Burning For Conservation In Australian Tropical Savannas: Implications From The Kapalga Fire Experiment

A.N. Andersen, G.D. Cook, R.J. Williams
CSIRO Sustainable Ecosystems, Darwin, NT, Australia

Abstract

The great majority of wildfires in Australia occur in the tropical north, where fire is actively used as a land management tool. Up to half or more of these landscapes are burnt each year. The dominant paradigm in conservation reserves is to burn extensively early during the winter dry season, in order to reduce the extent of higher intensity fires that inevitably occur late in the dry season. CSIRO recently completed a landscape-scale fire experiment at Kapalga in Kakadu National Park, where ecological responses to a range of fire regimes were tested. Here we present a synthesis of the responses of biodiversity to different fire regimes, and discuss the implications of our results for conservation management.

Annual Late (high intensity) fires at Kapalga reduced tree basal area by 20% over the five-year experimental period, whereas annual Early (low intensity) fires had no significant effect. However, high intensity fire had a far more limited effect on the diversity of both plants and animals. The abundances of most species remained totally unaffected by fire, and fire-sensitive species tended to be affected more by whether or not fire occurred, than by fire intensity. Fire frequency therefore appears to be a far more important factor than previously recognised. More particularly, a range of small mammal species – a group known to be prone to severe population declines, strongly prefer habitat that remains unburnt for several years.

The major management implications from Kapalga is that biodiversity values would be enhanced if the extent of burning were reduced. We propose a conservation goal of increasing the area remaining unburnt for five or more years to at least 10% (from the current <5%) at any given time. We also suggest that fire management on conservation lands would be considerably improved if there were a clearer articulation of ultimate conservation objectives, and improved ecological monitoring systems that provide timely feedback in an adaptive management framework.

Introduction

The vast majority of bushfires in Australia occur in the savanna landscapes of the tropical north. Fire frequency is especially high in the monsoonal tallgrass systems of the Top End of the Northern Territory and the northern Kimberley region of Western Australia, where half or more of the area is burnt each year (Russell-Smith et al. 1997; Edwards et al. 2001). The high intensity canopy fires that are typical of temperate eucalypt forests do not occur in tropical Australia, which instead experience grass fires of low to moderate intensity (Cheney & Sullivan 1997). Prescribed burning is extensively undertaken, but primarily for habitat management rather than for protection of life and property (Dyer et al. 2001).

Fire in Australian savannas occurs primarily during the winter dry season, following senescence of the large grass biomass that is produced during the summer wet season. Fire behaviour varies markedly over the dry season, with intensity increasing as the grass layer dries out and fire weather becomes more severe (Gill et al. 1996). Extensive dry season fire has been an integral part of the seasonal landscape of northern Australia since Aboriginal occupation up to 50,000 years ago. Traditional Aboriginal burning has been severely disrupted over the last century following European settlement. The dominant contemporary fire management paradigm is one of extensive prescribed burning early during the dry season (May/June) in order to limit the extent of higher intensity wildfires that inevitably sweep through the landscape later in the season (Dyer et al. 2001).

Despite the widespread use of prescribed fire for habitat management, including in major conservation reserves such as World Heritage-listed Kakadu National Park, the ecological effects of different fire regimes remain relatively poorly known. This is particularly true for fauna, and for key landscape processes such as nutrient cycling. Such scientific uncertainty provides an unwelcome backdrop for competing demands on savanna lands, ranging from the frustrated aspirations of traditional Aboriginal landowners, to the dismay expressed by tourists over landscapes extensively charred by prescribed fire.

To help meet this challenge, in the late 1980s CSIRO established a landscape fire experiment at Kapalga in Kakadu National Park, where ecological responses to a range of experimental fire regimes were assessed on replicate sub-catchment (15-20 km^2) units over a five-year period. A full account of the experiment is provided in Andersen et al. (2003). Here we summarise the effects of experimental fires on biodiversity, and discuss the implications of these results for conservation management.

Fire and vegetation

Fires lit early during the dry season had no impact on tree mortality, but repeated Late-season burning reduced tree basal area by 20% over the experimental period (Williams et al. 1999). As expected, very small trees were especially sensitive to Late-season fires, but, surprisingly, so too were the largest trees. We attribute this to the extensive 'piping' of mature trees by termites, which weakens the trees structurally, and provides internal access for flames. Fire had complex effects on tree flowering and fruiting, resulting in markedly reduced seed production with frequent burning, regardless of time of year. We have been able to extrapolate the long term effects of different fire regimes on habitat structure using the tree population simulation model FLAMES (Cook & Liedloff 2001). Our simulations indicate that the declines in tree basal area caused by repeated Late-season fires at Kapalga would not continue, but a stable population of mid-sized, fire-tolerant trees would persist for at least several decades, even with annual burning.

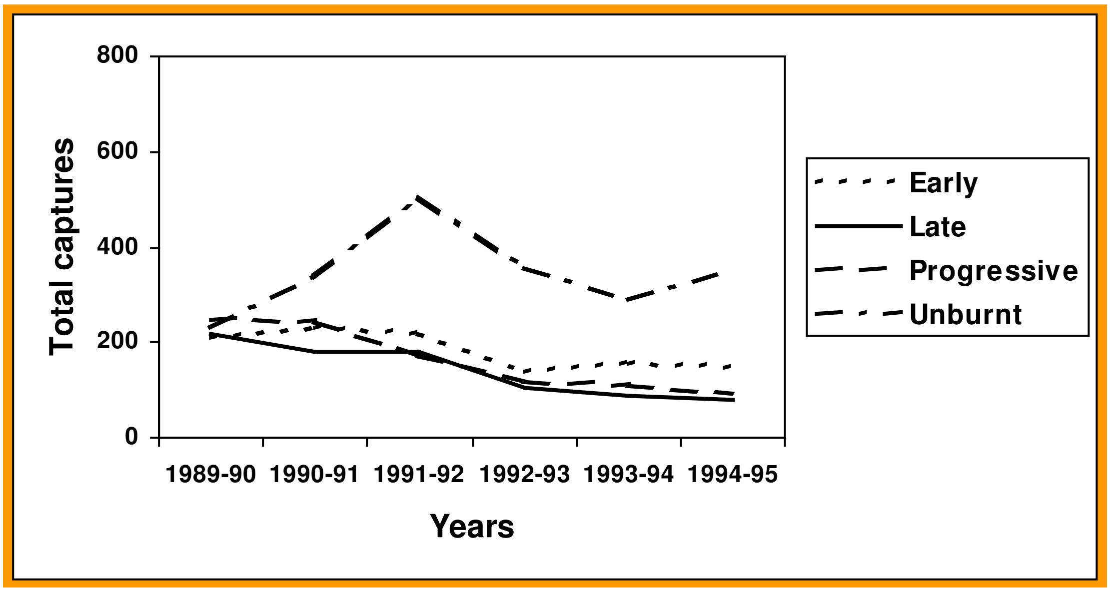
In contrast to tree populations, fire had almost no detectable effect on grass-layer vegetation over the study period. We attribute this to the fact that virtually all grass-layer species are senescent during the time of fires, and have well-developed powers of regeneration, either through re-sprouting or by seed.

Fire and fauna

Extensive studies were conducted on both invertebrate and vertebrate animals. The structure of arthropod assemblages was remarkably resilient to fire, with the overall abundance of most arthropod groups remaining unaffected. Unsurprisingly, those groups that were affected showed a range of responses. A common response among ground-foraging taxa was to be influenced by higher intensity (late season) fire, but not low intensity (early season), fire. For example, the overall abundances of spiders, silverfish and homopterans were reduced under late-season fires (Andersen & Müller 2000), which also prevented the rapid build-up of ground-foraging beetles following the first wet season rains (Blanche et al. 2001). For grass-layer taxa, on the other hand, the primary contrast was between fire and no fire, with fire intensity having little effect.

Most of the vertebrate fauna was also remarkably resilient to fire, with just 1 of 11 frog species, 5 of 16 lizards, and 5 of 25 birds being significantly affected. Small mammals, however, were a notable exception, with 8 out of the 9 common species showing a significant response to fire treatment. Late-season fires caused small mammal declines compared with early-season fires, but the main contrast was between unburnt habitat on one hand, which supported high mammal densities, and burnt habitat (whether early or late) on the other, where mammal populations were low (Fig. 1).

Fig. 1. Changes in total small mammal abundances under different fire regimes over the Kapalga experiment (modified from Andersen et al. 2003).



Fire and conservation management

Two recurring themes in relation to savanna fire and biodiversity emerge from the Kaplaga experiment. First, the Australian savanna biota is remarkably resilient to fire. Although experimental treatments encompassed the most extreme fire regimes possible, most plants and animals remained relatively unaffected. It is clear that higher intensity wildfire occurring late in the dry season is not nearly as ecologically ‘destructive’ as the appearance of burnt landscapes would suggest. Second, a wide range of faunal groups is influenced more by whether or not fire occurs, than by its intensity. Fire frequency is therefore a far more important factor than had previously been appreciated. This is especially true for extinction-prone small mammals, which have experienced serious population declines in recent decades across northern Australia (Woinarski et al. 2001).

The sensitivity of many faunal species to highly frequent fire raises a serious conservation concern for regions such as the Top End of the Northern Territory, where only a tiny fraction (<5%) of the landscape remains unburnt for five or more years (Gill et al. 2000; Edwards et al. 2001). Results from Kapalga suggest that biodiversity conservation will be significantly enhanced if this area were increased.

References

Andersen A. N., Cook G. D. & Williams R. J. (2003) *Fire in Tropical Savannas: The Kapalga Experiment*. Springer-Verlag, New York.

Andersen A. N. & Müller W. J. (2000) Arthropod responses to experimental fire regimes in an Australian tropical savannah: ordinal level analysis. *Austral Ecology* **25**, 199-209.

Blanche K. R., Andersen A. N. & Ludwig J. A. (2001) Rainfall-contingent detection of fire impacts: responses of beetles to experimental fire regimes in a tropical savanna. *Ecological Applications* **11**, 86-96.

Cheney N. P. & Sullivan A. (1997) *Grassfire Fuel, Weather and Fire Behaviour*. CSIRO Publishing, Melbourne.

Cook G. D. & Liedloff A. C. (2001) Simulating fire ecology and fire management in northern Australia. In *MODSIM 2001 Proceedings, International Congress on Modelling and Simulation, Australian National University, Canberra*. (Eds. Ghassemi F., Whetton P., Little R. & Littleboy M.), pp. 961-966. Modelling and Simulation Society of Australia and New Zealand, Canberra.

Dyer R., Jacklyn P., Partridge P., Russell-Smith J. & Williams D. (2001) *Savanna Burning: Understanding and Using Fire in Northern Australia*. Tropical Savannas Cooperative Research Centre, Darwin, Australia.

Edwards A, Hauser P., Anderson M., McCartney J., Armstrong M., Thackway R., Allan G., Hempel C. & Russell-Smith J. (2001) A tale of two parks: contemporary fire regimes of Litchfield and Nitmiluk National Parks, monsoonal northern Australia. *International Journal of Wildland Fire* **10**, 79-89.

Gill A. M. & Moore P. H. R. (1996) Fire weather in the wet-dry tropics of the World Heritage Kakadu National Park, Australia. *Australian Journal of Ecology* **21**, 302-308.

Gill A. M., Ryan P. G., Moore P. H. R. & Gibson M. (2000) Fire regimes of World Heritage Kakadu National Park, Australia. *Austral Ecology* **25**, 616-625.

Russell-Smith J., Ryan, P. G., & DuRieu R. (1997) A LANDSAT MSS-derived fire history of Kakadu National Park, monsoonal northern Australia, 1980-94: seasonal extent, frequency and patchiness. *Journal of Applied Ecology* **34**, 748-766.

Williams R. J., Cook G. D., Gill A. M. & Moore P. H. R. (1999) Fire regimes, fire intensity and tree survival in a tropical savanna in northern Australia. *Australian Journal of Ecology* **24**, 50-59.

Woinarski J. C. Z., Milne D. J. & Wanganee G. (2001) Changes in mammal poulations in relatively intact landscapes of Kakadu National Park, Northern Territory, Australia. Austral Ecology **26**, 360-370.