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# A METHOD FOR ASSESSING ECOLOGICAL INDICATORS FOR REGIONAL BIODIVERSITY CONDITION ASSESSMENT

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## INTRODUCTION

Managing the rangeland ecosystems services (ES) for all Australians is becoming increasingly important as some regions experience a decline in primary productivity, aging rural communities and changing climates. There is growing acceptance that the ecological processes which maintain ecosystem function and ES are controlled by mainly by biodiversity (Hooper et al., 2005).

Most work on biodiversity condition assessment has been in the development of “biodiversity significance scores” as a component of the metrics used for objectively selecting landholder service contracts in incentive schemes (e.g., Oliver & Parkes 2003). New work is also emerging (e.g., “Biohytes” by Read et al. 2005; “BioCondition” score by Eyre et al. 2006; recent trend summaries and rangeland condition review the ACRIS Management Committee). However, biodiversity condition assessment involves many activities, such as an audit of biodiversity, long term monitoring and evaluation of monitoring results for planning and management action. The challenges of these assessments is not so much in the monitoring as considerable detailed work has been done in this area by all jurisdictions over the past 15 years. The real challenges concern understanding what is biodiversity condition, what is the purpose of its assessment, especially relative to ES valuation, what biodiversity should be assessed, how best to measure it and evaluate its condition to inform policy and sustainable management of ES.

In this paper, we describe a method for identifying, selecting and evaluating indicators for assessing biodiversity condition at the regional level, and an application of it in the arid rangelands. We based our development on the Stony Plains Bioregion in the driest part of Australia in the southern rangelands as we had good information resources for the region. It is part of a detailed study which cannot be fully presented in the space available. We do not expand on the purpose of biodiversity condition assessment in ES management although a manuscript on a conceptual framework is in preparation. Nor do we cover biodiversity monitoring and evaluation of results. The method will be presented in detail in a journal paper. We presented it here to seek your feedback.

## BIODIVERSITY CONDITION ASSESSMENT METHOD

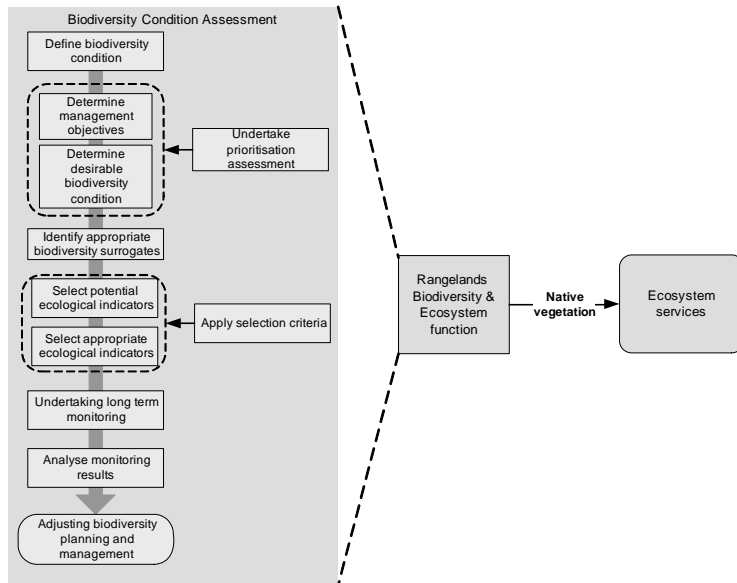
We propose that biodiversity condition assessment revolves around five activities: (i) definition of biodiversity condition, (ii) aspirational statements about management objectives and desired biodiversity condition (iii) selection of biodiversity surrogates and ecological indicators, (iv) long-term monitoring, and (v) evaluation of monitoring results (Figure 1). Much research has been done on biodiversity monitoring and a recent framework has been proposed by the ACRIS Management Committee, so we do not consider it further in this paper. There is a logical and sequential approach to biodiversity condition assessment with some activities requiring more resources than others.

### 1. Defining biodiversity condition

We defined biodiversity condition using the concept of ecological integrity because it is theoretically well developed and its measurement on the ground has been scientifically evaluated. Two studies have also applied it in Australia’s rangelands and new developments relating its measurement using ecological indicators relative to measuring ES is relevant. The concept itself describes the status of ecological phenomena based on sustainability, naturalness and resilience (Andreasen et al. 2001). Theoretically, this means biodiversity condition will reflect the multistate, cyclical and continual dynamics of rangeland ecosystems which makes it difficult to assess reliably but not impossible

(e.g., Westoby et al., 1989).

Figure 1. Method for biodiversity condition assessment.



## 2. Identifying management objectives and desirable biodiversity condition

Before identifying management objectives and desirable biodiversity condition, a biodiversity prioritisation assessment for the region was required first. The reasons for this were many. Biodiversity is hard to pin down on the ground; it is everywhere in all places, and not all biodiversity needs its condition assessed. It is difficult to know where to start to assess *what* condition of *which* biodiversity, especially when operating under

planning and implementation constraints. A biodiversity prioritisation assessment is the basis for identifying clear, unambiguous management objectives and aspirations for desirable biodiversity condition and scoping the problem. Once the scope of the biodiversity condition assessment is understood, identifying appropriate surrogates and ecological indicators for measurement becomes more tractable.

The prioritisation assessment involved obtaining information to carry out a number of tasks involving technical and stakeholder workshops and reviews of technical information for a region. Five tasks are carried out: (i) identification of biodiversity values and assets, (ii) analyses of threats and pressures, (iii) identification of biodiversity management priorities, (iv) an assessment of duty of care responsibilities as background information, and (v) identification of appropriate management action. A synthesis of this information determines the management objectives and desirable biodiversity condition for the region.

## 3. Identifying appropriate surrogates of biodiversity

We define biodiversity surrogates as any set of biodiversity features used to guide biodiversity management with the aspiration of representing broader biodiversity. Once we identified the desirable condition for biodiversity that explicitly related to the biodiversity management objectives for the Stony Plains, we first identified key surrogates that related to a subset of biodiversity values and assets (Task 1 and 2) that were prioritised for management (Task 2 and 3). In this context, the surrogates were linked to the desirable biodiversity condition. Where possible we used cross-taxon surrogates (terrestrial biodiversity features for different taxa) as several studies have shown these to have the highest although weak surrogacy value. Secondly, we assessed how the biodiversity surrogates related to ecosystem function and the ecological processes that may be involved. This step is important for linking biodiversity condition to ecological functioning and ES valuation. For most surrogates, this was a difficult task mainly because it required considerable ecological knowledge of the surrogates in a range of environmental contexts. Our assessment therefore was not as complete as we would have wished and we suggest further summaries of knowledge in this area.

## 4. Selecting appropriate ecological indicators for surrogates

Ecological indicators are often used interchangeably with surrogates but differ by being measures of the condition of environmental phenomena, as early-warning signals of environmental degradation, and as barometers for trends in natural resources. The scientific robustness of ecological indicators

applied in conservation planning is continually being challenged and improved, especially in relation to monitoring (e.g., Suter 2001). Criticisms mainly relate to the conceptual relevance, historical dimensions, measurement qualities, feasibility of implementation and policy and management utility. In technical workshops, we first identified a potential set of ecological indicators to be measured that specifically related to each of the key biodiversity surrogates identified above. Secondly, we assessed these against 33 selection criteria to filter out those with poor qualities. The criteria were derived from a synthesis of the ecological and ES scientific literature (Table 1).

Table 1. Example of criteria for selecting appropriate indicators for assessing biodiversity condition.

Category: Criteria	Information required
<b>3. Measurement Qualities</b>	
3.1 Anticipatory	Signifies an impending change in key characteristics
3.2 Predictable	Has low variability
3.3 Robustness	Relatively insensitive to expected sources of interference
3.4 Sensitive to pressures	Sensitive to land use pressures
3.5 Space-bound	Sensitive to changes in space
3.6 Time-bound	Sensitive to changes in time
3.7 Measurability	Measurable in qualitative or quantitative terms
3.8 Portability	Repeatable and reproducible in different contexts
3.9 Specificity	Clearly and unambiguously defined
3.10 Statistical properties	Allows unambiguous interpretations
3.11 Universality	Applicable to many areas, situations and scales

## RESULTS AND DISCUSSION

The aspirational management objective for the Stony Plains Bioregion was “to retain or restore (if possible) the resilience of ecological communities/habitats for land systems of the region”. Nine ecological communities were identified occurring across any of 52 land systems. Four broad types of desirable biodiversity condition were identified:

1. Native vegetation typical of the study region’s ecological communities maintained and restored.
2. No loss of existing complement of rare and regionally significant native flora and fauna species, populations and ecological communities.
3. Natural surface water flows maintained or restored.
4. A mosaic of ecologically linked water remote areas.

One to four surrogates were identified as appropriate for assessing each category of biodiversity condition (Table 2). The ‘natural water systems’ and ‘water remote areas’ categories were more specific expectations of condition and thus required fewer surrogates. The number of ecological indicators for each surrogate ranged from 2 to 21, reflecting the diversity of measures for biodiversity at different scales from landscapes to sites (Table 2). When we filtered out appropriate indicators by applying the selection criteria, half of the indicators for surrogates of ‘typical native vegetation’ and almost half of those for ‘natural water systems’ were dropped because of poor indicator performance. The performance of the ecological indicators for the five selection criteria categories (CR - conceptual relevance, HD - historical dimension, MQ – measurement qualities, FI – feasibility of implementation, PM – policy and management) ranged from 45% to 100% based on the number of cells met out of the total possible combinations (Fig. 2). HD indicators for ‘typical native vegetation’ had the lowest performance overall but, they with MQ indicators, were the highest for ‘water remote areas’. Performance of most indicators, independent of the categories of selection criteria and desirable biodiversity (DBC), was around the upper 50 and lower 60%. Indicators which are mostly measured at sites for assessing ‘typical native vegetation’ and ‘no loss of biodiversity’ condition types performed marginally lower in CR. The same indicators tended to perform marginally lower in terms of their usefulness for policy and management.

The assessment of the list of indicators against the selection criteria was expertly driven and some assignments will be debated. This step does suffer from two sources of error, expert assignment and

Table 2. Numbers of surrogates, potential and selected ecological indicators for each type of desirable biodiversity condition (see above text for full description)

Desirable Biodiversity Condition Types	No. of surrogates	No. of potential indicators	No. indicators after selection criteria filter (%)
1	4	21	10 (50)
2	6	19	14 (67)
3	1	8	5 (63)
4	1	2	2(100)

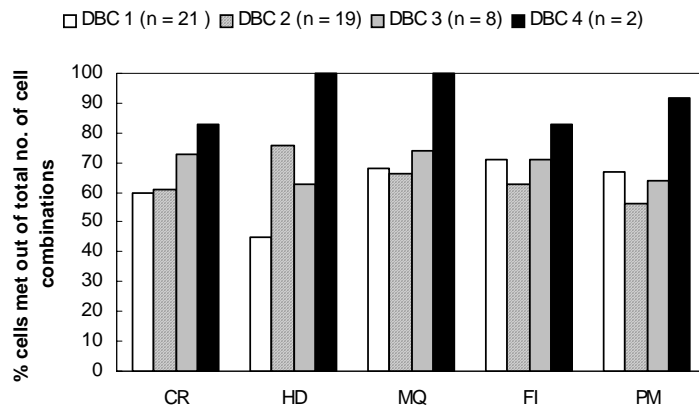


Figure 2. Performance of indicators for selection criteria and desirable biodiversity condition categories (see above text for abbreviations).

lack of detailed knowledge about ecological indicators. Assignment was mostly based on binary decisions (yes/no) although cases of “partly met” and “don’t know” were also recorded. The uncertainty of these latter two was mostly around 2% of the total combinations considered. More work using Bayesian belief approaches is required to select ecological indicators that are scientifically defensible. Nevertheless, the surrogates and indicators as they stand are an improvement on current practices as

they (i) relate the biodiversity condition assessment to ‘biodiversity at risk’ that are important for sustaining a range of ES, at least in the Stony Plains Bioregion; (ii) are also ecologically credible and practical for policy and management purposes to the best of expert knowledge, and (iii) can be measured mostly at sites but some remotely using GIS approaches. Applying indicator selection criteria had an additional benefit of highlighting the gaps in local knowledge of ecological systems.

## FUTURE AND CONCLUSIONS

Gaps remain in our knowledge on how to objectively select ecological indicators to the best of our knowledge for monitoring and assessment of biodiversity condition. More work is needed in this area. By using selection criteria to select indicators, we are adopting a precautionary approach to assessing biodiversity condition and hopefully managing ES sustainably for all Australians more effectively. Funding was provided by the Desert Knowledge Cooperative Research Centre with in-kind from the above organisations.

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