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VEGETATION STRUCTURE AND RESOURCE DYNAMICS IN FIRE RESPONSES OF KIMBERLEY MAMMALS

I.J. Radford[1], D. Pearson[2], L. McCaw[3], A.N. Andersen[4]

[1]WA Department of Environment and Conservation, PO Box 942, Kununurra WA
[2]WA Department of Environment and Conservation, PO Box 51, Wanneroo WA 6946
[3]WA Department of Environment and Conservation, Locked Bag 2, Manjimup WA 6258
[4]CSIRO, PMB 44 Winnellie NT 0822

Email: Ian.Radford@dec.wa.gov.au

INTRODUCTION

A key question in conservation management is what are the processes driving declines in small mammals across northern Australia. While it seems clear that current fire regimes may contribute to declines of some mammal species in some circumstances (Woinarski *et al.* 2001; Andersen *et al.* 2005), it is not yet clear what the key mechanisms underlying the effects of fire might be (Williams *et al.* 2003). If management actions do not target causal processes they may be ineffective, or even detrimental, to the threatened species they are designed to protect.

A number of studies have recently been initiated in the Kimberley region of far northern Western Australia in an attempt to gain an understanding of the mechanisms that underlie fire effects on mammal species. This work has targeted mammals between 35g and 5 kg (critical weight range CWR), thought to be among the most threatened (Woinarski *et al.* 2001). This work aims to identify ecosystem attributes that most strongly influence CWR mammal abundance with respect to fire. Measurements were undertaken to assess likely importance of habitat structure compared to resource limitation on dynamics of mammal species. By measuring response dynamics of key ecosystem attributes associated with fire we hope to recommend fire rotation rates, patch sizes and patterns, and season of prescribed burning that should be implemented for the benefit of threatened species.

METHODS

Mammal abundance was measured within the Mitchell River region, north Kimberley, at 8 sandstone sites representing a range of times since the most recent fire. In 2007 and 2008, mammals were sampled using elliot traps in standard grids of 30 or 50 traps with 20 m spacing. Species and number of individuals were recorded over 4 nights on 1 occasion in 2007 on 2 occasions in 2008.

Habitat structural attributes were assessed in several ways. Woody vegetation structure was sampled in four 20*20 m quadrats within each trapping grid. Trees and shrubs were identified and assigned size classes. Numbers of each species and size class were recorded for each quadrat. Size classes of dead trees and logs were recorded. A bitterlich gauge was used to assess canopy % cover in three vegetation strata, trees (>4 m), shrubs (1-4m) and ground level. Herbaceous vegetation was sampled in four 1*1 m quadrats. Herbaceous species were identified and percentage composition visually assessed. Herbaceous ground cover was estimated. Herbaceous vegetation was clipped at ground level and divided into grass, forb and tree litter components before being dried and weighed. Grass fuel age and presence of shelter boulders (>50*50cm) were recorded within all grid quadrats.

Potential ecosystem resources were assessed using several approaches. Soil nutrient analysis was undertaken to assess relative site productivity. Soil analysis was made of pooled 10 cm cores from herbaceous quadrats. Samples were dried and analysed for NO_3^-, NH_4^+, P, K, S, total & organic C, Fe, soil conductivity, Ph, Al, F:B Ratio and microbial biomass (bacterial, fungal and unknown components). Invertebrate pit fall traps, sweep net samples and funnel traps were used to assess different invertebrate components as potential food resources for mammals. An index of grass seed production was made as percentage of perennial grass tussocks with inflorescences.

Post-fire vegetation succession was measured in an independent study of pindan woodland, west Kimberley, to give a picture of long term structural change relevant to mammals. Sites here had been protected from fire for varying intervals by historical grazing (Derby town common) or prescribed fire management (Curtin RAAF base) from between 1 and 40 years. Sites were measured for woody and herbaceous structure in the same way as above.

RESULTS

Most common species captured included rodents *Zyzomys argurus*, *Pseudomys nanus* and *P. delicatulus* and marsupials *Dasyurus hallucatus* and *Isoodon macrourus.* Total rodent abundance, but not that of marsupials, was significantly related to post-fire interval. Rodent abundance was significantly related to vegetation structure, including herbaceous biomass, shrub (>1m) density and shrub ground cover (Fig. 1). These results highlight the short time scales (<24 months) over which a significant shrub layer can develop, and its apparent importance for rodent species.

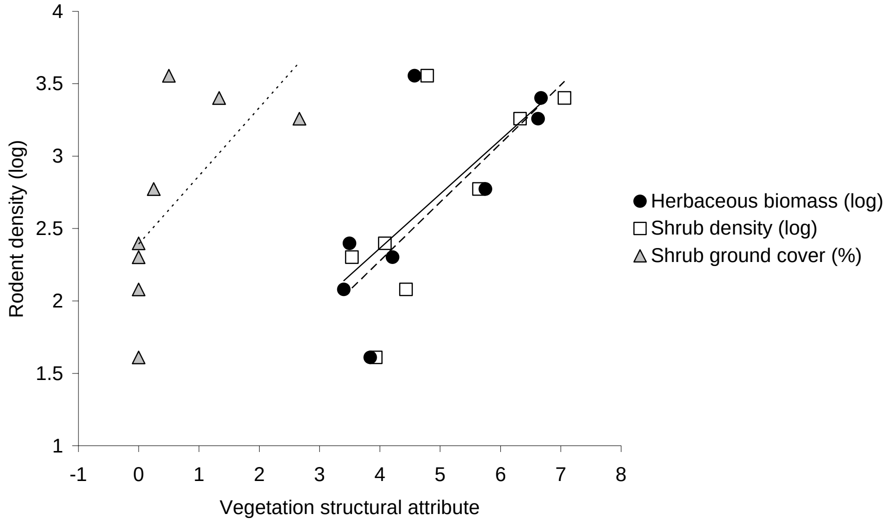

Figure 1. Regression of rodent density with vegetation structural attribute score including herbaceous biomass, shrub density and shrub cover. Lines represent regressions where *P*<0.1.

Ecosystem resources had variable relationships with post-fire interval (Fig. 2), but no clear relationship with mammal abundance. Ground dwelling invertebrates (e.g. ants and large invertebrates including cockroaches, scorpions, spiders and centipedes) showed no influence of time since fire. Some invertebrate groups, for instance functionally dominant ant species (Dolichoderinae), were less abundant with greater time since fire. Herbaceous layer invertebrates (e.g. grasshoppers, wasps, butterflies/caterpillars, flies, spiders, etc) and perennial grass seed (inflorescence) production were both positively related to time since fire, but neither were directly related to mammal abundance (data not shown).

The most suitable mammal habitat may be provided by intermediate, rather than long-term post-fire vegetation age. Vegetation data from the west Kimberley showed highest structural cover and complexity 3 years post-fire with high herbaceous and shrub cover values (Fig. 3). Both before and after this, vegetation structure was more simple. In the first year post-fire there was high herbaceous biomass but low shrub cover (1-4 m and ground level). By 6 years post-fire, however, herbaceous biomass and ground level shrub cover had dramatically declined. By 40 years post-fire both shrub density and herbaceous biomass were very low (Fig. 3) while tree density (>4 m) had increased (data not shown).

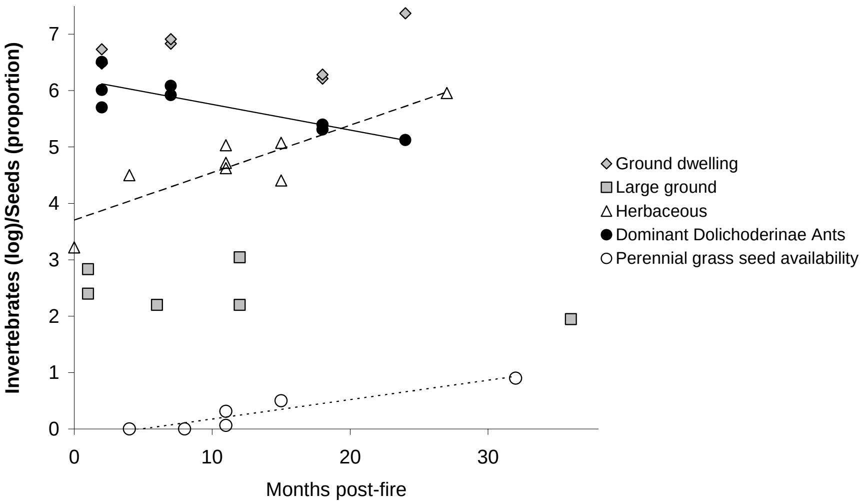

Figure 2. Invertebrate numbers and seed production index for perennial grasses with months post-fire. Lines represent significant regressions (*P*<0.1)

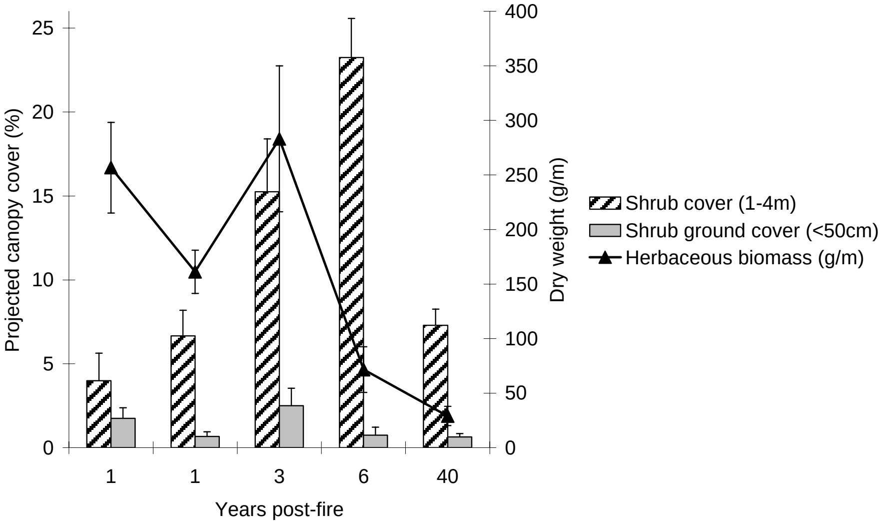

Figure 3. High (1-4m) and low (ground level) shrub cover at sites with differing time since post-fire. Bars represent shrub percentage cover (y axis 1), while points represent herbaceous biomass (y axis 2).

DISCUSSION

Previous fire research in northern Australia has shown that the relationship between CWR mammal abundance and fire regime is not simple (Andersen *et al* 2005). While mammals were negatively affected by the most intense late dry season fire regimes, declines were also evident even with fire exclusion, continuing a longer term pattern of decline in the region (Braithwaite & Müller 1997). These results could imply a number of things. They may suggest that no single fire regime is optimal for mammal species or that other, unknown regional-scale processes are the primary drivers of small mammal declines, and that fire is playing a secondary role. Another possibility is that the mechanism behind fire effects did not respond linearly with time since fire.

The results of this study, showing a direct relationship between vegetation structure and rodent abundance (Fig. 1), may provide a mechanism for the above results, at least for native rodents. While vegetation complexity increased initially after fire (1-3 years), it declines again over longer time frames (Fig. 3). If rodents respond directly to vegetation structure, then decreased abundance values 3 years post-fire could be related to the decreased value of the habitat shelter provided in long unburnt habitats. While the specific rates of structural change in Pindan woodland may not be directly applicable to other sites in northern Australia, similar changes in ground layer vegetation have been recorded in other studies after long periods without fire (Russell-Smith *et al*. 2003, Woinarski *et al*. 2004).

The relationship between rodent (but not marsupial) abundance and habitat structural attributes and complexity, rather than food resources, suggests that the mechanism behind the post-fire effects may be predator related rather than resource limited. This is consistent with increasing evidence for introduced predator (fox and cat) driven extinctions of CWR mammals throughout Australia since European settlement (Johnson 2006). No work has yet been undertaken in northern Australia on cat-fire interactions. This should be a priority for future research.

As yet we only present preliminary data which supports the vegetation structural hypothesis. More studies are needed to more fully test both the resource limitation and vegetation structure hypotheses. Studies including dietary analysis of mammal scats to identify food items, and testing vegetation structural complexity predictions on mammal abundance at other sites are needed. The link between vegetation structural complexity and predator effects also needs to be tested. Studies over larger spatial scales are needed to isolate mechanisms relating to marsupial abundance.

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