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Designing new monitoring programs for Mulga woodlands - lessons learned from the Pilbara

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Abstract

Mulga woodlands and shrublands are distributed across ~ 20 % of the Australian continent and are one of the dominant vegetation types of the semi-arid zone, with a long history of pastoralism. More recently, Mulga woodlands have been subject to increasing pressures from other landuses, including expansion of the mining industry and development of regional infrastructure. There is a pressing need for improved design and implementation of monitoring systems in Mulga woodlands and shrublands that are capable of attributing any detected changes in their composition, structure and function to anthropogenic impacts. We discuss some of the shortcomings of much of the current monitoring using examples from recent reviews and highlight the importance of designing monitoring systems that can relate cause and effect rather than simply observing change. We also highlight critical considerations for the design of future monitoring programs including, but not limited to, terrain features and soils, natural processes including fire and flood, stand demographics and composition, management history and the importance of redundancy/robustness in the design. Furthermore, we demonstrate how the power of a monitoring program can be improved through comparisons with other datasets, highlighting the importance of data standards and procedures among projects.

Introduction

Monitoring of vegetation condition is a major component of rangeland management, particularly where decisions need to be made regarding developmental approvals or prioritising conservation efforts in particular parts of a region or landscape. Demonstration of the maintenance or improvement in extent and quality of native vegetation may also be a condition for the renewal of pastoral leases (DERM 2010). Recently, Eyre et al. (2011) eloquently summarised the range of vegetation condition assessments that might be undertaken within a matrix of operational constraints and regulatory requirements for monitoring biodiversity under the *BioCondition* approach established for Queensland. However, most approaches to monitoring of vegetation condition generally fail to establish adequate baseline information on the natural spatial and temporal dynamics of particular systems. Consequently, interpretation of subsequent monitoring data to establish cause and effect associated with any particular question (e.g. impacts of grazing or of transport infrastructure) can be confounded. Here, we use the mulga woodlands and shrublands of northwest Australia as an example of some of the challenges faced by stakeholders in establishing effective monitoring programs, which often need to meet multiple objectives. Our primary concern here is focussed on maintenance of ecosystem function in relation to land use change associated with mining.

About mulga in the Pilbara

Mulga (*Acacia aneura/A. aptaneura;* Maslin and Reid 2012) forms the dominant canopy species of the mulga communities that dominate much of semi-arid and arid Australia (Johnson & Burrows 1994). The structure and patterning of mulga communities varies from strongly banded (groved) through to open shrublands and woodlands across the landscape. *Acacia aneura/A. aptaneura* and the closely associated species that form the mulga complex (including *A. ayersiana* and *A. catenulata*) are generally shallow-rooted (likely <5 m depth) and maintain very low rates of water use during extended drought to survive (Pressland 1973, Slatyer 1961a). During rainfall events, Mulga 'harvests' rainfall intercepted by the canopy and directs it to the surface soils around the base of the trunk (Pressland 1976, Pressland 1973, Slatyer 1961b). Some landscape positions may also increase the amount of water harvested by Mulga by intercepting runoff from higher elevations or inter-grove areas of lower infiltration (Greene 1992, Mabbutt & Fanning 1987, Tongway & Ludwig 1990).

In the Pilbara, *Acacia aneura/A. aptaneura* are morphologically highly variable (Miller *et al.* 2002, Page *et al.* 2011). Mulga also grow across a diverse range of landscape positions and soil types in the Pilbara (Van Vreeswyk *et al.* 2004); the region is topographically complex compared to mulga dominated regions further to the east and south. Variants of *Acacia aneura/A. aptaneura* can have specific landscape preferences that are also reflected by differences in physiological characteristics of water use and drought tolerance. For example, more terete forms of Mulga generally use less water than forms with broader phyllodes (Page *et al* in prep.). Furthermore, the different variants of Mulga also commonly co-occur in mulga communities (Miller *et al.* 2002, Page *et al.* 2011), which further complicates any integrated assessment of community health.

Numerous environmental management plans for mulga communities associated with mining have developed monitoring systems on the belief that any interruption to sheetflow will adversely affect their health and survival. Community level management at this scale assumes that (1) sheetflow is the most important input of water into mulga communities, (2) that all trees within a population are the same, and (3) that no differences exist among populations of Mulga. However, in reality mulga communities are complex assemblages of highly variable species and they occur in a very diverse array of landscapes and soil types. Consequently, the ecological water requirements of mulga communities will change depending on the landscape in which they occur and also because of the Mulga variants that constitute a particular community type. However, there is a general paucity of data on how Mulga respond to changes in water supply. In addition, there are no data on the water requirements of the understorey assemblages of mulga communities.

Monitoring of mulga in Western Australia

Given the diversity of mulga community types and Mulga variants contained within them in the Pilbara, the design of a monitoring program to detect changes in vegetation condition needs to be systematic and thorough. Below are a series of recommendations that highlight key facets we consider important for the design of a monitoring system for mulga communities in the Pilbara:

1Specifically identify areas to be 'impacted' by mining activity (and/or other disturbances), and analogous control (reference) areas that are unlikely to be impacted in the future.

2: Have suitable numbers of replicate sites to allow statistical analysis, *e.g.,* a minimum of five sites within each treatment.

3: Ensure the monitoring design is sufficiently robust to provide quantitative evidence of cause and effect (e.g., change in water supply or proximity to water table; or the cumulative effects of other disturbances such as fire or grazing) and to investigate the best measures of these effects.

4: If remote sensing is used as part of the monitoring program, ensure that all data are ground truthed and can be quantified using GIS so accurate interpretation of results can be made (e.g. Apan *et al.* 2011).

5: Map the mulga community types, specifically in regard to location within the landscape and drainage features, paying particular attention to woodland structure (e.g., banded or unbanded, low woodland or low open woodland). Determination of woodland structure should also involve determining the hydrological processes occurring within the woodland, particularly in banded woodlands i.e., slope orientation, size, relative elevation changes, and quantifying water flows across this system.

6. Quantify the catchment hydrology of the areas that support mulga communities. Specifically, investigate the upslope catchment area that may supply water to mulga communities.

7: Measure surface water flow, infiltration, and soil moisture content in both control and impact sites to elucidate the effect (if any) of mining on the hydrological processes that underpin the 'drainage shadow' hypothesis (Hick *et al.* 1997).

8: Recognise and identify the Mulga varieties and closely related species that occur within the mulga communities (e.g. Page *et al.* 2011), as these varieties may have different ecological water requirements.

9: Determine soil physical and chemical properties, including soil depth, that influence water availability and mineral nutrition in each mulga community.

10: Determine maximum rooting depth of Mulga (and other key species) to further complement the soil moisture data. Many management plans surrounding Mulga and mulga communities assume that Mulga roots are only in the shallow surface soils. While this is likely, there are few data to support this supposition. Are roots deep enough to access the water table, or to what depths are they able to extract stored soil water? These are all vital questions for determining the ecological water requirements of Mulga.

11: Similarly, investigate the water requirements of key understorey species that define the diversity of mulga communities across the area of interest with emphasis on clarifying rooting depth.

12: Recognise that fire is an inescapable process in the Pilbara (and much of Australia), and so include replication so that losses of sites do not change statistical rigour.

13: Consider implementing a post-fire recovery study of control and potential impact sites in the event on a fire destroying a portion of the monitoring sites.

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