Future scenarios for Australian bushfires: Report on a Bushfire CRC workshop

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ABSTRACT

A Bushfire CRC workshop on future bushfire scenarios was conducted at the Australian National University, Canberra, in November 2011. The workshop explored effects of global change on fire regimes, implications for socio-economic and environmental assets, potential mitigation strategies, and law and planning responses. These findings will be used to construct bushfire projections, and to assess implications for assets, including terrestrial carbon stocks and built assets in peri-urban environments, and their management. These analyses will provide critical input into economic evaluation of bushfires in Australian society, both currently and in the future.

Background

Climate change, and other aspects of global change, have considerable potential to directly and indirectly modify bushfire regimes (Gill 1975) (eg. Williams *et al*. 2009, Bradstock 2010, Cary *et al*. 2012). The 'Future Scenarios and Economics' project of the Bushfire Cooperative Research Centre (CRC) convened a workshop on 'Future Scenarios of Bushfires in Australia', at the Australian National University, Canberra, in November 2011. Seventeen researchers with expertise in bushfire dynamics and effects, bushfire management, land planning and bushfire law, explored: (i) the effect of global change on fire regimes; (ii) implications for a range of socio-economic and environmental assets; (iii) potential mitigation strategies; and (iv) society's response in relation to law and planning. The workshop agenda extended discussion on future bushfire scenarios significantly beyond recent syntheses (eg. Cary *et al*. 2012) (Figure 1).

The Bushfire CRC 'Future Scenarios' workshop was organised by Eddy Collett, Geoff Cary, Malcolm Gill and Josh Mulvaney. Workshop presentations were given by: Colleen Bryant, Geoff Cary, Helena Clayton, Steve Dovers, Michael Eburn, Malcolm Gill, Richard Groves, Craig James, Karen King, Darryl Low Choy, Andrew MacKenzie, Steve Roxburgh, Andrew Stark, Richard Thornton and Lyndsey Wright.

Global change effects on fire regimes

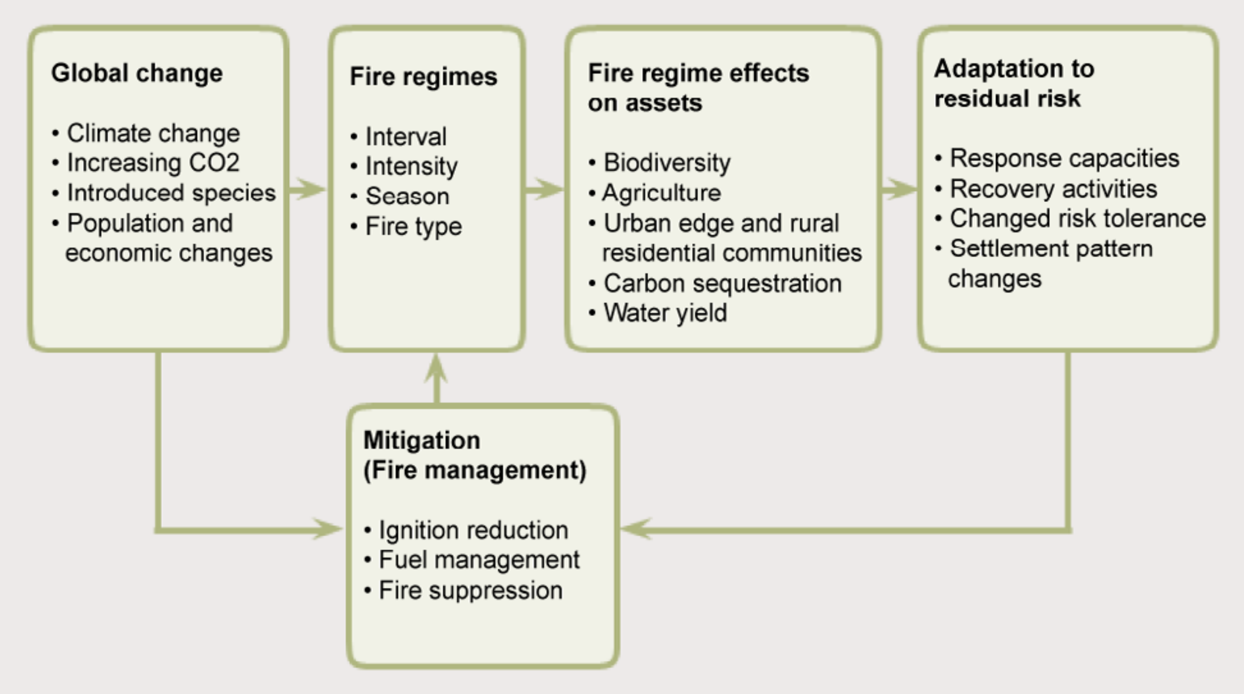
The direct effects of climate change on fire weather and fire regimes have been extensively studied in Australia (eg. Cary 2002) and elsewhere (Flannigan *et al*. 2009). Climate change effects on fire danger will vary by region (Williams *et al*. 2001, Lucas *et al*. 2007) (Table 1). In southern Australia, where increased fire danger is expected for most areas, warmer, drier climates are projected to shorten intervals between fires when the direct effects of climate are considered alone.

Understanding the effects of a changing climate and atmospheric CO_2 concentration on fuel dynamics is more complex. In many areas, drier conditions will reduce vegetation productivity, thus slowing rates of fuel accumulation (Table 1), although fuel decomposition will also be affected (see Williams *et al*. 2009). However, higher levels of atmospheric CO_2 concentration can increase plant photosynthetic efficiency, and hence productivity, although this enhancement will likely be limited by water and nutrient limitations (see Cary *et al*., 2012).

Future land-use changes, in response to global change, will be complex and difficult to predict, yet may have considerable effects on fire regimes. For example, a drier climate may cause Australia's major cropping zones to contract south and toward the coasts (Nidumolu *et al*. 2012), with the original cropping landscapes being either replaced by rangeland grazing or carbon sequestration, or being abandoned. These land use changes will likely result in greater connectivity of bushfire fuel (Moreira *et al*. 2009). Overall, considerable changes in plant communities are expected, particularly in arid, semi-arid and tropical savannah landscapes, with the emergence of 'novel' plant communities (see Seastedt *et al*. 2008) being highly likely (pers. comm. Craig James).

The spread of invasive, introduced plant species, especially grasses, has already changed fire regimes in large areas of Australia, and will continue to do so

Figure 1. Conceptual framework for exploring future bushfire scenarios. Global change will affect fire regimes that will influence assets directly, as well as indirectly via fire management efforts. More broadly, adaptation may involve changes to management, planning and legislation.



as invasive species increase their range. For example, Gamba grass (*Andropogon gayanus*) in northern Australia and Buffel grass (*Cenchrus ciliaris*) in central Australia, have increased fuel loads and continuity considerably, causing more frequent, and intense fires (Setterfield *et al*. 2010, Marshall et al. 2012). Similar circumstances surround the spread of leguminous shrubs in some temperate regions (pers. comm. Richard Groves).

Bushfire ignitions result from lightning or human activity. Climate projections indicate that lightning activity will increase in warmer climates (Williams 2005) and, combined with a shift toward increasing fire danger in some areas, will likely result in greater lightning ignitions. However, the majority of vegetation fires are human-caused (Bryant 2008). Fire ignitions are correlated with population size (Keeley & Fotheringham 2001), indicating areas that experience high levels of future population growth will likely experience more bushfires, although socio-economic status will likely remain a strong controlling influence (pers. comm. Colleen Bryant).

The combined effect of these factors on fire regimes remains uncertain because it is unclear whether controlling processes will have opposite or reinforcing effects on fire regime components (Bradstock 2010). For example, higher fire danger in south eastern Australia may be offset by lower overall fuel loads (Table 1), resulting small changes in fire intensity (eg. King *et al*. In press).

Effects on assets

Fire management objectives should involve protection and enhancement of natural and constructed assets, depending on location and legislated mandates, although noting assets can be valued differently by individuals, states and organisations. Bushfire- prone assets discussed at the 'Future Scenarios' workshop included human lives and houses in the urban-bushland interface and peri-urban landscapes, biodiversity, carbon stocks and water yield.

Residential areas contain high-value, constructed assets that face significant threat from bushfires. Peri- urban and rural-residential areas in particular are at significant threat given close proximity to remnant native vegetation and farmland (see Gibbons *et al*. 2012) (Figure 2), a characteristic that also increases their attractiveness as places to live (Eriksen *et al*. 2011). Low Choy *et al*. (2007) argue that peri- urban areas are now largely managed by a wave of recent settlers that can be categorised as 'Seekers', 'Survivors', 'Speculators', and 'Strugglers'. These groups bring, develop and foster vastly different types of assets in peri-urban areas, and this presents complex new challenges for management of natural resources and development in general (pers. comm. Darryl Low Choy), and for future bushfire management in particular. Further, future scenarios for peri-urban areas might range from continued development with little restriction in fire prone areas, to highly regulated development that effectively prohibits any further development. Communities subject to post-fire rebuilding in peri-urban and urban-interface areas may have additional financial resources to absorb losses and recover quickly (Cutter *et al*. 2000). As a result, the

Table 1. Global change scenarios in case studies in differing Australian ecosystems. Climatic predictions are 2070 (50th percentile) scenarios from CSIRO (2007) for Darwin (TF), Alice Springs (AW), Dubbo/Adelaide (TGW), Sydney/Perth (DSF) and Hobart (WSF). Bioregional zones from Hutchinson et al. (2005). (Modified from Bradstock 2010).

Global change attribute		Tropical open forest (TF)	Arid woodlands (AW)	Temperate grassy woodlands (TGW)		Temperate dry sclerophyll forests (DSF)	Cool temperate wet sclerophyll forests (WSF)
Fire Danger (based on fire weather)		Increase	Increase	Significant increase		Increase likely	Increase unlikely
Main fuel types		Annual grasses	Perennial grasses and annual herbs/ grasses	Perennial grasses and annual herbs/ grasses	Woody plant litter	Woody plant litter and shrub crowns	Woody plant litter
Sensitivity (direction of change in mass) of main fuel type to	Climate change	decrease	decrease	decrease	decrease	decrease	decrease
	Elevated CO_2	decrease	decrease	decrease	increase	increase	increase
Introduced plant types		Gamba grass	Buffel grass	Tree plantations		Exotic grasses – Mediterranean areas	
Trend in ignitions			+ human	– human		+ human	+ human

post fire reconstruction tends to follow national trends in house design while only incorporating minimal increases in fire-related building standards (pers. comm Andrew MacKenzie).

Fire regimes and biodiversity dynamics are intricately interlinked (Gill 1975, Bradstock et al. 2012a). However, climate-induced changes in fire regimes occur simultaneously with direct effect of climate change on species (Hughes 2000, Williams et al. 2009). Critical to understanding overall effects of future fire regimes on biodiversity will be the nature of formal and informal systems of biodiversity reserves, with the importance of informal and/or private reserves (see Dunlop & Brown 2008) likely to increase in future times (pers. Comm. Malcolm Gill, Wyborn 2011).

Fire regimes are integral for understanding carbon dynamics (Williams et al. 2012). Greenhouse gas emissions from bushfires are largely re-sequestered during post-fire recovery (Figure 3). However, future changes to fire frequency or intensity will likely result in significant changes in long-term carbon stocks (King et al. 2011). Similarly, water yield will respond directly to climate change and indirectly to changed fire regimes through effects on vegetation (Chiew et al. 2008). Typically, fire causes vegetation regrowth, from varying mechanisms, increasing overall water use (Kuczera 1985), leading to decreased water yield in some cases.

Nevertheless, as with effects on other assets, and the interactions among effects, a linked fire-water-vegetation-carbon ecosystem model would be required to fully understand dynamics and make reasonable projections for the future (pers. comm. Steve Roxburgh).

The complex and changing nature of bushfire impacts on assets, pose significant challenges to fire managers (per. comm. Shane Wiseman). There is increasing interest in economic evaluations of fire impacts to guide future fire management responses. In such evaluations there are multiple values and trade-offs to be considered along with the high levels of uncertainty and dynamic processes where the cause and effect is separated across time and space. Simply exploring the cost of fire events may not prove as valuable in bushfire decision making as integrated economic decision-support frameworks.

Management solutions

Fire management can mitigate, to some extent, future changes in fire regimes. Increased rates of prescribed burning, coupled with highly strategic location of treatment application, could conceivably mitigate future increases in area burned (King *et al*. 2006, Boer *et al*. 2009), although the increase in prescribed burning required will be large in many areas (Bradstock *et al*.

Figure 2. Houses destroyed in 2009 'Black Saturday' fires (Photo: Geoff Cary, March 2009).

Figure 3. Post-fire regeneration following the February 2003 bushfires near Canberra (Photo: Geoff Cary, February 2004).

2012b), with resultant total area burned increasing significantly (King *et al*. 2006). The cost-effectiveness of prescribed burning for meeting objectives into the future is likely to be a significant consideration for future fuel management responses (pers. comm. Helena Clayton, Bradstock *et al*. 2012b). Intensive management closer to houses will continue to be a key management solution for mitigating against future loss of houses (Gibbons *et al*. 2012), and intensive programs aimed at reducing rates of bushfire ignition, both in general (Cary *et al*. 2009) and from arson (pers. comm. Colleen Bryant), along with rapid initial attack of fires (Figure 4), will remain critical.

Fire managers are likely to face increasingly difficult conflicts in allocation of resources to address the complex and interacting facets of fire management required of them. It is important, therefore, to understand how all these issues relate in order to make effective decisions now that will determine how well fire management organisations can address bushfires in a future world (pers. comm. Andrew Stark), although understanding key drivers of land management in 2050 will also be important (pers. comm. Lyndsey Wright). Given the increasing global inter-connectedness of fire management, the extent that national and international sharing of bushfire suppression resources will be limited by altered global patterns of fire in a future world may need to be considered (pers. comm. Richard Thornton).

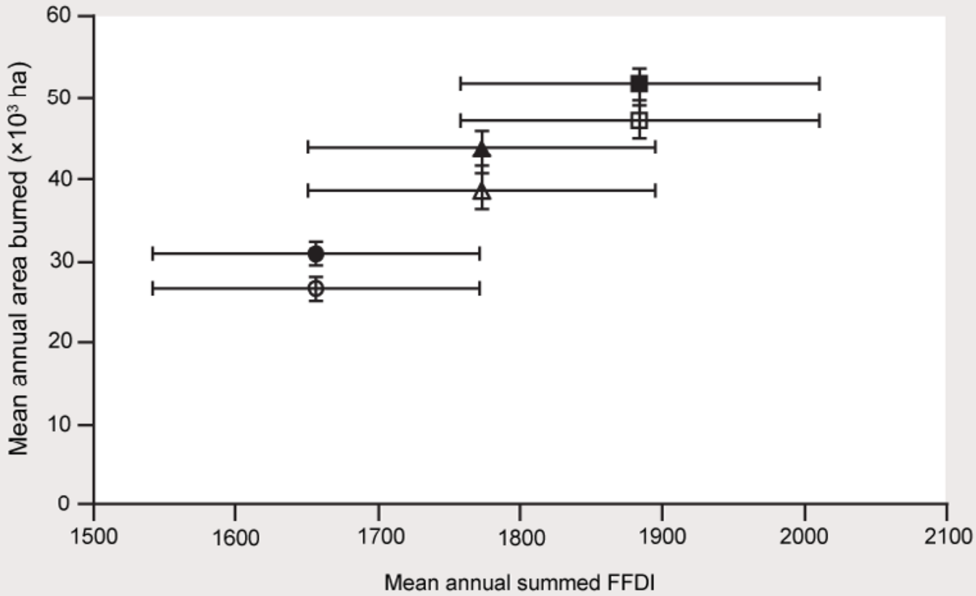
Law and planning

Notwithstanding that land owners in Australia have been subject to post-fire litigation since 1868, bushfires are not necessarily a significant focus for the law. Nevertheless, bushfire policy is significantly influenced by lawyers and inquiries, and is significantly influenced by the particular circumstances of the most recent events, rather than necessarily forecasting future requirements on time-scale relevant to the effects of global change. Therefore, endeavours by society tend toward becoming readied to respond to the last disaster, not the next one (pers. comm. Michael Eburn) and this discourages agencies to prepare well for the future (pers. comm Andrew Stark). Overall, there does not appear to be a trend in frequency of bushfire litigation. There is, however, an increasing tendency for land management agencies to be defendants in this kind of legal process, and this may be a trend that continues in the future. The role of land use planning as a tool to minimise vulnerability to fire in new settlements is difficult to predict, and will vary across jurisdictions.

Workshop outcomes and next key steps

The 'Future Scenarios' explored diverse aspects of future bushfires. Resultant discussion is informing subsequent analysis of future scenarios of bushfires in Australia. In developing new projections, it was noted that the A1FI IPCC greenhouse gas emission scenario (IPCC 2000) most closely matches observed emissions (Raupach et al. 2007), and fire regime projections

Figure 4. Effect of annual summed Forest Fire Danger Index, and rate of initial fire attack, on simulated area burned in the south-east Australian mainland high country. Climate scenarios are: present (● and ○); 2070 B1 (▲ and △); and 2070 A1FI (■ and □). Solid symbols represent historical rates of initial fire attack. Open symbols represent enhanced initial fire attack. Standard error bars are shown. Note the x axis does not commence at zero. (Source King et al., 2011).



produced in this project will be derived from the A1FI scenario. A most-likely bushfire projection for 2050–2070, that incorporates the effects of global and climate change outlined above, will be constructed for key regions broadly represented by some of the vegetation types in Table 1.

It is not envisaged that multiple fire projections would be written for each study region. Doing so would compromise the project's capacity to explore implications of fire projections on assets, effectiveness of management, and implications for legal systems and social planning processes. Discussion of key examples of assets that can be explored focussed on terrestrial carbon stocks and built assets in peri-urban environments, which are key considerations for future bushfire management, but also reflect the focus represented by workshop attendees.

This group envisages that ongoing analysis will draw on some aspects of scenario planning but will not take the form of a traditional scenario planning exercise. The various insights about future bushfires in Australia will provide critical input into economic evaluation of bushfires in Australian society, both currently and in the future. For example, significant scope exists for market-based and regulatory policy mechanisms to reduce the burden of changing fire regimes on public fire management agencies. Further, economics could help guide future policy responses by evaluating and comparing effectiveness of private and public investment in fire risk management in meeting social objectives (pers. comm. Helena Clayton). An important caveat though, is that predicting future policy choices and settings is difficult, and becomes more so the further the time horizon is stretched (pers. comm. Steve Dovers).

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