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Large fires and their ecological consequences: introduction to the special issue

Richard J. Williams[A] *and Ross A. Bradstock*[B]

[A]CSIRO Sustainable Ecosystems, PMB 44 Winnellie, NT 0822, Australia.
Email: dick.williams@csiro.au

[B]Centre for Environmental Risk Management of Bushfires, University of Wollongong, Northfields Road, Wollongong, NSW 2522, Australia. Email: rossb@uow.edu.au

Abstract. In the last decade, extensive fires have occurred on most continents, affecting a wide range of ecosystems. We convened a Symposium at the 3rd International Fire Ecology and Management Congress in 2006 to address the issue of large fires and their ecological consequences in landscapes. The 10 papers presented here variously discuss the place of large fires in the context of historical fire regimes, the heterogeneity of fire regime components that are associated with large fires, and the ecological consequences of large fires. The discussions cover a range of biomes, from tropical to temperate, across the world. Three consistent themes emerged: firstly, large fires are usually a part of the Historical Range of Variability; secondly, large fires are inherently heterogeneous, leaving footprints of spatial and temporal diversity that may influence landscapes for decades; and thirdly, large fires have been perceived as socially and ecologically 'disastrous', due to obvious and significant deleterious effects on life and property, and the scale of immediate environmental impact. However, the papers presented here indicate that the long-term ecological impacts of individual large fires are not necessarily disastrous. Crucial impacts of large fires on ecosystems may depend largely on their rate of recurrence as well as landscape-scale variation in severity. The incidence and characteristics of large fires may change in the future, as a consequence of global climate change, and other social drivers of landscape change.

Introduction

Within the last decade, extensive fires have occurred on most continents and have affected a wide range of ecosystems. *New Scientist* dubbed 2003 the 'year of the bushfire'. A symposium was organised at the 3rd International Fire Ecology and Management Congress in San Diego, USA, in November 2006 to address the issue of large fires and their ecological consequences. Perspectives covering a range of continents and biomes were presented. This Special Issue of the *International Journal of Wildland Fire* contains the bulk of these contributions.

The scale, intensity and assumed impact of such fires is commonly perceived as being 'disastrous', even 'unnatural', as noted in most contributions. Often, the occurrence of large fires is attributed to inadequate land management or, alternatively, global change. Uncertainty and debate surrounds both the causes and ecological consequences of large fires. The 10 papers presented here address the vexed issue of large fires and their ecological consequences by examining historical fire regimes, the heterogeneity of fire regime components associated with large fires, and the impacts of large fires on ecological processes. This is done for a range of biomes, from tropical to temperate, and in northern and southern hemispheres.

Large fires and their ecological impacts

Three consistent themes emerge from this anthology: firstly, large fires are usually a part of the Historical Range of Variability (HRV), especially in temperate biomes; secondly, large fires are inherently heterogeneous, leaving footprints of spatial and temporal diversity that may persist, and influence the nature of landscapes, for decades; and thirdly, although large fires may be perceived as socially and ecologically 'disastrous', there is evidence from multiple sources to indicate that the long-term ecological consequences of individual large fires are not necessarily disastrous.

Methods such as dendrochronology and charcoal analyses indicate that major landscape fires have a deep history of occurrence (i.e. they are not just a recent phenomenon). That large fires are part of the HRV is evident from the papers in this Issue. Major fire activity has been unequivocally associated with climatic variation (e.g. drought in temperate regions – Marlon *et al*. 2008; Swetnam and Anderson 2008; antecedent rainfall in tropical savannas – Harris *et al*. 2008) at decadal, century and millennial time scales in many ecosystems. Similar conclusions regarding the influence of climate on the occurrence of large fires are reached here, and are explored in examples for specific ecosystems (e.g. Bradstock 2008; temperate *Eucalyptus* forests in south-eastern Australia; Keane *et al*. 2008; and Schoennagel *et al*. 2008; for a variety of biomes in the United States; and Veblen *et al*. 2008; temperate *Nothofagus* forests in South America).

The bulk of papers presented here deal with the degree of heterogeneity of fire regime components that result from large fires. Gill and Allan (2008) discuss the place of large fires as 'events' within the fire regime concept. Yates *et al*. (2008) document seasonal variation in fire patch size in Australian savannas.

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Burton *et al*. (2008) document variation in fire severity. Diagnostics of such variation indicate that fire regimes will be substantially altered by large fires but the 'footprints' of large fires are not unequivocally homogeneous (i.e. there is wide variation in intensity, including unburnt patches) and that these footprints may persist for decades in landscapes (Schoennagel *et al*. 2008).

The development of appropriate diagnostic methodologies and metrics for monitoring fire regimes and variation in their components is important (e.g. Burton *et al*. 2008; Gill and Allan 2008; Yates *et al*. 2008); indeed it is a mandatory pre-requisite for interpreting ecosystem response and condition. Ultimately the ability to detect the effects of large fires in the future will hinge on the quality of information on the shape, size, heterogeneity and long-term effect on fire regime variation. This 'intelligence' is needed to design and direct future studies on ecological responses.

It is evident from the contributions that the fire regimes that result from the passage of large fires challenge the limits of our understanding of ecological effects. Different authors took different approaches. Some of the papers develop and present hypotheses in this regard. Yates *et al*. (2008) argue that fine-grained landscape patchiness of fire is important to biodiversity in savannas, with loss of this patchiness leading to adverse biodiversity outcomes. Burton *et al*. (2008) highlight the importance of landscape patchiness that results form large fires to ecological complexity in the Boreal forests of Canada. Other papers present and synthesise new results, and illustrate the importance of long-term datasets in addressing the ecological consequences of large fires: Baker *et al*. (2008) with respect to tropical rainforests in south-east Asia, and Williams *et al*. (2008) for Australian alpine landscapes. Changes to many communities that result from individual large fires may be substantial in some communities, yet direct evidence of large scale elimination of biota is lacking. Biota may therefore vary widely in their resilience to the fire regimes that emerge from the passage of large fires (Baker *et al*. 2008; Keane *et al*. 2008; Veblen *et al*. 2008; Williams *et al*. 2008).

Crucial impacts of large fires on ecosystems may depend largely on their rate of recurrence as well as on the range of resultant intensity (Baker *et al*. 2008; Bradstock 2008; Gill and Allan 2008; Williams *et al*. 2008; Yates *et al*. 2008). In this regard, Veblen *et al*. (2008) provide striking examples of the degree of change in vegetation that can occur across gradients of Patagonian vegetation. The recurrence rate of large fires may be either benign or adverse for differing elements of biota. An explicit understanding of the fire regimes that results from large fires is therefore of central importance to ongoing management of biodiversity and other ecological processes.

The contributions also offer a contrast in approaches and concepts. Ecological effects of large fires can be judged on the basis of historical range of variation: i.e. do large fires push fire regimes beyond known bounds? This is emphasised in contributions from the Americas (e.g. Keane *et al*. 2008; Veblen *et al*. 2008). In contrast, use of indicators of species response, based on life history attributes, has a long history in Australia as a basis for judging the ecological impact of variation in components of fire regimes; Williams *et al*. (2008) and Bradstock (2008) use this approach to examine the ecological impacts of large fires. Such an approach has also been developed and implemented in South Africa (van Wilgen *et al*. 2007). In addition, the effects of large fires on soils and catchment process may be important (Bradstock 2008; Pausas *et al*. 2008). While there are divergent approaches, there is little doubt that large fires strongly influence 'landscape memory' and may underpin the long-term structure of fire regimes in many ecosystems.

The incidence and characteristics of large fires will change in the future just as it has done in the past. While our comprehension of these events is partial, we arguably stand poised to benefit from both conceptual and technical developments in a wide range of disciplines (e.g. spatial sciences, palaeoecology, landscape ecology) that may rapidly enhance our ability to predict the incidence of large fires and comprehend and manage their impacts. This is especially important if global warming (i.e. increased fire danger Westerling *et al*. 2006; Pitman *et al*. 2007) and other social drivers of change (e.g. urbanisation and increased ignitions; Keeley and Fotheringham 2002) increase the likelihood of large fires.

Human activity may only recently (i.e. within the last 200 years) have changed the nexus between climate and fire activity (Marlon *et al*. 2008). Human activity will continue to affect the nature of global fire regimes, including the incidence of large fires, as climate change, changed patterns of settlement, and other land use changes alter weather, fuels and the distribution of assets, both commercial and non-commercial, within landscapes. Our understanding of large fires in our changing world undoubtedly requires further refinement. It is our hope that this Special Issue will prompt further scrutiny and evaluation of the problem of large fires in landscapes, including both their causes, and ecological consequences.

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