BIODIVERSITY MONITORING IN RANGELANDS

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ABSTRACT

The potential users of biodiversity monitoring tools and techniques have substantial constraints such as time and money, and so they require structured guidance on how to proceed in developing monitoring programs. I review the meaning of "biodiversity monitoring" and the usefulness of tools and techniques for monitoring biodiversity. I conclude that the practical application of resources to monitoring requires answers to the following questions: Why do people need to monitor biodiversity? At what scales and resolutions of data capture do they need biodiversity monitoring information? How can one identify the minimum and necessary set of attributes to measure within a biodiversity monitoring program? Techniques and protocols for scientific experimentation are different to those needed for monitoring, and scientists have a considerable challenge ahead of them to metamorphose scientific investigation techniques into monitoring tools and techniques that meet the specifications of groups wishing to apply them more widely.

INTRODUCTION

In striving to enact intent of sustainable use of natural resources, state government agencies and land managers face the problem of reifying the abstract term 'biodiversity', but also how to measure it so that long term detrimental trends can be detected and remedied in time. The term "biodiversity monitoring" has a series of hidden assumptions and questions: (1) that some element of it can be measured; (2) that those elements of biodiversity that could be measured will have broader meaning and appeal; (3) that measurement of those elements of biodiversity through time will yield trends of some sort; (4) that those trends could be changed if so desired; and (5) that there exists enough resources to devote to the activity of monitoring. An additional and most important assumption is that there is enough of an imperative for the results of monitoring to make the exercise necessary or worthwhile.

By it's very nature, biodiversity is a complex and multifaceted concept. The origin of the concept has only arisen in the last ten years, and it did so because of a dawning realization of the slow decline in the health of natural systems around the world: no one measurement of the natural world lead to an understanding of how biodiversity was declining. Therefore, it isn't realistic to expect one can monitor biodiversity by measuring a few, or even several hundred different aspects of the natural world. A more precise and concrete approach needs to be taken.

Biological scientists have developed a wealth of techniques for measuring different aspects of the environment. These can be techniques that directly assess the size or health of populations of particular species (e.g. counting endangered species), or techniques that measure threats to biodiversity (e.g. feral predator populations). Many of the techniques in use have been developed to answer specific questions of scientific investigation and are not necessarily transposable directly to biodiversity monitoring because they are, for example, too complex or not reliable.

As a result of an expert workshop in 2002 (Smyth *et al.* 2003; Smyth and James 2004), a comprehensive list of biodiversity monitoring techniques and indicators for rangelands were compiled. While the list of tools and techniques are all useful for scientific investigation, the need for biodiversity monitoring is no longer the sole domain of scientists. Community NRM groups, individual enterprises and governments are all calling for information on what to monitor and how to monitor it to be able to report on status and trends in "biodiversity". The results of the workshop offer prospective monitorers a shopping list from which to choose, but not necessarily a framework for which indicators or techniques are appropriate to their needs. In this paper I propose a conceptual framework for the organisation of the shopping list of techniques into subsets that are useful for particular purposes.

KNOW YOUR AUDIENCE

The reasons **why** biodiversity monitoring might be undertaken can be boiled down to two categories: (1) inform management; and (2) showcase good performance (to the market or for legislative compliance). The focus of each one is different and therefore has implications for what is required (Table 1). The first step is to critically analyse why you need to monitor and what information your audience requires.

Table 1. Key attributes of a biodiversity monitoring program depending on reasons for doing it.

INFORM MANAGEMENT	SHOWCASE PERFORMANCE
Detect and adjust for land use impacts that would have a negative effect on biodiversity and lead to reduced performance. *E.g. retain pasture grasses; manage visitor pressure; etc*	• Key legislative requirements • Key market sensitivities to biodiversity *E.g, management sympathetic to the maintenance of particular species/habitats; outcomes of rehabilitation; low impact use of natural resources; etc*

KNOW YOURSELF

The second filter for selecting potential biodiversity monitoring techniques from the shopping list (Smyth *et al.* 2003) is to specify what scale of information **you** require and what resources are available (time and money). A matrix of potential rangeland groups who might undertake some sort of biodiversity monitoring and the scale at which they require information is shown in Table 2. The sorts of information that would be useful to different groups with an interest in biodiversity (or any other) monitoring will be different depending on the resources they have available, and the reasons why they are monitoring (Section 1).

Table 2: Scales at which biodiversity monitoring data may be collected and be useful for different interest groups.

Group	Local scale (m^2, ha, km^2, paddock, property, reserve, local community and surrounds)	Regional (1000 km^2, catchment, NRM region, bioregion)	National (10000 km^2, state, nation)
Pastoral	•		
Local govt	•		
Indigenous	•		
Mining	•		
Tourism	•		
NRM groups	•	•	
State govt	•	•	
Federal govt		•	•

DEFINE WHAT YOU ARE MONITORING

Biodiversity is a shorthand way of expressing the phrase "biological diversity"; this is the variety of species and ecosystems, the interactions among and between these and their genetic diversity (e.g. Department of Environment Sport and Territories 1996). The concept of biodiversity grew relatively recently out of the slow realization of the collapse of the natural systems due to many pressures.

Natural systems are complex and the pressures on them causing disintegration are many, therefore, no simple view of the measurement of natural systems can summarise the problems and solutions.

When people talk of measuring biodiversity they often mean measuring some aspect of biodiversity like the number of species, the number of endemic species (species found only in that location), the types of species present (e.g. National Land & Water Resources Audit 2002). Given that biodiversity is about the variety of life, not the shear abundance of life, measurements of the number of individuals are misguided.

Different elements of biodiversity are chosen by different people to represent perspectives of biodiversity. For example, measurements of the number of species or size of populations of perennial plants and birds are frequently used to indicate the status of biodiversity. Others argue that invertebrates have to be measured because these make up the majority of species. Despite a lot of research it is clear that measurements of one species or group of species have little relevance to the trends and status of other groups of species (Abensperg-Traun *et al.* 1996). The question therefore is, what is the set of different things to measure that adds up to a credible picture of how healthy the environment is?

An analogy for this, that we accept in everyday life, is financial indicators. We know that no one indicator (e.g. Consumer Price Index, interest rates, different stock exchange indices, etc) tells us how the economy is going, and that analysts must look to a range of different ones to assess economic health. So too with biodiversity, a number of different aspects of it need to be examined to ascertain status and health.

My approach is to select at least one aspect of each of **three** elements of biodiversity (following Franklin *et al.* 1981, Noss, 1990): structural (e.g. appropriate age classes); compositional (e.g. species present); and functional (e.g. ecological processes are maintained). In addition, these aspects of biodiversity can be measured directly or via a pressure or threat surrogate such as land clearing. A balanced monitoring program across these structural aspects and targetting some response variables and some pressure/threat variables is desirable and will vary depending on circumstances as outlined in steps 1 and 2 above.

Table 3. Selected examples of a suggested necessary and sufficient set of elements to give a credible overview of the status and health of biodiversity.

Type of response	**Example monitoring group**	Structural	**Compositional**	**Functional**
Response of biota	Pastoral enterprise for **management feedback**	*Woody shrub distribution and abundance, especially noting where large numbers of new recruits are growing*	*Suite of palatable grass species are maintained*	*Patchiness caused by grass and shrub clumps is retained to capture and hold water and nutrients in the landscape*
Pressure or Threat to biota	State government conservation agency for **State of Environment reporting**	*Connectivity and fragmentation of patches in landscape is not getting worse*	*Key threatened species and threatened ecosystems are maintained or increasing*	*Disturbance processes are heterogeneous and at appropriate scales frequencies and intensities.*

HOW TO MONITOR

The OED defines the word '**monitor**' (verb) as "*To observe, supervise, or keep under review; to keep under observation; to measure or test at intervals, esp. for the purpose of regulation or control.*" Monitoring is done to detect *changes* through *time*. In terms of the natural environment this might be variation in the number of individuals present, the arrival of a new species, the loss of a species that has been present in the past etc. All monitoring has the implicit assumption that the measurement being taken is reliably able to detect some sort of change between times. While this sounds trite, in rangelands, we often find that measurements of plants and animals record fluctuations through time, but do these relate to changes induced by land use or pressure on some biota or just natural variation? While there does exist a number of techniques that are suitable for reporting change in some aspect of biodiversity in relation to land uses (e.g. remote sensing – Bastin *et al.* 1993, Ludwig *et al.* 2004), other techniques and indicators are still under scrutiny (e.g. ants – James 2004, Andersen *et al.* 2004). Some critical aspects of the techniques that are chosen are:

- ***objective repeatability:*** different people may be involved in measuring the chosen trait at different times and the results need to be independent of individual variation. Techniques should be developed that minimise training time for new observers and maximise simplicity and repeatability;
- ***reliable re-countability:*** the things being measured must be able to be measured each time. Many animals have an inactive stage during periods when the environmental conditions aren't favorable. Taking an extreme example of frogs, counting them during normally dry years (when the counts might be consistently zero) doesn't tell you anything about how many of them are actually alive and well under the ground. Birds can't go through stages of inactivity like frogs do, and so if they are alive and present they should be visible. However, birds raise another problem because some of them are migratory or nomadic and their absence at certain times shouldn't necessarily be taken as a sign of a problem.
- ***informative:*** if there are differences in the measurements between times, the information must be able to tell a reliable story of how things have changed and hopefully give some inkling of why they might have changed (but not always possible). Some background knowledge of the aspects being measured is almost certainly needed to make good interpretations.

According to the definition of monitoring, it does not include any suggestion of inferring the reasons why something might be changing through time. That is, monitoring might detect a correlation of things changing in some related way through time but it does not mean that it can attribute causation. Attributing causation between factors is the foundation of the scientific method and hypothesis testing (Underwood 1997), which occupies the pages of dozens of books. Most monitoring schema are not robust enough to detect these sorts of relationships and should not mistakenly be used in such a way. They can however be used to generate observations from which hypotheses and experiments are derived.

WHERE TO MONITOR

Having filtered the shopping list of potential indicators, and techniques to monitor those indicators (Smyth *et al.* 2003), down to a smaller set by making decisions outlined above, there remains an extremely difficult question of just where to do things on the ground to get the most effective result. The aims of monitoring will almost certainly mean that the results desired are different for each situation, and therefore the location of where and how it is implemented will be different. For some indicators, the location of monitoring is very simple (e.g. you monitor threatened species where they occur). For other indicators, sampling locations are not easily sited – as yet, there just isn't enough knowledge to know the most effective ways to use some techniques to get reliable, informative, and timely information about changes in the natural environment. For example, you could measure the abundance and health of pasture plants in an area of 10 m by 10 m. If you wanted to know about when to adjust stocking rates in a paddock to preserve forage resources you might make these measurements a kilometer or two from a water point where (arguably) threshold changes are most likely to be detected. If you wanted to know that long-term persistence of the native grasses was guaranteed, or that seed stores were still being generated for dry times you might make the same measurements 5-10 kilometers from a water point.

It is not possible to make any more prescriptions in this paper on how and where to use particular monitoring techniques because they will have to be customized for each implementation. However, there is a need for rangelands scientists to devote some time and effort to developing better *monitoring* techniques than are currently available to the range of land users.

EXAMPLE APPLICATION

Using the framework outlined above, it is possible to select a subset of indicators and techniques that could ***potentially*** be used in different circumstances. To illustrate this, Table 4 shows the subset that could be selected for relevance to a pastoral enterprise with low levels of resources (time or money) available. Within this there are some techniques that are relevant only to management feedback, and others to showcase performance. It is not intended that everything in this subset be done, but that it gives a reduced and targeted set of potential activities to select from. The detailed explanation of each indicator and how the 'Techniques' are applied is not shown due to space limitations but of course could be available as additional layers of information associated with the particular selections.

Table 4. Set of potential indicators and techniques that could be used by a pastoral enterprise with low levels of resources to monitor different aspects of the natural environment.

Reason for monitoring	Aspect of biodiversity measured	Indicator type	Indicator	Technique	Attribute measured	Variables recorded
Management feedback; Showcase status	Function; Structure	Pressure or threat	Average stocking rates	stocking rate	grazing pressure	density of stock
Management feedback	Composition	Pressure or threat	Distribution and abundance of feral animals	plot or transect count of species - scat counts	Feral animal - grazers	species ident and count
Management feedback; Showcase status	Composition	Pressure or threat	Distribution and abundance of feral animals	landholders' returns and records	Feral animal - predators	species ident and count
Management feedback	Composition	Pressure or threat	Distribution and abundance of feral animals	plot or transect count of species - spotlight	Feral animal - predators	species ident and count
Management feedback; Showcase status	Composition; Structure; Function	Pressure or threat	Distribution and abundance of invasive weed species	plot or transect count of species	weeds - terrestrial	species ident and count
Management feedback; Showcase status	Composition; Structure; Function	Pressure or threat	Distribution and abundance of invasive weed species	plot or transect count of species	weeds - aquatic	species ident and count
Management feedback	Composition	Pressure or threat	Localized grazing pressure on special assets	plot or transect count of species - scat counts	grazing pressure	species ident and count
Management feedback; Showcase status	Composition; Function	Response	Change in composition of bird fauna	plot or transect count of species	birds - terrestrial	species ident and count
Management feedback	Composition; Structure	Response	Change in composition of	photopoints	vegetation - terrestrial	species ident,

			perennial terrestrial vegetation			count, height
Management feedback	Structure; Function	Response	Change in composition of perennial terrestrial vegetation	plot or transect count of species	weeds - terrestrial	species ident and count
Management feedback; Showcase status	Composition; Function; Structure	Response	Change in composition of perennial terrestrial vegetation	plot or transect count of species and demography	weeds - terrestrial	species ident and age class
Showcase status; Management feedback	Composition; Structure	Response	Change in composition of perennial terrestrial vegetation	plot or transect count of species and demography	vegetation - terrestrial	species ident and age class
Management feedback	Structure; Composition	Response	Change in cover and structure of perennial terrestrial vegetation	photopoints	vegetation - terrestrial	species ident, count, height
Management feedback	Composition; Structure; Function	Response	Change in cover and structure of perennial terrestrial vegetation	plot or transect count of species and demography	vegetation - terrestrial	species ident and age class
Management feedback	Composition; Structure	Response	Change in cover and structure of perennial terrestrial vegetation	plot or transect count of species	vegetation - terrestrial woody shrubs	species ident and count
Management feedback	Structure; Composition	Response	Change in cover and structure of perennial terrestrial vegetation	photopoints	vegetation - terrestrial	species ident, count, height
Management feedback	Function; Structure	Response	Change in patchiness indicating loss of function	photopoints	vegetation - terrestrial	species ident, count, height
Management feedback; Showcase status	Composition; Structure	Response	Infrastructure to protect special assets	development of infrastructure or regime to protect assets from pressures	threatened species/ ecosystems	km new fencing, fire breaks etc

SUMMARY AND CONCLUSIONS

I have attempted to develop a decision framework in which subsets of potential tools for monitoring aspects of biodiversity could be selected to meet different users needs and resource availability.

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