three predictions to determine the combined effects of Aboriginal burning and hunting on euro (Macropus robustus) populations. Firstly by examining euro distributions across patches of different seral stages to determine if they do indeed prefer particular stages of vegetative regrowth. If this is the case, then more fine-grained mosaics of these different seral stages should provide euros with greater access to preferred resources within their daily foraging range. Secondly, if euros benefit from living within a fine-grained mosaic of alternating seral stages, then their densities should be higher in regions with greater seral-stage diversity and heterogeneity. Finally, because hunting pressure may covary spatially with burning, euro populations may be greatest at intermediate levels of human activity, where the net benefits of Aboriginal burning are high enough to offset any negative impact of Aboriginal hunting.	Euros are significantly more abundant in regions dominated by fine-grained seral-stage mosaics developed by Aboriginal burning. Aboriginal burning may provide a benefit to species whose distributions overlapped with these fine-grained mosaics for prolonged periods of time, including now vulnerable or extinct species.
Davies A. B., Eggleton P., van Rensburg B. J. & Parr C. L. (2012) The pyrodiversity–biodiversity hypothesis: a test with savanna termite assemblages. Journal of Applied Ecology 49, 422-30.	To explore how termite diversity varied with mean annual precipitation and whether faunal responses to fire regimes varied with rainfall.	Assemblages differed significantly across savanna types with higher levels of diversity in the wetter site using the active searching method. Diversity was lowest at the most arid site but certain feeding groups peaked in the savanna with intermediate rainfall. Differences between these savannas are attributed to broad underlying changes in net primary productivity and temperature, with mammalian herbivores thought to generate a peak in diversity of some faunal groups at the intermediate savanna through their role in facilitating nutrient cycling.
Enright N. J., Fontaine J. B., Lamont B. B., Miller B. P. & Westcott V. C. (2014) Resistance and resilience to changing climate and fire regime depend on plant functional traits. Journal of Ecology 102, 1572-81.	To quantify the effects of more frequent fire and lower rainfall – as projected to occur under a warming and drying climate – on population responses of shrub species in biodiverse Mediterranean- climate type shrublands near Eneabba, southwestern Australia.	At shortened fire intervals, species solely dependent on seedling recruitment for persistence were more vulnerable to local extinction than were species with both seedling recruitment and vegetativeregrowth. Nevertheless, seedling recruitment was essential for population maintenance of resproutingspecies. Serotinous species were less resilient than soil seed storage species regardless of regenerationmode. Critically, in relation to changing climate, a 20% reduction in post-fire winter rainfall(essential for seedling recruitment) is predicted to increase the minimum inter-fire interval requiredfor self-replacement by 50%, placing many species at risk of decline.
Farnsworth L. M., Nimmo D. G., Kelly L. T., Bennett A. F. & Clarke M. F. (2014) Does pyrodiversity beget alpha, beta or gamma diversity? A case study using reptiles from semi-arid Australia. Diversity and Distributions 20, 663-73.	To assess the hypothesis that pyrodiversity begets biodiversity by enhancing community differentiation (beta diversity), resulting in increased landscape-scale richness (gamma diversity).	The diversity of fire-age classes had little influence on the alpha, beta or gamma diversity of reptile assemblages. The properties of fire mosaics that most influenced assemblages were the extent of structurally important fire-age classes. The extent of long-unburned vegetation increased beta diversity but reduced alpha diversity of the total reptile assemblage, essentially cancelling each other out at the landscape scale.
Giljohann K. M., McCarthy M. A., Kelly L. T. & Regan T. J. (2015) Choice of biodiversity index drives optimal fire management decisions. Ecological Applications 25, 264-77.	To investigate the influence the choice of objective function and taxonomic focus has on the optimal fire management recommendations. To evaluated a recent hazard reduction policy to annually burn a fixed amount of the landscape and compare results to the optimal solution.	The optimal management strategy to maximize species persistence over a 100-year period is predominantly to minimize wildfires. This is because the majority of species are more likely to occur in intermediate and late successional vegetation. However the optimal solution showed sensitivity to the objective and the species included in the analysis.

doi:10.1111/aec.12604

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Gill A. M. & McCarthy M. A. (1998) Intervals between prescribed fires in Australia: what intrinsic variation should apply? Biological Conservation 85, 161-9.	To examine various sources of evidence that can be used to determine variation appropriate to the conservation of biodiversity while minimizing the chances of economically destructive fires.	Primary juvenile periods of plants (especially of 'serotinous seeders') and non-breeding periods of birds (especially poorly dispersed species) suggest extreme lower limits for fire intervals whereas longevity of plant species which usually only reproduce after fire, set the extreme upper limits. Modelling of the behaviour of selected plant and animal speciesmay be used to set 'optimal' mean intervals. Historical fire-interval data might seem a useful way to determine the variation aboutthe mean fire-interval but data are scarce and interpretations are controversial. The Weibull distribution and its special case, thenegative exponential distribution, have been the most supported in North American studies of unplanned fires.
Griffiths A. D., Garnett S. T. & Brook B. W. (2015) Fire frequency matters more than fire size: Testing the pyrodiversity–biodiversity paradigm for at-risk small mammals in an Australian tropical savanna. Biological Conservation 186, 337-46.	Evaluate the implications of contrasting patch-mosaic burning scenarios for the population dynamics and risk of decline of four species of small mammals in northern Australia.	Fire frequency has more influence on small-mammal persistence than fire extent. Risk of extinction increased for all four species when fire frequency exceeded once every five years. Under current ambient fire regimes, most Australia tropical savannas burn more frequently and therefore seem to have unfavourable consequences for this faunal group and risk precipitating severe future declines.
Haslem A., Kelly L. T., Nimmo D. G., Watson S. J., Kenny S. A., Taylor R. S., Avitabile S. C., Callister K. E., Spence-Bailey L. M., Clarke M. F. & Bennett A. F. (2011) Habitat or fuel? Implications of long-term, post-fire dynamics for the development of	To document temporal change in habitat and fuel attributes over an extended post-fire chronosequence in mallee vegetation.	Post-fire change in most habitat/fuel attributes continued for up to a century after fire, with patterns of change often being non-linear in shape. Most key fuel resources (e.g. litter, spinifex) did not increase substantially after 30-years post-fire, whereas other important habitat resources (e.g. live tree hollows) were still developing after a century after fire.
Keith D. A. & Bradstock R. A. (1994) Fire and competition in Australian heath: a conceptual model and field investigations. Journal of Vegetation Science 5, 347-54.	To describe a conceptual model of heath vegetation, in which species were classified into five functional groups based on characteristics of their propagule pools, post-fire growth, timing and mode of reproduction and competitive status. The model assumes no recruitment without fire and a simple competitive hierarchy based on vertical stature. A critical feature of the model is an initial post-fire window of 5-6 yr in which competition from overstorey species on understorey species is reduced. Understorey functional groups differ in their ability to exploit this window.	The results highlight significant conflicts for fire management directed at conservation of full plant diversity. Banksia ericifolia, the overstorey dominant, is a major winter food source for honeyeaters and nectar-feeding small mammals. Implementation of fire regimes to encourage dense populations of B. ericifolia and other overstorey dominants, may be at the risk of reducing overall community diversity, most of which is represented in the understorey. Management options include implementation of: (1) repeated infrequent fires (> 13-yr intervals) to maximise overstorey density; (2) repeated frequent fires (< 8-yr intervals) to eliminate overstorey; or (3) an intermediate course that will regulate overstorey density and the frequency of windows of reduced competition. However, fire frequency thresholds that distinguish these options vary, depending on site quality and post-fire rainfall. Thus, a constant fire interval between 8 and 13 yr is unlikely to maintain a non-equilibrium state which promotes coexistence of all species. Fire management is more likely to achieve this by varying the frequency and spatial extent of fires according to observed population levels. For example, a fire interval of less than 8 yr may be required, at least over part of an area, if overstorey is dense and adversely affecting understorey over a wide area.
Kelly L. T., Bennett A. F., Clarke M. F. & McCarthy M. A. (2015) Optimal fire histories for biodiversity conservation. Conservation Biology 29, 473-81.	To determine the optimal fire history of a given area for biological conservation with a method linking tools from 3 fields of research: species distribution modeling, composite indices of biodiversity, and decision science.	Pyrodiversity per se did not necessarily promote vertebrate biodiversity. Maximizing pyrodiversity by having an even allocation of successional states did not maximize the geometric mean abundance of bird species. Older vegetation was disproportionately important for the conservation of birds, reptiles, and small mammals.
Kelly L. T., Brotons L. & McCarthy M. A. (2016) Putting pyrodiversity to work for animal conservation. Conservation Biology, DOI:10.1111/cobi.12861.	To provide better guidance on managing 'pyrodiversity for biodiversity'.	This snapshot of studies shows that the relationship between pyrodiversity and biodiversity depends on context, being influenced by taxa, ecosystem, scale and location. How biodiversity is measured is also important.

Title	Aim	Key Results
Kelly L. T., Nimmo D. G., Spence-Bailey L. M., Taylor R. S., Watson S. J., Clarke M. F. & Bennett A. F. (2012) Managing fire mosaics for small mammal conservation: a landscape perspective. Journal of Applied Ecology 49, 412-21.	To establish the relative influence of five landscape properties - the proportional extent of fire age-classes, the diversity of fire age-classes, the extent of the dominant vegetation type, rainfall history and biogeographic context – on small mammal populations.	Three of four study species were associated with the spatial extent of fire age-classes. Older vegetation was found to provide important habitat for native small mammals. Overall, however, rainfall history and biogeographic context were dominant influences: for example, the species richness of native mammals was positively associated with above-average rainfall. There was little evidence that the diversity of fire age-classes influenced either the capture rate of individual species or species richness.
Lawes M. J., Murphy B. P., Fisher A., Woinarski J. C. Z., Edwards A. C. & Russell-Smith J. (2015) Small mammals decline with increasing fire extent in northern Australia: evidence from long-term monitoring in Kakadu National Park. International Journal of	(1) To examine the proposition that small mammals in the tropical savannas of northern Australia are being 'burnt out' of the landscape by frequent large-scale fires of low patchiness, because they typically have home ranges much smaller than contemporary fire sizes and cannot easily escape the effects of these large, homogeneous fires. (2) Compare the effect of fire extent, in conjunction with fire frequency, season and spatial heterogeneity (patchiness) of the burnt area, on mammal declines in Kakadu National Park over a recent decadal period.	Fire extent – an index incorporating fire size and fire frequency – was the best predictor of mammal declines, and was superior to the proportion of the surrounding area burnt and fire patchiness. Point-based fire frequency, a commonly used index for characterising fire effects, was a weak predictor of declines. Small-scale burns affected small mammals least of all. Crucially, the most important aspects of fire regimes that are associated with declines are spatial ones; extensive fires (at scales larger than the home ranges of small mammals) are the most detrimental, indicating that small mammals may not easily escape the effects of large and less patchy fires. Large fires that burn at a landscape scale (>1000 ha) appear to be burning small mammals out of the landscape.
Maravalhas J. & Vasconcelos H. L. (2014) Revisiting the pyrodiversity–biodiversity hypothesis: long-term fire regimes and the structure of ant communities in a Neotropical savanna hotspot. Journal of Applied Ecology 51, 1661-8.	To evaluate how communities of ants differ with variation in the frequency and seasonal timing of fire in Brazilian Cerrado (savanna), a global biodiversity hotspot.	There were no significant differences in ant species richness in trees, and there were no significant differences in the richness of ground-dwelling ants among plots burned at different times of the dry season. However, unburned plots had fewer ground-dwelling ant species than those burned at 2 or 4 year intervals. Marked differences in species composition were detected across regimes varying in both the frequency and the timing of fire, which were related to fire-induced changes in vegetation structure. Over 40% of the overall ant species richness recorded in the study site was attributed to differences in species composition among fire treatments.
Martin RE, Sapsis DB. 1992. Fires as agents of biodiversity: pyrodiversity promotes biodiversity. Proceedings of the Symposium on Biodiversity in Northwestern California. Wildland Resources Centre, University of California, Berkeley.	To discuss how changes in North American fire regimes, fire suppression and reductions in pyrodiversity influence biodiversity.	Pyrodiversity has been reduced in North America and this has tended to reduce biodiversity.
Nimmo D. G., Kelly L. T., Spence-Bailey L. M., Watson S. J., Taylor R. S., Clarke M. F. & Bennett A. F. (2013) Fire Mosaics and Reptile Conservation in a Fire-Prone Region. Conservation Biology 27, 345-53.	To investigate the landscape-level drivers of reptile distributions in a fire-prone, semiarid region of southeastern Australia.	The landscape-level occurrence of 9 of the 22 species modelled was associated with the spatial extent of vegetation age classes created by fire. Biogeographic context and the extent of a vegetation type influenced 7 and 4 species, respectively. No species were associated with the diversity of vegetation ages within a landscape. Negative relations between reptile occurrence and both extent of recently burned vegetation (≤10 years postfire, n = 6) and long unburned vegetation (>35 years postfire, n = 4) suggested that a coarse-grained mosaic of areas (e.g. >1000 ha) of midsuccessional vegetation (11–35 years postfire) may support the fire-sensitive reptile species we modeled. This age class coincides with a peak in spinifex cover, a keystone structure for reptiles in semiarid and arid Australia.
Parr C. L. & Andersen A. N. (2006) Patch mosaic burning for biodiversity conservation: a critique of the pyrodiversity paradigm. Conservation Biology 20, 1610-9.	To (1) provide an overview of patch mosaic burning theory, (2) explore how the theory is being applied in practice, (3) examine the relationship between pyrodiversity and biodiversity, and (4) discuss the way forward for improved patch mosaic burning.	Shortcomings of patch mosaic burning were identified: the ecological significance of different burning patterns remains unknown and details of desired fire mosaics remain unspecified. This has led to fire-management plans based on pyrodiversity rhetoric that lacks substance in terms of operational guidelines and capacity for meaningful evaluation.
Pastro L. A., Dickman C. R. & Letnic M. (2011) Burning for biodiversity or burning biodiversity? Prescribed burn vs. wildfire impacts on plants, lizards, and mammals. Ecological Applications 21, 3238-53.	To test the effects of wildfire and prescribed burns on alpha and beta diversity of plants, mammals and lizards.	Plants: alpha and beta diversity increased after both prescribed burns and wildfires. Mammals: alpha diversity was not affected by prescribed burns, and decreased after wildfire; beta diversity decreased after prescribed burns and increased after wildfire. Lizards: Alpha and beta diversity both increased after prescribed burns; neither measure of diversity changed strongly after wildfire.

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Penman T. D., Christie F. J., Andersen A. N., Bradstock R. A., Cary G. J., Henderson M. K., Price O., Tran C., Wardle G. M., Williams R. J. & York A. (2011) Prescribed burning: how can it work to conserve the things we value? International Journal of Wild	To address two questions: (1) to what extent can fuel reduction burning reduce the risk of loss of human life and economic assets posed from wildfires? (2) To what extent can prescribed burning be used to reduce the risk of biodiversity loss?	Data suggest that prescribed burning can achieve a reduction in the extent of wildfires; however, at such levels, the result is an overall increase in the total area of the landscape burnt. Simulation modelling indicates that fuel reduction has less influence than weather on the extent of unplanned fire.
Ponisio L. C., Wilkin K., M'Gonigle L. K., Kulhanek K., Cook L., Thorp R., Griswold T. & Kremen C. (2016) Pyrodiversity begets plant–pollinator community diversity. Global Change Biology 22, 1794-808.	To examine how pyrodiversity, combined with drought intensity, influences plant-pollinator communities.	Pyrodiversity was positively related to the richness of the pollinators, flowering plants, and plant–pollinator interactions. On average, a 5% increase in pyrodiversity led to the gain of approximately one pollinator and one flowering plant species and nearly two interactions. Diversity of fire characteristics contributes to the spatial heterogeneity (b-diversity) of plant and pollinator communities. There was evidence that fire diversity buffers pollinator communities against the effects of drought-induced floral resource scarcity.
Sitters H., Christie F. J., Di Stefano J., Swan M., Penman T., Collins P. C. & York A. (2014) Avian responses to the diversity and configuration of fire age classes and vegetation types across a rainfall gradient. Forest Ecology and Management 318, 13-20.	To test relationships between bird diversity and landscape diversity and configuration across a rainfall gradient. Landscape metrics were based on fire-history attributes and vegetation characteristics.	Species richness in 300-ha landscapes increased with age-class diversity, the complexity of age-class configuration, and vegetation-type diversity in study landscapes. Species richness relationships with fire-driven landscape complexity were consistent across the rainfall gradient. Species turnover was higher in landscapes with greater age-class diversity in low-rainfall areas, but the opposite relationship was found for landscapes in high rainfall areas. Vegetation type configuration did not influence with species richness or turnover.
Taylor R. S., Watson S. J., Nimmo D. G., Kelly L. T., Bennett A. F. & Clarke M. F. (2012) Landscape-scale effects of fire on bird assemblages: does pyrodiversity beget biodiversity? Diversity and Distributions 18, 519-29.	To examine the likely impact of two dominant fire-management strategies on the mallee avifauna: 1) the widely held, but rarely tested, assumption that 'pyrodiversity begets biodiversity' and 2) an alternative management strategy that greater proportions of older vegetation in the landscape will have a positive effect on species richness and diversity.	Species richness of birds was not strongly associated with fire-mediated heterogeneity. Species richness was associated with increasing amounts of older vegetation in landscapes, but not with the proportion of recently burned vegetation in landscapes.
Tozer M. G. & Bradstock R. A. (2003) Fire-mediated effects of overstorey on plant species diversity and abundance in an eastern Australian heath. Plant Ecology 164, 213-23.	To: (1) determine if floristic composition in Banksia heath is correlated with the distribution of the shrub overstorey; (2) determine if patterns in floristic composition related to the presence/absence of the shrub overstorey are similar at different points on a moisture (resource) gradient; (3) consider possible mechanisms for overstorey effects and the implications of fire regimes at a variety of spatial scales.	The authors compared patches of Banksia heath which had supported an overstorey during a fire interval of about 30 y with patches where the overstorey was absent during the same period, and tested for differences in species composition as a function of overstorey presence. Floristic composition varied significantly between overstorey patches and open patches. Most species were less abundant in overstorey patches, however some were more abundant. The relative abundance of species in relation to overstorey was unrelated to their fire response, propagule longevity or propagule storage location. There was significantly less biomass in overstorey patches compared with open patches. The effect of the overstorey varied with soil moisture. In a dry area, the number of species was lower in overstorey patches, with fewer herb and shrub species present compared with open patches. Fewer species were recorded in a wetter area, but overstorey had no effect on the number of species recorded. Reduced intensity of competition among understorey species in overstorey patches could be responsible for the higher abundance of some species in these patches. The authors postulate that full diversity will be maintained when the density of overstorey shrubs fluctuates widely over a relatively short period of time. This is most likely when fire frequency is highly variable.

 doi:10.1111/aec.12604

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Trauernicht C., Brook B. W., Murphy B. P., Williamson G. J. & Bowman D. M. J. S. (2015) Local and global pyrogeographic evidence that indigenous fire management creates pyrodiversity. Ecology and Evolution 5, 1908-18.	(1) To better understand the ecological outcomes of anthropogenic burning using the spatial distribution of Callitris groves in Arnhem Land and Kakadu National Park to examine fine-scale patterns in the availability of long-unburnt habitat; (2) Explore how altering fire size, and therefore the spatial grain of fire occurrence, affects both spatial and temporal aspects of pyrodiversity.	Smaller sizes led to increased spatial heterogeneity and decreased median habitat patch size, Shannon index of patch age diversity, and frequency of older (i.e. long-unburnt) habitat patches.

doi:10.1111/aec.12604