Australian Government

Biodiversity monitoring in the rangelands: A way forward

Managing for biodiversity in the rangelands

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Abstract

This paper looks at biodiversity monitoring in the rangelands, and includes both regional and enterprise-level examples.

Rangelands are a major contributor to the biodiversity of Australia. To maintain and enhance biodiversity, land managers need to be informed of appropriate monitoring practices and have the tools to implement such practices.

Monitoring biodiversity in the rangelands is complex and difficult to achieve. Despite increasing interest and attention given to maintaining biodiversity values, few biodiversity monitoring programs are actually implemented. While there is broad support for biodiversity monitoring programs among land managers and natural resource management groups, numerous constraints limit program implementation.

Constraints to biodiversity monitoring include technical difficulties with methods and indicators; a lack of basic environmental data for many properties and regions; a lack of relevant skills and expertise among regional people; the high cost of achieving credible monitoring results; uncertainty about the purpose and benefits of monitoring; and confusion about who is responsible for biodiversity monitoring.

In this paper, we review several indicators for their feasibility as biodiversity monitors at the regional and enterprise levels. The most useful indicators were those that required only limited expertise to measure; linked strongly to management activities; and were able to clearly demonstrate changes in biodiversity.

Key recommendations from this project include:

- establishment of individuals and/or organisations responsible for biodiversity monitoring
- support for local guidance and training for people involved in biodiversity monitoring at enterprise and regional levels
- help with collection and access to baseline data for property managers and regional land managers
- use of meaningful incentives, where appropriate, to increase involvement in biodiversity monitoring
- development of cost effective, meaningful, and robust indicators and surrogates for the broad-scale use required in the rangelands
- improved coordination of regional monitoring efforts to ensure systematic programs
- access to resources which support awareness, development, and implementation of biodiversity monitoring programs

This paper is part of a series of related publications on Managing for Biodiversity in the Rangelands, intended to provide government agencies, land managers and others with relevant information on protecting biodiversity in the rangelands.

Definitions

Biodiversity	Biodiversity is a measure of the relative diversity among organisms present in different ecosystems.
Indicators	Indicators demonstrate changes in biodiversity. Indicators can be grouped into two main types—pressure indicators or response indicators—according to what they assess. Both types of indicators have advantages and problems (see below).
Pressure indicators	Pressure indicators measure processes that threaten aspects of biodiversity such as land clearing, grazing pressure, weed density, and fire regimes. Pressure indicators are more easily measured than response indicators, particularly across large scales. However, the precise relationship between the pressure and the biota of an area may be poorly known, making it difficult to interpret monitoring results.
Response indicators	Response indicators assess how species, groups, or ecosystem attributes respond to land-use pressures. These involve a direct measurement of the biota – for example, the number of plant or bird species in a certain area. They may provide information about other biodiversity elements, as well as the ones directly sampled. Response indicators give a more direct understanding of biodiversity but can be more difficult to measure, and it may be more difficult to assess the result.
Surrogate measures	Surrogate measures are used to assess something that might otherwise be very difficult to assess. For example, there may be a clear relationship between the abundance of arboreal mammals and fire regimes. In this instance fire regimes might be measured as a surrogate for arboreal mammal populations, because they are much easier to measure. Surrogates can only be used confidently if they are tested for validity, and currently many are untested.

Introduction

Rangelands are a major contributor to the biodiversity of Australia. To maintain and enhance biodiversity, land managers need to be informed of appropriate monitoring practices and have the tools to implement such practices.

Biodiversity monitoring is the ongoing assessment of the abundance of biodiversity to ensure protection through effective management. Monitoring biodiversity in the rangelands is difficult to achieve with precision and at appropriate scales. Additionally, there is little information or support for land managers and natural resource management groups who seek to assist with biodiversity monitoring in the rangelands.

Why monitor biodiversity?

There are two main reasons for monitoring biodiversity at regional and enterprise levels:

– to support decision-making around land use and management

– to provide a measure of environmental performance

More specifically, biodiversity monitoring will also help to:

– initiate management action (for the protection or maintenance of biodiversity)

– assess whether management actions work

– improve ecosystem management

– determine whether biodiversity targets have been achieved

– demonstrate achievement of compliance or accreditation standards

– provide opportunities for community learning and informing the public about biodiversity and its management

The relative importance of these reasons will depend on the role of individuals and groups involved in land management. For example, while the manager of a grazing enterprise may be most interested in achieving accreditation standards, a catchment management board may be most interested in assessing which actions are working and educating the community.

Establishing the need for biodiversity monitoring is vitally important, yet often overlooked. Doing this for each case will scope more precisely how and when monitoring needs to occur: establishing need will determine factors such as the type of monitoring required; which indicators to use; the location and spatial extent of monitoring; and the frequency of monitoring.

This project

The purpose of the project described in this paper was to seek opinions from land managers and natural resource managers about the usefulness of current information on potential indicators in biodiversity monitoring (see Smyth et al. 2003). We also aim to provide additional support to any participants interested in developing a biodiversity monitoring program.

In this paper we discuss the context and fundamentals of biodiversity monitoring, the current situation in the rangelands, and some issues that are common across the regions. We list recommendations to address some of the factors that currently constrain the adoption of biodiversity monitoring at both enterprise and regional levels. We outline the requirements for regional monitoring and provide a worked example of biodiversity monitoring at the regional level. We also discuss biodiversity monitoring at the enterprise level.

The approach

In this project, we analysed how a biodiversity monitoring plan would be established in three cases studies, through workshops with the relevant community players. This enabled us to determine the practical requirements for a regional biodiversity monitoring plan. Two of the case studies (Western Catchment of NSW and the Burdekin Dry Tropics region of Queensland) were aligned with regional planning processes, and specifically discussed their own regions' monitoring of committed biodiversity targets. The third case study (northern Australia) addressed monitoring at the enterprise scale with property managers and their aides.

We present a summary of the project findings in this paper. For further details, consult the main report (see reference section for details).

Section 1:
Fundamentals of biodiversity monitoring



Important aspects of biodiversity monitoring include:

- proper recording of monitoring results – the data assessing the indicators as well as the methods and techniques used for monitoring
- details of the monitoring activities, such as the date of monitoring and location of monitoring sites
- background information on recent seasonal conditions and management of the area
- any unusual events (e.g. fire) at the site since the previous monitoring

Key principles in developing a biodiversity monitoring system

Monitoring biodiversity is a complex and difficult task to achieve at an appropriate scale and level of precision. The following list of principles will help to design an appropriate monitoring system, depending on the particular aims and circumstances of each case.

1. Identify the reasons for monitoring and how the information is to be used. For example, will it be used to support/inform management and decision making, or to demonstrate a level of environmental performance?
2. Seek expert advice on biodiversity management and monitoring.
3. Identify who is responsible for monitoring, collating, analysing and storing the data.
4. Obtain basic information on (a) the natural resources of the area, including basic soil and vegetation information provided by land resource surveys and land system/regional ecosystem maps, and (b) species presence, distribution and status, whether at risk or threatened. While this information is necessary, often it is not readily available. It may be available from local government agencies.
5. Identify and prioritise the risks to biodiversity values, including changes that may be occurring on the land. This should place emphasis on land uses that may be causing change in biodiversity values.
6. Define at least one aspect of each of structural, compositional and functional elements to be monitored. It is not possible to monitor all living aspects of biodiversity, so it is sensible to monitor the abundance of a mix of attributes from each of these three elements.
7. Consider the appropriate scales (temporal and spatial) for assessing these indicators. This will help identify the scale of information that is required and what resources (time and money) are available to conduct the monitoring.
8. Consider specific locations most appropriate for monitoring such as riverbanks, areas of grazing use, and areas of important habitat or concentrations of species.
9. Use monitoring methods that are objectively repeatable, informative, and have reliable ability to be re-counted.
10. Conduct a regular, informal review of the monitoring system to ensure it is meeting the intended needs, and/or whether the needs have changed.

Effective monitoring requires appropriate indicators

Indicators are the measures of the status of biodiversity and they influence subsequent decisions and management. Effective monitoring relies upon selection of the most appropriate indicators, yet this is difficult to achieve for practical and technical reasons.

We have identified a number of desired principles for indicators. They should be:

- *informative*, in terms of the biodiversity values of concern
- *sensitive* to changes in abundance of the species, or condition of the variable of interest, within a reasonable time frame
- *easy* to assess
- *meaningful* in terms of peoples understanding of biodiversity – they may directly relate to the specific biodiversity value or a surrogate.
- *linked* clearly to management actions – land managers need to be confident that the indicators will actually indicate whether management actions are effective.

Assessing and using indicators

This project identified and reviewed indicators through a series of workshops with a range of users. Our findings are presented in Table 1. These findings are not exhaustive, nor is the assessment of 'feasibility' appropriate for all regions. Some regionally specific indicators will be required; participants should work with their local authorities to identify these indicators. Additional 'aquatic' indicators may also be needed. Again, participants should consult appropriate experts to identify such indicators.

The actual practice of using and monitoring selected indicators can be difficult. Effective monitoring of most biodiversity indicators requires:

- sufficient time and funds
- knowledge of the monitoring methods available for particular indicators, and knowing the most appropriate method to use
- a decision on the location and number of monitoring sites
- on the frequency of monitoring
- knowledge of how to record and interpret the information

It is important that landowners and those involved in natural resource management groups are confident that their monitoring activities will produce meaningful results. To support the design and practical implementation of monitoring programs, and to increase participants' confidence and experience, more information and better access to resources is required.




Table 1:

Part A: Suggested indicators for biodiversity monitoring at a pastoral enterprise scale

Response type indicators

Indicator description	Suggested techniques	Indicator explanation	Comments	Technical feasibility (at scale of interest)	Likelihood of availability of skills and resources
change in cover & structure of perennial terrestrial vegetation (pasture grasses / woody shrubs)	• photo points • plots or transect counts • detailed demography • remote sensing	indicates a number of pressures e.g. grazing, fire, flood, drought, weed invasion, land clearing	• already done or partly done by pasture monitoring programs (e.g. Tier 1 photo points) • need to fied species • adding more detail to what is currently measured would require a specific purpose, e.g. may be able to monitor size or recruitment of a specified species	high	medium
change in composition of perennial vegetation (pasture species, shrubs, all)	• photo points • plot / transect counts	to maintain pastorally productive plant species & habitat important for biodiversity	• see above column	high	medium
change in composition of bird fauna (all or selected species)	• plot / transect counts	different suites of birds are good indicators of different pressures, based on mobility/dispersal characteristics	• could be done by pastoral staff if they have some expertise & monitoring is tightly focused • requires background/baseline information on which species occur, or should occur, on the property • need a specific purpose for the monitoring (e.g. assessing the effects of a change in land use) • even if changes over time are observed, they may be difficult to interpret	medium	low
change in composition of ant fauna	• pit trapping	ants are a ubiquitous yet sensitive grazing group	• not possible to do as it requires specialised expertise	low	low
change in composition of mammal / reptile fauna	• pit/Elliott trapping • counts (track, scat) • hair tube	a direct measure of components of biodiversity	• expertise to do this generally unavailable • may provide observations over time for some species that are readily identified & seen (but highly variable between observers)	medium	low
change in distribution or abundance of significant fauna species (e.g. threatened waterbirds)	• specific monitoring programs	a direct measure of significant components of biodiversity	• high value to monitor species identified as significant & informative (e.g. some waterbirds) • monitoring (& protecting) threatened/significant species promotes kudos for the pastoral enterprise • distribution of key species in property management plan, & defines effects of management • monitoring programs through specific projects (e.g. testing the effects of changing management) • may be done with external agencies (but concerns about how this can be sustained in the long-term)	low	low
effective recruitment in special biota populations	• photo points • plots or transect counts	key to persistence for high value species/ ecosystems	• possible if the targeted species was identified, distribution was known, & purpose of monitoring was clearly identified	medium	low
change in landscape function measures	• bare ground, erosion • photo points • transects • remote sensing	indicates long-term capacity of the landscape to support biota	• where some changes are readily perceived, importance is easily understood (e.g. erosion) • little information about the link to biodiversity	medium	low
riparian / aquatic condition	• rapid assessment techniques	indicates problems with sediment & nutrient loads, with implications for upland & riparian management	• potentially important & useful indicators, but more information needed • may be too coarse in scale (especially indicators that are easily measured) • very useful if it is easy to describe 'baseline' condition of riparian areas	high	medium
abundance of macropods	• dung counts • transect counts • aerial survey • cull returns	indicates a component of grazing pressure & macropod population viability	• subjective assessments by station managers (few versus lots) & knowledge of changes over time • mostly seen as a state agency responsibility	medium	medium

Pressure type

Indicator description	Suggested techniques	Indicator explanation	Comments	Technical feasibility (at scale of interest)	Likelihood of availability of skills and resources
average stocking rates	• stocking rate (by ecosystem)	an indicator of grazing pressure on the landscape/ecosystem	• already quantified for each property, usually on a paddock basis • difficult to interpret the direct implications for biodiversity	high	high
distribution & abundance of feral herbivores	• plot or transect count • scat counts • aerial survey	major uncontrolled source of grazing pressure - need to manage populations of feral herbivores to low levels	• subjective observations already made (e.g. while travelling around property) could easily be scored on a low, medium, high type scale, but this would vary between observers • more objective methods (spotlight counts / track counts / scat counts) need clearly defined purpose • aerial surveys need to be done on a regional basis (rather than by individual enterprises)	medium	low
distribution & abundance of feral predators	• spotlight transect counts • scat or track counts	removing predation is key for critically-endangered species - manage feral mammalian predators to low levels	• monitoring is achievable for specific sites where there is a clearly defined purpose (e.g. impacts of cats or foxes on bilby populations) otherwise, monitoring should be carried out on a regional basis	medium	low
distribution & abundance of invasive weeds (terrestrial & aquatic)	• locality records • plot or transect counts	controlling invasive weeds is a critical management tool to look after endangered species	• some monitoring of distribution & density of weeds undertaken as part of station management • new infestations reported on a fairly ad hoc basis • needs regional context for monitoring program (target species, priority areas)	medium	low
localised grazing pressure (on special or sensitive areas)	• track monitoring • dung counts • defoliation • photo points	specific to plant communities that need areas protected from grazing pressure (e.g. rabbits)	• easily achievable, but needs areas of interest to be identified	medium	low
density of artificial water points (by land type)*		surrogate of grazing pressure	• as an indicator it is easily measured & understood, but needs to be backed by evidence that shows relationship with biodiversity conservation (e.g. proof that decreaser species persist in water-remote areas)	high	medium
percentage of land area remote from water points (by land type)*	• estimated from maps or GIS data from state agencies	availability of refuges for grazing sensitive species	• see above column	medium	low
extent of clearing of native vegetation (by land type)*	• measured from maps or data from agencies	availability of habitat for native species; related measures of patch size / connectivity / fragmentation	• easily measured • data already available • but also need information on the condition of the remaining vegetation	high	high
frequency & extent of fire (in fire-sensitive* ecosystems)	• annual fire mapping by agencies • general data from managers	can link to recruitment for some indicator species in fire-prone communities	• already reported on through monthly managers reports • may be better done on a regional basis • need context to interpret this (what is a ‘desirable’ fire frequency; which ecosystems are of interest)	medium	medium

*these indicators are also quantifiable at a regional scale

Management action type

Indicator description	Indicator explanation	Comments	Technical feasibility (at scale of interest)	Likelihood of availability of skills and resources
infrastructure to protect special areas	care for special areas - fences to limit stock, fire breaks	• easily measured • but doesn’t prove whether they have been effective	high	high
biodiversity-friendly grazing management strategies		• see above column • would need to determine the particular grazing strategy in each case	medium	low
property environmental plans		• see above column	high	high

Table 1:

Part B: Suggested indicators for regional biodiversity monitoring (adapted from Table 4.2 Smyth et al. 2003)

1: Regulatory and compliance – Response type

Indicator description	Suggested techniques	Indicator explanation	Comments	Technical feasibility (at scale of interest)	Likelihood of availability of skills and resources
composition & abundance of waterbird fauna	• plot / transect counts	• waterbird fauna are sensitive to changes in water quality & pollution -a strong indicator, because they are the top of the food chain	• may be better to monitor water quality directly • some expertise required	high	medium
composition of perennial terrestrial vegetation	• photo points • plot / transect counts	• certain species indicate the level of disturbance • a long-term attribute of landscape function & habitat for other elements of biodiversity	• already done in many regions, although sometimes sporadically • an important indicator of grazing impacts • requires substantial resources for monitoring & promulgation of results & implications	high	high
composition of terrestrial fauna	• pit/Elliott trapping • Searches • counts (track, scat) • hair tube	• direct measure of biodiversity • differential responses among sub-groups may indicate specific pressures	• potentially valuable indicator but expertise is needed & is generally not available • currently occurring to a very limited extent in a few areas	medium	low
cover & structure of perennial terrestrial vegetation	• photo points • plot / transect counts • detailed demography • remote sensing	• broad indicator of several pressures (e.g. grazing, fire, flood, drought, weed invasion & land clearing) • long-term attribute of landscape function/ habitat for other biodiversity elements	• already done to some extent by pasture monitoring programs in most areas • need to understand if they are useful surrogates for biodiversity generally • monitoring recruitment of specified species would increase the value • remote sensing may provide a cost-effective way of broad-scale monitoring • easy to measure & readily interpretable by pastoralists • links to ground dwelling/ nesting fauna	high	high
vegetation 'greenness' indices	• remote sensing	• indicates condition of areas, maybe due to drought and/or grazing • indicates weed invasion or disturbance around water-points	• already being done in some states to monitor change in ground cover & woody vegetation • need to understand whether this is a useful surrogate for biodiversity more generally	high	high
status of threatened species & ecological communities	• specific monitoring programs & records from state conservation agencies	• improving condition of environment if threatened species & ecological communities are being delisted	• potential high value in monitoring specific species & communities • will usually require expertise for certain species • may not reflect biodiversity status more generally • include status of particular species & total no. of threatened species & communities	medium	medium
status of particular 'icon' plant species	• specific monitoring programs	• targets at-risk but currently unthreatened species	• intended to detect problems such as a lack of recruitment	high	medium
kangaroo abundance	• dung and/or transect counts • aerial survey • culling returns	• sustainability of harvest & to set quota • add to grazing pressure	• currently broad-scale surveys done in southern states by aerial survey • culling returns & kangaroo tags provide some data in some states • usually a state agency responsibility as part of harvesting programs	high	high
composition of aquatic invertebrate fauna	• micro-netting & volume sampling	• sensitive indicators of aquatic & riparian habitat condition	• considered important indicator, one aspect of riparian condition already done on a localised basis in a few areas but requires expertise for identification	medium	low
composition of bird fauna	• plot/transect counts	• certain bird species indicate disturbance levels • presence of some species in less pressured areas is needed for persistence	• requires some expertise • some alrseady done by NGO programs but no formal regular programs	high	low

Pressure type

Indicator description	Suggested techniques	Indicator explanation	Comments	Technical feasibility (at scale of interest)	Likelihood of availability of skills and resources
distribution & abundance of weed species	• locality records • plot / transect counts	• determine expansion through formal reports of new presence	• already done in some regions • considered an important indicator • target species & priority areas need to be identified	high	medium
distribution of foxes	• spotlight transect counts • scat or track counts	• determine expansion through formal reports of new presence	• not considered relevant as already widely distributed in southern (nontropical) areas • monitoring of abundance probably more important • already occurs in limited areas such as certain national parks	high	low
density of feral & native mammalian herbivores	• plot/transect count • dung counts • aerial survey	• in combination with stocking rate can indicate total grazing pressure on ecosystems	• often difficult & expensive to do accurately • goat monitoring occurs as part of aerial kangaroo surveys in some states	low	low
extent of clearing of remnant native vegetation	• measures of patch size, connectivity, fragmentation by land type • remote sensing, aerial photography, clearing applications	• habitat loss may directly affect biodiversity of resident communities, & connectivity of habitat patches within landscapes	• considered an important indicator • clearing already monitored in most states, often by state agencies • remote sensing often used • information on condition of remaining vegetation is also needed	high	high
fire frequency & extent across landscape	• annual fire mapping by remote sensing • aerial photography	• examine role of fire in changing habitat elements of landscape	• already done by state agencies using remote sensing	high	high
fire frequency & extent in fire-sensitive communities	• annual fire mapping by remote sensing & ground-based surveys with GPS	• to examine effects on fire-sensitive ecosystems	• already done in some areas but usually restricted to state government • relevant for reserves/parks • need context to interpret this information (e.g. desirable fire frequency)	medium	medium
land tenure change	• obtained from state land office records	• percentage of land class • tenure may relate to land use & potential pressures	• easily obtained • not an especially useful indicator	high	medium
landscape pattern metrics (patch sizes, connectivity)	• remote sensing	• indicators of fragmentation etc. leading to slow loss of species	• data easily obtained, usually collected by state agencies • only relevant where clearing continues	high	medium
percentage of land area that is remote from water points	• GIS mapping	• extent to which grazing sensitive, & water affected species have refuges from these pressures	• already measured in some states by state agencies • needs to be supported by information that demonstrates grazing sensitive species persist in water-remote areas	high	high
water quality	• rapid assessment techniques for water clarity, turbidity (sediment), algal growth, invertebrates	• potential indicator of aquatic & riparian habitat condition, but relationship needs to be clarified	• already occurs in a limited number of specific locations • requires considerable expertise & currently often done by the state (seen as state responsibility)	high	low

Management action type

Indicator description	Suggested techniques	Indicator explanation	Comments	Technical feasibility (at scale of interest)	Likelihood of availability of skills and resources
average stocking rates	• stocking rate (by ecosystem) from stock returns	• can assess grazing pressure with water point indicators	• already recorded for most regions on a property basis • difficult to interpret for biodiversity affects – need information on grazing level for sensitive areas	high	high
density of artificial	• surrogate of grazing pressure	• surrogate for grazing pressure & land-use intensity also correlated with changes in water-dependent species	• easily measured • already measured in some states by state agencies • needs to be supported by information that demonstrates grazing sensitive species persist in water-remote areas	high	high

Table 1:

Part B: Suggested indicators for regional biodiversity monitoring (adapted from Table 4.2 Smyth et al. 2003)

2: Investment allocation – Response type

Indicator description	Suggested techniques	Indicator explanation	Comments	Technical feasibility (at scale of interest)	Likelihood of availability of skills and resources
composition & abundance of waterbird fauna	• plot/transect counts	• indicates wetland health -functional linkage to hydrological change • easily understood, and has social appeal	• may be better to monitor water • quality directly • some expertise required	high	medium
abundance & distribution of aquatic & semi-aquatic vegetation	• greenline transects • photo points	• directly measures the effect of changed flow regimes & riparian vegetation & wetland health	• considered an important indicator • may require some expertise	medium	medium
extent & distribution of flood water	• remote sensing	• directly measures the effect of changed flow regimes by monitoring seasonality, duration, extent, & frequency	• considered an important indicator • needs to be supported by information that demonstrates • significant species relying on flooding persist • relevant data in the hands of state (& other) agencies, so require cooperation in sharing of data	high	medium
flow of perennial streams	• permanent flow gauge	• 'environmental' flows are required to maintain riparian habitat/species	• may already be done for some larger streams	high	medium
landscape pattern change	• may be possible using remote sensing	• indicates potential loss of function & habitat degradation • simple process, cost-effective at large scale	• impacts on biodiversity would not be directly apparent • would need additional supporting information on species & habitats likely to be adversely affected	medium	low
status of threatened species & ecological communities	• specific monitoring programs	• high public profile & easily collected information, useful for raising profile with decision makers & targeting investment	• potential high value in monitoring specific species & communities • will usually require expertise for certain species • may not reflect biodiversity status more generally	medium	medium
Structure of perennial terrestrial vegetation	• photo points • plots or transect counts • detailed demography • remote sensing	• established link between grazing pressure, vegetation structure & landscape change • methods well known and links with other ACRIS indicators • measure percentage cover & patchiness, composition & relative abundance	• information is already gathered through pasture monitoring programs, or could be extracted from these	high	high

Pressure type

Indicator description	Suggested techniques	Indicator explanation	Comments	Technical feasibility (at scale of interest)	Likelihood of availability of skills and resources
abundance & distribution of feral pest animals (herbivores)	• plot/transect counts • spotlight counts • dung counts • aerial survey	• distinction required between pest herbivores & carnivores • major threat to habitat & forage for native species	• subjective observations already made at property level • objective methods could be done if access to properties is possible • aerial surveys probably best method on a regional basis	high	high
abundance & distribution of carnivorous feral pests	• spotlight transect counts • scat or track counts	• main determinant of decline in small mammal species	• rarely done at present • more difficult than herbivores because carnivores are more cryptic (usually nocturnal)	medium	low
concentrations of pesticides & nutrient pollutants in waterways	• specific sampling programs	• reveals levels of pressure on landscape & links to aquatic systems • indicates potentially unsustainable development	• requires specialised analysis of samples, & possibly specialised • handling of samples at time of collection • for many rangeland areas is not likely to be a significant pressure	medium	low
number & extent of introduced weed species	• locality records • plot or transect counts	• implications for regional control costs	• already done in some regions/states. Requires context for important species & areas to target • requires considerable resources to do adequately	medium	medium
number of weed species changing to new category	• records from regulatory authorities	• Indicates effectiveness of control	• an indirect indicator generally reflecting increasing abundance of certain species • often monitored by local government	high	high
number of new agricultural species with weed potential		• potential for invasive introductions	• requires clarification of weed potential; may require uniform approach by different agencies (also see number of introduced weeds above)	low	low
number & output of free-flowing bores		• measure of number & effect of large artificial watering points (bore drains & terminal wetlands) affecting native biota • indirect measure of recovery of natural springs	• currently done	high	high

Management action type

Indicator description	Indicator explanation	Comments	Technical feasibility (at scale of interest)	Likelihood of availability of skills and resources
progress toward a CAR (comprehensive, adequate & representative) conservation network	• assessment of the number of hectares in a bioregion in reserves • percentage of ecosystems in reserves • median size of reserves in bioregion • easily measured variables showing proportion of land area explicitly managed for biodiversity outcomes & potential reduction in threats associated with land-use for production	• currently done by state agencies	high	high

Section 2:
Current status of biodiversity monitoring




Existing natural resource management monitoring activities

Currently, very little monitoring of biodiversity values takes place. Land managers and local community groups rarely undertake environmental monitoring and often fail to value monitoring programs. Most existing monitoring programs do not monitor biodiversity directly. Instead, they measure surrogates as an 'add-on' to monitoring for other natural resource values. Government agencies usually conduct these programs, which may be for research purposes or driven by legislative, policy or development objectives. Most of these programs cease once the short-term objectives are satisfied.

Existing biodiversity monitoring programs fit into the following categories, according to their primary monitoring purpose:

- pasture monitoring programs
- landscape and vegetation programs
- native species programs
- pest management programs
- aquatic programs

We discuss these programs in more detail below.

Types of monitoring

1. Pastoral monitoring programs

In the rangelands, the most common pastoral monitoring programs relate to extensive grazing. The ability of such programs to measure the status of biodiversity is often debated—most biodiversity scientists regarding them as inadequate.

Most state agencies conduct pastoral condition monitoring. Because government officers often conduct this monitoring, the pastoral community involved feels no 'ownership' over the programs, which often suffer from technical difficulties, irregular sampling, and inadequate financial support. Lack of cooperation between state government agencies, or between agencies and regional bodies, often adds to the difficulty of running programs.

Large pastoral companies can be an exception to the rule. They often have well-developed pasture and land condition monitoring programs to inform management of the property's status.

2. Landscape and vegetation programs

Landscape and vegetation mapping and monitoring programs are often structured around vegetation clearing. This can take place either locally, regionally or state-wide, usually through remote sensing.

3. Native species programs

Native flora and fauna monitoring programs are usually short-term, occasional, and designed to provide specific information about a single species. Exceptions that we know of include the monitoring of waterfowl across south-eastern Australia to establish wetland health; and the monitoring of macropods to determine harvest quotas (although this is closer to pest animal monitoring than conservation monitoring).



4. Pest animal and plant programs

Government organisations such as pest control boards and National Park services often share pest monitoring duties. Feral herbivore monitoring may occur as an add-on to kangaroo population monitoring. Carnivore monitoring may occur to assess a control program. Weed monitoring is neglected at the regional scale, but happens more frequently at the enterprise level, where mapping the extent of weed infestations is considered important.

5. Aquatic programs

State agencies conduct extensive aquatic and freshwater monitoring programs, partly due to the ease of sample collection. However, most monitoring focuses on measuring flow parameters rather than assessing water quality or biota. Sample testing (e.g. for water quality, invertebrates) requires technical expertise, and consequently testing is limited.

Community involvement in monitoring activities

At present, there is only a small pool of skilled and experienced people qualified to monitor biodiversity in the rangelands.

Community groups and individual landholders are rarely involved in existing regional-scale monitoring programs. Such programs are considered:

- to be too time consuming
- to be too difficult
- to require considerable assistance
- to be a government responsibility

Programs to monitor a component of biodiversity, such as a particular species, are often limited by unrealistic expectations of the detail of monitoring and the need for significant organisation and training.

Indigenous Australians (including Traditional Owners and other Indigenous groups) generally have little involvement with natural resource planning or monitoring. We recommend an increase in the involvement of Indigenous communities in monitoring activities, particularly in states such as New South Wales and the Northern Territory, where Indigenous involvement is particularly low.

Regional natural resource monitoring targets

Although little biodiversity monitoring currently occurs, all natural resource management plans considered in this study include targets and actions that affect biodiversity, either directly or indirectly. Most natural resource management plans require monitoring of these actions. While this occasionally leads to monitoring of explicit elements of biodiversity, monitoring usually focuses on surrogates.

Natural resource management boards tend to rely heavily on partnerships with government and research agencies for information and advice on biodiversity monitoring. While these government agencies have the technical capacity to monitor biodiversity, or at least surrogate indicators, they lack the resources to run ongoing monitoring programs.

Natural resource managers usually prefer to use their limited funds to manage the resource rather than monitor its condition. Some indicators are prohibitively expensive to monitor and would require significant government support to gain inclusion in monitoring programs. These are strong reasons to raise awareness about the importance of biodiversity monitoring

Issues and constraints for biodiversity monitoring

The regional and enterprise-level case studies highlight a number of common perceptions, constraints, and opportunities for biodiversity monitoring in the rangelands.

Three key themes emerge:

1. Technical difficulties with methods and indicators, such as:
   - > a limited range of indicators currently available
   - > a limited number of robust rapid-assessment indicators
   - > use of landscape-scale indicators which often lack credible scientific validation;
   - > a dearth of people with the skills, experience, and confidence to use monitoring techniques—land managers need support to be able to use techniques, interpret data, and apply this understanding to management
   - > a lack of basic environmental data on which to base monitoring schemes—often this information does not exist or is inaccessible

2. Confusion about what is required, including a lack of:
   > understanding about the principles of monitoring and effective implementation–land managers are unsure of what to monitor and how their enterprise will benefit
   > clarity over responsibility—even when there is broad support for a monitoring program it is not clear who should take responsibility
   > understanding about the purpose of monitoring to ensure data collected will fulfil that purpose
   > long-term commitment
   > understanding about what constitutes monitoring–confusion often occurs between 'genuine' monitoring (i.e. systematic monitoring of indicators) and data collection as part of discrete, short-term research studies
   > certainty of required actions once changes in biodiversity are detected
3. High cost of conducting credible biodiversity monitoring, in terms of:
   > funds
   > labour
   > time

A resource shortage means that the indicators selected for biodiversity monitoring tend to be those already monitored for another purposes (e.g. range condition monitoring), and/or those which are simple and cheap to assess.

Requirements for biodiversity monitoring in the rangelands

Successful biodiversity monitoring in the rangelands requires:

- training for people involved in biodiversity monitoring at enterprise and regional levels through training workshops incorporating hands-on activities
- biodiversity support officers equipped with strong skills in ecology and monitoring, good knowledge of the biota, ability to access relevant information, and strong networks with other biodiversity scientists
- processes that facilitate collection and sharing of baseline data at property and regional levels and among natural resource management groups
- systems that assist accessibility of data for resource managers
- a clear understanding of who is responsible for biodiversity monitoring
- meaningful incentives for those who undertake biodiversity monitoring
- meaningful indicators or surrogates, either ground-based or remotely sensed, which will make monitoring easier and instill the belief that monitoring is a genuine measure of change of biodiversity
- action-research teams to develop and test indicators with local people and groups
- robust, systematic monitoring programs which are coordinated and standardised at the regional level; the current approach with separate programs for each region promotes local 'ownership' and relevance but should also promote standards
- communication resources that support the development of biodiversity monitoring programs, such as web sites, contact officers, publications, and other internet resources

Section 3:

Biodiversity monitoring at different scales



The regional scale

Monitoring at the regional scale occurs through regional planning processes under the Natural Heritage Trust (NHT) or National Action Plan (NAP). Through this process, community Natural Resource Management Boards monitor biodiversity against Resource Condition Targets (see the main report for more information).

Factors to be considered in regional plans

1. The purpose of monitoring

The aim of regional monitoring is to demonstrate that the NHT investment is improving regional biodiversity. Regional plans will have explicit ideal targets, such as an increase from 50 - 75 per cent of land area in good condition or a reduction in population decline of a threatened species, but it may be difficult to demonstrate these changes. Instead, surrogates that monitor implementation of improved land management practices may be appropriate. However, it will still be problematic to evaluate what a change such as this may mean for regional biodiversity.

2. The scale of the issue

Monitoring needs to encompass an entire region, but in most cases it is impractical to survey such a large area. Consequently, a hierarchical approach can be used, with a suite of indicators assessed across the broad landscape supplemented by stratified (smaller-scale or local) and more intensive sampling of several other indicators. The hierarchical approach can supply representative data across a region as well as providing significant biodiversity values at a more localised scale.

3. Important elements of biodiversity and their best indicators

Ideally, monitoring will assess individual indicators that target particular biodiversity or resource issues. Monitoring should include a mix of response and pressure type indicators or surrogates.

Response type indicators are often the most appropriate. They directly measure biota, such as bird and plant composition, aquatic species, and water quality. Response type indicators are useful in areas of limited size because of the intensive methods required. They are suitable for the localised sampling of the hierarchical approach suggested above.

Pressure type indicators and surrogate measures of biodiversity are useful for large areas, where practical reasons require that the indicators are simple and easily measurable. Careful selection and interpretation of surrogates is required; due to a lack of testing, it is uncertain whether many pressure type indicators are accurate indicators of biodiversity status.

4. The level of monitoring effort

The large size and variation of regions in the rangelands makes it a challenge to conduct detailed sampling of any activities that might affect biodiversity.

A limit of available resources (i.e. labour, operating funds, equipment etc) requires careful design of the monitoring scheme. Monitoring more indicators at more sites and sampling more frequently will undoubtedly provide more meaningful information

Key components of regional biodiversity monitoring

This project identified five key components for developing a regional biodiversity monitoring program.

1. Obtain existing environmental mapping and biodiversity data for the region before planning the monitoring program. There is likely to be biophysical baseline mapping data for the region of interest, as well as information on land management regimes, land tenure, and other surveying data.
2. Identify significant biodiversity components using available information and expert knowledge—these may include ecosystems or threatened species.
3. Identify pressures on biodiversity, including: total grazing pressure, invasive 'pasture' plants or weeds, fire, thickening or thinning vegetation, proliferation of water points, and feral predators.
4. Select and measure pressure type indicators —other more general indicators might also be considered, such as Comprehensive Adequate Representative Reserve System status, any threatened species action plans, 'sustainable' management, connectedness of the landscape elements, and the relatedness of conserved and managed patches.
5. Select and measure response type indicators. This step requires experts, should be relatively comprehensive and incorporate existing programs, such as any monitoring at the property level.

Biodiversity elements to consider

Biodiversity elements to consider in a monitoring program could include: plants, birds, reptiles, mammals, fish, aquatic invertebrates, and any threatened species.

Other attributes that could verify the simple indicators being used at the property level could include: ground cover (or at least percentage bare ground), frequency of perennial plants, or vegetation structure.

Maximising the effectiveness of regional biodiversity monitoring

To maximise the effectiveness and efficiency of a biodiversity monitoring program, those planning a program should consider the following.

1. Complementary indicators and surrogates

Determine if the assessable indicators are complementary. For example, surveys to monitor bird species abundance can also collect complementary data on vegetation cover and composition.

For more rapid assessment at the regional scale, surrogates may be useful. For example, there may be a clear relationship between the abundance of arboreal mammals and fire regimes. In this instance fire regimes might be measured as a surrogate for arboreal mammal populations, because they are much easier to measure. Surrogates can only be used confidently if they are tested for validity, and currently many are untested.

2. Analyses, evaluation, and dissemination

Seek expert advice on storing, analysing, and evaluating collected data—these are critical steps.

Regularly (at least annually) distribute monitoring results to natural resource managers and land managers, so that they can review the value of the indicators and verify local management benefits. This often neglected phase is crucial to the success of a monitoring program. It is important to allocate adequate time and resources to the collection and distribution of results.

3. Adaptive management

Convey information on the status of biodiversity and the effects of management to land managers. This information sharing should enable an adaptive management approach.

4. Post-hoc responsibility

Programs and funding are often short-term (three to five years). Address issues of long-term data storage, management, and ownership, and an ongoing cycle of re-sampling.



Regional case study: Burdekin Dry Tropics

The Burdekin Dry Tropics region is located in north-eastern Queensland and covers an area of over 130,000 square kilometres. The population of approximately 190,000 people live primarily in urban centres. The region is comprised of, firstly, more densely populated coastal areas with urban, industrial, and irrigated agriculture land uses and higher rainfall and, secondly, sparsely populated inland areas mostly used for rangeland grazing, some dry-land agriculture, and mining. Annual rainfall is between 650 and 1500 millimetres. Dominant vegetation is open woodlands grasslands; key woody species are eucalypts, acacias and melaleucas.

Biodiversity values in the Burdekin Dry Tropics are significant. The region is recognised for species richness and endemism of vertebrate fauna, eucalypts and acacias. At least 70 fauna species within the region are listed as endangered, rare, vulnerable or extinct under the Queensland Nature Conservation Act 1992.

Regional NRM Plans

Regional investment occurs through the regional natural resource management (NRM) plans of the National Heritage Trust and the National Action Plan of south-west Queensland. These NRM plans identify the region's natural resource management targets and investment strategies to implement the monitoring program. A number of documents support regional NRM boards monitoring and evaluation (www.nrm.gov.au/publications/evaluation), and resource condition indicators (www.nrm.gov.au/monitoring/indicators/). However, these documents discuss only the broad principles of biodiversity monitoring rather than specific details.

Biodiversity Monitoring in the Burdekin Dry Tropics

This case study sits within the general framework for biodiversity monitoring at the regional scale, as described earlier in this paper. The basic monitoring included commonly used site-based sampling methods. More intensive sampling of response indicators included basic monitoring of the nested two hectare monitoring site.

We propose the following communication and training tools for the Burdekin Dry Tropics:

- customised training modules for a biodiversity condition assessment toolkit
- biodiversity managing and monitoring workshops for land managers
- biodiversity monitoring information presented at Grazing Land Management workshops
- regional newsletters to deliver information on project progress and outputs
- biodiversity toolkit manuals—either hard copies or digital reproductions
- primary data collected through regional monitoring to be lodged at:
  - > Queensland EPA Wildnet and historical database
  - > bird data at Birds Australia (RAOU) Atlas
  - > community groups–NRM boards, and Catchment and Landcare groups
  - > other existing state or Australian government information clearing-houses (Department of Environment and Water Resources, CRCs, etc)
- report on site data for property managers involved in the monitoring

For more detailed information on biodiversity monitoring in the Burdekin Dry Tropics, see the main report.

The enterprise scale

We cannot define a simple and universal approach to biodiversity monitoring—what and where to monitor is determined case-by-case. However, we can suggest some general principles and practical suggestions for monitoring at the enterprise scale.

Factors to consider

Effective biodiversity monitoring at the enterprise scale will depend on four factors:

1. The purpose of monitoring

Biodiversity monitoring at the enterprise scale is usually conducted to find out if land management practices are having a positive or negative effect on biodiversity and whether they should be re-evaluated.

2. The scale of the issue

By ‘scale’, we mean both the total area considered for monitoring and the complexity of the issue. These are generally related. There are four scales at which biodiversity monitoring may be required within a pastoral enterprise:

- a small area or individual feature with specific biodiversity values [1-100 hectares]
- a larger area, but generally smaller than a whole paddock [100-1000 hectares]
- an entire paddock(s) [c. 100 square kilometres]
- an entire property [1000-10,000 square kilometres]

3 Important elements of biodiversity and their best indicators

It is best to use a number of different indicators that will cover as broad a range of biodiversity elements as possible. For monitoring at the enterprise scale, stronger emphasis should be given to response indicators. These indicators directly measure biota and are likely to be more meaningful to pastoral land managers. They also overcome the difficulty associated with interpreting pressure indicators.

4. The level of monitoring effort

The more resources put into a monitoring program, the more likely it is to succeed. However, planners need to consider the limits of personnel, time, money and/or expertise. Some trade-off between monitoring effort and quality may be required.

In a pastoral enterprise, three levels of monitoring effort can apply in different circumstances (see Table 2 below). ‘Simple’ monitoring programs will be the easiest to implement, but such programs will provide less information and may not adequately answer the questions.

Table 2:

Pastoral enterprise—three levels of monitoring

Effort	Description
1. Simple	• minimal investment of time and effort • generally carried out by manager or other on-property staff • may require some initial training, but no specialised expertise • usually only one, or very few, indicators measured
2. Refined	• greater investment of time and effort (i.e. additional to current activities) • carried out by dedicated staff member, possibly with external assistance • likely to require some specialised expertise, although this may be provided through training • may involve several indicators, or intensive sampling of a particular group of plants or animals
3. Intensive	• requires a substantial investment of time and effort and a high level of expertise • likely to be carried out by another party in collaboration with the landholder • usually includes a broad range of indicators • may have a research focus

Further information

Those embarking on a biodiversity monitoring program may require expert advice.

Because natural resource management is organised at a regional scale, the relevant regional facilitator may be a useful first contact for information. Some regional natural resource management bodies now employ a dedicated biodiversity officer. A list of facilitators and their contact details is available at www.nrm.gov.au/index.html. Australian Government NRM facilitators based in each state and territory can provide similar assistance: see www.nrm.gov.au/contacts/facs/index.html.

The state and territory agencies undertake broad-scale regional rangelands biodiversity monitoring. The Australian Collaborative Rangeland Information System coordinates national monitoring. For more information see their website (ACRIS: www.deh.gov.au/land/management/rangelands/acris/).

The Rangelands Biodiversity Monitoring Group (RBMG) provides ACRIS with on biodiversity monitoring. RBMG members may be able to provide expert advice relevant to their region, as well as specific guidance on biodiversity monitoring methods. See below for a list of member names and contact details.

Name	Contact details
Jeff Foulkes	National Parks and Wildlife South Australia GPO Box 1047 Adelaide SA 5001 (08) 8124 4722 foulkes.jeff@saugov.sa.gov.au
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Teresa Eyre	Qld Environment Protection Agency teresa.eyre@epa.qld.gov.au
Anita Smyth	CSIRO Sustainable Ecosystems (Alice Springs) PO Box 2111 Alice Springs NT 0871 (08) 89507153 anita.smyth@csiro.au
Keith Claymore	WA Conservation & Land Management keithc@calm.wa.gov.au
Alaric Fisher	NT Dept. of Natural Resources, Environment and the Arts (Darwin) PO Box 496 Palmerston NT 0831 (08) 8944 8453 alaric.fisher@nt.gov.au




Useful web links

Some useful information about plant and animal distributions, threatened species, and significant ecosystems or habitats is available online.
Note that some of this data may be unverified or incomplete and should be used with discretion.

General biodiversity

National: http://audit.ea.gov.au/ANRA/vegetation/vegetation_frame.cfm?region_type=AUS&region_code=AUS&info=bio_asses (and select the state and region of interest)

WA: http://www.naturebase.net/content/view/960/1397/

NT: http://www.nt.gov.au/nreta/parks/management/masterplan/publications/index.html

QLD: http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/

NSW: http://www.nationalparks.nsw.gov.au/npws.nsf/Content/bioregions

Plants

National: http://www.chah.gov.au/avh/

WA: http://florabase.calm.wa.gov.au/

NT: http://www.nt.gov.au/nreta/wildlife/plants/index.html

QLD: http://www.epa.qld.gov.au/nature_conservation/wildlife/wildlife_online/

NSW: http://www.rbgsyd.nsw.gov.au/information_about_plants/botanical_info/plants_of_nsw

Fauna

National: http://www.environment.gov.au/biodiversity/abrs/online-resources/software/platypus/index.html

WA: http://www.museum.wa.gov.au/faunabase/prod/index.htm (includes NT and QLD museum records)

NT: http://www.nt.gov.au/nreta/wildlife/animals/index.html

QLD: http://www.epa.qld.gov.au/nature_conservation/wildlife/wildlife_online/

NSW: http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Native+plants+and+animals: http://www.austmus.gov.au/

Frogs

National: http://frogs.org.au/frogs/

Northern Australia: http://www.frogwatch.org.au/

Birds

National: http://www.birdata.com.au/

Wetlands

National: http://www.deh.gov.au/water/wetlands/database/

QLD: http://www.epa.qld.gov.au/nature_conservation/habitats/wetlands

NSW: http://www.naturalresources.nsw.gov.au/care/wetlands/index.html

Threatened species

National: http://www.deh.gov.au/cgi-bin/sprat/public/sprat.pl

WA: http://www.naturebase.net/content/view/273/1208/

NT: http://www.nt.gov.au/nreta/wildlife/threatened/index.html

QLD: http://www.epa.qld.gov.au/nature_conservation/wildlife/threatened_plants_and_animals/

NSW: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/index.aspx

References

For a comprehensive list of references and further information, refer to the main report:

Hunt L, Fisher A, Kutt A and Mazzer T 2006, Biodiversity Monitoring in the Rangelands: A way forward, Vol 2: Case Studies, Desert Knowledge CRC, Alice Springs.

Copies may be downloaded from www.environment.gov.au

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