

Great Barrier Reef

Second Report Card 2010
Reef Water Quality Protection Plan
Methods



Australian Government



Queensland Government

Great Barrier Reef

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Reef Water Quality Protection Plan

Methods

This section details how the key indicators were measured. Ongoing improvements will be made to the methods and data sources to improve the accuracy and precision of reporting over time.

Management practices

ABCD management practice frameworks describe a continuum of practices that are recommended to maintain and/or improve water quality and land resource condition. The assembly of specific management practices together describe a management system.

For cropping systems, the ABCD framework details management practices and systems for managing nutrients, herbicides and soils. For grazing systems, the framework describes practices impacting upon land condition, soil erosion and water quality. Gathering this information across the landscape will help to prioritise areas which need greater support to improve landholders' management practices.

Management practice system ABCD classes and definitions for sugarcane, horticulture and grains (Source: Drewy J, et al., 2008)					
Class	Description of practice	Farm management plan	Community and industry standard	Effect on resource condition	Effect on profitability
A	Cutting-edge practices that require further validation of environmental, social and economic costs/benefits	Yes, develops and tests innovative technology.	When validated is an acceptable practice for the long term. (May not be universally endorsed as feasible by industry and community.)	When validated, practice likely to achieve long term resource condition goals if widely adopted.	When validated, improves profitability in the medium to long term. (May reduce profitability during the transition.)
B	Currently promoted practices often referred to as 'Best Management Practices'.	Yes, and utilises common technology.	Acceptable practice for the medium term.	Practice likely to achieve medium term resource condition goals if widely adopted.	Improves profitability in the short to medium term.
C	Common practices. Often referred to as 'Code of Practice'.	Basic.	Acceptable practice today but may not be acceptable in medium term.	Practice unlikely to achieve acceptable resource condition goals if widely adopted.	Decline of profitability in the medium to long term.

D	Practices that are superseded or unacceptable by industry and community standards.	None.	Superseded or unacceptable practice today.	Practice likely to degrade resource condition if widely adopted.	Decline of profitability in the short to medium term.
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Management practice system ABCD classes and definitions for grazing				
Management practice category	A Practices are highly likely to maintain land in good (A) condition and/or improve land in lesser condition	B Practices are likely to maintain land in good or fair (A/B) condition and/or improve land in lesser condition	C Practices are likely to degrade some land to poor (C) condition or very poor (D) condition	D Practices are highly likely to degrade land to poor (C) or very poor (D) condition
Soil erosion and water quality risk associated with grazing land management*	Very low risk	Low risk	Low to moderate risk	Moderate to high risk

* While a number of factors affect erosion risk and individual situations will vary, the dominant factor in all grazing land is stocking rate and grazing pressure management to maintain adequate groundcover levels to minimise erosion. Other factors (spelling periods consistent with pasture recovery, management of frontage etc) are also important.

It is important to note that not all improved management practices result in a change in management practice system (rated from A to D for reporting purposes). This means that the number of landholders estimated to have improved management practices will typically be greater than the number estimated to have improved management systems.

The ABCD management systems in the Second Report Card are the best estimates given the data available at the time. Measures are in place to improve the rigour and confidence in ABCD management system estimates and the drivers of management change for future report cards.

The 2008-2009 baseline for management practice information in the First Report Card was based on limited data and, therefore, was of low confidence. As part of the Paddock to Reef program, new information has been collected through rigorous industry surveys, validated on ground. This has provided refined baseline data for 2008-2009 which is far more accurate and useful at the local scale. This Second Report Card uses the refined baseline and compares it against data collected in 2009-2010 using the same method.

These estimates of ABCD management system status assume that landholder management practices remain static or improve. The methods of data collection, collation and analysis generally do not identify any regression in management practice. As sample size and confidence improves over time, it is possible regressions in practice will be detected – if they occur.

Summary data sources used in estimating the 2009 Baseline and Second Report Card ABCD management system status				
	Horticulture	Grains	Grazing	Sugarcane
Establishment of baseline ABCD system status	Industry driven Farm Management System: Growcom FMS	Industry driven Farm Management System: Grains BMP	Hindcast from 2011 industry benchmarks. Randomised grazier survey. Supporting data from Grazing BMP program (Fitzroy) and Reef Catchments to improve confidence. Reviewed by regional experts.	Hindcast from 2011 industry benchmarks. Industry wide study on management practices. Reviewed by experts at regional scale, supported with data from Reef Rescue program.
Second Report Card ABCD system status	As above.	As above.	Identify improvements that have occurred since the baseline estimation, from various sources.	Identify improvements that have occurred since the baseline estimation, mostly through the Reef Rescue program.
Confidence for Second Report Card	Good.	Good.	Good (except moderate for Burnett Mary).	Good (except moderate for Burnett Mary).

Grazing

The ABCD management practice framework for the grazing industry describes management practices based on their likely impacts upon land condition, soil erosion and water quality. While there is a relationship between the processes contributing to sediment loss and the loss of nutrients and herbicides, the framework does not explicitly account for practices relating to nutrient and herbicide management in rangelands grazing systems. These practices are referred to in a version of the framework specifically tailored for use in intensive wet coastal grazing landscapes.

Data collection and synthesis

Baseline data collection and synthesis

The 2008-2009 baseline for management practice information in the First Report Card was based on limited data and, therefore, was of low confidence. As part of the Paddock to Reef program, new information has been collected through a survey and validated on ground:

- Surveys were conducted on a one-on-one basis by extension officers from the Queensland Department of Agriculture, Fisheries and Forestry.
- Landholders were selected from the grazier population in each region through a spatial randomisation process.
- Sampling was stratified by major sub-catchment in each region and by property size. Property size was stratified into small, medium and large based on the characteristics of the region.
- Survey responses were anonymously collated and analysed to provide estimates of overall management system status. These results were reviewed by grazing extension officers, considering any other relevant information.

Second Report Card data collection and synthesis

Estimates of management practice change within the grazing industry from July 2008 to June 2010 were collated from a range of sources:

- Reef Rescue Water Quality Grants for on-ground implementation of works
- evaluation of discrete research, development and evaluation projects, including training provided by the former Department of Employment, Economic Development and Innovation and AgForward
- training and professional advice provided by private sector consultants and training providers (through the Australian Government's FarmReady program)
- many information and awareness activities (e.g. field days) conducted by a range of providers across regions.

The data gap in the Second Report Card is management change which graziers may have implemented without direct influence or assistance. As such, the results presented are likely to be a conservative estimate of the degree of management practice improvement.

Collated datasets were reviewed by expert panels at the regional level. These expert panels identified data gaps and errors, and provided advice on the appropriate interpretation of management change resulting from the various drivers of management practice change. This review developed a small suite of change drivers which contributed to management practice improvements, and a further subset which are credited with achieving overall management system improvements.

Management system improvements are restricted to:

- completed Reef Rescue Water Quality grants projects (generally including training plus hard infrastructure improvements)
- a smaller group of highly intensive training/consultancy courses
- a small selection of Natural Resource Management body and/or State Government extension projects with documented impacts of management system change.

Sugarcane

Improved land management practices used in Reef Plan evaluation are described in a study commissioned by Canegrowers Ltd in 2010 (GHD, 2010) with funding from the Reef Rescue program.

There were no consistent industry wide systems in place for collecting data on improved land management practices in the sugarcane industry between 2008 and 2010. As such, the only reliable

source of data is the Reef Rescue Water Quality Grants program. Therefore, the reported number of growers adopting improved practices is likely to be a conservative estimate.

Management practice framework

The ABCD management practice framework for the sugarcane industry includes practices relating specifically to nutrients, herbicides, soils, on-farm water management (irrigation and drainage), record keeping and planning.

Data collection and synthesis

Baseline data collection and synthesis

Management system status estimates for sugarcane in the First Report Card were sourced from a study completed on behalf of Canegrowers Ltd in 2010 (GHD 2010). An industry wide survey of sugarcane farmers was conducted again in 2011. Results of this latter study have become the reference point for describing management system status in the sugarcane sector, with revised 2009 baseline estimates of ABCD management system status hindcast from the 2011 estimate.

The 2011 study was a collaboration involving the industry body Canegrowers Ltd, each of the regional Natural Resource Management bodies, local sugar mills and agronomic service providers. It used the same questions as the 2010 study which were developed to provide estimates of management status aligned with the industry wide management practice framework. The main advantages offered by the 2011 survey are:

- Improved process for developing regional estimates of ABCD management systems in use for nutrient, pesticide and soils management.
- The 2011 study collected data on the actual area managed as per specific practices. The previous study allowed only for estimates of the percentage of growers corresponding to each management level, and no corresponding area estimate.
- The 2011 study allowed spatial discrimination at the level of sub-catchment or sugarcane mill area within regions. The previous study allowed only for ABCD estimates at the whole-of-region level.
- The 2011 study is based on a sample size of approximately 2840 growers, or 75 per cent of the total number.

Second Report Card data collection and synthesis

Data on management practice change within the sugarcane sector from July 2008 to June 2010 was collated from a range of sources including:

- Reef Rescue Water Quality Grants: Natural Resource Management bodies brokering access to these incentives estimate the management system change resulting from the grant investment.
- Training and professional advice provided by private sector consultants and training providers, Canegrowers Ltd, regional Natural Resource Management bodies, and BSES Ltd (in many cases funded through the Reef Rescue program).
- Fertiliser sales volumes.
- An expert review process facilitated and coordinated by Canegrowers Ltd and regional Natural Resource Management bodies. This process drew upon more detailed data (where available) from local industry organisations and took account of local expert advice.

The data gaps for Second Report Card are:

- Management change which sugarcane growers have implemented without direct influence or assistance from regional Natural Resource Management bodies and the Reef Rescue initiative.
- Regional Natural Resource Management bodies, through the Reef Rescue program, have in several instances directed funding toward projects which are likely to have industry wide benefits.
- Evaluation of any early impact of the Queensland Government's Great Barrier Reef Protection Amendment Act 2009 (the Reef Protection Package), which came into effect on 1 January 2010 and information relating to any early and immediate impacts is not available.

Management system changes identified in this Second Report Card are generally restricted to those identified by regional Natural Resource Management bodies as an outcome of completed Reef Rescue Water Quality Grants projects (generally including training plus hard infrastructure improvements). The only instance where additional evidence was used was in the Wet Tropics region, where multiple lines of evidence showed progress from D level nutrient management systems in a significant portion of the grower population. This evidence included:

- 212 growers completed nutrient management training facilitated by Terrain Natural Resource Management and BSES Ltd, and funded by the Reef Rescue program (additional to the growers obtaining Water Quality Grants).
- An expert opinion review process led by Canegrowers in the Wet Tropics region indicated less than 10 per cent of growers were using D level nutrient management practices.
- Anecdotal advice from local agronomists indicated significant change in nutrient management practice due to concerted and targeted extension effort and the advent of the Reef Protection Package.
- Documented fertiliser sales volumes which indicate that mean nitrogen and phosphorus fertiliser rates have steadily declined to approximate the amount calculated to achieve district long term yield potential.

Horticulture

Improved land management practices are described within the Growcom Farm Management System (FMS) and Natural Resource Management body ABCD management practice frameworks.

Evidence of growers adopting improved management practices is limited to the number of Reef Rescue Water Quality Grants projects completed in 2008-2009 and 2009-2010. Therefore, the reported number of growers adopting improved practices is likely to be a conservative estimate. Reporting for the 2011 Report Card will include other lines of evidence relating to voluntary adoption of improved practice including:

- Growcom FMS
- industry training provided by Growcom
- industry training provided by private sector consultants
- a survey of horticulture growers conducted by Growcom with support from regional Natural Resource Management bodies.

Management practice frameworks

Practical application of ABCD management practice frameworks in an industry as diverse as horticulture means there are variations in the practices described for different crops or climatic zones. The Burnett Mary, Fitzroy, Mackay Whitsunday and Cape York regions share a common ABCD

management practice framework for horticulture. In the Burdekin region, the ABCD framework developed and used by NQ Dry Tropics specifically serves the regional production system, while remaining similar to other frameworks. In the Wet Tropics, Terrain Natural Resource Management uses separate management practice frameworks to describe practices in bananas, pawpaws and a combined 'multicrop' category.

Data collection and synthesis

Data on management practice adoption within the horticultural sector is collected through Growcom's Farm Management System (FMS). The Water Quality module within the FMS allows detailed assessment of water quality risks and key actions to reduce those risks. These assessments involve one-on-one interaction between growers and Growcom or Natural Resource Management body field officers. Results of these assessments are aligned with regional and industry ABCD frameworks to estimate ABCD proportions within the grower population, on a year-by-year basis.

Industry wide management practice adoption is estimated using the proportions established through the Growcom FMS in each region.

Coverage of Growcom FMS as at 30 June 2010							
Region	Burnett Mary	Fitzroy	Mackay Whitsunday	Burdekin	Wet Tropics		
					Banana	Pawpaw	Multicrop
Industry coverage (% of total area)	39%	18%	32%	51%	46%	75%	41%

The number of growers adopting improved practices represents those that successfully implemented Reef Rescue Water Quality Grants, as an outcome of their engagement with Growcom FMS. This is likely to provide a conservative estimate of the number of growers implementing improved practices.

Grains

Improved management practices are described within the industry-endorsed farm management system, Grains Best Management Practices (BMP).

Evidence of growers adopting improved management practices is limited to the number of successful Reef Rescue Water Quality Grants projects in 2009-2010. Therefore, the reported number of growers adopting improved practices is likely to be a very conservative estimate. Reporting for the 2011 Report Card will include other evidence relating to voluntary adoption of improved practice including:

- the Grains BMP program
- Reef Rescue Water Quality Grants
- research, development and evaluation project evaluation
- training and professional advice provided by private sector consultants.

Management practice frameworks

The ABCD management practice framework for the grains industry is derived from the Grains BMP program:

- nutrient management practices are described in the Crop Nutrition and Soil Fertility module
- chemical management practices are described in the Pesticide Application module
- soil management practices are described in the Property Design and Layout and Making Best Use of Rainfall modules.

The Grains BMP modules articulate three levels of practice for each key area – Below BMP Standard, Minimum BMP Standard and Above BMP Standard - which correspond to C/D, B and A, respectively.

Data collection and synthesis

Data on management practice status within the grains sector is collected through the Grains BMP program. Growers typically engage with the program through facilitated workshops where they complete self-assessments with process and technical support available. Management practice data is then able to be accurately reported on an area impacted, or number of growers basis.

Grains industry reporting for the Second Report Card is relevant to the Fitzroy region only (which includes the majority of the grains industry in Great Barrier Reef catchments). Industry wide management practice status is estimated using the proportions established through the Grains BMP in each sub-catchment of the Fitzroy region, and scaling these proportions to the overall grower population of 600. As the degree of engagement and spatial coverage of the Grains BMP program increases, so does the confidence in the accuracy of the management practice status estimates.

Increase in grower participation and area impacted by the Grains BMP program				
	2008-2009		2009-2010	
	Growers	Area	Growers	Area
Fitzroy region	66	90,178 ha	111	150,370 ha

Increasing program engagement can mean that overall management practice status appears to be static or regressing over time. This is not the case, and is an artefact of early program participants generally being relatively advanced farmers. It is, therefore, appropriate that 2009-2010 data is used as the best estimate of management practices, meaning that year one management practice status is hindcast from the year two (2009-2010) data.

The number of growers adopting improved practices is the number of growers that completed specific intensive training or consultancy and/or implemented infrastructure and equipment changes on-farm as a result of their engagement with Grains BMP and the Reef Rescue Water Quality Grants program (through the field network of the Fitzroy Basin Association). This is likely to provide a conservative estimate of the number of growers implementing improved practices.

Dairy

Improved land management practices are described in the dairy industry's accepted best practice program, Dairying Better 'n Better for the Reef (DBnBR). The program is funded through the Australian Government's Reef Rescue program and is driven by the industry peak body, the Queensland Dairyfarmer's Organisation Ltd (QDO), the Burnett Mary Regional Group (BMRG) and Terrain Natural Resource Management.

Evidence of dairy producers adopting improved management practices is limited to:

- the number of producers that completed soil and water management plans and Reef Rescue Water Quality Grants projects through the DBnBR program during 2008-2009 and 2009-2010
- producers implementing improved practices with the support of the Dairy and Fodder Water for Profit program.

The number of producers adopting improved practices is likely to be a conservative estimate.

Management practice frameworks

The DBnBR program includes detailed soil and nutrient management planning processes including benchmarking current practices, identifying risks and planning priorities for action. DBnBR assesses management practices against three categories:

- above acceptable industry practice
- acceptable industry practice
- unacceptable industry practice.

Data collection and synthesis

Data is provided through the DBnBR program. Reporting of regional or industry wide management system status is not possible. However, there is reliable evidence of the adoption of improved management practices as described by:

- the number of producers that have completed professional risk analyses and soil and nutrient management plans
- the number of producers that have implemented on-ground works with the support of Reef Rescue Water Quality Grants, as an outcome of their engagement with the soil and nutrient management planning process
- the number of producers accessing assistance through the Dairy and Fodder Water for Profit program.

Estimates of the proportion of producers adopting improved management practices are presented at the Great Barrier Reef-wide scale only.

Catchment indicators

This section presents information on catchment attributes (wetlands, riparian areas and groundcover) that play a role in water quality entering the reef.

The Wetlands section reports on the extent of wetlands in 2009 and changes in extent from 2001 to 2005 and 2005 to 2009. Information on historical loss of wetlands is provided by comparing current extent with pre-European extent. Wetlands are classified as three types – vegetated freshwater swamps (palustrine), lakes (lacustrine) and mangroves and salt flats (estuarine).

The Riparian section reports on the loss of riparian forest between 2001 and 2005 and 2005 and 2009 along with the 2009 and pre-European extent of riparian areas. In addition, the total loss in riparian forested vegetation from 1988 to 2009 is reported. The extent of forested areas is mapped and non-forested riparian areas have been separated into areas of low (less than 50 per cent) and high groundcover.

The Groundcover section reports on mean late dry season groundcover for 2010, the 23-year mean groundcover for the period 1987 to 2010 and the area of land with mean groundcover below 50 per cent.

Wetlands

Wetlands extent

The extent of wetlands in 2009 and changes in extent since 2001 and 2005 are reported. The change in extent is reported as a percentage of the 2009 data so catchments of different sizes can be compared. Information on historical loss of wetlands is provided by comparing current extent with pre-European extent.

The change in extent of wetlands is derived from two sources: the Queensland Wetlands Program wetland mapping version 3.0¹ (EPA 2005) and the Queensland regional ecosystem mapping version 7.1 (Neldner et al. 2005).

Information is summarised into three wetland systems:

- 1) Vegetated freshwater swamp (palustrine) systems are wetlands less than eight hectares with more than 30 per cent emergent vegetation cover.
- 2) Lake (lacustrine) systems are wetlands over eight hectares with less than 30 per cent emergent vegetation cover (but excluding riverine channels and associated fringing vegetation). Areas of open water less than eight hectares are classified as lacustrine if the water is over two metres deep.
- 3) Mangroves and salt flats (estuarine) wetlands occur in coastal areas that are tidally inundated and dominated by mangrove, salt flat or salt marsh communities. Coastal waters that are also components of the estuarine wetland system are not included in this analysis.

While rivers are also defined as wetlands, they are not addressed in this section.

Limitations and future improvements

Wetland mapping is continually reviewed and updated, where necessary, to improve its accuracy. The Second Report Card includes updated baseline estimates of the historical clearing and extent of wetlands in 2001 and 2005 as well as new information about the extent of wetlands in 2009.

Summarising wetlands extent across whole regions and at a broad wetland system level can mask variations in wetland loss across parts of the catchment or differential loss for different wetland types. In addition, summarising wetlands into three broad systems can mask variations of the types within these systems

For more information on the methods, please contact the Reef Plan Secretariat.

References

Environmental Protection Agency (2005) Wetland Mapping and Classification Methodology – Overall Framework – A Method to Provide Baseline Mapping and Classification for Wetlands in Queensland, Version 1.2, Queensland Government, Brisbane.

Neldner, V.J., Wilson, B. A., Thompson, E.J. and Dillewaard, H.A. (2005) *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland*. Version 3.1. Updated September 2005. Queensland Herbarium, Environmental Protection Agency, Brisbane. 128 pp.

Riparian

Riparian loss

The extent of woody vegetation (forest) in riparian areas was mapped and groundcover estimates were developed for non-forested riparian areas.

A 1:100,000 drainage layer including all stream orders (Geoscience Australia 2009), riverine wetlands and water body layers (Environmental Protection Agency 2005) were buffered by 50 metre margins and merged into a single mapping layer to represent the riparian areas of the Great Barrier Reef catchments.

Within the riparian areas, the foliage projective cover (the percentage of ground area occupied by the vertical projection of foliage) (Armston *et al.* 2009), groundcover (Scarth *et al.* 2006) and forest loss data were analysed. Areas with foliage projective cover of at least 11 per cent were considered forested in this study.

In areas where forested (woody) riparian vegetation was absent, the groundcover data was analysed and separated into areas of low cover (less than 50 per cent cover) and high cover (greater than or equal to 50 per cent cover). Groundcover consists of all non-woody plant cover near the soil surface and all litter, including woody litter. Results for areas without woody vegetation are presented as 'non-forested'.

The riparian forest loss data was extracted from the Statewide Landcover and Trees Study (SLATS) change detection mapping (Department of Environment and Resource Management 2010).

How change in riparian area is reported

The loss of riparian forest between 2001 and 2005 and 2005 and 2009 is reported along with the 2009 and pre-European extent of riparian areas. In addition, the total loss in riparian forested vegetation from 1988 to 2009 is reported to show changes in the rate of riparian forest loss. Changes in forested riparian areas can include loss of forests through tree clearing and gains in forest extent through regrowth or new plantings.

The extent of non-forested riparian areas with low groundcover as at 2009 is reported. These areas are potentially at higher risk of erosion than forested areas and areas with high groundcover (Lyons *et al.* 2000, Simon and Collision 2002). They include degraded areas, such as gullies, but also sandbars and rocky streams.

For more information on the methods, please contact the Reef Plan Secretariat.

References

Armston JD, Denham RJ, Danaher TJ, Scarth PF and Moffiet TN (2009). Prediction and validation of foliage projective cover from Landsat-5 TM and Landsat-7 ETM+ imagery. *Journal of applied remote sensing* 3:033540.

Department of Environment and Resource Management (2010). Landcover change in Queensland 2008–09: a Statewide Landcover and Trees Study (SLATS) Report, 2011. Department of Environment and Resource Management, Brisbane.

Environmental Protection Agency (2005). Wetland Mapping and Classification Methodology – Overall Framework – A Method to Provide Baseline Mapping Classification for Wetlands in Queensland. Version 1.2, Queensland Government, Brisbane. ISBN 0 9757 344 6 6.

Geoscience Australia (2009). Queensland Drainage 100K, Department of Environment and Resource Management SIRQRY database <<https://www.ga.gov.au/topographic-mapping/>>.

Kitchen J, Armston J, Clark A, Danaher T and Scarth P (2010). Operational use of annual Landsat-5 TM and Landsat-7 ETM+ image time-series for mapping wooded extent and foliage projective cover in north-eastern Australia. In Proceedings of the 15th Australasian Remote Sensing and Photogrammetry Conference, Alice Springs, Australia, 13 -17 September 2010.

Lyons J, Trimble SW and Paine LK (2000). Grasses versus trees: Managing riparian areas to benefit streams of central north America. *Journal of the American Water Resources Association* 36: 919-930.

Scarth P, Byrne M, Danaher T, Henry B, Hassett R, Carter J and Timmers P (2006). State of the paddock: monitoring condition and trend in ground cover across Queensland. In: Proc. of the 13th Australasian Remote Sensing Conference, November 2006, Canberra.

Simon A and Collision AJC (2002). Quantifying the mechanical and hydrological effects of riparian vegetation on stream bank stability. *Earth Surface Processes and Landforms* 27:527-546.

Groundcover

Reporting regions

Groundcover is not reported for the Cape York region and the Wet Tropics region, with the exception of the Herbert catchment. These areas are generally considered to have low grazing pressure and the tree cover is too high for groundcover monitoring derived from satellite imagery.

Grazing lands

Grazing lands in the reporting regions were spatially defined based on the most recent version of land use data provided by the Queensland Land Use Mapping Program (Department of Environment and Resource Management, 2008).

Groundcover data

Data derived from the Ground Cover Index (Scarth *et al.*, 2006) is used for reporting. The Ground Cover Index uses image data from satellites at approximately 30 metre pixel resolution to estimate groundcover levels based on the reflectance of bare ground. This data is calibrated using field observations.

The Ground Cover Index performs best where tree cover is low. The Ground Cover Index can only be calculated for grazing lands with a foliage projective cover of less than 15 per cent. Foliage projective cover is a measure of the density of woody vegetation and is defined as the percentage of ground area occupied by the vertical projection of foliage (Specht *et al.*, 1981).

2010 mean late dry season groundcover

The 2010 mean late dry season groundcover was calculated by predicting the groundcover for each (approximately 30 metre by 30 metre) pixel in a selected late dry season Landsat satellite image in 2010 and then averaged for the reporting area (grazing lands) of each region.

23-year mean groundcover

The 23-year mean groundcover was calculated by estimating, per pixel, the mean annual late dry season groundcover for the period 1987 to 2010, and averaging for the reporting area of each catchment. This is the period for which Landsat TM/ETM+ satellite imagery is available.

For more information on the methods, please contact the Reef Plan Secretariat.

References

Department of Environment and Resource Management, Remote Sensing Centre, Division of Environment and Resource Sciences 2008, *Queensland Land Use Mapping Program*, accessed 16 July 2011, <<http://www.derm.qld.gov.au/science/lump/index.html>>.

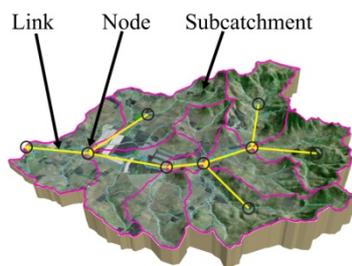
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Catchment pollutant loads

Catchment modelling

The Source Catchments modelling framework (eWater 2010) is used to report pollutant loads for the 35 catchments in the Great Barrier Reef region. It is a catchment scale water quantity and quality model which uses a node link network to represent the stream. The model generates runoff and pollutant loads for each landuse within a sub-catchment, and runoff and pollutants are transported through the node link stream network to the end of the catchment.



Example of a node link network generated in Source Catchments to represent a catchment and stream network.

Source Catchments runs at a daily time step which allows exploration of the interactions of climate and management at a range of time-steps. However, for the report card, average annual catchment loads are reported.

Modelled loads were generated for the fixed climate period using baseline land use/land management as at 2008-2009, and 2009-2010 landuse/land management following the adoption of improved management practices. A total of 17 pollutants were modelled including fine and course sediments, various nutrients and eight pesticides. Key land uses were modelled including open and timbered grazing, cane, cropping, horticulture and forestry.

Management practice change

An ABCD management system framework was used to describe and categorise farming practices according to recognised water quality improvements at a paddock scale. Improvements in water quality as a result of adopting improved management practices are determined by linking paddock model time series outputs to catchment models.

Limitations

The pollutant load reductions are likely to be slightly underestimated as the horticulture, dairy and cotton industries were not included due to a lack of available baseline or 2009-2010 management practice adoption data. Dissolved nitrogen has not been modelled in the grains system as there is no dissolved nitrogen model in HowLeaky? for grains.

Linking paddock and catchment models

Two constituent generation approaches were used in Great Barrier Reef modelling. Firstly, the constituent time-series (e.g. load per day per unit area) for any spatial unit in the Source Catchments model was replaced with an output time-series from a paddock model. In the second approach, a scaling approach, GRASP model groundcover time-series outputs were used to relate changes in grazing system management to changes in the groundcover time-series (or Revised Universal Soil Loss Equation (RUSLE) C-factors). These were modelled and applied to a range of climates and pasture productivity levels or land types.

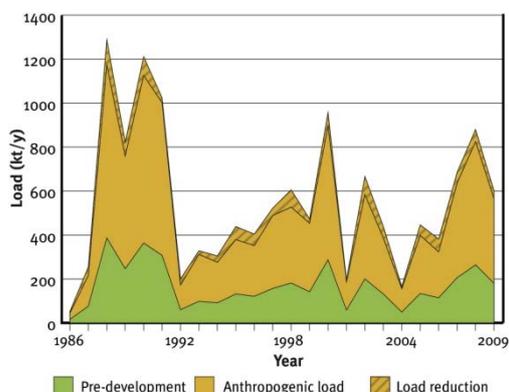
The outputs from each of the modelled land management practices were accumulated into a single time-series. This was done at a sub-catchment scale by weighting based on the proportion of the sub-catchment represented by each ABCD management practice.

Total load

The relative load reduction due to the adoption of improved management practices used the proportion of adoption of A, B, C and D management practices for each land use within each Great Barrier Reef catchment as at 2008-2009. The model was then run for a 23-year period to establish the total load over this period. Thus, the anthropogenic load was the total load less the pre-development load.

Load reductions

The model was then re-run for the same climate period using updated proportions of A, B, C and D areas to reflect investment in improved management practices since 2008-09. The relative change in pollutant loads from the anthropogenic baseline after investment reflects the load reduction due to changes in management practices.



Example of modelled loads for pre-development, anthropogenic baseline and the load reduction following investment in improved practices.

How the information is reported

Progress towards Reef Plan targets is measured by how much the pollutant load has reduced from the average annual anthropogenic baseline (total load less the pre-development load). This is calculated as a percentage reduction in average annual load.

Total suspended sediment, nitrogen, phosphorus and pesticides loads at the end of the catchment are reported for the total Great Barrier Reef region, six regions and the 35 catchments.

The average annual percentage reduction in load is calculated from:

$$\text{Reduction in load (\%)} = \frac{(\text{Anthropogenic baseline load less anthropogenic change}) \times 100}{\text{Anthropogenic baseline load}}$$

Where, anthropogenic baseline load = total load less pre-development load.

References

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Marine

Marine Monitoring Program

The water quality issues affecting the inshore waters of the Great Barrier Reef are significant, and most assessment and monitoring information relates to this area. The Reef Rescue Marine Monitoring Program monitors the water quality in the inshore reef lagoon and the long-term health of key marine ecosystems (inshore coral reefs and seagrasses). The four sub-programs are outlined below.

More information about the Marine Monitoring Program is available from <http://www.gbrmpa.gov.au/about-the-reef/how-the-reefs-managed/science-and-research/our-monitoring-and-assessment-programs/reef-rescue-marine-monitoring-program>.

Inshore water quality

Long term monitoring of marine water quality in inshore areas of the reef lagoon is essential to assess improvements in regional water quality.

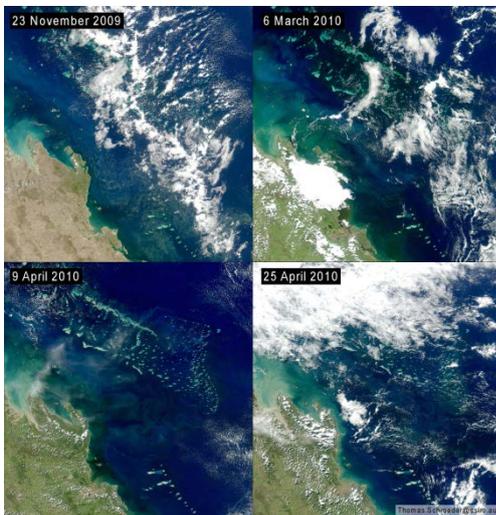
Monitoring includes the measurement of concentrations of nutrients (nitrogen and phosphorus), chlorophyll, suspended solids (water turbidity) and pesticides. Techniques used to monitor water quality include satellite remote sensing, automated data loggers, and collection of water samples from research vessels for standard laboratory analysis. Passive samplers are used to measure the concentration of pesticides in the water column integrated over time. (Booij et al., 2007; Shaw & Mueller, 2009).

View the remote sensing, in situ water quality and pesticide annual Marine Monitoring Program reports at <http://www.gbrmpa.gov.au/resources-and-publications/publications/scientific-and-technical-reports>.

Flood plume dynamics

The majority of the annual pollutant load to the reef is delivered by flood events in the wet season. Monitoring of water quality during flood events and the wet season includes measuring salinity, concentrations of nutrients, chlorophyll, suspended solids (water turbidity) and pesticides. The movement of the flood plume across inshore waters of the reef is assessed using images from aerial flyovers and remote sensing.

View the annual Marine Monitoring Program flood reports at <http://www.gbrmpa.gov.au/resources-and-publications/publications/scientific-and-technical-reports>.



Satellite images (MODIS-Aqua) of the Fitzroy Region of the Great Barrier Reef during normal (low) flow conditions in November 2009 (a) and flood conditions in March and April (b, c, d). The discharge from the Fitzroy River was more than four times the annual median flow and images b-d show large plumes of dissolved and suspended material in the coastal waters.

Seagrass status

Monitoring temporal and spatial variation in the status of intertidal seagrass meadows in relation to changes in local water quality is essential in evaluating long-term ecosystem health.

Monitoring includes assessing the abundance of seagrass species and seagrass reproductive effort, which provide an indication of the capacity of meadows to regenerate following disturbances. Tissue nutrient composition is assessed in the laboratory as an indicator of potential nutrient enrichment.

View the annual Marine Monitoring Program seagrass report at <http://www.gbrmpa.gov.au/resources-and-publications/publications/scientific-and-technical-reports>.



Seagrass monitoring along the Queensland Coast (Image: L. McKenzie, Queensland Government)

Coral reef status

In evaluating long-term ecosystem health, it is essential to monitor temporal and spatial variation in the status of inshore coral reef communities in relation to changes in local water quality. Monitoring covers a comprehensive set of community attributes including the assessment of hard and soft coral cover, the density of hard coral juvenile colonies, macroalgae cover, and the rate of change in coral cover as an indication of the recovery potential of the reef following a disturbance (Thompson and Dolman, 2010). Comprehensive water quality measurements are also collected at many of the coral reef sites.

View the annual Marine Monitoring Program coral report at <http://www.gbrmpa.gov.au/resources-and-publications/publications/scientific-and-technical-reports>.



Coral reefs being monitored on the Great Barrier Reef. (Image: Australian Institute of Marine Science)

Synthesis and integration of data and information

A sub-set of indicators was selected to calculate the water quality, seagrass and coral scores. These scores were expressed on a five-point scale and integrated into an overall score that describes the status of the Great Barrier Reef and each region.

An overview of the methods used to calculate the Great Barrier Reef wide and regional scores is available from the Marine Monitoring Program Quality Assurance Manual.

Great Barrier Reef wide and regional metrics

Water quality

Near-surface concentrations of chlorophyll *a* and total suspended solids from remotely sensed images were used to evaluate inshore water quality. Chlorophyll *a* is a measure of phytoplankton biomass that is related to the amount of available nutrients in the water column and therefore the productivity of the system. Total suspended solids is a measure of all other particulate matter in the water column.

Seagrass

Abundance, reproductive effort and nutrient status were used to evaluate inshore seagrass condition. Seagrass abundance includes assessment of percent cover determined in reference to the Seagrass Abundance Guidelines (McKenzie 2009). Reproductive effort is based on the average number of reproductive structures on an area basis and provides an indication of the capacity for recovery following disturbances. The nutrient status of seagrass is based on the ratio of carbon to nitrogen in leaf tissue and reflects the level of nutrients in the surrounding waters.

Corals

Coral cover, coral cover change, juvenile density and macroalgae cover were used to evaluate inshore coral reef condition. Coral cover is a measure of the abundance of hard and soft corals, and indicates the capacity of coral to persist under the current environmental conditions and to recover from disturbances by estimating the availability of adult broodstock. Coral change is a measure of the change in hard coral cover from the preceding three years and is an indicator of the balance between disturbance and recovery. Juvenile density is a measure of the abundance of hard coral juveniles and is an indicator of the potential of the community to recover from disturbances or stress. Macroalgal cover is a measure of the abundance of large, fleshy algae. High abundance of algae is an indicator of poor water quality and may negatively influence the resilience of coral communities.

Site specific assessments

Water quality

To complement the water quality scores derived from remotely sensed images, site-specific water quality data are reported using an interim Water Quality Index based on expert opinion. The Water Quality Index aggregates the scores for four indicators of water quality relative to the Great Barrier Reef Water Quality Guidelines (GBRMPA 2009) to give an overall rating for each of the 20 fixed sampling sites. The four indicators are an integrated assessment of turbidity, chlorophyll, and concentrations of particulate nitrogen and phosphorus. Decision rules for the Water Quality Index are outlined in Schaffelke *et al.* 2011 - <http://www.gbrmpa.gov.au/resources-and-publications/publications/annual-reef-rescue-marine-monitoring-science-report>.

Pesticides

The most frequently detected pesticides in inshore waters include those that inhibit the photosynthetic pathway (PSII) of plants in an additive manner: the PSII herbicides diuron, atrazine, hexazinone, simazine and tebuthiuron (Haynes *et al.*, 2000; Mitchell *et al.* 2005; Kapernick *et al.* 2006; Lewis *et al.* 2009; Packett *et al.* 2009). These PSII herbicides may also have a negative impact on non-target organisms such as algae, corals and seagrass (Magnusson *et al.*, 2008; Jones and Kerswell, 2003; Haynes *et al.*, 2000). The five categories of the PSII Herbicide Equivalent Index were developed with reference to the Great Barrier Reef Water Quality Guidelines.

For more information on the methods please contact Reef Plan Secretariat.

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Scoring system

A standardised scoring system was developed for each of the key indicators in the report card. The scoring system is used to assess and communicate the progress towards the goals and targets. The Reef Plan targets are considered ambitious. Therefore, progress that is equal to or exceeds the target is considered very good. Further details on the scoring system for each indicator are outlined below.

Management practices – sugarcane, horticulture and grains

Target: 80 per cent of landholders adopt improved practices by 2013.

Status/progress	Criteria for June 2010	Colour
Very poor progress towards target	NA	Red
Poor progress towards target	0 or % decrease in adoption of improved management practices	Orange
Moderate progress towards target	1 - 15% adoption of improved management practices	Yellow
Good progress towards target	16 - 20% adoption of improved management practices	Light green
Very good progress towards target	Greater than 20% adoption	Dark green

Management practices – grazing

Target: 50 per cent of landholders adopt improved practices by 2013.

Status/progress	Criteria for June 2010	Colour
Very poor progress towards target	NA	Red
Poor progress towards target	0 or % decrease in adoption of improved management practices	Orange
Moderate progress towards target	1-8% adoption of improved management practices	Yellow
Good progress towards target	9 - 13% adoption of improved management practices	Light green
Very good progress towards target	Greater than 13% adoption	Dark green

Groundcover

Target: minimum 50 per cent late dry season groundcover by 2013.

Status/progress	Criteria for June 2010	Colour
Very poor groundcover – Well below the target	Less than 30% groundcover	Red
Poor groundcover - Below the	Between 30-39% average	Orange

target	groundcover	
Moderate groundcover – Just below the target	Between 40-49% average groundcover	Yellow
Good groundcover – Above the target	Between 50-69% average groundcover	Light Green
Very good groundcover – Well above the target	Greater than 70% average groundcover	Dark Green

Riparian

Target: improved condition and extent of riparian areas.

Status/progress	Criteria for June 2010	Colour
Very poor progress towards target – Very high loss of riparian vegetation	Greater than 1.00% decrease	Red
Poor progress towards target – High loss of vegetation	0.51-1.00% decrease	Orange
Moderate progress towards target – Moderate loss of riparian vegetation	0.11-0.50% decrease	Yellow
Good progress towards target - No change or small loss of riparian vegetation	0-0.10 decrease	Light Green
Very good progress towards target – Increase in riparian vegetation	0 or increase	Dark Green

Wetlands

Target: no net loss or degradation of natural wetlands.

Status/progress	Criteria for June 2010	Colour
Very poor progress towards target – Very high loss of wetlands	Greater than 3.00% loss	Red
Poor progress towards target – High loss of wetlands	0.51-3.00% loss of wetlands	Orange
Moderate progress towards target – Loss of wetlands	0.11-0.50% loss of wetlands	Yellow
Good progress towards target – A small loss of wetlands	0-0.10 loss of wetlands	Light Green
Very good progress towards target – Increase in wetlands	0 and above	Dark Green

Catchment pollutant loads – pesticides, nitrogen and phosphorus

Target: 50 per cent reduction in load by 2013.

Status/progress	Criteria for June 2010	Colour
Very poor progress towards target – “Increase in the catchment load”	Greater than 2% increase in load	Red
Poor progress towards target – “No or small increase in the catchment load”	0-2% increase in load	Orange

Moderate progress towards target – “A small reduction in catchment load”	1-4% reduction in load	Yellow
Good progress towards target – “A significant reduction in catchment load”	5-11% reduction in load	Light green
Very good progress towards target – “A high reduction in catchment load”	12% reduction in load or greater.	Dark green

Catchment pollutant loads – sediment

Target: 20 per cent reduction in load by 2020.

Status/progress	Criteria for June 2010	Colour
Very poor progress towards target – “Increase in the catchment load”	Greater than 1% increase in load	Red
Poor progress towards target – “No or small increase in the catchment load”	0-1% increase in load	Orange
Moderate progress towards target – “A small reduction in catchment load”	0-1% reduction in load	Yellow
Good progress towards target – “A significant reduction in catchment load”	1-2% reduction in load	Light green
Very good progress towards target – “A high reduction in catchment load”	Greater than 2% reduction in load	Dark green

Marine

Status/progress	Marine indicators				
	Corals	Water quality	Seagrass	Overall score	
Very poor condition	Standardised scale (1-100)	Standardised scale (1-100)	Standardised scale (1-100)	Standardised scale (1-100)	Red
Poor condition					Orange
Moderate condition					Yellow
Good condition					Light Green
Very good condition					Dark Green