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Assessing land condition in a bi-polar landscape

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Abstract:

Reliable assessment of resource condition is a critical tool for managing and regulating the sustainable use of biological resources in the rangelands. Accepted approaches rely on comparisons with real or conceptual benchmarks characterised by low levels of disturbance. This approach works well in areas and systems that have been intensively studied and show predictable patterns of response to the important drivers of change. Where these factors are consistent, simple to measure indicators that reliably track change can be used as surrogates for the system, some of which can be scaled up and monitored using remote sensing.

Problems with these approaches for resource condition regulators arise for the following reasons:

1. resourcing to obtain the knowledge and understanding needed to define benchmarks and their condition indicators for all the land systems and component vegetation communities;
2. historic damage that has transitioned areas into irreversibly degraded condition states that are unlikely to return to benchmark states without expensive reconstruction;
3. unpredictable dynamic (bi-polar) landscapes that make useful benchmarks impossible to define, which is the case for most arid vegetation communities where the presence and abundance of even the long-lived species at any location can vary significantly in response to climate cycles.

To overcome these issues, the South Australian Pastoral Unit is developing a non-benchmark reliant, rapid assessment method that focuses on the herbivore utilisation of longer-lived perennial shrubs and trees, their age structure and relative palatability. All data, including physical disturbance indicators and site descriptors are collected within a 10-minute sample period to enable multiple sites to be sampled across a pastoral lease. Data collection can be interpreted by non-scientists and a site frequency approach to data analysis enables data to be logically presented.

Introduction

Land condition has been broadly defined as the capacity of vegetation to respond to rainfall. Governments have used a variety of approaches for assessing pastoral condition to meet statutory requirements (Bastin *et al.* 2008). Western Australian and South Australian assessment and monitoring programs focus on perennial vegetation with species density or cover estimates being assessed against benchmark communities derived from comparisons with sites with minimal disturbance from grazing, considered in “reference condition”. New South Wales, Queensland and Northern Territory methods include pasture composition and biomass to include short lived species. More recently the advent of affordable satellite data, increased computing power and the development of reliable fractional cover estimates, has prompted government agencies to augment their assessment programs with satellite image based land cover analyses (Bastin *et al.* 2014).

The South Australian *Pastoral Land Management and Conservation Act 1989* specifies that an assessment of each pastoral lease for the condition of the land must be conducted at intervals of not more than 14 years. Relevant objects of this Act are as follows: (a) to ensure that all pastoral land in the State is well managed and utilised prudently so that its renewable resources are maintained and its yield sustained; and (b) to provide for— (i) the effective monitoring of the condition of pastoral land; and (ii) the prevention of degradation of the land and its indigenous plant and animal life; and (iii) the rehabilitation of the land in cases of damage.

In response to the enactment of this legislation in 1989 the South Australian government collaborated with University of Adelaide researchers to develop an assessment program based on scientific principles. The core of this program was the Land Condition Index, a rapid assessment method that enable trained observers to rank sites as being in good, fair or poor condition, based on comparison with a reference benchmark for an identified pasture type (Lange *et al.* 1994). Pasture type was determined by the dominant perennial plant combinations within land systems and these were described in regional assessment manuals, along with perennial plant indicators. To provide rigour to the assessments all properties over 500 km^2 were sampled at 100 randomly selected points along their track networks. Smaller properties had reduced sampling efforts. A condition index was then calculated for each property based on the number of sites scored for each of the three categories. Pasture types were only described for the land systems south of the “dog fence” where perennial shrublands dominate. Attempts to extend these pasture type descriptions north, were confounded by the sparse and unpredictable distribution of the perennial vegetation in land types dominated by ephemeral native plants.

Bi-polar landscapes

The South Australian pastoral zone straddles the driest region of Australia with rainfall tending towards winter dominance in the south versus summer in the north, and predictability lowest in the north (Figure 1). Throughout the region, useful rain favours herb, forb and shrub growth in winter and native grasses in summer. The response of these land types can be referred to as behaving in a ‘bi-polar’ manner as plant growth greatly exceeds the capacity of animal species to utilise it following a good wet season, whilst prolonged droughts are characterised by depressed plant and animal populations, including localised extinctions. The unpredictability of these productivity swings provides survival challenges to long-lived perennial plants and dependent biota, which can be compromised by utilisation of pasture by livestock that appears sustainable when assessments are based on ephemeral species diversity and productivity.

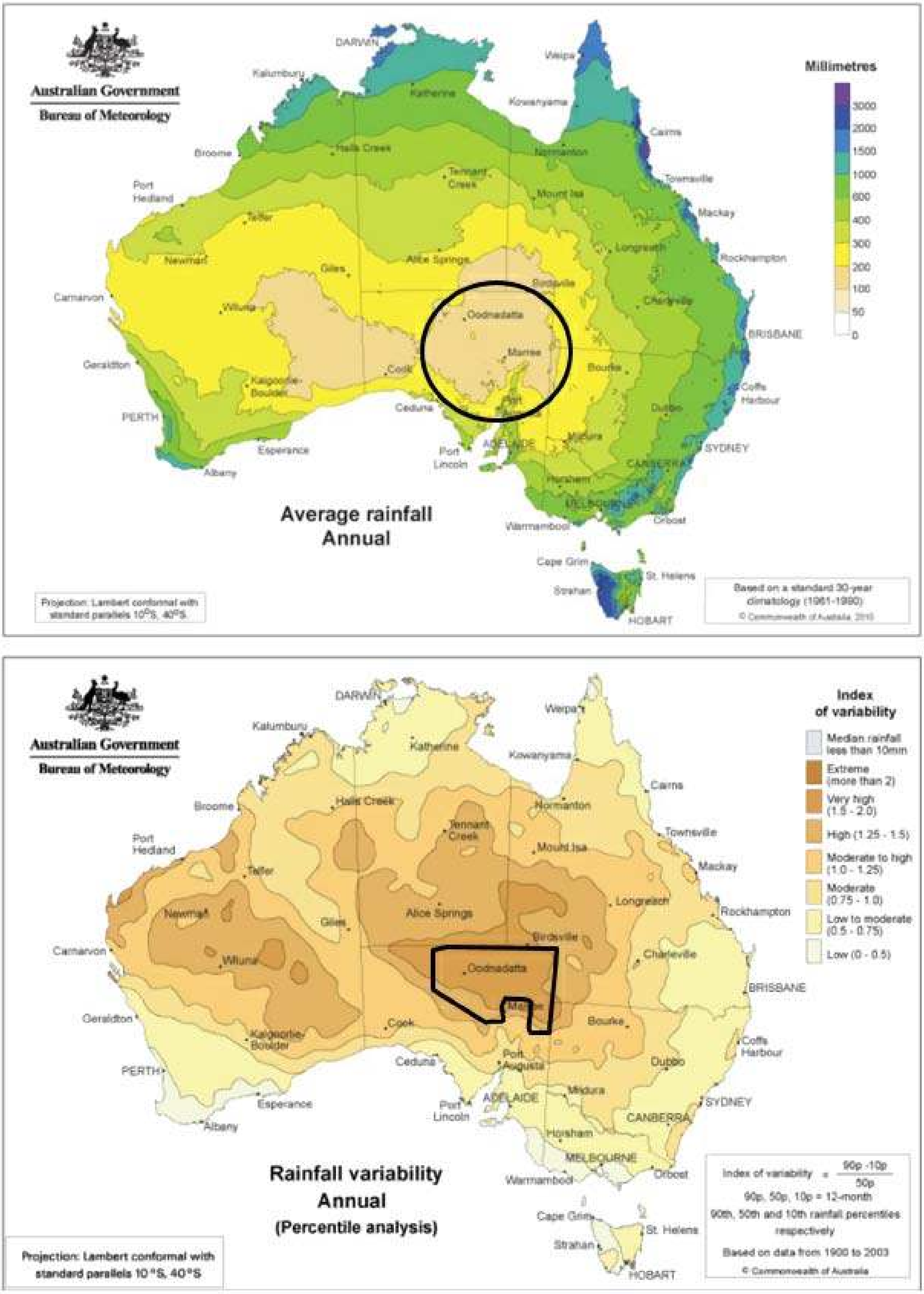

Figure 1. Average annual rainfall (upper map) highlighting the aridity of the SA pastoral region (black circle), and annual rainfall variability (lower map) highlighting the extreme variability in the SA pastoral region occurring north of the “dog fence” (black polygon).

Benchmarking for the Land Condition Index relies on the assumption that indicator species composition and their density are positively correlated with land condition. Both are difficult to predict when climatic variation and position in the landscape are the main drivers. Changes related to livestock management using these indicators are difficult to separate from climatic variation.

Developing a flexible on-ground assessment method for bi-polar landscapes

An alternative approach to determining pasture type and comparing with benchmarks is to assess the level of disturbance to durable elements contributing to landscape function, focussing on indicators that reflect mammalian herbivore pressure. Key disturbance indicators relate to plant utilisation and disturbance to ecosystem function.

Data collection needs to be rapid so that multiple sites across the landscape, as developed for the Land Condition Index, can be applied for completion of the current assessment round north of the dog fence. Proposed indicators that can be assessed during wet and dry seasons and their assessment criteria are outlined below.

- Species utilisation assessment
    - All plant species grow to a genetically determined functional form in the absence of disturbance. Utilisation refers to the amount of perennial plant material that has been removed by herbivores within grazing reach. For each long-lived perennial grass, shrub and tree species the proportion of individuals observed in one or more of three utilisation states, as described in Figure 3, are estimated into proportional classes. These have been simplified to facilitate rapid data collection and standardisation between observers. The classes are: >50% of observed individuals, <50% of observed individuals, or no individuals observed in that state. Refer to example in Figure 4. The proportional codes are used to describe the utilisation levels at sites, which in well managed landscapes would predominantly be intact to modified for palatable and unpalatable perennials,

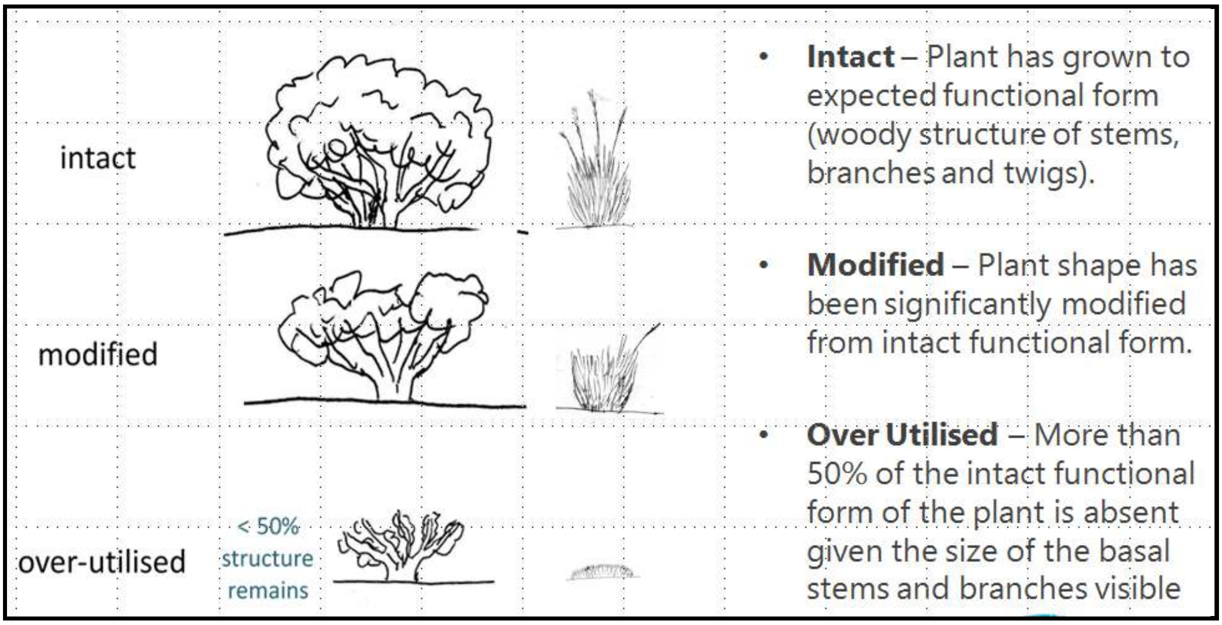

Figure 3. Utilisation states for grasses and shrubs. Tall shrubs and trees >3m will be browsed up and are considered over-utilised when they exhibit distinct browse lines.

Plant Species	Common name	Utilisation			Age Class (M/Y/A)
		Intact	Modified	Over utilised	
Maireana astrotricha	Low Bluebush	<50%	>50%		m
Atriplex vesicaria	Bladder Saltbush	<50%	>50%	0	m
Ptilotus obovatus	Silver Mulla Mulla	<50%	>50%	0	m
Pittosporum angustifolium	Native Apricot	0	>50%	0	y
Zygophyllum aurantiacum	Shrubby Twinleaf	>50%	<50%	0	m
Eremophila pentaptera		>50%	<50%	0	m
Ptilotus parvifolius	Small-leaf Mulla Mulla	<50%	2	<50%	a
Eragrostis setifolia	Neverfail	>50%	0	0	m

Figure 4. Illustrates how individual species are scored into frequency proportions for the three utilisation states >50% of total observed, <50% of total observed or none observed in that state.

  - Age cohorts are evaluated with respect to the functional form of a vegetation community. The age of species at sites are grouped into adult, young or mixed. Young includes all plants not yet in adult form, except seedlings which are ignored. In a sustainably managed landscape, senescing adult plants need to be replaced by younger plants. therefore cohorts of sub-adult plants should be expected. If only mature individuals of long lived species are present, removal of younger plants by herbivores is likely. Where only young are present then the site is likely to be recovering from previous disturbance, or there has been a shift in environmental conditions enabling new species to colonise.

- Disturbance indicators

  - Biotic indicators are recorded in predictable resource accumulation zones, which occur under trees and tall shrubs in all but regularly flooded drainage areas. This is where soil formation occurs and plants with fruits accumulate, providing refuge habitat for many species of fungi, plants and animals. The two indicators are: palatable grasses and shrubs with edible fruits (eg. *Rhagodia* spp.); and intactness of leaf litter mats which when undisturbed forms a cohesive ground cover. The proportion of trees/tall shrubs with palatable perennials and intact litter mats present are estimated as > or < 50%.

  - Physical indicators track extent of erosion for two common situations: open areas on flat to gently sloping locations where non-productive subsoils are exposed to the point that no evidence of ephemeral growth is apparent (recorded for patches > $100m^2$); and destabilised channel banks in creek lines where the banks have slumped (no vegetation remains or are actively eroding). Both indicators are estimated for one of three options: dominant (>50%), minor (<50%) or not present (0%).

The size of a sample site is flexible to accommodate sparse perennial plant cover (Fig 4), as the aim is to sample a representative proportion of the more common species within 200m of the starting location which does not need to be marked for repeat visits. The physical disturbance proportions are defined by the area observable whilst assessing utilisation.

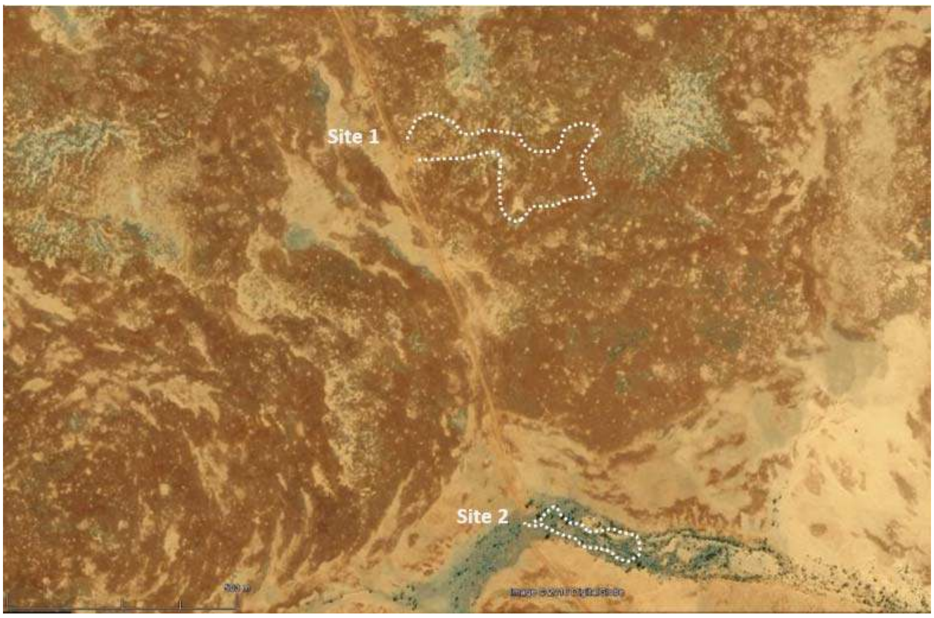

Figure 4. The satellite imagery shows an area with extremely patchy and sparse vegetation that is common in north-east SA. Site 1 samples an area of pavement gibber with vegetated sand spreads, whilst site 2 samples a more closely vegetated drainage line.

Conclusions

The methods outlined provide a practical alternative to the traditional benchmarking approach to land condition assessment. Data collection is rapid and uses simple decision points to categorise condition states and proportional categories that minimise interpretation variation. The results can be analysed through numerical scoring of indicator responses or by looking at proportions of indicators in utilisation/disturbance categories. This information can then be grouped for paddock and property level assessment.

The proportion of indicators and sites in different categories provide the baseline for future visits, and for pastoral leases with a high proportion of over-utilised and disturbed sample points the need for more frequent surveillance will be triggered. Key elements of the method will also feature in discussions with managers to help them identify when they are reaching sustainable management thresholds. The method also provides a standardised way to record disturbance information at any location on pastoral lease and conservation land and has application in ground-truthing vegetation cover anomalies detected through satellite image analyses.

Our utilisation and disturbance indicators can be objectively assessed in any season because they focus on long-lived and durable landscape elements that are also functionally important providers of habitat and ecosystem services for other species. While the method has been designed to meet requirements of the SA *Pastoral Land Management and Conservation Act 1989*, the main elements have also been adopted for determining clearance and offset requirements under the *Native Vegetation Act 1991* in the South Australian arid zone.

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