Australian Collaborative Rangeland Information System, Reporting Change in the Rangelands – 2007

Queensland Information for the National Report

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DISCLAIMER

Probably need advice from the ACRIS-MC (or DEWR, if they publish this on the ACRIS web site). In addition to the usual disclaimer content, I suggest we need to include something like "this report has undergone a reasonable degree of editing but the content was prepared primarily to assist the ACRIS Management Unit in its compiling content for the national report *Rangelands 2007 – Taking the Pulse* (published by the ACRIS Management Committee and printed by the National Land & Water Resources Audit). The reader should also refer to that report for published reporting of change in Queensland's rangelands.

CITATION

This report should be referenced as Carter *et al*. (2007)
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Datasticians (Graham Griffin and Sarah Dunlop) were contracted by the Desert Knowledge CRC to analyse and report on several of the NRW datasets. Their information is included in both this and the national report. We thank Datasticians for their contributions.

Members of the ACRIS Management Committee provided more general direction and guidance with jurisdictional contributions to the 2007 national report.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY

This document reports natural resource management (NRM) related information compiled for the Queensland rangelands that contributes to national reporting of change in Australia's rangelands for the period 1992 to 2005. This national synthesis has been compiled from relevant jurisdictional and national data by the Australian Collaborative Rangeland Information System (ACRIS). The national report will be published in early 2008.

Information in this (Queensland) report relates to:

- change in landscape function,
- change in two components of sustainable pastoral management, i.e. levels of pasture utilisation and change in woody cover, and
- rangeland land values as at June 2006.

Photo sequences showing change in mulga lands and Mitchell grass downs landscapes are also included.

Reporting is either at bioregion or sub-IBRA level (version 6.1 of the Interim Biogeographic Regionalisation of Australia, IBRA).

The ACRIS Biodiversity Working Group has compiled data and information for the 2007 report based on ten indicators. Queensland EPA, and particularly Teresa Eyre, has contributed biodiversity information for Queensland (but that information is not included in this report).

Available NRM data indicate that:

1. For landscape function:
    - Taking account of seasonal conditions, landscape function **increased** across the Mount Isa Inlier bioregion . This assessment is based on change in Aussie-GRASS simulated levels of pasture growth and utilisation supported by the SLATS-derived bare ground index (Multiple Regression Bare Ground Index, MRBGI version bi1).
    - Based on Rapid Mobile Data Collection (RMDC) data supplemented in some areas by Aussie-GRASS simulation of pasture growth and utilisation, landscape function **decreased** across the Mulga Lands, Gulf Fall & Uplands (one sub-IBRA), Desert Uplands, and the Brigalow Belt North bioregions. Half or more of sub-IBRAs in the Mitchell Grass Downs, Channel Country, Gulf Plains, Darling Riverine Plains and Brigalow Belt South bioregions had **decreased** landscape function.
2. For sustainable pastoral management based on Aussie-GRASS simulated levels of pasture utilisation:
    - Most of the Brigalow Belt North and South, Cape York Peninsula and Einasleigh Uplands bioregions had levels of pasture utilisation consistent with sustainable management. Three sub-IBRAs of the Mitchell Grass Downs (Barkly Tableland, Georgina Limestone and Northern Downs), the Simpson Desert and Dieri sub-

IBRAs of the Simpson Strzelecki Dunefields, and the Wellesley Islands (Gulf Plains bioregion) were also deemed to be sustainably managed.

- Simulated levels of pasture utilisation were considerably above specified safe thresholds (considered unsustainable) in the Desert Uplands, Mulga Lands and most of the Channel Country bioregions. Two sub-IBRAs of the Darling Riverine Plains (Culgoa-Bokhara and Warrambool-Moonie) and individual sub-IBRAs of four other bioregions (Gulf Plains, Mitchell Grass Downs, Mount Isa Inlier and Simpson Strzelecki Dunefields) were also considered to have unsustainable levels of pasture utilisation. Note that pest animals, and particularly feral goats and kangaroos, contributed substantially to total grazing pressure and high (unsustainable) levels of pasture utilisation in some bioregions, particularly the Mulga Lands.
- Simulated levels of pasture utilisation were close to the threshold safe level and sustainability was consequently rated as marginal for much of the Gulf Plains, parts of the Mitchell Grass Downs and individual sub-IBRAs elsewhere (Brigalow Belt South, Cape York Peninsula, Darling Riverine Plains, Einasleigh Uplands and Mount Isa Inlier).

  It should be noted that spatial averaging of utilisation levels across sub-IBRAs conceals likely local variability. It is probable that for most sub-IBRAs there were areas (paddocks and properties) with lower (more conservative) pasture utilisation than the reported average. There would also have been areas with higher (less sustainable) levels of pasture utilisation than the average.

3. Between 1991 and 2003, and at bioregion level, there were small to moderate decreases in the spatial extent of woody cover (foliar projected cover, FPC > ~7%) on the eastern margin of the rangelands. The area of woody decrease was relatively much larger (~20% of bioregion area) for individual sub-IBRAs of the Brigalow Belt North and Mulga Lands bioregions.

   Clearing was the principal reason for decline in woody cover.

   No bioregions (or component sub-IBRAs) showed an increase in the spatial extent of woody cover between 1991 and 2003.

In terms of land values, the most valuable regions (on average) of the rangelands are the north and north-east (Brigalow Belt North and Einasleigh Uplands). The least valuable areas are in the dry south-west (Channel Country and Simpson Strzelecki Dunefields). The Mount Isa Inlier is an exception and the high mean value and large range in land values here may be associated with mining interest in the region.

INTRODUCTION

The Australian Collaborative Rangeland Information System (ACRIS) is compiling a national report of change in the Australian rangelands for the period 1992 to 2005. This report will be published by the Australian Government in the early part of 2008. The national report has been compiled from available jurisdictional and national datasets and this report describes the datasets and information contributed by Queensland agencies. Reporting is by bioregion (IBRA v 6.1).

The national report is based on a number of biophysical and socio-economic themes and related products. Queensland contributions to these themes (through a contract with the Desert Knowledge Cooperative Research Centre (DK-CRC)) include:

Theme	Product	Datasets
Landscape function	Landscape function	Rapid Mobile Data Collection (RMDC) Aussie-GRASS simulated pasture utilisation Multiple Regression Bare Ground Index (MRBGI, version bi1)
Sustainable management	Critical stock forage	Aussie-GRASS simulated pasture utilisation
	Clearing	State-wide Landcover & Trees Study (SLATS)
Socio-economic	Land values	Queensland Valuations and Sales System (QVAS) and Digital Cadastral Data Base (DCDB)
Supporting information	Photos	Time-series photos of selected rangeland sites

The ACRIS Biodiversity Working Group has compiled data and information for the biodiversity theme of the 2007 report based on ten indicators. The Queensland Environmental Protection Agency (EPA), and particularly Teresa Eyre, contributed biodiversity information for Queensland. That information is not included in this report because it was not a required deliverable of the DK-CRC contract with Queensland agencies.

Reporting Area

Queensland is reporting for the rangelands by sub-IBRA (version 6.1) where there are sufficient and suitable data. Sub-IBRAs, grouped by bioregion, are shown in Fig. 1 and listed in Table 1.

Method of Reporting

Datasticians (Graham Griffin and Sarah Dunlop) were contracted by the DK-CRC to assist Queensland reporting to the ACRIS. Datasticians collated, analysed and reported on available data for the Landscape Function and Sustainable Management themes. The Climate

Impacts and Natural Resource Sciences (CINRS) group of the Queensland Department of Natural Resources and Water (NRW) provided relevant data to Datasticians.

A small steering committee comprising Richard Silcock (Queensland Department of Primary Industries and Fisheries, DPIF), John Carter (NRW) and Gary Bastin (CSIRO and ACRIS Management Unit) provided oversight of Datasticians' consultancy contract. Gary Bastin provided some expanded analysis of Datasticians' reporting on the MRBGI (v bi1) dataset and with input from John Carter and Robert Hassett, selectively compiled information from available datasets into the national synthesis of change in landscape function.

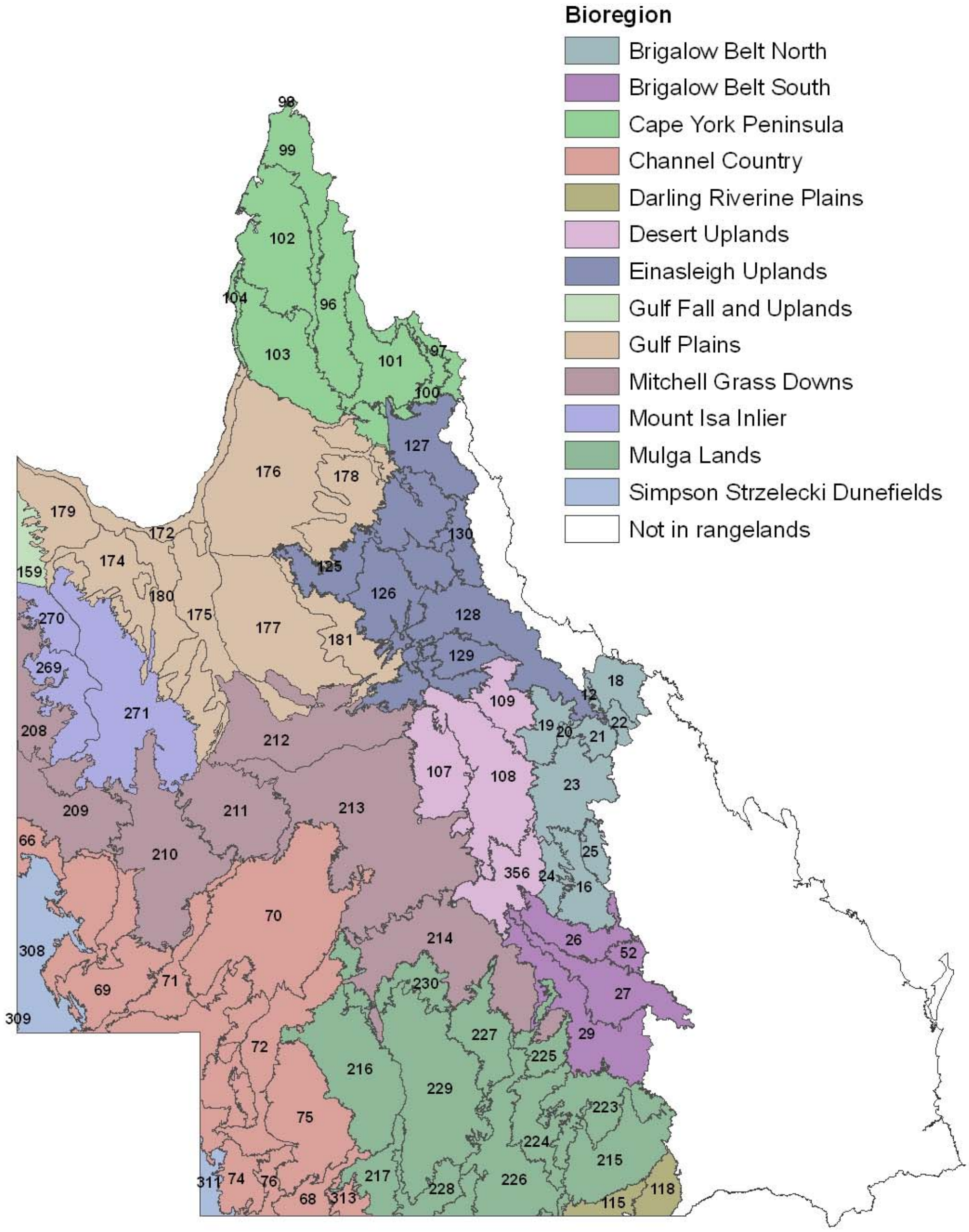


Figure 1. Sub-IBRAs of the Queensland rangelands.

Table 1. Queensland rangeland sub-IBRAs and their numeric codes.

IBRA	sub-IBRA	Sub #
Brigalow Belt North	Anakie Inlier	25
	Basalt Downs	13
	Belyando Downs	23
	Beucazon Hills	20
	Bogie River Hills	18
	Cape River Hills	19
	Isaac - Comet Downs	14
	Northern Bowen Basin	22
	South Drummond Basin	16
	Townsville Plains	12
	Upper Belyando Floodout	24
	Wyarra Hills	21
Brigalow Belt South	Arcadia	49
	Buckland Basalts	52
	Carnarvon Ranges	27
	Claude River Downs	26
	Moonie - Barwon Interfluve	38
	Moonie R. - Commoron Creek Floodout	36
	Narrandool	354
	Southern Downs	29
	Weribone High	32
Cape York Peninsula	(Northern) Holroyd Plain	103
	Battle Camp Sandstones	100
	Cape York - Torres Strait	98
	Coastal Plains	104
	Coen - Yambo Inlier	96
	Jardine - Pascoe Sandstones	99
	Laura Lowlands	101
	Starke Coastal Lowlands	97
	Weipa Plateau	102
Channel Country	Bulloo	68
	Bulloo Dunefields	313
	Cooper Plains	72
	Diamantina-Eyre	71
	Goneaway Tablelands	70
	Lake Pure	74
	Noccundra Slopes	75
	Sturt Stony Desert	69
	Tibooburra Downs	76
	Toko Plains	66
Darling Riverine Plains		
	Culgoa-Bokhara	115
	Warrambool-Moonie	118
Desert Uplands	Alice Tableland	108
	Cape-Campaspe Plains	109
	Jericho	356
	Prairie - Torrens Creeks Alluvials	107
Einasleigh Uplands	Broken River	128
	Georgetown - Croydon	125
	Herberton - Wairuna	130
	Hodgkinson Basin	127
	Kidston	126
	Undara - Toomba Basalts	129
Gulf Fall and Uplands	McArthur - South Nicholson Basins	159
Gulf Plains	Armraynald Plains	174
	Claraville Plains	177
	Donors Plateau	180
	Doomadgee Plains	179
	Gilberton Plateau	181
	Holroyd Plain - Red Plateau	178
	Karumba Plains	172
	Mitchell - Gilbert Fans	176
	Wellesley Islands	173
	Woondoola Plains	175
Mitchell Grass Downs	Barkly Tableland	208
	Central Downs	213
	Georgina Limestone	209
	Kynuna Plateau	211
	Northern Downs	212
	Southern Wooded Downs	214
	Southwestern Downs	210
Mount Isa Inlier	Mount Isa Inlier	271
	Southwestern Plateaus & Floodouts	269
	Thorntonia	270
Mulga Lands	Cuttaburra-Paroo	228
	Eastern Mulga Plains	223
	Langlo Plains	227
	Nebine Plains, Block Range	224
	North Eastern Plains	225
	Northern Uplands	230
	Urisino Sandplains	217
	Warrego Plains	226
	West Balonne Plains	215
	West Bulloo	216
	West Warrego	229
Simpson Strzelecki Dunefields	Dieri	309
	Simpson Desert	308
	Strzelecki Desert, Western Dunefields"	311

Report Contents

Summarised results from the analysed datasets are presented in the following sections (starting with Landscape Function, page 15). Further detail is provided in Appendix One and separate reports (available on CD).

Rangeland Assessment Programs

Queensland activities include:

- SLATS (Statewide Landcover and Trees Study) uses Landsat TM imagery to monitor woody vegetation clearing, regrowth and cover annually over most of the State. It is run by NRW and underpins the Vegetation Management Act which regulates tree clearing on all land.
- REs (Regional Ecosystems) are remnant vegetation communities consistently associated with a particular combination of geology, landform and soil. The aim is to produce RE mapping at the scale of 1:100,000 for the State of Queensland. At this stage, RE mapping is still underway for much of QLD rangelands and currently there are about 1,350 individual REs listed for the State. The mapping program is managed by the EPA.
- TRAPS (Transect Recording and Processing System) monitors woody vegetation dynamics at 84 fixed sites of 1 hectare area in 33 sub-IBRAs from eight bioregions in timbered QLD rangelands, except in Cape York (Fig. 2). TRAPS is managed by DPIF.
- QGraze is another protocol set up to monitor pasture condition state-wide. There are some 445 fixed sites currently and the data, plus photographs, are archived in a database within DPIF. The data deal with tree cover, pasture composition, ground cover and soil surface condition. The protocol is used by NRW for some of its work but the data are not in the DPIF database.
- Shrub monitoring transects stretch over 60 km through the mulga lands of south west QLD and provide a 40-year record of woody plant dynamics under normal property management. They have rarely been recorded in the past two decades but provide visual and hard data from 1965 to the present at fixed, relocatable locations. DPIF are the current custodians of these data.
- BAMM (Biodiversity Assessment and Mapping Methodology) identifies three levels of Biodiversity Significance – State, Regional and Local – based on a number of data queries that simultaneously integrate an array of current, available biodiversity information on rarity, diversity, fragmentation, resilience, threats, and ecosystem processes for a bioregion. This activity is managed by the EPA.
- RMDC (Rapid Mobile Data Collection) by NRW continues to obtain estimates of pasture biomass, composition, cover and other information with 30,000 to 100,000 geo-coded observations being collected annually. These data are used to calibrate and verify interpretation of satellite remote sensing imagery.

Data from these sources currently feed into Queensland's State of Environment reports. The first was in 2003 and the most recent assessments will be released in late 2007. The data also link into major national environmental initiatives such as the ACRIS, ReefPlan, Murray Darling Basin Commission and the Lake Eyre Basin Authority.

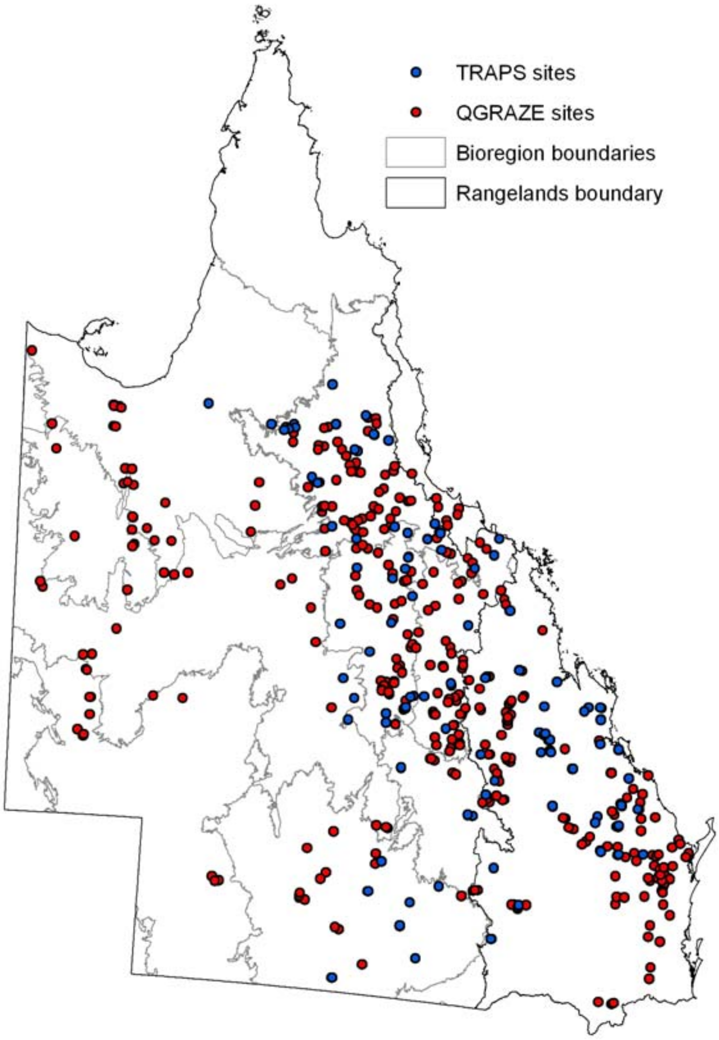


Figure 2. Location of TRAPS and QGraze monitoring sites in Queensland.

TRAPS sites by definition are located in areas of higher woody cover, with many sites outside (east of) the rangelands. Thus the TRAPS program has limited capacity to report vegetation change for the whole rangelands. QGraze continues to operate in some areas but similarly, is not able to report for all of Queensland's rangelands. Most of the data used to report change for the 2007 ACRIS report derive from SLATS and Aussie-GRASS simulation, plus their ground validation support program (RMDC). It should be noted that the data from some of these programs are not directly amenable to ACRIS-type reporting. Data analysis and results described in this report are somewhat exploratory and future reporting procedures are likely to differ, as described in the following section.

New initiatives in rangeland monitoring

Proposed new legislation may incorporate more regular and structured monitoring of leasehold lands where lease renewal is occurring. Regular pastoral lease inspections have not been a feature of land administration in Queensland over the past 30 years. Meanwhile NRW is enhancing a system to monitor bare ground levels using Landsat satellite images, and will have 20 years of annual assessments with improved calibration for the next reporting period.

Annual assessment, an improved version of the bare-ground cover index and better masking of woody vegetation should allow better identification of trends in land condition (particularly landscape function) than the two-yearly data prototyped in this report. DPIF is also assessing the value of satellite data for pasture condition assessment.

Queensland's monitoring strength is in satellite remote sensing and primary production modelling based on the GRASP model, backed by significant computer processing power. NRW has recently completed a MLA (Meat and Livestock Australia) research project to assess the use of MODIS satellite data for ground cover and pasture biomass monitoring. Ongoing research will focus on improved correction of problems caused by seasonally varying sun angles, use of 500-m scale MODIS products rather than the 1-km product, and automation of output. NRW is heavily involved in the MODIS project which is studying the suitability of that satellite's data for regular monitoring.

Aussie-GRASS is following a process of continuous improvement with better inputs for stock distribution, better algorithms for ground cover and plant nitrogen dilution with age, and more extensive calibration with increasing amounts of data from the RMDC program.

The Tropical Savannas CRC fostered close Queensland links to the NT and WA and delivered significant synergies to work on improved cattle production systems, fire management and biodiversity documentation. There will be a significant gap in savanna science without further investment because the Desert Knowledge CRC only deals with the driest fringes of the TS-CRC region.

Since the *Rangelands – Tracking Changes* report (NLWRA 2001), vegetation and bioregion mapping has continued to be updated, TRAPS woody vegetation assessment has continued but on-ground pasture monitoring (QGraze) has almost ceased. A project called VegMachine uses remote sensing data provided by NRW to assist landholders to monitor the condition of their property with MLA financial support and links to the NT rangeland monitoring program.

A rapid procedure for the assessment of vegetation condition for biodiversity values is currently being developed and tested by the EPA in partnership with DPIF with MLA financial support. This project works in collaboration with a similar project being run by CSIRO, with Natural Heritage Trust (NHT2) financial support. The aim of the assessment procedure is to be grazier-friendly, relevant to rangeland ecosystems, and compatible with the 'ABCD' grazing land condition assessment approach.

The rangelands of Queensland fall wholly or partly under the ambit of nine regional NRM bodies set up under the National Action Plan and Natural Heritage Trust. NRW, EPA and DPIF have a significant role in assisting them to deliver their monitoring outcomes and they are largely dependent on these three agencies for their base data and underlying resource inventory, plus maps.

LANDSCAPE FUNCTION

Landscape function describes the capacity of landscapes to regulate (i.e. capture and retain, not leak) rainwater and nutrients, which are the vital resources for plant growth (Ludwig *et al*. 1997). Functional landscapes have a good cover and arrangement of persistent vegetation patches (typically perennial vegetation) for their type. This means that much of the rain that falls soaks into the soil and is available for plant growth. There is generally minimal runoff and so there is limited loss of plant nutrients in transported sediment. Reduced overland flow also limits loss of organic matter (litter) and seeds. Similarly, a good cover and arrangement of vegetation patches minimises wind erosion and loss of nutrients in dust.

Change in the functionality of landscapes provides a sound basis from which to judge the effects of management on the rangelands. Functional landscapes are likely to recover quickly from disturbance (e.g. grazing, fire or drought), and to maintain adequate vegetation cover through variable seasonal conditions. Dysfunctional landscapes may not recover, take longer to recover, or change to a less desirable vegetation state.

Data Sources

Queensland does not have an active monitoring system which measures change in landscape function. In the absence of directly suitable data, it was considered that potentially useful datasets could be:

- Rapid Mobile Data Collection (RMDC) where vegetation and land condition attributes related to landscape function are collected along road traverses (Hassett *et al*. 2006). Repeat sampling allows reporting of change; in this case, at sub-IBRA resolution.
- Interpretation of Aussie-GRASS (AG) simulated pasture growth and utilisation (Carter *et al*. 2003) where RMDC date were unavailable or unsuitable. Stable or increased landscape function is presumed where modelled utilisation of pasture growth is relatively conservative and constant through time and cover levels are not likely to lead to erosion.
- The Multiple Regression Bare Ground Index (MRBGI, version bi1) derived from SLATS imagery (Scarth *et al*. 2006). Changes in ground cover are interpreted with respect to prior seasonal rainfall and used to support inferred landscape function based on RMDC and Aussie-GRASS data.

Comparison of Dataset Results

Ground cover (the converse of bare ground) is an important component of landscape function and therefore the MRBGI dataset would seem to have considerable value for reporting change in landscape function where tree or shrub cover is not dense. The data made available to Datasticians for their analysis and reporting were summaries of the mean and standard deviation of bare ground (by sub-IBRA) for each SLATS image date between 1989 and 2004. The spatial arrangement of ground cover, in addition to the mean level of cover, is critically important in regulating the movement of rain water and sediments containing plant nutrients.

Thus mean cover by itself is not adequate in indicating landscape function and the MRBGI dataset was deemed inadequate for satisfactorily reporting change in landscape function in the Queensland rangelands. (Note that there are alternative ways of spatially and temporally analysing the MRBGI data and there is considerable future potential for including these data in the monitoring and reporting of landscape function. These alternative methods need further development and were not available to the ACRIS for its current reporting.)

Datasticians' analyses and reporting of seasonally interpreted change in the spatially averaged MRBGI for consecutive image dates (2001, 2002, 2003 & 2004) for each sub-IBRA is included on the CD of compiled information as a separate report. Gary Bastin's expanded (and slightly modified) version of Datasticians' analysis is included as Appendix 1 to this report. (Bastin expanded Datasticians' analysis using their procedures to include all available image dates between 1991 and 2004).

Following exploration of the bare-ground data, the RMDC data were considered more suitable for reporting change in landscape function because of the nature of data acquired, and the spatial density and temporal frequency of road traverses (Fig. 3). NRW staff (Robert Hassett and John Carter) combined suitable RMDC data into an index of landscape function and then reported change for each sub-IBRA (Table 2). Changes in landscape function based on levels of pasture utilisation simulated by Aussie-GRASS and seasonally interpreted change in the bare ground index (Appendix 1) are also shown for comparison. Red coloured cells indicate a large decline in landscape function based on the data type used for reporting; orange, a lesser decline; yellow, no real change and blue, some degree of improvement.

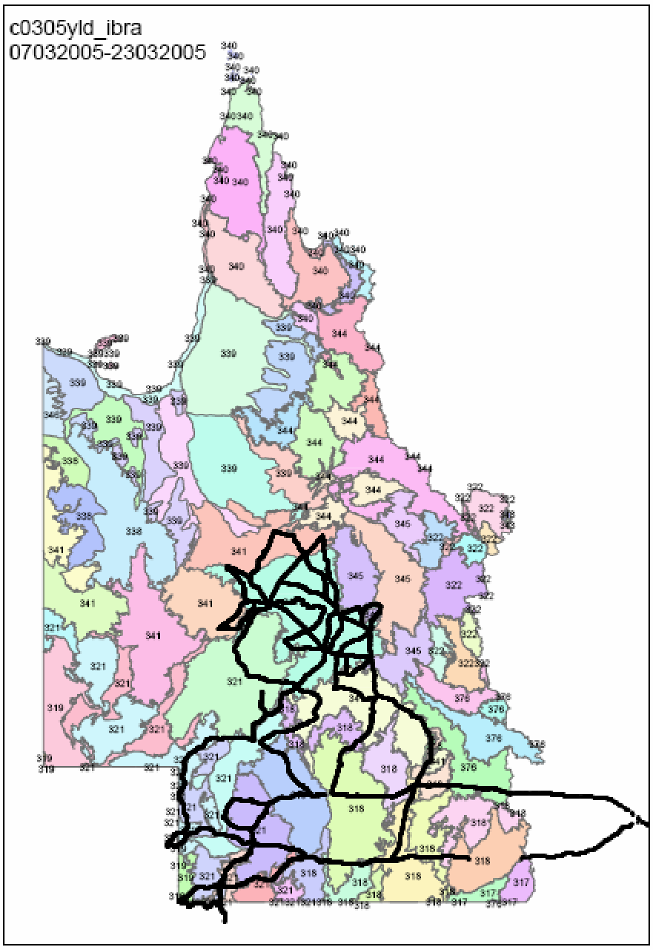


Figure 3. Example RMDC map.

The black lines show road traverses through numbered and coloured sub-IBRAs. Much of the Mulga Lands, eastern Mitchell Grass Downs and parts of the Brigalow Belt South bioregions were sampled in March 2005.

Table 2. Change in landscape function based on Rob Hassett's reporting of the Rapid Mobile Data Collection (RMDC) dataset. The level of agreement shown by Aussie-GRASS (AG) and Bare Ground index results is also shown.

IBRA		Change in Landscape Function		
Sub-IBRA	**#**	**Rob Hassett RMDC**	**John Carter AG**	**Seasonally adjusted Net Change in MRBGI (v bi1)**
		1994 2005	**1991 - 2005**	**1991 - 2003**
Brigalow Belt North (BBN)				
Anakie Inlier	25	Small decline	Stable (patchy) broadly agrees with RMDC	No change in LFn better than RMDC & AG
Belyando Downs	23	Small decline	Stable better than RMDC	No change in LFn Agrees with AG & better than RMDC
Beucazon Hills	20	Large decline	Stable better than RMDC	No change in LFn Agrees with AG & better than RMDC
Bogie River Hills	18	Small decline	Stable better than RMDC	Improvement better than AG much better than RMDC
Cape River Hills	19	Small decline	Stable better than RMDC	No change Agrees with AG & better than RMDC
Northern Bowen Basin	22	Small decline	Stable (patchy) broadly agrees with RMDC	Improvement much better than AG & RMDC
South Drummond Basin	16	Small decline	Stable (patchy) broadly agrees with RMDC	Small improvement much better than AG & RMDC
Townsville Plains	12	Large decline	Stable (patchy) better than RMDC	Improvement better than AG much better than RMDC
Upper Belyando Floodout	24	Small decline	Stable (patchy) broadly agrees with RMDC	No change in LFn better than RMDC & AG
Wyarra Hills	21	Large decline	Decline agrees with RMDC	Small improvement much better than RMDC & AG
Brigalow Belt South (BBS)				
Buckland Basalts	52	N/A	Stable	No change in LFn Broadly agrees with AG
Carnarvon Ranges	27	Stable	Stable agrees with RMDC	No change in LFn Broadly agrees with RMDC & AG
Claude River Downs	26	Small decline	Decline harsher than RMDC	No change in LFn better than RMDC much better than AG
Southern Downs	29	Small decline	Stable (patchy) broadly agrees with RMDC	No change in LFn better than RMDC & AG
Cape York Peninsular (CYP)				
(Northern) Holroyd Plain	103	N/A	Stable	Decline in LFn harsher than AG, probably due to fire
Battle Camp Sandstones	100	N/A	Stable	Decline in LFn harsher than AG, probably due to fire
Coastal Plains	104	N/A	Stable	Decline in LFn harsher than AG, probably due to fire
Coen – Yambo Inlier	96	N/A	Stable	No change in LFn Broadly agrees with AG
Laura Lowlands	101	N/A	Stable	Decline in LFn harsher than AG, probably due to fire
Starke Coastal Lowlands	97	N/A	Stable	Small decline in LFn slightly worse than AG, possibly due to fire
Weipa Plateau	102	N/A	Stable	Decline in LFn harsher than AG, probably due to fire

IBRA		Change in Landscape Function		
Sub-IBRA	**#**	**Rob Hassett RMDC**	**John Carter AG**	**Seasonally adjusted Net Change in MRBGI (v bi1)**
		1994 2005	**1991 - 2005**	**1991 - 2003**
Channel Country (CHC)				
Bulloo	68	Large decline	Decline agrees with RMDC	Small decline in LFn slightly better than RMDC & AG
Bulloo Dunefields	313	Large decline	Decline agrees with RMDC	Decline in LFn broadly agrees with RMDC & AG
Cooper Plains	72	Small decline	Decline worse than RMDC	Decline in LFn broadly agrees with AG
Diamantina-Eyre	71	Stable	Decline much worse than RMDC	Decline in LFn broadly agrees with AG
Goneaway Tablelands	70	Large decline	Decline agrees with RMDC	No Change in LFn much better than RMDC & AG
Lake Pure	74	Large decline	Decline agrees with RMDC	Small decline in LFn slightly better than RMDC & AG
Noccundra Slopes	75	Large decline	Decline agrees with RMDC	No Change in LFn much better than RMDC & AG
Sturts Stony Desert	69	Small decline	Decline (patchy) worse than RMDC	Small decline in LFn similar to RMDC & better than AG
Tibooburra Downs	76	Large decline	Decline agrees with RMDC	No Change in LFn much better than RMDC & AG
Toko Plains	66	Large decline	Improving much better than RMDC	Decline in LFn similar to RMDC &much worse than AG
Darling Riverine Plains (DRP)				
Culgoa-Bokhara	115	Large decline	Decline (patchy) broadly similar to RMDC	No Change in LFn much better than RMDC & AG
Warrambool-Moonie	118	Large decline	Stable (patchy) better than RMDC	No Change in LFn much better than RMDC slightly better than AG
Desert Uplands (DEU)				
Alice Tableland	108	Large decline	Decline (patchy) broadly similar to RMDC	No Change in LFn much better than RMDC & AG
Cape-Campaspe Plains	109	Small decline	Decline worse than RMDC	No Change in LFn better than RMDC & much better than AG
Jericho	356	Small decline	Decline worse than RMDC	No Change in LFn better than RMDC & much better than AG
Prairie – Torrens Creeks Alluvials	107	Small decline	Decline worse than RMDC	No Change in LFn better than RMDC & much better than AG
Einasleigh Uplands (EIU)				
Broken River	128	Small decline	Stable (patchy) broadly similar to RMDC	No change in LFn better than RMDC & AG
Georgetown – Croydon	125	N/A	Stable	Small decline in LFn slightly worse than AG (fire effect?)
Herberton – Wairuna	130	Stable	Stable agrees with RMDC	No Change in LFn broadly agrees with RMDC & AG
Hodgkinson Basin	127	N/A	Stable	No Change in LFn broadly agrees with AG
Kidston	126	N/A	Stable / Improve	Small improvement better than AG
Undara – Toomba Basalts	129	Stable	Stable agrees with RMDC	No Change in LFn broadly agrees with RMDC & AG

IBRA		Change in Landscape Function		
Sub-IBRA	#	Rob Hassett RMDC	John Carter AG	Seasonally adjusted Net Change in MRBGI (v bi1)
		1994 2005	1991 - 2005	1991 - 2003
Gulf Fall and Uplands (GFU)				
McArthur - South Nicholson Basins	159	Large decline	Stable / Improve much better than RMDC	Decline in LFn (fire effect?) agrees with RMDC
Gulf Plains (GUP)				
Armraynald Plains	174	Large decline	Stable much better than RMDC	No Change in LFn broadly agrees with AG much better than RMDC
Claraville Plains	177	N/A	Stable	No Change in LFn broadly agrees with AG
Donors Plateau	180	Small decline	Stable better than RMDC	No Change in LFn a little better than RMDC broadly agrees with AG
Doomadgee Plains	179	Large decline	Stable / Improve much better than RMDC	Decline in LFn (fire effect?) agrees with RMDC worse than AG
Gilberton Plateau	181	N/A	Stable	No Change in LFn broadly agrees with AG
Holroyd Plain – Red Plateau	178	N/A	Stable	No Change in LFn broadly agrees with AG
Karumba Plains	172	N/A	Stable	No Change in LFn broadly agrees with AG
Mitchell Gilbert Fans	176	Small decline	Stable better than RMDC	Small decline in LFn agrees with RMDC better than AG
Wellesley Islands	173	N/A	Stable	No Change in LFn broadly agrees with AG
Woondoola Plains	175	Stable	Stable agrees with RMDC	No Change in LFn broadly agrees with RMDC & AG
Mitchell Grass Downs (MGD)				
Barkly Tableland	208	N/A	Stable / Improve	Small decline in LFn slightly worse than AG
Central Downs	213	Small decline	D/D (Decline) worse than RMDC	No Change in LFn better than RMDC much better than AG
Georgina Limestone	209	Large decline	Stable / Improve much better than RMDC	Small Decline in LFn little better than RMDC worse than AG
Kynuna Plateau	211	Small decline	Stable little better than RMDC	Decline in LFn worse than RMDC much worse than AG
Northern Downs	212	Small decline	Stable little better than RMDC	No Change in LFn little better than RMDC similar to AG
Southern Wooded Downs	214	Small decline	Decline worse than RMDC	No Change in LFn better than RMDC much better than AG
Southwestern Downs	210	Small decline	Stable little better than RMDC	Decline in LFn worde than RMDC much worse than AG
Mount Isa Inlier (MII)				
Mount Isa Inlier	271	N/A	Improving	No Change in LFn worse than AG
Southwestern Plateaus & Floodouts	269	N/A	Improving	Small decline in LFn much worse than AG

IBRA		Change in Landscape Function		
Sub-IBRA	**#**	**Rob Hassett RMDC**	**John Carter AG**	**Seasonally adjusted Net Change in MRBGI (v bi1)**
		1994 2005	**1991 - 2005**	**1991 - 2003**
Thorntonia	270	N/A	Improving	Small decline in LFn much worse than AG
Mulga Lands (ML)				
Cuttaburra-Paroo	228	Large decline	Decline broadly similar to RMDC	Decline in LFn broadly similar to RMDC & AG
Eastern Mulga Plains	223	Small decline	Decline worse than RMDC	No Change in LFn too conservative – much better than RMDC & AG
Langlo Plains	227	Large decline	Decline broadly similar to RMDC	No Change in LFn too conservative – much better than RMDC & AG
Nebine Plains, Block Range	224	Small decline	Decline worse than RMDC	Small decline in LFn agrees with RMDC better than AG
North Eastern Plains	225	Large decline	Declin (patchy) broadly similar to RMDC	No Change in LFn too conservative – better than RMDC & AG
Northern Uplands	230	Small decline	Decline worse than RMDC	No Change in LFn too conservative – much better than AG
Urisino Sandplains	217	Large decline	D+ (severe) broadly similar to RMDC	Decline in LFn broadly similar to RMDC & AG
Warrego Plains	226	Large decline	Decline broadly similar to RMDC	No Change in LFn too conservative – much better than RMDC & AG
West Balonne Plains	215	Small decline	Decline worse than RMDC	No Change in LFn too conservative – much better than AG
West Bulloo	216	Large decline	Decline broadly similar to RMDC	No Change in LFn too conservative – better than RMDC & AG
West Warrego	229	Large decline	D+ (severe) broadly similar to RMDC	Decline in LFn broadly similar to RMDC & AG
Simpson Strzelecki Dunefields (SSD)				
Dieri	309	Stable	Improving better than RMDC	No Change in LFn broadly agrees with RMDC worse than AG
Simpson Desert	308	Stable	Improving better than RMDC	Decline in LFn much worse than RMDC & AG
Strzelecki Desert, Western Dunefields	311	Small decline	Decline worse than RMDC	Decline in LFn worse than RMDC similar to AG

Codes relevant to Aussie-GRASS

S	Stable	Modifiers:	
D	Degrading	**P**	Patchy & probably in parts only
NA	Data not available	+	Severe
I	Improving		

In about half the cases, the assessment of change based on the RMDC and Aussie-GRASS data coincide. There are considerable differences where change in landscape function has been inferred from the MRBGI (v bi1) data and as noted above this table, considerable further development is required before this product can reliably report change in landscape function.

The RMDC data are used to report change in landscape function for most IBRAs in the following section. Aussie-GRASS results are used to supplement this assessment for some sub-IBRAs.

Change in Landscape Function

Taking account of seasonal conditions, landscape function **increased** across the Mount Isa Inlier bioregion (Fig. 4). This assessment is based on change in Aussie-GRASS simulated levels of pasture growth and utilisation supported by the bare ground index (MRBGI, v bi1).

Based on RMDC data supplemented in some areas by Aussie-GRASS simulation of pasture growth and utilisation, landscape function **decreased** across the Mulga Lands, Gulf Fall & Uplands (one sub-IBRA), Desert Uplands, and the Brigalow Belt North bioregions (Fig. 4). Fifty percent or more of sub-IBRAs in the Mitchell Grass Downs, Channel Country, Gulf Plains, Darling Riverine Plains and Brigalow Belt South bioregions had **decreased** landscape function. Refer to Fig. 5 for an assessment of reliability in reporting these results.

Sub-IBRAs assessed as having a large decrease in landscape function (from Table 2) were:

Bioregion	sub-IBRA
Brigalow Belt North	Beucazon Hills, Townsville Plains, Wyarra Hills
Channel Country	Bulloo, Bulloo Dunefields, Goneaway Tablelands, Lake Pure, Noccundra Slopes, Tibooburra Downs, Toko Plains
Desert Uplands	Alice Tableland
Darling Riverine Plains	Culgoa-Bokhara, Warrambool-Moonie
Gulf Fall & Uplands	McArthur – South Nicholson
Gulf Plains	Armraynald Plains, Doomadgee Plains
Mitchell Grass Downs	Georgina Limestone
Mulga Lands	Cuttaburra-Paroo, Langlo Plains, North Eastern Plains, Urisino Sandplains, Warrego Plains, West Bulloo, West Warrego

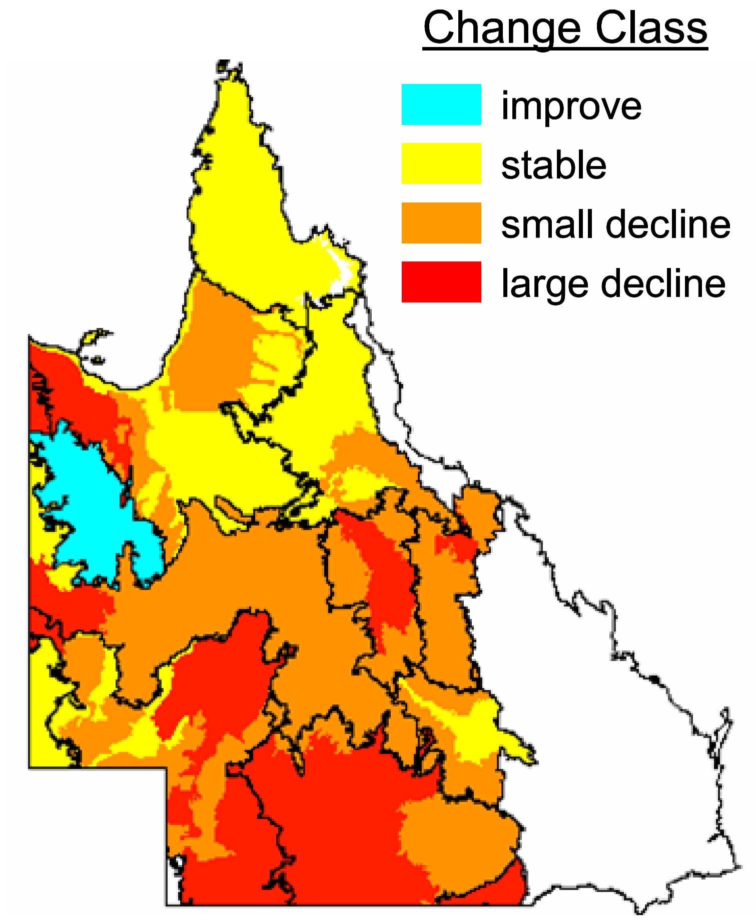


Figure 4. Mapped change in landscape function based on RMDC data supplemented with Aussie-GRASS simulation of pasture growth and utilisation. Change classes are mapped at sub-IBRA resolution. Line work shows bioregion boundaries.

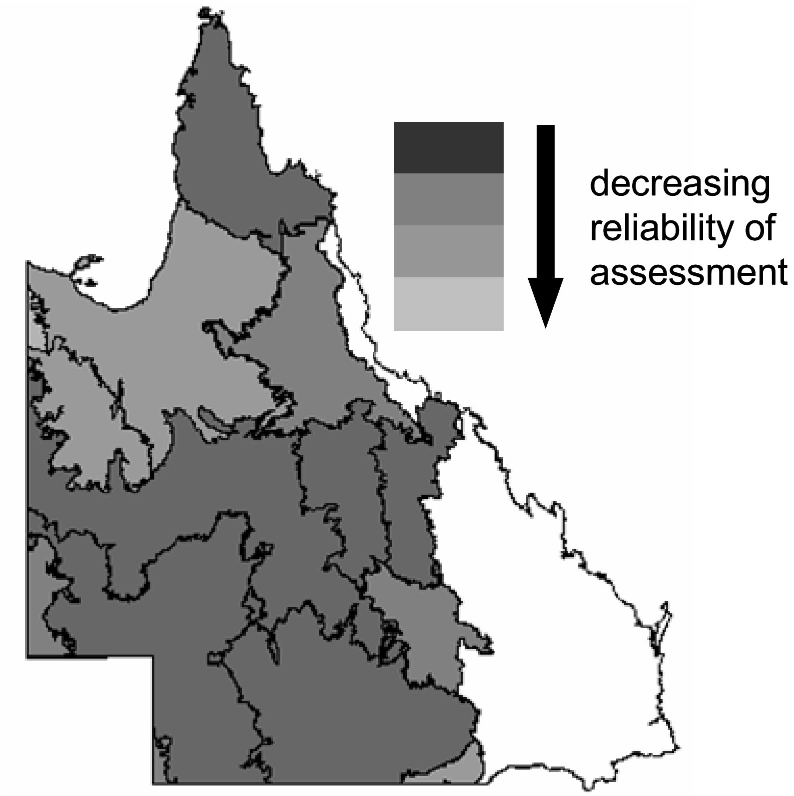


Figure 5. Reliability in reporting change in landscape function by bioregion based on density and frequency of RMDC road traverses, and relevance of available data to reporting change in landscape function

SUSTAINABLE MANAGEMENT

Grazing of native pastures is the most extensive commercial land use in the Queensland rangelands. The landscape function results above indicate that the ability of some rangeland environments to regulate resources (rain water, plant nutrients, litter, seeds etc) has been altered. It is important that current grazing management practices are sustainable (and remain so) because:

1. We shouldn't degrade natural systems (as a matter of principle).
2. Repairing degraded ecosystems is expensive and where degradation has occurred, restoration is often not economically viable or sensible on a large scale.
3. That will assist future marketing of meat and wool by maintaining the image of Australia's rangeland products as "clean" and "green".
4. It will prevent further loss of biodiversity, particularly those components vulnerable to standard agricultural practices.

ACRIS is reporting a number of components under 'sustainable management'. These include critical stock forage, plant species richness (where suitable data are available), woody cover change and distance from stock water. Allied reporting covers components of grazing pressure (domestic stock, kangaroos and feral herbivores), fire and dust.

Queensland is contributing data to the national reporting of change in stock forage and woody cover.

Critical stock forage

Critical stock forage refers to those plant (pasture) species within broad regions (e.g. group of bioregions), that underpin or support longer-term livestock production. Queensland does not have an active site-based monitoring system that contributes direct information about changes in the palatable, perennial and productive (3P) grasses critical to its rangeland beef and wool production. However, levels of pasture utilisation simulated by Aussie-GRASS can be used to indicate total stock forage and because individual animal performance declines at high utilisation rates, pressure is thus increased on the more palatable species. This is particularly important in much of northern Australia where cattle are now routinely fed nitrogen-based supplements to increase the digestion and nutritional value of low-quality pastures. Levels of pasture utilisation, and change in these levels, beyond a critical safe threshold has implications for longer-term sustainability of native pastures and the livestock industries they support.

Data source

Sustainability of stock forage is based on Aussie-GRASS simulation of pasture utilisation at sub-IBRA resolution (see Rickert *et al*. 2000 and Carter *et al*. 2003 for further information about Aussie-GRASS). Lower levels of spatially-averaged utilisation are considered more sustainable. Change in simulated space- and time-averaged utilisation is reported for two time periods (1976-90 compared with 1991-2005, data in Table 22, Appendix 2). These two periods encompass similar climate variability so the effects of seasonal conditions on change are accounted for to some degree. Where utilisation averaged over the two time periods has remained relatively constant and conservative (as suggested by analyses presented in Hall *et al*. 1998), or has decreased, grazing management is considered to have been more sustainable (compared with elsewhere). It is not possible to directly model change in individual species composition from utilisation rates.

Change in stock forage

Sustainability of pasture utilisation, 1991-2005

The degree to which recent management of stock forage has been sustainable is indicated in Fig. 6a. This assessment is based upon space- and time-averaging of simulated pasture utilisation by sub-IBRA for the period 1991 to 2005. This is calculated within Aussie-GRASS from daily rainfall and other climate data, fire events and the number of grazing animals from ABS data and other sources. Where utilisation is less than a specified safe threshold for each region, grazing management is considered sustainable.

Most of the Brigalow Belt North and South, Cape York Peninsula and Einasleigh Uplands bioregions had utilisation levels during the 1991-2005 period that were less than the specified threshold and levels of stock forage were therefore deemed to be sustainably managed. Three sub-IBRAs of the Mitchell Grass Downs (Barkly Tableland, Georgina Limestone and Northern Downs), the Simpson Desert and Dieri sub-IBRAs of the Simpson Strzelecki Dunefields, and the Wellesley Islands (Gulf Plains bioregion) also experienced sustainable levels of pasture utilisation.

Spatially averaged levels of simulated pasture utilisation were considerably above specified safe thresholds and were considered unsustainable throughout much of the 1991-2005 period in the Desert Uplands, Mulga Lands and most of the Channel Country bioregions. Two sub-IBRAs of the Darling Riverine Plains (Culgoa-Bokhara and Warrambool-Moonie) and individual sub-IBRAs of other bioregions were also considered to have unsustainable levels of pasture utilisation. These were:

- Donors Plateau (Gulf Plains bioregion),
- Kynuna Plateau (Mitchell Grass Downs bioregion),
- South-western Plateaus & Floodouts and Mount Isa Inlier (Mount Isa Inlier bioregion), and
- Strzelecki Desert – Western Dunefields (Simpson Strzelecki Dunefields bioregion).

Note that pest animals, and particularly feral goats and kangaroos, contributed substantially to total grazing pressure and high (unsustainable) levels of pasture utilisation in some bioregions, particularly the Mulga Lands.

Simulated levels of pasture utilisation were close to the threshold safe level and sustainability was consequently rated as marginal for much of the Gulf Plains, parts of the Mitchell Grass Downs and individual sub-IBRAs elsewhere (Brigalow Belt South, Cape York Peninsula, Darling Riverine Plains, Einasleigh Uplands and Mount Isa Inlier).

Note that spatial averaging of utilisation levels across sub-IBRAs conceals likely local variability. It is probable that for most sub-IBRAs there were areas (paddocks and properties) with lower (more conservative) pasture utilisation than the reported average. There would also have been areas with higher (less sustainable) levels of pasture utilisation than the average.

In interpreting Fig. 6 and the above results, the reader should refer to Fig. 7 for an indication of reliability in reporting.

Change in pasture utilisation

The space and time-averaged levels of simulated pasture utilisation between the 1976-90 period and 1991-2005 are illustrated graphically in Fig. 8 and mapped in Fig. 6b. These changes are broadly summarised as:

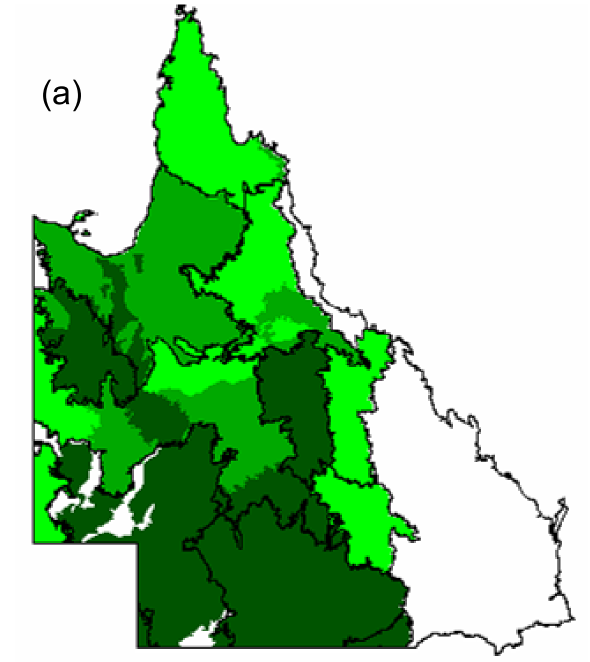
- Decreased levels of pasture utilisation in the 1991-2005 period compared with 1976-90 (indicating improving trend) across much of the Cape York Peninsula, Gulf Plains and Mitchell Grass Downs bioregions; also sub-IBRAs of the Mount Isa Inlier (2), Mulga Lands (3) and Darling Riverine Plains (2); and individual sub-IBRAs of the Brigalow Belt South, Einasleigh Uplands and Simpson Strzelecki Dunefields bioregions. Note however that many (15 of the 23) sub-IBRAs had utilisation levels close to, or above, the threshold safe level in the 1991-2005 period.

  Decreased levels of pasture utilisation in northern Queensland may have been due to better cattle management following the Brucellosis and Tuberculosis Eradication Campaign. Also the depressed cattle market in the second half of the 1970s caused animals to be held rather than sold for many years, resulting in an abnormally high level of utilisation in the initial comparative period. Despite overall decreases in utilisation over the entire period, there are often more recent trends towards increasing utilisation and current utilisation rates may not be sustainable with regards to sustaining a fire frequency adequate to control woody species. The Mitchell Grass Downs bioregion appears to be close to maximum safe levels of pasture utilisation with the Kynuna Plateau and Southern Wooded Downs having the highest rates of utilisation for that bioregion (see Table 22 for complete data).

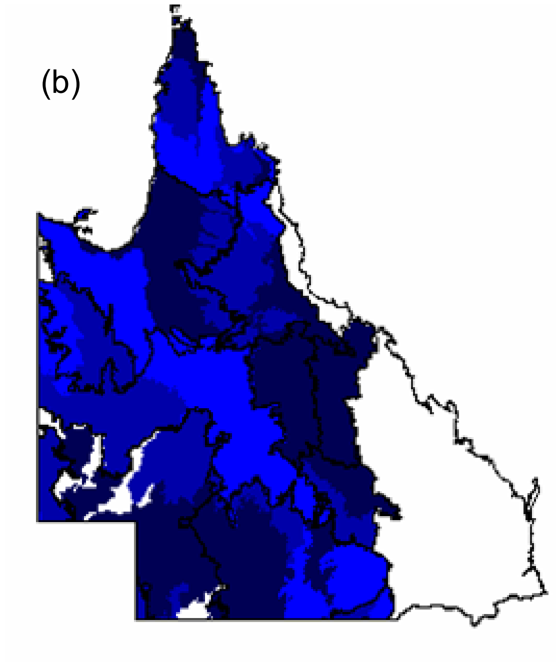
- Neutral trend, i.e. no real change in levels of utilisation between the two periods: three sub-IBRAs of the Mitchell Grass Downs and Einasleigh Uplands bioregions, two-sub-IBRAs in each of several other bioregions and individual sub-IBRAs of another three bioregions. Eleven (of these 17) sub-IBRAs had utilisation levels close to or above the threshold safe level in the 1991-2005 period.

- Increased utilisation in the 1991-2005 period compared with 1976-90 (i.e. declining trend): the Desert Uplands bioregion; much of the Brigalow Belts North & South, Channel Country and the Mulga Lands; and parts of the Gulf Plains, Einasleigh Uplands and Cape York Peninsula bioregions. Eighteen (of the 21) sub-IBRAs had utilisation levels close to or above the threshold safe level in the 1991-2005 period.

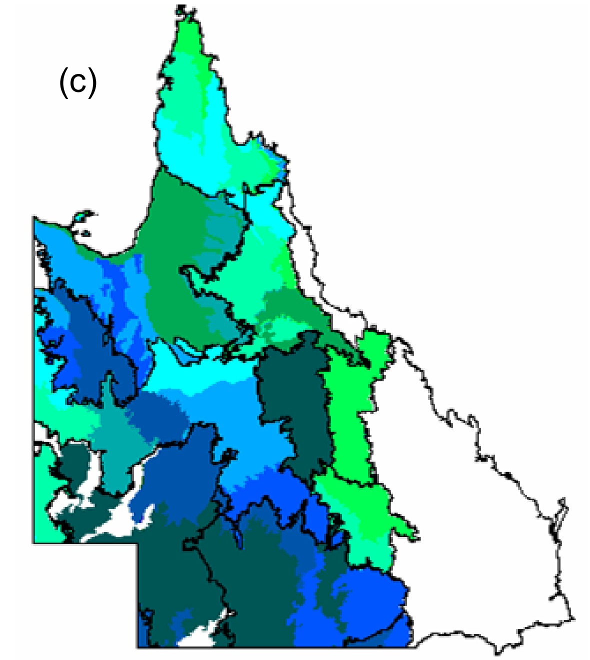
  Increased levels of pasture utilisation in the Brigalow Belt North & South bioregions, and parts of the Desert Uplands bioregion were likely associated with tree clearing and the establishment of exotic pasture species. Utilisation also increased in many regions due to relatively low rainfall, particularly between 2002 and 2005.



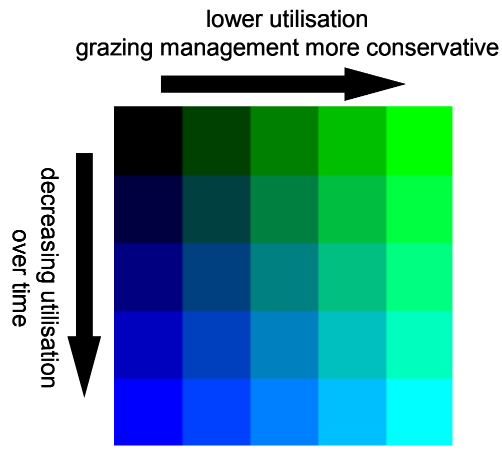
Sustainability of pasture utilisation based on Aussie-GRASS simulation for the 1991-2005 period. Increasing intensity of green means decreased utilisation relative to the safe threshold. Thus grazing is more conservative (i.e. sustainable) where lighter green.



Trend: i.e. change in mean level of pasture utilisation based on Aussie-GRASS simulation between the 1976-90 and 1991-2005 periods. Increased intensity (i.e. lighter shades) of blue means reduced average utilisation in the latter period.



Pasture sustainability and trend combined. Darker colours indicate high utilisation (relative to the safe threshold) and increased utilisation. Light blue (aqua) indicates conservative grazing and decreased utilisation.



Colour scheme for interpreting sustainability of pasture utilisation and trend in sustainability for the reporting period (1976 to 2005).

Figure 6. Queensland reporting of change in sustainable management of stock forage based on Aussie-GRASS simulation of levels of pasture utilisation.

Mapping (in Fig. 6) is at sub-IBRA resolution and overlaid line-work shows bioregion boundaries. Utilisation levels were space- and time-averaged for each rangeland sub-IBRA for two periods: 1976-1990 and 1991-2005 (note that data are not available for the small number of rangeland sub-IBRAs shown without colour). Each period included similar levels of climate variability (particularly rainfall). **Map (a)** indicates sustainability of stock forage based on levels of pasture utilisation for the 1991-2005 period (increasing sustainability, i.e. decreasing utilisation, is shown by increased intensity of green). **Map (b)** shows degree of sustainability (i.e. change in utilisation) between the 1976-90 and 1991-2005 periods (decreasing utilisation shown by increased intensity of blue). **Map (c)** illustrates combined sustainability and trend information (see colour scheme at bottom right of the above figure for interpretation): darker coloured sub-IBRAs represent a low level of sustainability and increased utilisation in the later period; bright green indicates sustainable utilisation but a trend towards reduced sustainability (again, increased utilisation in the later period); bright blue shows low sustainability and improving trend (decreased utilisation); and light blue (aqua) depicts sub-IBRAs with sustainable utilisation and improving trend. See Fig. 7 for indicated reliability of results.

Combining recent sustainability and trend

Fig. 6c maps the various combinations of sustainability and trend (change) in utilisation reported above. The darker (blacker) colours depict the worst outcome for sustainable management of critical stock forage (unsustainable recent levels of pasture utilisation and time-averaged utilisation levels increasing between 1976-90 and 1991-2005). Light blue (aqua) colouration shows the better outcome (relatively conservative levels of utilisation between 1991 and 2005, and utilisation rates decreased between 1976-90 and 1991-2005).

- Regions in the former category (high and increasing utilisation) include: the Desert Uplands, much of the Mulga Lands (6 sub-IBRAs) and much of the Channel Country (5 sub-IBRAs).
- Regions with relatively conservative, and declining, levels of utilisation (equal potentially improving trend) include: parts of the Cape York Peninsula (5 sub-IBRAs), Mitchell Grass Downs (2 sub-IBRAs) and individual sub-IBRAs of the Einasleigh Uplands, Gulf Plains and Simpson Strzelecki Dunefields bioregions.

Fig. 6c is reproduced as Fig. 9 using a unidirectional colour scheme that combines ranked levels of utilisation for the 1991-2005 period and change in utilisation between the two periods. The purple – dark blue end represents the potentially more favourable outcome for sustainable grazing management (i.e. relatively conservative utilisation through the 1991-2005 period, and decreased overall utilisation between 1976-90 and 1991-2005). Conversely, red and orange colours show high and increasing utilisation and thus indicate areas of concern with regard to sustaining stock forage supplies.

Reliability in reporting

The reliability of reporting levels of, and change in, space- and time-averaged pasture utilisation based on Aussie-GRASS simulation is indicated in Fig. 7.

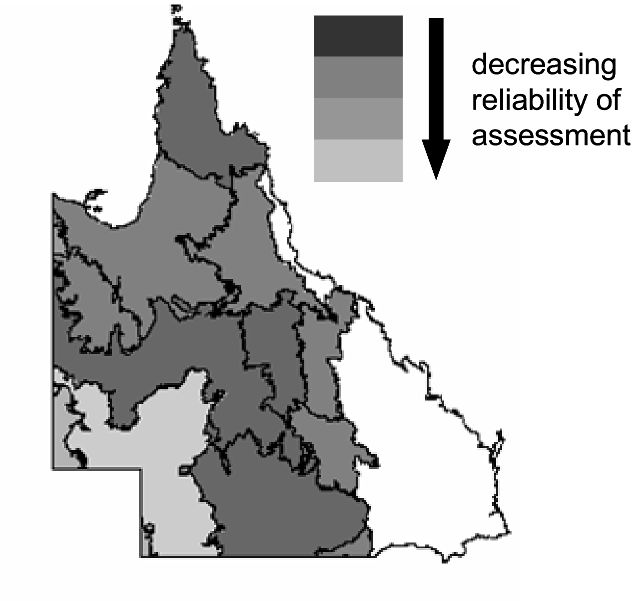


Figure 7. Reliability in reporting levels of, and change in, pasture utilisation as an indicator of critical stock forage based on Aussie-GRASS simulation.

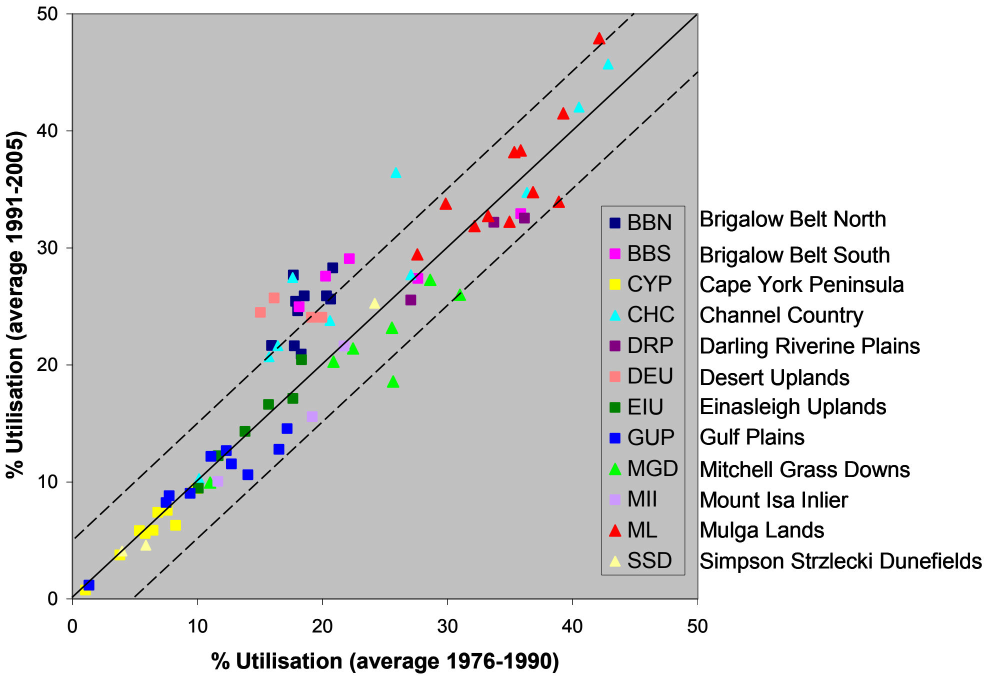


Figure 8. Shifts in space- and time-averaged levels of Aussie-GRASS simulated pasture utilisation for Queensland rangeland sub-IBRAs, grouped by bioregion.

The diagonal 1:1 line (in Fig. 8) represents no change between the mean of the two time periods 1976-90 and 1991-2005: sub-IBRAs plotting above this line had increased average utilisation in the 1991-2005 period compared with 1976-90. The parallel dashed lines represent 5% absolute change from the 1:1 line, so sub-IBRAs plotted below and above these lines had a substantial decrease, or increase, respectively in mean utilisation for the 1991-2005 period compared with 1976-90. Sub-IBRAs of more arid bioregions are shown with the ▲ symbol and have generally lower safe theoretical levels of pasture utilisation. Remaining sub-IBRAs (or bioregions) shown with the ■ symbol are located in relatively wetter parts of the rangelands and most can safely sustain higher levels of pasture utilisation compared with arid bioregions.

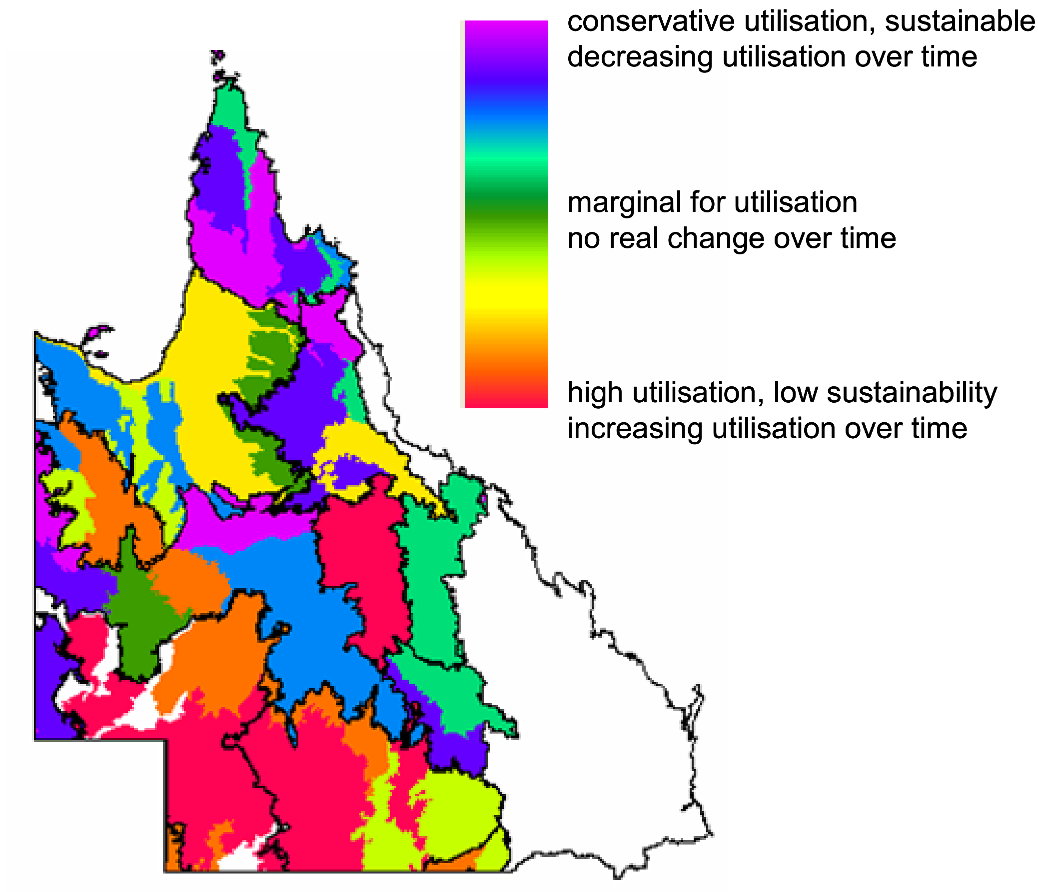


Figure 9. Sustainable management of stock forage based on Aussie-GRASS simulation where sustainability and change (trend) are combined in a uni-directional colour scheme.

Caveats on reporting change based on Aussie-GRASS simulation of pasture utilisation

The following comments apply to the results reported here:

- ABS-sourced data on stock numbers are essential to Aussie-GRASS simulations and survey data are possibly inadequate in some areas, especially the far west and Cape York regions where there are few pastoral holdings.
- The safe utilisation level for the Mulga Lands bioregion was set at 20% rather than the 15% in Hall *et al*. (1998). This higher figure takes account of grazing by macropods and feral animals (mainly goats) that were not included in Hall *et al*.'s original analysis.
- Trends in regions with well below-maximum utilisation levels may not be very meaningful.
- Data include conservation reserves and other areas without domestic stock so actual utilisation rates on commercial holdings will tend to be higher than calculated for sub-IBRAs with significant areas of non-pastoral land.

- Changed levels of simulated pasture utilisation in the Brigalow Belt and Desert Uplands regions are likely to be partly due to increased stock numbers associated with tree clearing in the last 15 years.
- Trends in pasture production due to clearing and woodland thickening are not well captured and are opposite in sign. Their net effect is uncertain.
- Part of the impact of clearing on pasture production is likely to be transient due to nitrogen dynamics.
- The long term pasture dynamics with respect to increased atmospheric CO_2 level and nitrogen dynamics from reduced fire frequency have not been captured in this analysis. Their effects may be significant relative to changes in pasture utilisation and if so, should be included in future analyses.
- Even those sub-IBRAs with simulated levels of **average** utilisation below or close to the specified safe threshold could have problems in patches because, by definition, half the sub-IBRA area will be running above the mean and half below the mean.
- Ideally, utilisation estimates would be combined with point measurements of species composition.

Woody Cover

There are a number of processes that contribute to change in woody cover: woodland thickening and thinning, development (clearing) and re-clearing of regrowth and clearing of remanent native vegetation. In the mulga lands, trees are lopped or pushed for drought fodder. Tree death is yet another contributor to change in woody cover.

Extensive clearing has implications for sustainable pastoral management. Livestock production is obviously increased where productive perennial pastures are successfully established following tree removal. However there may also be environmental costs:

- Water regimes are often adversely affected by tree removal. The problems of dryland salinity associated with tree clearing in the southern agricultural areas are well documented and similar problems have intruded into parts of the cleared rangelands (Hughes 1979). However, in comparison with agricultural areas, issues of rising ground water and salinisation are generally local and limited in extent.
- Clearing is detrimental to carbon balance as woody biomass following clearing is burnt or decays to carbon dioxide. Conversely, thickening and regrowth are processes that will continue to remove CO_2 from the atmosphere until the woody vegetation equilibrates with environmental conditions.

Data source

The Queensland Statewide Landcover and Trees Study (SLATS) maps and reports change in the extent of woody cover (see for example, Department of Natural Resources and Mines 2005). The SLATS program generates a continuous classification of woody density and reports for all perennial woody vegetation that can be distinguished with Landsat TM (and

ETM+) imagery. The ability to do this varies with image date, particularly with regard to the "greenness" (photosynthetic activity) of non-woody vegetation so woody cover (as opposed to clearing) is determined using data from multiple years. Where images are chosen in a dry season, there is good discrimination between the woody plants and grasses and it is possible to map woody vegetation with cover as low as 7% foliage projected cover (FPC). This threshold level of reliably detecting woody cover when pastures are green (even in dryer months) increases to approximately 12% FPC (~20% crown cover).

Here we report at sub-IBRA resolution the extent of woody cover mapped in 2003 and change in woody cover extent between 1991 and 2003.

Woody cover: 2003

The highest extent of woody cover (as the percentage of sub-IBRA area) occurs in the northern tropics (Fig. 10; Einasleigh Uplands, Cape York Peninsular, Gulf Fall and Uplands and Desert Uplands bioregions, in order of decreasing percentage cover in 2003; all woody cover levels ≥70%). The Brigalow Belts South and North, Gulf Plains, Mulga Lands and Mount Isa Inlier bioregions also have appreciable woody cover (68.3% for Brigalow Belt South decreasing to 45.0% [Mount Isa Inlier] in 2003).

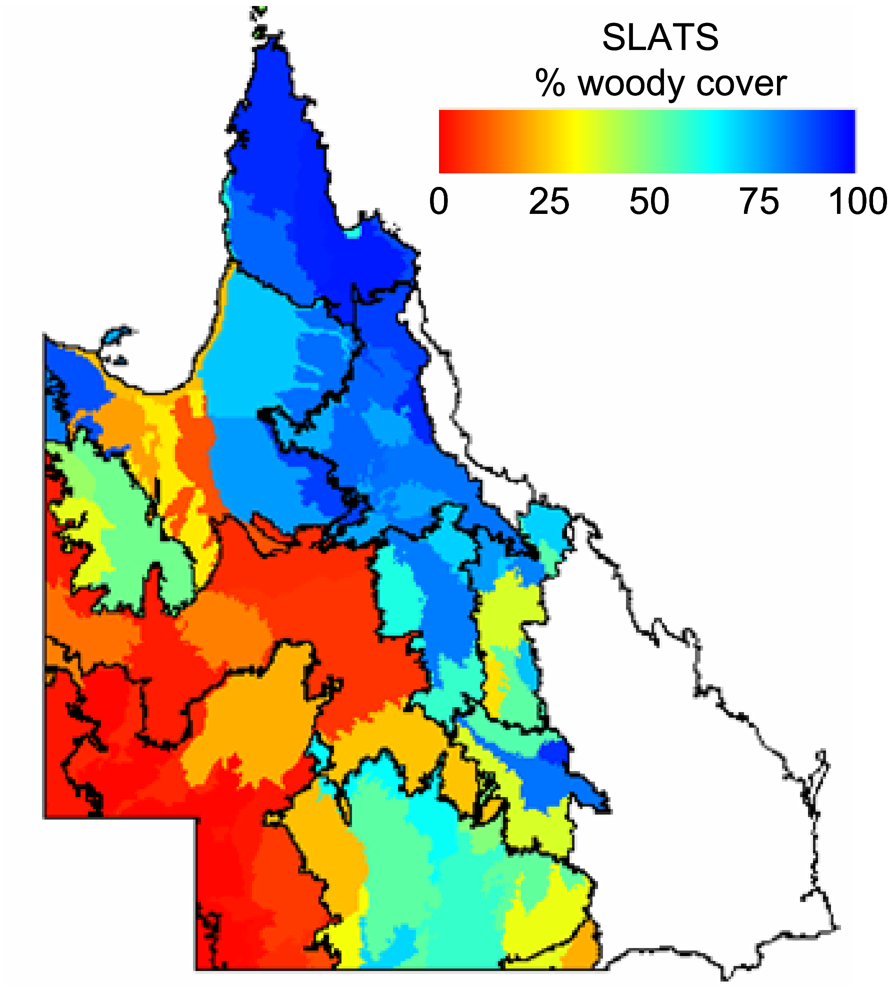


Figure 10. 2003 extent of woody vegetation, as a percentage of sub-IBRA area, in the Queensland rangelands.

Mapping based on SLATS determination of perennial woody vegetation in the 2003 Landsat TM imagery (approximately >7% FPC). Mapping is at sub-IBRA resolution. Line work shows bioregion boundaries.

Change in woody cover: 1991 to 2003

No bioregions (or component sub-IBRAs) showed an increase in the spatial extent of woody cover between 1991 and 2003. At bioregion level, there were small to moderate decreases on the eastern margin of the rangelands (Fig. 11) due to substantial decreases in woody cover for several sub-IBRAs within these bioregions. Spatial extent of woody cover decreased by:

- 6.8% averaged across sub-IBRAs of the Desert Uplands bioregion (largest decrease in the Jericho sub-IBRA, 14.3%).
- 6.0% on average across the Mulga Lands (largest decreases in the North Eastern Plains [20.8%], Eastern Mulga Plains [14.0%] and West Balonne Plains [12.4%] sub-IBRAs).
- 5.7% for the Brigalow Belt South bioregion (most substantially in the Claude River Downs [9.9%] and Southern Downs [9.1%] sub-IBRAs).
- 5.4% in the Brigalow Belt North bioregion (most extensively in the Upper Belyando Floodout [19.7%] and less so in the Belyando Downs [9.3%] and South Drummond Basin [8.8%] sub-IBRAs).
- 5.3% in the Darling Riverine Plains bioregion (most notably, a 7.1% decrease in woody cover in the Culgoa-Bokhara sub-IBRA).

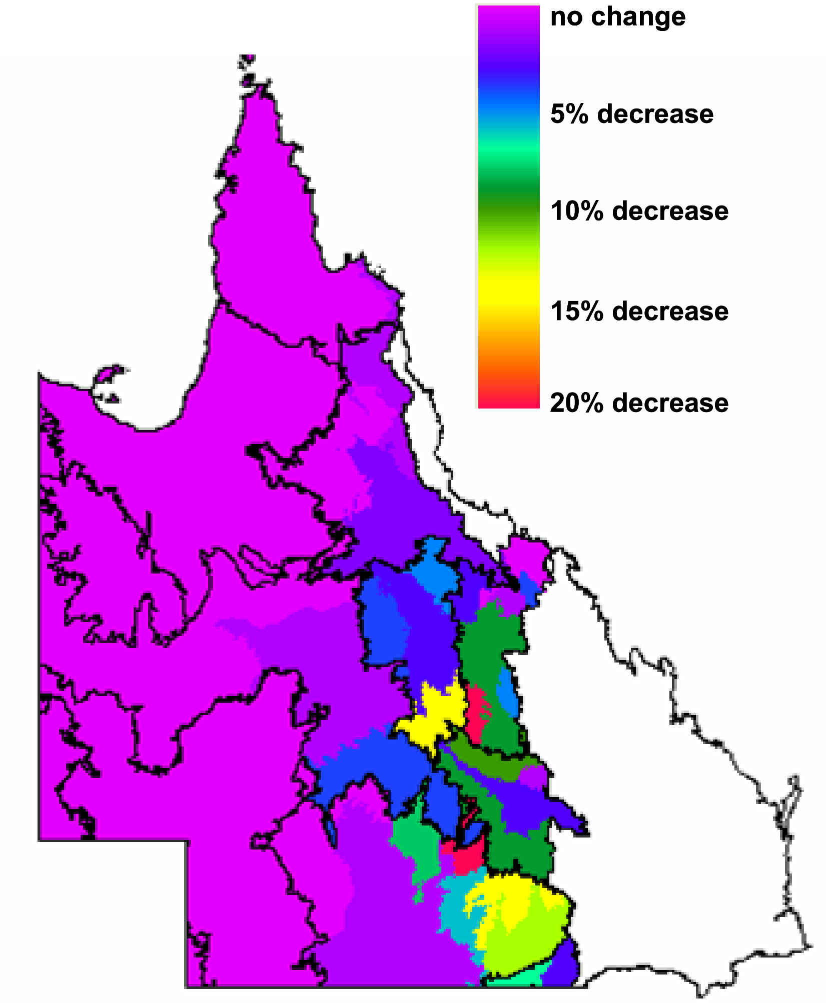


Figure 11. Change in the extent of woody cover, 1991-2003, for the Queensland rangelands.

Mapping based on SLATS determination of perennial woody vegetation in the 1991 and 2003 sequences of Landsat TM imagery (approximately >7% FPC). Mapping is by sub-IBRA. Line work shows IBRA boundaries.

SUPPORTING PHOTOGRAPHIC IMAGES

Photographs exist which serve as point data about woody vegetation extent in a few places, including some which document change over long periods of time (40 years). The most extensive rangeland sets are for 60 km of belt transects in the mulga lands bioregion (Burrows and Beale 1969). These pictures were taken at fixed points (marked by steel fence posts) facing a fixed direction every 100 m at various times from 1966 to 2006. In most cases there are four or five shots to make up a time series that shows the cycles of drought and excellent seasons and the associated fluxes in pasture, tree and shrub densities. The collaborating properties in the West Warrego and West Bulloo sub-IBRAs are large commercial family grazing businesses running Merino sheep and an assortment of cattle.

On the accompanying CD to this report, there are 21 photo sequences (B&W images) from the two mulga regions as well as two colour film examples taken 36 years apart from the Southern Wooded Downs of the Mitchell Grass Downs bioregion. The latter shows that tree and shrub density is largely unchanged there on the naturally open landscape. The former B&W sets show a range of woody vegetation responses depending on where the site is in the gently undulating landscape. Absence of significant fires has led to marked thickening of mulga (*A. aneura*) and allied *Acacia* species but on the better-watered flats where growth is faster these have been pushed for drought fodder in many places at some time in that 40 years.

Along creek frontages, gidgee (*A. cambagei*) has often recruited or thickened up markedly. On stony, open rockgrass (*Eriachne mucronata*) ridges there has been negligible shrub recruitment while scalded river frontages remain in the recent drought looking as they did after the 1965 drought, despite plenty of ephemeral plant coverage during the wet 1970s era in that region.

Figs. 12 to 16 illustrate some of these comments and reinforce the caveats made about the mean utilization and available forage levels presented in earlier figures.

Mulga Lands Bioregion

Post 2 **West Warrego sub-IBRA** **Soft mulga plain by Paroo River**

Dominant trees are mulga and poplar box (*E. populnea*). Regenerating mulga saplings are very common and heavily utilized at most times. Selective pushing of mulga was common. Traditionally sheep raising country but nowadays has a significant proportion of the grazing pressure coming from beef cattle. Note hedge grazing pattern of the small mulgas by cattle. Grasses are mainly perennial with *Thyridolepis, Monachather, Aristida, Digitaria* and *Eragrostis* species common.

1965

1972

1974

1979

1984

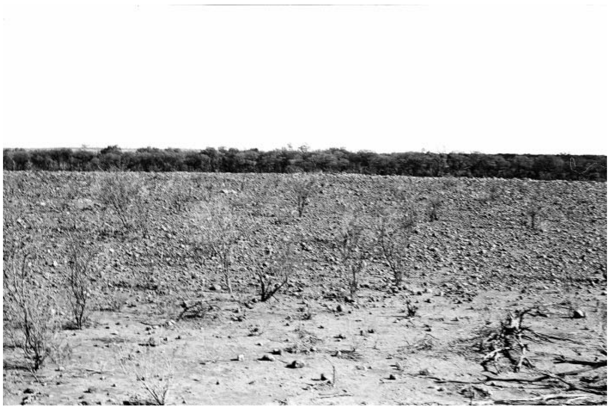
2006

Figure 12. Photo sequence at a mulga site in the West Warrego sub-IBRA.

Post 306 **West Bulloo sub-IBRA** **Stony toprock mulga country**

No structural change between 1965 and 2006 although there were intervening flushes of shrub growth in good seasons. One mulga tree in the centre background has grown noticeably.

1965



1974

1980

1984

2006

Figure 13. Photo sequence from a shrubby site in the West Bulloo sub-IBRA.

Mitchell Grass Downs Bioregion

The three photo pairs for this bioregion show land in the very southern extremity of the Southern Wooded Downs sub-IBRA in April 1969 and January 2006. The first pair (Ivanhoe, Fig. 14) looking to the mountains in the distance is taken looking NNE across the Barcoo River headwaters from about 21 km SE of Tambo on the Matilda Highway. There are no significant visual changes in these rolling Mitchell grass (*Astrebla* spp.) downs, although close to the road which has been reconstructed in the interval there are a few small shrubs of gundabluey (*Acacia victoriae*) on the stock route.

Ivanhoe, 1969

Ivanhoe, 2006

Figure 14. Ivanhoe photo pair about 21 km SE of Tambo on the Matilda Highway.

The second pair of shots (Tambo Hills, Fig. 15) is from the same place but looking due north along the highway. The trees in the mid-ground have grown a little and there are more small shrubs of gundabluey and mimosa (*Acacia farnesiana*) on the stock route. The clump of trees in the mid-background is along a small local watercourse and remains intact after 37 years. Buffel grass (*Cenchrus ciliaris*) grows densely on the roadside embankment in 2006 but it is unclear if the grass there in 1969 was that or something else. The highway has been upgraded from single to dual lane in common with development that has occurred in most of rangeland Australia since the 1960s.

Tambo Hills, 1969

Tambo Hills, 2006

Figure 15. Tambo Hills photo pair SE of Tambo on the Matilda Highway.

The third set (Tambo stock route, Fig. 16) are from about 700 m north of the other panoramic shots. They show the interface between the stock route (including the Matilda Highway) and the adjoining grazing property at each time. In 1969, the stock route had been very heavily grazed while the commercial paddock retained a good cover of Mitchell grass and no woody weeds. In 2006, the commercial paddock remains in good condition while the stock route pasture has recovered but now has a scattered cover of shrubs, mainly gundabluey and mimosa. There is a single, new tree pear (*Opuntia tomentosa*) on the fence in 2006 which was absent in 1969. The telephone line along the fence has now gone and a *Stylosanthes* species pasture legume like Verano was growing in patches close to the edge of the bitumen here and at other places along the highway between Morven and Barcaldine.

Between 1969 and 2006, use of the stock route by domestic animals has been light and sporadic while the adjacent property has continued as a typical commercial grazing enterprise with sheep and cattle. Seasons have varied from severe drought to excellent during the time but in both 1969 and 2006 recent seasonal rainfall had been below par. The good seasons included winter and summer seasons which have long term mean totals of 163 and 360 mm respectively.

Tambo Stock Route, 1969

Tambo Stock Route, 2006

Figure 16. Tambo Stock Route photo pair SE of Tambo on the Matilda Highway.

LAND VALUES

Land values presented for the rangelands of Queensland are unimproved values as defined by the Queensland Department of Natural Resources & Water (http://www.nrw.qld.gov.au/property/valuations/unimproved_valuation.html).

The results were generated from three primary data sources:

1. Unimproved property values from the QVAS (Queensland Valuations And Sales System), http://www.nrw.qld.gov.au/asdd/qsii2/ANZQL0053000006.html
2. The DCDB (Digital Cadastral Data Base) for Queensland, and
3. Queensland 2005 rangeland boundaries as defined for the Australian Collaborative Rangeland Information System (ACRIS) (http://www.deh.gov.au/land/management/rangelands/index.html).

Mapped results use IBRA v6.1 boundaries for bioregions.

Methodology

The methodology used is fully described on the CD that accompanies this report.

Land values were compiled regionally with valuations made progressively during the period June 2002 to June 2006 (but only reported in 2006). These valuations were averaged for rural land parcels (entities) after applying a number of filters for minimal size and primary land use. Valuations were based on 'unimproved' property values sourced from QVAS and these are expressed in 2005 dollars, adjusted using the CPI (ABS CPI All Groups Index for Brisbane for each quarter).

Many parcels, particularly State Lands such as National Parks and stock routes, had no valuation in QVAS. Small holdings less than 5 ha in area (typically country town blocks) were excluded as not being representative of rangelands, leaving 8,266 valued entities.

Further non-agricultural lands were removed on a number of criteria so that the final data set contained 4,843 valued entities which were distributed amongst the IBRAs as shown in Table 3. These included five valued at over $5,000 per hectare in five different sub-IBRAs and four IBRAs. Some IBRAs had only one or two entities and were excluded from the presented data for privacy reasons. As an example, the Gulf Falls and Uplands (GFU) IBRA on the NT border northwest of Mt Isa only ever had one entity with a valuation and so information about it is not presented (n.d. in Table 3).

The value of the land per hectare of each entity was derived by dividing the total unimproved value of the entity as recorded in QVAS by the area of the entity in hectares. Thus large entities with very contrasting land types within would have values per hectare that may be unhelpful when attributing a value to land in different regions.

IBRAs too are mixes of landforms and vegetation types but are regarded as internally consistent climatically and geologically. It is only when country is classed as regional ecosystems that the landform becomes consistent and the vegetation cover relatively predictable (see Sattler and Williams 1999).

It is not possible to report changes in land values.

IBRA rangeland values

All data were initially aggregated to sub-IBRA boundaries and then further aggregated to IBRA. In some cases the proportion of the sub-IBRA encompassed was small, e.g. 11% of the Starke Coastal Lowlands and 17% of the Battle Camp Sandstones sub-IBRAs. In these cases a large proportion of each sub-IBRA was covered by unvalued State lands such as National Parks. In a few cases the proportion is well over 100% of the sub-IBRA's rangeland because the valued properties extended well beyond the sub-IBRA boundaries, e.g. Northern Bowen Basin sub-IBRA in the north and Bulloo sub-IBRA in the far southwest.

The sub-IBRAs with the highest valued land (>$45,000/sq km) are found in the north-east regions)Table 3). The lowest valued land at <$250/sq km is found in the arid southwest (Simpson Desert, Sturt Stony Desert and Urisino Sandplains sub-IBRAs) and in parts of the Gulf Plains (Doomadgee Plains) and the Mt Isa Inlier (Thorntonia) in the far northwest.

Similarly, the IBRAs with the most valuable land were in the north and northeast of the State (Brigalow Belt North and Einasleigh Uplands bioregions) and the least valuable in the dry southwest, as expected (Table 3). However there were large differences in land values between similar sub-IBRAs which reflect the soils and resulting vegetation that grows there under similar climatic conditions. The Mulga Lands had sub-IBRA mean values ranging from $220 to $4,582 per sq km and an even larger range was found in the Gulf Plains - $38 to $12,610 per sq km. In some cases only a small number of entities were involved and hence reduced confidence can be ascribed to any interpretation of causes, e.g. Cape York Peninsula and Mount Isa Inlier bioregions.

The average area of entities in the Mulga Lands, Desert Uplands, Mitchell Grass Downs and Einasleigh Uplands bioregions was similar but their average value was much less in the Mulga Lands and comparatively high in the Einasleigh Uplands. Values were not well correlated with mean property size such that relatively small Darling Riverine Plains entities were much less valuable in a fair climatic zone than Brigalow Belt North entities which were much larger on average. Fig. 17 shows relative land values when aggregated to a bioregion.

No assessment of relative change in land values can be made from readily available data but this analysis can be the basis for any future assessments of change in rangeland values in Queensland.

Table 3. Unimproved rangeland values for Queensland bioregions.

Valuations were made progressively during the period June 2002 to June 2006 (but only reported in 2006) and are expressed in 2005 dollars.

Bioregion	Average unimproved value ($ / km^2)	Standard Deviation of values	Total valued area (km^2)	Average ($M) unimproved value of entities	SubIBRA value range ($/km^2)	Number of valued entities
Brigalow Belt North	34,873	80,013	58,636	1.058	3,772 – 64,328	587
Brigalow Belt South	17,780	48,707	50,149	0.559	3,293 – 21,182	567
Channel Country	598	1,359	196,820	0.535	104 – 1,234	105
Cape York Peninsula	11,731	21,164	49,737	0.457	420 – 34,234	73
Darling Riverine Plains	10,950	21,967	7,283	0.373	5,272 – 13,571	125
Desert Uplands	4,953	8,256	62,690	0.441	1,183 – 14,031	372
Einasleigh Uplands	26,712	62,133	105,915	0.637	6,282 – 52,058	601
Gulf Fall & Uplands	n.d.	-	2,415	n.d.	n.d.	1
Gulf Plains	2,876	6,303	203,029	0.736	38 – 12,610	259
Mitchell Grass Downs	4,792	8,929	242,952	0.504	333 – 6,668	1166
Mount Isa Inlier	16,246	97,605	53,852	0.203	302 – 19,074	73
Mulga Lands	2,262	7,060	168,576	0.187	220 – 4,582	909
Simpson Strzelecki Dunefields	43	17	12,858	0.113	39 - 49	5

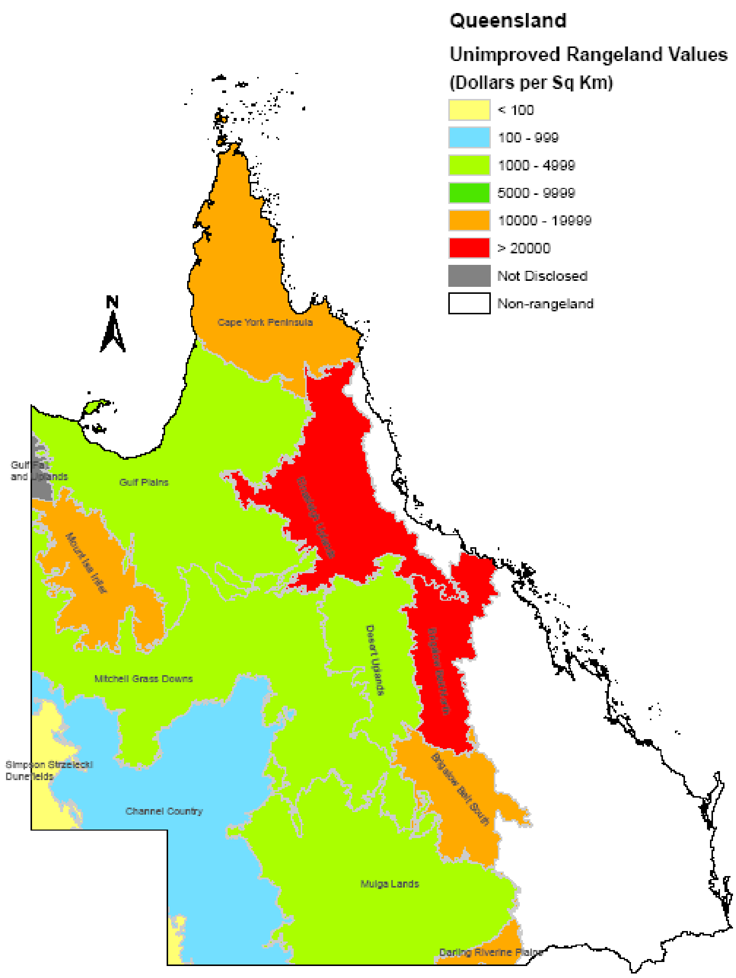


Figure 17. Unimproved land values for Queensland rangelands by bioregion, standardised to June 2005 dollars.

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John Arrowsmith, DPIF Biosecurity Group, provided great assistance in the extraction of the spatial data from QVAS and in the preparation of the mapped product.

REPORTING BY DATASTICIANS

Table 4 lists reports provided by Datasticians that describe their analyses of NRW datasets. These reports were generated to assist Queensland reporting to the ACRIS.

Table 4. Datasticians' reports describing analyses of NRW datasets provided to the ACRIS.

Report	NRW Dataset	Brief Description
Biomass report.doc	RMDC – biomass estimates made by Rob Hassett	• Mean & standard error of estimated biomass by sub-IBRA for each date (assessment trip). • Method for separating prior rainfall from management in interpreting change. Fire also included where relevant. • Profile of biomass change for each sub-IBRA. • Summarised results for all sub-IBRAs showing times when biomass changes were counter to seasonal expectations. • Detailed discussion of data issues for reporting change. Large seasonal changes in biomass. Biomass data were subsequently combined with other RMDC attributes by NRW (John Carter & Rob Hassett) to provide a composite index of landscape function for ACRIS reporting.
Cover Report.doc	MRBGI (version bi1) – SLATS derived index of change in bare ground	• Mean & difference variable (to indicate meaningful differences in bare ground) by sub-IBRA for annual image dates (2001 to 2004). • Similar method to that of biomass (above) for separating effects of prior rainfall from management in interpreting change. Fire also included where relevant. • Profile of bare-ground change for each sub-IBRA. • Summarised results for all sub-IBRAs showing times when changes in bare ground were counter to seasonal expectations. • Detailed discussion of data issues for reporting change. Bastin expanded Datasticians' analyses to include all available image dates between 1991 and 2004 (see Appendix 1). Mean levels of bare ground (converse of ground cover) alone are a poor indicator of change in landscape function. As above, relevant RMDC data were subsequently combined to provide a composite index of landscape function for ACRIS reporting.
SLATS Report.doc	SLATS reporting of change in extent of woody cover	• Percentage of sub-IBRA area cleared between 1991 & 2003 and comparison of sub-IBRAs according to extent of clearing. • Detailed comparison of SLATS results with Australian Greenhouse Office reporting of change in 'forest' extent. Purpose was to try and explain differences in reporting between SLATS % AGO. • A profile of clearing for each sub-IBRA. SLATS data used by ACRIS for reporting change in extent of woody cover and clearing.

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APPENDIX ONE: BASTIN'S MODIFICATIONS TO DATASTICIANS' REPORTING OF CHANGE IN BARE GROUND

Introduction

ACRIS (the Australian Collaborative Rangelands Information System) is reporting change in the rangelands for a number of themes for the period 1992-2005. There are three themes in the area of environmental change: landscape function, sustainable management and biodiversity.

It should be possible to monitor landscape function at a range of scales using either ground-based or remote sensing methods. While the results from various monitoring methods provide different levels of information about actual landscape and vegetation processes, each indicates (at varying scale) the degree to which landscapes are resource conserving or leaky, albeit with varying precision.

The Queensland Department of Natural Resources & Water (NRW) Multiple Regression Bare Ground Index (MRBGI, version bi1) was used to report (in part) change in landscape function for Queensland's rangelands. This version is known to be occasionally influenced by atmospheric aerosols for some times and locations. Some of the variation between dates at sub-IBRA scales may have been influenced by atmospheric effects.

Because ACRIS is reporting change for large areas (bioregions, and for Queensland, sub-IBRAs), MRBGI values were spatially averaged to calculate the mean and standard deviation of bare ground for each rangeland sub-IBRA by year of available imagery. This spatial averaging may conceal a large amount of spatial variation in levels of bare ground (e.g. amongst land types and amongst management areas [paddocks and pastoral leases] within sub-IBRAs). The spatial location of persistent ground cover, in addition to the mean level of ground cover, is important for specifying the level of landscape function (and reporting change). At this stage of ACRIS reporting, it was not possible to include information about spatial variation in ground cover (converse of bare ground) into a remote sensing-based index of landscape function when reporting at sub-IBRA scale. Thus we are using change in mean levels of bare ground alone (and Datasticians' 'difference' variable, explained later) to indicate seasonally-interpreted change in landscape function.

Peter Scarth provided statistics of mean and standard deviation of MRBGI for rangeland sub-IBRAs by image date to our consultants, Datasticians. Datasticians provided a framework for analysis and reporting change in bare ground as an indicator of landscape function (see Datasticians' report, *Cover Report.doc*).

Datasticians' contribution to Queensland reporting into ACRIS is acknowledged and their approach is here expanded using a procedure agreed with John Carter and Peter Scarth (NRW).

Rationale for Additional Analysis and Reporting

Datasticians (Graham Griffin and Sarah Dunlop) did a commendable job in analysing and reporting change in bare ground for sub-IBRAs in the Queensland rangelands. Notwithstanding their cautionary comments under 'Data issues' in their Discussion (pages 13-15 of *Cover Report.doc*), their approach to specifying 'significant' differences amongst regional cover levels using the 'median difference variable' has particular merit for reporting change by ACRIS.

The main concern of the ACRIS Management Unit with Datasticians' analysis and reporting was their restriction of reporting to only those periods when there were consecutive years of available bare-ground data (i.e. reporting of change between 2001 and 2004 only). Through an agreed procedure with NRW, Datasticians' methods were adapted to allow reporting of change in bare ground for the period 1991 to 2003.

Additional analysis

Additional analysis conducted by the ACRIS Management Unit included:

1. Specifying 'ground cover' as 100 minus 'bare ground'. However, uncertainty in interpreting results based on applying the median difference variable, based on ground cover, to mean levels of ground cover has meant that results have been reported in this Appendix based on percentage bare ground (not ground cover).

2. All years of biennial-date imagery available between 1991 and 2003 (i.e. 1991, 1993, 1995, 1997, 1999, 2001, & 2003).

3. Using a modified 'median difference variable' calculated from this expanded range of image dates. Datasticians chose (page 5 of their report under "Bare ground")

   "a 'difference variable' that meant 50% of bare ground differences were treated as meaningful, and 50% were treated as too small to be meaningful: changes in bare ground between years were treated as meaningful if the difference was ≥20.446% (of the mean bare ground value for that subIBRA, averaged over all available years); the area of bare ground was treated as invariant if the difference was <20.446%".

4. Using the 'ACRIS method' to filter the effects of prior rainfall on reported levels of bare ground using a weighted index of rainfall (explained later):

5. Reporting the expanded set of results as tables, maps and sub-IBRA profiles (similar to Datasticians' Appendix 1 in their report, *Cover Report.doc*).

Methods

Median difference variable

Datasticians' procedure was used to calculate the value of the median difference variable for bare ground using the previously listed biennial image dates (1991, 1993, 1995, 1997, 1999, 2001 and 2003).

1. First, the absolute difference in bare ground was calculated for all image dates used (1988 to 2004) for all sub-IBRAs.

2. Then, for each sub-IBRA, the difference in bare ground was calculated for each image-date pair as a percentage of the mean level of bare ground for the 10 image dates between 1988 and 2004.

Calculations as per Datasticians' formula:

If $M_{(x)}$ = mean % bare ground in year x, then the percent difference between, say, 2001 and 2002 = $(M_{(2002)} - M_{(2001)})/(\Sigma M_{(x)}/n) \times 100$, with n=10 (i.e. number of image dates used)

3. Finally, the median difference variable was calculated for bare ground: median bare ground difference variable = 23.445%

   Data and calculations are in spreadsheet *median_Groundcover_Summary_By_SubIBRA_Nov06.xls*

4. As defined by Datasticians, changes in bare ground between biennial image dates (years) were treated as meaningful if the difference was ≥23.445% (of the mean bare ground value for that sub-IBRA, averaged over all available years); the area of bare ground was treated as invariant if the difference was <23.445%

   Two-yearly periods in which the bare ground was greater than the preceding two-year period were indicated by an "I"; two-yearly periods in which the bare ground was less than the preceding two-year period were indicated by a "D" and two-year periods in which the bare ground was not different from the preceding two-year period (i.e. the difference was <23.445% of the mean) were indicated by a "N".

Seasonal Quality

Seasonal quality for each two-year period was assigned by:

1. <u>Weighting seasonal rainfall and summing to produce a weighted index of cumulative rainfall (mm).</u> Biennial images were assumed to have a median image acquisition date of August each year. The two-year period was broken into seasons consisting of:
   - immediately preceding winter (May-August) – rainfall multiplied by 1
   - immediately preceding summer (November-April) – rainfall multiplied by 0.9
   - previous winter (May-October) – rainfall multiplied by 0.5
   - previous summer (November-April) – rainfall multiplied by 0.2.

2. Weighting applied to all bioregions equally.

3. Weighting applied to all two-year periods between 1890-92 and 2003-05.

4. Tercile ranks determined for each two-year period:
   - H = highest tercile (above average seasonal conditions)
   - M = middle tercile (average seasonal conditions)
   - L = lowest tercile (below average seasonal conditions).

Direction of Change

The five categories defined by Datasticians were used to represent potential change (Table 1, copy of Datasticians' Table 1, page 7 of *Cover Report.doc*):

Table 5. Symbols and their meaning for interpreting the change in bare ground in sub-IBRAs.

M	decrease in bare ground (i.e. increase in ground cover) when seasonal conditions would suggest a clear potential for bare ground to increase
^	decline or no change in bare ground when seasonal conditions would suggest an increase is probable
~	stable, no change in bare ground or a change consistent with the past season's conditions
v	increase or no change in bare ground when seasonal conditions would suggest a decrease is probable
W	increase in bare ground when seasonal conditions would suggest a clear potential to decrease

Results

Sub-IBRA change classes

Revised change results for bare ground are shown in Table 7. These results are based on the median bare-ground 'difference' variable of 23.445%. The interpretation symbols and colours are as for 'Table 1' in Datasticians' report (*Cover Report.doc* dated 2/10/06, reproduced on the following page as Table 6 to assist interpretation). An additional column has been added (to Datasticians' table) to indicate inferred change in landscape function.

Datasticians plotted, for each sub-IBRA, the mean level of bare ground over time and added their 'difference' variable (as an 'error' bar) to show the significance of change. Bastin did the same for the expanded analysis and his style of reporting is shown on page 65 of this document (example extracted from Bastin's Appendix 1 report to NRW [Word document *Cover-Report_Bastin-modified_Nov06.doc* dated 29/11/06]). The index of weighted rainfall accumulated over each two-year period is also graphed for each sub-IBRA (see page 65 example). The table at the bottom of page 65 (and repeated for each sub-IBRA in Bastin's Appendix 1) summarises seasonally-interpreted change results for each sub-IBRA.

Note that here we report change in bare ground, not change in ground cover. It is probably inappropriate to calculate error bars for ground cover using the ground cover difference variable (±9.021% of mean ground cover) because high ground cover (= low level of bare ground) should have a small value for the difference variable, and vice-versa.

Table 6. Symbols and their meaning for interpreting change in bare ground of sub-IBRAs.

(Adapted from page 7 of Datasticians' *Cover Report.doc* [October 2006] report for ACRIS.)

Change symbol	Ranked prior seasonal conditions	+	Bare ground relative to previous image date	⇒	Change description	Implications for Changed Landscape Function
M	Lower tercile		Decrease		Decline in bare ground when seasonal conditions would suggest the potential for high levels of bare ground.	Increased landscape function (alternatively, reduced landscape leakiness) given prior seasonal conditions.
^	Lower tercile Middle tercile		No change Decrease		Decline or no change in bare ground when seasonal conditions would suggest the potential for moderate or high levels.	Small increase in, or maintenance of, landscape function (converse for leakiness) based on seasonal conditions experienced.
~	Lower tercile Middle tercile Upper tercile		Increase No change Decrease		Stable, no change in bare ground or a change consistent with that of recent seasonal conditions.	Landscape function maintained or change direction consistent with recent seasonal conditions.
v	Middle tercile Upper tercile		Increase No change		Increase or no change in bare ground when past seasons would indicate potential for moderate or low levels.	Small decline or maintenance of landscape function (converse for leakiness) based on prior seasonal conditions.
W	Upper tercile		Increase		Increase in bare ground when the past season would indicate a clear potential for low levels of bare ground.	Considerable decline in landscape function (& increased landscape leakiness) given prior seasonal conditions.
•					Insufficient data	

Table 7. Expanded reporting of seasonally-interpreted change in bare ground for Queensland rangeland sub-IBRAs.

(Refer to Table 6 for interpretation of symbols and colours.)

IBRA		% area included in analysis	Seasonally Interpreted Change in Bare Ground for Period					
Sub-IBRA	**#**		**1991-93**	**1993-95**	**1995-97**	**1997-99**	**1999-01**	**2001-03**
Brigalow Belt North (BBN)								
Anakie Inlier	25	75	~	^	^	~	v	~
Belyando Downs	23	98	~	^	~	~	v	~
Beucazon Hills	20	**26**	~	^	~	~	v	~
Bogie River Hills	18	100	~	^	^	^	~	~

IBRA		% area included in analysis	Seasonally Interpreted Change in Bare Ground for Period					
Sub-IBRA	**#**		**1991-93**	**1993-95**	**1995-97**	**1997-99**	**1999-01**	**2001-03**
Cape River Hills	19	78	~	^	^	~	v	~
Northern Bowen Basin	22	**68**	~	^	M	~	~	~
South Drummond Basin	16	100	^	^	~	~	~	~
Townsville Plains	12	100	~	M	^	~	~	~
Upper Belyando Floodout	24	**64**	^	^	~	~	v	~
Wyarra Hills	21	97	~	^	M	~	v	~
Brigalow Belt South (BBS)								
Buckland Basalts	52	100	^	^	v	~	v	~
Carnarvon Ranges	27	**37**	^	^	v	~	~	~
Claude River Downs	26	75	^	^	v	~	v	~
Southern Downs	29	100	^	^	~	~	v	~
Cape York Peninsular (BBS)								
(Northern) Holroyd Plain	103	84	v	^	v	~	v	v
Battle Camp Sandstones	100	100	v	^	~	~	W	~
Coastal Plains	104	**5**	~	~	~	~	W	~
Coen – Yambo Inlier	96	100	~	~	^	~	W	~
Laura Lowlands	101	**51**	v	^	^	~	W	~
Starke Coastal Lowlands	97	**9**	~	^	v	~	W	^
Weipa Plateau	102	**1**	~	^	W	~	v	v
Channel Country (CHC)								
Bulloo	68	100	v	^	v	v	~	~
Bulloo Dunefields	313	100	v	~	v	v	~	~
Cooper Plains	72	97	~	~	v	v	v	~
Diamantina-Eyre	71	93	v	~	v	~	~	v
Goneaway Tablelands	70	100	^	~	v	~	v	~
Lake Pure	74	100	~	~	v	~	v	~
Noccundra Slopes	75	100	~	^	v	~	v	~
Sturts Stony Desert	69	99	~	v	v	~	~	~
Tibooburra Downs	76	97	~	~	v	~	~	~
Toko Plains	66	100	~	v	v	~	~	v
Darling Riverine Plains (DRP)								
Culgoa-Bokhara	115	100	^	^	v	~	v	~
Warrambool-Moonie	118	100	^	^	v	~	~	~
Desert Uplands (DEU)								
Alice Tableland	108	93	~	^	~	v	v	~
Cape-Campaspe Plains	109	**49**	~	^	~	~	v	~
Jericho	356	98	^	^	v	~	v	~
Prairie – Torrens Creeks Alluvials	107	100	^	^	~	~	v	~
Einasleigh Uplands (EIU)								
Broken River	128	76	~	^	^	~	v	~
Georgetown – Croydon	125	100	^	~	~	~	W	~

IBRA Sub-IBRA	#	% area included in analysis	Seasonally Interpreted Change in Bare Ground for Period					
			1991-93	1993-95	1995-97	1997-99	1999-01	2001-03
Herberton – Wairuna	130	**24**	~	^	^	~	W	^
Hodgkinson Basin	127	**57**	~	^	^	~	v	^
Kidston	126	93	^	^	^	~	v	~
Undara – Toomba Basalts	129	**59**	~	^	^	~	v	~
Gulf Fall and Uplands (GFU)								
McArthur - South Nicholson Basins	159	100	v	v	~	~	v	W
Gulf Plains (GUP)								
Armraynald Plains	174	95	v	^	^	~	v	v
Claraville Plains	177	**69**	^	~	v	~	v	~
Donors Plateau	180	81	~	^	~	~	v	~
Doomadgee Plains	179	**60**	v	~	^	~	v	W
Gilberton Plateau	181	**68**	^	~	~	~	v	~
Holroyd Plain – Red Plateau	178	**68**	^	~	~	~	v	~
Karumba Plains	172	100	~	~	^	~	v	v
Mitchell Gilbert Fans	176	97	^	~	~	~	W	~
Wellesley Islands	173	**19**	v	^	^	^	v	W
Woondoola Plains	175	96	^	~	~	~	~	~
Mitchell Grass Downs (MGD)								
Barkly Tableland	208	100	v	~	~	v	~	v
Central Downs	213	99	~	^	^	v	~	~
Georgina Limestone	209	99	v	~	~	~	~	v
Kynuna Plateau	211	97	~	~	~	v	v	v
Northern Downs	212	97	v	^	~	v	~	~
Southern Wooded Downs	214	95	^	^	v	~	v	~
Southwestern Downs	210	99	v	~	v	v	~	v
Mount Isa Inlier (MII)								
Mount Isa Inlier	271	99	~	^	~	~	v	~
Southwestern Plateaus & Floodouts	269	100	v	~	~	v	~	~
Thorntonia	270	84	v	~	v	~	~	~
Mulga Lands (ML)								
Cuttaburra-Paroo	228	**57**	^	~	W	v	v	~
Eastern Mulga Plains	223	100	^	^	~	v	v	~
Langlo Plains	227	75	M	~	~	~	v	~
Nebine Plains, Block Range	224	**66**	^	~	v	v	v	~
North Eastern Plains	225	**66**	M	^	~	~	v	~
Northern Uplands	230	**59**	^	~	v	~	v	~
Urisino Sandplains	217	89	~	~	W	v	v	~
Warrego Plains	226	89	M	~	v	~	v	~
West Balonne Plains	215	77	^	~	~	~	v	~
West Bulloo	216	87	~	^	~	v	v	~
West Warrego	229	98	~	~	v	v	v	~

IBRA		% area included in analysis	Seasonally Interpreted Change in Bare Ground for Period					
Sub-IBRA	#		1991-93	1993-95	1995-97	1997-99	1999-01	2001-03
Simpson Strzelecki Dunefields (SSD)								
Dieri	309	94	^	~	v	~	~	v
Simpson Desert	308	100	~	v	v	~	~	v
Strzelecki Desert, Westrn Dunefields	311	100	~	~	~	v	v	v

Note. As per Datasticians' scheme, where less than 75% of the sub-IBRA was assessed for change in bare ground, the area percentage is shown in bold.

Summary results by bioregion

Brigalow Belt North

The majority of sub-IBRAs across the majority of biennial image dates showed no unexpected change in mean levels of bare ground (and landscape function) given prior seasonal conditions (symbol **~**, Table 8; 35 of 60 sub-IBRA – season combinations). Sixteen sub-IBRA – season combinations showed no change or a small decrease (symbol ^) in bare ground when prior seasons would have suggested a small increase or no change in bare ground. This infers maintenance of, or a slight increase, in landscape function. Three sub-IBRA – season combinations had a decrease in bare ground when prior seasonal conditions (weighted rainfall) would have indicated an increase (symbol **M**, Table 8). This infers an increase in landscape function under conditions of below-average rainfall. Several sub-IBRAs (6) had either a small increase or no change in bare ground when seasonal conditions indicated that bare ground levels should have remained stable or declined (symbol **v**). Landscape function may have been adversely affected at these times for these sub-IBRAs.

Table 8. Summary of bare ground change results for the Brigalow Belt North bioregion.

Sub-IBRA	Sub #	% area	Number of Periods when Bare Ground Changed				
			W	v	~	^	M
Anakie Inlier	25	75		1	3	2	
Belyando Downs	23	98		1	4	1	
Beucazon Hills	20	**26**		1	4	1	
Bogie River Hills	18	100			3	3	
Cape River Hills	19	78		1	3	2	
Northern Bowen Basin	22	**68**			4	1	1
South Drummond Basin	16	100			4	2	
Townsville Plains	12	100			4	1	1
Upper Belyando Floodout	24	**64**		1	3	2	
Wyarra Hills	21	97		1	3	1	1

Bolded figures indicate where less than 75% of the sub-IBRA was assessed for change in bare ground.

Brigalow Belt South

Less than half of the sub-IBRA – season combinations (10 of 24) showed change in bare ground consistent with immediately prior seasonal conditions (symbol **~**, Table 9; i.e. no unexpected change in landscape function). Six sub-IBRA – season combinations had no change or an increase in bare ground (column **v**, Table 9) when past seasons would have indicated a small decrease or no change (inferred as mildly deleterious change for landscape function). An encouraging sign was that eight sub-IBRA – season combinations had no change or a small decrease in bare ground (^, Table 9) when prior seasons would have suggested a small increase or no change in bare ground. This suggests a positive signal for landscape function at these times.

Note that the Narrandool sub-IBRA has been excluded because of its very small area in the Queensland rangelands.

Table 9. Summary of change results for the Brigalow Belt South bioregion.

SubIBRA	Sub #	% area	Number of Periods when Bare Ground Changed				
			W	v	~	^	M
Buckland Basalts	52	100		2	2	2	
Carnarvon Ranges	27	**37**		1	3	2	
Claude River Downs	26	75		2	2	2	
Southern Downs	29	100		1	3	2	

Bolded figures indicate where less than 75% of the sub-IBRA was assessed for change in bare ground.

Cape York Peninsula

Five sub-IBRAs had:

i. Either no reported areas of bare ground (Cape York – Torres Strait and Jardine – Pascoe Sandstones [FPC of the woody layer >20% so these areas masked out]), or

ii. <10% of their area analysed (Coastal Plains, Starke Coastal Lowlands, Weipa Plateau).

Focussing on four of the remaining sub-IBRAs ([Northern] Holroyd Plain, Battle Camp Sandstones, Coen - Yambo Inlier and Laura Lowlands), nine (of 24) sub-IBRA – season combinations showed change in bare ground consistent with immediately prior seasonal conditions (symbol ~; Table 10; i.e. change in landscape function consistent with seasonal conditions). A slightly smaller number of combinations (6) had no change or an increase in bare ground (**v**, Table 10) when past seasons would have indicated a small decrease or no change (a mildly adverse result for landscape function). Three sub-IBRAs had an increase in bare ground between 1999 and 2001, a period when the preceding two-year period of weighted rainfall was ranked above-average. This infers a decline in landscape function during this period. Fire was significant during this time (between 10% and 20% of each sub-IBRA burnt, see Datasticians' report) and probably largely contributed to the increased level of bare ground (and inferred temporary decline of landscape function).

Five sub-IBRA – season combinations had no change or a small decrease in bare ground (symbol ^, Table 10) when prior seasons would have suggested a small increase or no change in bare ground, a probable positive signal for landscape function.

Table 10. Summary of change results for the Cape York Peninsula bioregion.

SubIBRA	Sub #	% area	No Periods when Bare Ground Changed				
			W	v	~	^	M
(Northern) Holroyd Plain	103	84		4	1	1	
Battle Camp Sandstones	100	100	1	1	3	1	
Coastal Plains	104	**5**	1		5		
Coen - Yambo Inlier	96	100	1		3	1	
Laura Lowlands	101	**51**	1	1	2	2	
Starke Coastal Lowlands	97	**9**	1	1	2	2	
Weipa Plateau	102	**1**	1	2	2	1	

Bolded figures indicate where less than 75% of the sub-IBRA was assessed for change in bare ground.

Channel Country

Levels of bare ground (converse of ground cover) are related to flood events as well as rainfall for this bioregion. Thus it is inappropriate to relate change in mean levels of bare ground (and associated inferences about landscape function) to prior rainfall alone for those sub-IBRAs encompassing distributary flood channels, swamps and lakes. The Bulloo, Cooper Plains and Diamantina Eyre sub-IBRAs are mainly fluvial and most of the other sub-IBRAs are predominantly higher in the landscape and less flood affected.

For Bulloo Dunefields, Goneaway Tablelands, Noccundra Slopes, Sturts Stony Desert, Tibooburra Downs and Toko Plains sub-IBRAs, 21 (of 36) sub-IBRA – season combinations had changes in mean levels of bare ground (and inferred landscape function) in line with seasonal expectations (based on prior weighted rainfall, symbol ~, Table 11). Only two (of the 36) combinations had maintained or decreased levels of bare ground when prior weighted rainfall would have indicated some level of increase or maintenance of bare ground (symbol ^, Table 11; i.e. small inferred increase in landscape function). Thirteen sub-IBRA – season combinations showed the reverse situation (symbol **v**); an increase or maintenance of bare ground (and associated reduced landscape function) when the amount of prior rainfall would have indicated the probability of no change or a decrease in bare ground (i.e. no change or increased landscape function expected).

Table 11. Summary of change results for the Channel Country bioregion.

SubIBRA	Sub #	% area	No Periods when Bare Ground Changed				
			W	v	~	^	M
Bulloo	68	100		3	2	1	
Bulloo Dunefields	313	100		3	3		
Cooper Plains	72	97		3	3		
Diamantina-Eyre	71	93		3	3		
Goneaway Tablelands	70	100		2	3	1	
Lake Pure	74	100		2	4		
Noccundra Slopes	75	100		2	3	1	
Sturts Stony Desert	69	99		2	4		
Tibooburra Downs	76	97		1	5		
Toko Plains	66	100		3	3		

Darling Riverine Plains

Flooding may also contribute to changes in amount of bare ground in these two sub-IBRAs in addition to rainfall. If rainfall was the primary driver of changes in bare ground over the 1991-2003 period, then five (of 12) changes were in line with that expected given prior rainfall (symbol ~, Table 12). This translates to no unexpected changes in landscape function. Both sub-IBRAs in the 1991-95 period had a decrease in bare ground when prior weighted rainfall would have suggested no change or an increase (symbol ^, Table 12; i.e. inferred increase in landscape function given prevailing seasonal quality).

Table 12. Summary of bare ground change results for the Darling Riverine Plains bioregion.

SubIBRA	Sub #	% area	No Periods when Bare Ground Changed				
			W	v	~	^	M
Culgoa-Bokhara	115	100		2	2	2	
Warrambool-Moonie	118	100		1	3	2	

Desert Uplands

Half of the possible sub-IBRA – season combinations (12 of 24) had changes in bare ground in line with seasonal expectations (symbol ~, Table 13; i.e. no inferred adverse implications for landscape function). There was an equal occurrence of sub-IBRA – season combinations (6 of 24) where inferred landscape function declined counter to seasonal expectations (symbol **v**) and increased when a decline would have been expected (symbol ^, Table 13). This is not the sort of country where producers will retain stock unnecessarily long in the hope of rain, so a lack of improvement (decreased bare ground) following low rainfall (**M** ratings) is to be expected. Neither have seasonal conditions been so good as to expect decline (increase in bare ground, **W** ratings) over the assessment period.

Table 13. Summary of change results for the Desert Uplands bioregion.

SubIBRA	Sub #	% area	No Periods when Bare Ground Changed				
			W	v	~	^	M
Alice Tableland	108	93		2	3	1	
Cape-Campaspe Plains	109	**49**		1	4	1	
Jericho	356	98		2	2	2	
Prairie - Torrens Creeks Alluvials	107	100		1	3	2	

Bolded figures indicate where less than 75% of the sub-IBRA was assessed for change in bare ground.

Einasleigh Uplands

The summarised and inferred pattern of changes in landscape function for this bioregion is somewhat similar to that for the Desert Uplands bioregion (Table 14). However, a higher proportion of sub-IBRA – season combinations (14 of 36) showed a decrease in bare ground (and inferred maintenance of, or increase in, landscape function) when prior seasonal conditions (based on weighted two-yearly rainfall) would have suggested an increase or no change in bare ground (symbol ^, Table 14). A similar number of combinations (16 of 36) had changes in bare ground consistent with seasonal expectations (symbol ~). The level of bare ground increased between 1999 and 2001 for two sub-IBRAs (Georgetown – Croyden and Herberton – Wairuna) when weighted rainfall in this two-year period would have suggested a decrease (column **W**, Table 14). Fire is probably implicated in this increase in bare ground as both sub-IBRAs had up to 10% of their area burnt in some years (see Appendix 1of Datasticians' report, *Cover Report.doc*).

Table 14. Summary of change results for the Einasleigh Uplands bioregion.

SubIBRA	Sub #	% area	No Periods when Bare Ground Changed				
			W	v	~	^	M
Broken River	128	76		1	3	2	
Georgetown - Croydon	125	100	1		4	1	
Herberton - Wairuna	130	**24**	1		2	3	
Hodgkinson Basin	127	**57**		1	2	3	
Kidston	126	93		1	2	3	
Undara - Toomba Basalts	129	**59**		1	3	2	

Bolded figures indicate where less than 75% of the sub-IBRA was assessed for change in bare ground.

Gulf Fall and Uplands

The inferences for changed landscape function for this bioregion are largely self evident from Table 15. It is a small area in Queensland with most (95%) of this bioregion in the Northern Territory. Changes in the level of bare ground accorded with seasonal expectations for two periods (symbol ~). For the remaining four intervals, bare ground increased (between 2001 and 2003) when a decrease would have been expected (column **W**), and remained stable or increased when a decrease or no change was expected (column **v**). These changes infer loss of landscape function based on rainfall. It is not possible to say if fire was implicated in these unexpected changes in bare ground.

Table 15. Summary of change results for the Gulf Fall & Uplands bioregion.

SubIBRA	Sub #	% area	No Periods when Bare Ground Changed				
			W	v	~	^	M
McArthur - South Nicholson Basins	159	100	1	3	2		

Gulf Plains

Excluding the Wellesley Islands (19% of sub-IBRA covered by the bare ground index), the predominant direction of change in bare ground (and inferred landscape change) was in line with seasonal expectations (symbol ~, Table 16; for 30 of 54 sub-IBRA –season combinations). Of the remaining 24 possibilities, 14 sub-IBRA – season combinations had an inferred negative change in landscape function (columns **v** & **W**, Table 16) and 10 a positive change (symbol ^; i.e. for the latter, bare ground decreased or remained stable when prior rainfall suggested stability or some increase in bare ground). There were two periods when a sub-IBRA showed an increase in bare ground when a decrease would have been expected (column **W**, Mitchell Gilbert Fans in 1999-2001 and Doomadgee Plains in 2001-03). This is interpreted as loss of landscape function. There was a high incidence of fire for the first sub-IBRA during the 1999-2001 period (up to 50% of area burnt) and fire was probably the main cause of increase in bare ground. (Fire data not available for the Doomadgee Plains sub-IBRA.)

Table 16. Summary of change results for the Gulf Plains bioregion.

SubIBRA	Sub #	% area	No Periods when Bare Ground Changed				
			W	v	~	^	M
Armraynald Plains	174	95		3	1	2	
Claraville Plains	177	**69**		2	3	1	
Donors Plateau	180	81		1	4	1	
Doomadgee Plains	179	**60**	1	2	2	1	
Gilberton Plateau	181	**68**		1	4	1	
Holroyd Plain - Red Plateau	178	**68**		1	4	1	
Karumba Plains	172	100		2	3	1	
Mitchell Gilbert Fans	176	97	1		4	1	
Wellesley Islands	173	**19**	1	2		3	
Woondoola Plains	175	96			5	1	

Bolded figures indicate where less than 75% of the sub-IBRA was assessed for change in bare ground.

Mitchell Grass Downs

Based on the described approach for reporting significance of changes in bare ground as an indicator of changes in landscape function, the Mitchell Grass Downs sub-IBRAs appeared to suffer a loss in landscape function through the 1991-2003 reporting period (Table 17). Although twenty (of 42) sub-IBRA – season combinations had changes in the level of bare ground in line with seasonal expectations (symbol ~, Table 17), a further 17 combinations had no change or an increase in bare ground when a decrease or no change was expected (column **v**, Table 17; i.e. inferred small loss of landscape function given prior rainfall on a weighted basis). On the positive side of the ledger, only five (of 42) sub-IBRA – season combinations showed a decrease or no change in bare ground when no change or an increase was expected (symbol ^, Table 17; i.e. inferred increase in landscape function given recent seasonal conditions). All of this improvement was in the early period (up to 1997, and for only three sub-IBRAs). Increase or no change in bare ground against seasonal expectations (i.e. the 17 sub-IBRA – season combinations in column **v**, Table 17) was spread throughout the period but concentrated in the 1991-93 and 1997-99 periods.

The widely publicised recent death of Mitchell grass probably partly accounts for unexpected change in bare ground (and inferred loss of landscape function) across four sub-IBRAs in the 2001-03 period. (Unexpected change relates to no change or an increase in bare ground when a reduction or no change was expected based on rainfall alone.)

Table 17. Summary of change results for the Mitchell Grass Downs bioregion.

SubIBRA	Sub #	% area	No Periods when Bare Ground Changed				
			W	v	~	^	M
Barkly Tableland	208	100		3	3		
Central Downs	213	99		1	3	2	
Georgina Limestone	209	99		2	4		
Kynuna Plateau	211	97		3	3		
Northern Downs	212	97		2	3	1	
Southern Wooded Downs	214	95		2	2	2	
Southwestern Downs	210	99		4	2		

Mount Isa Inlier

Twelve (of 18) sub-IBRA by season combinations had changes in bare ground (and associated inferred landscape function) in line with preceding seasonal conditions (symbol ~, Table 18). Perhaps of some concern, five sub-IBRA – season combinations were interpreted as experiencing relative loss in landscape function (column **v**) while only one (Mount Isa Inlier in the 1993-95 period) showed the reverse result (relative increase given prior seasonal conditions, column ^). This assessment is based on, for the first case, no change or an increase in bare ground when prior rainfall indicated a decrease or no change should have occurred, and for the second, a decrease or no change in bare ground when no change or an increase was expected based on rainfall.

The apparent seasonally-adjusted adverse trend may not be entirely due to grazing management. All three sub-IBRAs had >15% of their total area burnt in the 2001 calendar year so increased bare ground in the 2001-03 period may have been partly a residual effect of fairly extensive wildfire one to two years previously.

Table 18. Summary of bare ground change results for the Mount Isa Inlier bioregion.

SubIBRA	Sub #	% area	No Periods when Bare Ground Changed				
			W	v	~	^	M
Mount Isa Inlier	271	99		1	4	1	
Southwestern Plateaus & Floodouts	269	100		2	4		
Thorntonia	270	84		2	4		

Mulga Lands

The dominant trend for sub-IBRAs within the Mulga Lands bioregion was movement in levels of bare ground (and inferred landscape function) in line with prior seasonal conditions (symbol ~, Table 19). For this column, 32 (of 66) sub-IBRA – season combinations had changes in bare ground in line with preceding seasonal conditions. A further 21 sub-IBRA – season combinations had an inferred decline in landscape function over various periods (particularly 1999-2001) when bare ground increased or remained relatively stable while prior rainfall indicated that it should have remained stable or decreased (column **v**, Table 19). During the 1995-97 period, two sub-IBRAs (Cuttaburra-Paroo and Urisino Sandplains) had increased levels of bare ground when a decrease would have been expected (i.e. loss of landscape function based on prior rainfall, column **W** in Table 19).

A relatively small number of sub-IBRA – season combinations (8 of 66) had a small relative increase in landscape function given prior seasonal conditions (i.e. the level of bare ground was unchanged or decreased when an increase or no change would have been expected; symbol ^, Table 19). All of this small improvement occurred in the 1991-95 period which included some dry years from 1992-94. A further three sub-IBRAs (in 1991-93) had decreased levels of bare ground when preceding rainfall suggested an increase (column **W**, Table 19).

The inferred general loss of landscape function across the Mulga Lands bioregion over the latter part of the 1991-2003 reporting period sets this region apart from previously reported bioregions.

Table 19. Summary of change results for the Mulga Lands bioregion.

SubIBRA	Sub #	% area	No Periods when Bare Ground Changed				
			W	v	~	^	M
Cuttaburra-Paroo	228	**57**	1	2	2	1	
Eastern Mulga Plains	223	100		2	2	2	
Langlo Plains	227	75		1	4		1
Nebine Plains, Block Range	224	**66**		3	2	1	
North Eastern Plains	225	**66**		1	3	1	1
Northern Uplands	230	**59**		2	3	1	
Urisino Sandplains	217	89	1	2	3		
Warrego Plains	226	89		2	3		1
West Balonne Plains	215	77		1	4	1	
West Bulloo	216	87		2	3	1	
West Warrego	229	98		3	3		

Bolded figures indicate where less than 75% of the sub-IBRA was assessed for change in bare ground.

Simpson Strzelecki Dunefields

This bioregion appears to have some similarity with the Mulga Lands in terms of seasonally-adjusted loss of landscape function, again concentrated towards the end of the reporting period (2001-03) and focussed on the Strzelecki Desert, Western Dunefields sub-IBRA. Nine (of the 18) sub-IBRA – season combinations had movements in levels of bare ground in accord with seasonal expectations (i.e. no adverse implications for landscape function; symbol ~, Table 20). However, eight combinations had no change or an increase in bare ground when a decrease or no change would have been expected, based on rainfall (column **v**). This is inferred as seasonally-adjusted loss of landscape function.

Table 20. Summary of change results for the Simpson Strzelecki Dunefields bioregion.

SubIBRA	Sub #	% area	No Periods when Bare Ground Changed				
			W	v	~	^	M
Dieri	309	94		2	3	1	
Simpson Desert	308	100		3	3		
Strzelecki Desert, Western Dunefields	311	100		3	3		

Maps of change class by bioregion

The frequency of occurrence of periods during which changes in bare ground (and inferred landscape function) were in line with seasonal expectations or counter to expectations are shown in Fig. 18. The map of numbered sub-IBRAs in Fig. 1 (page 10) may assist interpretation of change.

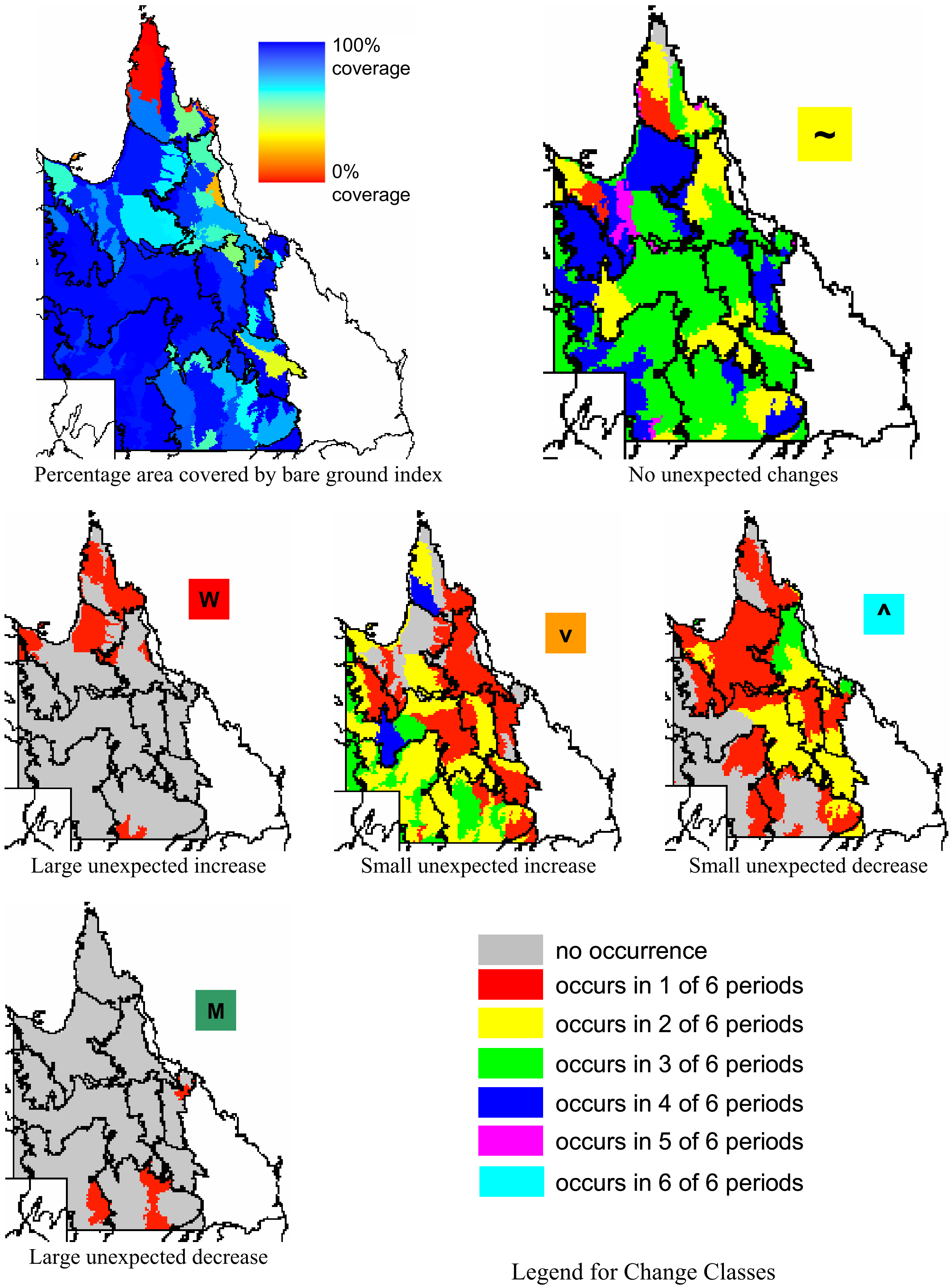


Figure 18. Percentage coverage of bare ground index and frequency of occurrence of bare ground change classes based on preceding seasonal conditions..

Validating bare-ground change classes

Rob Hassett's extensive Rapid Mobile Data Collection (RMDC) dataset may provide suitable data for validating the analyses of change in levels of bare ground to indicate change in landscape function. Datasticians reported change in the RMDC biomass data using a similar procedure to that used for the bare-ground dataset (see Datasticians' report *Biomass report.doc*).

The degree of correspondence between Datasticians' reporting of the RMDC data and Bastin's revised analysis of the bare-ground dataset is reported for selected sub-IBRAs within the Mulga Lands bioregion. This bioregion was selected because it appears to have suffered loss of landscape function, based on seasonally-interpreted changes in bare ground, towards the end of the ACRIS reporting period (Tables 7 and 19). This validation exercise is not intended to test the relationship between trends in pasture biomass and bare ground for all sub-IBRAs where there are suitable RMDC data.

Mulga Lands bioregion

Datasticians reported (in their RMDC "Results", page 5 of *Biomass report.doc*) that:

"Across all sub-IBRAs and all years, biomass levels increased or did not change (when past seasons suggested the potential for decline) more frequently than they declined. More sub-IBRAs had increases in biomass when there was a clear potential for decline, than had decreases in biomass (given the potential for improvement) in 1998/99, 2002/03, 2003/04 and 2004/05. In 2001/02, all sub-IBRAs where comparisons were possible either had a decline or no change in biomass when seasonal conditions would suggest that improvement should have occurred. In most years, the biomass levels in most sub-IBRAs were stable (there was no change in biomass or change was consistent with the past season's conditions)."

However, further down page 5 of their report, they noted that:

"In the same period (2003-2004 and 2004-2005), a number of sub-IBRAs further south and west, from the Mulga Lands and Mitchell Grass Downs IBRAs, (typically with lower average rainfalls) showed the opposite pattern: decreases not predicted by seasonal conditions."

That is, Datasticians' analysis of the RMDC data showed that some sub-IBRAs in the Mulga Lands (and Mitchell Grass Downs) bioregion had decreased levels of pasture biomass during periods when rainfall (compared to the long-term record) suggested that increased biomass should have been present (Table 21). This general result seems to conform with what is reported here; i.e. taking account of prior rainfall, increased levels of bare ground (and inferred loss of landscape function) leading up to the 2003-2005 period.

Such trends may be linked to the widespread use of mulga trees as a fodder source in droughts. Conditions have been very dry for several years since 2002 with large numbers of deaths of sheep and kangaroos from starvation-related causes.

Table 21. Change in pasture biomass for sub-IBRAs within the Mulga Lands bioregion.

NB: table entries extracted from Datasticians' Table 2 of *Biomass report.doc*. Change classes are shown below the table. The West Bulloo sub-IBRA is bolded as the only region with a moderate to high level of sampling (>200 assessments in the sub-IBRA in the last three periods).

SubIBRA name	Sub-IBRA no.	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/01	2001/02	2002/03	2003/04	2004/05
Cuttaburra-Paroo	228												~
Eastern Mulga Plains	223									v			~
Langlo Plains	227											^	~
Nebine Plains, Block Range	224												
North Eastern Plains	225						~				~	v	~
Northern Uplands	230										^	~	~
Urisino Sandplains	217												~
Warrego Plains	226									v	M	v	~
West Balonne Plains	215									v			v
West Bulloo	216									~	~	v	~
West Warrego	229										M	v	~

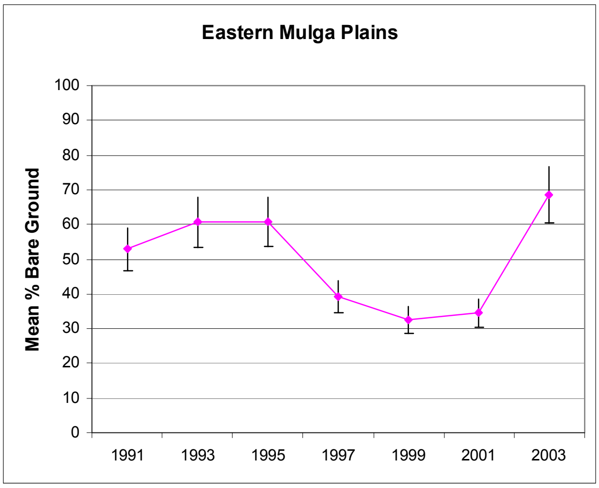
Change classes:

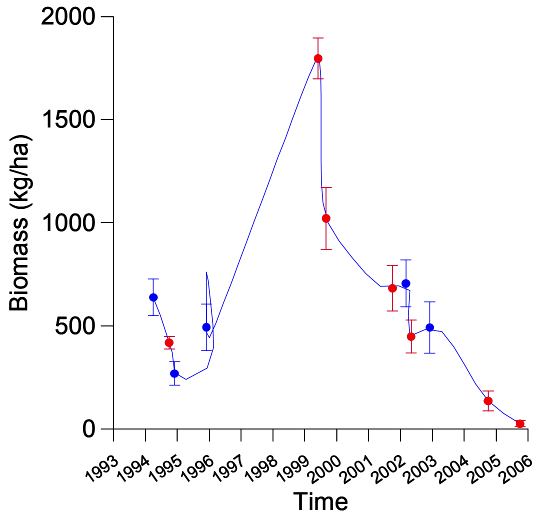
M	Increase in biomass when the past season would indicate a clear potential for relatively low levels of biomass
^	Increase or no change in biomass when the past season would indicate a clear potential for moderate or low levels
~	Stable, no change in biomass or a change consistent with the past season's conditions
v	Decline or no change in biomass when seasonal conditions would suggest the potential for moderate or high levels
W	Decline in biomass when seasonal conditions would suggest the potential for relatively high levels of biomass

Eastern Mulga Plains

Profiles of bare ground (converse of ground cover) and pasture biomass are shown in Fig. 19. The bare ground data show the mean level of bare ground and the median 'difference' variable applied as 'error' bars. The graph is a copy of that presented for the Eastern Mulga Plains in Bastin's Appendix 1 (see *Cover-Report_Bastin-modified_Nov06.doc*). The biomass data (right hand graph) have been extracted from Datasticians' *Biomass report.doc* (page 82). This graph (Fig. 19) shows (following text extracted from Datasticians' report):

"The mean and SE for each sampling occasion. Blue symbols represent those records that were made in the summer months (October-March) and could not be used for determining biomass change between years (with the exception of October data, which were later included). Red symbols represent those records that were made in the winter months (April-September) and could be used for determining biomass change between years. We have fitted a spline function through the mean biomass values for all years for which there were records in each subIBRA. The function does not model biomass values in the intervening periods, but is intended solely to show the connection between sampling occasions."





change in bare ground change in pasture biomass

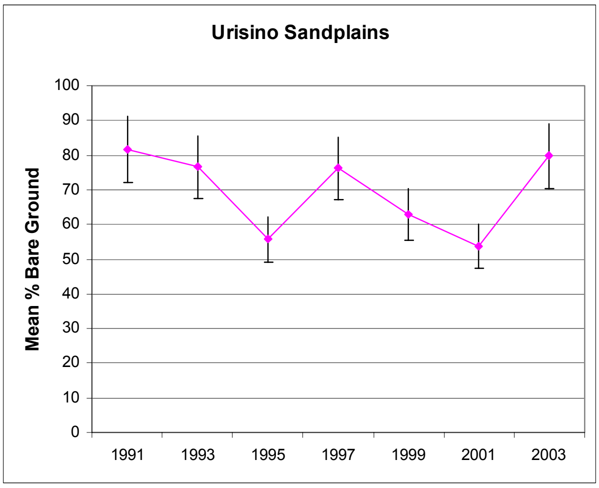
Figure 19. Change in levels of bare ground (left) and pasture biomass (right) for the Eastern Mulga Plains sub-IBRA.

There is a reasonably strong relationship between changes in bare ground (converse of ground cover) and biomass (although the RMDC data are sparse for this sub-IBRA, ≤60 records from 2000-01 on). Estimated biomass declined sharply from 1999 onwards, although less steeply since 2000. The percentage of bare ground increased considerably between 2001 and 2003 (although some of this change was expected given below-average weighted rainfall in this period). Both datasets suggest loss of landscape function, although some of this decline was in line with seasonal expectations and may recover when good rainfall occurs again.

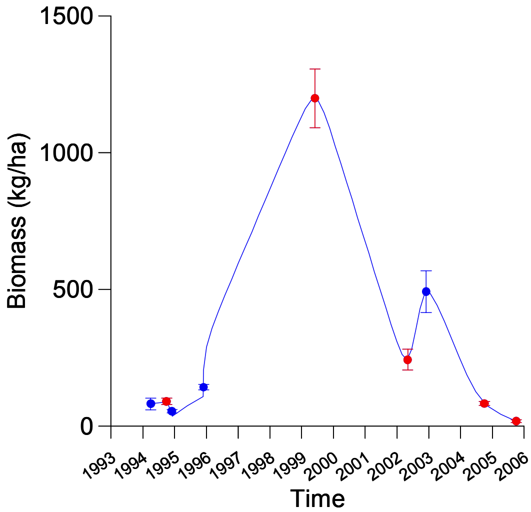
Urisino Sandplains

Similar profiles of bare ground and pasture biomass are shown for the Urisino Sandplains sub-IBRA in Fig. 20.

The pattern of change for these two datasets shows some similarity with that for the Eastern Mulga Plains sub-IBRA. Discounting the 2003 summer assessment, pasture biomass declined from 1999 onwards (although in the absence of estimates for 2000 and 2001, it is not possible to say if this decrease was continuous, and indeed, is unlikely given the amount of rainfall). The percentage of bare ground (converse of ground cover) initially decreased (1999-2001) and then increased (2001-03). The latter period of increase is aligned with continuing decline in biomass and supports the inferred loss of landscape function drawn from the bare ground data (although some of this decline was within seasonal expectations, Tables 7 and 19).



change in bare ground



change in pasture biomass

Figure 20. Change in levels of bare ground (left) and pasture biomass (right) for the Urisino Sandplains sub-IBRA.

Lack of correspondence between the two datasets during the 1999-2001 period was probably due to lack of data points. The rainfall data show that 2000 was a wet year (by far the highest annual rainfall during the 1992-2005 period, see Datasticians' graph, page 87 of *Biomass report.doc*) and pasture biomass, if assessed that year, would likely have been higher than that estimated in 1999. It is also probable that some of this elevated biomass would have carried over to 2001, a year with rainfall in the middle tercile (i.e. 'average' rainfall). Presuming that 2000 and 2001 were years of higher biomass (and that the large reduction to the 2002 value occurred between 2001 and 2002), then the anticipated change in biomass between 1999 and 2001 would better align with that shown for bare ground (left hand panel, Fig. 20). That is, pasture biomass was probably high (and maybe increased) between 1999 and 2001, better aligning with the graphed decrease in bare ground over this period.

Taking account of the various suppositions, inferences and interpolations made using these two sub-IBRAs as examples, it is possible to show that the RMDC biomass data can be used to validate trends in bare ground and that inferences about changes in landscape function drawn from the bare-ground data may have some basis. If making further comparisons elsewhere, one should also take account of sample size (and spatial distribution) within the various sub-IBRAs covered by multitemporal RMDC data.

Example Sub-IBRA Profile of Ground Cover

The following example is extracted from Appendix One of Bastin's report, *Cover-Report_Bastin-modified_Nov06.doc*. It is reproduced here to show the style of reporting for seasonally interpreted change in levels of bare ground for rangeland sub-IBRAs in Queensland.

Using Datasticians' reporting format, Bastin graphed change in ground cover for each sub-IBRA where data were available. He also applied 'error' bars to show the level of significance using the median difference variable (23.445%) of the mean level of bare ground.

<u>Cover of bare ground</u>: mean, ± 'difference variable', for each sampling occasion. The 'difference variable' = 23.445% of the average of the means for that sub-IBRA (across all years). Mean levels of bare ground are treated as indistinguishable if the means ± 'difference variable' overlap, i.e. if the difference between spatially averaged levels of bare ground between years is <23.445% of the average of the ten means. The time axis is labelled by the end year of the comparison period (i.e. 1991-93 period labelled as 1993).

<u>Rainfall</u>: the plotted values cover each two-year period preceding each image date (i.e. 1991 to 1993, 1993 to 1995, 1995 to 1997, 1997 to 1999, 1999 to 2001, 2001 to 2003). Image date is considered to be August in each of these years. Rainfall for various periods during each two-year period was weighted:
- May to August of image-date year * 1.0
- preceding summer (November to April) * 0.9
- preceding winter (May to October of previous year) * 0.5
- summer (November to April) of previous year * 0.2.

Terciles based on two-year rainfall accumulated and weighted in the same way between 1890-1892 and 2003-05 are shown with dashed lines.

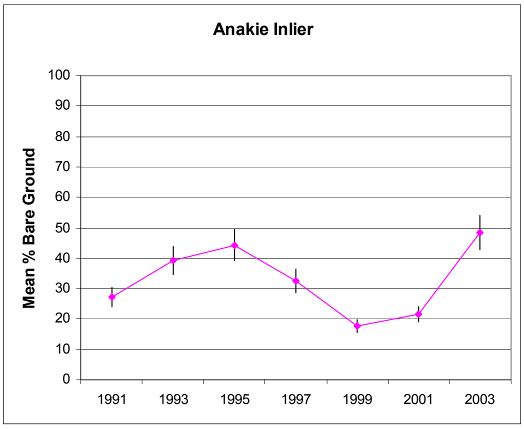
Bastin produced a similar table to that used by Datasticians to summarise rainfall and bare-ground change between years (tercile value for rainfall, two-yearly change in ground cover) and added the change state for each two-year period. The percentage of the sub-IBRA used to calculate the bare-ground figures is also shown (areas with woody FPC ≤ 20% in 2003). This percent-area figure is highlighted where <75% of the sub-IBRA's area was included.

The sub-IBRAs are organised alphabetically within the corresponding IBRA, which are also listed alphabetically (example output for one sub-IBRA shown on the following page, the complete profiling of sub-IBRAs can be found in Bastin's report on the CD that has compiled material for Queensland).

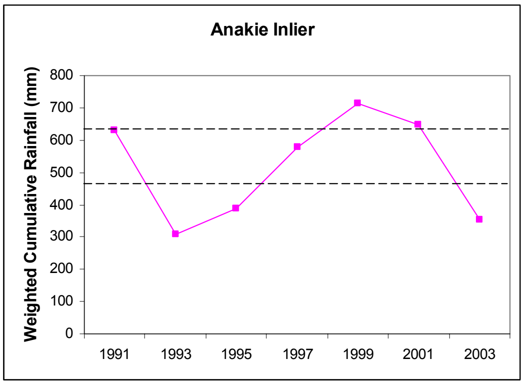
Sub-IBRA name: Anakie Inlier

IBRA: Brigalow Belt North

<u>Bare ground</u>



<u>Cumulative rainfall</u>



<u>Bare ground change</u> (75% of sub-IBRA included)

Period	Season Condition Tercile	Bare ground Change	Change rating
1989 – 1991	H		
1991 – 1993	L	I	~
1993 – 1995	L	N	^
1995 – 1997	M	D	^
1997 – 1999	H	D	~
1999 – 2001	H	N	v
2001 – 2003	L	I	~

Tercile H — Highest tercile (above-average weighted rainfall)
Tercile M — Middle tercile (about-average weighted rainfall)
Tercile L — Lowest tercile (below-average weighted rainfall)

Appendix Two. Aussie-GRASS results; critical stock forage, sustainable management theme

Table 22. Aussie-GRASS simulated space- and time-averaged pasture utilisation for the periods 1976-90 and 1991-2005.

Bioregion	Sub-IBRA	% Utilisation 1976-1990 (t_1)	% Utilisation 1991-2005 (t_2)	% Absolute Change (t_2-t_1)	% Relative Change	Safe Level of Utilisation	1991-2005 Rated Level Sustainability	Trend [1] 1976-90 cf 1991-2005
Brigalow Belt North	Townsville Plains	18.02	24.63	6.61	36.66	32	Yes	Down
	South Drummond Basin	20.81	28.29	7.48	35.97	32	Yes	Down
	Bogie River Hills	17.74	21.63	3.89	21.93	32	Yes	Down
	Cape River Hills	18.3	20.93	2.63	14.39	32	Yes	Down
	Beucazon Hills	15.93	21.67	5.74	36.05	32	Yes	Down
	Wyarra Hills	17.84	25.43	7.59	42.56	32	Yes	Down
	Northern Bowen Basin	18.54	25.9	7.35	39.64	32	Yes	Down
	Belyando Downs	20.31	25.91	5.61	27.62	32	Yes	Down
	Upper Belyando Floodout	20.65	25.63	4.98	24.13	32	Yes	Down
	Anakie Inlier	17.66	27.68	10.02	56.76	32	Yes	Down
Brigalow Belt South	Claude River Downs	20.24	27.58	7.34	36.27	32	Yes	Down
	Carnarvon Ranges	18.14	24.96	6.82	37.59	32	Yes	Down
	Southern Downs	27.63	27.38	-0.25	-0.9	32	Yes	Neutral
	Buckland Basalts	22.14	29.07	6.93	31.31	32	Yes	Down
	Narrandool	35.86	32.93	-2.93	-8.16	32	Marginal	Up
Channel Country	Sturt Stony Desert	16.43	21.64	5.21	31.69	10	Low	Down
	Goneaway Tablelands	27.07	27.71	0.64	2.37	10	Low	Neutral
	Cooper Plains	20.58	23.79	3.21	15.59	10	Low	Down
	Lake Pure	17.61	27.46	9.85	55.92	10	Low	Down
	Noccundra Slopes	25.87	36.44	10.57	40.88	10	Low	Down
	Tibooburra Downs	40.51	42.03	1.52	3.76	10	Low	Neutral
	Bulloo Dunefields	42.84	45.71	2.88	6.71	10	Low	Down
Cape York Peninsula	Coen - Yambo Inlier	5.81	5.59	-0.23	-3.89	8	Yes	Up
	Starke Coastal Lowlands	9.95	9.41	-0.54	-5.43	8	Marginal	Up
	Cape York - Torres Strait	1.05	0.76	-0.29	-27.72	8	Yes	Up
	Jardine - Pascoe Sandstones	6.83	7.4	0.57	8.42	8	Yes	Down
	Battle Camp Sandstones	5.36	5.84	0.48	8.92	8	Yes	Down
	Laura Lowlands	3.8	3.75	-0.05	-1.34	8	Yes	Neutral
	Weipa Plateau	7.58	7.58	0.01	0.09	8	Yes	Neutral

Bioregion	Sub-IBRA	% Utilisation 1976-1990 (t_1)	% Utilisation 1991-2005 (t_2)	% Absolute Change (t_2-t_1)	% Relative Change	Safe Level of Utilisation	1991-2005 Rated Level Sustainability	Trend [1] 1976-90 cf 1991-2005
	Northern Holroyd Plain	6.45	5.86	-0.59	-9.11	8	Yes	Up
	Coastal Plains	8.25	6.28	-1.97	-23.91	8	Yes	Up
Desert Uplands	Prairie - Torrens Creek Alluviums	19.12	24.06	4.94	25.85	10	Low	Down
	Alice Tableland	15.03	24.49	9.45	62.88	10	Low	Down
	Cape-Campaspe Plains	19.95	24.07	4.13	20.68	10	Low	Down
	Jericho	16.13	25.73	9.6	59.52	10	Low	Down
Darling Riverine Plains	Culgoa-Bokhara	33.71	32.19	-1.52	-4.5	21	Low	Neutral
	Warrambool-Moonie	36.15	32.54	-3.6	-9.96	21	Low	Up
	Castlereagh-Barwon	27.07	25.55	-1.52	-5.61	21	Marginal	Up
Einasleigh Uplands	Georgetown – Croydon	13.81	14.31	0.5	3.62	19	Yes	Neutral
	Kidston	11.66	12.23	0.57	4.86	19	Yes	Neutral
	Hodgkinson Basin	10.07	9.46	-0.61	-6.08	19	Yes	Up
	Broken River	18.31	20.44	2.13	11.62	19	Marginal	Down
	Undara - Toomba Basalts	17.63	17.14	-0.49	-2.78	19	Yes	Neutral
	Herberton – Wairuna	15.68	16.62	0.94	5.99	19	Yes	Down
Gulf Plains	Karumba Plains	7.49	8.23	0.75	9.96	8	Marginal	Down
	Wellesley Islands	1.33	1.18	-0.15	-11.49	8	Yes	Up
	Armraynald Plains	14.03	10.61	-3.42	-24.37	8	Marginal	Up
	Woondoola Plains	16.51	12.78	-3.74	-22.64	8	Marginal	Up
	Mitchell - Gilbert Fans	7.74	8.81	1.07	13.83	8	Marginal	Down
	Claraville Plains	11.08	12.18	1.1	9.92	8	Marginal	Down
	Holroyd Plain - Red Plateau	9.41	9.02	-0.4	-4.23	8	Marginal	Neutral
	Doomadgee Plains	12.72	11.54	-1.18	-9.27	8	Marginal	Up
	Donors Plateau	17.17	14.56	-2.6	-15.15	8	Low	Up
	Gilberton Plateau	12.31	12.67	0.37	2.98	8	Marginal	Neutral
Mitchell Grass Downs	Barkly Tableland	11.01	9.95	-1.06	-9.62	21	Yes	Up
	Georgina Limestone	20.87	20.27	-0.6	-2.86	21	Yes	Neutral
	Southwestern Downs	22.43	21.41	-1.02	-4.55	21	Marginal	Neutral
	Kynuna Plateau	28.61	27.27	-1.34	-4.69	21	Low	Neutral
	Northern Downs	25.65	18.59	-7.06	-27.53	21	Yes	Up
	Central Downs	25.55	23.18	-2.37	-9.28	21	Marginal	Up
	Southern Wooded Downs	30.98	26	-4.98	-16.08	21	Marginal	Up
Mulga Lands	West Balonne Plains	38.89	33.95	-4.94	-12.7	20	Low	Up
	West Bulloo	29.85	33.78	3.93	13.17	20	Low	Down

Bioregion	Sub-IBRA	% Utilisation 1976-1990 (t_1)	% Utilisation 1991-2005 (t_2)	% Absolute Change (t_2-t_1)	% Relative Change	Safe Level of Utilisation	1991-2005 Rated Level Sustainability	Trend [1] 1976-90 cf 1991-2005
	Urisino Sandplains	42.13	47.92	5.78	13.72	20	Low	Down
	Eastern Mulga Plains	36.83	34.77	-2.06	-5.6	20	Low	Up
	Nebine Plains- Block Range	39.25	41.5	2.25	5.74	20	Low	Down
	North Eastern Plains	27.58	29.45	1.87	6.78	20	Low	Down
	Warrego Plains	34.95	32.23	-2.73	-7.8	20	Low	Up
	Langlo Plains	33.24	32.74	-0.5	-1.5	20	Low	Neutral
	Cuttaburra-Paroo	35.84	38.33	2.48	6.93	20	Low	Down
	West Warrego	35.33	38.19	2.85	8.08	20	Low	Down
	Northern Uplands	32.16	31.87	-0.28	-0.88	20	Low	Neutral
Mount Isa Inlier	Southwestern Plateaus - Floodouts	19.18	15.57	-3.6	-18.78	10	Low	Up
	Thorntonia	11.63	10.04	-1.59	-13.71	10	Marginal	Up
	Mount Isa Inlier	21.72	21.62	-0.1	-0.44	10	Low	Neutral
Simpson Strzelecki Dunefields	Simpson Desert	3.97	4.09	0.12	3.01	10	Yes	Neutral
	Dieri	5.87	4.59	-1.28	-21.8	10	Yes	Up
	Strzelecki Desert- Western Dunefields	24.18	25.27	1.09	4.52	10	Low	Neutral

[1] Trend is inferred consequences for critical stock forage and sustainable management based on the level of pasture utilisation at time 2 and change in utilisation between time 1 and time 2.