Indicators of Sustainability for Production and Biodiversity Conservation in Australian Rangelands

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Indicators of sustainability for production and biodiversity conservation in Australian rangelands

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Key points : Australian rangelands provide a diversity of ecosystem services and there is a growing demand for monitoring that is based on biophysical , economic and social values . Federal and state government agencies are collaborating to report on change in rangelands , at scales relevant to federal , state and regional needs . The Australian Collaborative Rangeland Information System (ACRIS) takes the pragmatic approach of reporting against themes using available data . The ACRIS collates the data from diverse sources , conducts meta-analyses using derived indices as appropriate and provides a national synthesis at regional resolution to enable comparisons amongst regions . A number of indicators need testing , as does the validity of up-scaling point-based data . Aspirational targets for reporting are avoided , recognising that institutional capacity is declining and short-term funding cycles hinder the implementation and maintenance of long-term monitoring .

Key words : monitoring , collaborative information system , institutional capacity

Introduction

Rangelands occupy 81% of Australia's land area (Figure 1) , popularly known as the outback' . While they generally include hot climate deserts , the land area is large enough to encompass summer-dominant (monsoonal) and winter-dominant rainfall patterns from north to south (Bastin *et al* . , in press) . Tropical woodlands and savannas prevail in the far north , *Acacia* woodlands and shrublands occupy the arid central regions and chenopod shrublands predominate in the south . Soils are characteristically low in fertility , rainfall is highly variable and growing seasons are short .

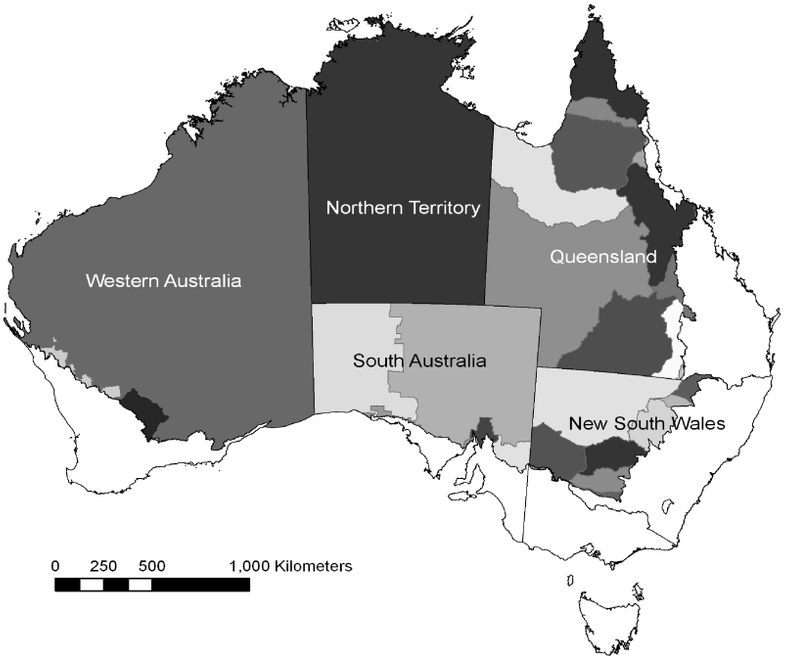

Figure 1 *Natural Resource Management regions wholly or partly within the Australian rangelands (shaded area) . The Northern Territory is one NRM region as is most of Western Australia . Elsewhere , NRM regions are much smaller .*

Commercial livestock grazing is by far the most widespread use of rangelands in terms of area (3 .67m km^2 , 59% of the rangelands in 2001) , but mining and tourism bring greater economic returns . Through the Aboriginal Land Rights (Northern Territory) Act 1976 and other legislation indigenous people have regained primary responsibility for 27% of the rangelands , while conservation lands occupy under 10% .

Rangeland monitoring in Australia evolved from the late 1960s as a means of understanding the impact of grazing on pastoral rangelands . Most of the pastoral lands are publicly owned . Administration of land management is a state rather than a federal

responsibility and so monitoring has been a state-based activity . The type and quality of data gathered is variable because each of the states collects data for different reasons , with varying degrees of regulatory backing .

While monitoring for pastoral production has been established for some time , albeit with a history of false starts and irregular reporting , the capacity to monitor biodiversity outcomes is in its infancy . Baseline data have been gathered in many areas by state agencies but coverage is incomplete for the rangelands and re-sampling (to report change) is limited to local or regional scales (Bastin *et al* . , in press) . Various indicators have been proposed for monitoring biodiversity (Smyth *et al* . 2003) but the choice of indicator is often dependent on ease of use or the professional interest of the individual rather than the validity of its connection to biodiversity .

With growing recognition of the capacity of Australian rangelands to provide diverse ecosystem services , demand has increased for monitoring that is based not only on biophysical values but economic and social values as well . Information about the current status and trend of rangelands is essential for a number of purposes . Federal and state governments need information to support legislative and policy initiatives , to meet international reporting requirements and for periodic ' state of the environment' reporting . Regional bodies (Figure 1) now have increasing responsibility for setting and meeting targets for natural resource management , which includes both production and conservation outcomes (http ://www .nrm .gov .au/nrm/region .html , accessed 17/11/2007) . In addition , comprehensive reporting will contribute to Australia's capacity to predict the outcomes of , and respond to , climate change .

Monitoring activities

Some form of pastoral monitoring has been in place in state jurisdictions for several decades . What is monitored is dependent on each state's objectives and is intimately linked to spatial and temporal scale (Friedel *et al* . , 2000) . Most monitoring systems are ground-based and hence data collection is focussed at a very local scale , so that the point-based assessments provide only a sample of the national context . A summary of commonly used indicators and methodologies is provided by Friedel *et al* . (2000) .

Point-based data are particularly relevant for enterprise-level management but there is an inherent danger in extrapolating to regional level or higher . How many points are enough to represent variability within or between land types ? Are there sufficient to represent regional status ? Remotely sensed data can provide a regional perspective and are collected by some jurisdictions , but they are rarely an integral part of institutional monitoring . Queensland uses Landsat TM imagery to routinely monitor the extent of woody vegetation , clearing for agriculture , regrowth and ground cover over the entire state (http ://www .nrw .qld .gov .au/slats/ , accessed 20/11/2007 ; DNRM , 2005) . Elsewhere remote sensing is used to support ground-based monitoring but is not embedded as a key component of pastoral monitoring systems .

The development of a framework for biodiversity monitoring in Australia has been relatively recent (Smyth *et al* . , 2003 ; Hunt *et al* . , 2006) . Smyth and James (2004) outlined the multiplicity of purposes for monitoring biodiversity , not all mutually exclusive : policy-making , regulation , early warning of change , detecting effects of management , assessing niche markets for rangeland products , improving public knowledge and improving communication and education . As with pastoral monitoring , a single system cannot meet all needs . Attributes that could be used as indicators were categorised into four types : biotic , ecophysical , pressure and management . Until now data have been collected using ground-based plots on a local to regional scale but there has been very little resurveying from which to report change .

Recently Smyth *et al* . (in press) developed an approach to biodiversity monitoring based on ecological risk assessment . The first step was to identify the desired outcomes or endpoints for assessing biodiversity condition . In their case study region of some 130 ,000 km^2 , these were :

- Native vegetation typical of the study region's communities maintained or restored
- Reduction in the loss of the existing complement of rare and regionally significant native species , populations and ecological communities
- Natural surface water flows maintained or restored
- A mosaic of water-remote areas maintained . (Research in other parts of the Australian rangelands has shown that some biota are adversely affected by grazing disturbance (James *et al* . , 1999) and maintaining areas remote from stock water is recommended to assist in conserving these species .)

Having identified for each outcome the biodiversity values and how these helped to maintain condition , they selected a number of candidate indicators , such as average percent vegetation cover after long dry periods , presence of non-native invasive weeds , presence of terrestrial endemic and threatened fauna , and percent area remote from stock water by length of time , using an integrated set of attributes such as availability of historical records , quality of measurements and feasibility of implementation . They were not successful in identifying derived indicators such as persistent grazing gradients and modelled floristics for the case study area . The notion of a single biodiversity condition metric was rejected in favour of presenting the values for a suite of selected indicators for each desired outcome . They concluded that a problem formulation framework as outlined was fundamental to devising a candidate set of indicators for assessing biodiversity condition . However there is no evidence yet that this approach will be implemented as part of routine monitoring .

While there may be general acceptance at state and federal level of what needs to be done , implementation is constrained by institutional capacity (Watson and Novelly , 2004) . Resources are limited , with the consequence that the proposed indicators remain largely aspirational . Without the potential for commitments from state agencies to fund and maintain dedicated and extensive biodiversity monitoring systems across their jurisdiction for the long term , a comprehensive system will remain aspirational . Recognising the competing demands placed on agencies , it is important to find pragmatic ways of obtaining useful information on biodiversity status and trends . The following section explains what is being done by a partnership between federal and state agencies to report on change in a number of rangeland-relevant themes , including biodiversity .

ACRIS

The Australian Collaborative Rangeland Information System (ACRIS) (http ://www .environment .gov .au/land/management/rangelands/acris/index .html ,accessed 17/11/2007) was established in 2003 to facilitate data collection and documentation for reporting on regional and national changes in the rangelands . It is a partnership between the federal and state agencies that are responsible for resource management and biodiversity conservation . The main activity to date has been collation and synthesis of available datasets (including jurisdictional monitoring data) to provide more complete understanding of change in the rangelands (Bastin *et al* . , in press) .

The initial motivation for creating the ACRIS came from the states involved in rangeland monitoring . They recognised in the 1990s that it should be possible to build a broader collective view of change in the rangelands by combining their various data . This desire was strengthened when the earliest attempts at national ' state of the environment' reporting , built largely on expert opinion , were published . However individual jurisdictions lacked the required resources to report beyond their borders until the National Land and Water Resources Audit provided the means in the late 1990s (http ://audit .ea .gov .au/ANRA/rangelands/rangelands _ frame .cfm ?region _ type=AUS&region _ code=AUS&info=description , accessed 23/11/2007) . The resultant report described 16 information products for reporting change and proposed the ACRIS as the coordinating mechanism to collate and continually update a wide diversity of rangeland information .

In addition , over the last 20 years , land uses other than pastoralism have been growing in importance . There has been a transfer in ownership of pastoral properties , often of marginal pastoral value , to conservation , indigenous and in some cases tourism interests (Bastin *et al* . , in press) . With the increase in indigenous land ownership , there are growing expectations amongst both government and community sectors that indigenous people will engage more fully in livelihood activities such as tourism , harvesting of bush foods for generating income and natural resource management (e .g . http ://www .desertknowledgecrc .com .au/research/livelihoods .html , accessed 18/11/2007) . The consequences are that there are additional data requirements and a need to provide results in culturally appropriate ways .

ACRIS reporting occurs within a framework of themes : climate variability , landscape function (Ludwig *et al* . , 1997) , sustainable management , total grazing pressure , water use and management , biodiversity and socio-economic change (Table 1) . The ACRIS does not have an independent capacity to gather data . Instead it depends on state and territory agency partners willingly contributing their data for these themes , assisted by national datasets where available and relevant . The state agencies have collected their data for a diversity of purposes , and the methods used are often specific to particular environments , for example pastoral monitoring in grasslands or shrublands . Thus , the data are not directly comparable . The ACRIS Management Unit (Bastin *et al* . , in press) assists by collating these disparate data , conducting meta-analyses using derived indices (e .g . of landscape function) as appropriate and providing the national synthesis , but at regional resolution so that inter-regional comparisons are possible . In 2008 , the ACRIS will publish its national report of change in the rangelands between 1992 and 2005 for the themes shown in Table 1 (Bastin *et al* . , in press) .

Table 1 *Information products grouped by theme used by the ACRIS to report change in the Australian rangelands between 1992 and 2005* .

Theme	Information product
Climate variability	• seasonal quality as context for interpreting change
Landscape function	• change in landscape function (the capacity of landscapes to capture and retain rainwater and soil-borne nutrients for plant growth)
Sustainable management	• change in critical stock forage • change in pastoral plant species richness • distance from stock water • invasive weeds
Total grazing pressure	• change in domestic stocking density • change in kangaroo density • feral herbivores

Products that support landscape function and sustainable management	• change in fire regime • change in atmospheric dust (dust storm index)
Water resources	• information sources for water availability and sustainability
Biodiversity	• change in protected areas • change in number & status of threatened species / communities • habitat loss by clearing • effects of stock watering points on biota • fauna records and surveys • flora records and surveys • transformer weeds • wetlands : condition and change • habitat condition derived from remotely sensed ground cover • bird composition
Socio-economics	• socio-economic profiles • value of non-pastoral products in the rangelands • change in land use • change in pastoral land values

Having demonstrated that national reporting is feasible , the ACRIS now needs to increase its ability to meet regional needs . As part of devolved federal government responsibility for natural resource management , regional groups (Figure 1) are required to report progress towards specified resource condition targets . To assist them with their reporting obligations under the National Natural Resource Management Monitoring and Evaluation Framework (http ://www .nht .gov .au/publications/annual-reports/2004-05/index .html , accessed 18/11/2007) , the ACRIS could provide broader context against which progress towards agreed condition targets is judged .

Table 2 *Method used by ACRIS to assign causality to change detected at monitoring locations (left) and the associated probable response by state agencies or regional boards to such change (right) (adapted from Bastin* et al ., *in press) .*

Prior seasonal quality	Change in Landscape Function or Sustainable Management					
	Biophysical change at monitoring sites			Probable institutional response when most of the region is showing		
	Decline	No change	Increase	Decline	No change	Increase
Above average	XX	X	~	Management has suppressed the expected response *Further investigation required*	Management has not allowed the landscape to respond to favourable seasons *Further investigation required*	Management has delivered a response consistent with expectations
Average	X	~	√	Management has not delivered the expected response *Further investigation required*	Management has delivered a response consistent with expectations	Management has delivered a better than expected response *Investigate , acknowledge and promote*
Below average	~	√	√√	Management has delivered a response consistent with expectations	Management has delivered a better than expected response *Investigate , acknowledge and promote*	Management has had a significantly beneficial impact on the outcome *Investigate , acknowledge and promote*

√√ *indicates an increase although seasonal conditions were below average (decline in the measure expected at this time)*
XX *indicates a decrease although seasonal conditions were above average (increase expected at this time)*
~ *indicates no change*

The Australian rangelands are characterised by considerable climate variability (e .g . Friedel *et al* . , 1990) and prior rainfall , in particular , is the major driver of biophysical change (e .g . vegetation amount , composition and demography) . In order to report at the regional scale in a way which assigned causality between seasonal variation and management impacts , the point-based data for landscape function and sustainable management were expressed in terms of change relative to values expected for prevailing seasonal conditions (Table 2 , left) . This approach has been adapted from that used by at least one state agency monitoring system (Watson *et al* . , 2007) . The matrix structure is expanded to show the effectiveness of management and probable institutional responses by land management agencies (Table 2 , right) .

Indicator value

The pragmatic approach by the ACRIS to thematically reporting change based on available data has highlighted several issues related to indicator value . These include the suitability of an indicator for reporting change against a particular theme , and the appropriateness of available data for use with some indicators .

A number of the ACRIS indicators are yet to be fully tested for their accuracy . For example , there is a recommended methodology for assessing landscape function (Tongway and Hindley , 2004) but it is only in Western Australia that these procedures have been implemented as part of routine monitoring . The ACRIS Management Unit constructed a number of indices to estimate landscape function from available jurisdictional datasets but the effectiveness of these indices has not yet been tested . Landscape function is a potential surrogate for several ecosystem services such as maintenance and regeneration of habitat , prevention of soil erosion , maintenance of soil fertility , maintenance of soil health and water infiltration (Ludwig *et al* . , 1997) , but both the proposition and the capacity of available data to quantify ecosystem services need testing . A further requirement is testing of the ability to up-scale point-based monitoring of landscape function using remote sensing-based methods such as the leakiness index (Ludwig *et al* . 2007) .

Reasonably reliable data reporting change in livestock and kangaroo densities are available for parts of the rangelands but good data are lacking for feral herbivores such as goats , camels , donkeys and horses . Thus it is not possible to confidently report trends in total grazing pressure as one of the key components affecting sustainable use of the rangelands . Feral animal distributions are known with some confidence but there is a need for regular semi-quantitative estimates of density by species . The large area and remoteness of much of the rangelands means that systematic surveys to estimate feral animal numbers will remain infrequent and so indices that can reliably indicate changes in their relative density would be valuable .

The ability to report on indicators of sustainability for biodiversity conservation is limited . The 10 indicators in Table 1 were selected from over 50 previously evaluated (Smyth *et al* . , 2003 ; Hunt *et al* . , 2006) . The choice of indicators was based on their potential to provide a national view , whether sufficient monitoring data were available and whether they could provide reliable and consistent information . Of these , data on protected areas , number and status of threatened species / communities , rangeland avifauna and habitat loss by clearing contributed to the national perspective of change in components of biodiversity . It is unlikely that a more comprehensive assessment will be available until systematic regional monitoring of flora and fauna is in place , complemented by information on habitat and wetland condition , and broader contextual information about transformer weeds , fire , grazing (including changes in stock watering points) and other threats to biodiversity . It is interesting that one of the most valuable datasets for indicating change in rangelands avifauna is that contributed by Birds Australia , a volunteer community-based reporting scheme . The Birds Australia Atlas provides Australia-wide coverage but there are limitations in the more remote parts of the rangelands due to scarce data and high seasonal variability .

Socio-economic indicators are also an important aspect of sustainability for pastoral production and biodiversity conservation but they are not easy to report on meaningfully . One of the main requirements is improved understanding of the capacity of pastoralists and other land managers to adapt to , at times , rapidly changing environmental , economic and social circumstances . Indicators such as the median age of pastoralists , net emigration of young people from regions and age dependency ratio (the proportion of regional population younger than 15 and older than 65) have been proposed but subsequent testing with data from five-yearly national population censuses and targeted surveys have shown them to be poor indicators of actual change in rangeland management practices (Hanslip and Kelson , 2007) . Other methods for understanding socio-economic differences amongst regions are being investigated (e .g . Maru and Chewings , in press) .

In the absence of suitable indicators of pastoralists' capacity to adapt and change their management practices , the ACRIS has reported on changing land use , pastoral land values and the importance of non-pastoral agricultural production in the rangelands (Bastin *et al* . , in press) . Pastoral land values have increased by as much as 150 to 300 percent in different regions between 1992 and 2005 . These increases are well beyond real increases in productivity and while they represent a substantial increase in asset wealth , they raise concerns about the ability of recent purchasers to cope with debt in the face of climate variability and any downturn in commodity prices .

Improving future reporting

ACRIS reporting faces several challenges . As already discussed , extrapolating point-based data to broader spatial scales is problematic . Furthermore , the current report (Bastin *et al* . , in press) focuses on reporting change with little recognition of the baseline from which change is occurring . The value of future reporting will be enhanced where the direction and magnitude of change takes account of initial condition state . For example , a no change' result in critical stock forage after rain on degraded land will require a different institutional response to no change on the same kind of country at maximum productive capacity . Although objectively assigning condition in the Australian rangelands can be complex (Friedel *et al* . , 2000) , suitable statements of baseline condition for the various information products (Table 1) are required to provide improved context for understanding the meaning of change .

The ACRIS partnership has avoided developing aspirational targets for which data do not exist . A key component is its collaborative nature which avoids imposing a grand plan' on its partner jurisdictions . Declining institutional support , including staff , is a reality in the Australian rangelands . Short term funding timeframes as a consequence of a government's term in office , agency restructuring and staff turnover make long term monitoring programs difficult to implement and even harder to sustain (Watson and Novelly , 2004) . Moreover the scientific basis for monitoring is contested from time to time and very few established monitoring systems have persisted past an initial iteration . The goal is not to start yet again , but to derive whatever benefit is possible from existing data . The pragmatic approach is to support gradual improvement in line with institutional capacity .

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