CONTINUUMS OF FUNCTIONALITY OF AUSTRALIAN SAVANNA LANDSCAPES: ASSESSING CHANGES OVER TIME WITH REMOTE SENSING

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INTRODUCTION

Unlike Australia's temperate ecosystems, the tropical savanna landscapes are in relatively unmodified condition (Woinarski *et al.*, 2007). Disturbances such as fire, logging/thinning, cycles of drought and rainfall excess, and grazing occur within these landscapes and can be both temporally and spatially variable, increasing landscape heterogeneity but rarely resulting in well-defined patch boundaries (Pearson, 2002; Woinarski *et al.*, 2005). Instead, the tree-grass structure varies continuously at local to landscape-scales (100s-1000s ha).

Traditional models for analysis of heterogeneity in landscape structure and relevant functionality for fauna species have depicted landscapes as static arrays of vegetation patches with discrete boundaries between habitat and matrix patches (Forman and Godron, 1986; Wiens, 1976). However, many rangeland and savanna landscapes with gradual spatial and temporal variation in structure do not fit this model.

Many species require more than one type of habitat during different life stages or for different functions such as foraging or nesting (Fahrig, 2003; Law and Dickman, 1998; Wiens, 1997). Thus, to gain an understanding of change in ecological function with change in landscape structure it is important to recognise the ecological value of a variety of landscape components, and their changes over time. Few previous studies have considered these varying requirements.

This work aims to provide quantitative and continuous measures of habitat quality of relevance to fauna in a tropical savanna landscape. In addition this work will investigate how these measures of habitat quality vary over time by looking at time series of remote sensing imagery, and measure how important temporal changes are for biodiversity.

MATERIALS & METHODS

This study is based in the Desert Uplands bioregion of Queensland, Australia (Figure 1). The region has a semi-arid climate with a mean annual rainfall of 350- 600 mm/yr. Vegetation consists predominantly of *Acacia* and *Eucalyptus* woodlands, ephemeral lake habitats and grasslands (Sattler and Williams, 1999). Open *Eucalytpus* woodlands (height < 15 m) on sandy soils are dominant (~85% of the region). However, within these woodlands, there is considerable spatial variation in tree density according to soil type, fire frequency, anthropogenic thinning and drought-related dieback (Fensham and Holman, 1999).

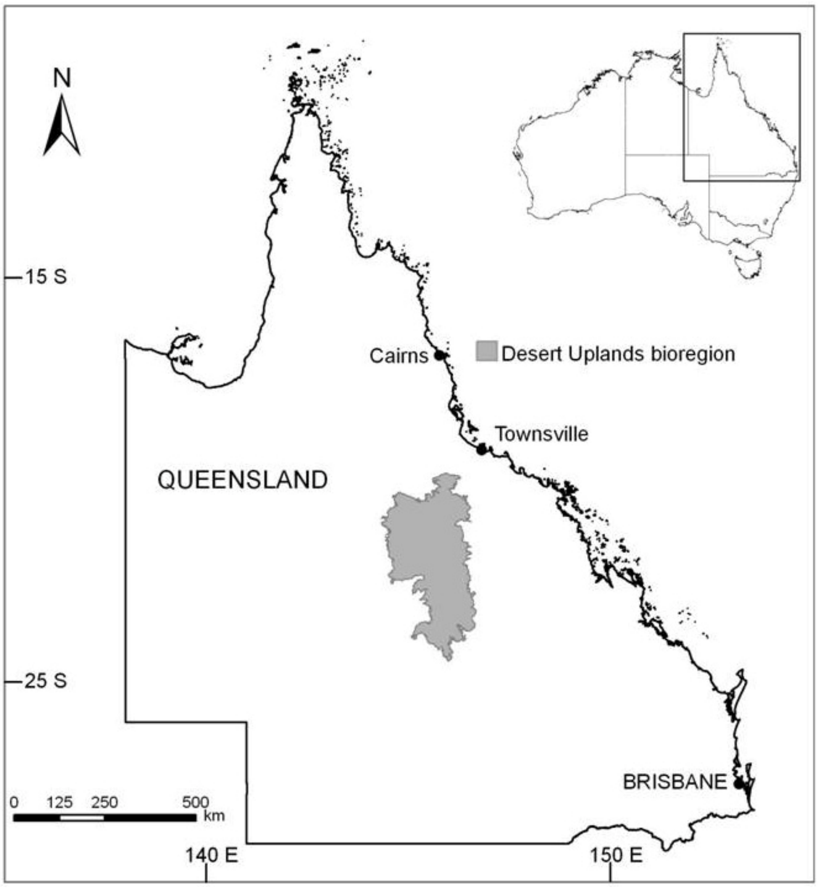

Figure 1: Location of case study area in the Desert Uplands bioregion, Queensland, Australia.

Landsat Imagery has been captured over the study area each year from 1988 to 2007. We map and model changes in amount and spatial configuration of different habitat elements from this time series using a variety of approaches. The Queensland Statewide Landcover and Trees Study (Department of Natural Resources and Water) has calculated Foliage Projected Cover surfaces for all of these images providing a measures of woody vegetation cover. In addition we have calculated the normalised difference vegetation index (NDVI) across the time series which provides a proxy measure of biomass and productivity (Wiegand *et al.*, 2008). An object-oriented approach within the software Definiens Professional 5.0 (Definiens AG, 2006) allows classification of the imagery into key habitat elements, in particular grass cover and tree cover resulting in cover maps. Using spatial filters within ArcGIS version 9.1 (ESRI, 2005) we create continuous surfaces of the vegetation elements, and include information on water availability as a relevant habitat element. Generalised linear modelling and information theoretic approaches are used to describe the relative importance each of the vegetation elements, including FPC and measured biomass for the diversity, presence and abundance of a variety of small mammals, reptiles and birds (Mac Nally *et al.*, 2004). Habitat variables are weighted and combined to create a continuous surface measuring overall habitat quality for each image in the time-series. Further modelling establishes the relationship between the temporal variation in habitat quality and the diversity and abundance of fauna.

RESULTS AND DISCUSSION

This work establishes a quantitative relationship between continuous spatial variation of habitat elements and the diversity and abundance of fauna, and investigates temporal changes in those relationships. Preliminary results from one time step results show that there is much variation in the response of individual species to the variation in spatial structure of different habitat elements. Different species respond to different vegetation elements depending on their behavioural and foraging ecology, and general predictions about species diversity and abundance need to consider landscape gradients, as well as patch and site factors. Weighting and combining the habitat elements by relative importance results in a continuous surface of overall habitat quality. This model remains ecologically relevant as the new measures can explain a significant proportion of spatial variation in abundance of individual species and diversity of species. Temporal variation in landscape function, which is often ignored due to time and resource constraints, is also of importance.

Using remote sensing technology and time series data allowed us to describe how landscape function can vary across a spatial continuum and through time. The approach used in this study was ecologically relevant as it takes into account the different habitat requirements of a variety of species, instead of assuming a generic response to landscape structure covering multiple species. This study also takes into account temporal variation in landscape structure and function which is a common shortcoming of most studies of the influence of landscape structure and composition on fauna. Of particular relevance to savanna ecosystems is the ability to quantitatively measure continuums in habitat structure since these landscapes rarely exhibit distinct boundaries between vegetation cover types, nor are the fauna limited to one vegetation type.

REFERENCES

Definiens AG (2006). *Definiens Professional 5 User Guide*. Definiens AG, Munich.

ESRI (2005). ArcGIS 9.1.

Fahrig, L. (2003). Effects of habitat fragmentation on biodiversity. *Annu. Rev. Ecol. Evol. S.* 34: 487-515.

Fensham, R.J., and Holman, J.E. (1999). Temporal and spatial patterns in drought-related tree dieback in Australian savanna. *J.App. Ecol.*. 36: 1035-1050.

Forman, R.T.T., and Godron, M. (1986). 'Landscape ecology.' **John Wiley and Sons, New York, NY, USA**.

Law, B.S., and Dickman, C.R. (1998). The use of habitat mosaics by terrestrial vertebrate fauna: implications for conservation and management. *Biodivers Conserv.* 7: 323-333.

Mac Nally, R., Ellis, M., and Barrett, G. (2004). Avian biodiversity monitoring in Australian rangelands. *Austral Ecol.* 29: 93-99.

Pearson, D.M. (2002). The application of local measures of spatial autocorrelation for describing pattern in north Australian landscapes. *J. Environ. Manage.* 64: 85-95.

Sattler, P., and Williams, R. (1999). 'The conservation status of Queensland’s bioregional ecosystems.' **Environmental Protection Agency, Brisbane, Queensland**.

Wiegand, T., Naves, J., Garbulsky, M.F., and Fernandez, N. (2008). Animal habitat quality and ecosystem functioning: Exploring seasonal patterns using NDVI. *Ecol. Monogr.* 78: 87-103.

Wiens, J.A. (1976). Population responses to patchy environments. *Annu. Rev. Ecol. Evol. S.* 7: 81-120.

Wiens, J.A. (1997). The emerging role of patchiness in Conservation Biology. *In* 'The Ecological Basis of Conservation.'Vol. (Eds S.T.A. Pickett, R.S. Ostfeld, M. Shachak and G.E. Likens). **Chapman & Hall, New York**, pp. pp93-107.

Woinarski, J., Mackey, B., Nix, H., and Traill, B. (2007). 'The Nature of Northern Australia:Natural values, ecological processes and future prospects.' **ANU E Press, Canberra**.

Woinarski, J.C.Z., Williams, R.J., Price, O., and Rankmore, B. (2005). Landscapes without boundaries: wildlife and their environments in northern Australia. *Wildlife Res.* 32: 377-388.