Results

Great Barrier Reef

Report Card 2016

Reef Water Quality Protection Plan

Australian Government

Queensland Government

Management practice results

The management practice target in the Reef Water Quality Protection Plan (Reef Plan) 2013 is:

- 90 per cent of sugarcane, horticulture, cropping and grazing lands are managed using best management practice systems (soil, nutrient and pesticides) in priority areas by 2018.

Landholders manage complex farming systems made up of many diverse individual management practices. The target acknowledges that the largest water quality benefits will be realised through use of **management systems** that include adoption and integration of a number of critical management practices.

Best management practices in this context are defined in the Reef Plan's water quality risk frameworks for each major agricultural industry. These frameworks identify the management practices with greatest potential influence on off-farm water quality, and articulate a reasonable *best practice* level which can be expected to result in a moderate-to-low water quality risk. The risk levels described for each practice, where relevant, are:

- High risk (superseded or outdated practices)
- Moderate risk (a minimum standard)
- Moderate–low risk (best practice)
- Lowest risk (where innovative practices are expected to result in further water quality benefits, but commercial feasibility is not well understood).

The Reef report card estimates the area of land managed using best management practice systems as at June 2016.

Drivers of reported adoption

It is important to acknowledge how challenging the achievement of a best management practice system is for many landholders. To varying degrees, each component practice requires new knowledge and skills, and in some cases considerable direct investment in farm equipment and infrastructure.

For those management improvements that are relatively simple to implement and present little perceived production risk, adoption can be fostered through awareness activities and modest extension efforts. Financial incentives can greatly assist landholders to implement these changes rapidly. For example, incentives provided over the previous eight years have enabled more rapid adoption of the following practices:

- using GPS guidance systems, more targeted herbicide application, and improved levels of irrigation water recycling in the sugarcane industry
- fencing to manage cattle access to streambanks and riparian areas in the grazing industry
- installing erosion control structures such as contour banks in the grains industry
- installing fertigation systems in banana and other horticultural crops.

This type of program has been a feature of Reef Plan investments to date. However, since 2013 the investment mix has been changing to reflect more challenging adoption issues—those changes that require new knowledge and skills, and sometimes the trialling of new practices, before landholders have sufficient confidence to invest in implementing the change across the farm.

Investments from both the Queensland and Australian governments have increased the emphasis on extension to build landholders' capacity through:

- industry Best Management Practice (BMP) programs, which support individual landholders in assessing their own management and comparing it with commonly accepted industry standards. This clarifies where there is scope for beneficial management improvements.
- technical extension services to support the industry BMP programs. Where landholders identify potential improvements, accessing professional opinion and advice is often necessary to act on opportunities for improvement.
- delivering programmed learning (training) for certain technical issues
- in-field demonstrations of improved practices in practical situations
- working with facilitated landholder groups to develop a local understanding of how new practices best fit into their farming system
- providing support for on-farm research by farmers, trialling practices that are new for them and working out if the risks associated with adoption are acceptable.

This report describes adoption progress based on the degree of management improvement reported through various federal and Queensland Government projects and programs (see the Management Practices Methods report for details of programs evaluated). The changes are mainly management changes that have been more rapidly implemented due to a level of fiscal subsidy and technical support.

Many other ongoing programs are engaging with landholders, and some of these are occurring on a much larger scale. These processes of engagement, and follow-up interactions to enhance knowledge and skills, are generally **not** included in the Reef report card estimates of best management system *adoption*, or in modelling conducted to estimate pollutant load reductions. These are the outcomes expected from these programs, but learning new knowledge and skills takes time, as does implementing new practices in farming systems with long production cycles (such as sugarcane and beef cattle).

The following programs are expected to *begin* to spatially describe the extent of implemented farm management improvements for the next Reef report card (2016–17):

- industry BMP programs (sugarcane, grazing, grains, horticulture)
- Reef Trust Phase 1 grazing land management projects in the Burdekin and Fitzroy natural resource management (NRM) regions (there are several phases and many distinct projects within the Reef Trust; see www.environment.gov.au/marine/gbr/reef-trust)
- Queensland Government 'major integrated projects' in the Wet Tropics and Burdekin regions
- Reef Trust Phase 2 gully remediation projects in the Theresa Creek, Mary, Mackenzie, Isaac, Fitzroy, Bowen, Don, East Burdekin, and Normanby river basins
- Reef Trust Phase 3:
  - Reef Alliance – Growing a Great Barrier Reef (all Reef catchments)
  - Mackay Whitsunday Isaac – Sustainable Agriculture – Sugarcane (Mackay Whitsunday NRM region)
  - Project Pioneer: Innovation in Grazing Land Management (Burnett Mary, Fitzroy, Burdekin, and Cape York NRM regions)
  - Project Catalyst (sugarcane farms in the Mackay Whitsunday, Burdekin, and Wet Tropics NRM regions)
- Reef Trust Phase 4 – Sugarcane Reverse Tenders in the Burdekin and Wet Tropics NRM regions (distinct from previous reverse tender projects reported in this 2016 Reef report card)
- the Queensland Government Department of Environment and Heritage Protection's Environmental Services and Regulation service.

How progress is reported

The metrics used to describe progress towards the adoption of best management practice systems refer to the degree of adoption of practices relating to major pollutant categories.

For the cropping industries, metrics refer to the adoption of practices that minimise the loss of soil, nutrients and pesticides off-farm. For the grazing industry, metrics refer to the adoption of practices that minimise soil lost through surface (hillslope), streambank and gully erosion processes.

Farm land estimated to be in the two lowest risk categories (lowest risk and moderate–low risk) is reported as being managed under best management practice systems.

The proportions of total areas estimated to be managed under best management practice systems are rounded to the nearest whole number. In instances where the reported areas of management improvement are small, this can result in no apparent change to the (whole number) value.

For each sector in each region, the estimated proportion of farm land managed under each category of management system (from low risk to high risk) is also reported. This indicates where management improvements have occurred in the progression toward best management practice systems.

Estimates of adoption for key constituent practices are also reported, and summarised in a bar graph displaying the proportion of area estimated to be managed at each risk state (low to high).

Paddock to Reef modelling of estimated mean annual pollutant load reductions is based on estimated changes to these farm management practice systems, with off-farm water quality impacts decreasing as management systems progress from high risk towards low risk.

Table 1: Colour-coded scoring system used to indicate progress

Adoption progress – scoring system		
0–22%	E – Red	Very poor
23–45%	D – Orange	Poor
46–67%	C – Yellow	Moderate
68–89%	B – Light green	Good
90–100 %	A – Dark green	Very good

Factors affecting agricultural industries in 2015–16

Changing management practice can be a long and complex process that requires new or expanded knowledge and skills, and sometimes significant capital investment. An agricultural business's capacity to afford such an investment is typically closely related to climatic and market forces beyond the landholder's control. Recent challenges for landholders are summarised below.

Grazing

Drought conditions throughout much of Queensland have limited the ability of graziers to afford and implement farm management improvements. Most of Queensland continued to be drought-declared at June 2016 (Figure 1), with large portions of central and northern Reef catchments receiving well below average rainfall between 2015 and 2016 (Figure 2). The driest areas included the majority of the Mackay Whitsunday, Burdekin and Wet Tropics NRM regions. With landholders in drought affected areas continuing to destock, fewer cattle were consigned to saleyards and slaughter, resulting in high cattle prices towards the end of the 2015-16 financial year. Increased revenue from high cattle prices may prompt

landholders to invest in farm management improvements and spell pastures which may have resulting ground cover benefits following the next wet season.

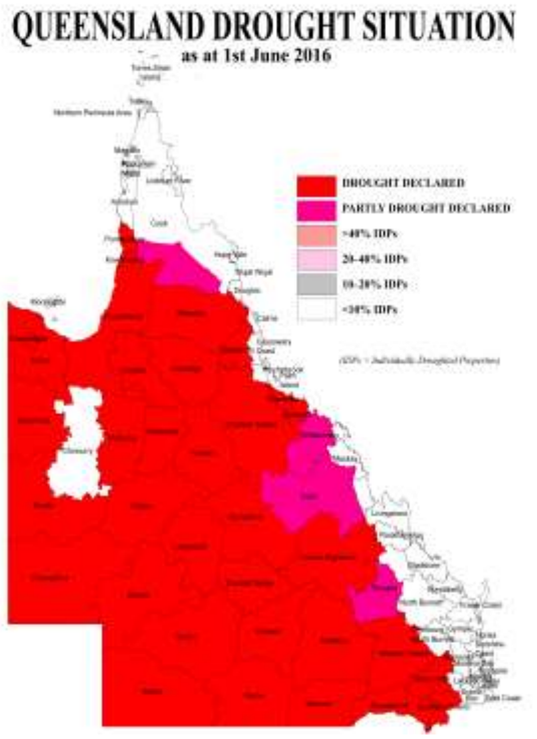

Figure 1: Most of Queensland remained drought-declared at June 2016.

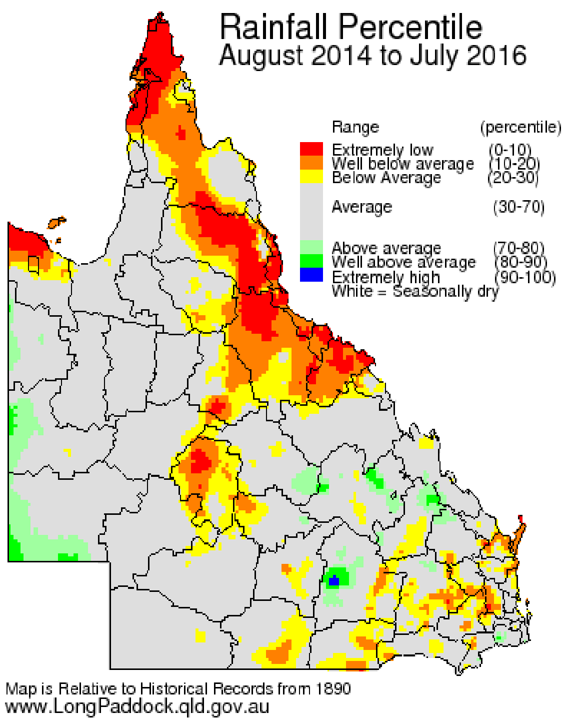

Figure 2: Large parts of the Reef catchment received well below average rainfall between 2015 and 2016.

Sugarcane

The 2015/16 sugarcane growing season in Queensland produced yields that were above district averages in most regions, with 32.65 million tonnes of cane cut, and an above average CCS reading of 13.97 (CCS represents the sugar content and determines the payment made to the grower). Rainfall was below average for most growing regions during 2015, with the Burdekin and Tablelands cane farming areas being drought-declared.

Following modest sugar prices in the 2014/15 season, predictions of a global sugar deficit and a decline in the Australian dollar pushed sugar prices up by 12–15 per cent in early 2016 and these prices were maintained until late in the year. The cost of fertiliser, particularly urea, has generally fallen since June 2015, although this does not seem to have influenced application rates significantly in this reporting period. While affecting profitability, increases in electricity costs have not appreciably affected the number of growers irrigating or the total area of sugarcane.

Horticulture

For most major production areas, 2015–16 generally produced good growing conditions and typical market prices for commodities. The value of production of most horticultural commodities in the Reef catchments was at or above that achieved in recent years. The exception to this was the banana industry, with confirmation of the Panama Tropical Race 4 plant disease on a farm near Tully in March 2015. All banana plants on the 140-hectare property were subsequently destroyed. Efforts are now focused on a longer-term response strategy and improved biosecurity measures.

Grains

Following a wet 2014/15 summer, numerous grain crops were severely damaged by locusts across a wide area of Central Queensland, with many sorghum crops being sprayed multiple times, primarily with the insecticides fipronil and fenitrothion.

All grain growing districts across Central Queensland experienced below average 2015/16 summer rainfall, reducing the area of grain sorghum planted and, consequently, the volumes of residual herbicides applied (especially atrazine and s-metolochlor). High commodity price resulted in large areas being planted to mungbeans during the summer, a crop that typically requires very little use of residual herbicides.

The winter crop planted in 2015 was reduced by a lack of planting rain in some growing regions, particularly the Central Highlands and the Callide, with little to no follow-up rain after Tropical Cyclone Marcia in February 2015. Some regions have since being drought-declared.

Winter crops planted between April and June 2016 experienced mixed conditions. High chickpea prices resulted in a relatively large area planted to chickpea during the 2015/16 winter. Favourable growing conditions for most areas resulted in one of the best chickpea harvests many growers have seen. High yields and high prices enabled many farmers to retire debt and/or upgrade machinery and infrastructure. Much of the chickpea area was treated with the residual herbicides simazine, isoxaflutole or terbuthyylazine, and the insecticides thiodicarb and/or indoxacarb.

Great Barrier Reef-wide

Grazing

D
36 %

Erosion source	**Area managed under best management practice systems**	
	Proportion (%)	Area (hectares or kilometres)
Pastures	**29%**	8,976,761 ha
Streambanks	**55%**	60,390 km
Gullies	**25%**	7,599,458 ha

Target: 90 per cent of grazing lands are managed using best management practice systems by 2018.

Approximately 8545 graziers manage 31.1 million hectares of land and over 100,000 kilometres of streambanks across the Reef catchment. By June 2016, approximately 29 per cent of grazing land was being managed under best practice management systems for practices related to erosion from pastures (8,976,761 hectares), 55 per cent for practices relating to streambank erosion (60,390 kilometres of streambanks) and 25 per cent for practices relating to gully erosion (7,599,458 hectares). On average, this represents a total of 36 per cent.

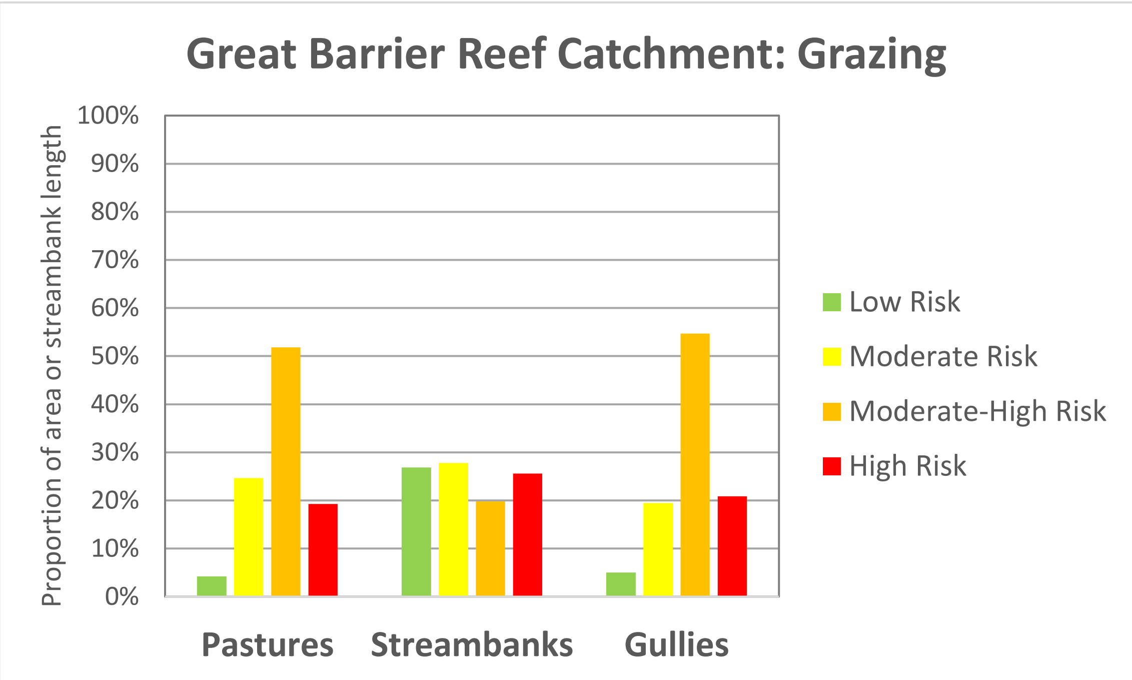

Figure 3: Reef-wide proportional area of grazing water quality risk by erosion type

The Australian Government's Reef Programme directly funded on-farm infrastructure improvements related to best practice adoption on 204 farms and over 109,931 hectares, in the process protecting 999 kilometres of streambanks during 2015–16.

The Grazing BMP program, a partnership involving the Fitzroy Basin Association, AgForce and the Queensland Government, worked with 394 individual grazing businesses during 2015–16. These businesses, managing over 3.7 million hectares, completed BMP (best management practice) modules on soil health and grazing land management which were directly relevant to run-off and soil loss. No soil erosion

reductions are associated with this engagement in this Reef report card, which should not be taken as an indication that the program does not foster improved land management practices. An independent evaluation of the Grazing BMP program contacted 92 grazier participants in the program at the end of the 2015–16 year. Of these, 73 per cent reported commencing or completing some kind of farm management changes as a result of the Grazing BMP, with 61 per cent of these changes related to improved grazing land management. These changes are not reflected in Reef report card results because the program was unable at the time to supply details of which practice changes have occurred, and where. It is acknowledged that the Grazing BMP program is a highly effective and efficient means of engaging with large numbers of land managers; however, verifying the impacts of this engagement and capacity building effort in terms of reduced risk of erosion on farms will require time and evidence.

Queensland Government extension programs supported the implementation of the Grazing BMP program in the Fitzroy and Burdekin NRM regions. The extension teams focused their efforts with graziers in priority areas and graziers of larger commercial scale. During 2015–16 the extension programs engaged with 156 individual businesses managing over 3.1 million hectares of grazing land and one million livestock. Follow-up surveying of participants by a professional independent evaluator in May 2016 indicated that 74 per cent of graziers (n=73) had improved their knowledge and skills, and implemented some kind of management practice improvement, some of which have direct and/or indirect links to risk of soil erosion (for example, preventative measures to reduce the risk of initiating gully erosion). Again, this Reef report card adopts a conservative approach to attributing soil erosion and water quality benefits, and few sediment reductions are attributed to this engagement at this stage. This is expected to change as the impacts become apparent and the spatial extent of management improvements can be described.

Table 2: Reef-wide grazing water quality risk over time, by erosion type

Pastures	Baseline	2014 Report card	2015 Report card	2016 Report card
Very Low Risk	4%	4%	4%	4%
Low Risk	23%	23%	24%	25%
Moderate Risk	54%	53%	52%	52%
Moderate - High Risk	20%	19%	19%	19%
Streambank				
Very Low Risk	26%	26%	26%	27%
Low Risk	27%	27%	27%	28%
Moderate Risk	20%	20%	20%	20%
Moderate - High Risk	26%	26%	26%	26%
Gully				
Very Low Risk	5%	5%	5%	5%
Low Risk	20%	19%	20%	19%
Moderate Risk	55%	55%	55%	55%
Moderate - High Risk	21%	21%	21%	21%

Sugarcane

D
32 %

Pollutant	Area managed under best management practice systems	
	Proportion (%)	Area (hectares)
Sediment	**40%**	176,962
Nutrients	**18%**	77,423
Pesticides	**39%**	173,042

Target: 90 per cent of sugarcane lands are managed using best management practice systems by 2018.

Approximately 3777 growers are managing 400,000 hectares of land for sugarcane production across the Reef catchment. By June 2016, best management practice systems were used on approximately 39 per cent of sugarcane land for pesticides (173,042 hectares), 18 per cent for nutrients (77,423 hectares) and 40 per cent for soil (176,962 hectares).

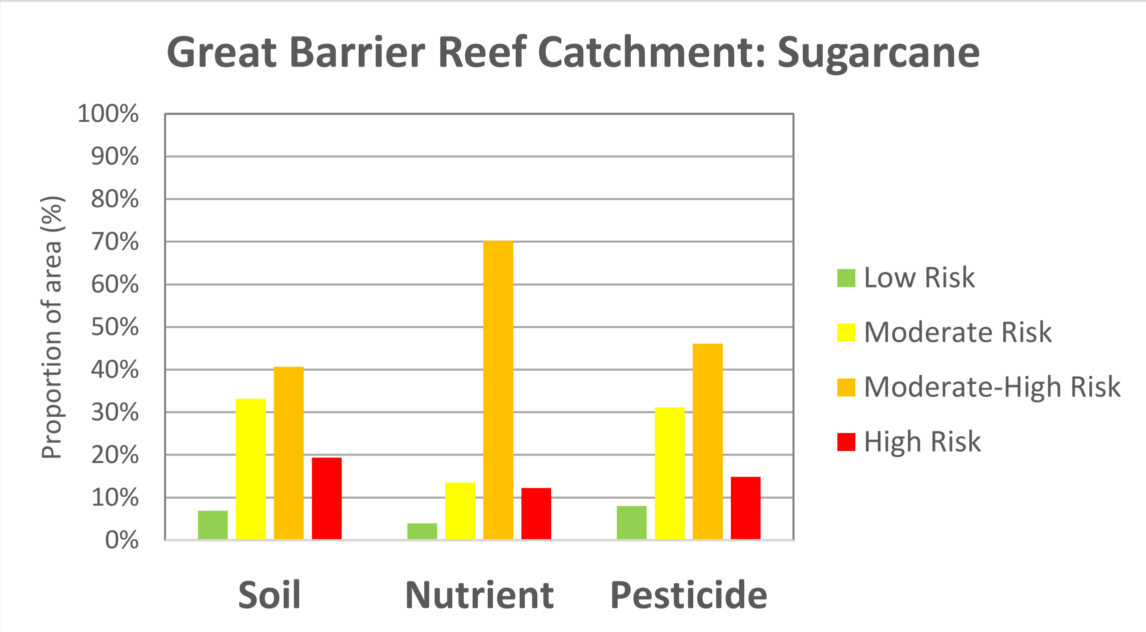

Figure 4: Reef-wide proportional area of sugarcane water quality risk by pollutant

Table 3: Reef-wide sugarcane water quality risk over time, by pollutant

Soil	Baseline	2014 Report card	2015 Report card	2016 Report card
Low Risk	5%	7%	7%	7%
Moderate Risk	30%	31%	31%	33%
Moderate-High Risk	43%	43%	43%	41%
High Risk	21%	20%	19%	19%
Nutrient				
Low Risk	1%	3%	3%	4%
Moderate Risk	10%	10%	11%	14%
Moderate-High Risk	70%	68%	68%	70%
High Risk	19%	18%	17%	12%
Pesticide				
Low Risk	7%	8%	8%	8%
Moderate Risk	22%	24%	28%	31%
Moderate-High Risk	53%	51%	47%	46%
High Risk	18%	18%	17%	15%

Table 4: Reef wide adoption of sugarcane best management practices over time

Key practices	Proportion of area where key practice has been adopted			
	Baseline	2014 Report card	2015 Report card	2016 Report card
Green cane trash blanketing	75%	75%	75%	75%
Fallow management	33%	35%	35%	38%
Controlled machinery traffic	41%	43%	43%	45%
Tillage - plant cane	25%	27%	28%	32%
Nitrogen surplus	12%	13%	16%	19%
Fertiliser placement	73%	74%	75%	76%
Residual herbicide targeting	25%	28%	31%	34%
Residual herbicide strategy	53%	55%	57%	60%

The major reported influencers of farm management change modelled for this Reef report card during 2015–16 were through regional NRM organisations facilitating financial incentives from the Australian Government's Reef Programme, Reef Trust Phase 2 reverse tender projects, and the Queensland Government's RP20C Project in the Burdekin catchment. Table 5 summarises the number of farms and hectares engaged in each program across all catchments and, where data was provided, the reduction in annually applied nitrogen fertiliser achieved through these projects.

Table 5: The number of farms and hectares engaged in government programs across all catchments

	Reef Programme*	Reverse Tender^	RP20C (Burdekin only)
Hectares	71,937	10,571	12,721
Farms	270	38	23
Reduction in N fertiliser (tonnes N/year)	-	299	499

* Wet Tropics, Mackay Whitsundays and Burnett Mary ^ Wet Tropics and Burdekin

The Smartcane BMP program is an initiative of Canegrowers Ltd, supported by the Queensland Government. Smartcane BMP supports growers in assessing their own farm management practices against

a range of industry standards. This allows identification of priorities for potential management improvements by growers, and of the support needs (e.g. follow-up technical support) necessary for industry and governments to foster those improvements. By July 2016, the Smartcane BMP program had engaged directly with 1339 growers (managing 233,497 hectares of sugarcane) and accredited a further 116 (managing 36,091 hectares) in the Reef catchments. The number of newly benchmarked growers during 2015-2016 was 630. As this process of engagement and capacity building evolves and the spatial extent of change can be described, future Reef report cards will aim to estimate the impacts of improvements in farm management practice on water quality.

Both the Australian and Queensland governments also invested in extension services in priority sugarcane growing regions, often in support of the Smartcane BMP and/or the fiscal incentives of the Reef Programme and the Reef Trust. As of June 2016, the Queensland Department of Agriculture and Fisheries (DAF) cane extension team reported management change on 42 sugarcane farms covering 6241 hectares of cane. These changes were designed to support the acquisition of new knowledge and skills among growers and their advisors.

An independent evaluation study of growers involved in all extension activities conducted for DAF and Terrain NRM (n=170) at the end of the 2015–16 period revealed the following:

- 41 per cent (69) of the overall study population indicated they had made changes to their farm operations or decision making during the year. Half of these growers also believed that they had some level of influence on other growers who were now making similar changes.
- The greatest influences on change were (1) the provision of fiscal incentives and (2) extension support from DAF and/or Terrain NRM.

Horticulture

C
47 %

Pollutant	Area managed under best management practice systems	
	Proportion (%)	Area (hectares)
Sediment	**72%**	61,561
Nutrients	**24%**	20,605
Pesticides	**45%**	38,687

Target: 90 per cent of horticulture lands are managed using best management practice systems by 2018

By June 2016, best management practice systems were used on approximately 45 per cent of horticultural land for pesticides (38,687 hectares), 24 per cent for nutrients (20,605 hectares) and 72 per cent for soil (61,561 hectares)**.** Approximately 970 horticulture producers are farming 86,000 hectares of land in the Reef catchment. The major identified driver of change in the horticulture industry during 2015–16 was the Australian Government's Reef Programme, delivered by regional NRM organisations and Growcom, and covering six farms and 98 hectares of crop area.

The Growcom Horticulture Best Management Practice, Hort360, is a voluntary program developed by industry, science and growers to help horticulture growers manage risk and identify opportunities for the growth and durability of their agribusiness. Hort360 helps growers develop action plans to address areas of opportunity that have potential economic, social and/or natural resource management outcomes. Action plans link growers to existing information sources, on-farm assistance, and services to help them carry out the actions.

Delivery of Reef Programme by Growcom in 2015–16 assisted growers in the Burnett, Fitzroy, Bowen and Burdekin river basins to implement improved practices. Extension and on-farm technical support was

driven via Hort360 enabling Growcom staff to target efforts towards addressing risks and enabling growers to seize opportunities. During this period, activities in the Bowen, Burdekin and Fitzroy regions focused on finalising projects for previously incentivised growers, extension and on-farm technical support. Within the Burnett Mary region, Growcom delivered and finalised a $100,000 incentive package following two years of extension and on-farm technical support.

By June 2016, 808 horticulture businesses farming on 65,000 hectares had completed over 1400 Hort360 modules. As this process of engagement and capacity building evolves and the spatial extent of change can be described, future Reef report cards will aim to estimate the impacts on water quality of these improvements in farm management practice.

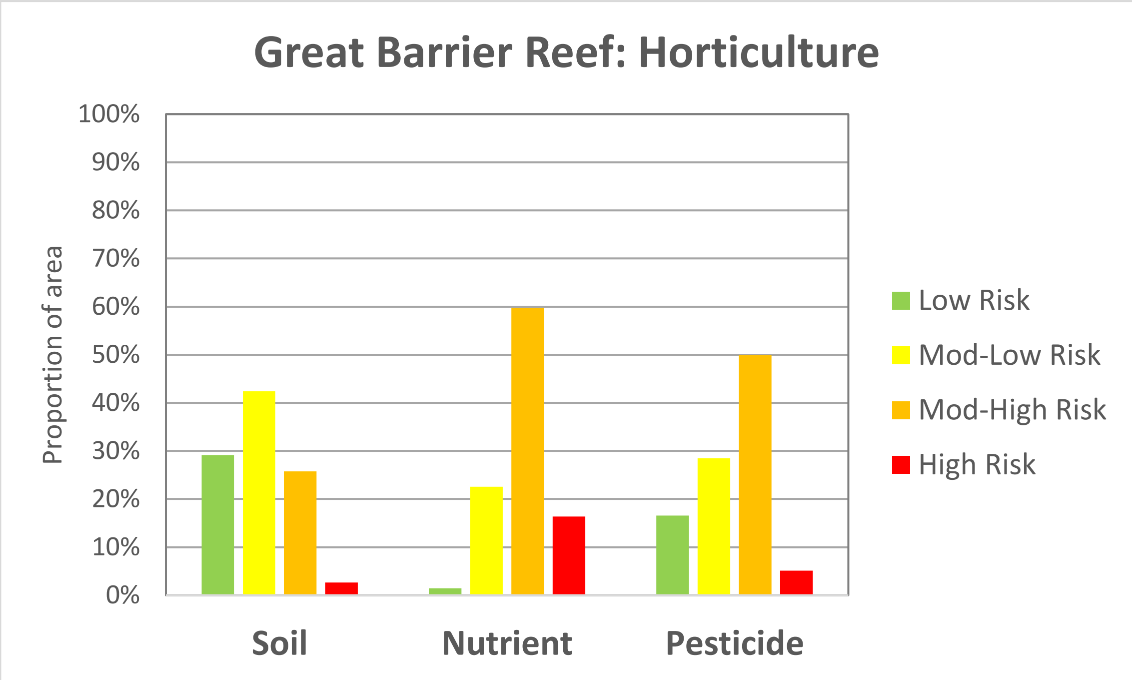

Figure 5: Reef-wide proportional area of horticulture water quality risk by pollutant

Grains

C
57%

Pollutant	Area managed under best management practice systems	
	Proportion (%)	Area (hectares)
Sediment	**45%**	816,914
Nutrients	**54%**	606,853
Pesticides	**73%**	503,242

Target: 90 per cent of grain farming land is managed using best management practice systems by 2018.

By June 2016, best management practice systems were used on approximately 73 per cent of grain farming land for pesticides (503,242 hectares), 54 per cent for nutrients (606,853 hectares) and 45 per cent for soil (816,914 hectares).

Approximately 600 grain growers are managing about 914,000 hectares of land in the Fitzroy region, and 280 growers are managing 80,000 hectares in the Burnett river basin. The amount of land under grain

production in both areas can vary considerably over time due to some land alternating between grain production and pastures for beef cattle. Approximately 44 growers are managing 123,000 hectares under grain crops in the Burdekin region.

The Grains Best Management Practice (BMP) program, developed by the Queensland Government, the Fitzroy Basin Association and Agforce, is a voluntary, industry-led program which helps grain growers identify opportunities to improve management practices and thereby improve the long-term sustainability and productivity of their enterprise. By June 2016, 418 growers across 517,382 hectares had completed the Grains BMP program. As this process of engagement and capacity building evolves and the spatial extent of change can be described, future Reef report cards will aim to estimate the impacts on water quality of improvements in farm management practice.

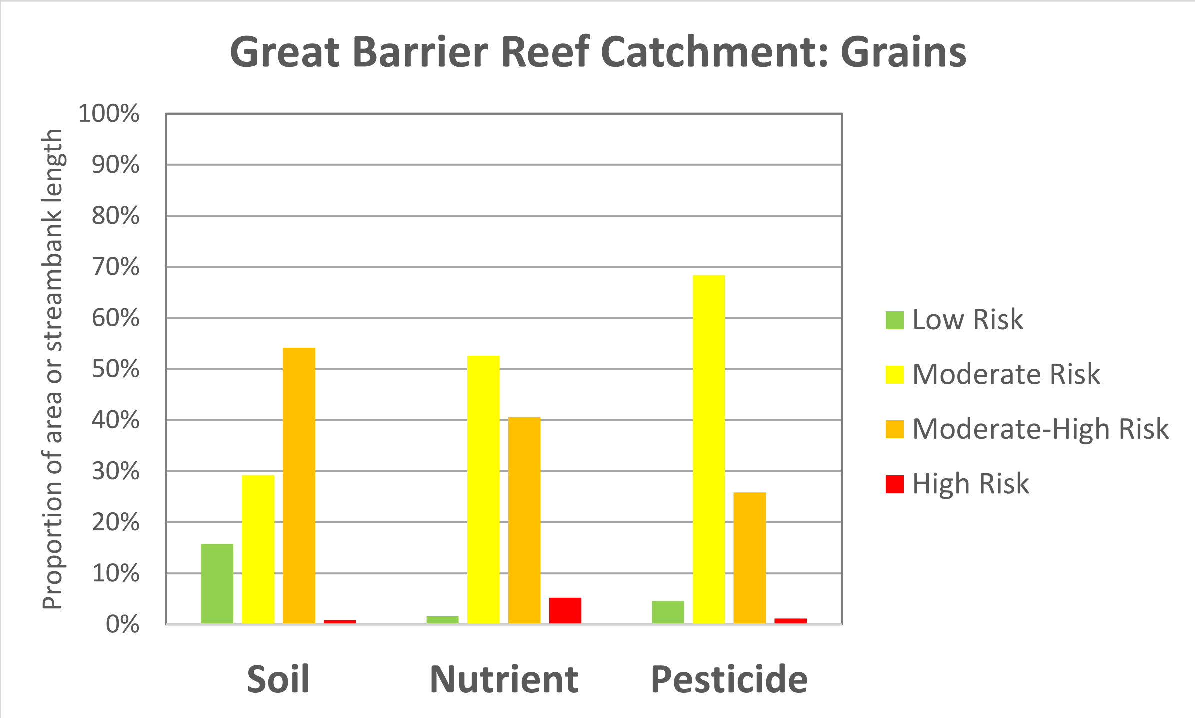

Figure 6: Reef-wide proportional area of grains water quality risk by pollutant

Table 6: Reef-wide grains water quality risk over time, by pollutant

Soil	Baseline	2014 Report Card	2015 Report Card	2016 Report Card
Lowest Risk	15%	15%	16%	16%
Moderate-Low Risk	29%	29%	29%	29%
Moderate Risk	55%	55%	54%	54%
High Risk	2%	2%	1%	1%
Nutrient				
Lowest Risk	2%	2%	2%	2%
Moderate-Low Risk	52%	52%	53%	53%
Moderate Risk	41%	41%	41%	41%
High Risk	5%	5%	5%	5%
Pesticide				
Lowest Risk	4%	4%	5%	5%
Moderate-Low Risk	68%	68%	68%	68%
Moderate Risk	27%	26%	26%	26%
High Risk	1%	1%	1%	1%

Cape York

Grazing

D
28%

Erosion source	**Area managed under best management practice systems**	
	Proportion (%)	Area (hectares or kilometres)
Pastures	**20%**	439,684 ha
Streambanks	**29%**	2,944 km
Gullies	**34%**	739,688 ha

Target: 90 per cent of grazing lands are managed using best management practice systems by 2018.

Approximately 48 graziers are managing 2.16 million hectares of land in the Normanby River catchment in the Cape York region. As at June 2016, approximately 20 per cent of grazing land was being managed using best management for practices relating to pasture (hillslope) erosion (439,684 hectares), 28 per cent for practices related to streambank erosion (2944 kilometres of streambank), and 34 per cent for practices related to gully erosion (739,688 hectares). Management practice adoption efforts in the Normanby River catchment have focused upon the Hann River sub catchment.

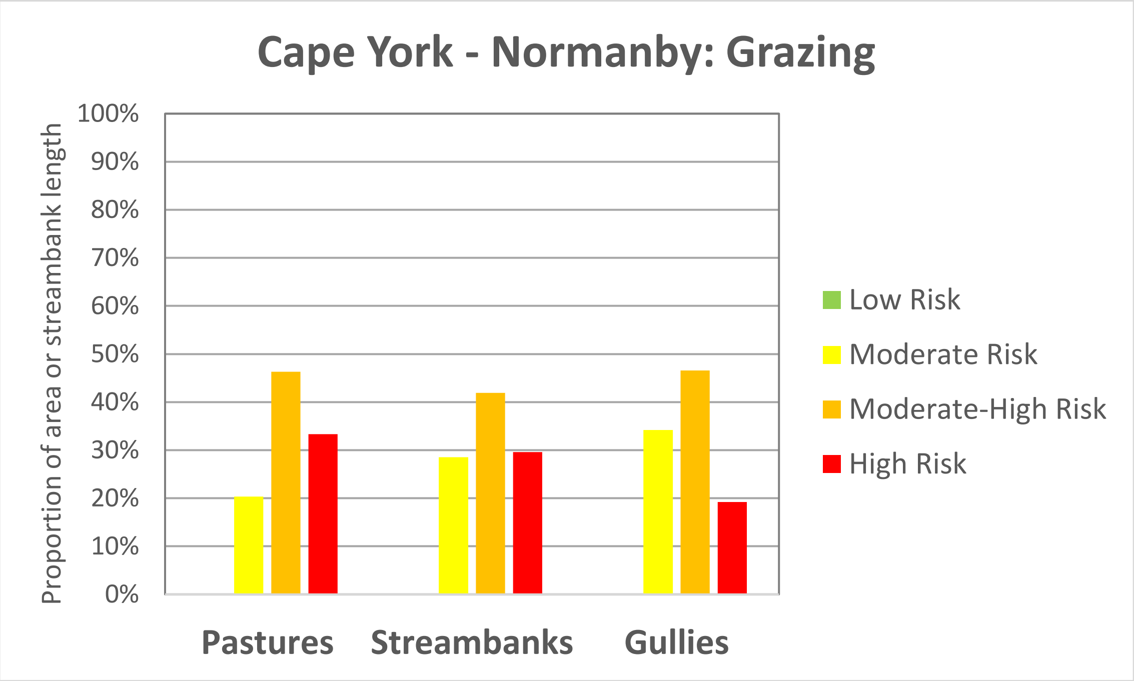

Figure 7: Cape York proportional area of grazing water quality risk by erosion type

Cape York NRM facilitated funding through the Australian Government's Reef Programme to improve management of 5987 hectares on a single grazing property. Work included fencing, construction and repair of whoa-boys to control erosion, and the installation of a new watering point to exclude livestock from streambanks and other degraded areas.

Table 7: Cape York grazing water quality risk over time, by pollutant

Pastures	Baseline	2014 Report Card	2015 Report card	2016 Report card
Very Low Risk	0%	0%	0%	0%
Low Risk	20%	20%	20%	20%
Moderate Risk	47%	47%	47%	46%
Moderate - High Risk	33%	33%	33%	33%
Streambank				
Very Low Risk	0%	0%	0%	0%
Low Risk	28%	28%	29%	29%
Moderate Risk	42%	42%	42%	4%
Moderate - High Risk	30%	30%	30%	30%
Gully				
Very Low Risk	0%	0%	0%	0%
Low Risk	34%	34%	34%	34%
Moderate Risk	47%	47%	47%	47%
Moderate - High Risk	19%	19%	19%	19%

Wet Tropics

Grazing

D
35%

Erosion source	Area managed under best management practice systems	
	Proportion (%)	Area (hectares or kilometres)
Pastures	**21%**	145,000 ha
Streambanks	**82%**	5,800 km
Gullies	**3%**	23,000 ha

Target: 90 per cent of grazing lands are managed using best management practice systems by 2018.

No discrete management practice change investments targeted water quality improvements in the grazing industry in the Wet Tropics region during 2015–16. As at June 2016, approximately 21 per cent of grazing land was under best management practice systems relating to pasture (hillslope) erosion (145,000 hectares), 82 per cent for practices related to streambank erosion (5800 kilometres of streambank) and 3 per cent for practices related to gully erosion (23,000 hectares).

Approximately 935 graziers are managing 698,000 hectares of land in the Wet Tropics region. A large proportion of this grazing land is rangelands in the upper catchment of the Herbert River, where a relatively small number of larger holdings strongly influence the management adoption benchmarks.

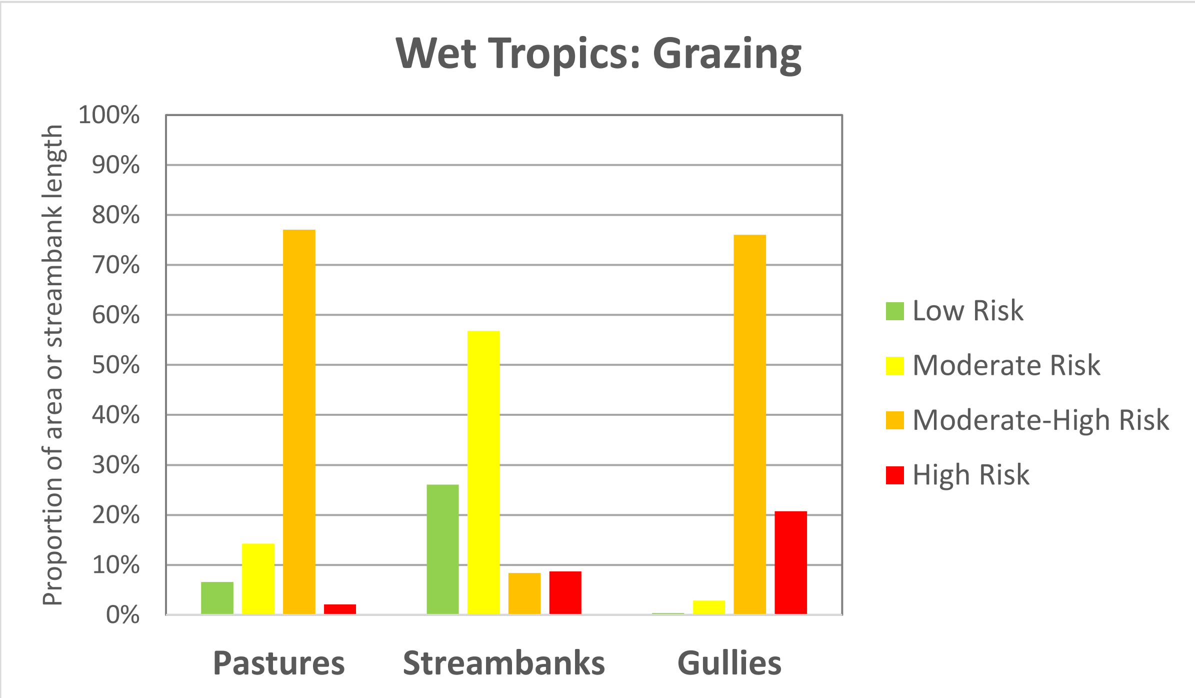

Figure 8: Wet Tropics proportional area of grazing water quality risk by erosion

Sugarcane

D
33%

Pollutant	Area managed under best management practice systems	
	Proportion (%)	Area (hectares)
Sediment	**52%**	71,363
Nutrients	**16%**	21,804
Pesticides	**30%**	40,862

Target: 90 per cent of sugarcane lands are managed using best management practice systems by 2018.

Approximately 1343 growers are managing 136,000 hectares of sugarcane in the Wet Tropics region. As at June 2016, best management practice systems were used on approximately 30 per cent of sugarcane growing land for pesticides (40,862 hectares), 16 per cent for nutrients (21,804 hectares) and 52 per cent for soil (71,363 hectares).

Table 8: Wet Tropics sugarcane best management practices and their adoption over time

Key practices	**Proportion of area where key practice has been adopted**			
	Baseline	2014 Report card	2015 Report card	2016 Report card
Green cane trash blanketing	98%	98%	98%	98%
Fallow management	52%	57%	58%	63%
Controlled machinery traffic	39%	43%	44%	48%
Tillage - plant cane	31%	36%	38%	47%
Nitrogen surplus	5%	9%	9%	16%
Fertiliser placement	73%	76%	77%	82%
Residual herbicide targeting	12%	20%	23%	29%
Residual herbicide strategy	50%	56%	60%	66%

Adoption of improved management practices occurred largely through the Australian Government's Reef Programme, facilitated in the Wet Tropics by Terrain NRM. Terrain NRM worked directly with 128 sugarcane growers (managing 42,517 hectares of sugarcane) in implementing on-farm changes with financial incentives that supported the purchase or modification of farm equipment. Changes included the following:

- 45 farms made changes to row spacing and moved towards controlled machinery wheel traffic.
- 35 farms made fallow management changes, most commonly through equipment that enabled the inclusion of legume break crops in rotation with sugarcane.
- 39 farms modernised tillage equipment resulting in reduced or zonal tillage in preparing land for planting cane.
- 38 farms made changes to the timing of nitrogen fertiliser application, six of them adjusting rates to account for nitrogen variability within blocks.
- 24 farms began applying fertiliser below the soil surface instead of on top of the surface.

- 23 farms made changes to reduce the loss of residual herbicides, which involved purchasing or modifying equipment to enable directed and/or shielded herbicide spraying (which can significantly reduce the volume of residual herbicide applied).
- 54 farms improved application of residual herbicides, and a further 53 indicated they were changing their use of residuals in ratoon cane.
- 16 farms changed the way they dealt with rainfall run-off through laser levelling or modifying headlands, drains and drainage lines.

The Reef Trust Tender – Wet Tropics, funded by the Australian Government and facilitated in the Wet Tropics by Terrain NRM, aimed to reduce the potential nitrogen fertiliser surplus in sugarcane on 22 farms through a market-based competitive tender process. Terrain NRM worked directly with 22 sugarcane growers (managing 2507 hectares) and achieved an annual reported reduction of 116 tonnes of applied nitrogen as fertiliser.

The Smartcane BMP program supports sugarcane growers in self-assessing their farm management practices against a range of industry standards. This allows growers to identify and prioritise areas for potential management improvement. As at July 2016, the Smartcane BMP program had directly engaged with 557 businesses (98,835 hectares) and accredited 75 cane growers (22,621 hectares) in the Wet Tropics region. Future Reef report cards will aim to describe the specific practice change and spatial extent of management improvements resulting from this ongoing engagement and follow-up support.

The Queensland Government Department of Agriculture and Fisheries (DAF) cane extension team reported management improvements on 35 sugarcane farms and 6152 hectares through one-on-one extension support. Management practice changes achieved by the DAF extension team include:

- 10 growers implemented controlled traffic farming systems.
- 21 growers increased row spacing to 1.8–2.0 metres and incorporated a zonal tilled legume/cover crop.
- 10 growers reduced cultivation to less than five passes while 11 growers moved to zonal tillage only.
- 18 growers improved residual herbicide use by implementing a single application of residuals in each ratoon crop as well as band spraying and managing inter-rows with knockdowns.

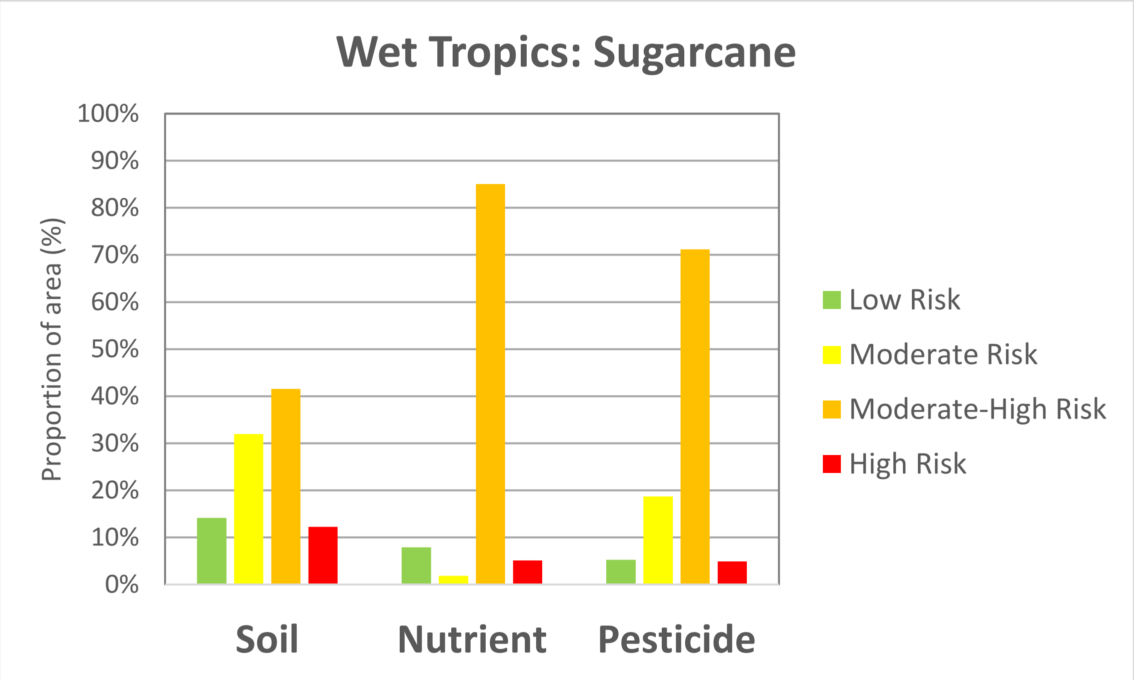

Figure 9: Wet Tropics proportional area of sugarcane grains water quality risk by pollutant

Table 9: Wet Tropics sugarcane water quality risk over time, by pollutant

Soil	Baseline	2014 Report card	2015 Report card	2016 Report card
Low Risk	9%	13%	14%	14%
Moderate Risk	31%	32%	32%	38%
Moderate-High Risk	43%	42%	42%	36%
High Risk	16%	12%	12%	12%
Nutrient				
Low Risk	2%	8%	8%	10%
Moderate Risk	3%	1%	2%	6%
Moderate-High Risk	89%	86%	85%	84%
High Risk	6%	5%	5%	0%
Pesticide				
Low Risk	4%	4%	5%	5%
Moderate Risk	8%	16%	19%	25%
Moderate-High Risk	81%	75%	71%	70%
High Risk	7%	5%	5%	0%

Bananas

C
62%

Pollutant	**Area managed under best management practice systems**	
	Proportion (%)	Area(hectares)
Sediment	**60%**	7522
Nutrients	**63%**	7831

Target: 90 per cent of banana farming lands are managed using best management practice systems by 2018.

Approximately 250 growers are managing 11,800 hectares of bananas in the Wet Tropics region. By June 2016, approximately 63 per cent of banana farming land was being managed under best practice systems for nutrients (7831 hectares) and 60 per cent for soil (7522 hectares). Pesticide management systems are not reported due to the relatively low level of use of residual herbicides and insecticides with high potential ecological toxicity.

The main source of identified farm management practice change in 2015–16 was the Australian Government's Reef Programme, facilitated by Terrain NRM in collaboration with the Australian Banana Growers Association. This program worked with 30 farms across 3338 hectares to fund farm equipment and infrastructure improvements, including the following:

- 4 farms implemented minimum tillages practices necessary for planting crops through installation of GPS units.
- 5 farms improved inter-row ground cover management by maintaining grassed inter-rows and headlands, enabled by purchasing inter-row slashers.

- 4 farms implemented changes to reduce the risk of nitrogen and phosphorus loss by undertaking an annual fertiliser program supported by soil and leaf testing.
- 20 farms installed automated fertigation systems and implemented nutrient management plans, which can significantly reduce risk of nutrient loss associated with nitrogen surplus.
- 13 farms improved their irrigation application methods and 10 farms improved their irrigation scheduling.

The Banana BMP program supports banana growers in self-assessing their farm management practices against a range of industry standards. This allows growers to identify and prioritise areas for potential management improvement. As at July 2016, the Banana BMP program had directly engaged with 73 businesses in the Wet Tropics region, representing 6836 hectares of bananas. Future Reef report cards will aim to describe any management improvements resulting from this ongoing engagement and follow-up support.

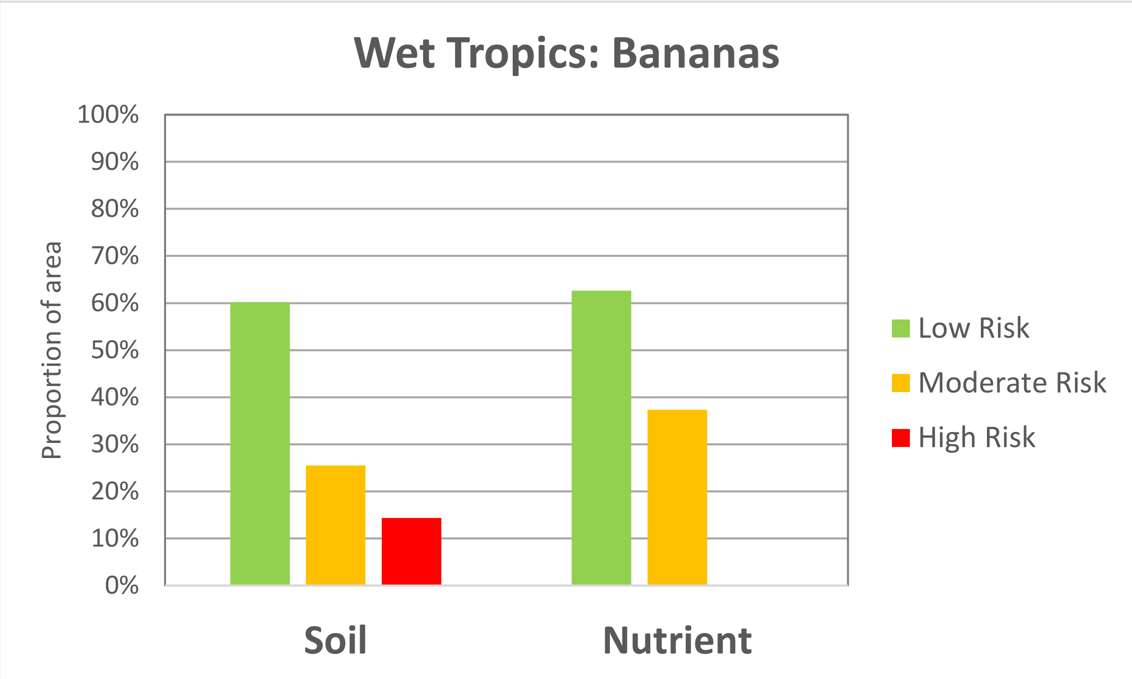

Figure 10: Wet Tropics proportional area of bananas water quality risk by pollutant

Table 10: Wet Tropics bananas water quality risk over time, by pollutant

Soil	**Baseline**	**2014 Report Card**	**2015 Report Card**	**2016 Report card**
Moderate-Low Risk	45%	53%	57%	60%
Moderate Risk	38%	29%	28%	25%
High Risk	17%	17%	15%	14%
Nutrient				
Moderate-Low Risk	42%	52%	56%	63%
Moderate Risk	50%	40%	37%	37%
High Risk	8%	8%	7%	0%

Burdekin

Grazing

D
44%

Erosion source	Area managed under best management practice systems	
	Proportion (%)	Area (hectares or kilometres)
Pastures	**33%**	4,060,585 ha
Streambanks	**73%**	27,301 km
Gullies	**27%**	3,293,439 ha

Target: 90 per cent of grazing lands are managed using best management practice systems by 2018.

Approximately 983 graziers are managing 12.4 million hectares of land and 37,000 kilometres of streambanks in the Burdekin region. By June 2016, approximately 33 per cent of grazing land was under best management practices relating to pasture (hillslope) erosion (4,060,585 hectares), 72 per cent for practices related to streambank erosion (27,301 kilometres of streambank) and 27 per cent for practices related to gully erosion 3,293,439 hectares).

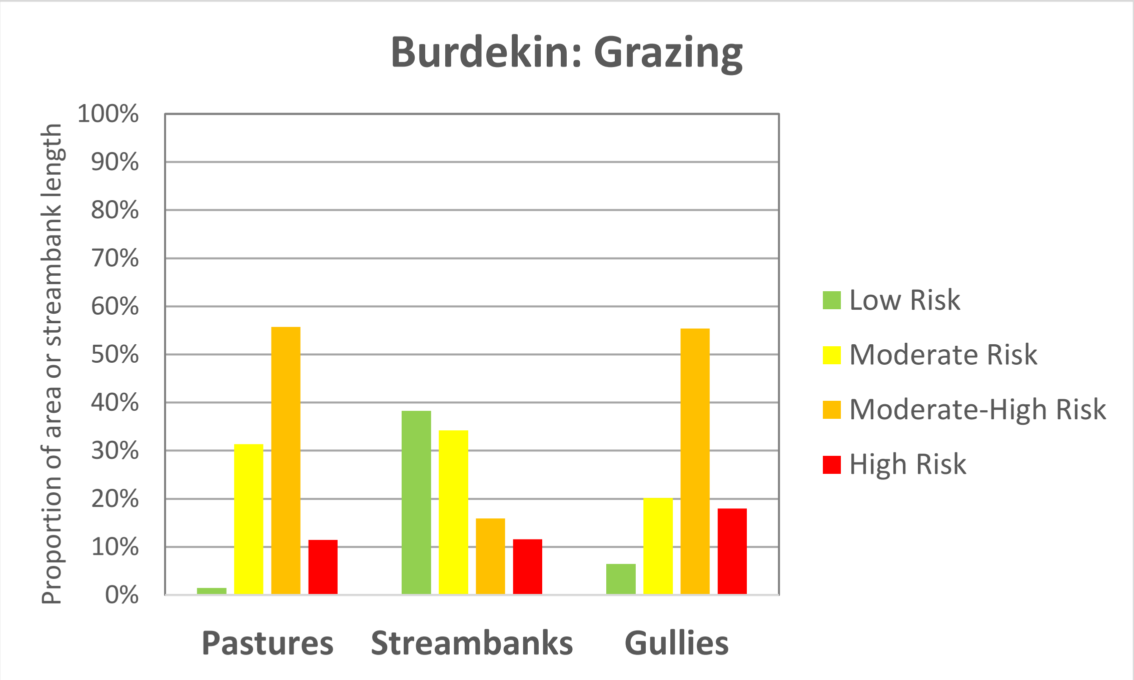

Figure 11: Burdekin proportional area of grazing water quality risk by erosion type

Adoption of improved management practices occurred with 16 graziers through collaboration with NQ Dry Tropics (funded through the Australian Government's Reef Programme), which co-funded management improvements on more than 31,777 hectares.

The beef extension team of the Queensland Government Department of Agriculture and Fisheries (DAF) focused on providing BMP follow-up services and providing information on grazing land management and the sediment loss process and how it impacts end-of-catchment water quality. Management changes reported included improved matching of grazing pressure to feed supply, and preventative measures taken

to minimise the risk of initiating gully erosion. During 2015–16, a total of 121 beef businesses across 2.7 million hectares were engaged by the DAF team through activities to assist with practice changes.

The Grazing BMP program delivered locally by NQ Dry Tropics, in combination with Queensland Government extension support, engaged with 98 grazing businesses that collectively managed 2.5 million hectares of grazing land during 2015, and 20 landholders completed the Grazing BMP audit process. The BMP programs enable graziers to assess their management practices and aim to support them in acquiring the knowledge and skills necessary to adopt improved practices. Many of these grazing businesses have begun to implement management changes; as these changes become apparent the impacts will be estimated in future Reef report cards.

Table 11: Burdekin grazing water quality risk over time, by pollutant

Pastures	**Baseline**	**2014 Report Card**	**2015 Report card**	**2016 Report card**
Very Low Risk	0%	1%	1%	1%
Low Risk	29%	29%	32%	31%
Moderate Risk	59%	59%	56%	56%
Moderate - High Risk	12%	12%	12%	11%
Streambank				
Very Low Risk	38%	38%	38%	38%
Low Risk	34%	34%	34%	34%
Moderate Risk	16%	16%	16%	16%
Moderate - High Risk	12%	12%	12%	12%
Gully				
Very Low Risk	5%	6%	6%	6%
Low Risk	21%	20%	20%	20%
Moderate Risk	56%	56%	56%	55%
Moderate - High Risk	18%	18%	18%	18%

Sugarcane

E
22%

Pollutant	**Area managed under best management practice systems**	
	Proportion (%)	Area (hectares)
Sediment	**17%**	14,066
Nutrients	**14%**	11,954
Pesticides	**36%**	30,217

Target: 90 per cent of sugarcane lands are managed using best management practice systems by 2018.

Approximately 556 growers are managing 83,000 hectares of sugarcane in the Burdekin region. By June 2016, approximately 36 per cent of sugarcane land was being managed using best management practice systems for practices relating to pesticides (30,000 hectares), 14 per cent for nutrients (12,000 hectares) and 17 per cent for soil (14,000 hectares).

Table 12: Key sugarcane best management practices and their adoption rate over time in the Burdekin

Key practices	Proportion of area where key practice has been adopted			
	Baseline	2014 Report Card	2015 Report Card	2016 Report Card
Green cane trash blanketing	2%	2%	2%	2%
Fallow management	7%	8%	9%	9%
Controlled machinery traffic	12%	12%	12%	12%
Tillage - plant cane	29%	31%	31%	31%
Nitrogen surplus	8%	10%	18%	18%
Fertiliser placement	91%	91%	92%	92%
Residual herbicide targeting	6%	6%	16%	16%
Residual herbicide strategy	64%	65%	68%	68%
Irrigation scheduling	45%	45%	45%	50%
Tailwater recycling	35%	39%	47%	47%

The Smartcane BMP program engaged with 179 growers in the Burdekin region (managing 37,551 hectares of sugarcane), with 24 growers (managing 6593 hectares) undertaking the BMP accreditation process up to July 2016. These growers were supported in completing self-assessments of their farm management practices against a range of industry standards, with a view to identifying priorities for potential improvement. Future Reef report cards will aim to describe the impacts of these management changes as they are reported.

The Reef Trust Tender programme, funded by the Australian Government and facilitated in the Burdekin by NQ Dry Tropics, aimed to improve nitrogen and irrigation management practices on sugarcane farms through a competitive tender process. Growers participated in a reverse auction which involved tender submissions outlining how and to what extent nitrogen and irrigation management practices could be improved. Funding was allocated on the basis of maximum value for money in terms of nitrogen reductions. NQ Dry Tropics contracted 16 sugarcane growers (managing 8064 hectares) and achieved an annual reduction in fertiliser application equivalent to 183 tonnes of nitrogen (an average of more than 22 kg N/ha/year).

The RP20C Burdekin Nitrogen Project, funded by the Queensland Government Department of Environment and Heritage Protection under the Reef Water Quality Science Program, aimed to provide further evidence supporting the industry standard for nitrogen applications and the Six Easy Steps nutrient budgeting process. Sugar Research Australia facilitated the delivery of the project and engaged with 23 cane farmers in the Burdekin catchment. The project has achieved an annual reduction of 499 tonnes of applied nitrogen across 12,721 hectares of cane, with an average reduction of 39 kg N/ha/year and improved irrigation scheduling practices through the installation of soil moisture probes on 3936 hectares.

Both of the above projects (RP20C and the Reef Trust Tender) have successfully targeted high risk nitrogen fertiliser rates. While many of the improvements reported are not reflected in the best management system metric used in this report, they must be acknowledged as having driven significant water quality improvements.

The DAF cane extension team engaged with 7 cane farmers managing 89 hectares. On-farm management practice changes included the following:

- 2 farmers changed fallow management to include a zonal tilled legume/cover crop and changed to calculating nitrogen rate based on Six Easy Steps and the farm or block yield history.
- 5 farmers changed residual herbicide application to incorporate band spraying, only using knockdowns in ratoon crops, and only using residuals when required, thereby reducing the amount of herbicide used across the farm area.

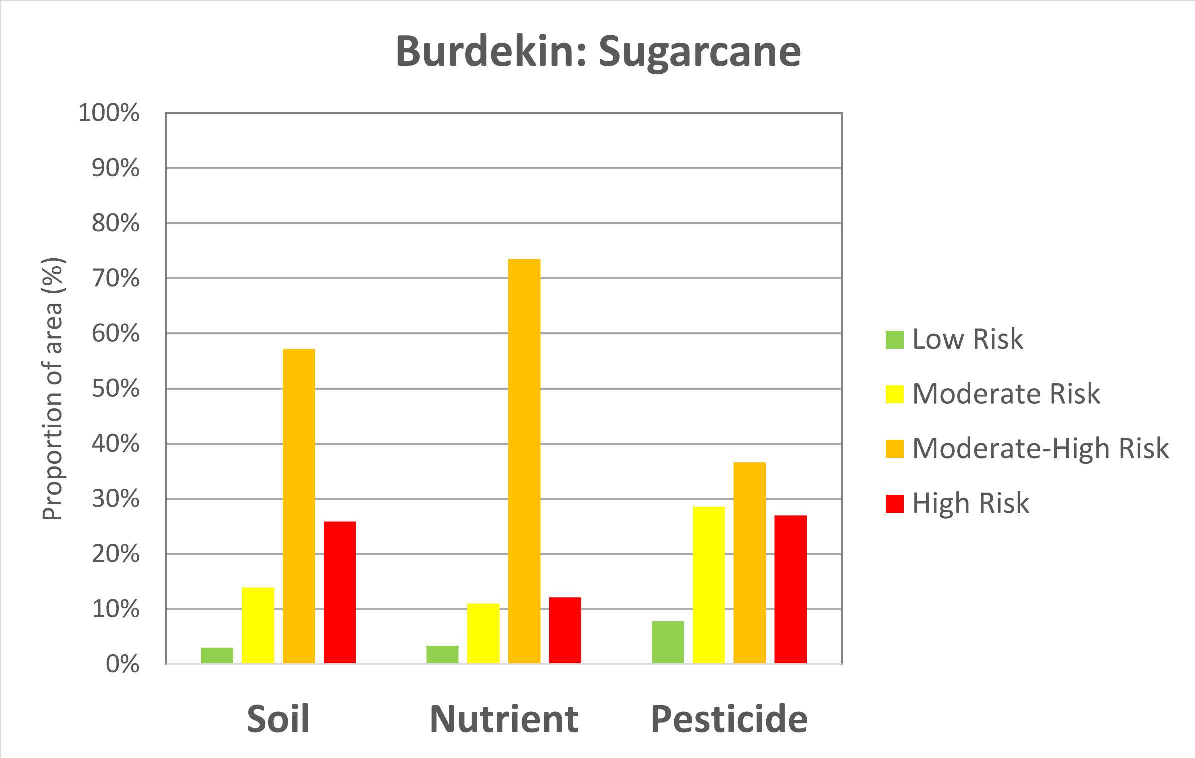

Figure 12: Burdekin proportional area of sugarcane water quality risk by pollutant

Table 13: Burdekin sugarcane water quality risk over time, by pollutant

Soil	**Baseline**	**2014 Report card**	**2015 Report card**	**2016 Report card**
Low Risk	3%	3%	3%	3%
Moderate Risk	13%	14%	14%	14%
Moderate-High Risk	58%	57%	57%	57%
High Risk	26%	26%	26%	26%
Nutrient				
Low Risk	3%	3%	3%	3%
Moderate Risk	5%	7%	10%	11%
Moderate-High Risk	67%	65%	62%	73%
High Risk	25%	25%	24%	12%
Pesticide				
Low Risk	7%	7%	8%	8%
Moderate Risk	19%	18%	29%	29%
Moderate-High Risk	47%	47%	37%	37%
High Risk	28%	28%	27%	27%

Horticulture

C
49%

Pollutant	**Area managed under best management practice systems**	
	Proportion (%)	Area (hectares)
Sediment	**67%**	16,822
Nutrients	**19%**	4,635
Pesticides	**60%**	14,864

Target: 90 per cent of horticulture lands are managed using best management practice systems by 2018.

Approximately 200 horticulture producers are farming 25,000 hectares of land in the Burdekin region. By June 2016, best management practice systems were used on approximately 60 per cent of horticultural land for pesticides (14,800 hectares), 19 per cent for nutrients (4,600 hectares) and 67 per cent for soil (16,800 hectares). There was no Australian or Queensland Governments investment in horticulture in the Burdekin during 2015–16.

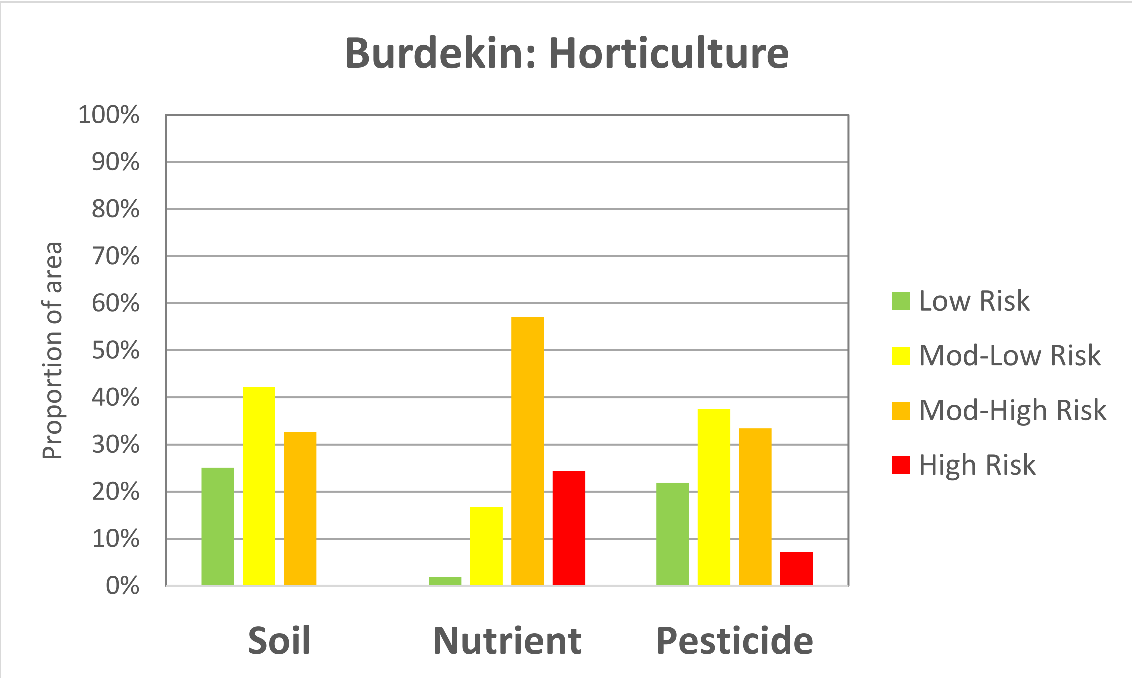

Figure 12: Burdekin proportional area of horticulture water quality risk by pollutant

Grains

C
57%

Pollutant	Area managed under best management practice systems	
	Proportion (%)	Area (hectares)
Sediment	**31%**	38,612
Nutrients	**48%**	59,321
Pesticides	**92%**	113,227

Target: 90 per cent of grain farming land is managed using best management practice systems by 2018.

Approximately 44 growers are managing 123,000 hectares under grain crops in the Burdekin region. By June 2016, best management systems were being used on approximately 92 per cent of grain farming land for pesticides (113,000 hectares), 48 per cent for nutrients (59,000 hectares) and 31 per cent for soil (38,000 hectares).

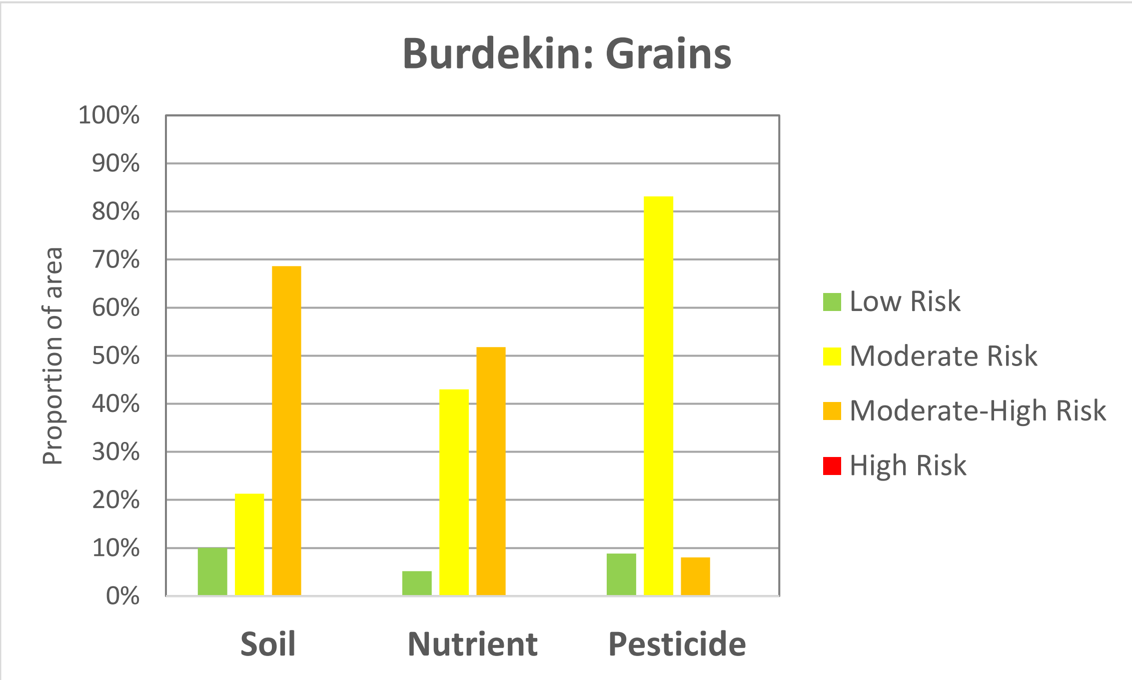

Figure 13: Burdekin proportional area of grains water quality risk by pollutant

As of June 2016, **the Grains BMP program** had engaged 34 grain growers managing 98,923 hectares. During 2015–16, no further growers completed the Grains BMP program in the Burdekin catchment, but the total grain production area assessed under the Grains BMP program increased by 6000 hectares.

Table 14: Burdekin grains water quality risk over time, by pollutant

Soil	Baseline	2014 Report card	2015 Report card	2016 Report card
Lowest Risk	5%	6%	10%	10%
Moderate-Low Risk	26%	26%	21%	21%
Moderate Risk	69%	69%	69%	69%
High Risk	0%	0%	0%	0%
Nutrient				
Lowest Risk	5%	5%	5%	5%
Moderate-Low Risk	43%	43%	43%	43%
Moderate Risk	52%	52%	52%	52%
High Risk	0%	0%	0%	0%
Pesticide				
Lowest Risk	4%	8%	9%	9%
Moderate-Low Risk	82%	83%	83%	83%
Moderate Risk	14%	9%	8%	8%
High Risk	0%	0%	0%	0%

Mackay Whitsunday

Grazing

D
33%

Erosion source	**Area managed under best management practice systems**	
	Proportion (%)	Area (hectares or kilometres)
Pastures	**40%**	120,715 ha
Streambanks	**21%**	474 km
Gullies	**38%**	113,087 ha

Target: 90 per cent of grazing lands are managed using best management practice systems by 2018.

Approximately 416 graziers are managing 304,000 hectares of land and 2300 kilometres of streambanks in the Mackay Whitsunday region. By June 2016, approximately 40 per cent of grazing land was being managed using best management practice systems for practices related to pasture (hillslope) erosion (120,715 hectares), 21 per cent for practices relating to streambank erosion (474 kilometres of streambank) and 38 per cent for practices relating to gully erosion (113,087 hectares).

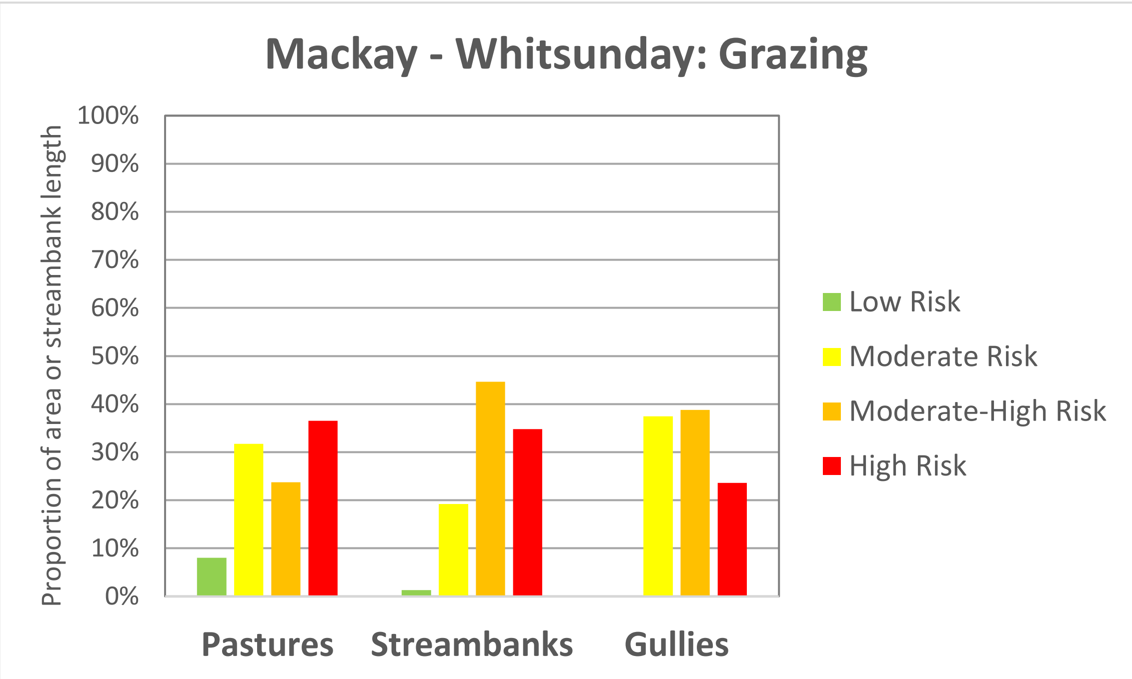

Figure 14: Mackay Whitsunday proportional area of grazing water quality risk by erosion type

A total of 22 graziers in the Mackay Whitsunday region improved their grazing land management practices on 2112 hectares of land and 8 kilometres of streambanks with the assistance of Reef Catchments NRM and the Australian Government's Reef Programme. At most of these sites, fencing was used to exclude cattle from streams and off-stream watering points were installed.

Through the assistance of the Australian Government Reef program -funded Systems Repair grants, Reef Catchments NRM repaired 30 gully sites and 57 streambank sites protecting 35 kilometres of streambank. Repairs at gully restoration sites included rock armouring and using geofabric to prevent further erosion,

and revegetation of gully heads. Repairs at streambank restoration sties included construction of riparian fences, revegetation of eroding banks and stabilising of bank walls with rocks.

DAF's beef extension team focused on providing BMP follow-up services, information on grazing land management, and information about the sediment loss process and how it impacts end-of-catchment water quality. During the 2015–16 financial year the DAF team engaged with three beef businesses across 8263 hectares to assist with practice changes.

Table 15: Mackay Whitsunday grazing water quality risk over time, by pollutant

Pastures	Baseline	2014 Report Card	2015 Report card	2016 Report card
Very Low Risk	8%	8%	8%	8%
Low Risk	30%	31%	31%	32%
Moderate Risk	25%	25%	24%	24%
Moderate - High Risk	37%	37%	37%	37%
Streambank				
Very Low Risk	1%	1%	1%	1%
Low Risk	17%	17%	18%	19%
Moderate Risk	46%	46%	45%	45%
Moderate - High Risk	35%	35%	35%	35%
Gully				
Very Low Risk	0%	0%	0%	0%
Low Risk	37%	37%	37%	37%
Moderate Risk	38%	38%	38%	39%
Moderate - High Risk	24%	24%	24%	24%

Sugarcane

D
36%

Pollutant	Area managed under best management practice systems	
	Proportion (%)	Area (hectares)
Soil	**42%**	57,641
Nutrients	**23%**	31,074
Pesticides	**43%**	58,711

Target: 90 per cent of sugarcane lands are managed using best management practice systems by 2018.

In the Mackay Whitsunday region, 1380 sugarcane growers are managing 136,000 hectares of land. As at June 2016, approximately 43 per cent of sugarcane farming land was being managed using best practice management for practices relating to pesticides (58,711 hectares), 23 per cent for nutrients (31,074 hectares) and 42 per cent for soil (57,641 hectares).

Table 16: Mackay Whitsunday key sugarcane best management practices and their adoption rate over time

Key practices	Proportion of area where key practice has been adopted			
	Baseline	2014 Report card	2015 Report card	2016 Report card
Green cane trash blanketing	84%	84%	84%	86%
Fallow management	13%	13%	13%	14%
Controlled machinery traffic	55%	55%	55%	56%
Tillage - plant cane	17%	17%	19%	20%
Nitrogen surplus	19%	20%	22%	24%
Fertiliser placement	69%	69%	70%	71%
Residual herbicide targeting	37%	37%	39%	41%
Residual herbicide strategy	41%	41%	42%	44%

Reef Catchments NRM, through the Australian Government's Reef Programme, facilitated management practice improvements with 88 sugarcane growers over 21,833 hectares. These farm management changes resulted from a mix of one-on-one extension and agronomic support, and financial incentives for taking on best practice or innovative practices. Management changes included the following:

- 41 growers undertook Six Easy Steps nutrient management planning on a block-by-block basis to determine the most efficient nitrogen fertiliser rates. Planning also included electrical conductivity soil mapping to understand spatial soil variability and constraints. This work is expected to result in significant reductions in nitrogen surplus in future sugarcane crops.
- 9 growers completed block-by-block chemical management plans to determine the most efficient and lowest risk use of herbicides.
- 38 growers completed both a Six Easy Steps nutrient management planning on a block-by-block basis and a block-by-block chemical management plan.

The Smartcane BMP program engaged with 479 growers (managing 81,001 hectares of sugarcane). At July 2016, 18 of these growers (managing 3779 hectares) had achieved BMP accreditation. These growers were supported in completing self-assessments of their farm management practices against a range of industry standards, with a view to identifying priorities for potential improvement. Future Reef report cards will aim to describe the impacts of these management changes as they are reported.

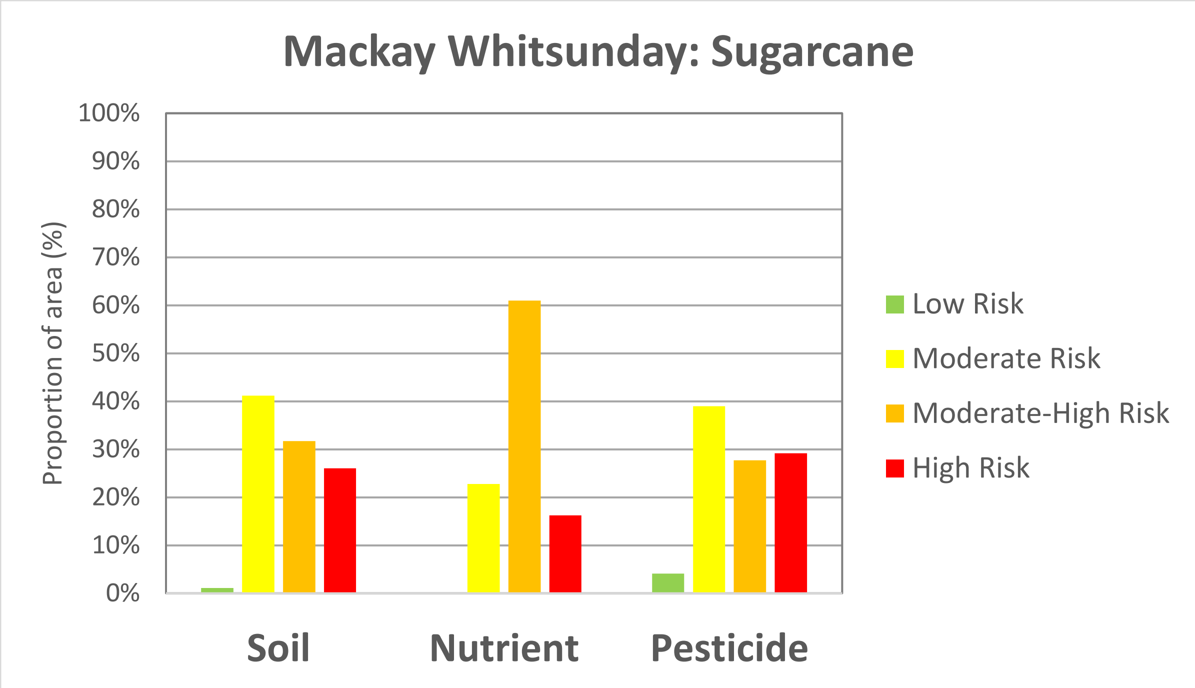

Figure 15: Mackay Whitsunday proportional area of sugarcane water quality risk by pollutant

Table 17: Mackay Whitsunday sugarcane water quality risk over time, by pollutant

Soil	**Baseline**	**2014 Report card**	**2015 Report card**	**2016 Report card**
Low Risk	1%	1%	1%	1%
Moderate Risk	40%	40%	40%	41%
Moderate-High Risk	31%	31%	33%	32%
High Risk	28%	28%	26%	26%
Nutrient				
Low Risk	0%	0%	0%	0%
Moderate Risk	19%	20%	21%	23%
Moderate-High Risk	59%	58%	60%	61%
High Risk	22%	22%	19%	16%
Pesticide				
Low Risk	4%	4%	4%	4%
Moderate Risk	32%	32%	36%	39%
Moderate-High Risk	31%	31%	28%	28%
High Risk	33%	33%	32%	29%

Fitzroy

Grazing

D
29%

Erosion source	Area managed under best management practice systems	
	Proportion (%)	Area (hectares or kilometres)
Pastures	**23%**	2,893,407 ha
Streambanks	**43%**	16,870 km
Gullies	**20%**	2,575,754 ha

Target: 90 per cent of grazing lands are managed using best management practice systems by 2018.

Approximately 3666 graziers are managing 12.7 million hectares of land and 39,000 kilometres of streambanks in the Fitzroy region. By June 2016, approximately 23 per cent of grazing land (2,893,407 hectares) was under best management practice for practices relating to surface (hillslope) erosion from pastures, 43 per cent (16,870 kilometres of streambank) for practices relating to streambank erosion and 20 per cent (2,575,754 hectares) for practices relating to gully erosion.

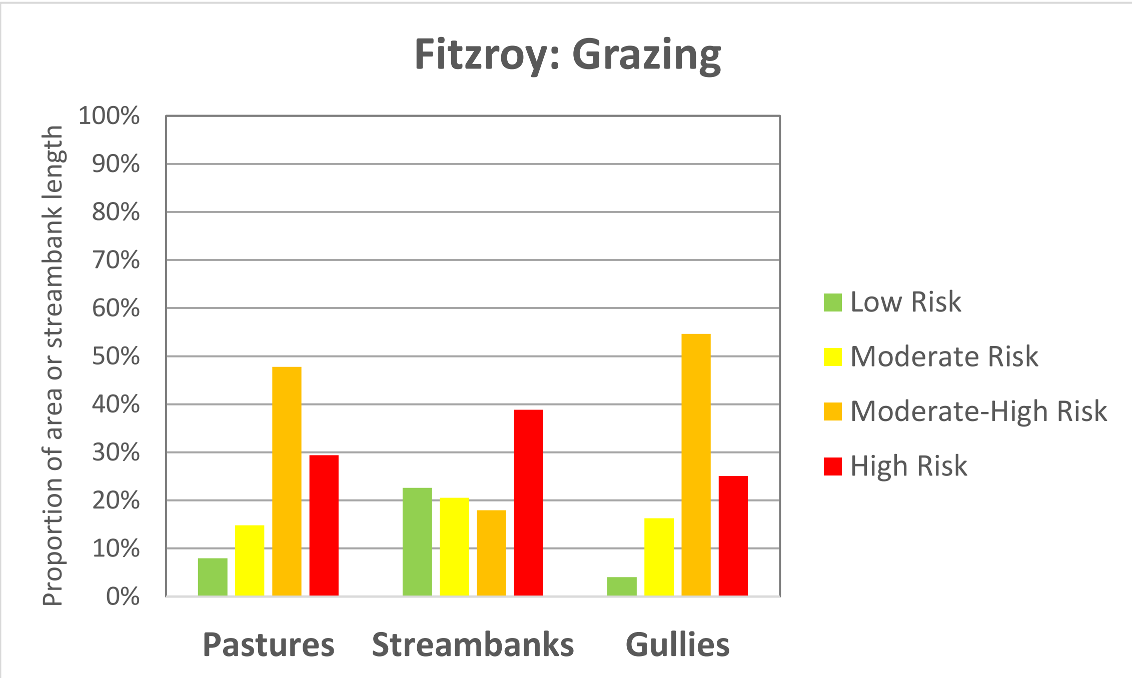

Figure 16: Fitzroy proportional area of grazing water quality risk by erosion type

A total of 117 graziers adopted improved management practices through collaboration with the Fitzroy Basin Association (funded through the Australian Government's Reef Programme), which co-funded management improvements on 90,736 hectares of predominantly river frontage and 921 kilometres of streambank. Of the projects completed, six were specific gully remediation projects aimed at reducing sediment from active gully erosion.

The Natural Resource Management Investment Programme (funded through the Queensland Department of Natural Resources and Mines), facilitated through the Fitzroy Basin Association, funded management improvements with 21 graziers across 5465 hectares and 31 kilometres of streambank frontage to improve,

protect and restore riparian areas and rangelands by managing pests and weeds, and ultimately to improve end-of-catchment water quality.

Through funding from the Australian Government's National Landcare Program, the Fitzroy Basin Association engaged with 21 landholders (managing 96,375 hectares) on a one-to-one basis to develop grazing land management plans.

The Grazing BMP program and associated Queensland Government extension staff worked with 169 graziers managing 1.1 million hectares of grazing land to assess farm management practices and identify potential actions to improve practices. A further 14 landholders achieved accreditation in the BMP process. With ongoing support, it is expected that graziers will be able to acquire new knowledge and skills which will drive management practice changes on farms. Future Reef report cards will aim to estimate the impacts of such changes as they become apparent and as the spatial extent can be described.

The DAF beef extension team focused on providing BMP follow-up services, providing information on grazing land management, and providing information on the sediment loss process and how it impacts end-of-catchment water quality. During the 2015–16 financial year, the DAF team engaged an additional 35 beef businesses across 390,000 hectares to assist with practice changes.

Table 18: Fitzroy grazing water quality risk over time, by pollutant

Pastures	**Baseline**	**2014 Report Card**	**2015 Report card**	**2016 Report card**
Very Low Risk	8%	8%	8%	8%
Low Risk	13%	14%	14%	15%
Moderate Risk	49%	49%	49%	48%
Moderate - High Risk	30%	30%	30%	29%
Streambank				
Very Low Risk	21%	21%	21%	23%
Low Risk	20%	20%	20%	21%
Moderate Risk	19%	19%	19%	18%
Moderate - High Risk	41%	40%	40%	39%
Gully				
Very Low Risk	4%	4%	4%	4%
Low Risk	16%	16%	16%	16%
Moderate Risk	55%	55%	55%	55%
Moderate - High Risk	25%	25%	25%	25%

Horticulture

D
32%

Pollutant	**Area managed under best management practice systems**	
	Proportion (%)	Area (hectares)
Soil	**61%**	4,663
Nutrients	**9%**	698
Pesticides	**25%**	1,889

Target: 90 per cent of horticulture lands are managed using best management practice systems by 2018

Approximately 100 horticulture producers are farming 7700 hectares of land in the Fitzroy region. By June 2016, best management practice systems were being used by approximately 25 per cent (1,889 hectares) of horticulture growers for pesticides, 9 per cent (698 hectares) for nutrients and 61 per cent (4,663 hectares) for soil**.**

The Fitzroy Basin Association, through the Australian Government's Reef Programme, facilitated financial incentives for farm management improvements on 6 farms and 98 hectares of horticultural land during 2015–16. These improvements involved more efficient use of insecticides and fertilisers, improved irrigation scheduling, and practices to increase ground cover around crop rows.

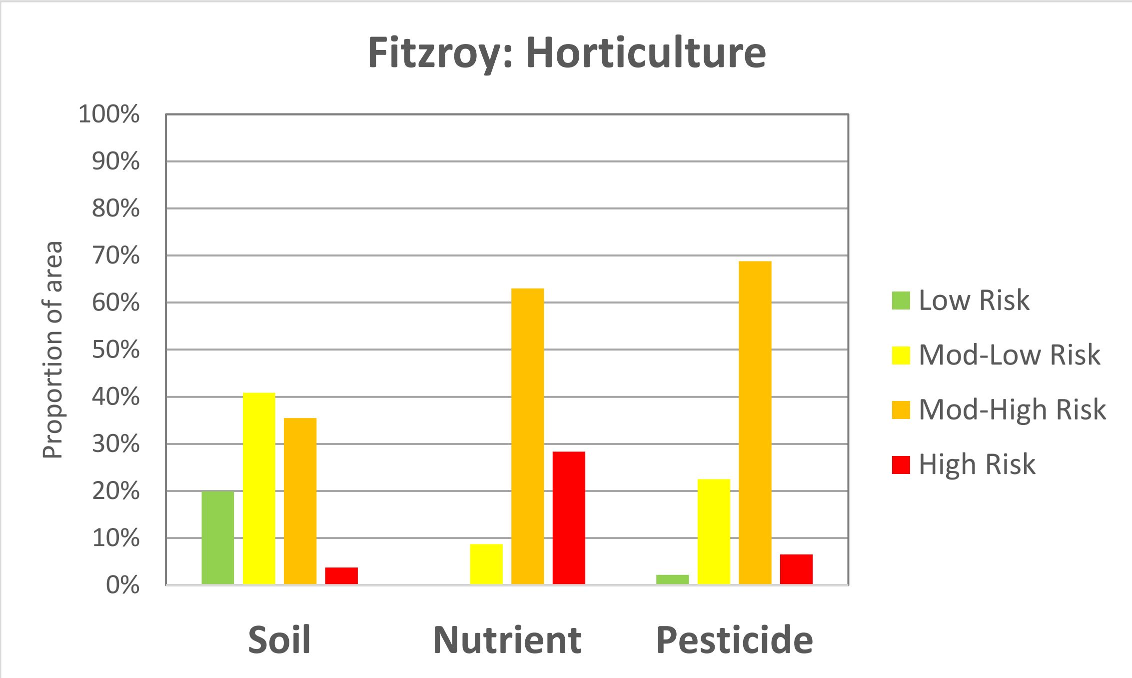

Figure 16: Fitzroy proportional area of horticulture water quality risk by pollutant

Grains

C
56%

Pollutant	Area managed under best management practice systems	
	Proportion (%)	Area (hectares)
Soil	**44%**	400,311
Nutrients	**54%**	495,257
Pesticides	**70%**	642,698

Target: 90 per cent of grain farming land is managed using best management practice systems by 2018.

Approximately 600 grain growers are managing about 914,000 hectares of land in the Fitzroy region. The amount of land under grain production can vary considerably over time due to some land alternating between grain production and pastures for beef cattle. By June 2016, best practice management systems were being used on approximately 70 per cent (642,698 hectares) of grain-growing land for pesticides, 54 per cent (495,257 hectares) for nutrients and 44 per cent (400,311 hectares) for soil.

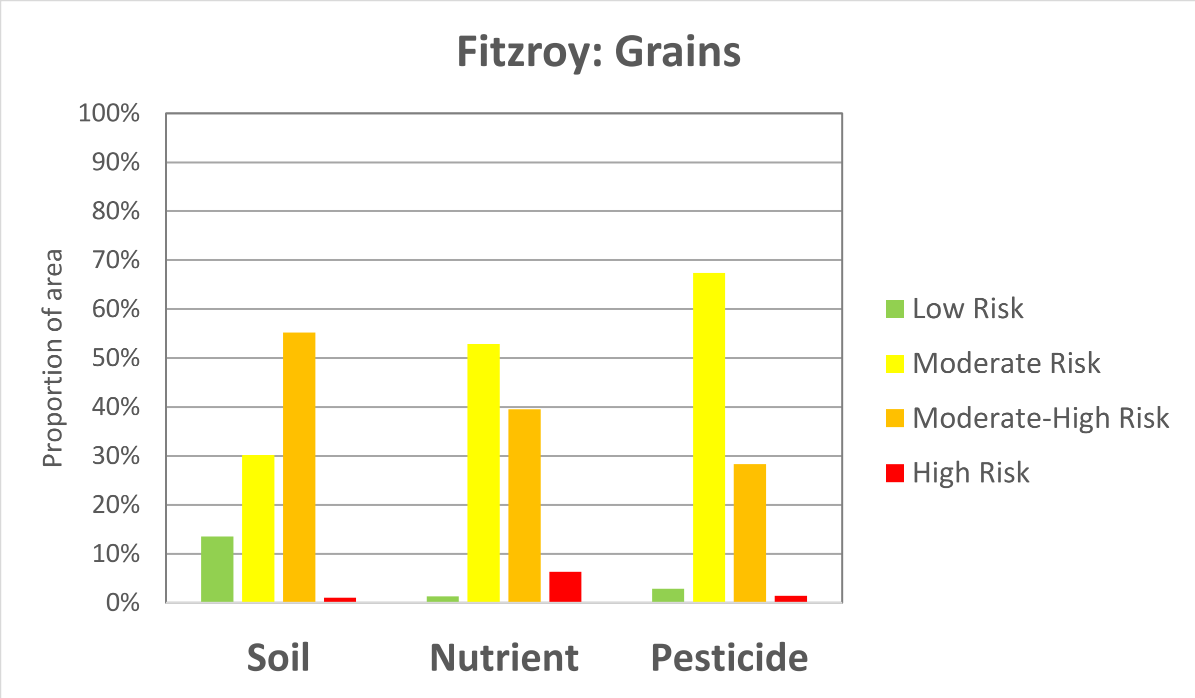

Figure 17: Fitzroy proportional area of grains water quality risk by pollutant

During 2015–16, the Grains BMP program engaged with 37 growers managing 139,815 hectares in the Fitzroy region. Growers identifying scope for practice improvement relating to off-farm water quality then became eligible for incentive funding to make these changes.

A total of 26 grain growers implemented best practice improvements on 11,693 hectares of land through working directly with the Fitzroy Basin Association (funded through the Australian Government's Reef Programme), which co-funded management improvements, including the following:

- 18 growers installed contour banks. Contour banks are a critical element of best practice systems for minimising soil erosion from cropped lands.
- 4 growers modified machinery to enable implementation of zero tillage.
- 4 growers adopted innovative controlled traffic farming systems.

The Natural Resource Management Investment Programme (funded through the Queensland Department of Natural Resources and Mines), facilitated through the Fitzroy Basin Association, engaged with 9 grain growers (15,305 hectares) on a one-on-one basis to make the following changes:

- 2 growers (2645 hectares) adopted precision nutrient application practices based on yield data.
- 4 growers (10,143 hectares) purchased equipment to improve fertiliser application efficiency.
- 1 grower (284 hectares) changed from a partially controlled machinery traffic system to a fully controlled traffic farming system.
- 2 growers (2232 hectares) installed contour banks to reduce soil erosion.

Table 19: Fitzroy gains water quality risk over time, by pollutant

Soil	Baseline	2014 Report Card	2015 Report Card	2016 Report Card
Lowest Risk	13%	13%	13%	14%
Moderate-Low Risk	29%	30%	30%	30%
Moderate Risk	56%	56%	55%	55%
High Risk	2%	2%	1%	1%
Nutrient				
Lowest Risk	1%	1%	1%	1%
Moderate-Low Risk	52%	52%	53%	53%
Moderate Risk	40%	40%	40%	40%
High Risk	6%	6%	6%	6%
Pesticide				
Lowest Risk	3%	3%	3%	3%
Moderate-Low Risk	67%	67%	67%	67%
Moderate Risk	29%	28%	28%	28%
High Risk	1%	1%	1%	1%

Burnett Mary

Grazing

D
42%

Erosion source	Area managed under best management practice systems	
	Proportion (%)	Area (hectares or kilometres)
Pastures	**46%**	1,316,893 ha
Streambanks	**49%**	6,945 km
Gullies	**30%**	854,931 ha

Target: 90 per cent of grazing lands are managed using best management practice systems by 2018.

Approximately 2495 graziers are managing 2.66 million hectares of land in the Burnett Mary region and about 14,078 kilometres of mapped streambanks. By June 2016, approximately 46 per cent (1,316,893 hectares) of grazing land was under best practice management systems for practices relating to surface (hillslope) erosion from pastures, 49 per cent (6945 kilometres of streambank) for practices relating to streambank erosion and 30 per cent (854,931 hectares) for practices relating to gully erosion.

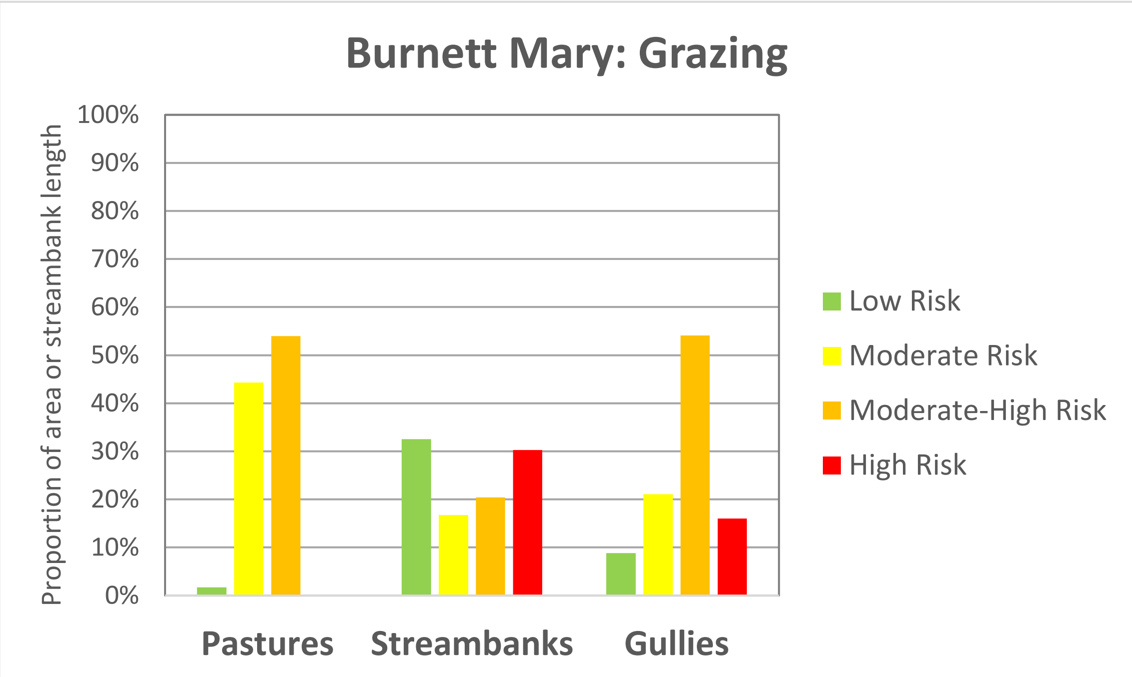

Figure 18: Burnett Mary proportional area of grazing water quality risk by erosion type

A total of 64 graziers managing 11,096 hectares of grazing lands adopted improved management practice through collaboration with the Burnett Mary Regional Group and financial incentives provided by the Australian Government's Reef Programme. Most of these projects involved fencing to limit livestock access to a total of 70 kilometres of streambank frontage.

The Sustainable Agriculture project (funded through the Queensland Department of Natural Resources and Mines), facilitated through the Burnett Mary Regional Group, funded management improvements with 17 graziers across 4920 hectares to mitigate erosion and sediment loss, provide advice and support on sustainable best management practices, and develop property management plans with landholders.

Through the assistance of the Australian Government Reef program -funded Systems Repair grants, Burnett Mary Regional Group engaged with 14 landholders across 258 hectares to improve riparian management and reduce erosion across the landscape, which involved fencing 12 kilometres of stream frontages to limit livestock access. Specifically:

- 8 landholders undertook streambank rehabilitation and restoration projects
- 6 landholders completed work to reduce gully erosion in riparian areas.

The Grazing BMP program and associated Queensland Government extension staff worked with 34 grazing businesses managing over 91,000 hectares of grazing lands. As in the Burdekin and Fitzroy regions, the graziers assessed their own management with a view to identifying areas where new knowledge and skills may be beneficial. Future Reef report cards will describe the water quality impacts of farm management changes influenced by this process.

Table 20: Burnett Mary grazing water quality risk over time, by pollutant

Pastures	Baseline	2014 Report Card	2015 Report card	2016 Report card
Low Risk	2%	2%	2%	2%
Moderate Risk	44%	44%	44%	44%
Moderate-High Risk	54%	54%	54%	54%
High Risk	0%	0%	0%	0%
Streambank				
Low Risk	32%	32%	32%	33%
Moderate Risk	16%	16%	16%	17%
Moderate-High Risk	21%	21%	20%	20%
High Risk	31%	31%	31%	30%
Gully				
Low Risk	9%	9%	9%	9%
Moderate Risk	21%	21%	21%	21%
Moderate-High Risk	54%	54%	54%	54%
High Risk	16%	16%	16%	16%

Sugarcane

D
35%

Pollutant	Area managed under best management practice systems	
	Proportion (%)	Area (hectares)
Soil	**39%**	33,891
Nutrients	**15%**	12,590
Pesticides	**50%**	43,251

Target: 90 per cent of sugarcane lands are managed using best management practice systems by 2018.

Approximately 498 growers are managing 86,000 hectares of land in the Burnett Mary region. As at June 2016, approximately 50 per cent (43,251 hectares) of sugarcane land was being managed using best

practice management systems for practices relating to pesticides, 15 per cent (12,590 hectares) for nutrients and 39 per cent (33,891 hectares) for soil.

Table 21: Burnett Mary key sugarcane best management practices and their adoption rate over time

Key practices	Proportion of area where key practice has been adopted			
	Baseline	2014 Report Card	2015 Report Card	2016 Report Card
Green cane trash blanketing	93%	94%	94%	94%
Fallow management	59%	59%	60%	61%
Controlled machinery traffic	52%	53%	53%	54%
Tillage - plant cane	24%	25%	25%	27%
Nitrogen surplus	13%	13%	13%	15%
Fertiliser placement	61%	62%	62%	62%
Residual herbicide targeting	47%	47%	48%	50%
Residual herbicide strategy	66%	66%	67%	67%

A total of 54 sugarcane growers adopted improved practices on 7587 hectares of land through collaboration with the Burnett Mary Regional Group and accessing financial incentives through the Australian Government's Reef Programme, including but not limited to the following:

- 9 growers improved fallow management by reducing tillage through purchasing equipment.
- 5 growers moved to zonal tillage prior to planting cane.
- 7 growers adopted the Six Easy Steps nutrient budgeting process.
- 13 growers changed to sub-surface application of nitrogen fertiliser.
- 11 growers improved the application of residual herbicides.
- 3 growers improved management of irrigation and rainfall run-off.

The Smartcane BMP program worked with 124 growers (16,111 hectares of sugarcane) and had accredited 5 growers (3098 hectares) in the Burnett Mary region by July 2016. These growers completed self-assessments of their farm management practices against a range of industry standards, with a view to identifying priorities for future improvement. Future Reef report cards will aim to describe the impacts of management changes stemming from this engagement, as they are realised.

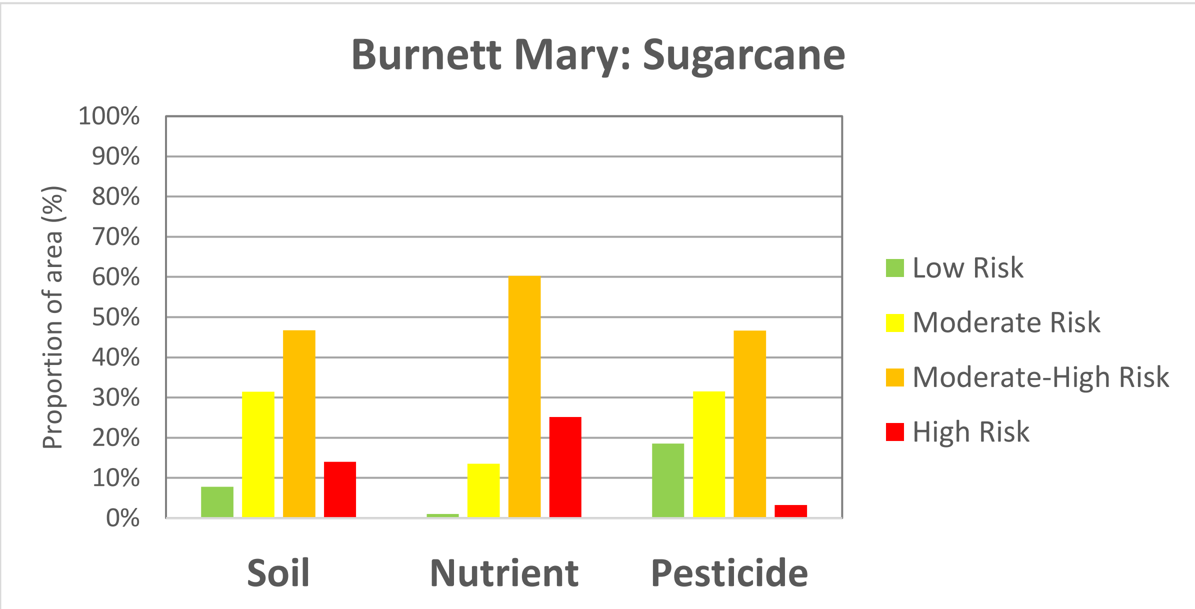

Figure 19: Burnett Mary proportional area of sugarcane water quality risk by pollutant

Table 22: Burnett Mary sugarcane water quality risk over time, by pollutant

Soil	Baseline	2014 Report card	2015 Report card	2016 Report card
Low Risk	8%	8%	8%	8%
Moderate Risk	31%	31%	31%	31%
Moderate-High Risk	48%	47%	47%	47%
High Risk	14%	14%	14%	14%
Nutrient				
Low Risk	1%	1%	1%	1%
Moderate Risk	12%	12%	12%	14%
Moderate-High Risk	60%	60%	60%	60%
High Risk	27%	27%	27%	25%
Pesticide				
Low Risk	18%	19%	19%	19%
Moderate Risk	29%	29%	29%	32%
Moderate-High Risk	48%	48%	47%	47%
High Risk	5%	5%	5%	3%

Horticulture

C
48%

Pollutant	Area managed under best management practice systems	
	Proportion (%)	Area (hectares)
Soil	**76%**	17,572
Nutrients	**33%**	7,552
Pesticides	**36%**	8,223

Target: 90 per cent of horticulture lands are managed using best management practice systems by 2018

Approximately 280 horticulture producers are farming around 23,000 hectares of land in the Burnett Mary region. The area under horticulture in this region can vary considerably on an annual basis due to rotations between sugarcane and annual vegetable crops. As at June 2016, best practice management systems for pesticides were in place on approximately 36 per cent (8,223 hectares) of horticulture land, 33 per cent (7,552 hectares) for nutrients and 76 per cent (17,572 hectares) for soil.

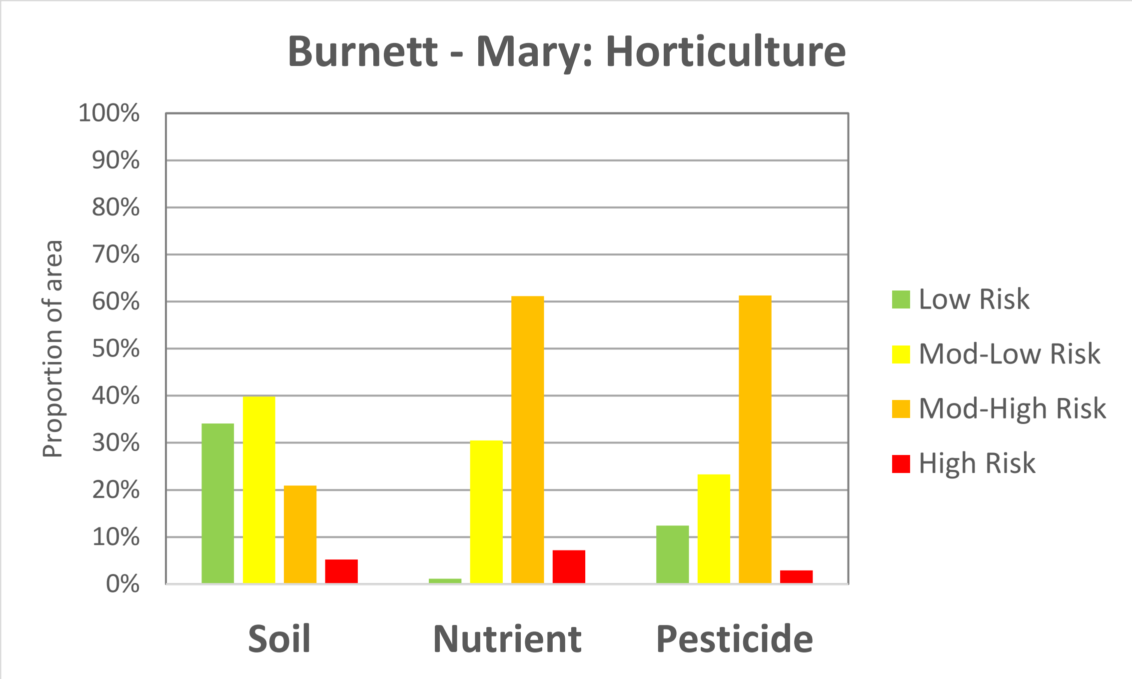

Figure 20: Burnett Mary proportional area of horticulture water quality risk by pollutant

Grains

B
74%

Pollutant	Area managed under best management practice systems	
	Proportion (%)	Area (hectares)
Soil	**80%**	64,318
Nutrients	**65%**	52,275
Pesticides	**76%**	60,989

Target: 90 per cent of grain farming land is managed using best management practice systems by 2018.

Approximately 280 grain growers are managing about 80,000 hectares of land in the Burnett Mary region. The amount of land under grain production can vary considerably over time due to some land alternating between grain production and pastures for beef cattle. By June 2016, best management systems for pesticides were being used on approximately 76 per cent (60,989 hectares) of grain-growing land, 65 per cent for nutrients (52,275 hectares) and 79 per cent for soil (64,318 hectares).

The Sustainable Agriculture project (funded through the Queensland Department of Natural Resources and Mines), facilitated through the Burnett Mary Regional Group, funded management improvements with 6 grain growers across 944 hectares.

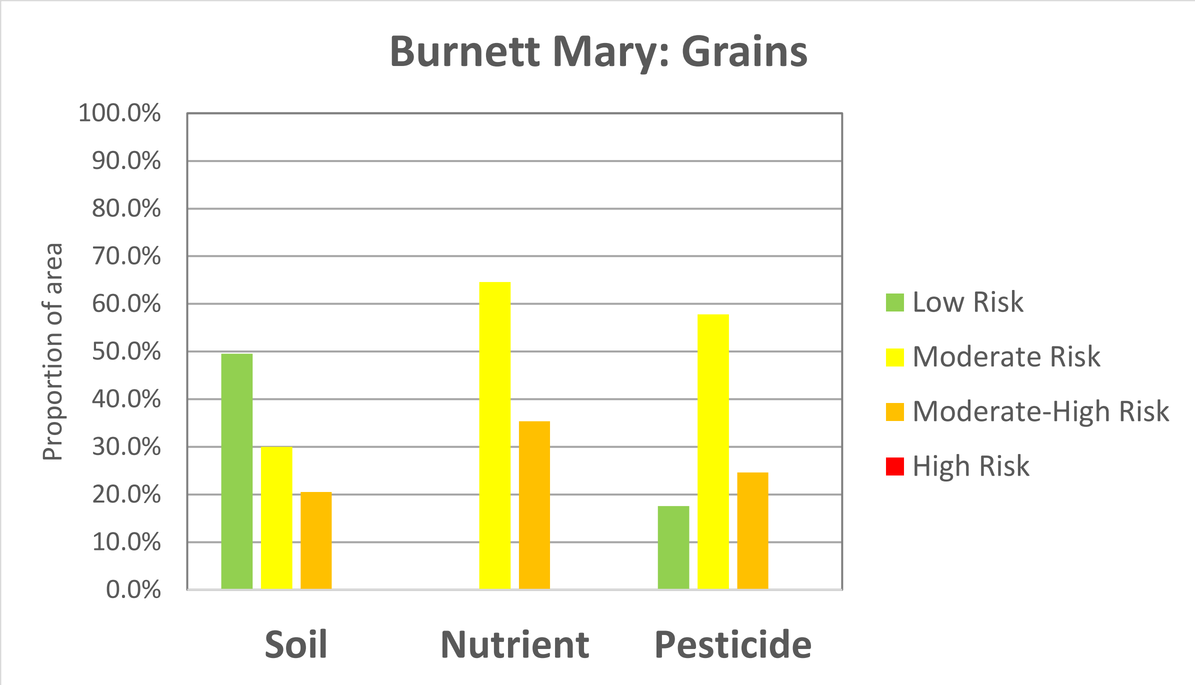

Figure 21: Burnett Mary proportional area of grains water quality risk by pollutant

Table 23: Burnett Mary grains water quality risk over time, by pollutant

Soil	**Baseline**	**2014 Report Card**	**2015 Report Card**	**2016 Report Card**
Lowest Risk	50%	50%	50%	50%
Moderate-Low Risk	30%	30%	30%	30%
Moderate Risk	21%	21%	21%	21%
High Risk	0%	0%	0%	0%
Nutrient				
Lowest Risk	0%	0%	0%	0%
Moderate-Low Risk	65%	65%	65%	65%
Moderate Risk	35%	35%	35%	35%
High Risk	0%	0%	0%	0%
Pesticide				
Lowest Risk	18%	18%	18%	18%
Moderate-Low Risk	58%	58%	58%	58%
Moderate Risk	25%	25%	25%	25%
High Risk	0%	0%	0%	0%

Ground cover results

The ground cover target in the Reef Water Quality Protection Plan 2013 is:

- Minimum 70 per cent late dry season ground cover on grazing lands by 2018.

The mean late dry-season ground cover in 2015-16 for grazing lands in the Great Barrier Reef region was above the target at 80 per cent and was slightly above the 29-year mean of 79 per cent. Mean annual rainfall for 2015–16 was 780 millimetres, slightly below the 29-year mean annual rainfall of 807 millimetres.

Much of Queensland remained either wholly or partially drought-declared in the dry season of 2016, including large areas of the Burdekin and Fitzroy regions. El Niño patterns continued into 2016 but rainfall increased from 2015 levels in all regions except for the Burnett Mary. Consequently, mean ground-cover levels increased across most regions but the localised effects of drought may have been more pronounced for some areas.

Scoring system

Grade	Status	Mean ground cover (%) for late dry season 2016	Colour
E	Very poor	0–30%	Red
D	Poor	30–39%	Orange
C	Moderate	40–49%	Yellow
B	Good	50–69%	Light green
A	Very good	70–100%	Dark green

Great Barrier Reef-wide

A
80%

Target: 70 per cent late-dry-season ground cover by 2018.

Very good: Late-dry-season mean ground cover across the grazing lands was 80 per cent, above the Reef Water Quality Protection Plan target of 70 per cent. The 29-year mean ground cover was 79 per cent.

Approximately 73 per cent of the total land area of the Great Barrier Reef region is reported here as grazing lands.

All reporting regions had mean ground cover levels above the target in 2016, ranging from 74 per cent (Burdekin) to 90 per cent (Mackay Whitsunday). The area below the 70 per cent target was 19 per cent in 2016, compared with 23 per cent over the 29-year period (Table 1).

Table 1: Ground cover results for the Great Barrier Reef catchment and regions

Region	29-year mean ground cover (%)	2016 mean ground cover (%)	Area with less than 70% ground cover averaged over past 29 years (%)	Area with less than 70% ground cover in 2016 (%)
Cape York	85	87	13	13
Wet Tropics	87	88	6	4
Burdekin	75	74	33	33
Mackay Whitsunday	89	90	5	3
Fitzroy	80	84	20	8
Burnett Mary	86	84	7	8
Total Great Barrier Reef	79	80	23	19

The ground cover frequency distribution for the Great Barrier Reef region provides a visual representation of the results (Figure 1). The proportion of the region with less than 70 per cent cover is shaded blue and labelled ‘19%’. The frequency distribution of the long-term mean ground cover levels is displayed as the dashed line, and the 2016 frequency distribution of ground cover levels as the solid line. The median of the long-term mean and 2016 cover are presented (vertical dashed and solid lines, respectively), with the actual median value in 2016 (83 per cent) shown in red at the base of the solid line.

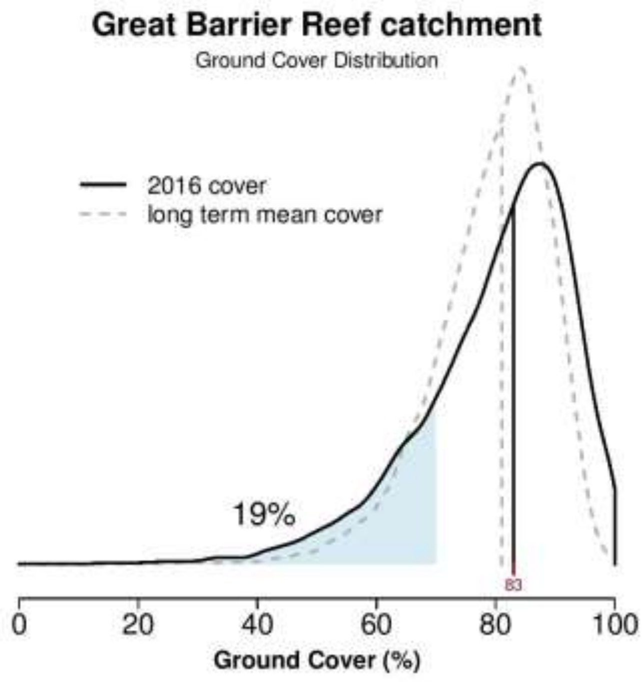

Figure 1: Great Barrier Reef catchment ground cover frequency distribution for late dry season 2016 (solid line) and the long-term mean (dashed line)

Ground cover changes over time

The mean ground cover across the Reef region had been declining between 2010 and 2015, but has increased in this reporting period from 77 per cent in 2015 to 80 per cent in 2016. The very high rainfall of 2010 and 2011 resulted in a very high proportion of the region being above 70 per cent ground cover, and the subsequent drier years had resulted in a decrease in mean ground cover. Historically, the years with the lowest ground cover were 1987–1988, 1994, 2004 and 2006. During these years, mean ground cover for the region was just over 70 per cent and the percentage of area with mean ground cover below 70 per cent was in the range of 37 to 41 per cent (Figures 2 and 3). These years had low mean annual rainfall in preceding years.

Mean annual rainfall in 2016 was slightly above the 29-year mean for the Fitzroy region, and slightly below the mean for the Burdekin, Mackay Whitsunday, Burnett Mary and Cape York regions (Table 2; Figure 4). The Wet Tropics was further below the 29-year mean than the other regions (257 millimetres below the 29-year mean); however, the region has a relatively high 29-year mean annual rainfall (1877 millimetres) (Table 2; Figure 4).

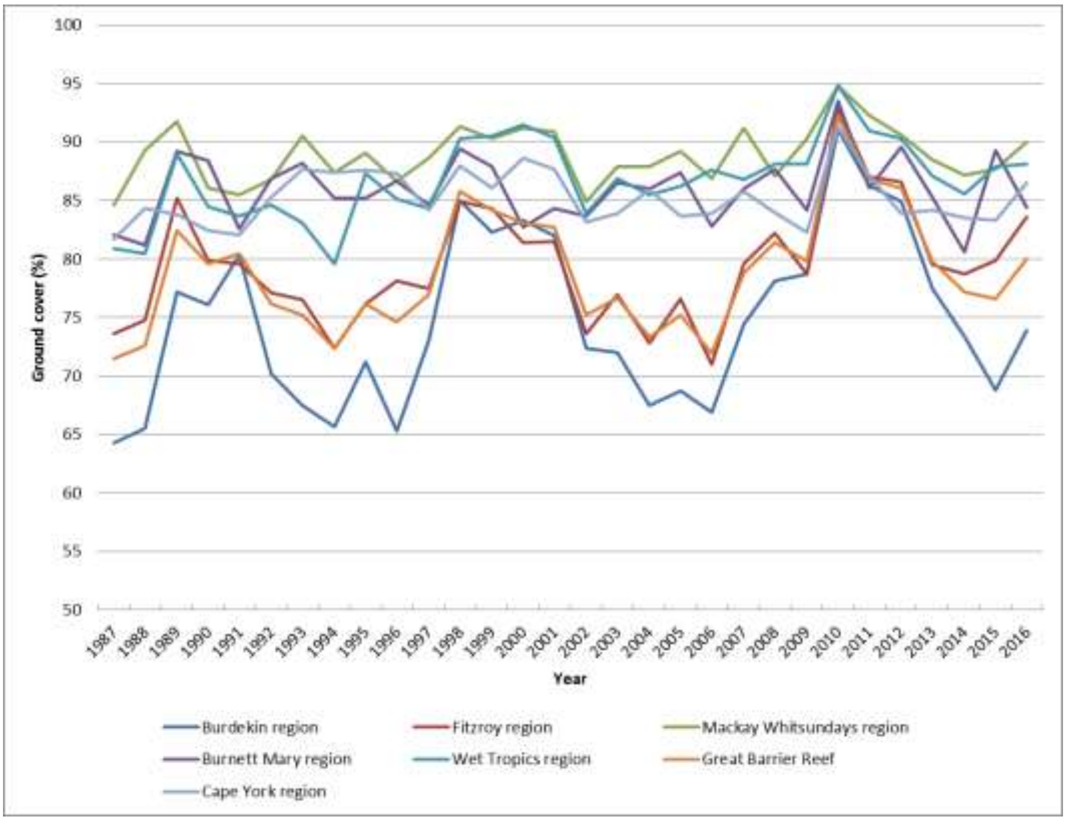

Figure 2: Great Barrier Reef regions – mean late-dry-season ground cover (1987–2016). Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover

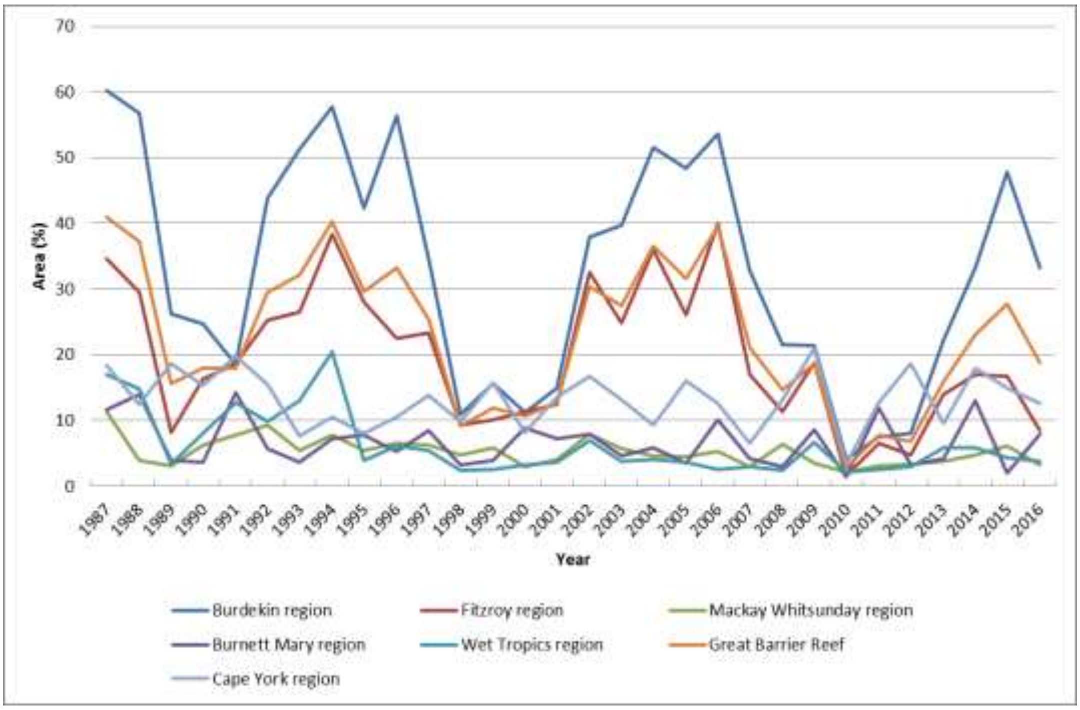

Figure 3: Great Barrier Reef regions – percentage area with ground cover below 70 per cent (1987–2016)

Regions with generally high average annual rainfall have consistently high levels of ground cover. For example, the Mackay Whitsunday, Wet Tropics, Burnett Mary and Cape York regions had mean ground cover greater than or equal to 85 per cent over the 29-year period.

In addition, the area with mean ground cover below 70 per cent for these regions has been less than 21 per cent for the entire monitoring period. In comparison, regions with lower, more variable annual rainfall (e.g. Fitzroy and Burdekin) show greater fluctuations in ground cover over time. In these regions, mean ground cover declines in drier years, increasing the area which is below the 70 per cent ground cover target.

It is interesting to note that in these regions, in general, a prolonged time lag follows the end of a wet period before larger areas of lower ground cover appear, because reserves of ground cover diminish and are not replaced by new growth due to the lack of rainfall. However, the ground cover returns to higher levels comparatively quickly following significant rainfall after a dry period. These lags and the response time after rainfall can be influenced by a range of factors including stocking rates during wet and dry periods, localised climate effects, soil type, land condition and pasture composition.

Although ground cover is above the target in all regions, sediment loads can still be affected by localised sources of sediment such as over-grazed patches, and erosion features such as gullies, scalds and unstable streambanks, particularly during localised heavy rainfall.

Table 2: Rainfall data for the Great Barrier Reef catchment and regions

Region	29-year mean rainfall (mm)	2016 mean annual rainfall (mm)	2016 difference from 29-year mean annual rainfall (mm)
Cape York	1266	1176	–90
Wet Tropics	1877	1620	–257
Burdekin	637	588	–49
Mackay Whitsunday	1517	1493	–24
Fitzroy	658	702	44
Burnett Mary	797	759	–38
Total Great Barrier Reef	807	780	–27

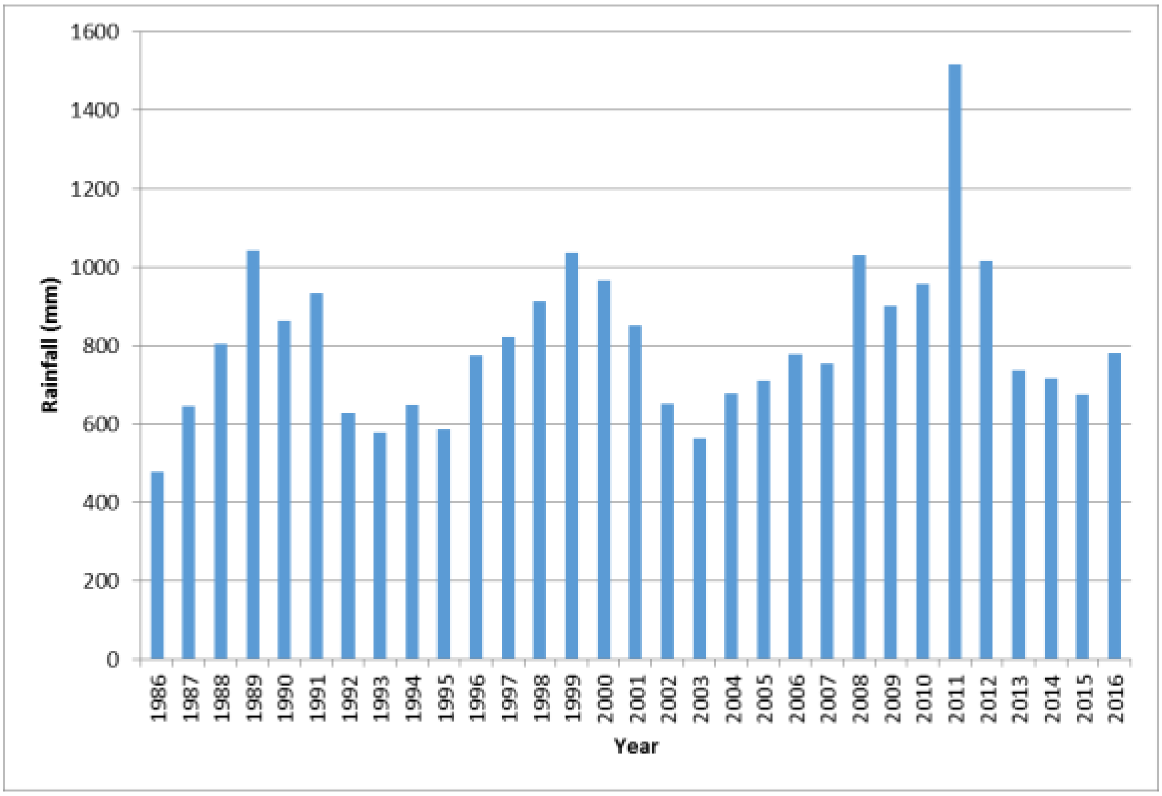

Figure 4: Mean annual rainfall (mm) for the Great Barrier Reef catchment (1986–2016). Note that a year is from October to September to align with late-dry-season reporting.

Ground cover in the regions

The percentage of ground cover for each of the regions in 2016 is shown in Figure 5. Most of the Burdekin region remained drought-declared in the spring of 2016 and this is reflected in the fact that about one-third of the region fell below the target. It highlights the importance of drought management strategies in grazing systems to maintain cover in drier periods, preventing degradation and erosion when heavy rainfall occurs at the break-of-season and/or the end of the drought conditions.

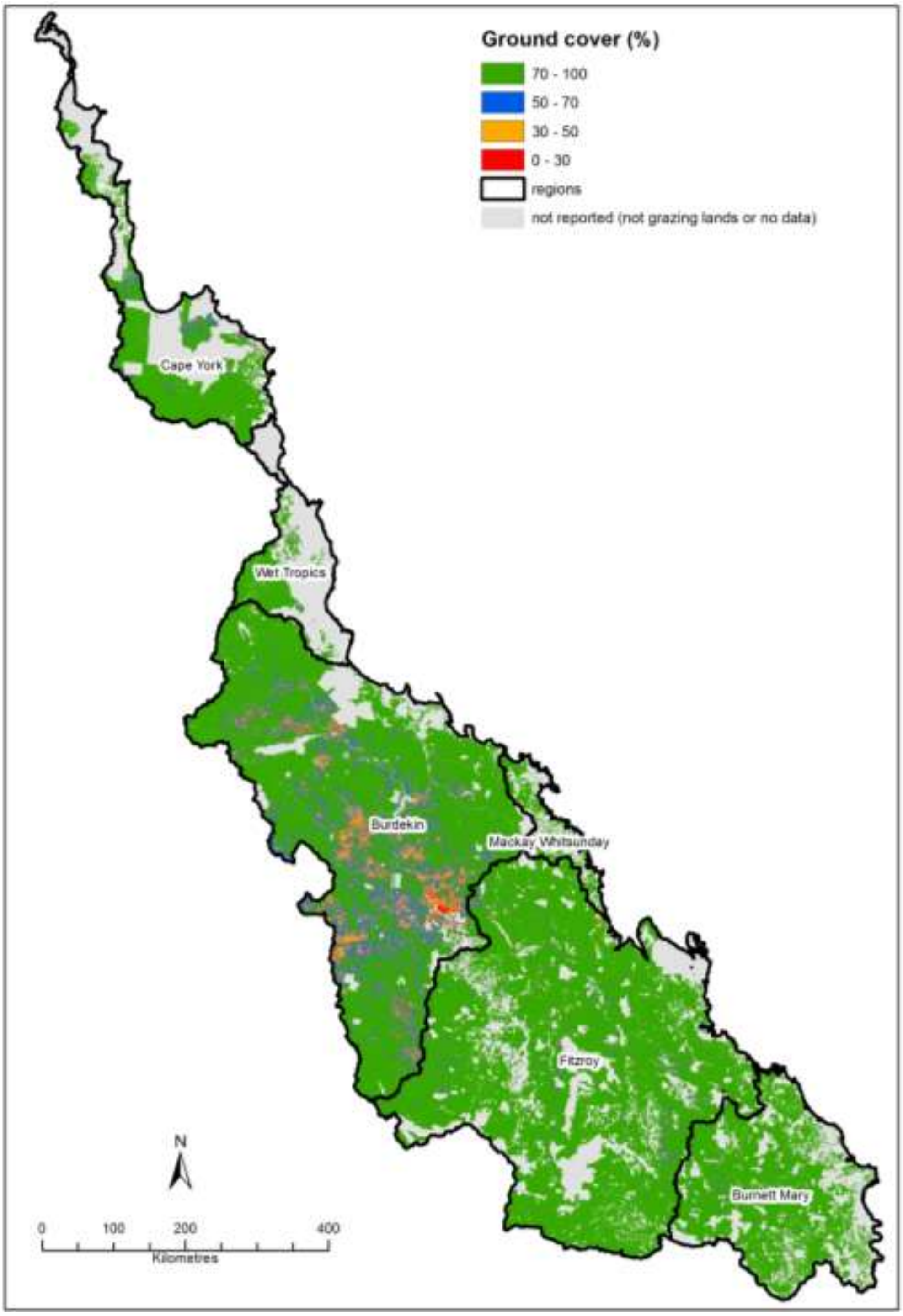

Figure 5: Late-dry-season ground cover levels in 2016 for Reef grazing lands

The map of ground cover deciles (Figure 6) shows the spring 2016 ground cover in comparison to the long-term (1988–2012 baseline) spring ground cover. Red indicates where ground cover is in the lowest deciles (i.e. the lowest level of ground cover experienced in that location relative to the baseline) while blue shows locations where ground cover is at the highest levels (or deciles) it has been relative to the baseline period. This map can be used as a guide to indicate areas of concern or improvement, or conversely, those areas that had good ground cover levels in 2016.

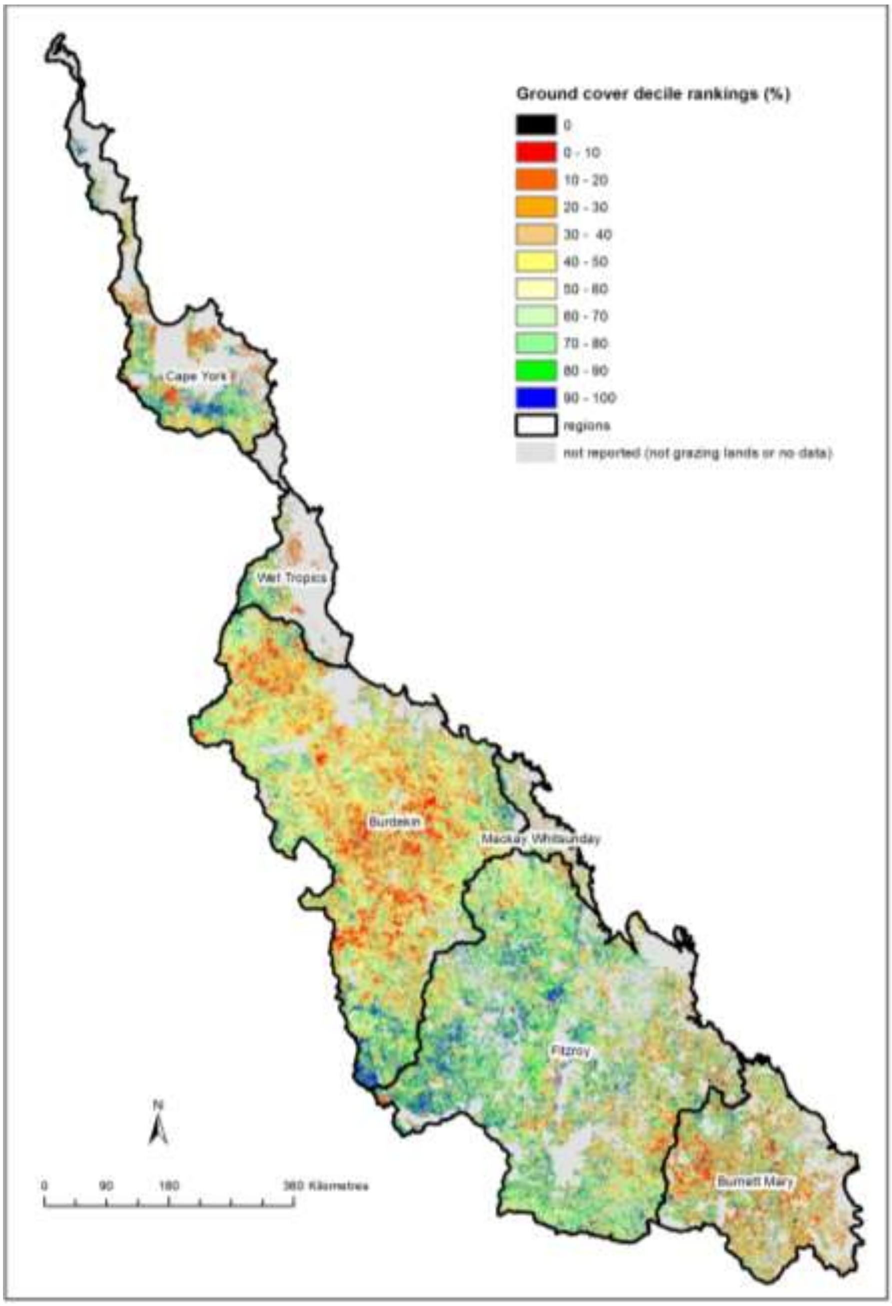

Figure 6: Ground cover decile rankings for Great Barrier Reef catchments. This map shows spring 2016 ground cover in comparison to the long-term (1988–2012 baseline) spring cover. The lowest decile (red) indicates where ground cover was at the lowest level relative to the baseline period, and the highest decile (blue) indicates where ground cover was at the highest level relative to the baseline period.

Figure 6 shows that large parts of the Burdekin region, parts of the Fitzroy and Burnett Mary, and patches of the Wet Tropics, Mackay Whitsunday and Cape York regions had very low cover compared to long-term levels in those areas. Ground cover levels in 2016 were very high (compared to the long-term levels) in the western parts of the Fitzroy, far southern Burdekin, southern Cape York and patches of the Wet Tropics and Mackay Whitsunday regions.

An overview of each of the regions is provided below.

Cape York

A
87%

Target: 70 per cent late dry season ground cover by 2018.

Very good: Late-dry-season mean ground cover across grazing lands was 87 per cent.

Table 3: Ground cover results for the Cape York region and catchments

Region	**29-year mean ground cover (%)**	**2016 mean ground cover (%)**	**Area with less than 70% ground cover averaged over past 29 years (%)**	**Area with less than 70% ground cover in 2016 (%)**
Olive–Pascoe	85	90	16	8
Lockhart	84	84	17	16
Normanby	86	88	12	9
Jeannie	81	75	23	39
Endeavour	86	89	12	9
Stewart	85	79	17	32
Cape York region (excluding Jacky Jacky catchment)	85	87	13	13

The ground cover frequency distribution for Cape York (Figure 7) provides a visual representation of the results. The proportion of the region with less than 70 per cent cover is shaded blue and labelled '13%'. The median value in 2016 (91 per cent) is shown in red at the base of the solid line. Figure 7 shows that the general frequency distribution of ground cover across the Cape York region was higher than the long-term mean frequency distribution; this is also reflected in the mean ground cover level for 2016, being 2 per cent above the 29-year mean.

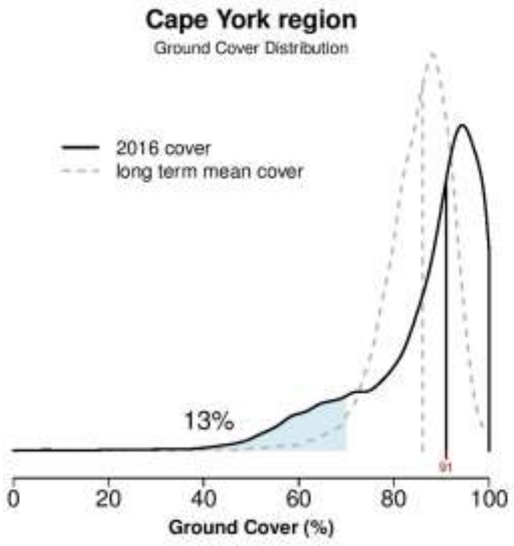

Figure 7: Cape York ground cover frequency distribution for late dry season 2016 (solid line) and the long-term mean (dashed line)

The percentage of ground cover for the Cape York region and catchments is shown in Figure 8.

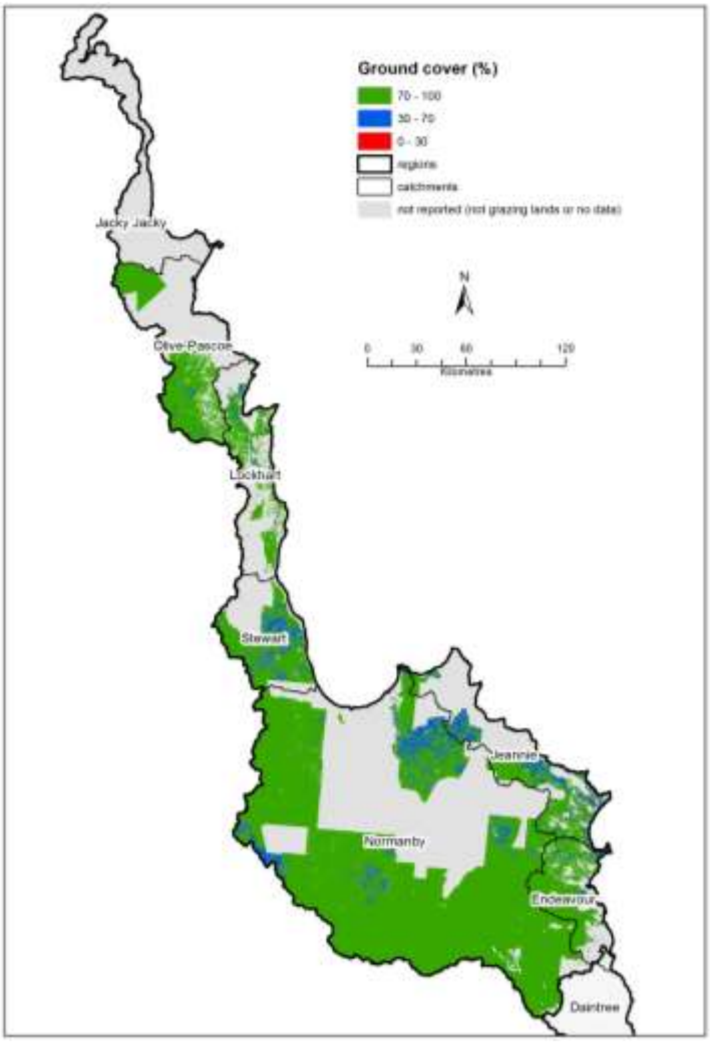

Figure 8: Late-dry-season ground cover levels in 2016 for the Cape York region grazing lands

The Cape York region had mean ground cover of 87 per cent in 2016 and consistently high mean ground cover from 1987 to 2016 with a 29-year mean ground cover level of 85 per cent. The proportion of grazing lands falling below the target of 70 per cent ground cover was 13 per cent in 2016, and 13 per cent for the 29-year period (Table 3 and Figure 7).

However, this proportion has fluctuated quite considerably over time, particularly for individual catchments. For example, the area below the 70 per cent target in the Jeannie catchment was 14 per cent in 1990, and 44 per cent in 1991. In this instance, a large fire was found to have occurred during 1991, causing significant loss of ground cover at the time of monitoring. In the Endeavour catchment, the decline in mean ground cover and increase in area under 70 per cent for 2014 was also due to fire. Fire scars were also evident at the time of reporting in 2016 in some areas of lower ground cover across Cape York. In general, the ground cover responds quickly after fire in this region, although repeated burning of some locations can expose the soil to rainfall and also lead to a shift in ground cover and woody vegetation dynamics and species composition, which can affect erosion rates and productivity. Appropriate fire management regimes can help to address these potential issues.

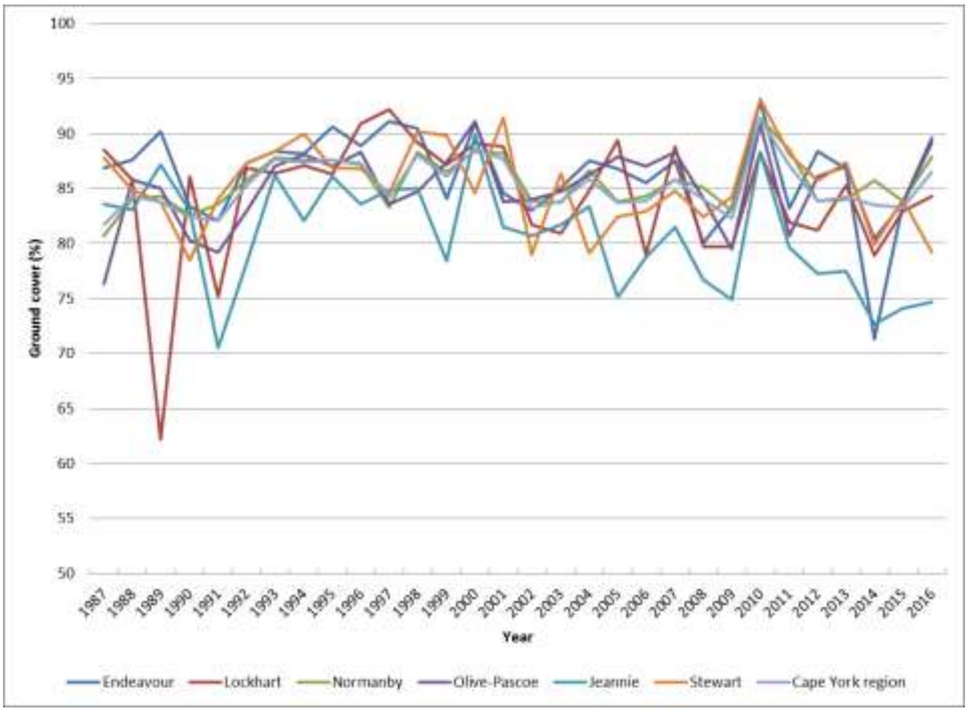

Figure 9: Cape York region and catchments - mean late-dry-season ground cover. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

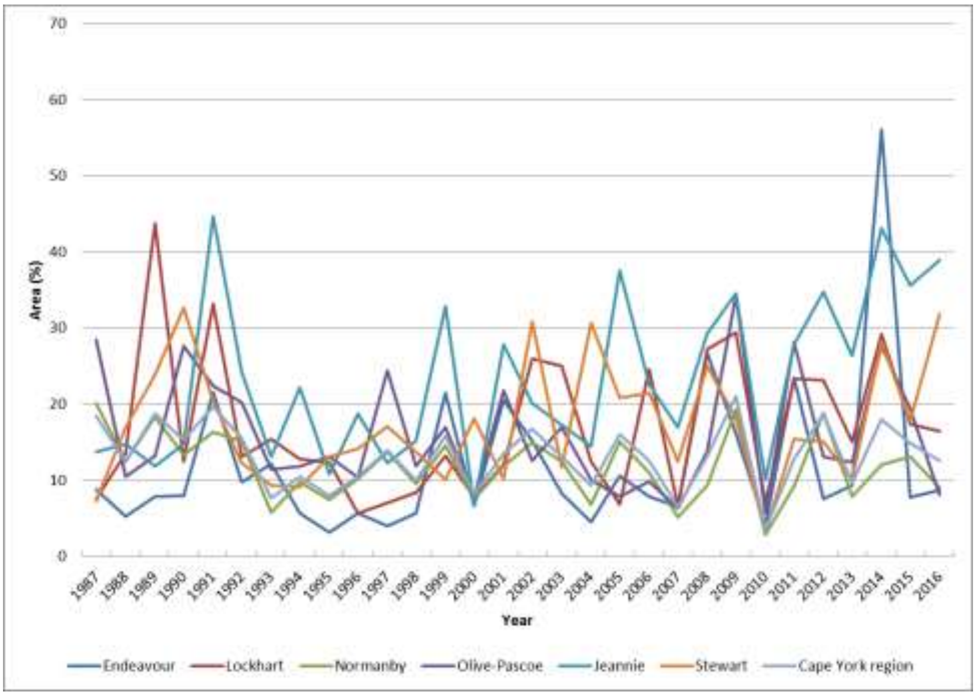

Figure 10: Cape York region and catchments - percentage area with ground cover below 70 per cent (1987–2016)

The map of ground cover deciles for the Cape York region (Figure 11) shows the spring 2016 ground cover in comparison to the long-term spring ground cover (1988–2012 baseline). Some of the large areas of red in the Normanby, Stewart, Jeannie and Endeavour catchments are the result of fires that occurred in 2014, 2015 and 2016.

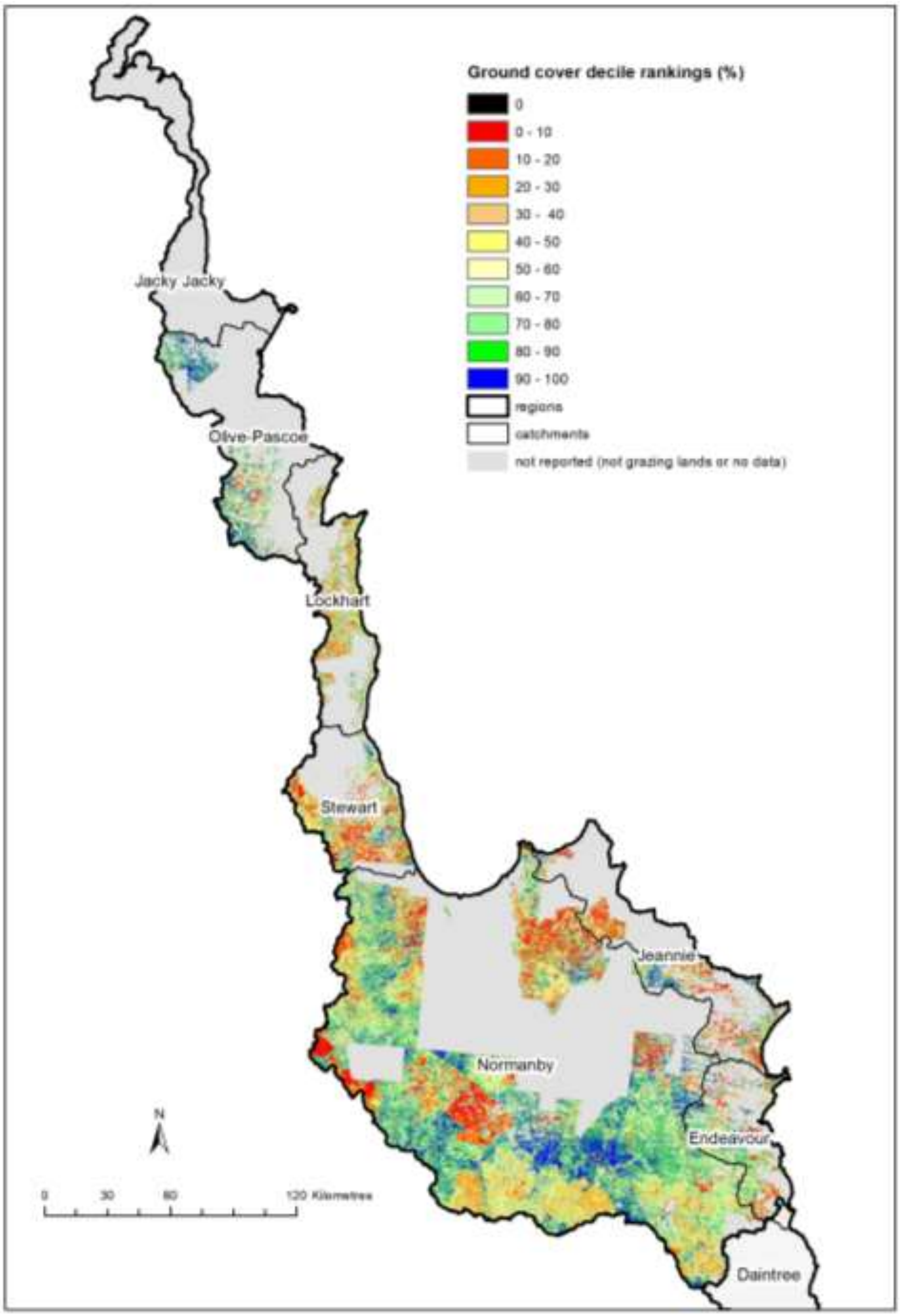

Figure 11: Cape York region ground cover decile rankings. This map shows spring 2016 ground cover in comparison to the long-term spring cover (1988–2012 baseline). The lowest decile (red) indicates where ground cover was at the lowest level relative to the baseline period, and the highest decile (blue) indicates where ground cover was at the highest level relative to the baseline period.

The Cape York region is the third wettest of the areas reported (1266 millimetres mean annual rainfall). Rainfall in 2015 was below the mean at 1023 millimetres, and again in 2016 (1176 millimetres) (Figure 12).

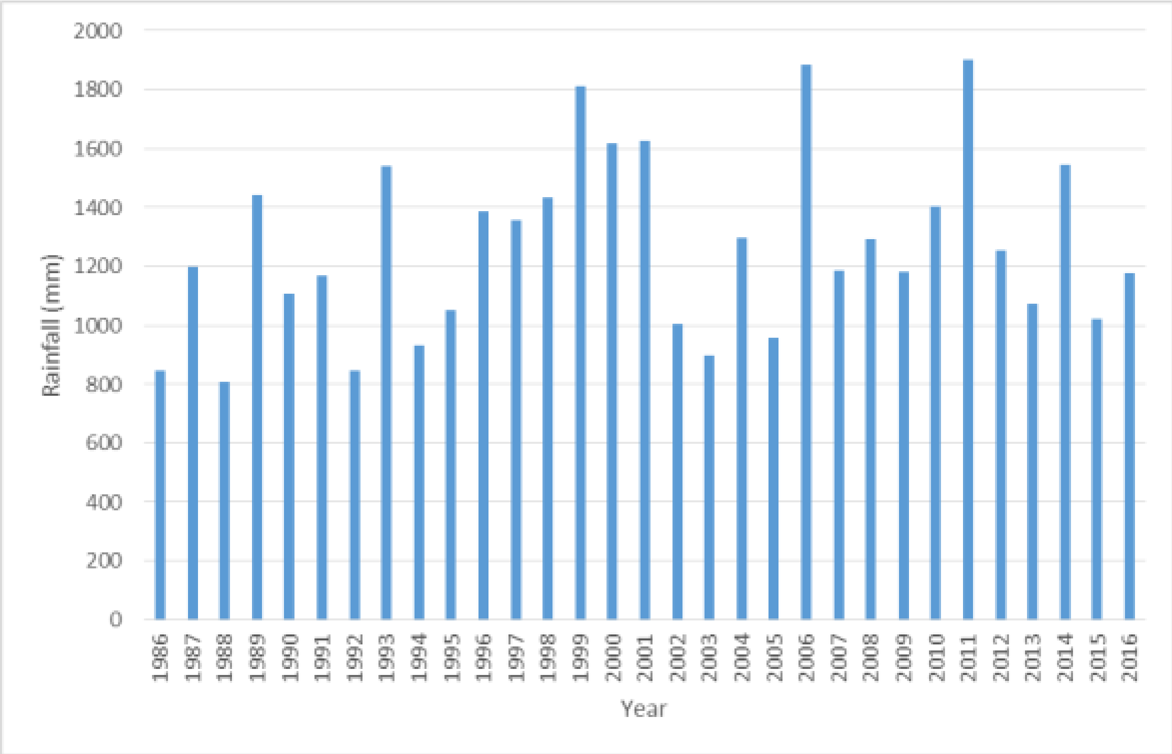

Figure 12: Mean annual rainfall for Cape York region (1986–2016). Note that a year is from October to September to align with late-dry-season reporting.

Wet Tropics

A
88%

Target: 70 per cent late dry season ground cover by 2018.

Very good: Late-dry-season mean ground cover across grazing lands was 88 per cent.

Table 4: Ground cover results for the Wet Tropics region and catchments

Region	29-year mean ground cover (%)	2016 mean ground cover (%)	Area with less than 70% ground cover averaged over past 29 years (%)	Area with less than 70% ground cover in 2016 (%)
Herbert	87	89	6	3
Johnstone	78	76	20	21
Barron	86	84	9	10
Wet Tropics region (Herbert, Johnstone and Barron only)	87	88	6	4

The ground cover frequency distribution for the Wet Tropics (Figure 13) provides a visual representation of the results. The proportion of the region with less than 70 per cent cover is shaded blue and labelled '4%'. The median value in 2016 (90 per cent) is shown in red at the base of the solid line. The frequency distribution of ground cover in 2016 was higher than the long-term frequency distribution, indicating slightly higher ground cover levels across the region in 2016.

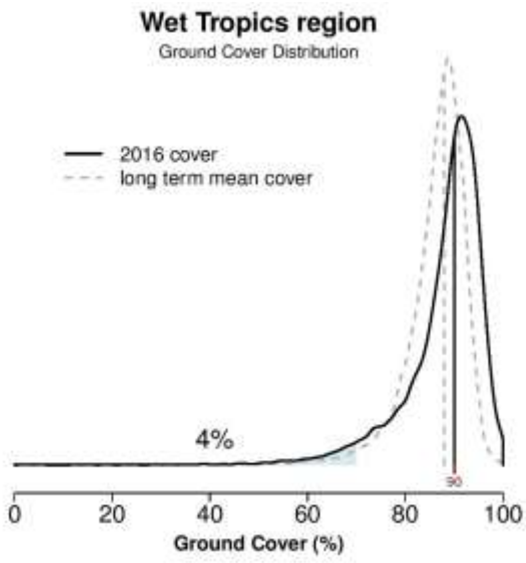

Figure 13: Wet Tropics ground cover distribution for late dry season 2016 (solid line) and the long-term mean (dashed line)

The percentage of ground cover for the Wet Tropics region and catchments is shown in Figure 14.

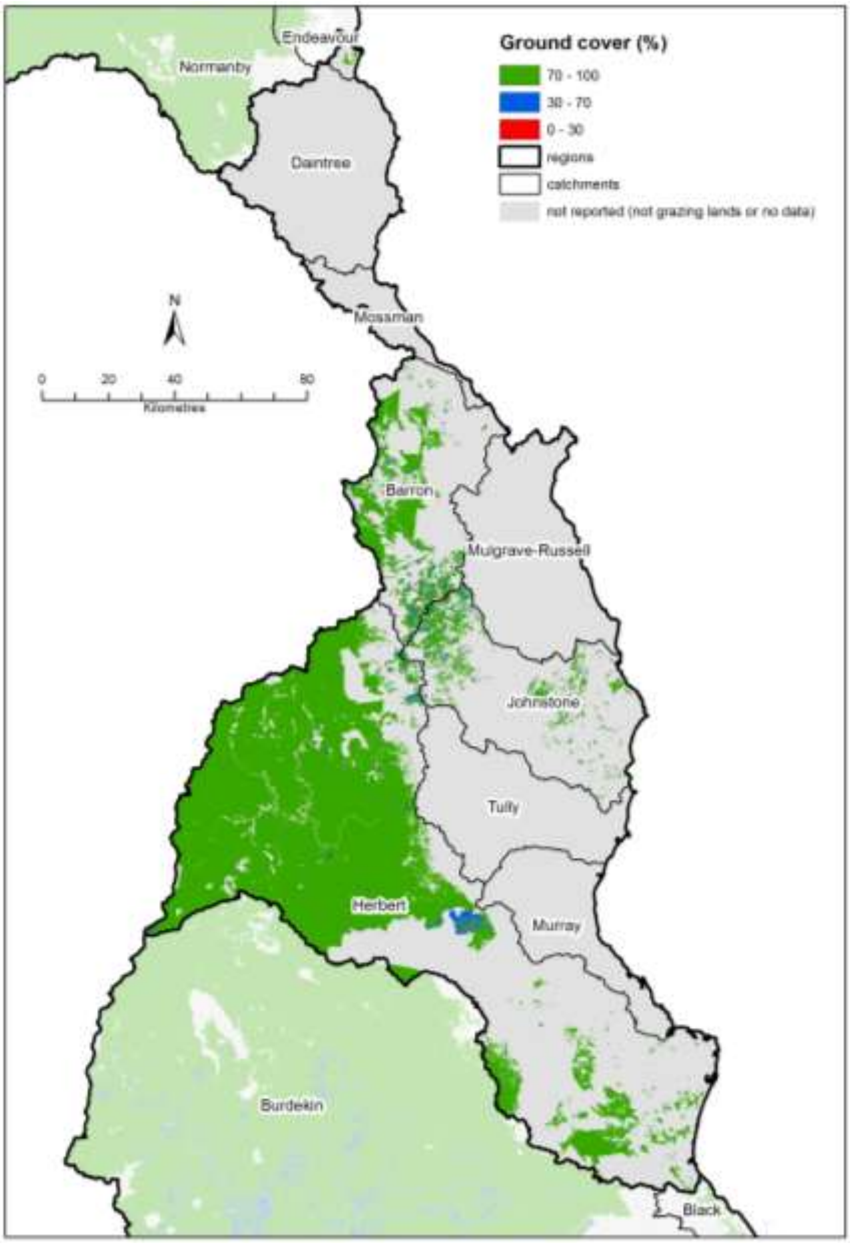

Figure 14: Late-dry-season ground cover levels in 2016 for the Wet Tropics region grazing lands

The Wet Tropics region had mean ground cover of 88 per cent in 2016 and consistently high mean ground cover (87 per cent) from 1987 to 2016. The minimum mean ground cover during this period was 80 per cent in 1994. The proportion of grazing lands falling below the target of 70 per cent was also consistently low with a mean of 4 per cent for 2016 and 6 per cent over the 29-year period (Table 4 and Figure 13). Only the grazing lands of the Herbert, Barron and Johnstone catchments were reported on in this region as the other catchments in the Wet Tropics had less than 10 per cent grazing lands.

Within the region, the Herbert and Barron catchments are well above the target for both the 29-year mean and 2016 results. The Johnstone catchment tends to fluctuate more, with the lowest mean ground cover recorded in 2014 at 65 per cent and the highest recorded in 2001 at 85 per cent. Mean ground cover for the Johnstone catchment was 76 per cent in 2016.

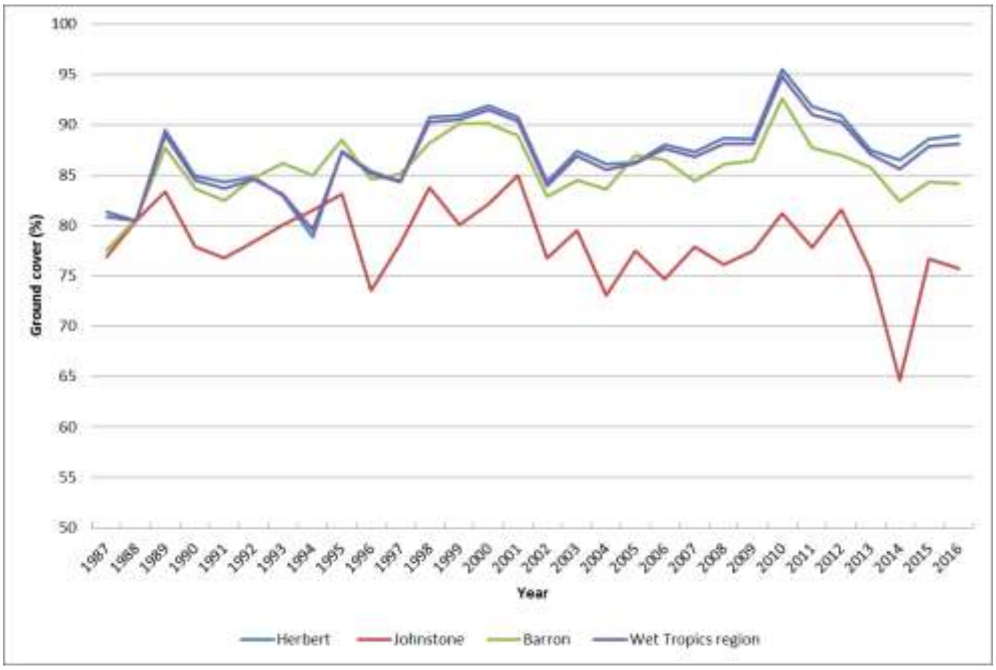

Figure 15: Wet Tropics region and catchments - mean late-dry-season ground cover. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

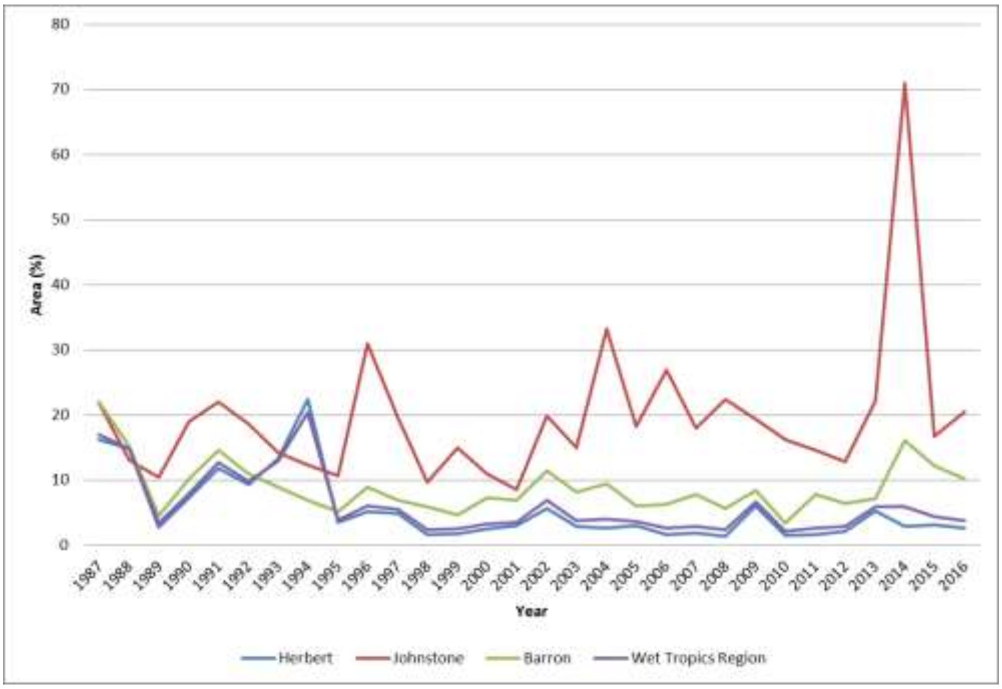

Figure 16: Wet Tropics region and catchments - percentage area with ground cover below 70 per cent (1987–2016)

The map of ground cover deciles (Figure 17) shows the spring 2016 ground cover in comparison to the long-term spring ground cover (1988–2012 baseline). Only the Herbert, Barron and Johnstone catchments were reported on as the other catchments in the Wet Tropics had less than 10 per cent grazing land. This map shows that, while the Johnstone exceeded the target for 2016, much of the grazing lands in the upper catchment were at some of the lowest levels of ground cover relative to the long-term baseline.

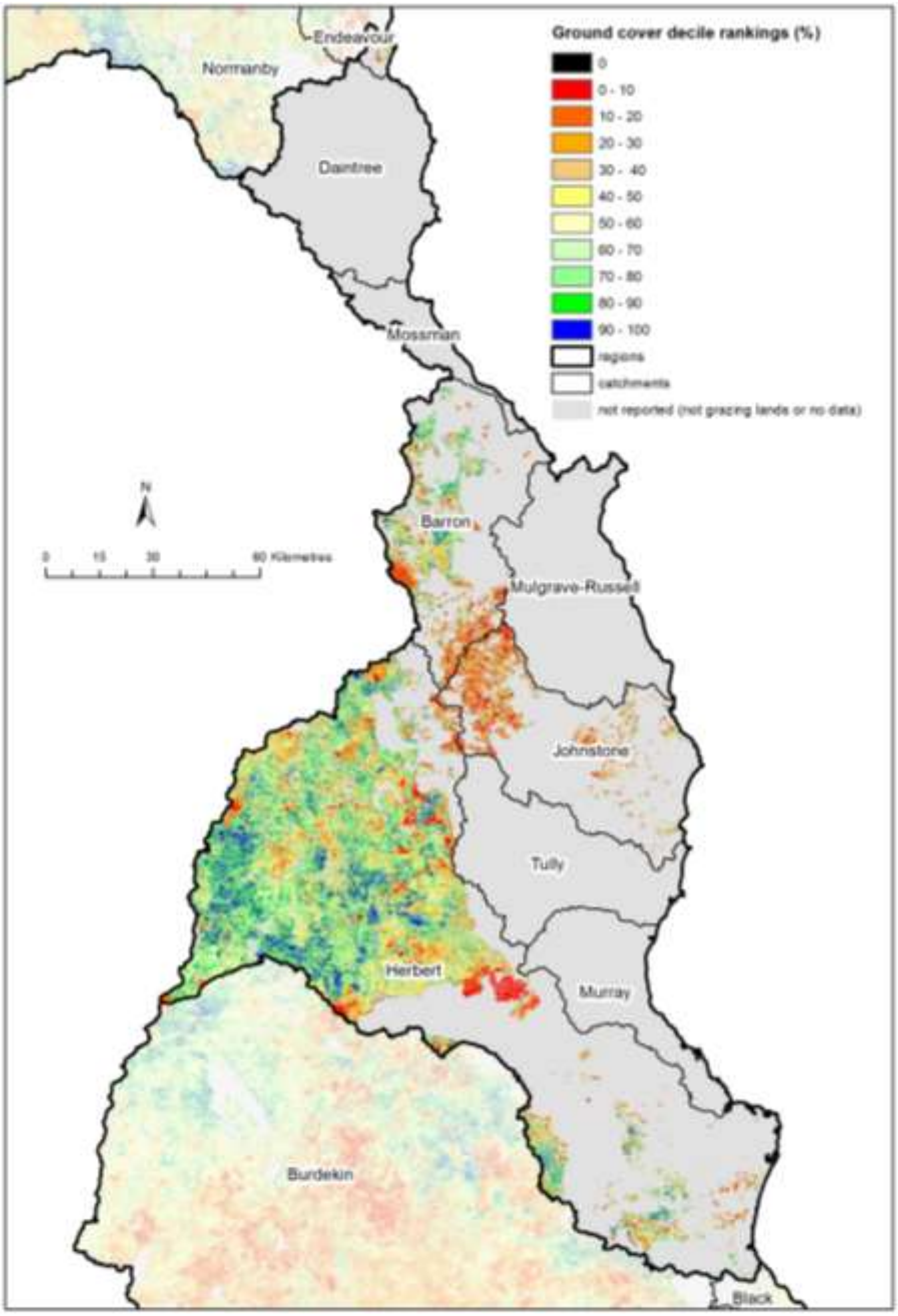

Figure 17: Wet Tropics region ground cover decile rankings. This map shows spring 2016 ground cover in comparison to the long-term spring cover (1988–2012 baseline). The lowest decile (red) indicates where ground cover was at the lowest level relative to the baseline period, and the highest decile (blue) indicates where ground cover was at the highest level relative to the baseline period.

The Wet Tropics is the wettest of all the regions (1877 millimetres mean annual rainfall). Rainfall in 2015 was below the mean at 1255 millimetres, and again in 2016 (1620 millimetres) (Figure 18).

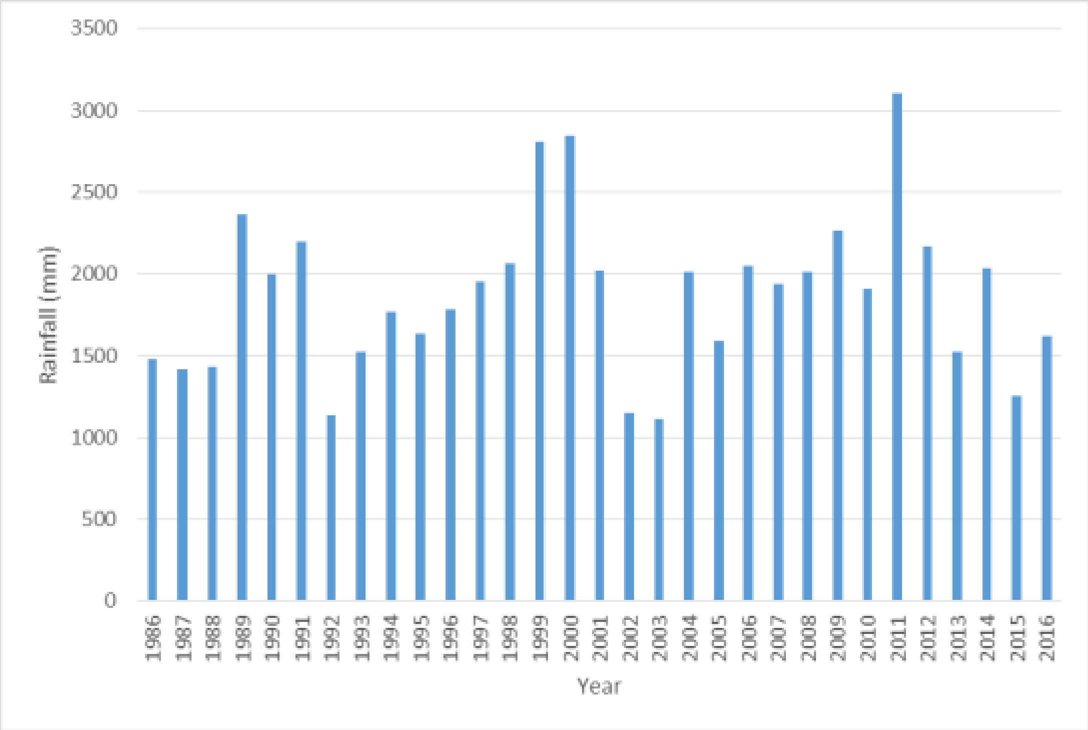

Figure 18: Mean annual rainfall for the Wet Tropics region (1986–2016). Note that a year is from October to September to align with late-dry-season reporting.

Burdekin

A
74%

Target: 70 per cent late dry season ground cover by 2018.

Good: Late-dry-season mean ground cover across grazing lands was 74 per cent.

Table 5: Ground cover results for the Burdekin region and catchments

Region	29-year mean ground cover (%)	2016 mean ground cover (%)	Area with less than 70% ground cover averaged over past 29 years (%)	Area with less than 70% ground cover in 2016 (%)
Black	87	89	10	4
Burdekin	74	73	34	35
Don	84	85	11	6
Haughton	82	81	17	14
Ross	83	86	15	7
Burdekin region	75	74	33	33

The ground cover frequency distribution for the Burdekin (Figure 19) provides a visual representation of the results. The proportion of the region with less than 70 per cent cover is shaded blue and labelled '33%'. The median value in 2016 (76 per cent) is shown in red at the base of the solid line. The frequency distribution of ground cover in 2016 was similar to the frequency distribution of the long-term mean. This is also reflected by the similarity between in the 2016 mean ground cover (75 per cent) and the 29 year mean ground cover (74 per cent) (Table 5). Further, the area of the region with ground cover below the target was the same for 2016 as the 29 year mean. These results suggest that for the Burdekin region, 2016 was an average year of ground cover levels when compared with the past 29 years.

The percentage of ground cover for the Burdekin region and catchments is shown in Figure 20.

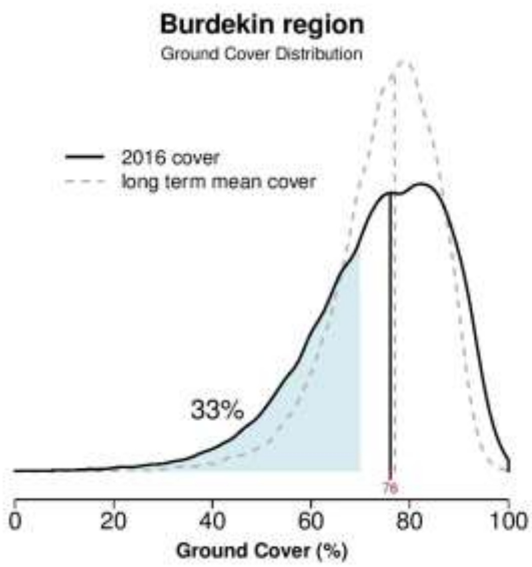

Figure 19: Burdekin ground cover frequency distribution for late dry season 2016 (solid line) and the long-term mean (dashed line)

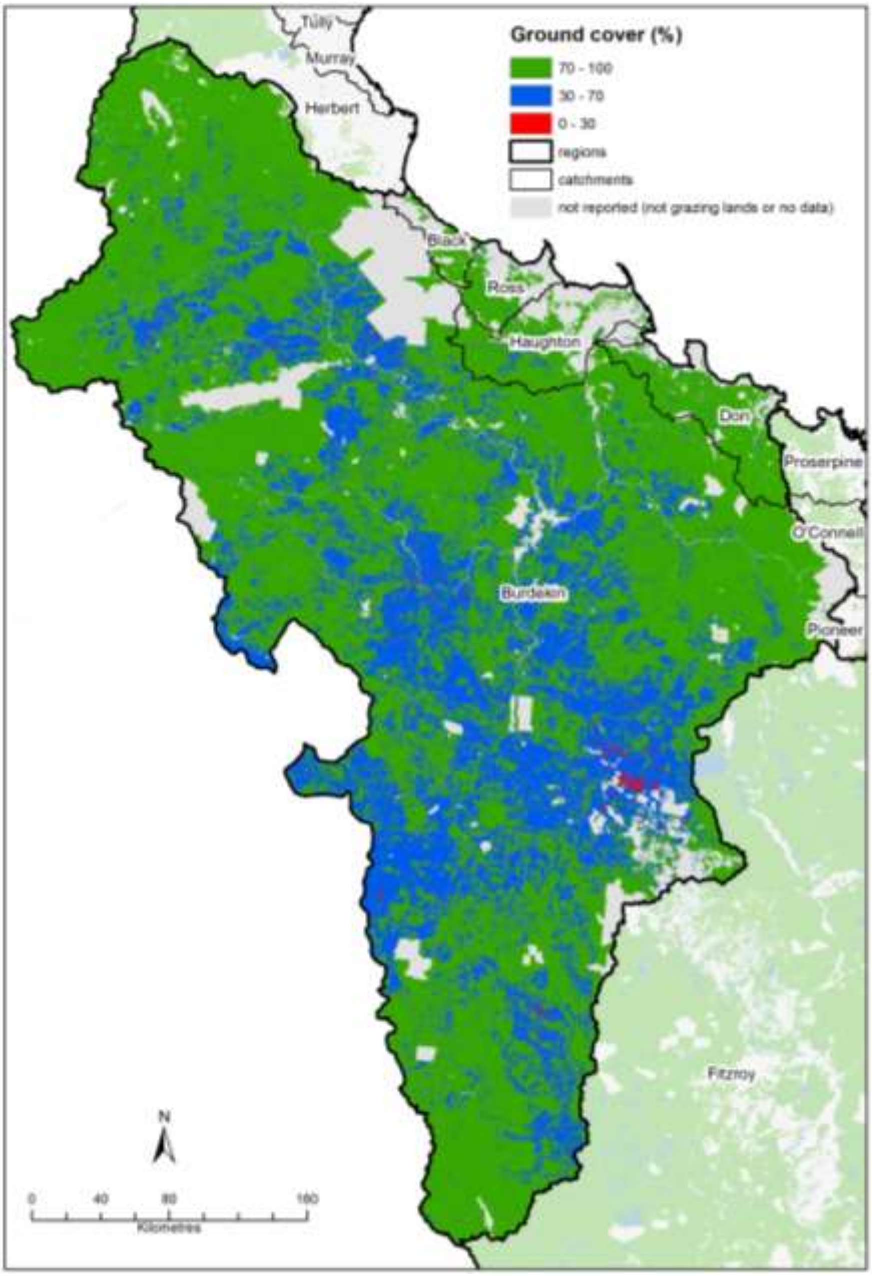

Figure 20: Late-dry-season ground cover levels in 2016 for the Burdekin region grazing lands

At 74 per cent, the mean ground cover for the Burdekin region in 2016 was above target. Comparatively, the 29-year mean ground cover is 75 per cent. Ground cover levels in the Burdekin region fluctuate significantly over time; for example, in 1988 the mean late-dry-season ground cover was 66 per cent, while the following year it was 77 per cent. The proportion of grazing lands falling below the target of 70 per cent was 33 per cent in 2016, and 33 per cent for the 29-year period (Table 5 and Figure 19). Increases in the area with less than 70 per cent ground cover correspond to low mean late-dry-season ground cover coinciding with below-average annual rainfall.

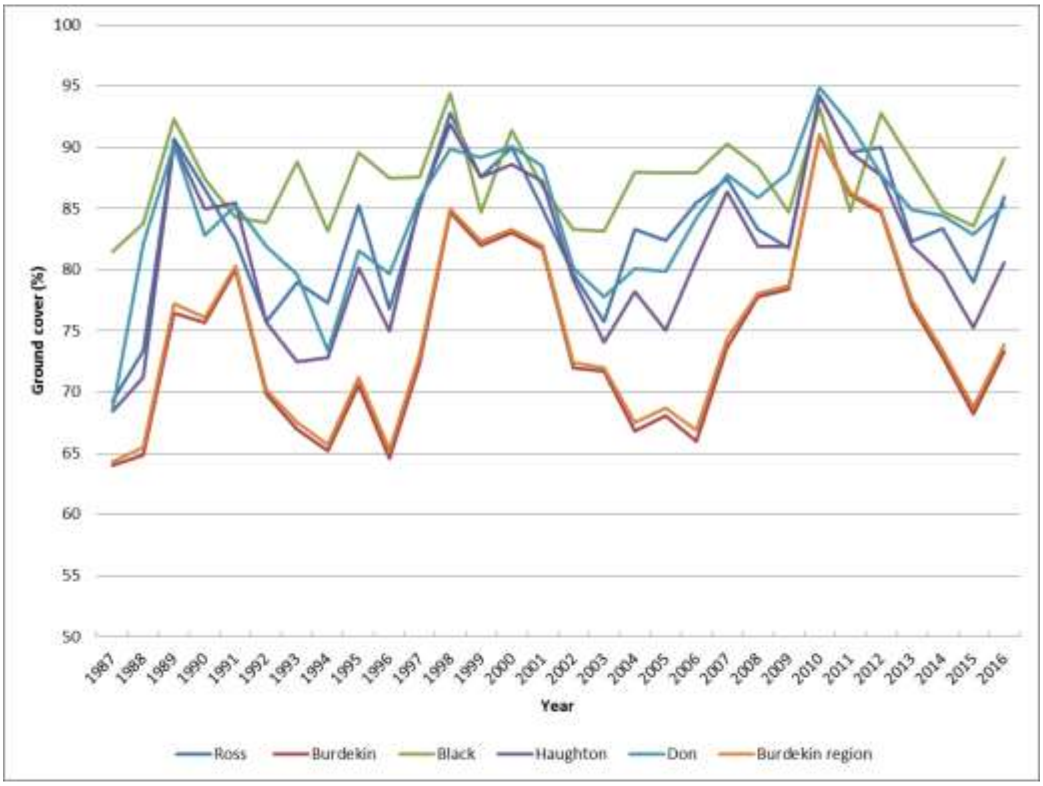

Figure 21: Burdekin region and catchments - mean late-dry-season ground cover. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

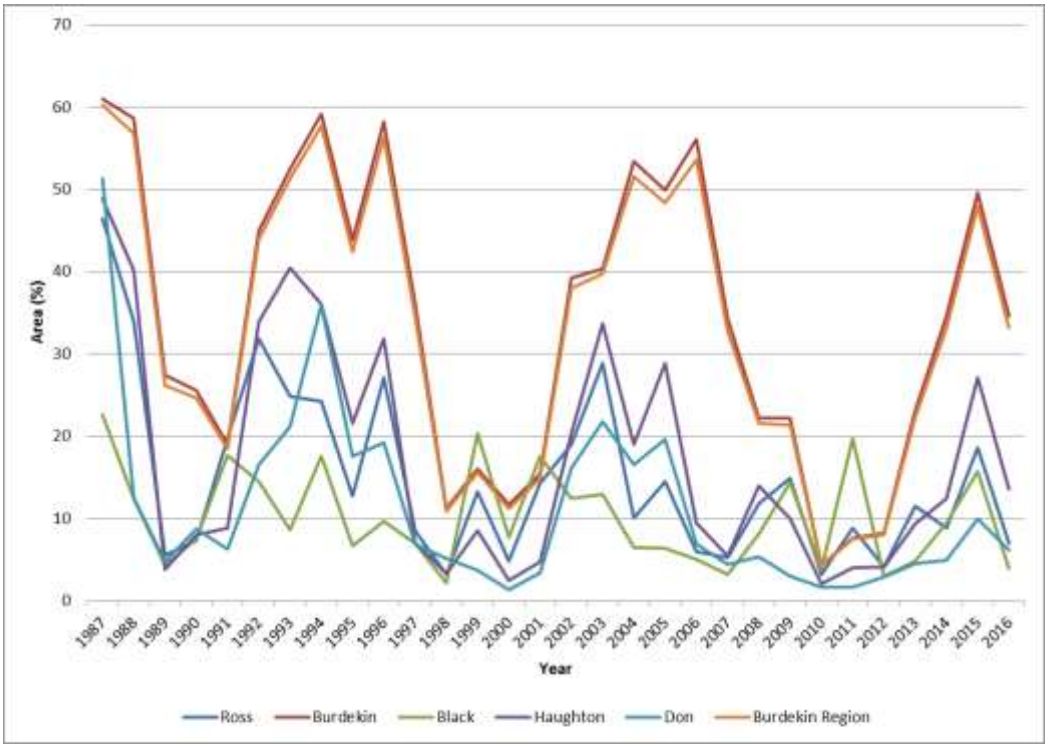

Figure 22: Burdekin region and catchments - percentage area with ground cover below 70 per cent (1987–2016)

The map of ground cover deciles (Figure 23) shows the spring 2016 ground cover in comparison to the long-term (1988–2012) spring baseline. Many areas of the Burdekin region remained low in ground cover compared to the baseline period. Much of this could be attributed to the continuation of drought conditions in the region in spring 2016; however, there are likely to be localised impacts on ground cover due to stocking rates inappropriate for the drought conditions. It is important, however, to interpret the deciles relative to the actual level of ground cover at any given time—even with a low decile ranking,

ground cover can still be above target levels, as the deciles are a relative measure against a long-term baseline.

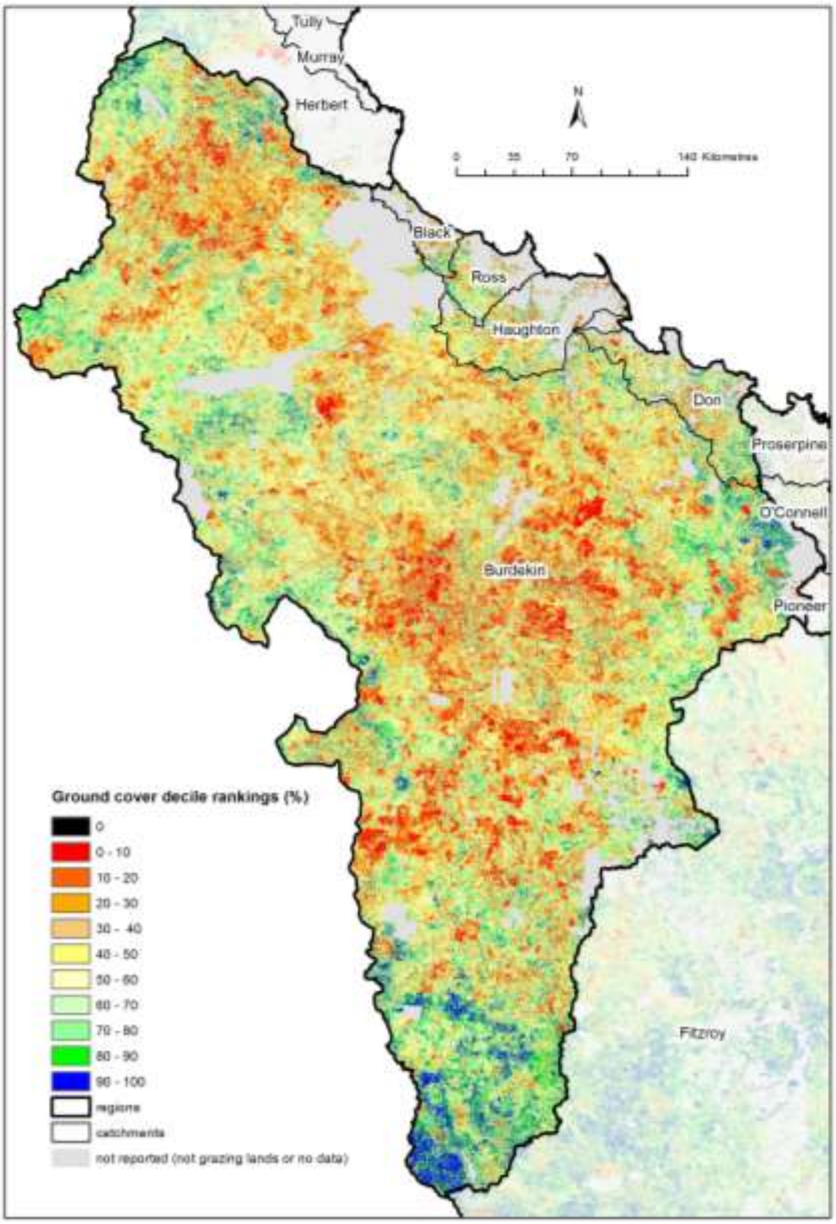

Figure 23: Burdekin region ground cover decile rankings. This map shows spring 2016 ground cover in comparison to the long-term spring cover (1988–2012 baseline). The lowest decile (red) indicates where ground cover was at the lowest level relative to the baseline period, and the highest decile (blue) indicates where ground cover was at the highest level relative to the baseline period.

The Burdekin region is the driest of the regions reported (637 millimetres mean annual rainfall). Rainfall in 2015 was well below the mean at 392 millimetres and again in 2016 at 588 millimetres (Figure 24).

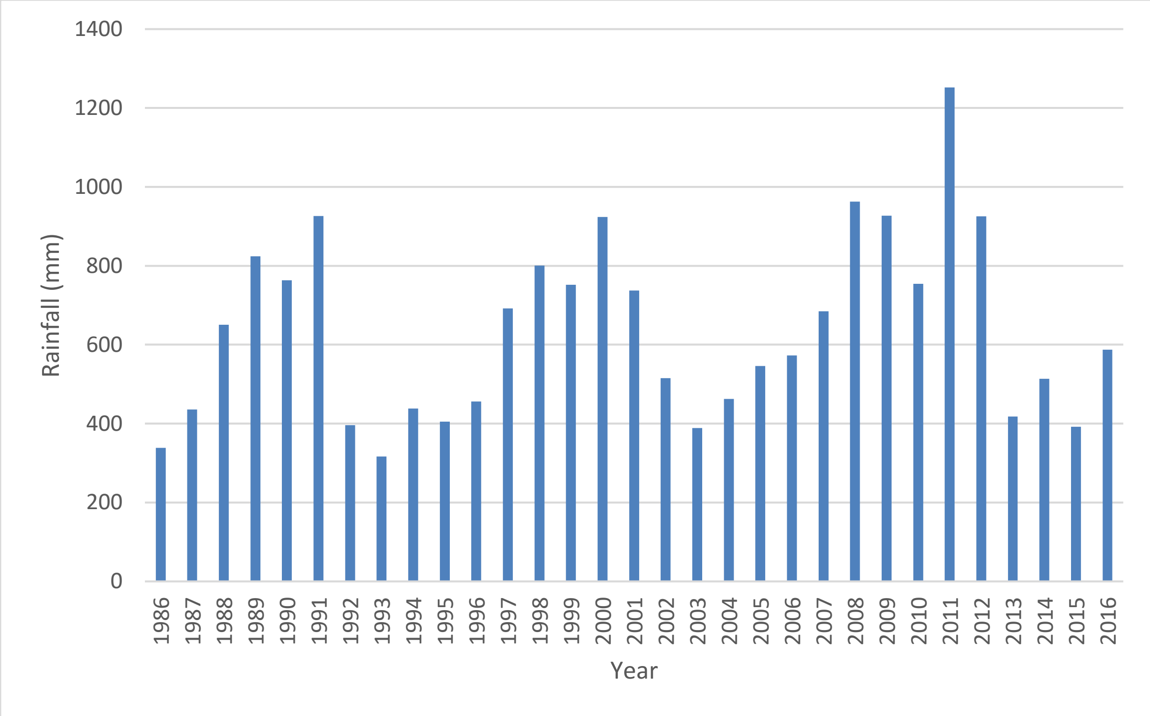

Figure 24: Mean annual rainfall for the Burdekin region (1986–2016). Note that a year is from October to September to align with late-dry-season reporting.

Mackay Whitsunday

A
90%

Target: 70 per cent late dry season ground cover by 2018.

Very good: Late-dry-season mean ground cover across grazing lands was 90 per cent.

Table 6: Ground cover results for the Mackay Whitsunday region and catchments

Region	29-year mean ground cover (%)	2016 mean ground cover (%)	Area with less than 70% ground cover averaged over past 29 years (%)	Area with less than 70% ground cover in 2016 (%)
O'Connell	90	92	4	2
Pioneer	91	93	3	2
Plane Creek	89	88	6	6
Proserpine	87	89	7	3
Mackay Whitsunday region	89	90	5	3

The ground cover frequency distribution map (Figure 25) for the Mackay Whitsunday region provides a visual representation of the results The proportion of the region with less than 70 per cent cover is shaded blue and labelled '3%'. The median value in 2016 (92 per cent) is shown in red at the base of the solid line. The frequency distribution of ground cover in 2016 across the region was generally higher than the long-term mean; this is reflected in the generally higher mean ground cover levels for 2016 and the very low area of the region's catchments that were below the target.

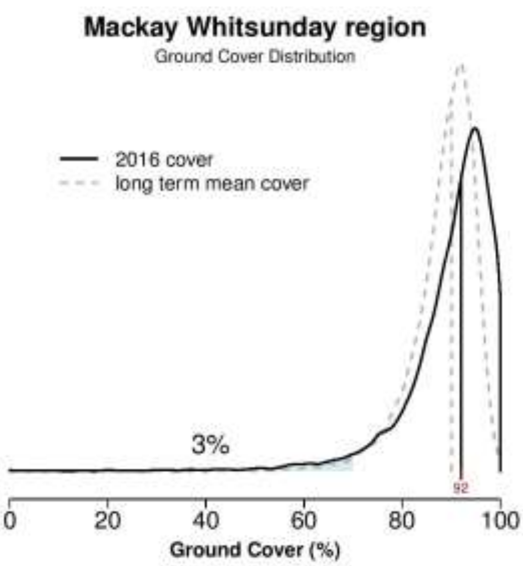

Figure 25: Mackay Whitsunday ground cover frequency distribution for late dry season 2016 (solid line) and the long-term mean (dashed line)

The percentage of ground cover for the Mackay Whitsunday region and catchments is shown in Figure 26.

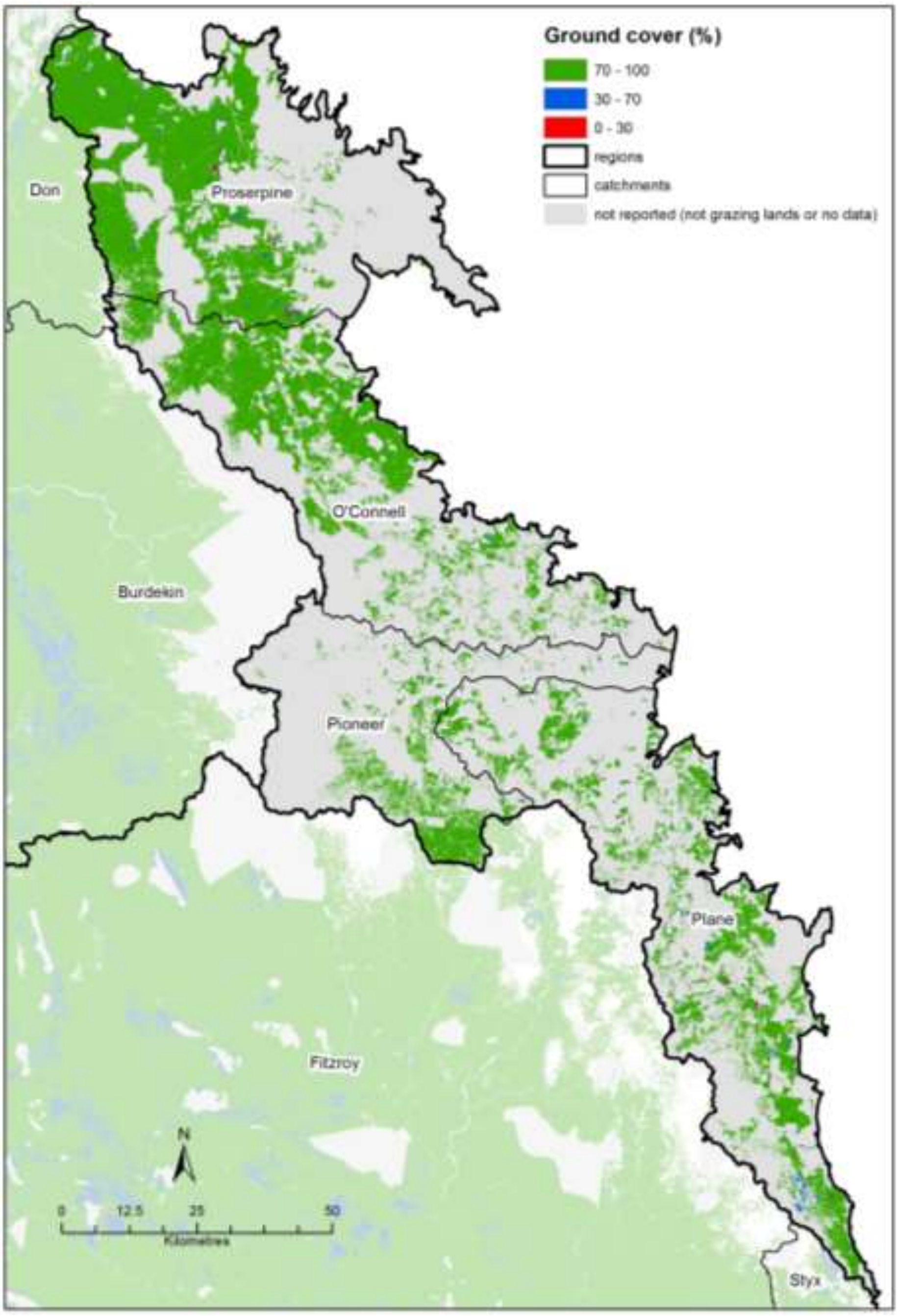

Figure 26: Late-dry-season ground cover levels in 2016 for the Mackay Whitsunday region grazing lands

The Mackay Whitsunday region had mean ground cover of 90 per cent in 2016 and consistently high mean ground cover from 1987 to 2016 (89 per cent). The area with ground cover less than 70 per cent has also been consistently low across all years, with a mean of 3 per cent for 2016 and 5 per cent for the 29-year period (Table 6 and Figure 25).

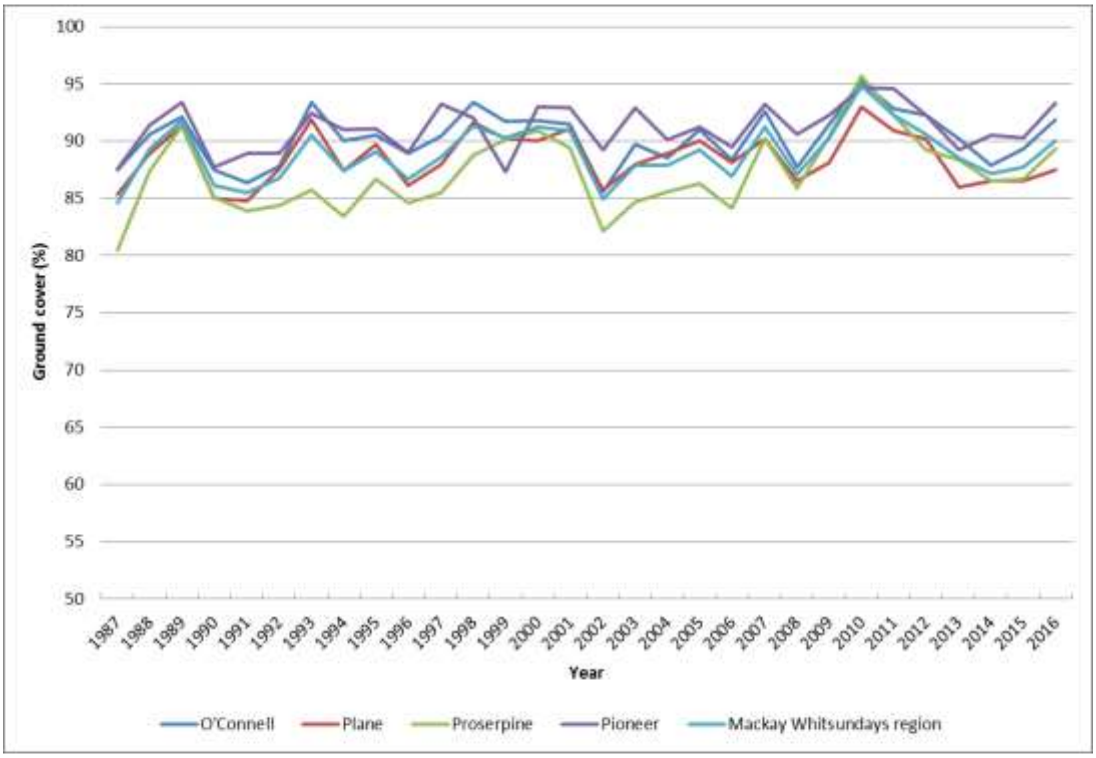

Figure 27: Mackay Whitsunday region and catchments - mean late-dry-season ground cover. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

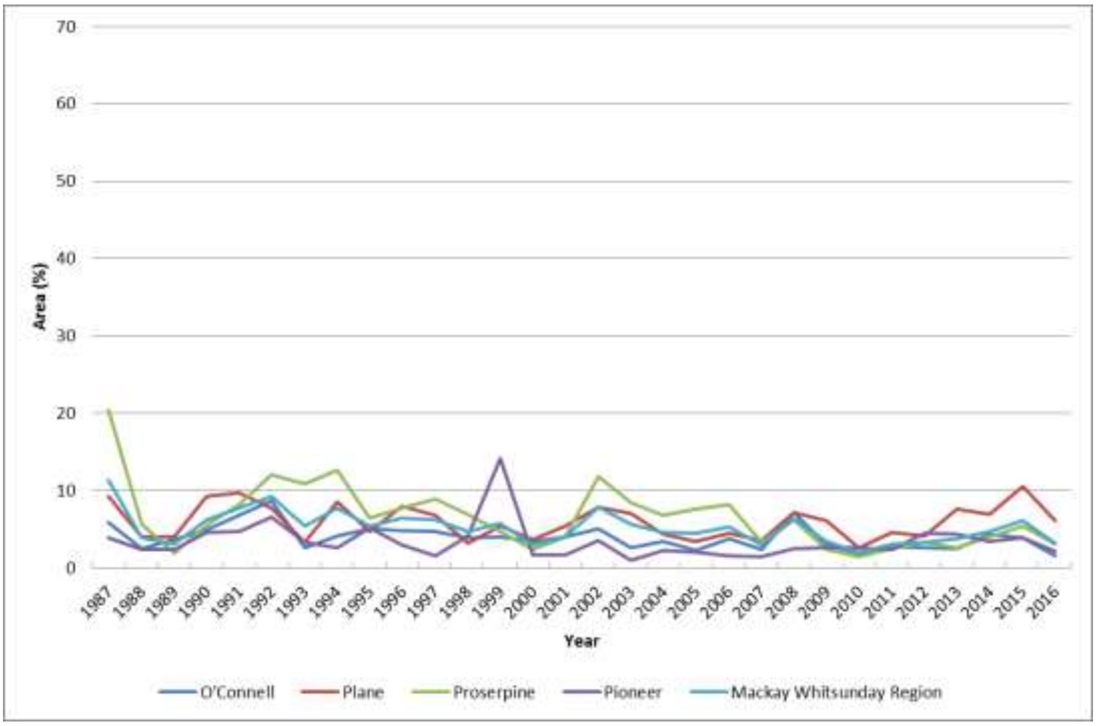

Figure 28: Mackay Whitsunday region and catchments - percentage area with ground cover below 70 per cent (1987–2016).

The map of ground cover deciles (Figure 29) shows the spring 2016 ground cover in comparison to the long-term (1988–2012) spring baseline. While some areas are relatively low in ground cover compared to the baseline period, they generally still have high-to-very-high levels of ground cover, mainly due to the consistently high rainfall in the region.

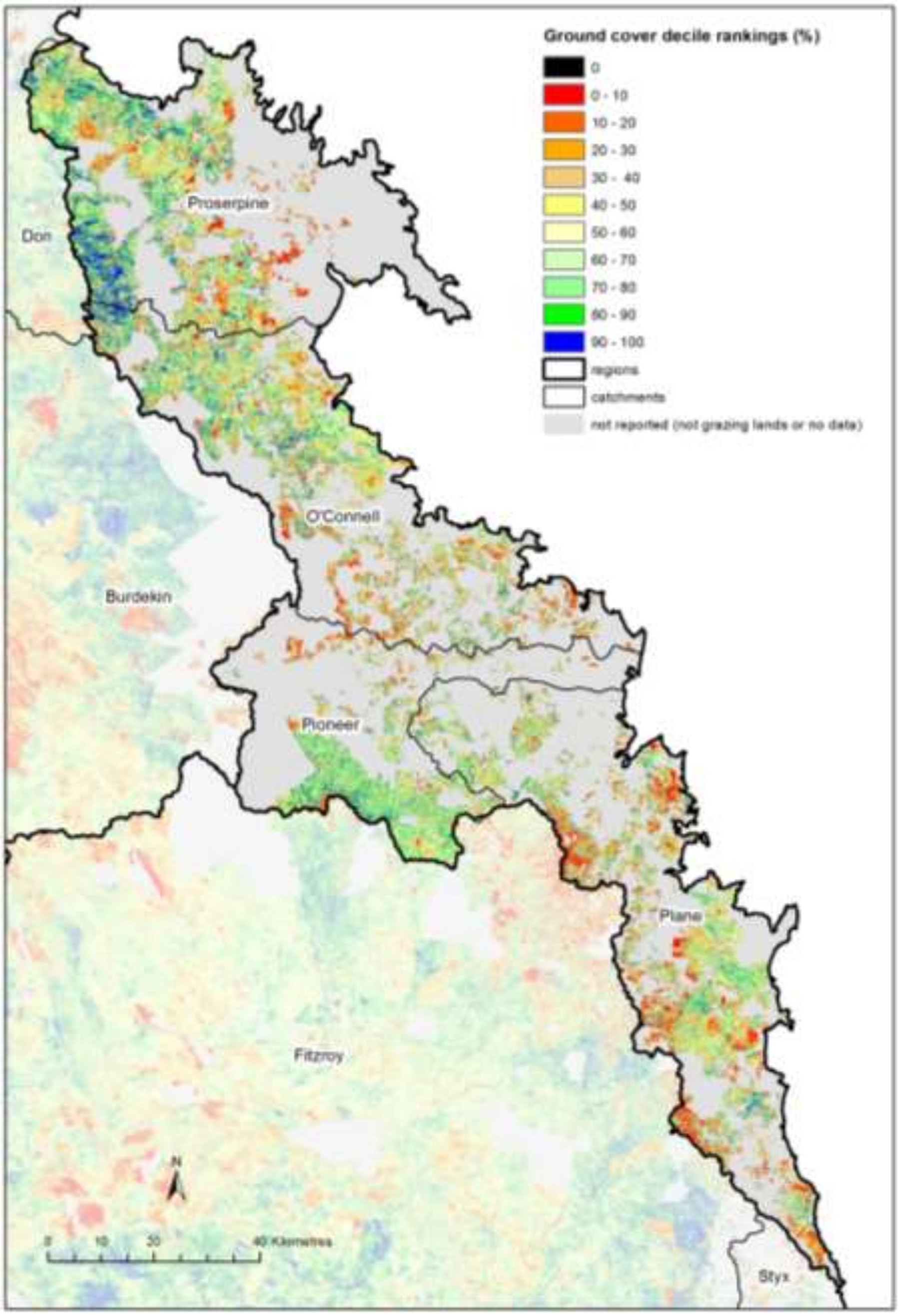

Figure 29: Mackay Whitsunday region ground cover decile rankings. This map shows spring 2016 ground cover in comparison to the long-term (1988–2012 baseline) spring cover. The lowest decile (red) indicates where ground cover was at the lowest level relative to the baseline period, and the highest decile (blue) indicates where ground cover was at the highest level relative to the baseline period.

The Mackay Whitsunday region is the second wettest of the regions reported (1517 millimetres mean annual rainfall). Rainfall in 2015 was below the mean at 887 millimetres and just below the mean in 2016 (1493 millimetres) (Figure 30).

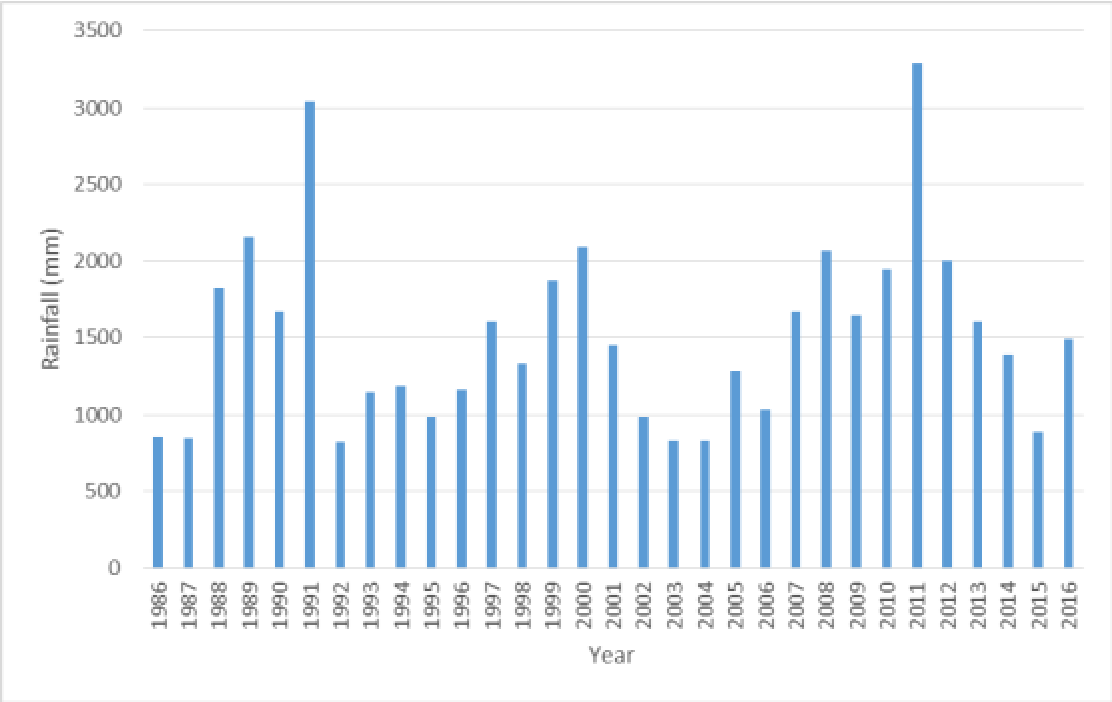

Figure 30: Mean annual rainfall for Mackay Whitsunday region (1986–2016). Note that a year is from October to September to align with late-dry-season reporting.

Fitzroy

A
84%

Target: 70 per cent late dry season ground cover by 2018.

Very good: Late-dry-season mean ground cover across grazing lands was 84 per cent.

Table 7: Ground cover results for the Fitzroy region and catchments

Region	29-year mean ground cover (%)	2016 mean ground cover (%)	Area with less than 70% ground cover averaged over past 29 years (%)	Area with less than 70% ground cover in 2016 (%)
Boyne	87	87	6	6
Calliope	87	88	6	4
Fitzroy	79	83	20	9
Shoalwater	87	90	9	3
Styx	86	91	9	3
Waterpark	87	83	8	13
Fitzroy region	79	84	20	8

The ground cover frequency distribution for the Fitzroy region (Figure 31) provides a visual representation of the results. The proportion of the region with less than 70 per cent cover is shaded blue and labelled '8%'. The median value in 2016 (85 per cent) is shown in red at the base of the solid line. The frequency distribution of ground cover across the region in 2016 was higher than the long-term mean. The area below the target (8 per cent) was much lower than the long-term mean and was more than half that of 2015, which had 17 per cent of the area below the target. This is an encouraging trend, given rainfall in 2016 was only slightly higher than the long-term mean, and was similar to 2015 rainfall. However, the Fitzroy region did receive somewhat unseasonal winter rainfall in 2016, which may have contributed to improvements in the 2016 levels.

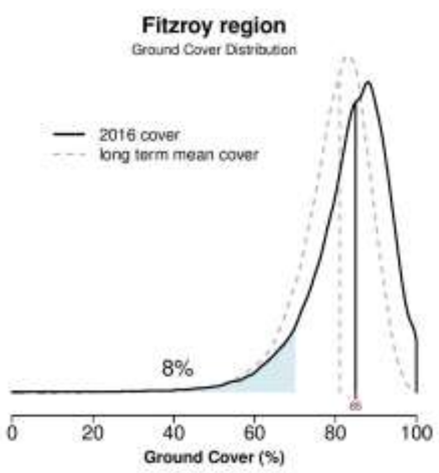

Figure 31: Fitzroy ground cover frequency distribution for late dry season 2016 (solid line) and the long-term mean (dashed line)

The percentage of ground cover for the Fitzroy region and catchments is shown in Figure 32.

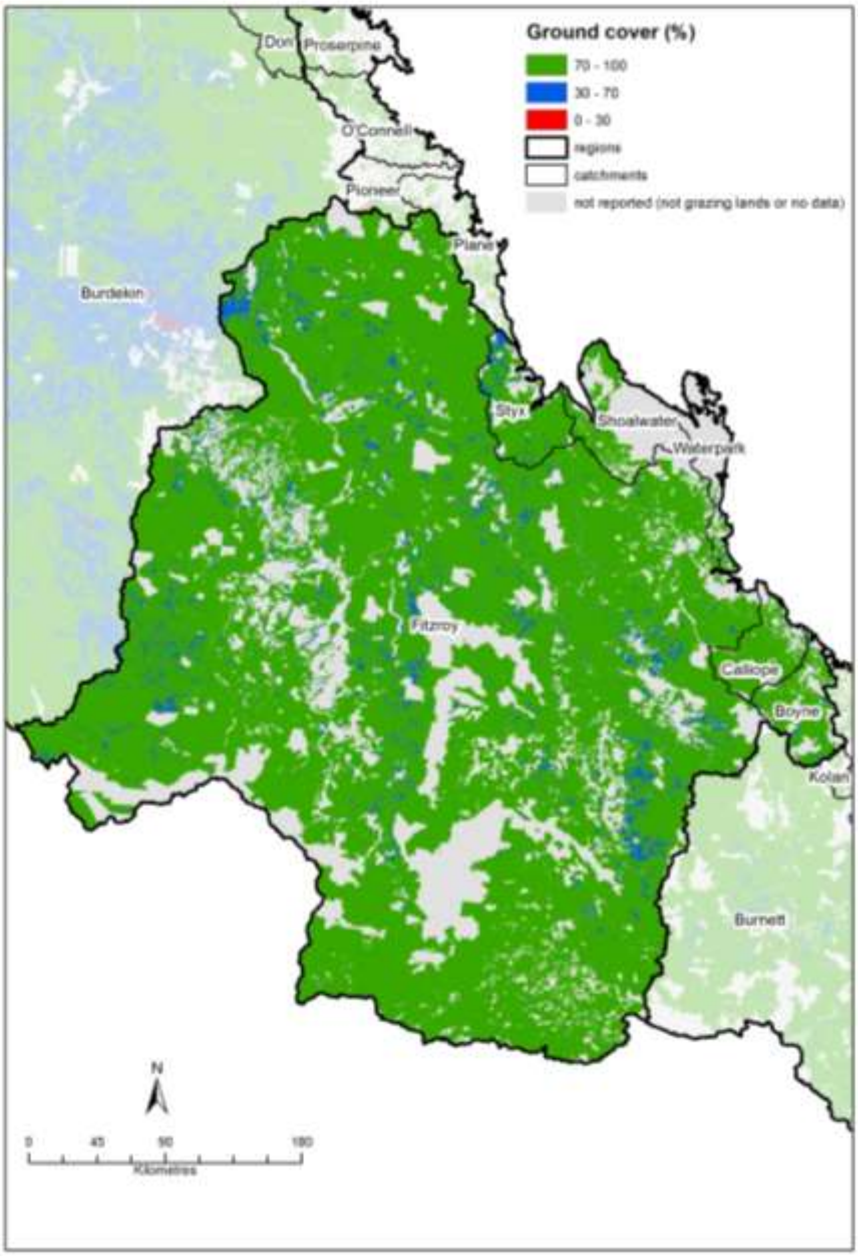

Figure 32: Late-dry-season ground cover levels in 2016 for the Fitzroy region grazing lands

The Fitzroy region had mean ground cover of 84 per cent in 2016 and 79 per cent for the 29-year period. Mean ground cover in the Fitzroy region fluctuates considerably over time. For example, in 2006 the mean ground cover was 71 per cent, in 2008 it was 82 per cent, and in 2010 it was as high as 93 per cent. The proportion of grazing lands falling below the target of 70 per cent ground cover was 8 per cent in 2016 and 20 per cent for the 29-year period (Table 7 and Figure 31). Increases in the area with less than 70 per cent ground cover correspond to low mean late-dry-season ground cover and below average annual rainfall in the current and preceding years. For example, in 1994 the mean late-dry-season ground cover was 72 per cent, the area with ground cover below 70 per cent was 38 per cent, and the mean annual rainfall had been declining since 1989. In 1993, the annual rainfall was 396 millimetres—more than 250 millimetres lower than the region's mean annual rainfall for 1987–2016.

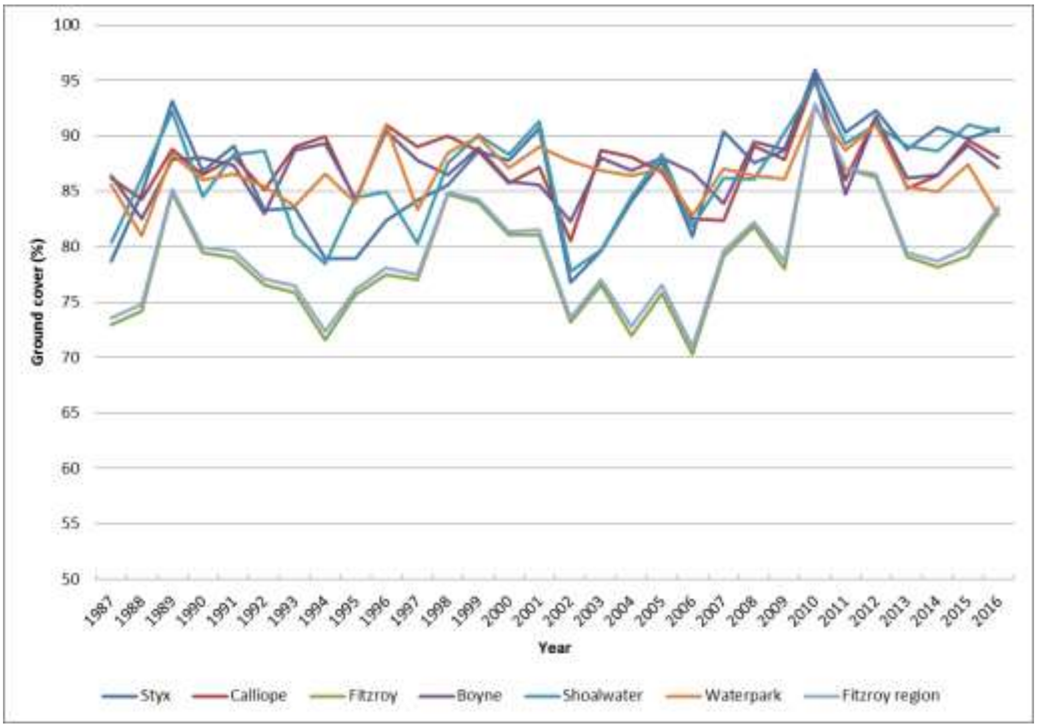

Figure 33: Fitzroy region and catchments - mean late-dry-season ground cover. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover

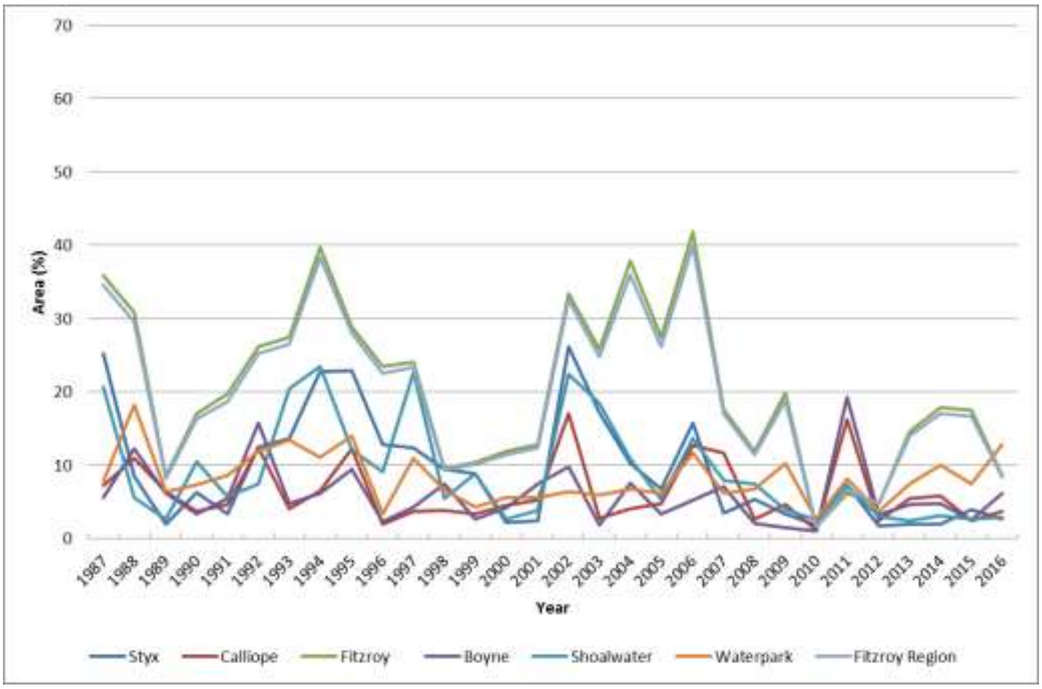

Figure 34: Fitzroy region and catchments - percentage area with ground cover below 70 per cent (1987–2016)

The map of ground cover deciles (Figure 35) shows the spring 2016 ground cover in comparison to the long-term (1988–2012 baseline) spring ground cover. The map shows that some areas in the western parts of the Fitzroy catchment had relatively higher ground cover levels in 2016 compared to the baseline period (blue areas on the map). Some localised areas in the north-west and south-east of the large Fitzroy catchment had lower relative ground cover levels (red areas). A further partition of the large Fitzroy catchment into its constituent sub-catchments is given in the ground cover technical report (DSITI, 2017 in prep.)

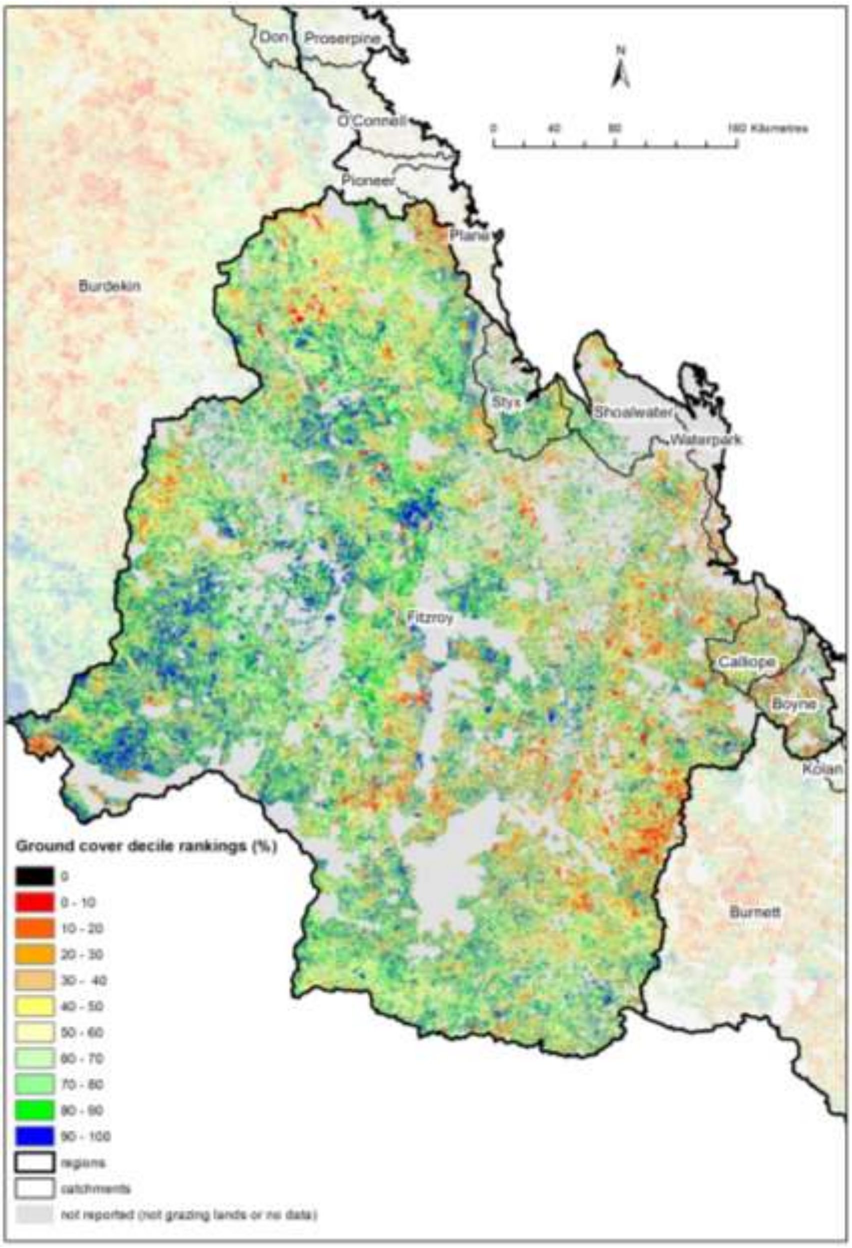

Figure 35: Fitzroy region ground cover decile rankings. This map shows spring 2016 ground cover in comparison to the long-term (1988–2012 baseline) spring cover. The lowest decile (red) indicates where ground cover was at the lowest level relative to the baseline period, and the highest decile (blue) indicates where ground cover was at the highest level relative to the baseline period.

The Fitzroy region is the second driest of the regions reported (658 millimetres mean annual rainfall). Rainfall in 2015 was above the mean at 689 millimetres, and again in 2016 (702 millimetres) (Figure 36).

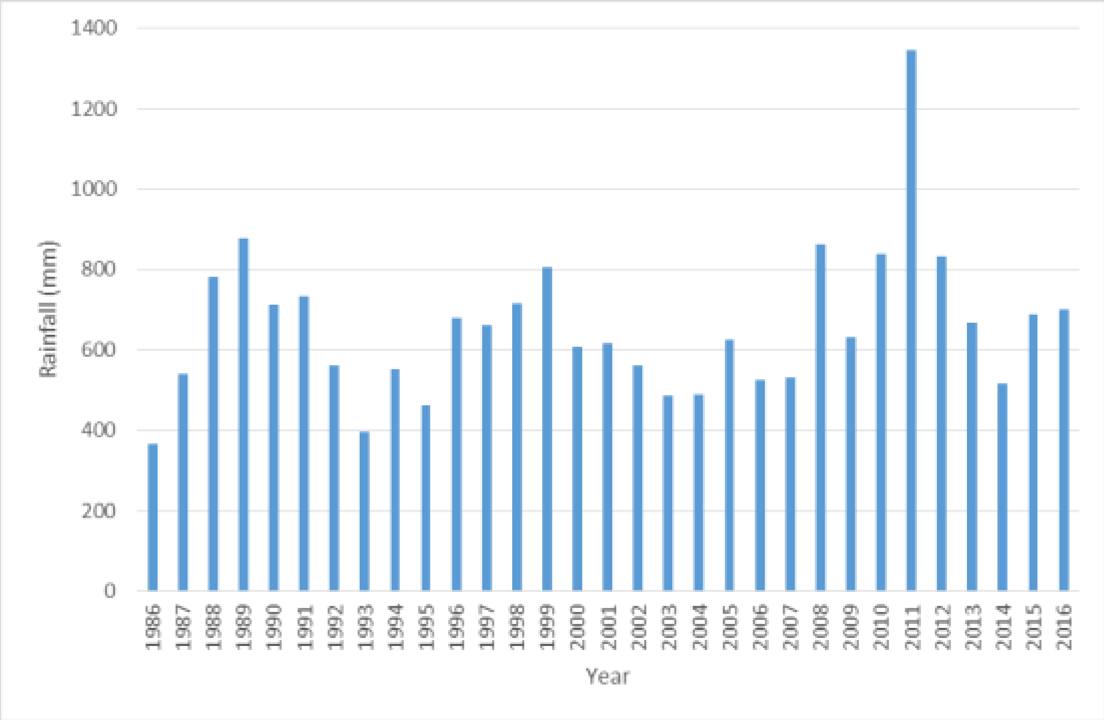

Figure 36: Mean annual rainfall for Fitzroy region (1986–2016). Note that a year is from October to September to align with late-dry-season reporting.

Burnett Mary

A
84%

Target: 70 per cent late dry season ground cover by 2018.

Very good: Late-dry-season mean ground cover across grazing lands was 84 per cent.

Table 8: Ground cover results for the Burnett Mary region and catchments

Region	29-year mean ground cover (%)	2016 mean ground cover (%)	Area with less than 70% ground cover averaged over past 29 years (%)	Area with less than 70% ground cover in 2016 (%)
Baffle	88	89	6	4
Burnett	85	84	7	9
Burrum	87	86	9	8
Kolan	88	86	4	5
Mary	88	85	5	6
Burnett Mary region	86	84	7	8

The ground cover frequency distribution (Figure 37) for the Burnett Mary region provides a visual representation of the results. The proportion of the region with less than 70 per cent cover is shaded blue and labelled ‘8%’. The median value in 2016 (86 per cent) is shown in red at the base of the solid line. The frequency distribution of ground cover across the Burnett Mary region was very similar to the long-term mean. This similarity is also reflected in the catchments of the region.

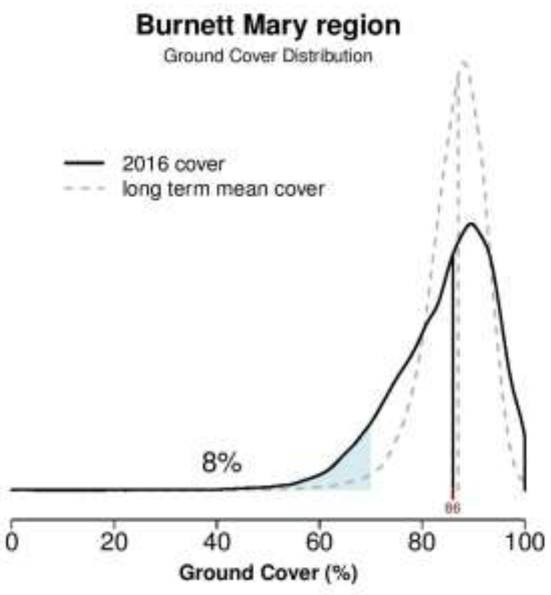

Figure 37: Burnett Mary ground cover distribution for late dry season 2016 (solid line) and the long term mean (dashed line)

The percentage of ground cover for the Burnett Mary region and catchments is shown in Figure 38.

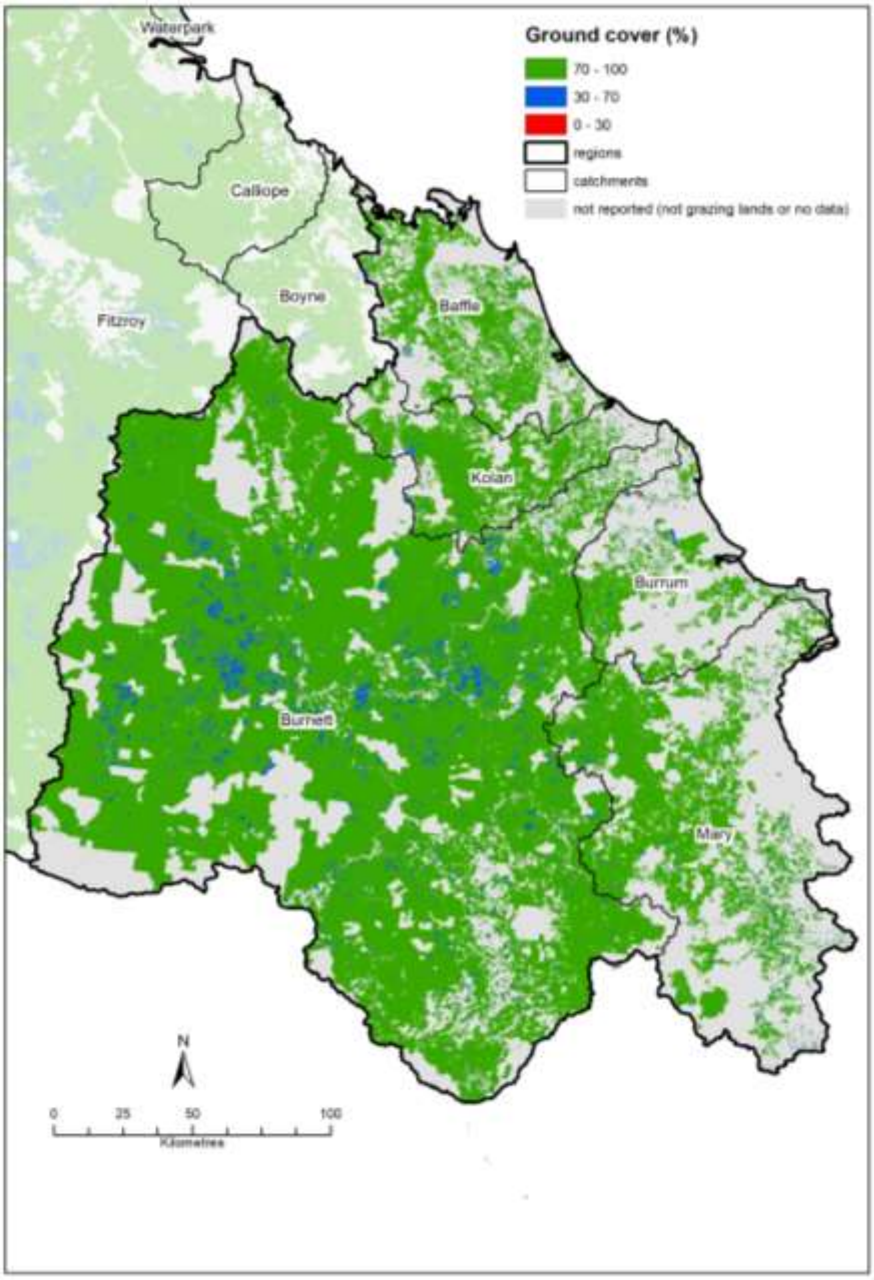

Figure 38: Late-dry-season ground cover levels in 2016 for the Burnett Mary region grazing lands

The Burnett Mary region had mean ground cover of 84 per cent in 2016 and consistently high mean ground cover from 1987 to 2016 (86 per cent). The highest level of ground cover was in 2010 (94 per cent). The lowest was 81 per cent in 1988 and 2014. The area with ground cover less than 70 per cent has been consistently low across all years, with a mean of 8 per cent for 2016 and a 29-year mean of 7 per cent (Table 8 and Figure 37). The largest area below the target was in 1991 (14 per cent). This corresponded with a low rainfall year for the area, more than 250 millimetres below the mean annual rainfall.

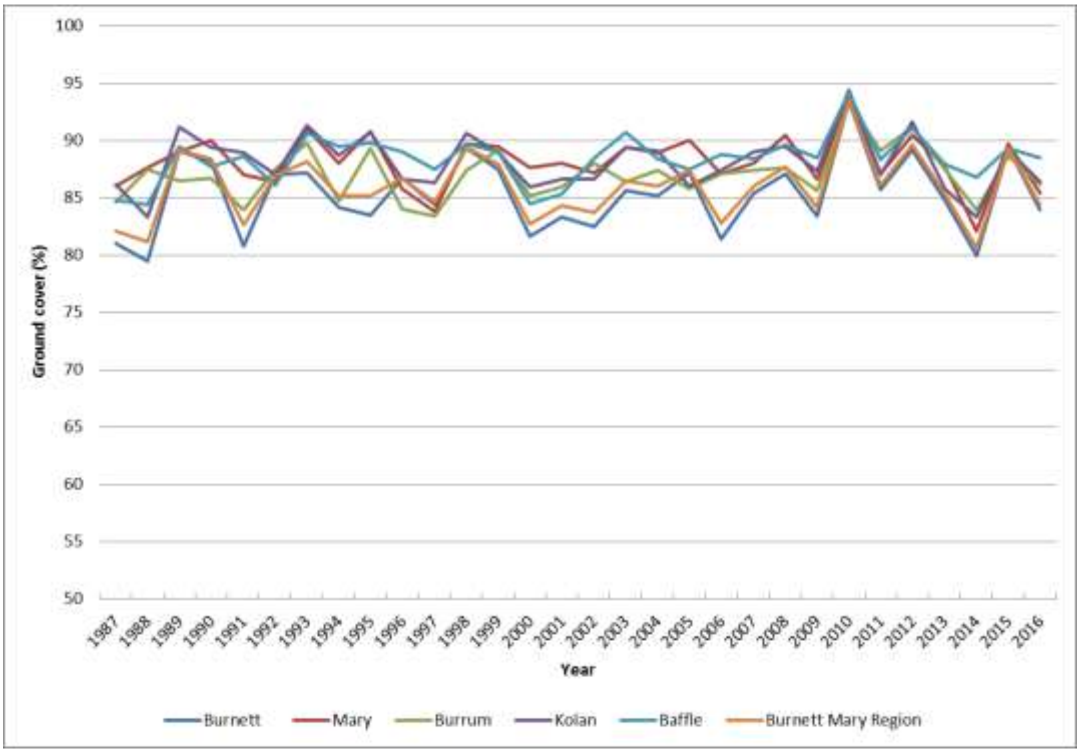

Figure 39: Burnett Mary region and catchments - mean late-dry-season ground cover. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

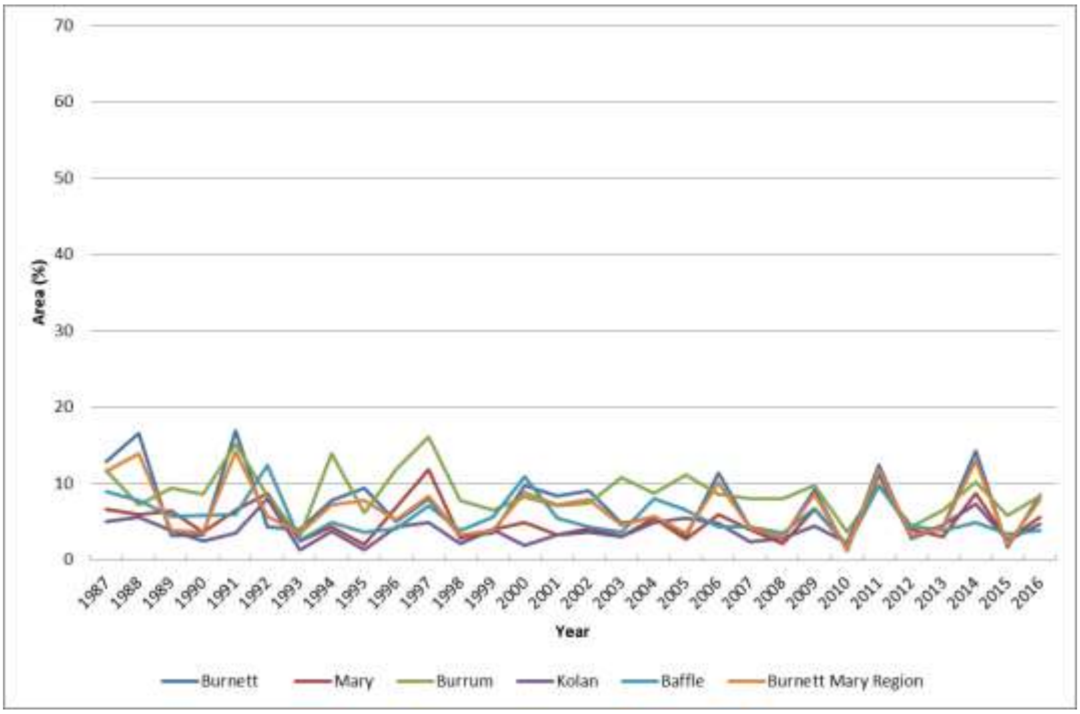

Figure 40: Burnett Mary region and catchments - percentage area with ground cover below 70 per cent (1987–2016)

The map of ground cover deciles (Figure 41) shows the spring 2016 ground cover in comparison to the long-term (1988–2012 baseline) spring cover. The map shows that, relative to the long-term baseline, in 2016 there were significant areas at their lowest comparative level of ground cover. This may indicate some localised areas which are at risk of erosion. However, given ground cover levels remain generally high in the region, these risk areas are likely to be minimal. Although, further investigation may be needed as to the cause for the relatively lower ground cover levels, given rainfall levels were similar to the long-term mean.

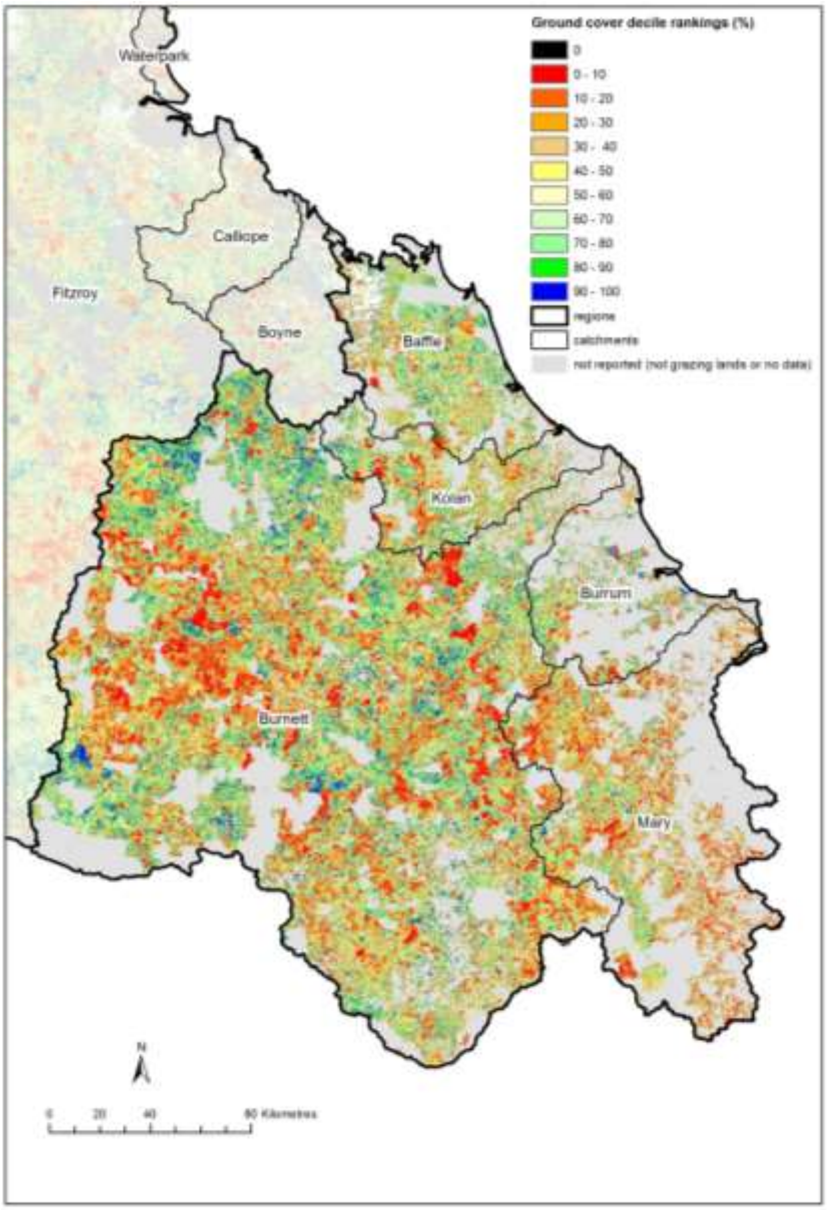

Figure 41: Burnett Mary region ground cover decile rankings. This map shows spring 2016 ground cover in comparison to the long-term (1988–2012 baseline) spring cover. The lowest decile (red) indicates where ground cover was at the lowest level relative to the baseline period, and the highest decile (blue) indicates where ground cover was at the highest level relative to the baseline period.

Mean annual rainfall for the Burnett Mary region over the period 1986 to 2016 is approximately 797 millimetres. Rainfall in 2015 was above the mean at 840 millimetres, and just below the mean in 2016 (759 millimetres) (Figure 42).

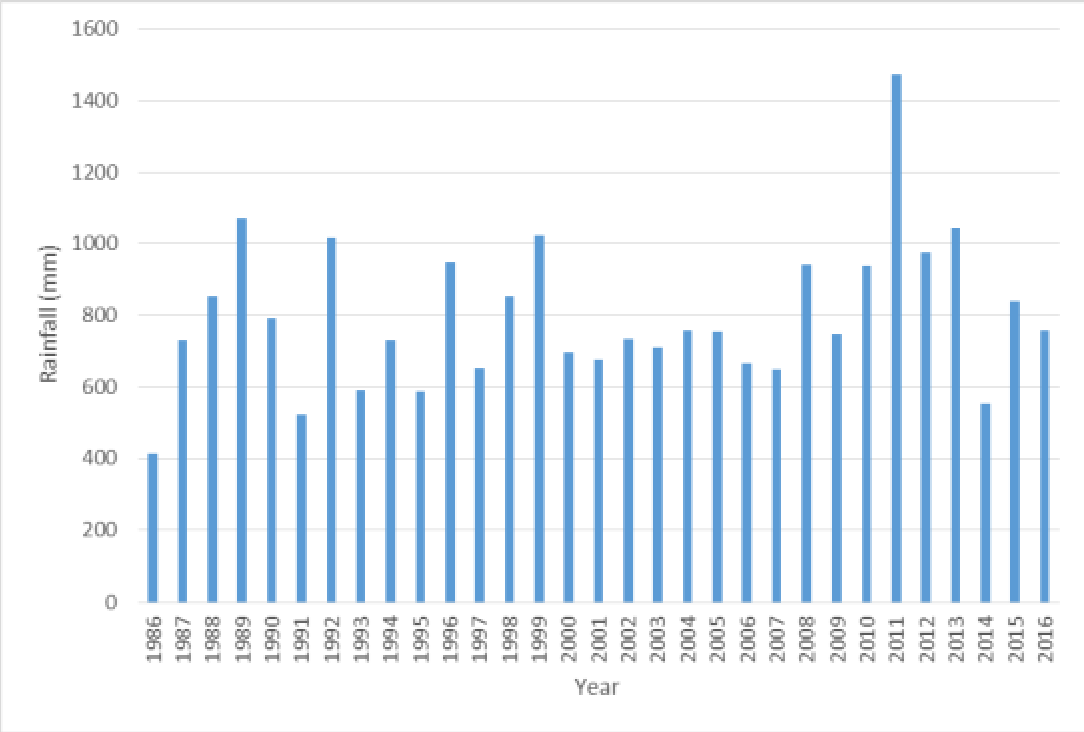

Figure 42: Mean annual rainfall for Burnett Mary region (1986–2016). Note that a year is from October to September to align with late-dry-season reporting.

References

Department of Science, Information Technology and Innovation 2017, *Ground cover technical report 2015-16: Great Barrier Reef catchments*, Queensland Department of Science, Information Technology and Innovation, Brisbane.

DSITI—see Department of Science, Information Technology and Innovation

Wetland condition results

Summary

The wetlands target in the Reef Water Quality Protection Plan 2013 (Australian and Queensland governments, 2013) is:

- There is no net loss in extent, and an improvement in the ecological processes and environmental values, of natural wetlands.

With the establishment of the Great Barrier Reef catchment wetland monitoring program, reporting on changes in wetland environmental values and, ultimately, ecological processes of natural freshwater wetlands is now included as part of the Paddock to Reef Monitoring, Modelling and Reporting Program. This allows wetland condition results to be reported in the 2016 Reef report card, for the first time.

This baseline report covers the component of the 2013 Great Barrier Reef Water Quality Protection Plan wetland target addressing wetland values and ecological processes. The baseline data for floodplain wetlands in the Reef catchments show that, overall, wetlands are in moderate condition and are under moderate exposure to pressures, putting them in the ‘C’ grade.

The overall scores on the two scoring indices—pressure on wetland values, and state of wetland values (condition)—were both 6 out of a possible 13[1] after correcting for a non-response bias in the data, related to land-use intensity. Managers of wetlands surrounded by intensive land uses such as cropping and mining were less likely to allow access to their wetlands than those whose wetlands were within conservation areas, with moderate land-use intensity producing an intermediate likelihood of a positive response from land managers. Correcting for this bias adjusts the average condition of freshwater floodplain wetlands in the Reef catchments one point towards the more disturbed end of the assessment spectrum.

However, this finding masks an important difference between wetlands surrounded by conservation land uses, such as national parks and water treatment reserves, and those surrounded by all other land uses, with condition scores for ‘other uses’ being four points towards the more disturbed end of the scale than those surrounded by conservation lands (uncorrected scores of 7 and 3 respectively). As well, wetlands surrounded by non-conservation land uses suffer higher levels of anthropogenic pressure (4 for conservation land uses and 7 for non-conservation uses). In wetlands surrounded by non-conservation land use, there is considerable opportunity for land managers to reduce pressure on wetland values, especially in intensive land-use areas, in order to bring about the improvement in wetland ecological processes and environmental values sought by the Reef Plan target.

The 2015–16 baseline study used a purpose-made rapid assessment tool, the Wetland Field Assessment Tool for Monitoring (WFAT–M)[2]. The capability of the tool to discriminate across the range of human disturbance to wetlands in the Reef catchment has been demonstrated. Using the results to date and the logic of statistics, it is reasonable to speculate that the tool has the level of precision needed to detect a change – or lack of change – between two assessment times i.e. a finding of ‘no change’ has an acceptable likelihood (>80%) of indicating that there really has been no change, rather than indicating a lack of precision in the tool. This level of precision will be empirically confirmed with a second round of assessments of the wetlands in this baseline study, due to be completed by the end of 2018.

[1] The score of 6 on the 13-point WFAT–M scale corresponds to a score of ‘C’ on the 5 point report card scale. Lower scores on the WFAT–M scale indicate less disturbance to wetland environmental values. The report card score ‘C’ covers the WFAT–M score band from 6 to 8.

[2] An adaptation of the Wetland Field Assessment Toolkit (WFAT), under development by the Queensland Wetlands Program.

Results

Summary statistics

Pressure

The mean pressure for the 41[3] wetlands assessed was 5.6 (on a 13-point scale), corresponding to a WFAT–M score of 6 and a report card score of C. The median was 6. Standard deviation is 2.53 (variance 6.40) and interquartile range 5.

Figure 1 shows the distribution of overall pressure scores on the 13-point scale.

Figure 2 shows the distribution of pressure scores by wetland environmental value (WEV), on a scale of 1 to 5, where 1 represents the least pressure on wetland environmental values. The mean pressure scores for each of the WEVs were:

- WEV 1 (biotic integrity) = 3.0 (report card score C)
- WEV 2 (physical integrity) = 1.2 (A)
- WEV 3 (hydrology) = 2.0 (B)
- WEV 4 (connectivity) = 3.0 (C).

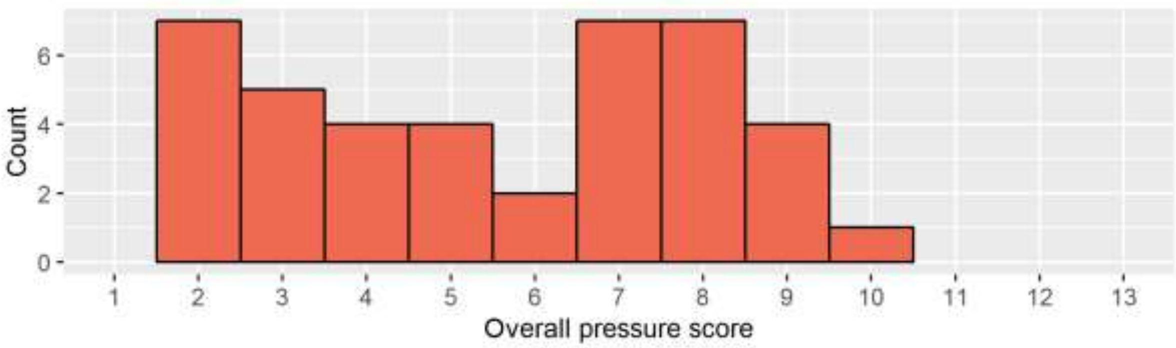

Figure 1: Scores for overall pressure on floodplain wetlands in the Reef catchment (N=41)

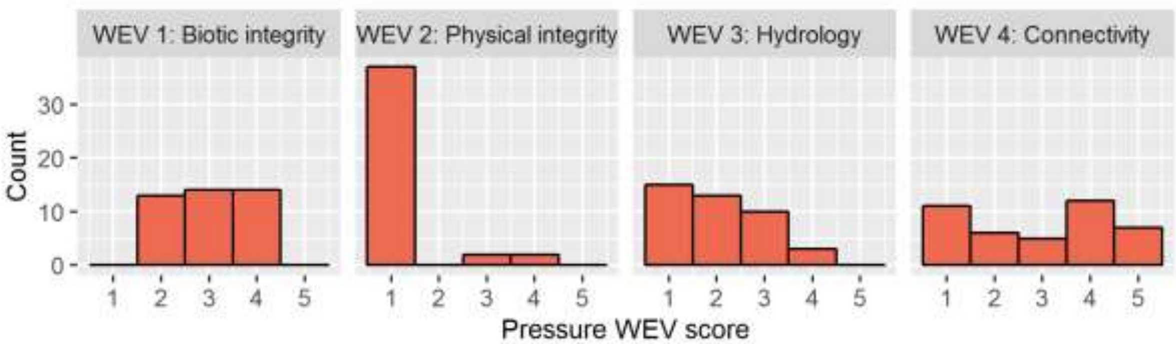

Figure 2: Scores for pressure on wetland environmental values (WEVs) for wetlands in the Reef catchment (N=41)

[3] A sample of 40 wetlands was planned for the baseline assessments (as per the Wetland Condition Methods report). An additional wetland was included in panel 1 to avoid having an entire region (Mackay Whitsunday) represented by just one wetland. This was done more for operational than scientific reasons, as one out of 40 wetlands is an accurate proportional representation of the number of floodplain wetlands in the Mackay Whitsunday region. The assessment results for this extra wetland were included in the baseline analysis but the wetland was excluded from the test for the effect of region on non-response. The technical reason for this is explained in footnote 6 of the methods report.

State

The mean state score for the 41 wetlands assessed was 5.2, corresponding to a WFAT–M score of 5 and a report card score of B. The median was 5. Standard deviation is 2.57 (variance 6.63) and interquartile range 4.

Figure 3 shows the distribution of overall state scores on the 13-point scale.

Figure 4 shows the distribution of state scores by wetland environmental value (WEV), on a scale of 1 to 5, where 1 represents the best state of wetland environmental values. The mean state scores for each of the WEVs were:

- WEV 1 (biotic integrity) = 2.0 (report card score B)
- WEV 2 (physical integrity) = 2.8 (C)
- WEV 3 (hydrology) = 1.3 (A)
- WEV 4 (connectivity) = 2.5 (B).

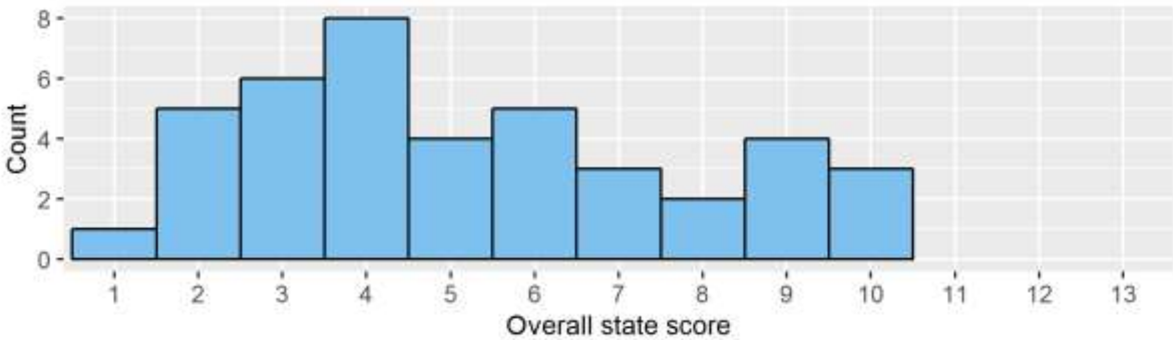

Figure 3: Scores for the overall state of floodplain wetlands in the Reef catchment (N=41)

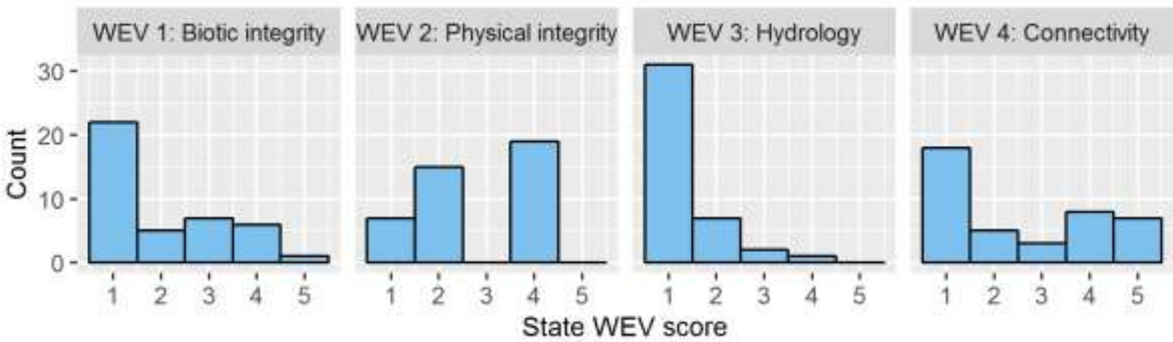

Figure 4: Scores for the state of wetland environmental values (WEVs) of floodplain wetlands in the Reef catchment (N=41)

Combined pressure and state results

Figure 5 plots the distributions for overall pressure and state scores for the 2015–16 baseline data. Pressure and state scores have similar ranges, means and variance, and are highly correlated (r = 0.72). These results differ from the pilot study in that the baseline pressure and state data have restricted ranges compared with the pilot results and there is no significant difference between mean pressure and state scores. For comparison, pilot study data are also plotted in Figure 5.

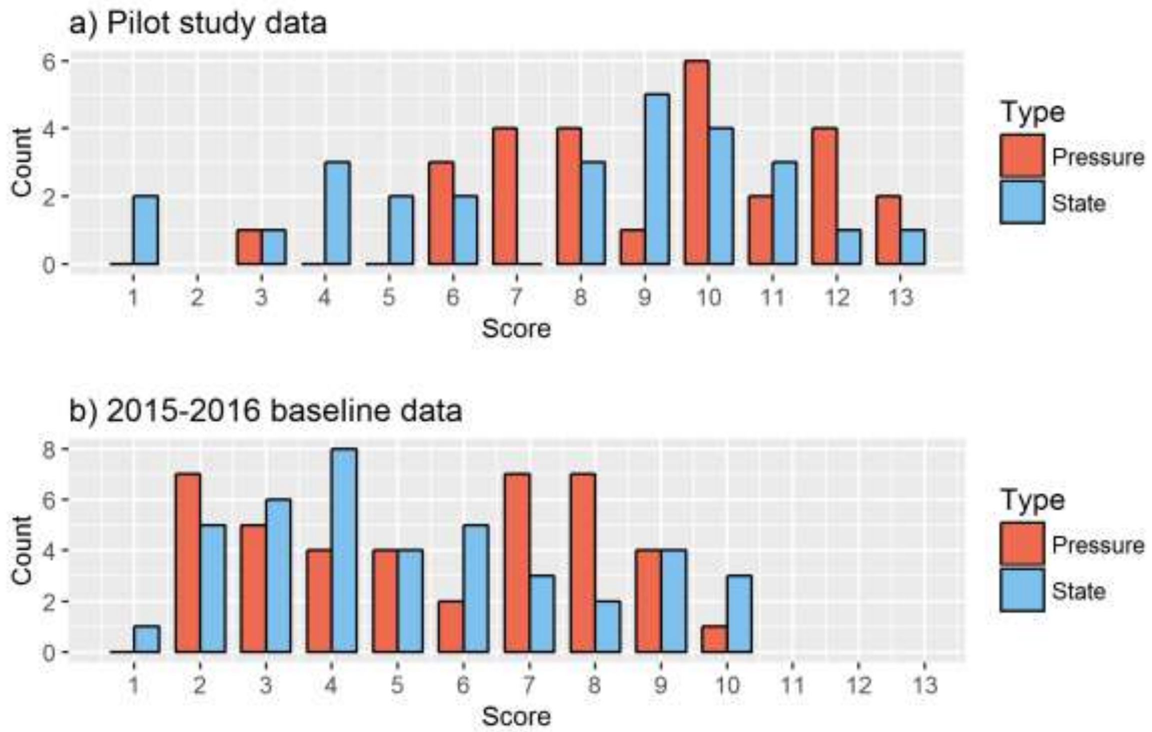

Figure 5: The distributions of overall scores for pressure (red) and state (blue) for the pilot study of 2014 (top) compared with those of the 2015–16 baseline study

These results were as expected. The pilot study was based on a purposive sample of wetlands designed to test the WFAT–M across the range of possible wetland states and pressures, whereas the baseline study is a random sample of wetlands drawn from the chosen sub-population of freshwater floodplain wetlands in dense aggregations in the Reef catchment. The explanation for the restricted score range of the baseline data is likely to involve some or all of the following:

- The pilot study wetlands were purposely chosen to test the full range of the WFAT–M without regard to the representativeness of the sample. Consequently, wetlands at the more disturbed end of the disturbance gradient were over-represented in the pilot sample.
- There is a non-response bias in the baseline data linked to land-use intensity and type, which would underestimate the average overall pressure on WEVs (producing a lower score) and also bias the estimated state of wetland values towards less disturbed levels.
- The WFAT–M was modified in response to the pilot study findings. The ability of the current version to yield scores at the higher end of the range needs further verification, especially in relation to the contribution of the pressure sub-index of physical integrity (WEV 2). This work is underway and will be reported in an upcoming evaluation of the performance of the WFAT–M.

Also in need of explanation is a difference between pressure and state means in the pilot data, which was not replicated in the baseline data (see Tilden et al., 2015). Several hypotheses were advanced to explain the difference between pressure and state means at the completion of the pilot study. One suggestion was that the pilot sample did not adequately represent wetlands at the less disturbed end of the disturbance gradient, so that the relationship between pressure and state found in that study was a distortion of their true relationship. Evidence noted in support of this conjecture was the fact that 'Dismal Swamp', the most pristine wetland ever assessed with the WFAT–M and one specifically included in the pilot study as an example of a wetland in the best possible condition, appeared as an outlier in the pilot scatterplot of pressure and state overall scores.

In Figure 6, Dismal Swamp, assessed in the pilot study, is represented by the red diamond at the bottom left of the graph. As can be seen, while this wetland is an outlier in its own (2014) pilot data set, represented by blue dots and trend line, it is close to the trend line for the 2015–16 baseline scatterplot

(green dots). This supports the hypothesis put forward at the conclusion of the pilot study that the difference between mean overall pressure and mean overall state of wetlands in the pilot study was an artefact of the sampling design rather than a reflection of an underlying difference in the sub-population.

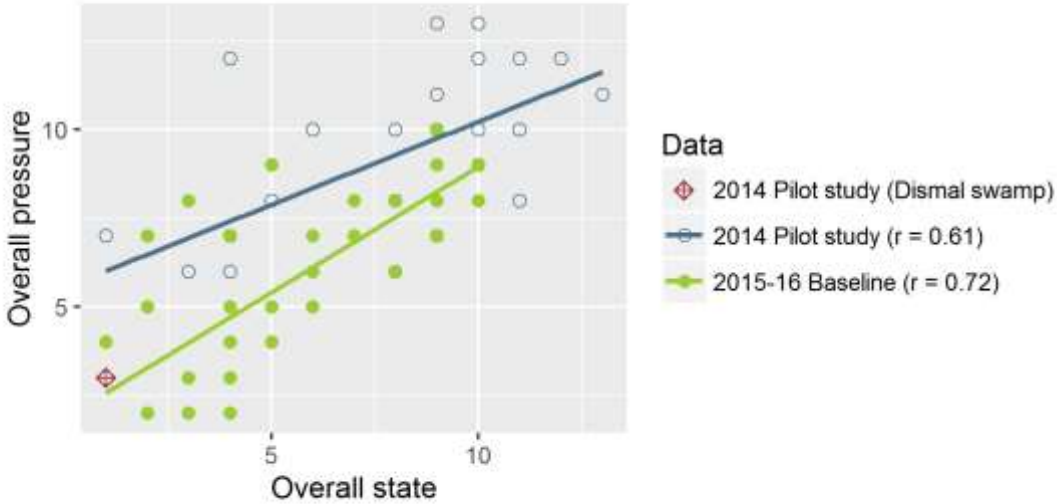

Figure 6: The relationship between pressure and state in the 2014 pilot data (blue dots and trend line) and in the 2015–16 baseline data (green dots and trend line). Dismal Swamp, a pristine wetland assessed in the pilot study, is represented by the red diamond at the bottom left of the graph.

The effect of land-use type on pressure and state distributions

There was a suggestion of bimodality in some of the WFAT–M sub-indices (WEVs) for pressure and state (refer to figures 2 and 4) as well as in the distribution of overall pressure scores. It is hypothesised that there could, in effect, be two sub-populations associated with these distributions—those wetlands embedded in conserved areas and those in land managed for other purposes. Figure 7 shows the outcome of plotting these two groups separately. Exact Wilcoxon rank sum tests were performed on the score distributions of wetlands in conserved areas and 'other use' areas for pressure and state. For both tests, the likelihood of the conserved and 'other use' wetlands being drawn from the same distribution was extremely low. For pressure, $W = 326$ with $p = .001$ and for state $W = 374.5$ with $p < .0001$.

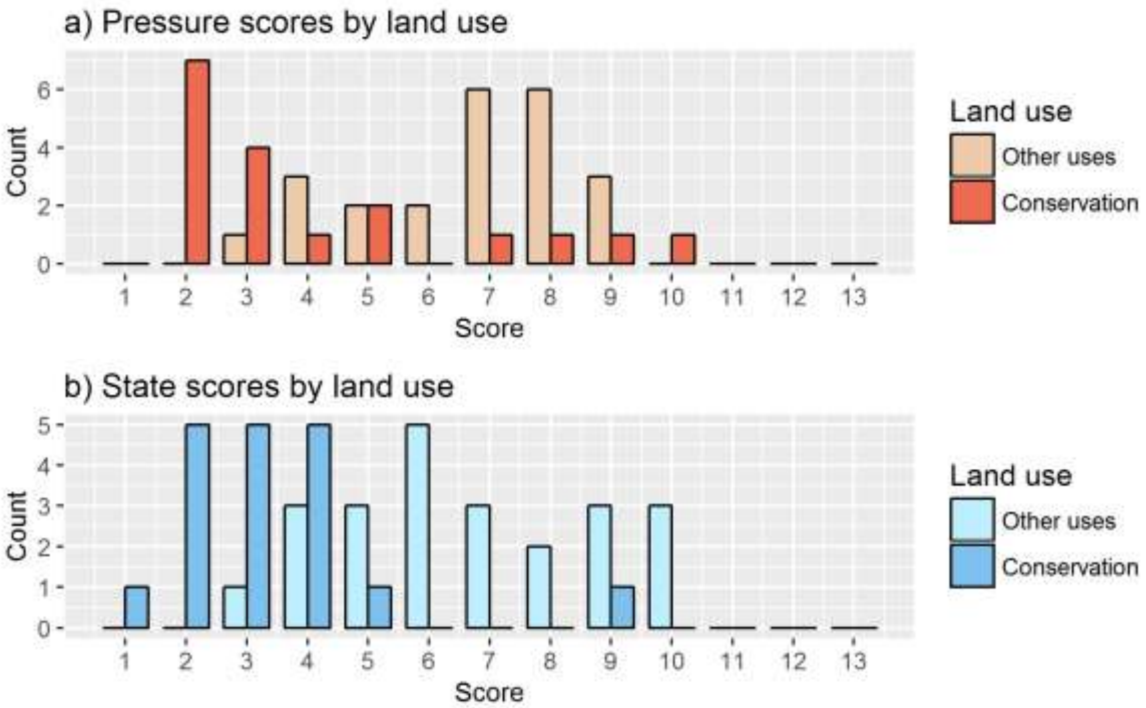

Figure 7: Overall pressure and state scores for Reef catchment wetlands in two land-use groups – conserved areas in dark red and dark blue (pressure and state, respectively) and all other land uses in the paler colours

The effects of the non-response bias

Testing for non-response bias

A chi-square test for linear trend in proportions was performed on the data displayed in Table 1 to determine whether there was a non-response bias in the baseline wetland sample due to different acceptance rates for three surrounding land-use intensity classes. The hypothesis that the surrounding land-use intensity had no effect on acceptance rate was rejected (chi square = 9.45, critical chi sq = 9.21 for $\alpha = .01$, df = 2). The effect of land-use intensity on acceptance rates is graphed in Figure 8.

Land managers of wetlands in areas of high land-use intensity were the least likely of the three groups to allow their wetlands to be assessed (29% acceptance) while access was granted to 86% of wetlands in areas of low land-use intensity. Moderate land use produced an intermediate rate of acceptance (52%).

Table 1: Landholder acceptance rates associated with intensity of land use surrounding the wetland

Land-use intensity	Approached (N)	Observed (N)	Acceptance rate (as a proportion)
Low	21	18	0.86
Moderate	38	20	0.52
High	7	2	0.29
Total	**66**	**40**	**0.61**

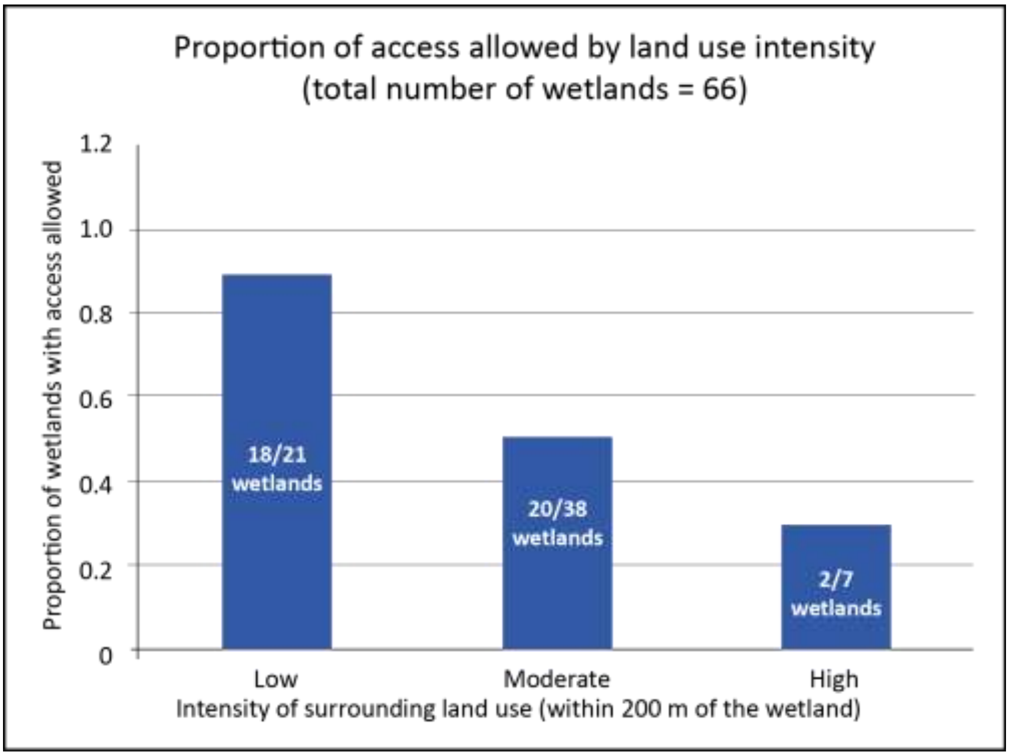

Figure 8: Proportion of wetlands accessed, by land-use intensity

Calculating non-response weights

It follows that the average scores for pressure and state of wetlands across the whole Reef catchment will be biased towards the less disturbed end of the scale unless individual wetland scores are weighted to correct for the non-response bias. Using the method of Johnson (2008), weights have been calculated by dividing the expected proportions of wetlands in each land-use intensity class (i.e. the sub-population proportions), by the observed proportions.

Effect of non-response bias on results

Correcting baseline pressure and state scores for the bias in rates of acceptance associated with land-use intensity moves the overall mean pressure score from 5.6 to 5.9 and the overall mean state score from 5.2 to 5.7. That is, the average condition of wetlands is assessed as more disturbed when the bias is taken into account. In the case of the state of wetland values, the increase in average score tips the score into the next report card grade, i.e. from a B to a C. Table 2 shows the impact of correcting for the bias on the overall scores, and on the WEV scores for pressure and state. Pressure WEV 2 (physical integrity) and State WEV 4 (connectivity) also change their report grades, in the direction of more disturbed, when the correction is applied.

Table 2: Mean overall WFAT–M scores and WEV scores, corrected and uncorrected for non-response bias

	Overall Pressure	WEV 1 Pressure	WEV 2 Pressure	WEV 3 Pressure	WEV 4 Pressure	Overall State	WEV 1 State	WEV 2 State	WEV 3 State	WEV 4 State
Uncorrected mean score	5.56	3.02	1.24	2.02	2.95	5.22	2.00	2.76	1.34	2.54
Corrected mean score	5.88	3.16	2.01	2.10	3.12	5.65	2.23	2.70	1.41	2.79
Uncorrected report card grade	C	C	A	B	C	B	B	C	A	B
Corrected report card grade	C	C	B	B	C	C	B	C	A	C

Relationship between baseline pressure and state and landscape hazard to wetlands

Land-use hazard assessment scores were attributed to wetlands based on land use in the 200-metre buffer zone of the wetland. Spearman's rho correlations were calculated for the relationships of these land-use hazard scores (on an ordinal scale of one to six) to overall pressure and overall state of the wetlands in the 2015–16 baseline sample.

Null hypotheses, that there are no relationships between land-use hazard score and either overall pressure score or overall state score, were tested and rejected. A significant correlation was found between land-use hazard score and both overall pressure score and overall state score, though not as high as the correlations in the pilot study. For pressure, the values were $\rho = 0.37$, $p < 0.05$, while for state the values were $\rho = 0.46$, $p < 0.01$. The mid-rank method was used to deal with tied ranks (Amerise and Tarsitano, 2014).

The significance of these findings for validation of the WFAT–M or, conversely, validation of the hazard assessment, is discussed below.

Discussion

Baseline status of freshwater floodplain wetlands in the Reef catchment

Figure 9 illustrates baseline pressure on wetland environmental values and the state of environmental values in floodplain wetlands of the Reef catchment. The overall scores have been corrected for a non-response bias that would have resulted in an underestimate of the average level of disturbance to the wetlands.

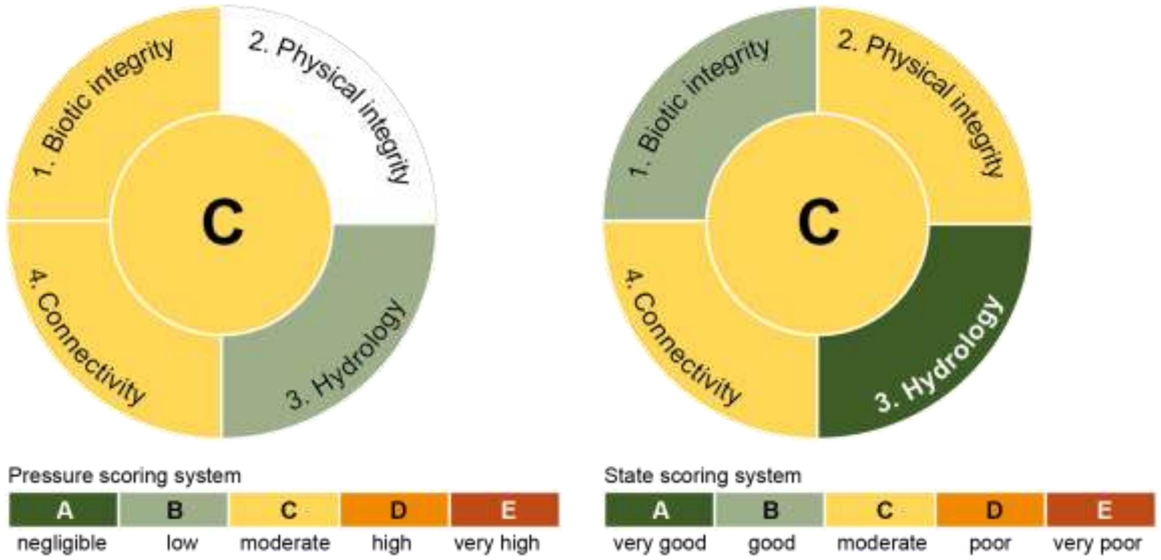

Figure 9: Corrected baseline pressure on wetland values (left) and state of wetland values (right) of floodplain wetlands in dense aggregations across the Reef catchment, as measured with the WFAT–M. Overall scores are in the centre of each circle with the four WEV scores arranged around the perimeter. There is no score for pressure on wetlands' physical integrity due to problems with the scaling of indicators for this sub-index.

The overall score on the pressure index was C before and after the correction was applied. For the state of wetland values, the score changed from B to C after correction, placing the average level of disturbance to freshwater floodplain wetlands in the Reef catchments at the midpoint of the reporting scale. As predicted, the overall scores achieved with a random sample of floodplain wetlands from dense wetland aggregations across the whole catchment showed less disturbance than those achieved with a purposive sample designed to test the WFAT–M across the full spectrum of wetland disturbance (Tilden et al., 2015). Overall scores in the 2014 pilot study were D for pressure and C for state.

These findings indicate that:

- overall, the WFAT–M is capable of discriminating across the spectrum of freshwater wetland disturbance
- wetland environmental values of freshwater floodplain wetlands in the Reef catchment are assessed as moderate in terms of both pressure and current state.

Across the four sub-indices, and with the exception of WEV 2 physical integrity, pressure scores tend to be higher (indicating more disturbance) than state scores. Hypothetically, this could signal lags between the application of anthropogenic pressures and their impacts on wetland condition. More work needs to be done on the WFAT–M index before any statement can be made with confidence about pressure on the physical integrity of wetlands. This issue is further discussed in the next section.

The 'Very good' state score for WEV 3, 'hydrology', representing the wetland's natural hydrological cycle, is notable. Possible reasons for this finding are also discussed in the next section.

The finding that the average pressure on WEVs and the average state of WEVs are both moderate masks an important difference between wetlands surrounded by conservation land uses, such as national parks or water treatment reserves, and those surrounded by all other land uses. Wetlands surrounded by non-conservation land uses suffer higher levels of anthropogenic pressure. This is reflected in higher pressure and state scores, indicating greater levels of disturbance to wetland environmental values. Figure 10 shows

the difference in *uncorrected* scores[4] between wetlands in conservation areas and wetlands surrounded by more intensive land uses.

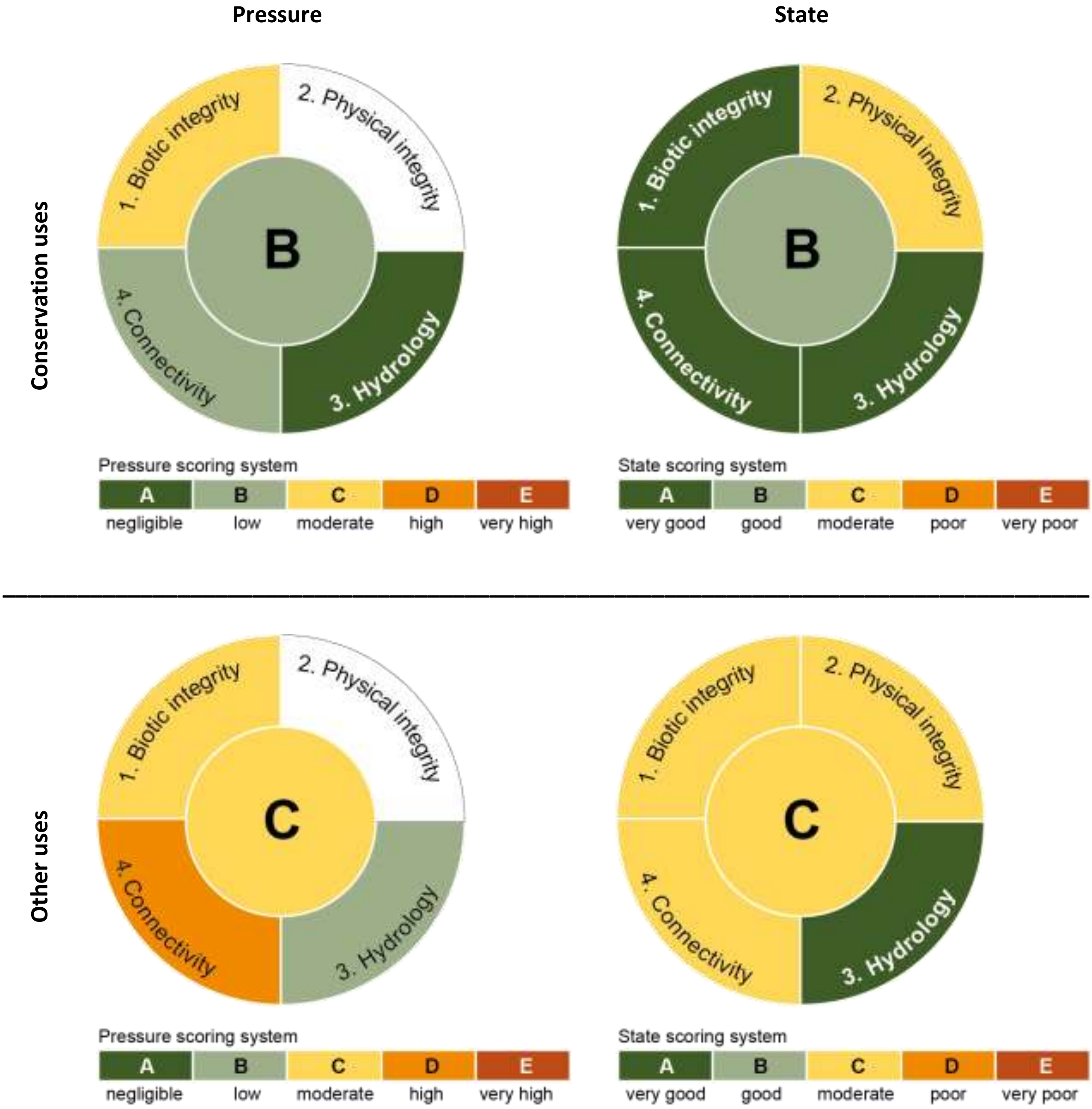

Figure 10: Baseline pressure on wetland values (left) and state of wetland values (right) of floodplain wetlands in the Reef catchment. The two top circles show pressure and state of wetlands surrounded by conservation areas, while the two at the bottom show pressure and state of wetlands surrounded by other land uses such as cropping, urban development, grazing and mining.

To make progress towards the target of improving 'the ecological processes and environmental values of natural wetlands', management actions could be applied in conserved areas to reduce pressure on the biotic integrity and connectivity of wetlands.

[4] The correction should not be applied in this case, as the non-response variable 'land-use intensity' and classification 'conservation land use' vs 'other land uses' are highly correlated. For this reason, applying the correction would erroneously inflate the difference between the two groups.

In wetlands surrounded by other (non-conservation) land use, there is considerable scope for reducing pressure on wetland values, especially on biotic integrity and connectivity but also on hydrology. Again, it is not possible to comment at this stage on the average level of pressures on the physical integrity of Reef wetlands.

Validity of WFAT–M conceptual modelling

There is a high overall correlation of 0.72 (Pearson's r) between the overall pressure and overall state scores. This validates the conceptual link between pressure and state illustrated in the wetland condition methods section of the Reef report card. While it cannot be said exactly what the causal links are between the two aggregate scores, it is clear that anthropogenic pressure on wetlands is strongly related to the overall condition of wetlands, as measured by the WFAT–M.

This relationship is upheld by three of the four sub-indices, with moderate to high Pearson's r correlations between pressure and state scores for WEV 1, 3 and 4 ($r = 0.61$, 0.51 and 0.82 respectively). There is no correlation between pressure and state for the measurements of disturbance to a wetland's physical integrity ($r = 0.17$). As Figure 2 shows, the sub-index measuring pressure on a wetland's physical integrity fails to discriminate across the range of disturbance to wetlands included in the 2015–16 baseline sample.

This sub-index comprises three indicators: P 10 – modelled sediment supply, P 12 – number of point inflows per hectare of wetland, and P 13 – recreational use (see Appendix 1 for the complete list of indicators). All three indicators lack sensitivity to discriminate at the less disturbed end of the score range, but for different reasons. It is proposed to address this problem in version 2 of the WFAT–M by recalibrating indicator scales for the field indicators and replacing P 10 with a better desktop indicator of sediment supply. It will be possible to hind-cast these changes so that the baseline assessments can still be compared with the results of future assessments, monitoring for change and trends in levels of disturbance to wetlands. For now, no average score is reported for pressure on the physical integrity of Reef wetlands.

Regarding the conceptual validity of WEV 3 'the wetland's natural hydrological cycle', there is a moderate positive correlation between the pressure and state scores for this sub-index; however, the finding of 'Very good' for the average hydrological condition of Reef floodplain wetlands is notable and bears examining.

In the context of a random sample of wetlands from the sub-population assessed, this result is expected to be an accurate reflection of the average hydrological condition of wetlands *at the wetland level*. About 85 per cent of wetlands in the baseline sample are H1 wetlands i.e. they have 'no modifications observed' that would affect their hydrology (at the 1:100,000 wetland mapping scale (EPA, 2005)). This is representative of the sub-population as a whole, as illustrated in Figure 11. The remainder are H2M2 wetlands—palustrine or lacustrine wetlands where size and/or hydrology has been changed by levee banks.

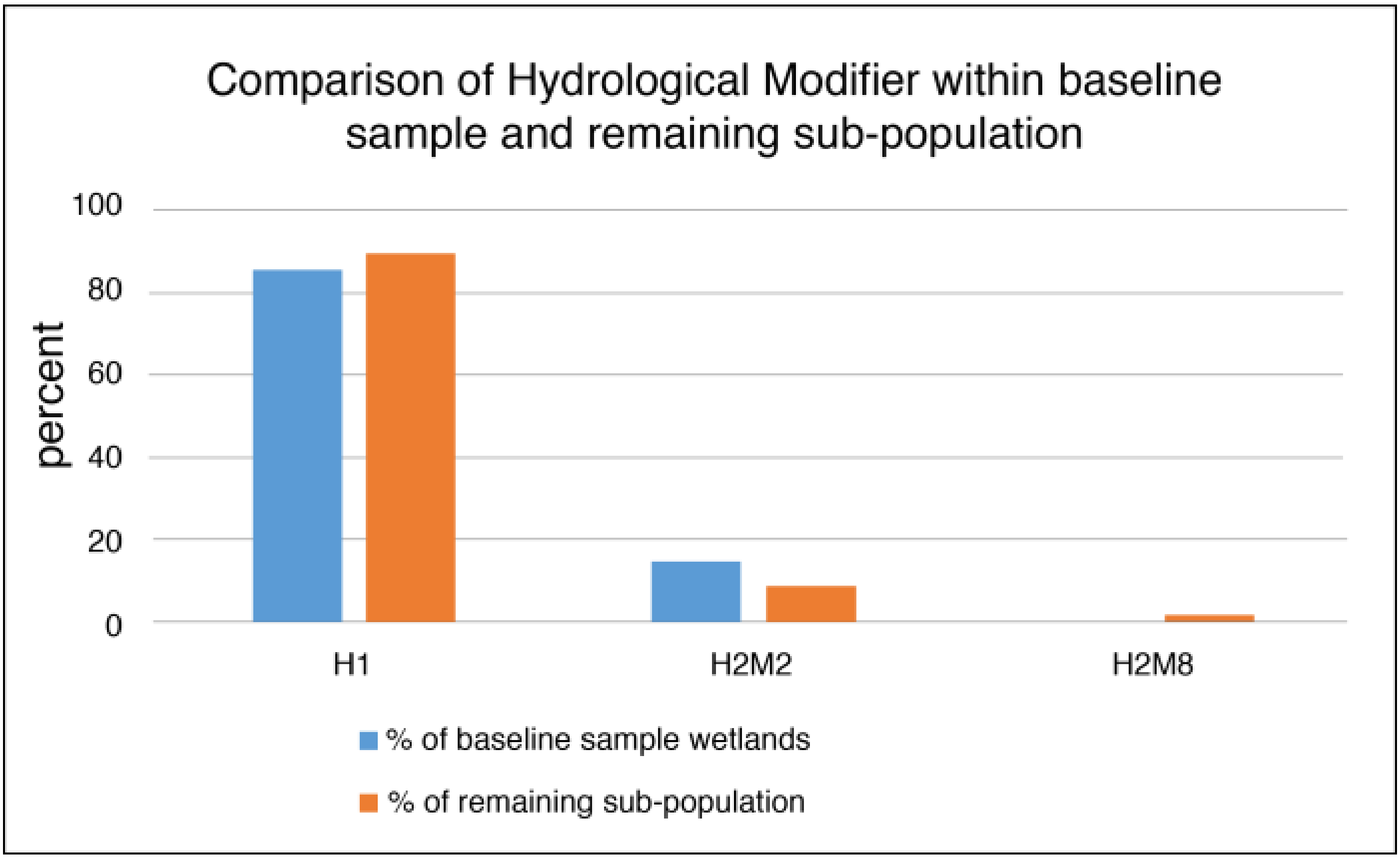

Figure 11: Representativeness of the 2015–16 baseline sample of Reef wetlands with respect to hydromodifier class

The state of wetland hydrology was assessed at the paddock scale to the wetland scale using indicators related to abstraction, additional water inputs, and physical barriers or drainage. While a wetland's hydrological state at this scale may appear to be very good, wetlands may be degraded by landscape scale alterations to hydrological processes which are difficult or impossible to assess *at the level of the individual wetland* with current levels of knowledge and research.

In this case, it would be possible to calibrate the WFAT–M hydrological state sub-index, moving the average state of the wetlands' hydrology towards the more disturbed end of the scale. This could compensate for the absence of wetland-level state indicators of landscape-scale degradation processes. However, any such change would need to be supported by empirical or modelled data, literature, and/or expert opinion that landscape-scale alterations to hydrology are ubiquitous across the Reef catchments, including in regions such as Cape York, which are relatively undisturbed.

It remains to be demonstrated whether or not the 'Very good' *average* state reported for wetland hydrology is an accurate reflection of the *average* sub-population condition across the whole Reef catchment. While the hydrology of wetlands in developed areas is known to be heavily impacted by human activity, most of the wetlands in our Reef-wide representative sample may indeed be in 'Very good' hydrological condition.

WFAT–M construct validity

As part of an ongoing internal review of the WFAT–M to inform the development of Version 2.0 in 2018, level 1 and level 3 data sets are being sought to test the tool's construct validity i.e. whether it measures what it purports to measure. One line of evidence, based on level 1 data that is both recent and Reef-wide, is the correlation between WFAT–M state scores and the magnitude of land-use hazard to wetlands, as assessed by the landscape hazard assessment (DSITI, 2015).

The correlation between WFAT–M overall pressure score and land-use hazard score was, in a sense, built in to the WFAT–M. Several of the pressure indicators were directly based on the relationships of particular types of land use to particular pressures on wetlands, as described in the landscape hazard assessment. On the other hand, the WFAT–M state indicators were adapted from other rapid assessment instruments or developed independently with expert advice not connected to the hazard assessment study.

In terms of the wetland monitoring program's Driver–Pressure–Impact–State–Response framework, pressure on wetland values is driven by land use. This conceptual link was operationalised in the land-use hazard assessment. The finding that WFAT–M overall pressure and state scores are highly correlated validates the conceptual link between WFAT–M pressure on wetland values and WFAT–M state of values (or condition). The correlation of land-use *hazard* to wetlands with the state of wetland values is an empirical link between two independent measures, both related to the level of disturbance to wetlands and with strong conceptual links to each other. This provides one valid line of evidence that the WFAT–M state index does indeed measure the condition of wetlands across a disturbance gradient i.e. it measures what it purports to measure.

Work is needed to find other lines of evidence to assess the construct validity of the WFAT–M; however, it is not necessary to benchmark the WFAT–M to independent indicators of wetland condition in order to measure changes and trends across time in pressure on wetland values and state of wetland values. What is needed is an instrument that (a) measures consistently across the range of possible pressures and states and (b) is capable of detecting the signal of anthropogenic disturbance within the considerable noise of natural wetland variability in space and time.

Baseline wetland condition and validation of the landscape hazard assessment for wetlands

As noted above, there is an empirical relationship between the state of wetland environmental values (i.e. wetland condition) as measured by the WFAT–M (a level 2 rapid assessment instrument), and the independently designed and conducted level 1 landscape-hazard assessment for wetlands. This relationship serves to validate the WFAT–M as a measure of disturbance to wetlands. It also offers some validation of the hazard assessment itself.

In effect, the correlation between the Reef-wide scores on both instruments is a triangulation on the variable that both sought to measure using very different methods but the same conceptual basis—anthropogenic disturbance to wetlands.

Power to detect change

By the end of 2018, 40 wetlands will have been assessed twice. This will allow us to measure the power of the WFAT–M to detect change between two times, at a level of sensitivity of ±1 point on the WFAT–M scale, with a sample of 40 wetlands.

What can be said about the power to detect change in 2017 when we have only the baseline data?

The 2014 pilot study measured the pressure on wetland values and the state of wetland values for 27 wetlands at a point in time. In order to estimate sample size, scenarios of likely and possible change between *two points in time* were generated. This exercise revealed that, for individual wetlands, incremental improvements or deteriorations were possible within one or two years, as were larger deteriorations (up to +4 points on the 13-point scale) due to 'catastrophic' events such as land clearing, development and drainage of wetlands. Large improvements were not likely to occur in such a short time.

The variance in overall *pressure* scores in the pilot study was 6.33, while the variance in overall *state* scores was 10.86. On the other hand, in the simulated scenarios of the difference of overall state between two points in time, the average variance was 3.88, while the most extreme variance was 5.29. A variance of 5.29 equates to a sample size of 42 (for a precision of ±1, power= .8, α= 05), while a variance of 3.88 equates to a sample size of 31. On this basis, a sample size of 40 was a conservatively high estimate of the number of

wetlands that would be needed to achieve the desired precision for a difference between two points in time. For 40 wetlands, the critical level of variance is 4.85.

In the 2015–16 baseline assessment, the variances of the wetland WFAT–M scores were 6.40 for overall pressure and 6.63 for overall state. Because the same wetlands are being assessed twice, a strong correlation between the scores at time 1 and the scores at time 2 is expected and a considerably lower variance for the difference between scores would also be expected. This was borne out in the pilot study simulations; the variance in overall state score for the wetlands in the pilot study was 10.86, whereas the average variance of the difference between two assessment times generated by the scenarios was just 3.88.

It is, therefore, likely that the measured variance for the difference between wetlands in 2016 and the same wetlands measured in 2018 will be less than the critical value of 4.85, meaning the desired precision will have been achieved with a random sample of 40 wetlands. This would allow us to say with reasonable confidence by the end of 2018 whether or not there has been any change in the average level of anthropogenic disturbance to freshwater floodplain wetlands across the Reef catchment between 2015–16 and 2018.

There is one factor of potential concern in this speculative analysis of the power of the WFAT–M to detect change with a sample of 40 wetlands. The scenarios of possible and likely change between two times used to calculate the required sample size may have underestimated error variance associated with the reliability of the WFAT–M. Should the variance of the difference between times exceed the threshold value of 4.85, contingencies are in place to (a) improve the precision of the instrument and/or (b) increase the baseline sample size to 60 wetlands.

Methods development and research

As discussed above, refinements to the WFAT–M will ensure greater precision as well as confidence that what is being reported is as accurate as possible. Further developments will include:

- adjusting the WFAT–M, especially the physical integrity sub-index, by recalibrating indicator scales for some field indicators and replacing non-functioning indicators
- further validation of the WFAT–M using multiple lines of evidence.

A project involving more intense sampling of wetlands to assess their condition in basins with high exposure to water quality and ecosystem pressures will help direct management resources and ensure progress towards the wetland target.

Also, there is a need to understand better the relationship between intensity of land use and willingness to allow access for wetland assessment.

- What more can we discover about the barriers to access?
- Does the relationship between land-use intensity and willingness to allow access to wetlands affect the likelihood that land managers will adopt best practice for wetland and whole-of-property management?
- Are there implications for the uptake of water quality improvement practices in agriculture?

While best practice guidelines are available for managing wetlands (see, for example, DEEDI, 2011), little is known about land managers' attitudes and perceptions related to the management of wetlands. Qualitative surveys would help establish better understanding of the barriers and pathways to reducing pressures on wetlands and improving their condition through best management practice.

Presently, there is no baseline assessment of land managers' knowledge and application of wetland management practices. Monitoring of Reef-wide management practices would complement the wetland extent and condition monitoring programs.

Finally, there are significant opportunities to apply the WFAT–M to wetland rehabilitation case studies, demonstrating both the versatility of the assessment tool and the results of locally and regionally important wetland management projects.

Conclusion

With the assessment of 41 randomly selected wetlands across the Reef catchment, a baseline has been established for the anthropogenic pressure on wetland environmental values and the state of wetland environmental values of natural floodplain wetlands in the Reef catchment. For the first time, it is possible to report on the 2013 Reef Plan wetland target:

> 'There is … an improvement in the ecological processes and environmental values, of natural wetlands'.

Addressing this target is a primary objective of the wetland monitoring program.

The 2015–16 baseline study used a purpose-made rapid assessment instrument, the Wetland Field Assessment Tool for Monitoring (WFAT–M). The capability of the WFAT–M to discriminate across the range of human disturbance to wetlands in the Reef catchment has been demonstrated. Using the logic of statistics it is also reasonable to speculate that the WFAT–M has the level of precision needed to detect a change, or lack of change, between two assessment times i.e. that a finding of 'no change' has an acceptable likelihood (>80%) of indicating that there really has been no change, rather than indicating a lack of precision in the measuring instrument. This level of precision will be empirically confirmed with a second round of assessments of the 41 wetlands, due to be completed by the end of 2018.

The baseline scores reported for pressure on wetland environmental values and state of wetland environmental values were weighted before being aggregated into average catchment-wide scores. This step in the analysis addressed a non-response bias in the sample. Most wetlands in the Reef catchment are on private property, so land manager permission must be sought to assess them. We found that land manager acceptance rates decreased as the intensity of land use surrounding the wetlands increased. For example, managers of land surrounded by intensive cropping were less likely to allow access than those whose wetlands were surrounded by conservation lands. Intermediate levels of land-use intensity were associated with intermediate levels of acceptance. Both corrected and uncorrected overall scores are presented in this report.

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Appendix 1. WFAT–M indicators

PRESSURE INDICATORS		
WEV 1 Biological health and diversity of the wetland's ecosystems		**Indicator type**
P1	**Land use associated with the introduction or perpetuation of pest species**	**Desktop (field verified)**
P2	**Modification of vegetation in the 200 m buffer (excluding mapped wetland)**	**Desktop**
P3	**Land use associated with pesticide residue inputs**	**Desktop**
P4	**Land use associated with nutrient inputs**	**Desktop**
P5	**Number of septic systems within 200 m of the wetland per ha of mapped wetland**	**Desktop (field verified)**
P7	**Plant pest cover in the mapped wetland**	**Field**
P8	**Plant pest cover in the 200 m buffer**	**Field**
P9	**Fishing (or other fauna taking) within the mapped wetland**	**Field**
WEV 2 The wetland's natural physical state and integrity		
P10	**Sediment supply (modelled, GBR)**	**Desktop**
P12	**Number of stormwater or other point inflows per hectare of wetland**	**Field**
P13	**Recreational use**	**Field**
WEV 3 The wetland's natural hydrological cycle		
P15	**Floodplain hydrology**	**Desktop**
P16	**Land use associated with changes to natural water flow patterns**	**Desktop**
P17	**Area under constructed water storages**	**Desktop**
P18	**QWP hydrological modifier code for the mapped wetland**	**Desktop (field verified)**
WEV 4 The natural interaction of the wetland with other ecosystems, including other wetlands		
P20	**Native vegetation cleared within 5 km of the wetland**	**Desktop**
P21	**Loss of wetland regional ecosystems within 5 km of the wetland**	**Desktop**

STATE INDICATORS		
WEV 1 Biological health and diversity of the wetland's ecosystems		
S1	**Floristic composition and vegetation structure**	**Field (sampling site)**
S2	**Disturbance to native plant cover by people, pests (plant or animal), or livestock**	**Field (sampling site)**
S3	**Exotic plant cover**	**Field (sampling site)**
WEV 2 The wetland's natural physical state and integrity		
S5	**Integrity and stability of the upper water body margin**	**Field (traverse)**
S6	**Naturalness of landform**	**Field (sampling site)**
S7	**Direct disturbance by humans, livestock or pigs physically impacting soil**	**Field (sampling site)**
S8	**Pugging by livestock and feral pests in the mapped wetland**	**Field (traverse)**
WEV 3 The wetland's natural hydrological cycle		
S9	**Drainage modifications and artificial structures altering natural surface water flow patterns**	**Field (traverse)**
S10	**Wetland water regime – wetland water source**	**Field (traverse)**
S11	**Wetland water regime – abstraction (water taken out for use)**	**Field (traverse)**
WEV 4 The natural interaction of the wetland with other ecosystems, including other wetlands		
S13	**Connectivity of the wetland within a landscape context**	**Desktop (traverse)**
S14	**Native vegetation in the wetland's 200 m buffer zone (excluding the mapped wetland)**	**Desktop (field verified)**

Catchment pollutant loads results

The catchment pollutant load targets in the Reef Water Quality Protection Plan 2013 (Reef Plan) are:

- At least a 50 per cent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas by 2018.
- At least a 20 percent reduction in anthropogenic end-of-catchment loads of sediment and particulate nutrients in priority areas by 2018.
- At least a 60 per cent reduction in end-of-catchment pesticide loads in priority areas by 2018.

The targets are based on the estimated load reductions that can be achieved through delivery of best management practice systems. The exception is the dissolved inorganic nitrogen target which remains ambitious and may not be achievable using current best practice alone.

The catchment load targets are reported as cumulative progress since 2009.

Figure 1: Scoring system

June 2016 Criteria	**Dissolved inorganic nitrogen** % reduction (Target 50% reduction)	**Sediment and particulate nutrients** % reduction (Target 20% reduction)	**Pesticides** % reduction (Target 60% reduction)
Very poor progress	<25	<11	<30
Poor progress	25–<30	11–<13	30–<36
Moderate progress	30–<35	13–<15	36–<42
Good progress	35–<40	15–<16	42–<48
Very good progress	≥40	≥16	≥48

Great Barrier Reef-wide

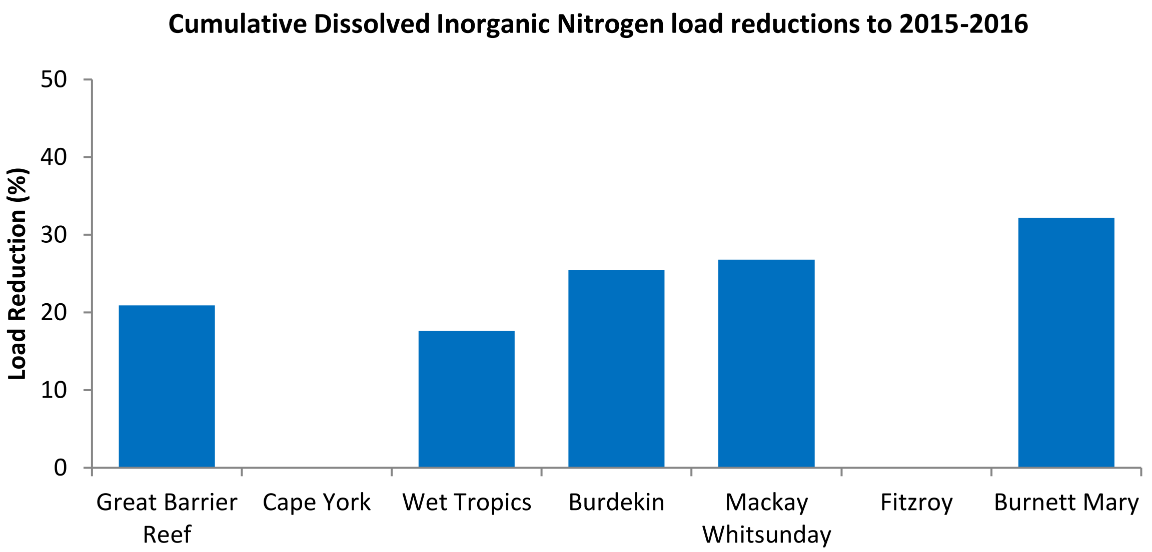
Catchment modelling has been used to estimate the long term annual load reductions due to the adoption of improved management practices. The model is run over a fixed climate period to account for climate variability.

Dissolved inorganic nitrogen

E
20.9%

Target: At least a 50 per cent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas by 2018.

Very poor progress: The estimated annual average dissolved inorganic nitrogen load leaving catchments had reduced by 20.9 per cent at June 2016. The greatest cumulative reduction (32.2 per cent) was in the Burnett Mary region. The greatest annual reduction was 5.5 per cent in the Burdekin region which has a cumulative total of 25.5 per cent. The reduction in the Burdekin is the result of less nitrogen fertiliser being applied following the adoption by cane growers of the Six Easy Steps nutrient management process.



Note: Dissolved inorganic nitrogen reductions are only modelled for regions where sugarcane is grown.

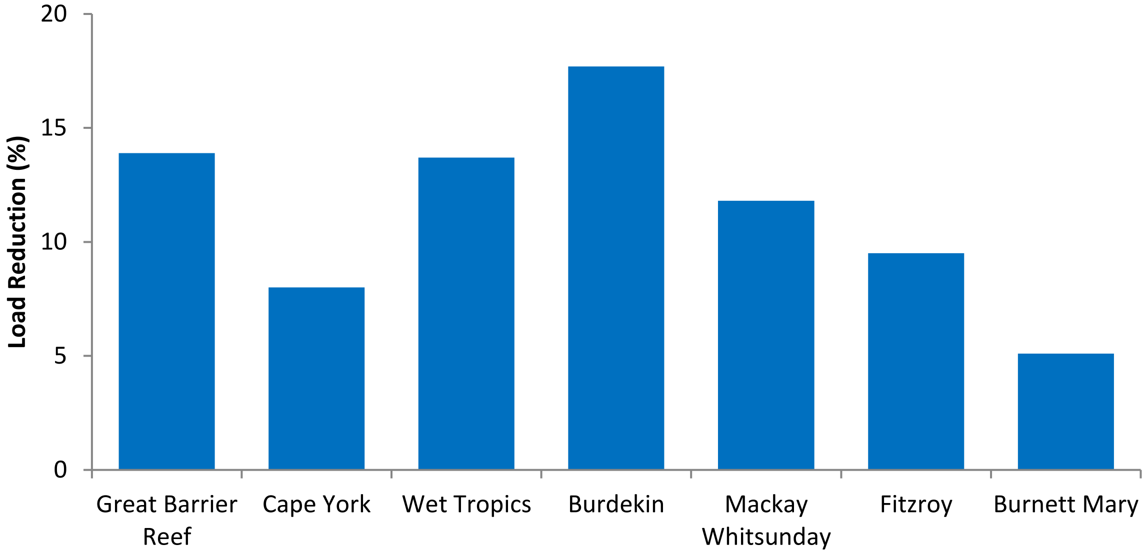
Sediment

C
13.9%

Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment and particulate nutrients in priority areas by 2018.

Moderate progress: The estimated average annual sediment load leaving catchments had reduced by 13.9 per cent at June 2016. The greatest cumulative reduction was from the Burdekin region with 17.7 per cent. The greatest annual reduction was from the Fitzroy region with 4.1 per cent, followed by Mackay Whitsunday at 2.7 per cent. The reduction in total suspended sediment (TSS) from the Fitzroy was predominantly due to the streambank protection projects (such as installation of riparian fencing and off-stream watering points). Most of these off-stream watering points were targeted in high priority locations to maximise load reductions.

Cumulative Total Suspended Sediment load reductions to 2015-2016



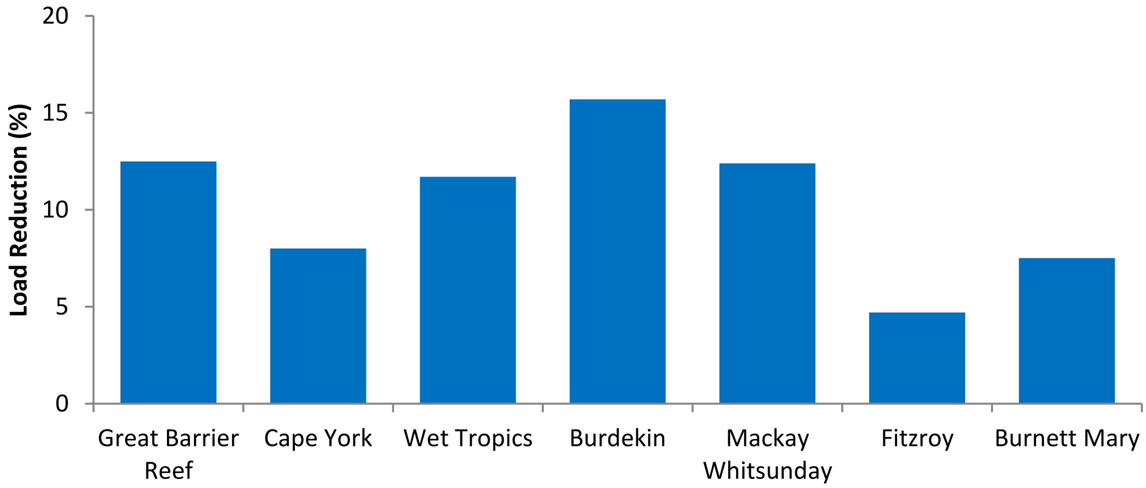
Particulate nitrogen

D
12.5%

Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment and particulate nutrients in priority areas by 2018.

Poor progress: The estimated average annual particulate nitrogen load leaving catchments had reduced by 12.5 per cent at June 2016. The greatest cumulative reduction (15.7 per cent) was in the Burdekin region, with less than 0.5 per cent reduction for the year. The greatest annual reduction was from the Fitzroy and Burnett Mary regions at 1.5 per cent each. The reduction in the Fitzroy was associated with the streambank protection projects referred to under Sediment above. For the Burnett Mary region, the reduction was due to management of hillslope erosion on grazing land, with the installation of land type and riparian fencing and additional water points allowing paddocks to be subdivided for better rotational grazing, improved ground cover and erosion control.

Cumulative Particulate Nitrogen load reductions to 2015-2016

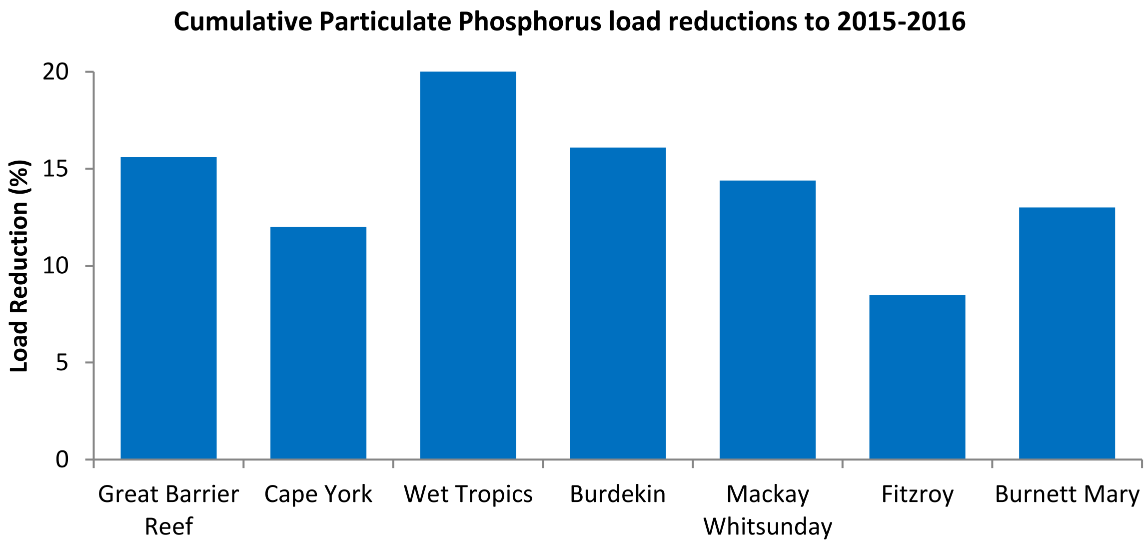


Particulate phosphorus

B
15.6%

Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment and particulate nutrients in priority areas by 2018.

Good progress: The estimated average annual particulate phosphorus load leaving catchments had reduced by 15.6 per cent at June 2016. The greatest cumulative reduction was from the Wet Tropics region (20.8 per cent). The greatest annual reduction was from the Fitzroy region at 1.8 per cent followed by Mackay Whitsunday at 1.3 per cent. The reduction in the Fitzroy was again associated with streambank protection projects referred to above.

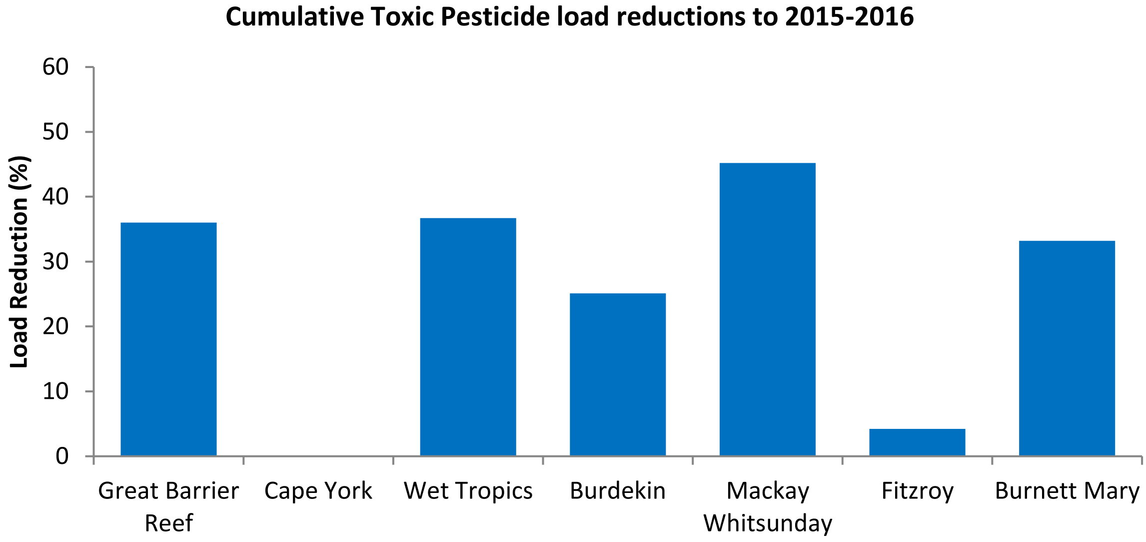


Pesticides

C
36%

Target: At least a 60 per cent reduction in end-of-catchment pesticide loads in priority areas by 2018.

Moderate progress: The estimated annual average toxic- equivalent pesticide load leaving catchments had reduced by 36 per cent at June 2016. The greatest cumulative reduction was the Mackay Whitsunday region with 45.2 per cent. The greatest annual reduction was from the Wet Tropics region (4.8 per cent), where the reduction was due to increased adoption of band spraying for residual herbicides, and decreased use of residual herbicides in ratoon cane crops.



Note: No pesticide management data is available for Cape York.

Cape York

Only a small number of projects were undertaken in the Cape York region in 2015–2016. As a result, all load reductions remain the same as last year. Load reductions are reported to only one decimal place.

Sediment

E
8%

Very poor progress: The estimated average annual sediment load leaving catchments remained at 8 per cent at June 2016. Hillslope erosion on grazing lands was targeted with fencing, construction and repair of whoa-boys to control erosion, and the installation of a new watering point to exclude livestock from streambanks and other degraded areas. Management change occurred on only 0.4% of the total grazing area in Cape York and did not change the cumulative sediment load leaving catchments.

Particulate nitrogen

E
8%

Very poor progress: The estimated average annual particulate nitrogen load leaving catchments remained at 8 per cent at June 2016.

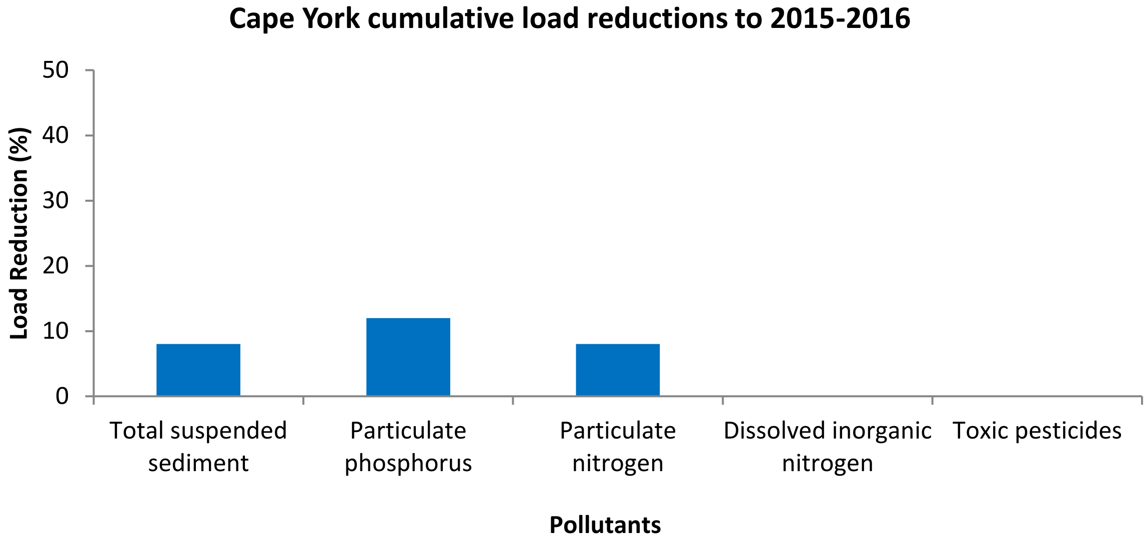
Particulate phosphorus

D
12%

Poor progress: The estimated average annual particulate phosphorus load leaving catchments remained at 12 per cent at June 2016.

Dissolved inorganic nitrogen

Dissolved inorganic nitrogen reductions are modelled only in regions with significant sugarcane areas and where investment in nitrogen reduction takes place.



Notes:

- Dissolved inorganic nitrogen reductions are modelled only in regions with significant sugarcane areas.
- No pesticide management data is available for Cape York.

Wet Tropics

Sediment

C
13.7%

Moderate progress: The estimated annual average total suspended sediment load leaving catchments had reduced to 13.7 per cent at June 2016, a reduction of 0.1 per cent for the year. This reduction was mainly from changes in sugarcane soil management, in the form of better controlled machinery traffic, less tillage during land preparation, and an increase in legume break-crops during cane fallows (creating more ground cover during the wet season).

Particulate nitrogen

D
11.7%

Poor progress: The estimated annual average particulate nitrogen load leaving catchments had reduced to 11.7 per cent at June 2016, a reduction of 0.1 per cent for the year. The reasons for the reduction are as for sediment management above.

Particulate phosphorus

A
20.8%

Very good progress: The estimated annual average particulate phosphorus load leaving catchments had reduced 20.8 per cent at June 2016, a reduction of 0.1 per cent for the year, and exceeding the target. The reasons for the reduction are as for sediment management above.

Dissolved inorganic nitrogen

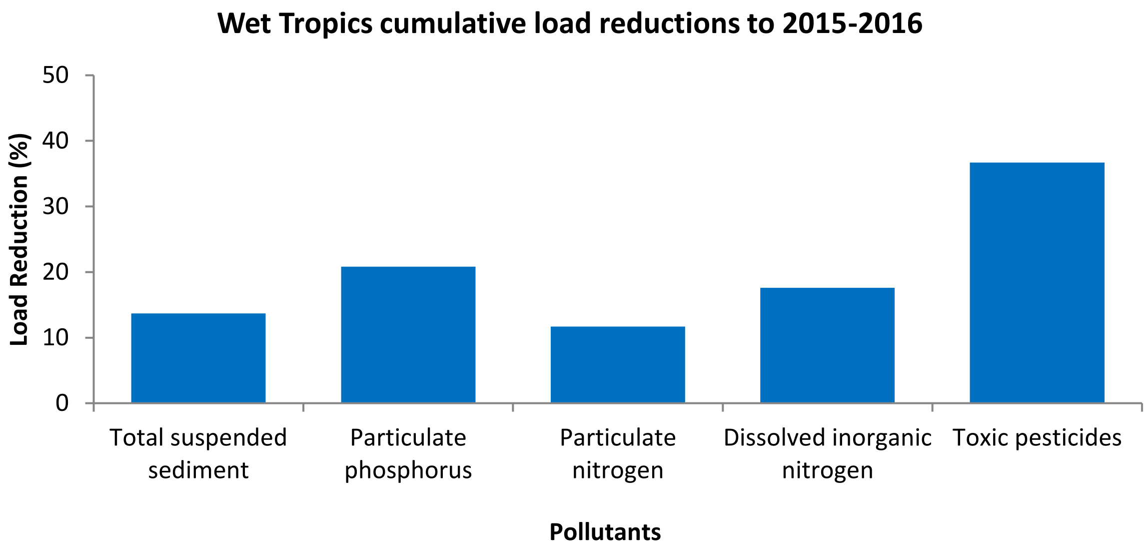
E
17.6%

Very poor progress: The estimated annual average dissolved inorganic nitrogen load leaving catchments had reduced to 17.6 per cent at June 2016, a reduction of 2.9 per cent for the year. This reduction was mainly from changes in sugarcane nutrient management where growers reduced nitrogen fertiliser application rates in accordance with the Six Easy Steps nutrient management process.

Pesticides

C
36.7%

Moderate progress: The estimated annual average toxic-equivalent pesticide load leaving catchments had reduced by 36.7 per cent at June 2016, a reduction of 4.8 per cent for the year. This reduction was solely from changes in sugarcane pesticide management through improved targeting of herbicide (band spraying residuals) and an overall reduction in the use of some residual herbicides.



Note: Land management changes in the horticulture (other than bananas) and dairy industries have not been modelled.

Burdekin

Sediment

A
17.7%

Very good progress: The estimated annual average total suspended sediment load leaving catchments had reduced to 17.7 per cent at June 2016, a reduction of 0.5 per cent for the year. This reduction was mainly from changes in grazing soil management, mostly from reducing hillslope erosion by use of forage budgeting to determine sustainable carrying capacity, and the adoption of rotational grazing and wet-season spelling.

Particulate nitrogen

B
15.7%

Good progress: The estimated annual average particulate nitrogen load leaving catchments had reduced by 15.7 per cent at June 2016, a reduction of 0.4 per cent for the year. The reasons for the reduction are as for sediment management above.

Particulate phosphorus

A
16.1%

Very good progress: The estimated annual average particulate phosphorus load leaving catchments had reduced by 16.1 per cent at June 2016, a reduction of 0.3 per cent for the year. The reasons for the reduction are as for sediment management above.

Dissolved inorganic nitrogen

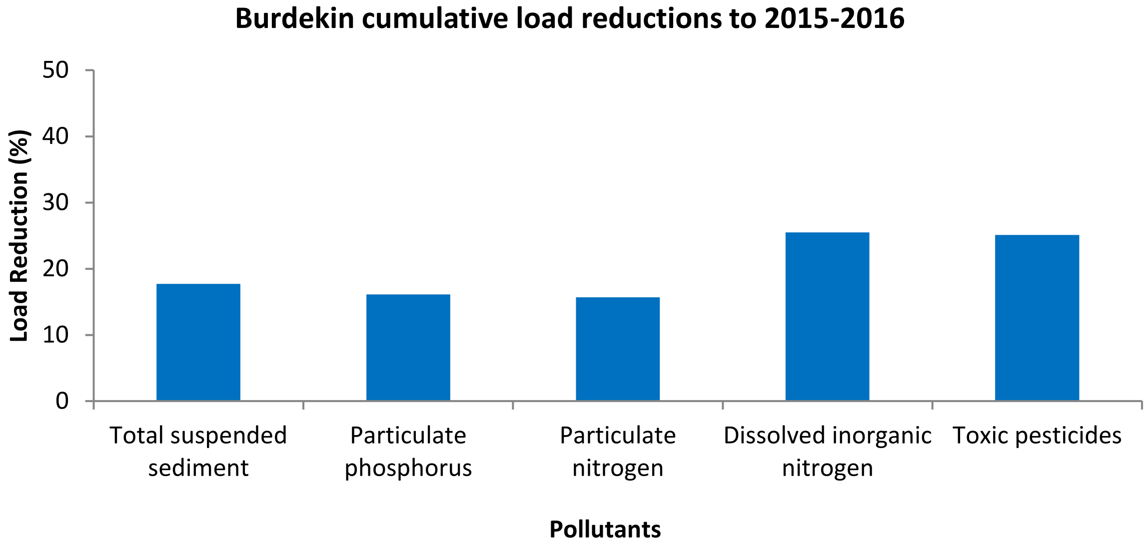
D
25.5%

Poor progress: The estimated annual average dissolved inorganic nitrogen load leaving catchments had reduced by 25.5 per cent at June 2016, a reduction of 5.5 per cent for the year. This reduction was from changes in sugarcane nutrient management where growers applied less nitrogen fertiliser through following the Six Easy Steps nutrient management process. Reported improvements in irrigation scheduling (3444 hectares) also contributed to the reductions in sediment, dissolved inorganic nitrogen and pesticide loads.

Pesticides

E
25.1%

Very poor progress: The estimated annual average toxic-equivalent pesticide load leaving catchments had reduced by 25.1 per cent at June 2016, a reduction of 1.5 per cent for the year. This reduction was from reported adoption of band spraying to apply residual herbicides in sugarcane.



Note: Land management changes in the horticulture industry have not been modelled.

Mackay Whitsunday

Sediment

D
11.8%

Poor progress: The estimated annual average total suspended sediment load leaving catchments had reduced by 11.8 per cent at June 2016, a reduction of 2.7 per cent for the year. This reduction was mainly from reported reductions in the degree of tillage on sugarcane farms.

Particulate nitrogen

D
12.4%

Poor progress: The estimated annual average particulate nitrogen load leaving catchments had reduced by 12.4 per cent at June 2016, a reduction of 1.3 per cent for the year. The reasons for the reduction are as for sediment management above.

Particulate phosphorus

C
14.4%

Moderate progress: The estimated annual average particulate phosphorus load leaving catchments had reduced by 14.4 per cent at June 2016, a reduction of 1.3 per cent for the year. The reasons for the reduction are as for sediment management above.

Dissolved inorganic nitrogen

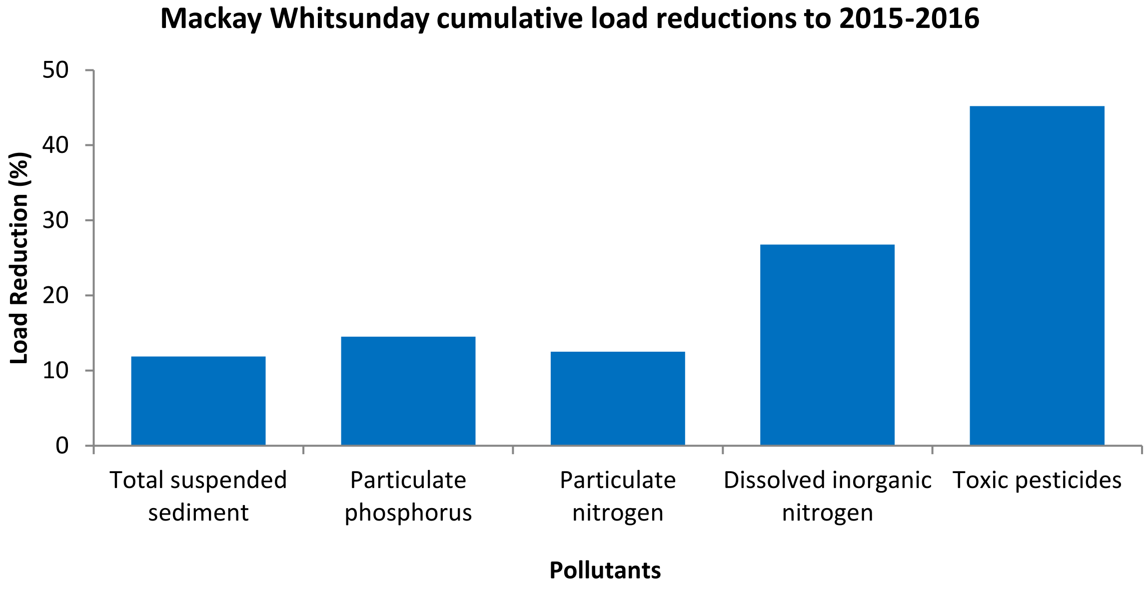
D
26.8%

Poor progress: The estimated annual average dissolved inorganic nitrogen load leaving catchments had reduced by 26.8 per cent at June 2016, a reduction of 1.7 per cent for the year. This reduction was from improvements in sugarcane nutrient management through adoption of the Six Easy Steps nutrient management process.

Pesticides

B
45.2%

Good progress: The estimated annual average toxic-equivalent pesticide load leaving catchments had reduced by 45.2 per cent at June 2016, a reduction of 1.2 per cent for the year. This reduction was from improvements in herbicide management in sugarcane farming, through practices that result in a reduction in the total volume of residual herbicide applied.



Note: Land management changes in the horticulture industry have not been modelled.

Fitzroy

Sediment

E
9.6%

Very poor progress: The estimated annual average total suspended sediment load leaving catchments had reduced by 9.6 per cent at June 2016, a reduction of 4.1 per cent for the year. This reduction was mainly from protection of streambanks through limiting cattle access to streams (via fencing and off-stream water points) in locations that deliver relatively large amounts of fine sediments to the Reef lagoon.

Particulate nitrogen

E
4.7%

Very poor progress: The estimated annual average particulate nitrogen load leaving catchments had reduced by 4.7 per cent at June 2016, a reduction of 1.5 per cent for the year. The reasons for the reduction are as for sediment management above.

Particulate phosphorus

E
8.5%

Very poor progress: The estimated annual average particulate phosphorus load leaving catchments had reduced to 8.5 per cent at June 2016, a reduction of 1.8 per cent for the year. The reasons for the reduction are as for sediment management above.

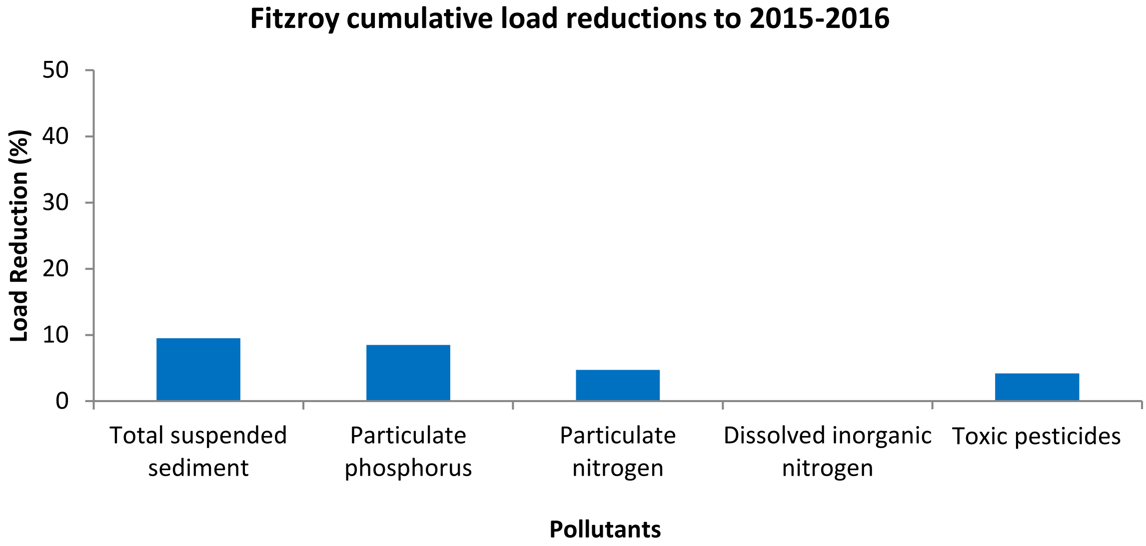
Dissolved inorganic nitrogen

Dissolved inorganic nitrogen reductions are modelled only in regions with significant sugarcane areas.

Pesticides

E
4.3%

Very poor progress: The estimated annual average toxic-equivalent pesticide load leaving catchments remained at 4.3 per cent at June 2016.



Notes:

- Dissolved inorganic nitrogen reductions are modelled only for regions with significant sugarcane areas.
- Land management changes in horticulture have not been modelled.

Burnett Mary

Sediment

E
5.1%

Very poor progress: The estimated annual average total suspended sediment load leaving catchments had reduced by 5.1 per cent at June 2016, a reduction of 2.1 per cent for the year. This reduction was mainly from changes in grazing land management, mostly through excluding cattle from gullies and streambanks with riparian fences and the establishment of watering points away from drainage lines to encourage revegetation and reduce erosion.

Particulate nitrogen

E
7.5%

Very poor progress: The estimated annual average particulate nitrogen load leaving catchments had reduced by 7.5 per cent at June 2016, a reduction of 1.5 per cent for the year. The reasons for the reduction are as for sediment management above.

Particulate phosphorus

C
13%

Moderate progress: The estimated annual average particulate phosphorus load leaving catchments had reduced by 13 per cent at June 2016, a reduction of 1 per cent for the year. The reasons for the reduction are as for sediment management above.

Dissolved inorganic nitrogen

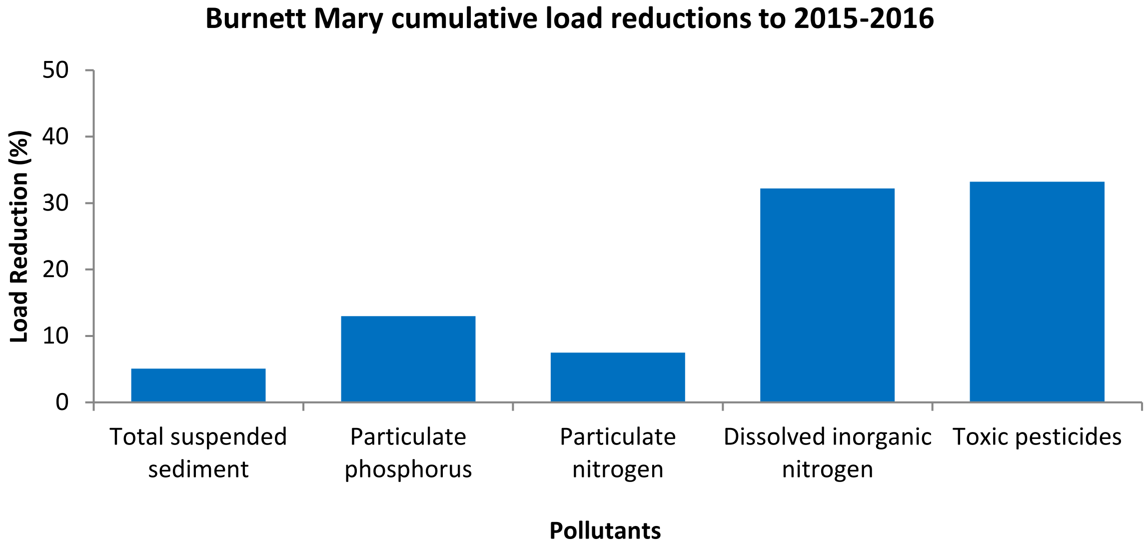
C
32.2%

Moderate progress: The estimated annual average dissolved inorganic nitrogen load leaving catchments had reduced by 32.2 per cent at June 2016, a reduction of 0.7 per cent for the year. This reduction was from changes in sugarcane nutrient management where nitrogen application rates were reduced following the adoption of the Six Easy Steps nutrient management process.

Pesticides

D
33.2%

Poor progress: The estimated annual average toxic-equivalent pesticide load leaving catchments had reduced by 33.2 per cent at June 2016, a reduction of 0.1 per cent for the year. This reduction was due to the adoption of practices which reduce the volume of residual herbicide applied in sugarcane.



Note: Land management changes in the horticulture industry have not been modelled.

Marine results

The Marine Monitoring Program target in the Reef Water Quality Protection Plan 2013 (Australian and Queensland governments, 2013) is to:

- Ensure that by 2020 the quality of water entering the Reef from broad-scale landuse has no detrimental impact on the health and resilience of the Great Barrier Reef.

The objective of the Marine Monitoring Program (Great Barrier Reef Marine Park Authority, 2016a) is to assess trends in ecosystem health and resilience indicators for the Great Barrier Reef in relation to water quality and its linkages to end-of-catchment loads.

The Reef Water Quality Protection Plan (Reef Plan) is now a key component of the Great Barrier Reef 2050 Long-term Sustainability Plan (Commonwealth of Australia, 2015), which provides the overarching framework for the integrated management of the Great Barrier Reef (the Reef) World Heritage Area and its catchments.

A range of pressures affect the health and resilience of the Reef at local and regional scales (Great Barrier Reef Marine Park Authority, 2014a). An ecosystem is considered healthy and resilient if it has the ability to resist a disturbance and recover quickly from any impact without a significant shift in its structure, function, identity and feedback processes (Walker and Meyers 2004; Costanza and Mageau 1999). The Reef ecosystem relies on the integrity of its physical, chemical and ecological processes (Figure 1) which are all interconnected, and the overall health of the ecosystem depends on these processes all functioning.

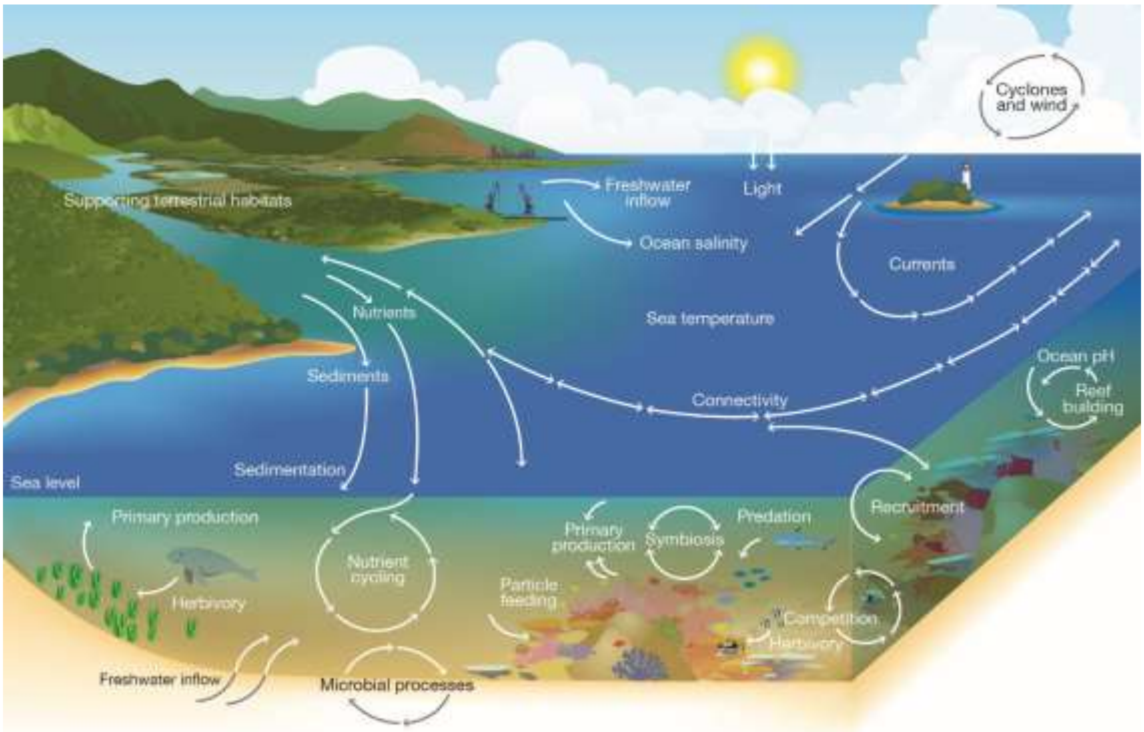


Figure 1: Major physical, chemical and ecological processes. The health of the Great Barrier Reef ecosystem is assessed by considering its physical, chemical and ecological processes as well as the condition of its supporting habitats. Outbreaks of pests and diseases are also considered as a guide to overall health. Reproduced from Outlook Report 2014 (Great Barrier Reef Marine Park Authority, 2014b).

The Marine Monitoring Program focuses on the Reef's inshore environment, which represents approximately eight per cent of the Marine Park and supports a unique variety of marine communities of high ecological relevance for the overall health of the Reef. This inshore environment is the area most used

by recreational visitors, tourism operators and some commercial fisheries (Great Barrier Reef Marine Park Authority, 2014a), and is also the area most vulnerable to land-based run-off (Great Barrier Reef Marine Park Authority, 2012). The program tracks the condition and trend of inshore seagrass and coral reefs, and synthesises and interprets information on the main pressures affecting the health and resilience of the Reef, such as poor water quality. This report summarises the information collected by the program and provides the basis for the Reef report card marine scores, both Reef-wide and at regional scales.

Pressures and impacts

Catchment run-off contains multiple pollutants (primarily nutrients, pesticides and sediment) that adversely affect the quality of water entering the Reef lagoon. The inshore area is highly influenced by land-based run-off, particularly during the wet season (through increased river discharge), with flow-on effects for ecosystem health (Álvarez-Romero et al., 2013; Schaffelke et al., 2017). Mid-shelf and off-shore areas, on the other hand, are less influenced by catchment run-off (except in extreme events), and water quality is generally good to very good (Schaffelke et al., 2017; Waterhouse et al., 2017a). The condition of the Reef is also strongly influenced by severe weather events, such as tropical cyclones and floods, which have affected all regions over the past decade.

Freshwater inflow

The 2015–16 wet season was declared an El Niño year. Rainfall and, therefore, freshwater discharge was below the long-term median for the Reef catchment, similar to 2014–15 (Figure 2) (Waterhouse et al., 2017b).

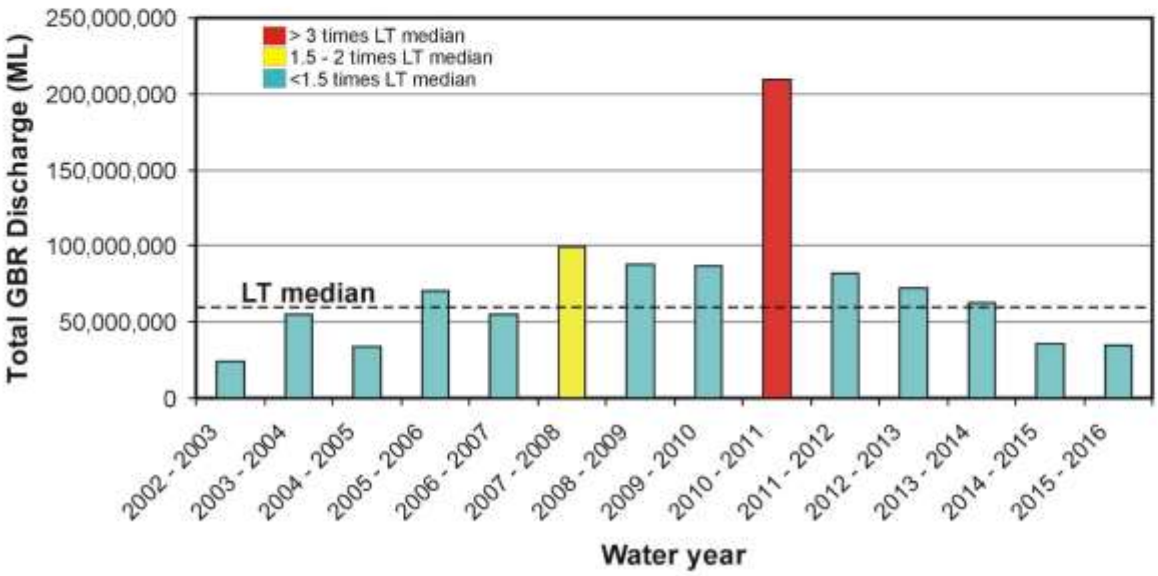


Figure 2: Annual combined discharge (megalitres) from major coastal rivers (35) into the Great Barrier Reef lagoon from 2002 to 2016 (water year: 1 October to 30 September). The long-term (LT) median is from 1986–87 to 2015–16 (Waterhouse et al., 2017b). Source: DNRM, http://watermonitoring.dnrm.qld.gov.au/host.htm

Nutrients, sediments and pesticides in catchment run-off

As a consequence of the below-median river discharge in 2015–16, sediment, nutrient and pesticide loads were comparatively low (Figure 3), and load profiles for each region were similar to 2014–15 (Reef Water Quality Protection Plan partners, 2016). In summary, monitored end-of-catchment loads of dissolved inorganic nitrogen were higher in the Wet Tropics compared to all other regions. Loads of total suspended solids (sediment) were highest in the Burdekin and Fitzroy regions, with the Fitzroy also having the highest loads of particulate nitrogen and phosphorus. Overall, toxic-equivalent loads of pesticides were higher in

the Wet Tropics and Mackay Whitsunday regions, where the dominant pesticide detected was diuron, compared to other regions.

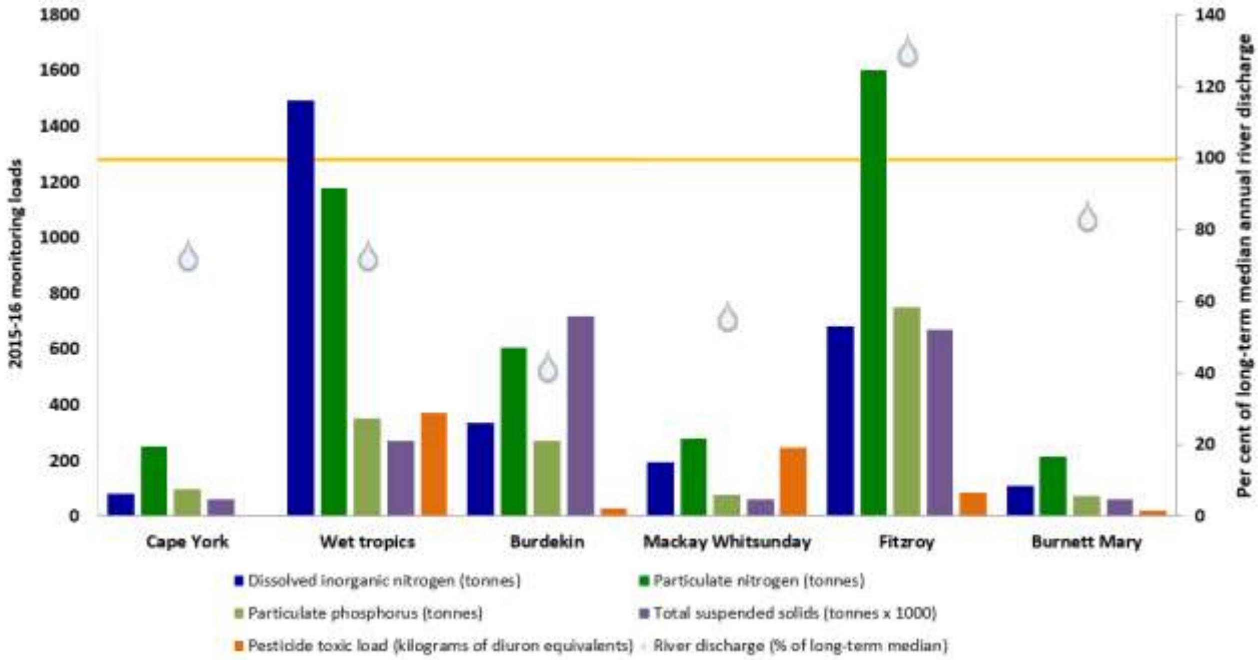


Figure 3: Annual pollutant loads and discharge from major rivers in each natural resource management (NRM) region (1 July 2015 to 30 June 16). Note: Pesticide loads are not monitored in Cape York. River discharge is presented as a percentage of the long-term (1986–2017) median (yellow line). Source: (Department of Science, Information Technology and Innovation 2016).

A large proportion of dissolved inorganic nitrogen and total suspended solids present in the Reef lagoon is of anthropogenic origin from land-based run-off (Brodie et al., 2012). However, it is recognised that there are also some areas where these concentrations may be naturally elevated (Waterhouse et al., 2017b). The areas with the greatest difference in sediment and nutrient discharge to the marine environment since development of the Reef catchment area, reflect patterns of current agricultural land use (Great Barrier Reef Marine Park Authority, 2012; Waterhouse et al., 2017a). To illustrate which marine areas are influenced by land-based anthropogenic pollutant loads, modelled pre-development loads of dissolved inorganic nitrogen and total suspended solids were compared to current load estimates (Figure 4 and Figure 5, respectively).

The analysis highlighted that, for the 2015–16 water year, the areas with the greatest estimated difference in dissolved inorganic nitrogen concentrations compared to pre-development were in the Wet Tropics region, and to a lesser extent in the Burdekin, Mackay Whitsunday, and Burnett Mary regions (Figure 4). For total suspended solids, the greatest estimated difference was in the Burdekin region and to a lesser extent in the Wet Tropics, Mackay Whitsunday and Burnett Mary regions (Figure 5).These results are consistent with the high priority catchments identified by the pollutant exposure assessment conducted for the 2017 Scientific Consensus Statement update (Waterhouse et al., 2017a).

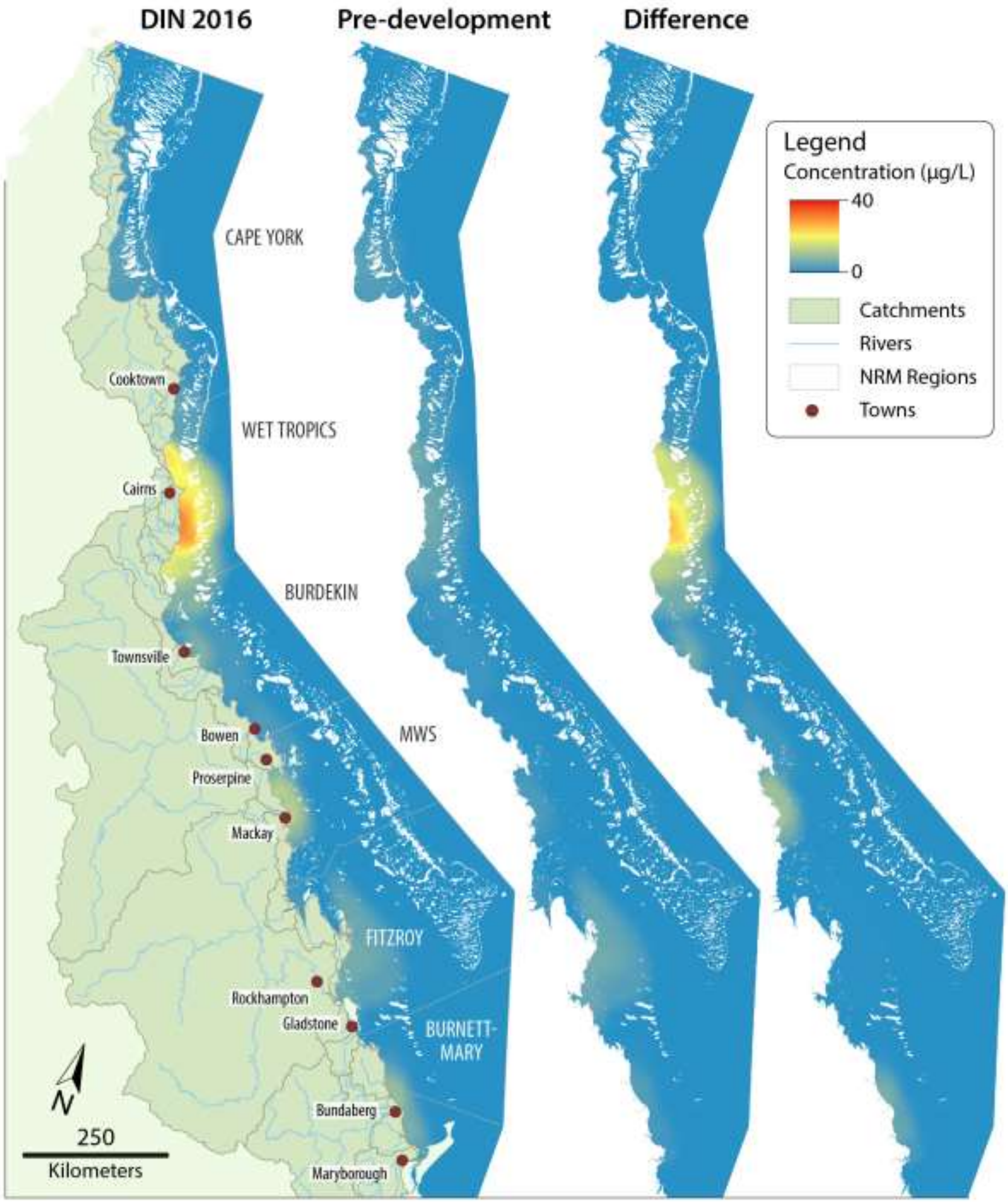


Figure 4: Dissolved inorganic nitrogen concentration (DIN, µg/L) modelled from catchment loads transported to the Great Barrier Reef lagoon for the 2015–16 water year (1 October to 30 September). From left to right, DIN concetrations were modelled from the total DIN load (left panel), estimated pre-development loads (centre panel), and the difference between the two (i.e. the anthropogenic load; right panel) (Waterhouse et al. 2017b). To illustrate the 2015–16 modelled DIN concentrations relative to previous years, the colour scale was generated from the modelled maximum DIN concentrations that occurred between 2003 and 2016.

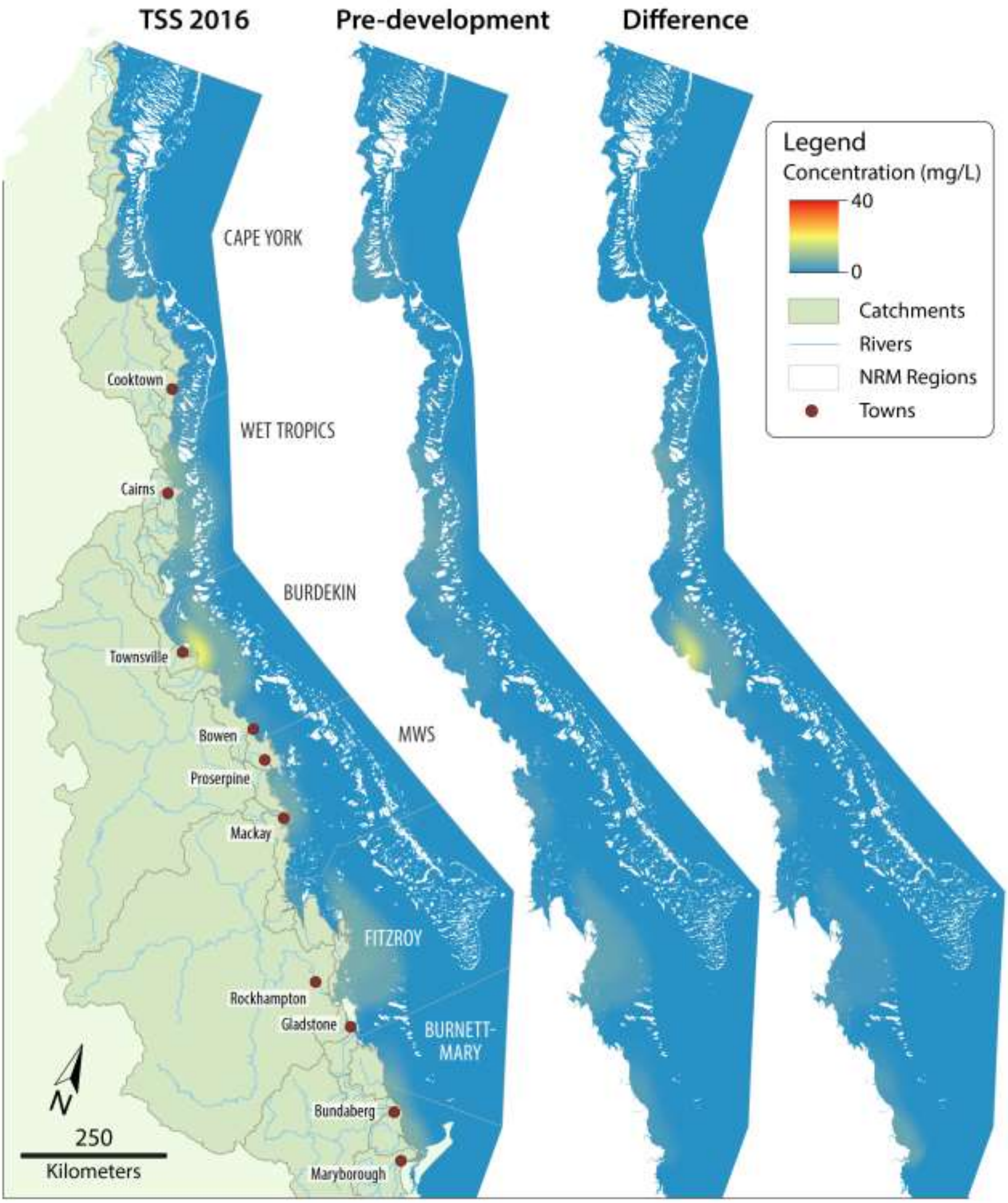


Figure 5: Total suspended solids (TSS, mg/L) modelled from catchment loads transported to the Great Barrier Reef lagoon for the 2015–16 water year (1 October to 30 September). From left to right, TSS concetrations were modelled from the total DIN load (left panel), estimated pre-development loads (centre panel), and the difference between the two (i.e. the anthropogenic load; right panel) (Waterhouse et al., 2017b). To illustrate the 2015–16 modelled TSS concentrations relative to previous years, the colour scale was generated from the modelled maximum TSS concentrations that occurred between 2003 and 2016.

In addition to the decline of marine water quality associated with terrestrial run-off from the adjacent catchments, Reef ecosystems have been severely impacted by a number of recent events, including the progression of the fourth wave (since the 1960s) of crown-of-thorns starfish population outbreaks; tropical cyclones; and prolonged periods of extreme sea-surface temperatures.

Crown-of-thorns starfish

Outbreaks of the coral-eating crown-of-thorns starfish are one of the main direct causes of the decline in coral cover Reef-wide (Osborne et al., 2011). Most outbreaks occur on mid-shelf reefs, beginning along the narrow northern shelf between Cairns and Lizard Island (the 'initiation zone') and then moving to southern reefs as larvae are transported by the East Australian Current. Scientific models indicate that outbreaks are likely to be linked to elevated nutrient levels in lagoon waters serviced by rivers in the Wet Tropics (Furnas et al., 2013; Fabricius et al., 2010; Schaffelke et al., 2017). An active outbreak of crown-of-thorns starfish occurs when the starfish consume coral tissue faster than corals can grow. This is generally estimated to be more than 15 starfish per hectare when coral cover is moderate to high (Moran and De'ath 1992).

In 2015–16, outbreaks of crown-of-thorns starfish were recorded at six per cent of reefs monitored by the Long-term (Reef) Monitoring Program (Australian Institute of Marine Science, 2017) (Figure 6). The current outbreak mostly occurs in the northern part of the Reef, but has recently extended south to Innisfail, on both inshore and mid-shelf reefs (Thompson et al., 2017). In general, crown-of-thorns starfish are not prevalent on inshore reefs; however, Marine Monitoring Program surveys in 2015–16 found an elevated number in the Barron, Daintree, Johnstone and Mulgrave-Russell sub-regions, mirroring the larger populations offshore (Thompson et al., 2017). The proportion of surveyed reefs with outbreaks of crown-of-thorns starfish was less in 2015–16 than the previous year (Figure 6) and the density of crown-of-thorns starfish found on these reefs was lower than the previous year (Figure 7). The proportion of surveyed reefs with outbreaks may appear lower because coral cover on some reefs has been reduced to very low levels, or because the timing of surveys coincided with remedial action undertaken as part of the Australian Government crown-of-thorns starfish management program.

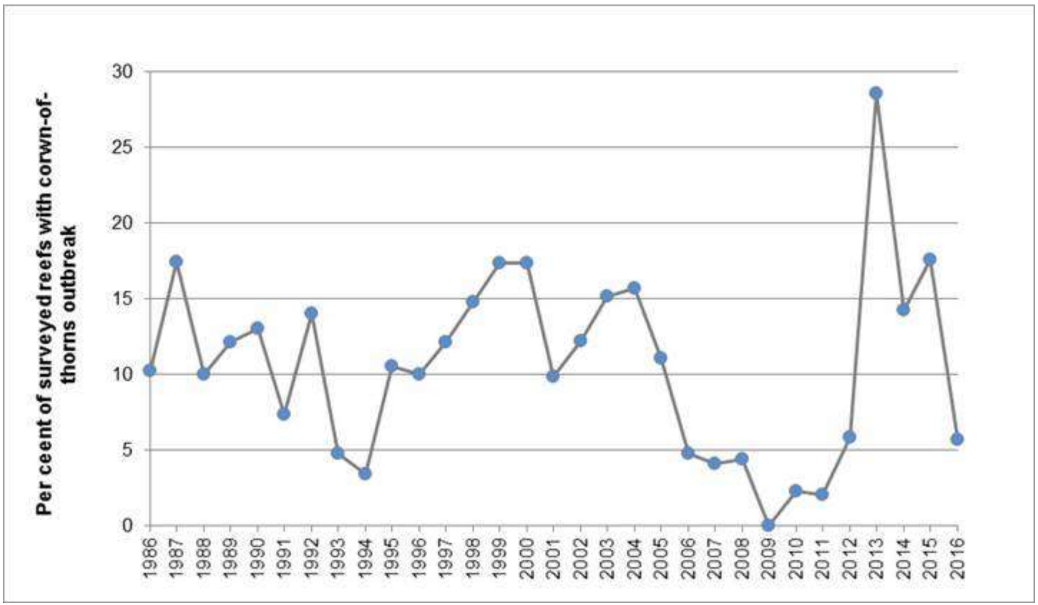


Figure 6: Proportion of surveyed reefs in the Great Barrier Reef with observed outbreaks of crown-of-thorns starfish from 1986 to 2016. Note that the same reefs are not necessarily surveyed every year and some of the outbreaks overlap in time. Source: Australian Institute of Marine Science Long-term Monitoring Program (http://data.aims.gov.au/waCOTSPage/cotspage.jsp).

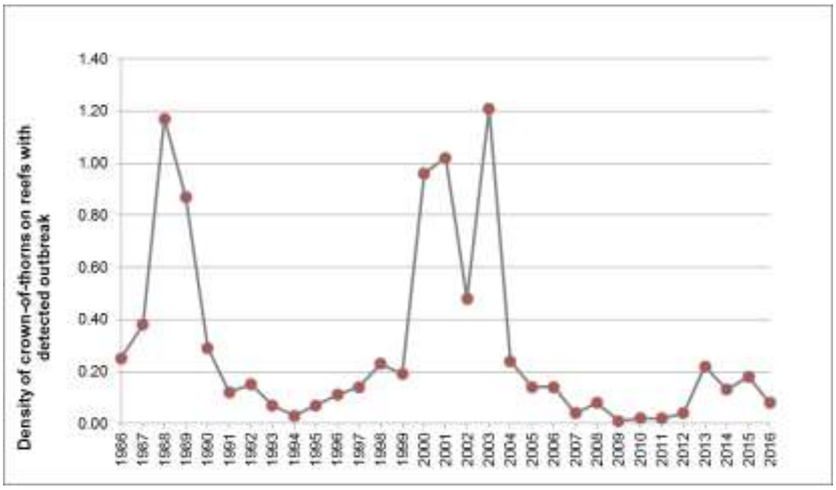


Figure 7: Density of crown-of-thorns outbreaks on reefs with detected outbreaks in the Great Barrier Reef from 1986 to 2016. Density is the number of crown-of-thorns per two-minute manta tow. Note that the same reefs are not necessarily surveyed every year and some of the outbreaks overlap in time. Source: Australian Institute of Marine Science Long-term Monitoring Program (http://data.aims.gov.au/waCOTSPage/cotspage.jsp).

Cyclones

Cyclone damage is one of several factors contributing to major losses of coral and seagrass across the Reef (De'ath et al. 2012; Thompson et al. 2017; McKenzie et al. 2017). All of the Category 5 cyclones that have affected the Reef since 1970 have occurred in the last decade, including Larry (2006), Hamish (2009), Yasi (2011), Ita (2014) and Marcia (2015) (Bureau of Meteorology, 2016; Waterhouse et al., 2017b). The combined paths of severe cyclones since 2005 have exposed more than 80 per cent of the region to gale-force or stronger winds (Figure 9).

During 2015–16, no cyclones affected the Reef (Figure 8), allowing coral and seagrass communities time to recover from the severe weather events of previous years (especially 2007–12). Recovery is still in its early stages—the legacy of impacts from severe tropical cyclones on the Reef may last for decades, and can take many years for diverse seagrass and coral communities to re-establish (Thompson et al., 2017; Mumby et al., 2011; McKenzie et al., 2017).

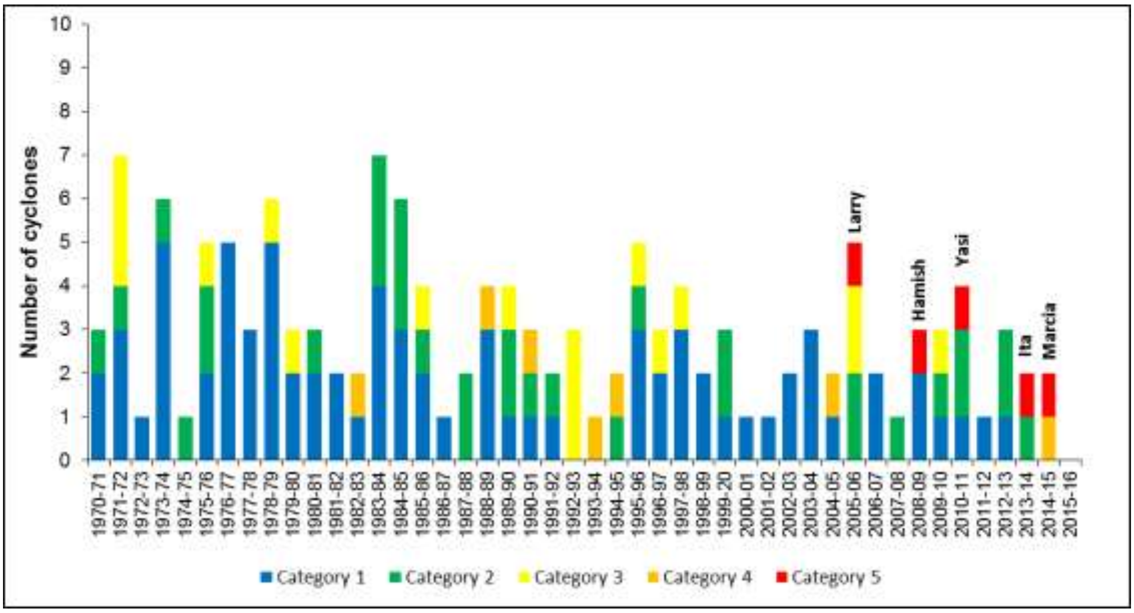


Figure 8: Number and severity of cyclones that have affected the Great Barrier Reef, 1970–2016. Source: (Bureau of Meteorology 2016).

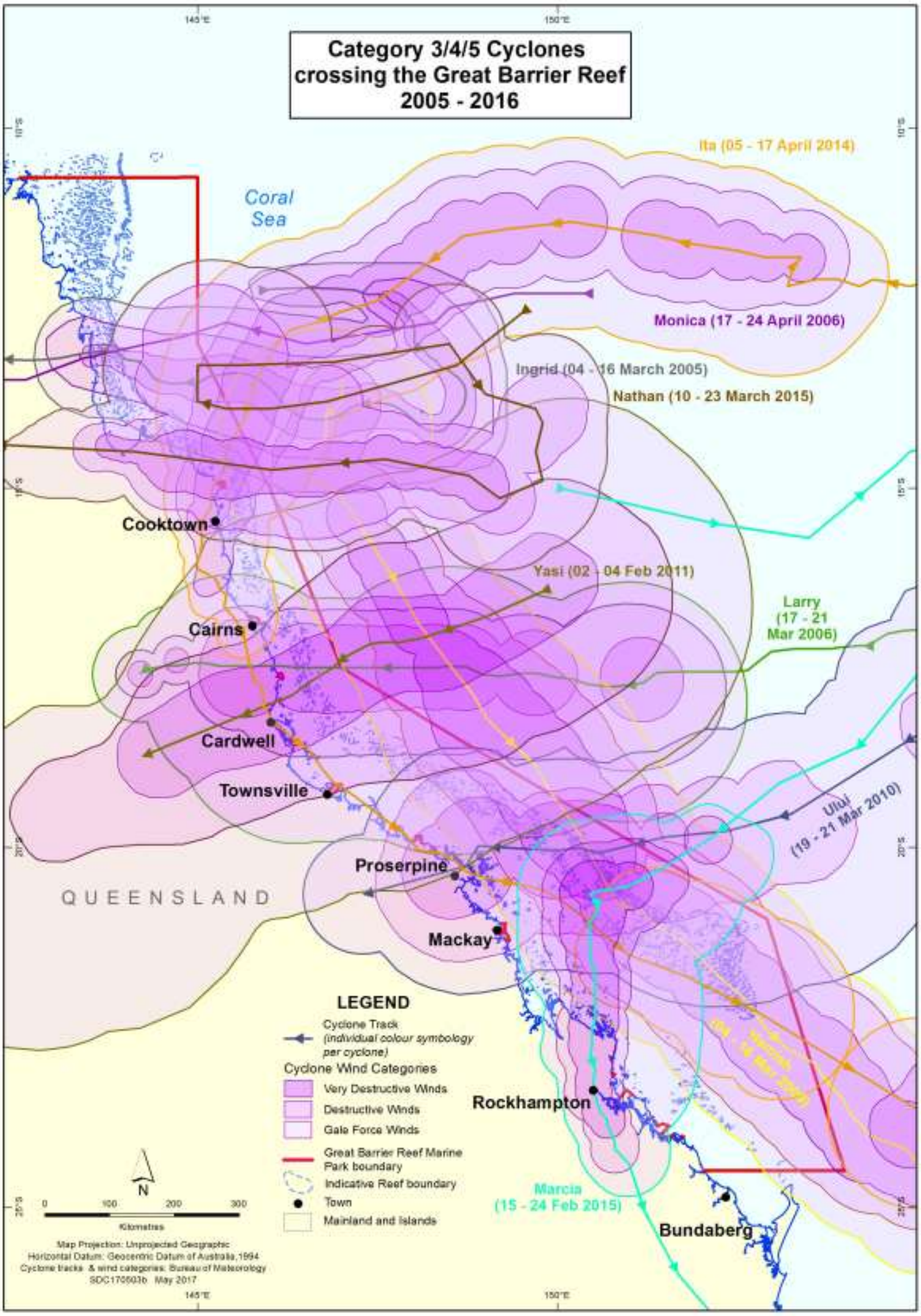


Figure 9: Cyclonic winds associated with category 3, 4 and 5 cyclones, 2005–16. Source: (Bureau of Meteorology 2016).

Elevated sea temperatures

Rising sea-surface temperature is one of the greatest threats to the survival of corals on the Reef (Hoegh-Guldberg et al., 2007, Great Barrier Reef Marine Park Authority, 2014a). In 2016, sea-surface temperatures were the highest since records began in 1900 (Great Barrier Reef Marine Park Authority, 2016b). Coral bleaching commonly occurs when the accumulated temperature stress—measured as the number of 'degree heating days' over the summer months—exceeds a threshold of about 60 to 100 degree heating days (Maynard, 2010).

By the end of March 2016, most of the Reef had accumulated between 60 and 80 degree heating days (Figure 10), which triggered the worst mass coral bleaching event ever recorded on the Reef (Figure 11) (Great Barrier Reef Marine Park Authority, 2017). Northern areas of the Reef were the most heat-stressed, with mid-shelf and outer-shelf areas accumulating up to 90 degree heating days and the inshore area in the far north accumulating up to 110 degree heating days (Figure 10).

Coral bleaching

High temperatures combined with an El Niño year triggered the worst coral bleaching event on record in 2016. An estimated 29 per cent of shallow-water coral was lost across the Marine Park (Figure 11) (Great Barrier Reef Marine Park, Authority 2017). The impacts of coral bleaching were highly variable across the Reef, with severity decreasing from north to south:

- The northern region of the Marine Park (Cape York to Port Douglas) was the area most affected by severe bleaching and subsequent loss of coral. However, in comparison, reefs offshore from Cape York to Stanley Island were not as severely affected and coral bleaching was variable (Hughes et al., 2017, Great Barrier Reef Marine Park Authority 2017).
- In the central areas of the Marine Park south of Port Douglas to Mackay, the loss of coral was highly variable and ranged from low to medium (Hughes et al., 2017; Thompson et al., 2017; Great Barrier Reef Marine Park Authority, 2017).
- The southern areas of the Marine Park (Mackay to Bundaberg) had little or no loss of coral (Hughes et al., 2017; Thompson et al., 2017; Great Barrier Reef Marine Park Authority, 2017).
- At inshore reefs south of Snapper Island, coral bleaching was patchy and large sections of the inshore showed only minor impacts (Thompson et al., 2017; Great Barrier Reef Marine Park Authority, 2017).

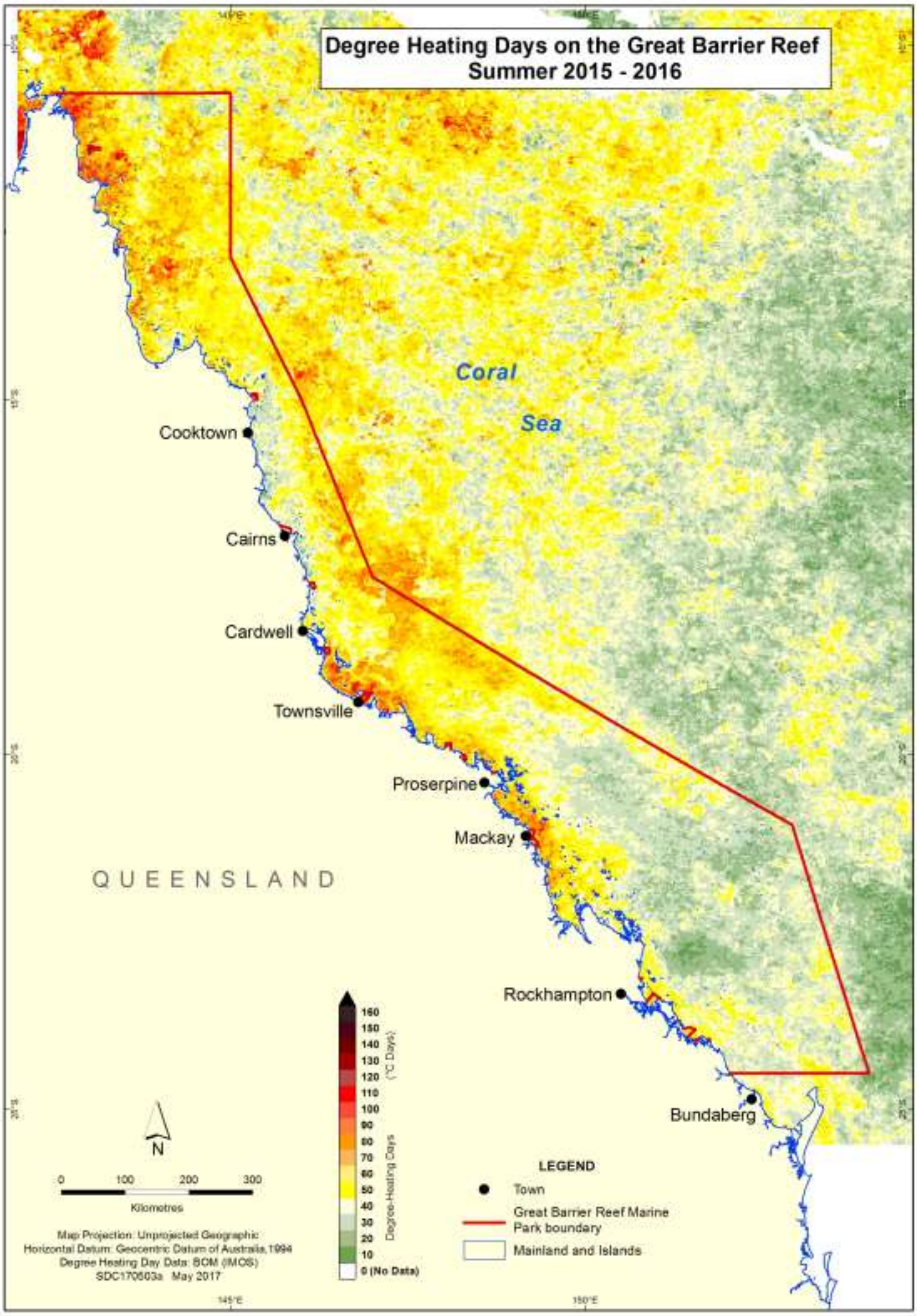


Figure 10: Water temperature, measured as the number of 'degree heating days' occurring in 2015–16 (Bureau of Meteorology 2017).

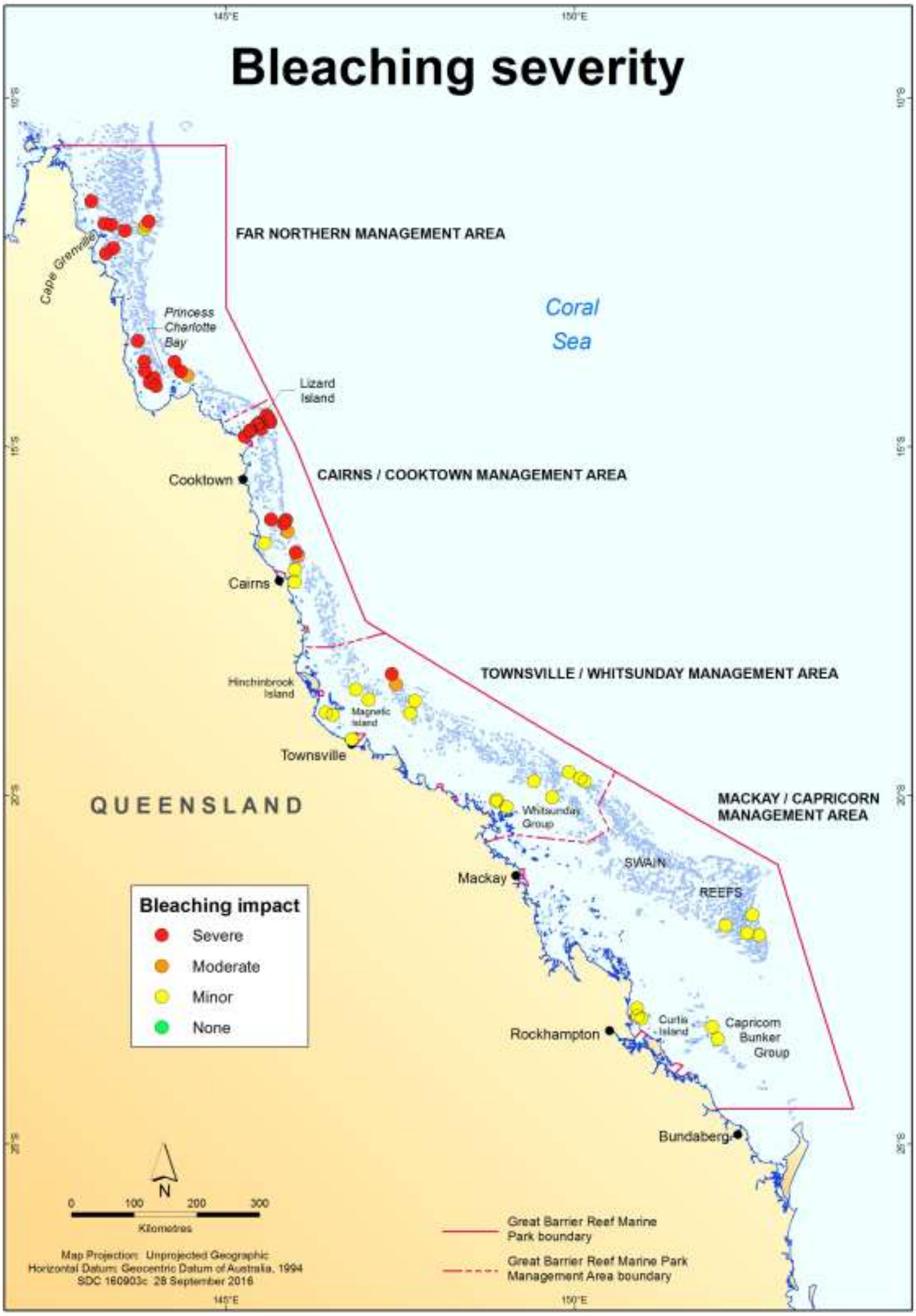


Figure 11: Areas of the Reef where coral bleaching occurred in 2015–16. The mortality level is indicated by the coloured circles.

Outlook for the Great Barrier Reef

Climate change is recognised as the most serious threat to the Reef (Great Barrier Reef Marine Park, Authority 2014b). Climate-change-related threats include increased sea-surface temperature, altered ocean currents, increased severity of tropical storms, increased run-off from adjacent catchments, ocean acidification and rising sea level. Potential consequences for species, habitats and ecosystems include mass coral mortality, declining growth rates of coral, increased frequency of crown-of-thorns outbreaks, and losses of key habitats and ecosystems (De'ath et al., 2012). The effects, both individually and combined, are likely to have far-reaching consequences for the region's ecosystem and its Outstanding Universal Value as a World Heritage Area (De'ath et al., 2012; Poloczanska et al., 2012; Bustamante et al., 2012; Lough et al., 2012; Jones and Berkelmans, 2014).

These concerns are reiterated in the 2017 Scientific Consensus Statement (Waterhouse et al., 2017a) which concluded that:

> Key Great Barrier Reef ecosystems continue to be in poor condition. This is largely due to the collective impact of land run-off associated with past and ongoing catchment development, coastal development activities, extreme weather events and climate change impacts such as the recent coral bleaching events.

Inshore seagrass meadows and coral reefs are continuing to recover from previous losses sustained during major floods and cyclones, but remain in moderate to poor condition overall (McKenzie et al., 2017; Thompson et al., 2017). Continuing recovery of inshore communities during the recent period of low rainfall and run-off (see Results) demonstrates the capacity of these communities to recover from acute disturbances and supports the ongoing efforts to reduce anthropogenic pollutant loads delivered to the Reef. In the past, mid-shelf and outer-shelf reefs in the southern half of the Reef have also shown a capacity to rapidly recover from disturbances (Great Barrier Reef Marine Park Authority, 2014a).

Resilient coral and seagrass communities can have high rates of recruitment and growth, which compensate for the losses resulting from acute disturbances, such as cyclones. However, ongoing chronic pressures—such as poor water quality—can decrease the resilience of coral and seagrass in the Reef by slowing or inhibiting their rates of recovery (Roff et al., 2013; McKenzie et al., 2012; Osborne et al., 2011; Meager and Limpus 2014; Jones and Berkelmans 2014; Folke et al., 2004). Therefore, there is a strong imperative to improve water quality in the Reef, especially given the recent bleaching event, which caused significant coral mortality, especially north of Port Douglas.

Results

Overall condition of the inshore marine area

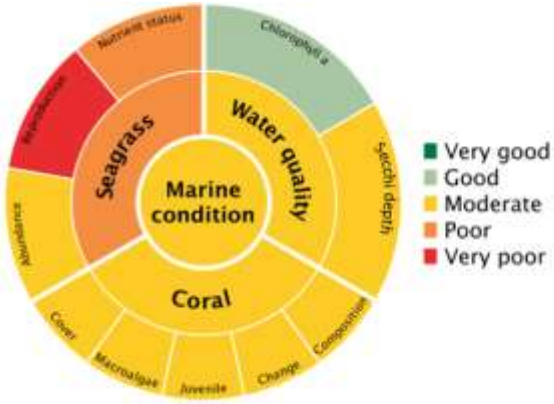


Figure 12: Overall condition of the inshore marine environment for water quality, seagrass and coral in 2015–16. Note: Corals are assessed only in the Wet Tropics, Burdekin, Mackay Whitsunday and Fitzroy regions.

In 2015–16, the overall condition of the Reef's inshore marine environment was moderate (Figure 12).

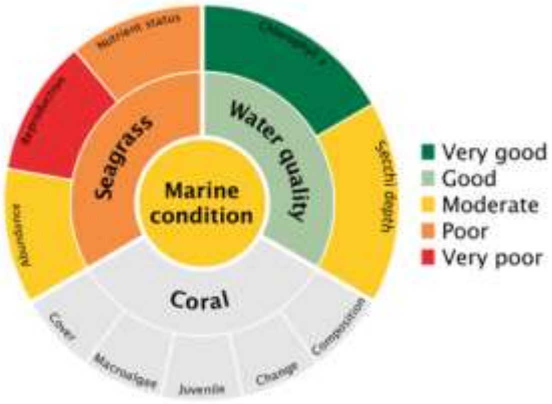
Inshore water quality for the Reef was also moderate (Figure 15).

Inshore seagrass meadows showed slight improvements in condition, but remained in poor condition overall. Indicator scores for seagrass abundance improved in 2015–16 compared to the previous year, but remained in moderate condition. Reproductive effort remained very poor and nutrient status remained in poor condition.

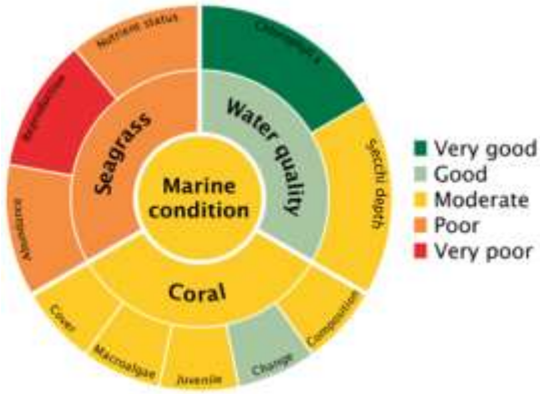
Inshore coral reefs remained in moderate condition overall, despite the 2016 bleaching event. Coral condition has continued to improve since 2011–12 when it was in its worst condition following repeated cyclones and storms. Coral cover, macroalgae cover and juvenile density remained in moderate condition. Coral change and community composition increased from poor to moderate condition.

Regional highlights

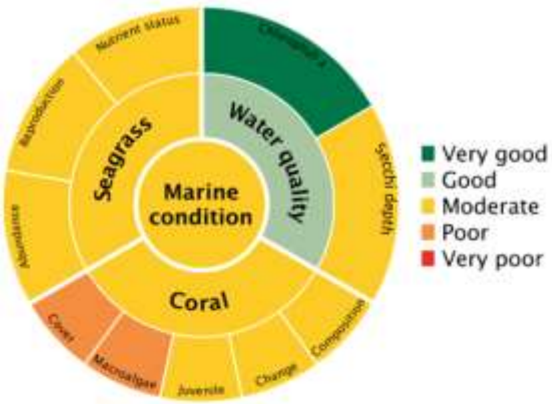
- The inshore marine environment was in moderate condition in all regions except the Fitzroy, where it was in poor condition (Figure 13).
- Sea-surface temperatures were above average along the Reef in 2015–16, but rainfall and discharge were below the long-term average and there were no cyclones.
- Inshore marine water quality was good in Cape York, good in the Wet Tropics, Burdekin and Burnett Mary, and moderate in the Mackay Whitsunday and Fitzroy regions (Figure 15).
- Regionally, the condition of seagrass and coral remained relatively stable in 2015–16 compared to 2014–15. Highlights include improvements in coral condition in the Burdekin (poor to moderate) and Mackay Whitsunday (moderate to good). The condition of seagrass meadows improved from very poor to poor in the Fitzroy region.
- There is no coral monitoring in the inshore waters of Cape York and Burnett Mary region (grey shading) (Figure 13).



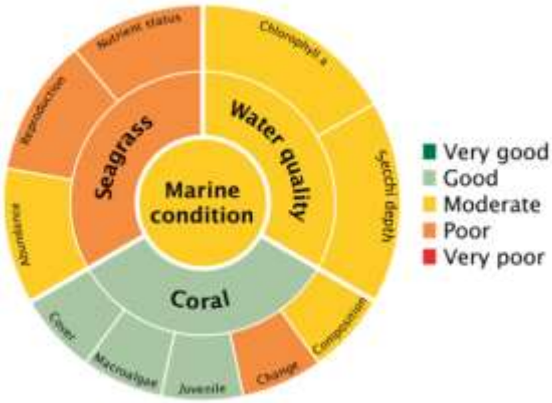
Cape York



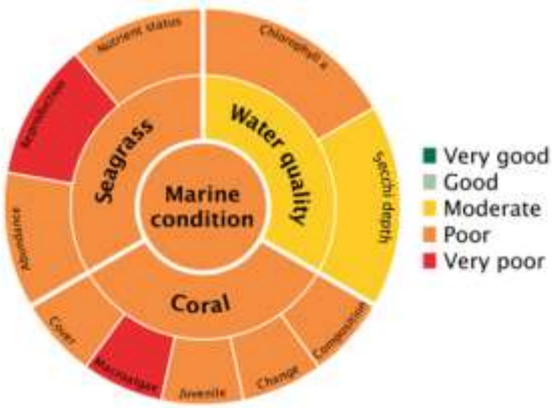
Wet Tropics



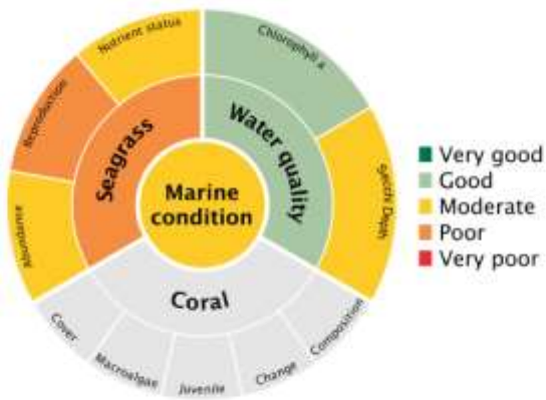
Burdekin



Mackay Whitsunday



Fitzroy



Burnett Mary

Figure 13. Overall condition of the marine environment of the six natural resource management regions for water quality, seagrass and coral in 2015–16. Grey shading indicates that no monitoring occurred.

Trends in the overall condition of the inshore marine environment

The Reef's inshore marine environment has declined markedly from its pre-development condition, especially in inshore areas adjacent to the developed coast (Great Barrier Reef Marine Park Authority, 2014a).

- Reduced pollutant loads, as a result of below average river discharge for the last two years, gave the Reef a chance to recover from the impact of earlier severe weather events such as Tropical Cyclone Yasi in 2011–12.
- The regional differences in condition reflect historical exposure to acute environmental disturbances such as cyclones, as well as differences in long-term cumulative pressures, for example from adjacent land development and marine activities.
- The consistently poor score for the Fitzroy reflects the cumulative effects of multiple severe disturbances since 2006, including major (and in some cases record) floods; cyclones; high levels of macroalgae; bleaching;and outbreaks of coral disease. The small increase in the score for the overall marine condition in 2015–16 represents the first signs of recovery of seagrass and coral communites.

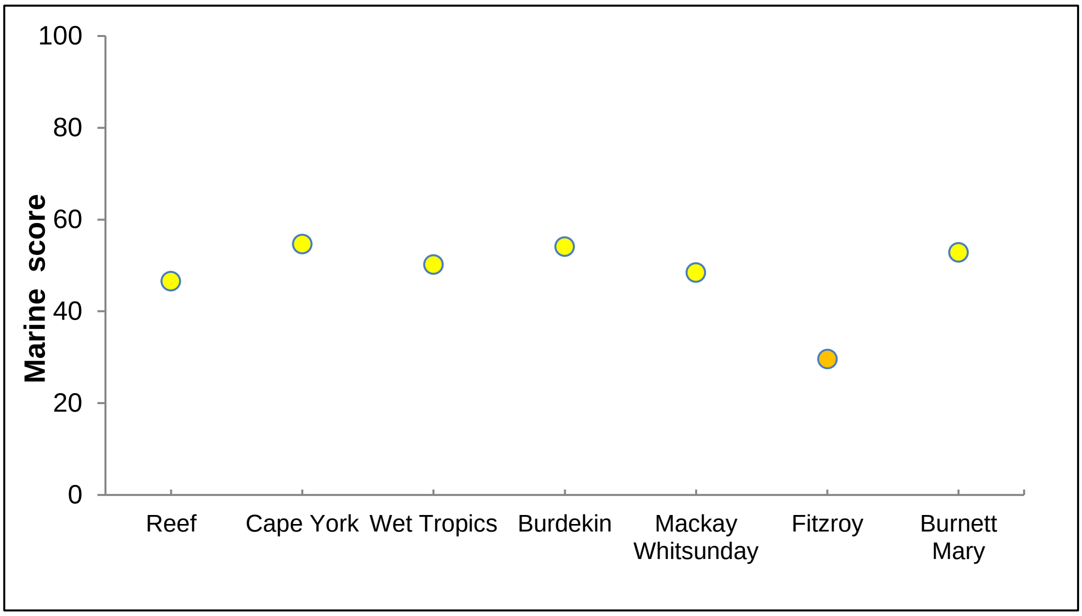


Figure 14: Marine condition for the inshore Great Barrier Reef and NRM regions for 2015–16. Values are indexed scores scaled from 0 to100; ● = very good (81–100), ●= good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). NB: Scores are unitless.

Water quality

Water quality condition and trend

This summary is adapted from Waterhouse et al., 2017b; Grant et al., 2017; and Robillot et al., 2017.

Revisions to the water quality metric

A revised water quality metric was developed in 2015–16 as an initial step towards integrating multiple streams of data to measure and report water quality condition. The previous metric relied exclusively on satellite data. The new metric is underpinned by the eReefs biogeochemical model integrated with satellite images for improved accuracy in what is commonly referred to as a data assimilation process. All marine water quality results presented in this report were generated using the revised metric (see the Marine Methods report for details). Modelled data was available for three years only and inshore water quality scores are for open coastal waters only.

Note that the revised metric is not directly comparable to the metric used in previous Reef report cards.

The main points for 2015–16 are as follows:

- Inshore water quality across the Reef was assessed as moderate overall using modelled data, with a north-south gradient of declining water quality from Cape York (good) to the Fitzroy (moderate) (Figure 15). For the individual indicators, chlorophyll a was rated as good overall and Secchi depth was rated as moderate overall; however, chlorophyll a was highly variable across the regions and scores ranged from poor to very good (Figure 19).
- In 2015–16, the levels of sediments and nutrients entering the Reef were low (categories I and II) (Figure 16), because runoff was low. Sediment resuspension from wind was higher closer to the coast in some regions (e.g. Burdekin region), which may have affected the amount of light available for seagrass growth.
- Pesticides were detected at relatively low concentrations at most sites in 2015–16 (Figure 17), consistent with the low river discharge. The exception to this was at Round Top Island in the Mackay Whitsunday region, which recorded the highest herbicide-equivalent concentrations (Category 2, which have been shown to inhibit photosynthesis in some species of coral and seagrass) detected at any site since monitoring began in 2014–15 (Grant et al., 2017). Ongoing monitoring is required to ascertain whether high pesticide concentrations are common to this site. In addition, the Reef water quality guideline value for chlorpyrifos, 0.50 ng/L for 99 per cent species protection (Great Barrier Reef Marine Park Authority, 2010), was marginally exceeded during one wet-season sampling period at Round Top Island (0.52 ng/L). More recently, new and revised pesticide guideline values for marine ecosystems have been proposed (King et al., 2017); the proposed 99 per cent species protection values for diuron (430 ng/L) and imidacloprid (33 ng/L) were also exceeded at Round Top Island (462 ng/L and 36 ng/L, respectively).
- Variability between regions was high in the profiles of pesticides detected (type and concentration) (Figure 18). The most frequently detected pesticides in inshore waters (diuron, atrazine, hexazinone and tebuthiuron) were herbicides that inhibit photosynthesis (known as Photosystem II inhibiting (PSII) herbicides). This finding is consistent with pesticide use in adjacent catchments, mainly by the sugarcane, horticulture, grain, cropping and grazing industries.

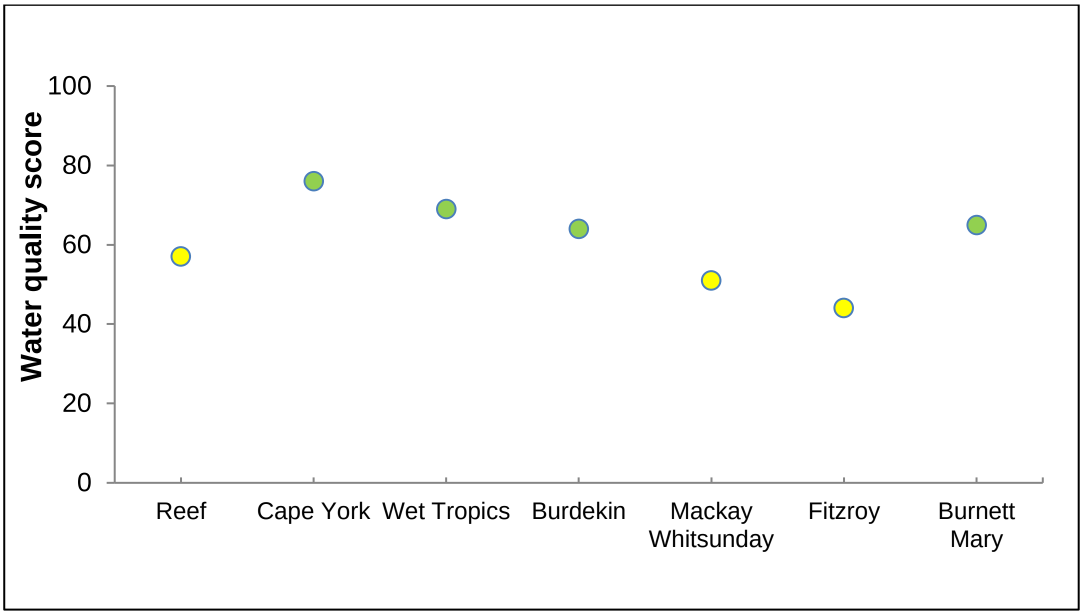


Figure 15: Water quality condition for the inshore Great Barrier Reef and regions for 2015–16. Values are indexed scores scaled from 0 to100; ●= very good (81–100), ● = good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). Note: Scores are unitless. Note: Inshore water quality scores are for open coastal waters only. For the Burnett Mary region, only the area in the Marine Park was modelled and scored. Modelled data was available for three years only and is not directly comparable to previous report cards.

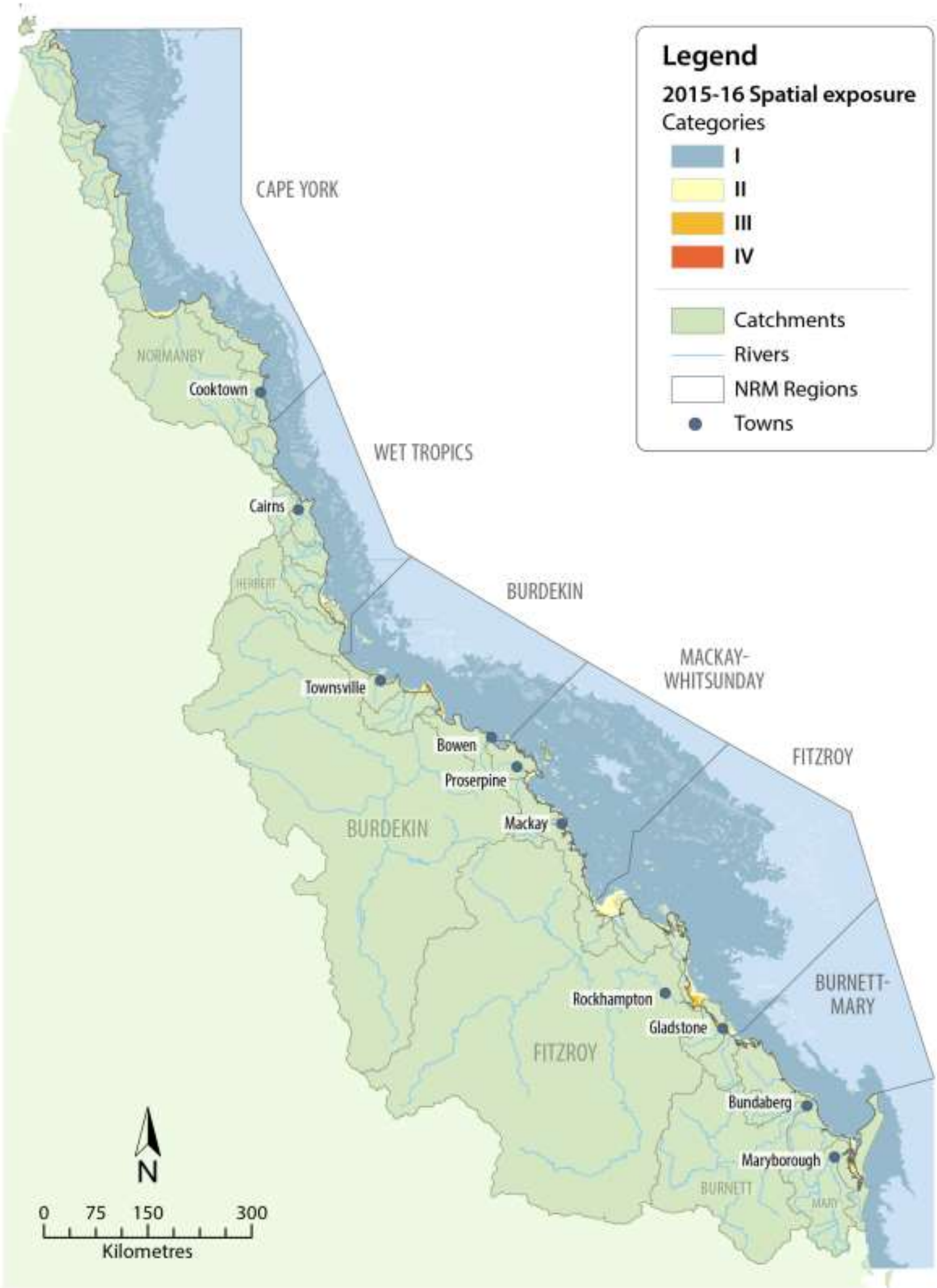


Figure 16: Surface exposure of sediments and nutrients for the Reef in 2015–16 (Waterhouse et al., 2017b). This assessment combined remotely sensed, true-colour imagery with in-situ water quality data. The method takes into account the frequency of exposure to different types of water (characterised by certain water quality conditions), predicted water quality concentrations, and ecological thresholds (see Waterhouse et al., 2016b and Petus et al., 2016).

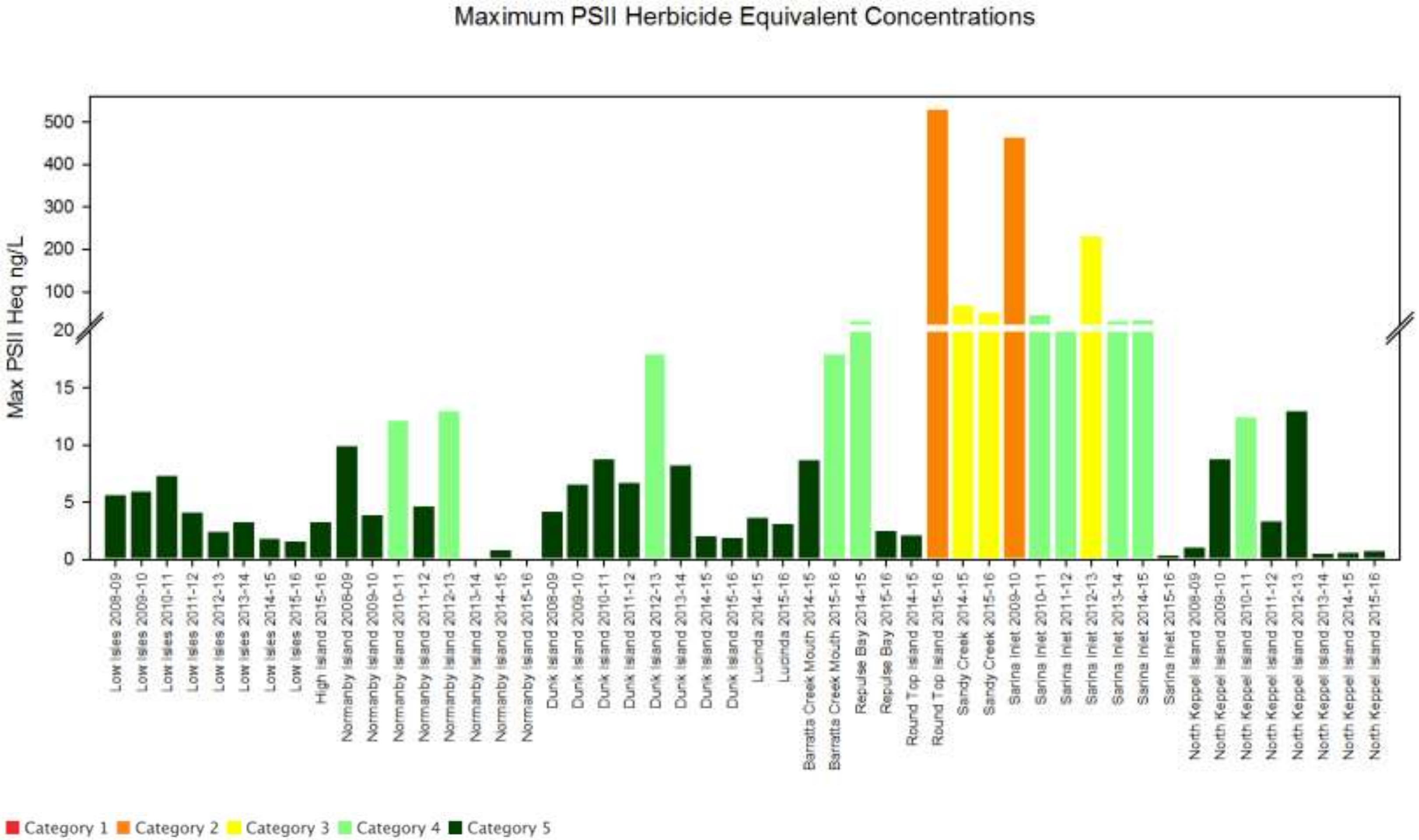


Figure 17: Maximum PSII herbicide equivalent concentrations at all sites monitored in the Great Barrier Reef in 2015–16 compared to previous years. Eleven sites have been included in the monitoring program since 2014–15. These include five long-term monitoring sites: Low Isles, Normanby Island, Dunk Island, Sarina Inlet and North Keppel Island. New sites introduced in 2014–15 were High Island, Lucinda, Barratta Creek, Repulse Bay, Round Top Island and Sandy Creek. The five categories of the index reflect published effects on photosynthesis at levels of pesticides below guideline levels, where Category 5 is no impact and Category 1 is the equivalent to the 99 per cent species protection guideline value for diuron (Great Barrier Reef Marine Park Authority, 2016c) . The PSII herbicide equivalent concentrations include nine PSII herbicides and the two atrazine breakdown products. Source: (Grant et al., 2017).

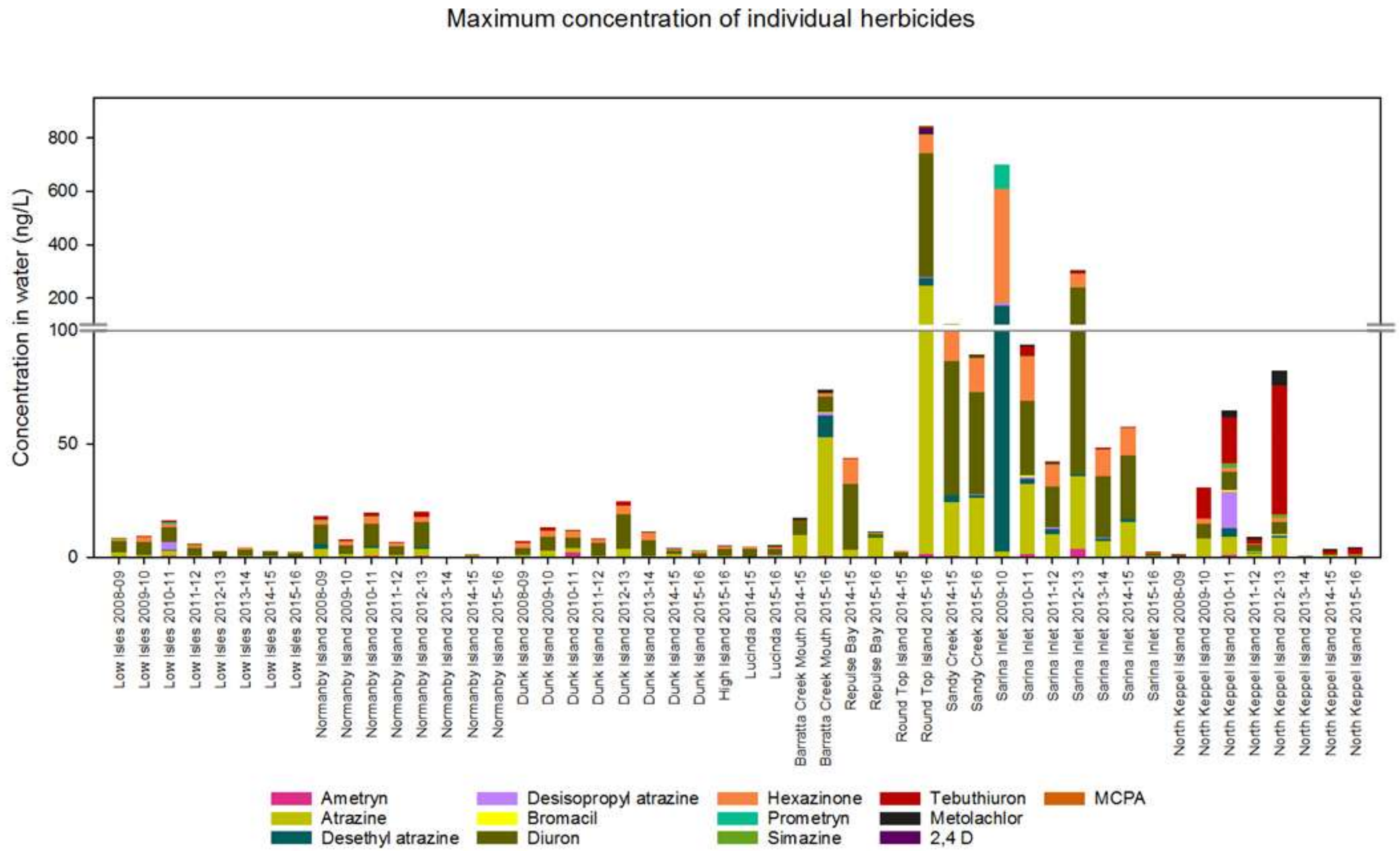


Figure 18: Maximum concentration of the main herbicides detected at all sites monitored across the Great Barrier Reef in 2015–16 compared to previous years. Eleven sites have been included in the monitoring program since 2014–15. These include five long-term monitoring sites: Low Isles, Normanby Island, Dunk Island, Sarina Inlet and North Keppel Island. New sites introduced in 2014–15 were High Island, Lucinda, Barratta Creek, Repulse Bay, Round Top Island and Sandy Creek. Note that this figure shows the concentrations of the main herbicides detected at each site, not just PSII herbicides. Other pesticides detected but which have not been included in this figure include imidacloprid, haloxyfop, fluroxypyr, imazapic, metsulfuron-methyl, chlorpyriofops, pendimethalin and trifluralin. Source: (Grant et al., 2017).

Regional trends in water quality

This summary of regional trends in water quality is adapted from Waterhouse et al., 2017b; Grant et al., 2017; and Robillot et al., 2017.

Cape York

- Inshore water quality in Cape York was good in 2015–16. For the individual indicators, chlorophyll a was very good, and Secchi depth was moderate.
- Regular in situ water quality monitoring was not conducted in 2015–16, but commenced in 2016–17.

Wet Tropics

- Inshore water quality in the Wet Tropics region was good in 2015–16. For the individual indicators, chlorophyll *a* was very good and Secchi depth was moderate .
- River discharge was below the long-term median. In the three focus regions (Russell-Mulgrave, Tully, Cairns long-term transect), most water quality parameters fluctuated around guideline values, with some exceedances (Table 1).
- Concentrations of PSII herbicides were similar to the low concentrations detected across all sites in 2014–15 and were below those known to have any observable effect on marine plants and animals (Category 5) (Figure 17 and Figure 18).
- In the wet season, biologically relevant concentrations of herbicides were detected in grab samples collected near the Russell-Mulgrave River mouth (Category 3 or 4),and in the vicinity of the Tully River mouth (Category 3).
- In recent years, other emerging pesticides—including 'alternatives' to the traditional five priority PSII herbicides—are being increasingly detected in catchments discharging to the Reef (Department of Science, Information Technology and Innovation, 2016). Other herbicides, insecticides and fungicides detected in 2015–16 included 2,4-D, haloxyfop, MCPA, metolachlor, metribuzin,simazine, imidacloprid, tebuconazole and two atrazine metabolites. The region where the greatest number of alternative pesticides were detected was the Wet Tropics. Note that many of these pesticides are not included in the maximum PSII herbicide equivalent calculation and, therefore, the ecological risk from all pesticides would be higher than that reported here.

Table 1: Wet Tropics sites where mean or median concentrations of chlorophyll *a*, Secchi depth, nitrate/nitrite, particulate phosphorus and total suspended solids did not meet water quality guidelines (grey shading) (Waterhouse et al., 2017b)

Region	Site	Chlorophyll *a*	Secchi Depth	Nitrate/ nitrite	Particulate phosphorus	Total Suspended Solids
Wet Tropics	Cape Tribulation					
	Port Douglas					
	Double					
	Green					
	Yorkey's Knob					
	Fairlead Buoy					
	Fitzroy West					
	RM3					
	High West					
	Russell Mulgrave Mouth Mooring					
	Franklands West					
	Clump Point East					
	Dunk North					
	Dunk South					
	Between Tam O'Shanter and Timana					
	Bedarra					
	Tully Mouth Mooring					

Burdekin

- Inshore water quality in the Burdekin region was good in 2015–16. For the individual indicators, chlorophyll a was very good and Secchi depth was moderate.
- Rainfall in the Burdekin was below the long-term median in 2015–16. However, several water quality parameters exceeded the guidelines at some sites (Table 2).
- Atrazine had the highest concentrations detected at the Barratta Creek site. In total, 18 pesticides (as well as two atrazine metabolites) were detected including 2,4-D, ametryn, bromacil, diuron, fluroxypyr, haloxyfop, hexazinone, MCPA, metolachlor, metribuzin, metsulfuron-methyl, pendimethalin, propazine, simazine, tebuthiuron, imidacloprid and chlorpyrifos.
- The main rainfall event in early 2016 resulted in a maximum PSII herbicide equivalent concentration in the low Category 4 range (Figure 17) in grab samples collected around the Barratta Creek mouth and within the Burdekin River mouth.

Table 2: Burdekin sites where mean or median concentrations of chlorophyll *a*, Secchi depth, nitrate/nitrite, particulate phosphorus and total suspended solids did not meet water quality guidelines (grey shading) (Waterhouse et al., 2017b)

Region	Site	Chlorophyll *a*	Secchi Depth	Nitrate/ nitrite	Particulate phosphorus	Total Suspended Solids
Burdekin	Palms West					
	Pandora					
	Magnetic					
	Haughton					
	Yongala					
	Burdekin Mouth Mooring					

Mackay Whitsunday

- Inshore water quality in the Mackay Whitsunday region was moderate in 2015–16. For the individual indicators, chlorophyll a and Secchi depth were rated as moderate.
- The combined discharge from all rivers and loads of pollutants were among the lowest over the past 10 years. However, several water quality parameters exceeded the guidelines at some sites (Table 3).
- Diuron had the highest concertrations detected in the region with the exception of Repulse Bay, which was dominated by atrazine (Figure 14). At two of the four sites monitored in 2015–16, the maximum PSII herbicide equivalent concentrations were below those known to have any observable effect on marine plants and animals (Category 5) (Figure 17). However, at Round Top Island and Sandy Creek the maximum PSII herbicide equivalent concentrations detected could inhibit photosynthesis in coral and seagrass (Category 2 and 3, respectively). Concentrations at Round Top Island during 2015–16 were the highest recorded at any site in the last eight years and were associated with relatively high flow events in the Pioneer River and neighbouring catchments, compared to other regions.
- Other pesticides detected included metolachlor, 2,4-D, haloxyfop, MCPA, fluroxypyr, imazapic, metsulfuron-methyl, pendimethalin, trifluralin, imidacloprid and chlorpyrifos. In total, 19 pesticides were detected, 11 of which were not included in the maximum PSII herbicide equivalent calculation.

Table 3: Mackay Whitsunday sites where mean or median concentrations of chlorophyll *a*, Secchi depth, nitrate/nitrite, particulate phosphorus and total suspended solids did not meet water quality guidelines (grey shading) (Waterhouse et al., 2017b)

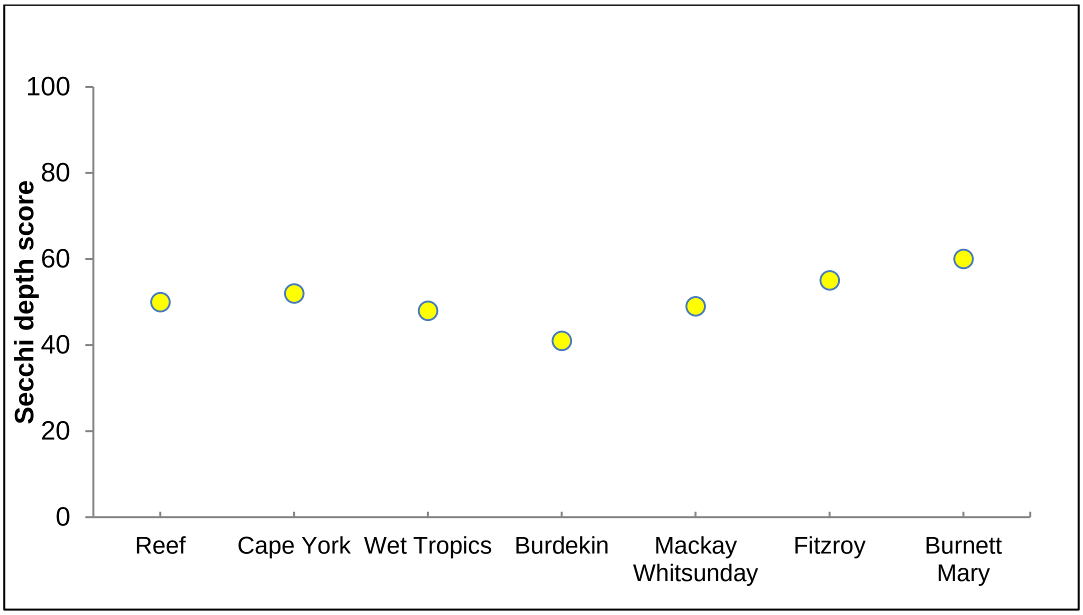
Region	Site	Chlorophyll *a*	Secchi Depth	Nitrate/ nitrite	Particulate phosphorus	Total Suspended Solids
Mackay Whitsunday	Double					
	Pine					
	Seaforth					
	Repulse					
	O'Connell Mouth					

Fitzroy

- Inshore water quality in the Fitzroy region was moderate in 2015–16. For the individual indicators, chlorophyll a was rated poor and Secchi depth was moderate.
- Pesticides were monitored only at North Keppel Island and concentrations of PSII herbicides in 2015–16 were below those known to have any observable effect on marine plants and animals (Category 5) (Figure 17). Consistent with previous years, tebuthiuron was the dominant herbicide detected at North Keppel Island. In total, eight pesticides (plus two atrazine metabolites) were detected, three of which were not included in the maximum PSII herbicide equivalent calculation.

Burnett Mary

- Inshore water quality in the Burnett Mary region was good in 2015–16. For the individual indicators, chlorophyll a was good and Secchi depth was moderate.



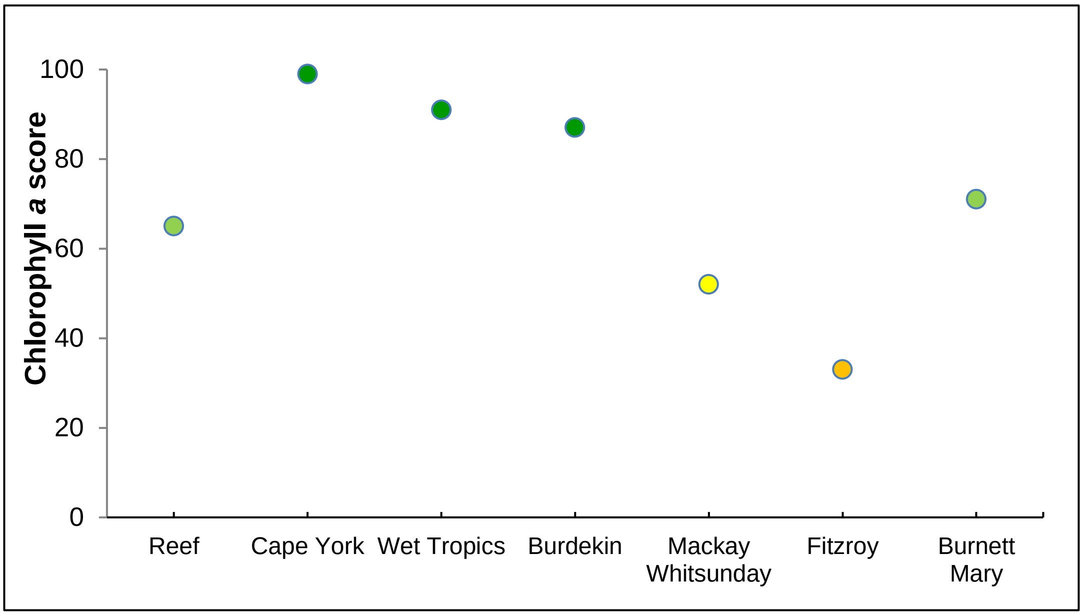


Figure 19: Water quality indicators, Secchi depth (top) and chlorophyll *a* (bottom), for the inshore Great Barrier Reef and NRM regions for 2015–16. Values are indexed scores scaled from 0 to100; ● = very good (81–100), ● = good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). Note: Scores are unitless. Note: inshore water quality scores are for open coastal waters only. For the Burnett Mary region, only the area in the Marine Park was modelled and scored.

Seagrass

Inshore seagrass condition and trend

This summary is adapted from McKenzie et al., 2017.

The main points for 2015–16 are as follows:

- Overall, the condition of inshore seagrass meadows changed very little. There were small improvements in the Cape York, Mackay Whitsunday, Fitzroy and Burnett Mary regions; however, inshore seagrass condition declined slightly in the Wet Tropics and Burdekin regions (Figure 20).
- Seagrass abundance across the inshore Reef remained moderate, but most regions continued the upward trend in recovery that began in 2013 after widespread losses from multiple years of above-average rainfall, associated flood events and extreme cyclones (Figure 21). Overall, there was a return to more stable foundation communities.
- Reproductive effort declined slightly and remained very poor, fluctuating across regions and habitats (Figure 21). Seed banks showed signs of recovery at some sites, but declined or were variable at others. These results suggest that seagrass resilience has been affected by the multiple floods and cyclones that have occurred since 2009.
- Seagrass leaf tissue nutrients remained poor (C:N reduced), suggesting that insufficient light was available for photosynthesis relative to nutrient availability (Figure 21).
- The overall increase in abundance and the fluctuating scores for other indicators across the Reef indicate a system in a state of recovery, with past climate impacts leaving a legacy of reduced resilience. There are signs that reproductive effort and seed bank density may increase in some regions leading to greater resilience of seagrass meadows, if there are no further disturbances.

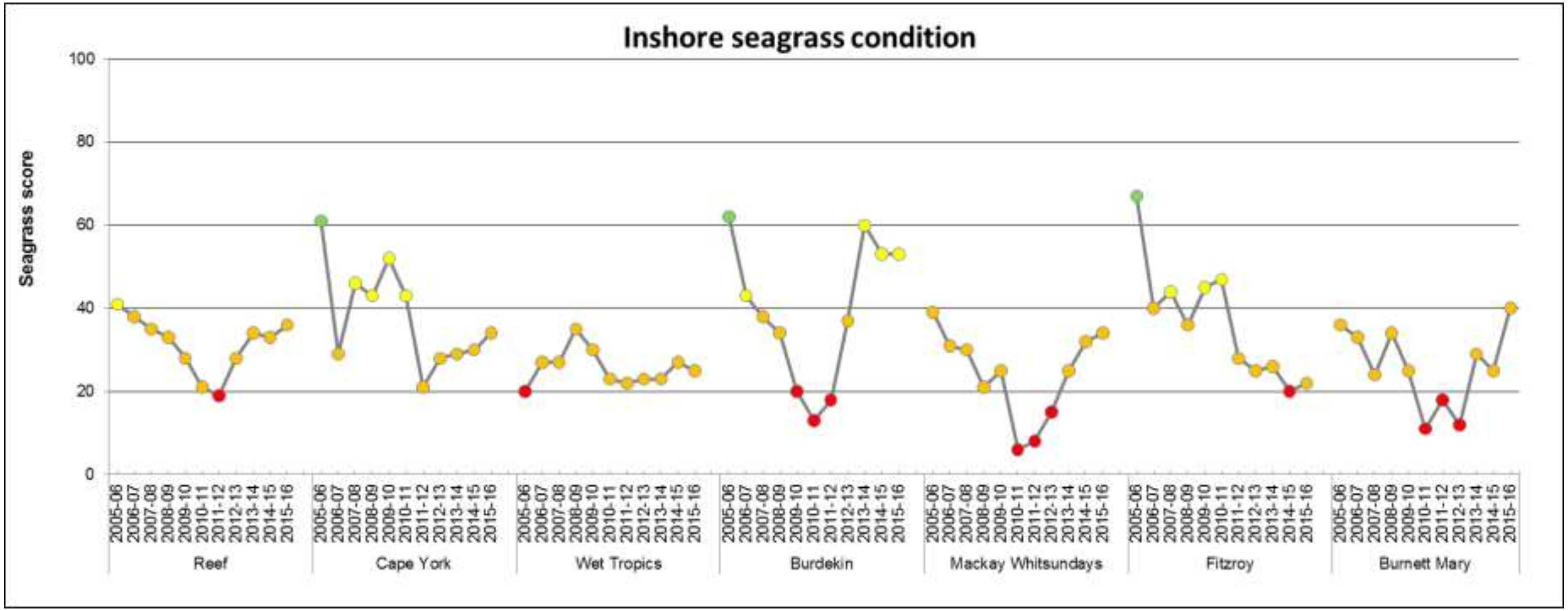


Figure 20: Seagrass condition for the inshore Great Barrier Reef and NRM regions from 2005–06 to 2015–16. The overall score for seagrass condition is the average of the component scores for reproduction, abundance and nutrient status. Values are indexed scores scaled from 0 to 100; ● = very good (81–100), ● = good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). Note: Scores are unitless. Data source: McKenzie et al., 2017

Regional trends in seagrass

This summary is adapted from McKenzie et al., 2017.

Cape York

- Seagrass condition in the Cape York region continued to improve for the fourth year in a row after the low of 2011–12, suggesting seagrass was in a recovery phase. However, the overall condition of seagrass was poor and remained below the 2005–06 Marine Monitoring Program baseline because increases in abundance were offset by the very poor score for reproductive effort and the poor score for nutrient status (Figure 21). Additional seagrass monitoring locations were added in 2012–13, so a more accurate assessment of regional trends will be available in the future (before 2012–13, this region had only one long-term monitored site, Archer Point).
- Seagrass reproductive effort across the region remained very poor in 2015–16, with coastal sites generally having higher seed banks and reproductive effort than reef sites (Figure 21).
- Seagrass leaf tissue nutrients remained largely unchanged (poor) (Figure 21), suggesting seagrass are experiencing sub-optimal light conditions for growth.

Wet Tropics

- Seagrass meadows across the region remained in poor condition and were in a vulnerable state, with limited signs of recovery since the decline in 2010–11 (Figure 21).
- Seagrass abundance increased from very poor to poor in 2015–16 (Figure 21) and was influenced by a complex range of environmental and biological processes.
- Reproductive effort and the number of seed banks remained low at all locations, resulting in a decline in the score for reproductive effort from poor to very poor (Figure 21). The limited capacity for seagrass in this region to recover from seed stock has implications for its resilience to future disturbances—seagrass meadows in the Wet Tropics are considered to be at high risk of further losses.
- Nutrient status remained poor (Figure 21). This indicates that nitrogen potentially exceeds requirements for growth, or that seagrass is limited by low light from high turbidity.

Burdekin

- Seagrass condition remained moderate, which was the highest score for seagrass across all regions in 2015–16 (Figure 21). Seagrass meadows in the Burdekin region have demonstrated high resilience through their capacity to recover from past disturbances. This may reflect a pre-conditioning to disturbance, as seagrass meadows in the region have a high seed-bank density and high species diversity compared to other regions.
- Seagrass abundance remained moderate (Figure 21). Average abundance across all coastal sites was relatively unchanged, while abundance at reef sites declined.
- Reproductive effort increased to moderate in 2015–16 after a poor rating in 2014–15 (Figure 21). The increase in reproductive effort was substantial at coastal sites, leading to an accumulation of seed banks that resulted in the Burdekin region having the highest seedbank density of all regions. Note that reproductive effort is based only on the number of reproductive structures and does not include seed banks.
- Seagrass nutrient status declined to moderate (Figure 21). Exposure from wind-driven sediment resuspension was high close to the coast, which may have affected the amount of light available for seagrass growth.

Mackay Whitsunday

- The overall condition of seagrass continued to improve for the fifth consecutive year, but the index score remained poor (Figure 20). Meadows in the region showed signs of resilience and recovery.
- Seagrass abundance increased at all sites except Hamilton Island (low and stable), resulting in an increase in the score from poor to moderate (Figure 21). This demonstrates rapid recovery over the past two years from very poor abundance in 2013–14.
- Seagrass reproductive effort continued to improve at coastal and estuarine sites, but remained poor overall (Figure 21) due to the low reproductive effort at reef sites. Seed banks also continued to increase at coastal sites and estuarine sites, which may facilitate recovery from future disturbances. Note that reproductive effort is based only on the number of reproductive structures and does not include seed banks.
- Seagrass nutrient status was similar to 2014–15 and remained poor (Figure 21).

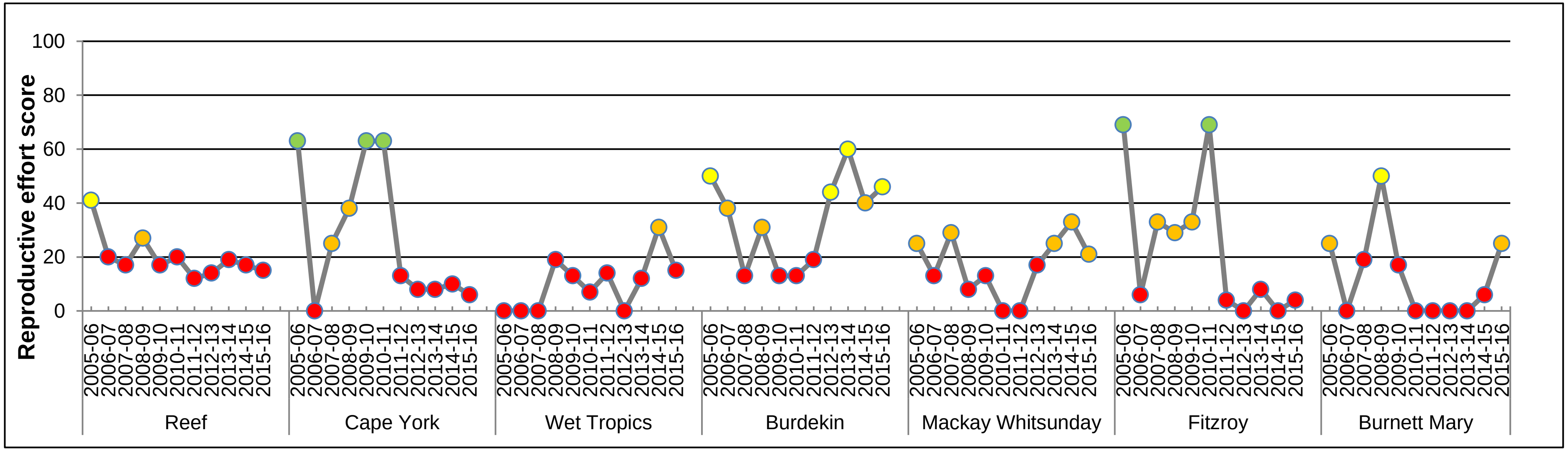
Fitzroy

- The condition of seagrass meadows increased from very poor to poor in 2015–16 (Figure 21). Meadows were in the early stages of recovery and remain in a highly vulnerable state following multiple years of climate-related disturbances.
- Seagrass abundance was poor, which was unchanged from 2014–15 (Figure 21).
- Reproductive effort remained very poor, as it has been since 2011–12 (Figure 21). This may indicate that seagrass were using all their resources to maximise vegetative recovery, as seed banks have been stable since 2011.
- Seagrass nutrient status remained poor in 2015–16 (Figure 21), which suggests that light conditions for recovery were sub-optimal.

Burnett Mary

- Seagrass meadows in the Burnett Mary region continued to improve from the very poor condition observed in 2012–13, achieving their best condition in a decade of sampling (Figure 21). However, the overall score remained poor, just below the threshold for moderate.
- Seagrass abundance continued to increase for the second year in a row to moderate, reaching the highest abundance recorded since sampling began (Figure 21). The recent increases in abundance suggest that these meadows are recovering well following many years of poor environmental conditions (cyclones and turbid water).
- Reproductive effort increased from the previous year, improving from very poor to poor (Figure 21). Seed banks remained stable, but low.
- Seagrass nutrient status increased from poor in 2014–15 to moderate in 2015–16 (Figure 21). This, combined with other changes, suggest water quality conditions were improving for seagrass growth.


Seagrass abundance score
100
80
60
40
20
0
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
Reef
Cape York
Wet Tropics
Burdekin
Mackay Whitsunday
Fitzroy
Burnett Mary


Reproductive effort score
100
80
60
40
20
0
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
Reef
Cape York
Wet Tropics
Burdekin
Mackay Whitsunday
Fitzroy
Burnett Mary

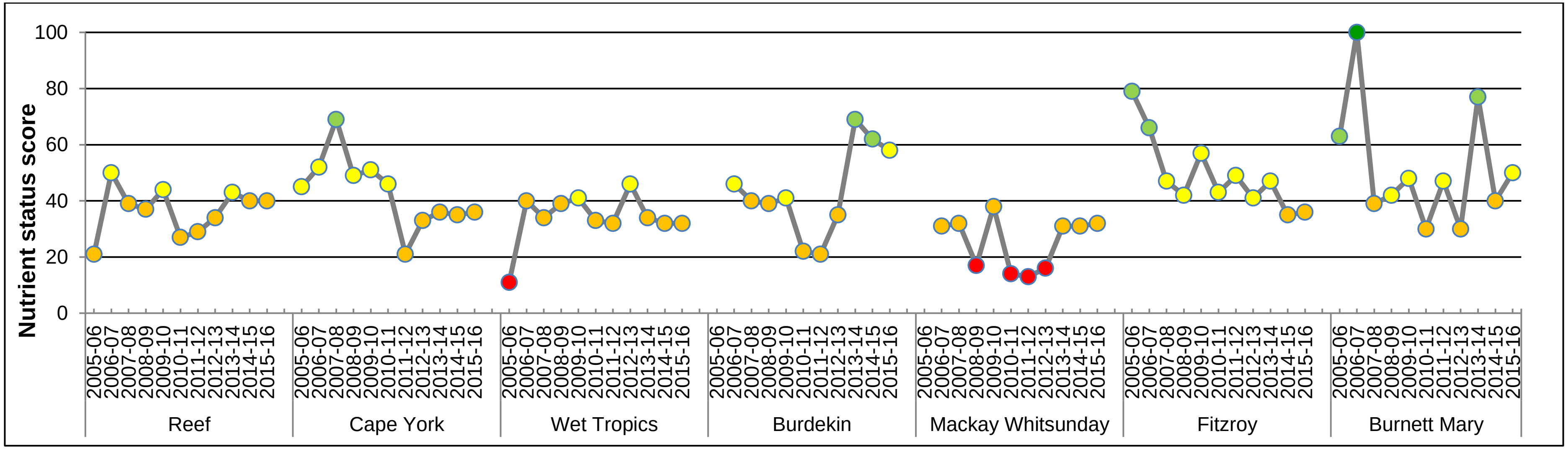


Figure 21: Trends in seagrass indicators, abundance (top), reproduction (middle), nutrient status (bottom), for the inshore Great Barrier Reef and NRM regions from 2005–06 to 2015–16. Values are indexed scores scaled from 0 to100; ● = very good (81–100), ● = good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). Note: Scores are unitless. Data source: McKenzie et al., 2017

Coral

Inshore coral condition and trend

This summary is adapted from Thompson et al., 2017.

The main points for 2015–16 are as follows:

- Coral condition across the entire inshore Reef was rated as moderate in 2015–16 and continued to improve since the lowest condition score in 2012. The improvement occurred despite the 2016 bleaching event and indicates a degree of resilience in inshore coral communities. Coral condition increased slightly to remain moderate in the Wet Tropics region, and increased from poor to moderate in the Burdekin region (Figure 22). In the Mackay Whitsunday region, coral condition improved from moderate to good, while in the Fitzroy it increased slightly, but remained poor. The scores for coral condition were mainly driven by changes in the indicators for coral cover, coral change and coral community composition.
- Coral cover increased in all regions, but the condition assessments remained the same as in 2014–15 (Figure 23).
- Scores for coral change increased in all regions. In the Wet Tropics, coral change increased from moderate to good; in the Burdekin coral change increased from poor to moderate; and in the Mackay Whitsundays and Fitzroy regions, coral change remained poor (Figure 23).
- Scores for the density of juvenile corals were relatively stable, remaining moderate in the Wet Tropics and Burdekin regions. There was a small increase in scores for juvenile coral density in both the Mackay Whitsunday and Fitzroy regions, which improved from moderate to good and very poor to poor, respectively (Figure 23).
- Macroalgae cover remained relatively stable across all regions and regional scores for 2015–16 were the same as for 2014–15 (Figure 23).
- Coral community composition improved and remained moderate in all regions except Fitzroy where the coral community was characterised by a lack of sensitive species, resulting in a poor score (Figure 23).

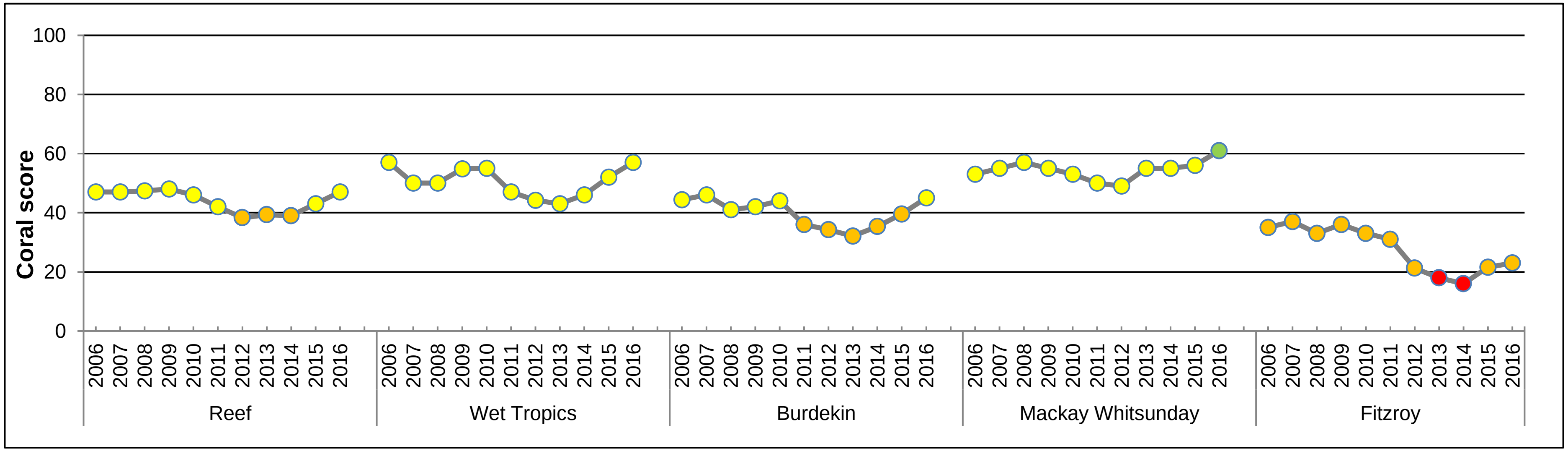


Figure 22: Coral condition scores for the inshore Great Barrier Reef and NRM regions from 2006 to 2016. Values are indexed scores scaled from 0 to 100; ● = very good (81–100), ● = good (61–80), ● = moderate (41–60), ● = poor (21–40), ● = very poor (0–20). Note: Scores are unitless. Data source: Thompson et al., 2017 Note: The 2015–16 data was collected before the 2017 coral bleaching events and does not represent the condition at time of publication.

Regional trends

This summary is adapted from Thompson et al., 2017.

Wet Tropics

- Coral condition continued to increase for the third consecutive year from the low condition recorded in 2013, and scores were at the upper range of moderate (Figure 22).
- Coral cover increased but remained moderate, while the indicator for coral change increased to good (Figure 23). The steady improvements in coral cover and coral change over the past two years coincided with low river discharge and a lack of acute disturbances.
- Juvenile density remained stable, in moderate condition.
- Regionally, macroalgae remained low and had reduced in some areas.
- Community composition remained moderate.

Burdekin

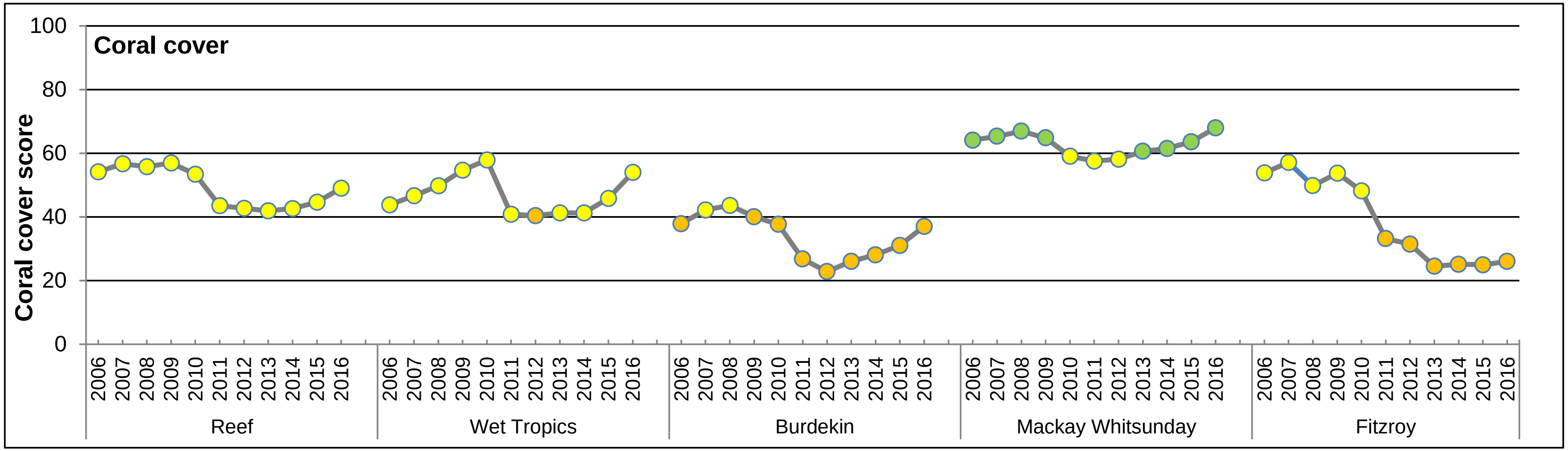
- Coral condition improved from poor to moderate in 2015–16.
- Coral cover and coral change both increased for the fourth consecutive year, with coral cover still in poor condition and coral change increasing to moderate (Figure 23). The steady improvements in coral cover and coral change over the last four years indicate coral communities in this region are inherently resilient.
- There have been slight improvements in the density of juvenile corals, along with a gradual return of sensitive species. Indicators for both juvenile coral density and community composition were at the upper range of moderate (Figure 23).
- The only indicator that did not improve was the proportion of macroalgae. Macroalgae maintained a dominant presence at most locations, indicating the availability of nutrients and light.

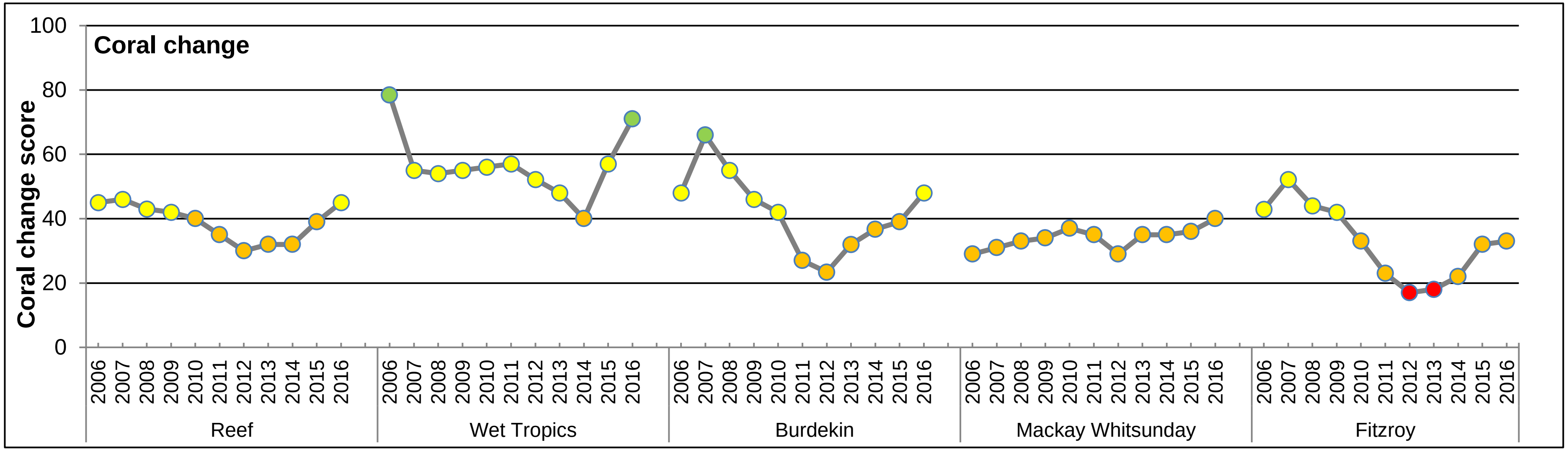
Mackay Whitsunday

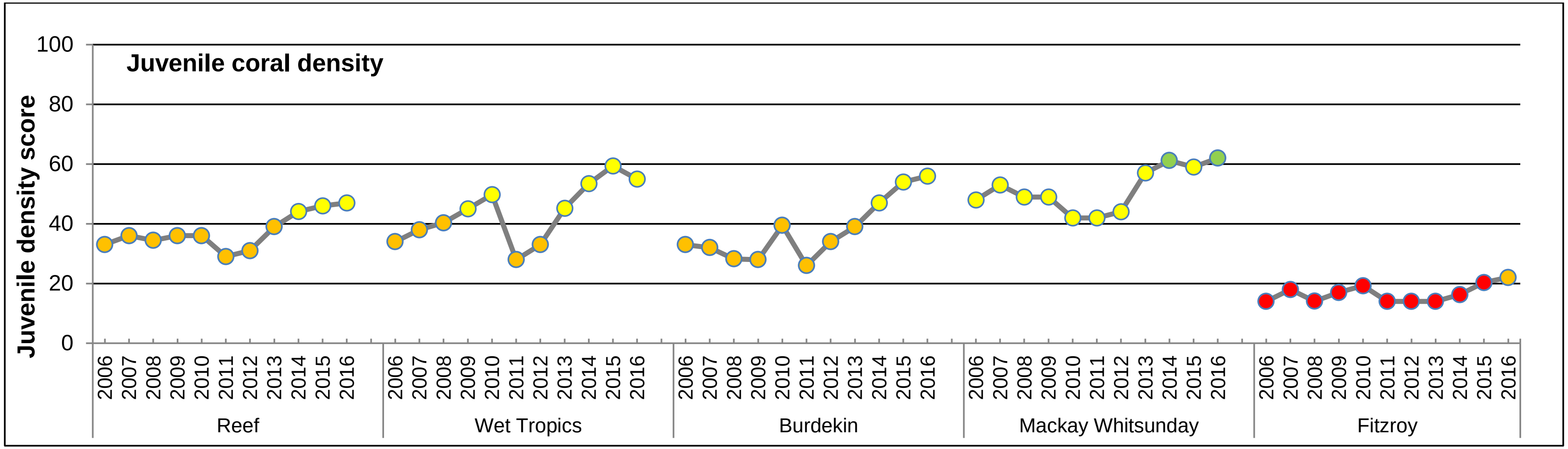
- The score for coral condition in the Mackay Whitsunday region was the highest of all regions monitored in the Reef. After being relatively stable for the two preceding years, there was a slight improvement in 2016 from moderate to good, resulting in the highest rating since monitoring began in 2006 (Figure 22).
- The majority of coral health indicators increased in 2015–16. There were moderate to high levels of coral cover, increasing densities of juvenile corals, increasing presence of species sensitive to water quality, and a low, but improving, rate of coral cover change (Figure 23).
- The cover of macroalgae remained consistently low, being absent from most reefs in the region.

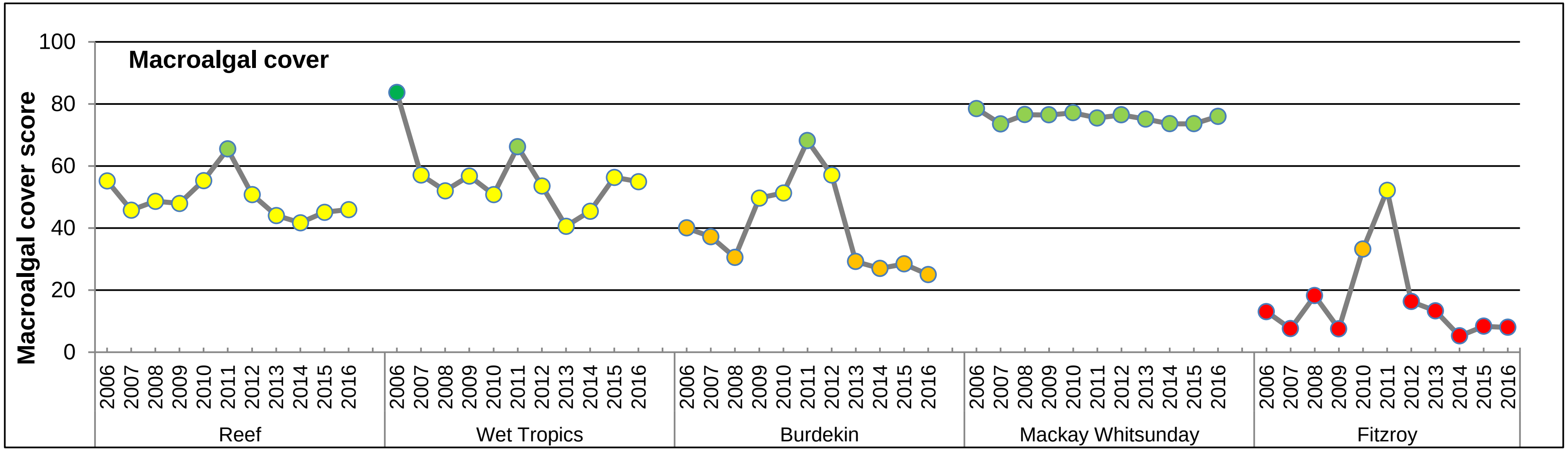
Fitzroy

- The score for coral condition in the Fitzroy region remained poor; however, it has improved from very poor in 2014 (Figure 22). A small increase in the rate of change in coral cover demonstrated that the coral communities are beginning to recover following a period multiple disturbances.
- Most indicators of coral condition (coral cover, coral change and coral community composition) remained stable, but in poor condition. Juvenile density showed slight improvements from very poor to poor, and macroalgae remained very poor, showing no sign of decline this year (Figure 23).


Coral cover
Coral cover score
100
80
60
40
20
0
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Reef
Wet Tropics
Burdekin
Mackay Whitsunday
Fitzroy


Coral change
Coral change score
100
80
60
40
20
0
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Reef
Wet Tropics
Burdekin
Mackay Whitsunday
Fitzroy


Juvenile coral density
Juvenile density score
100
80
60
40
20
0
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Reef
Wet Tropics
Burdekin
Mackay Whitsunday
Fitzroy


Macroalgal cover
Macroalgal cover score
100
80
60
40
20
0
2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Reef
Wet Tropics
Burdekin
Mackay Whitsunday
Fitzroy

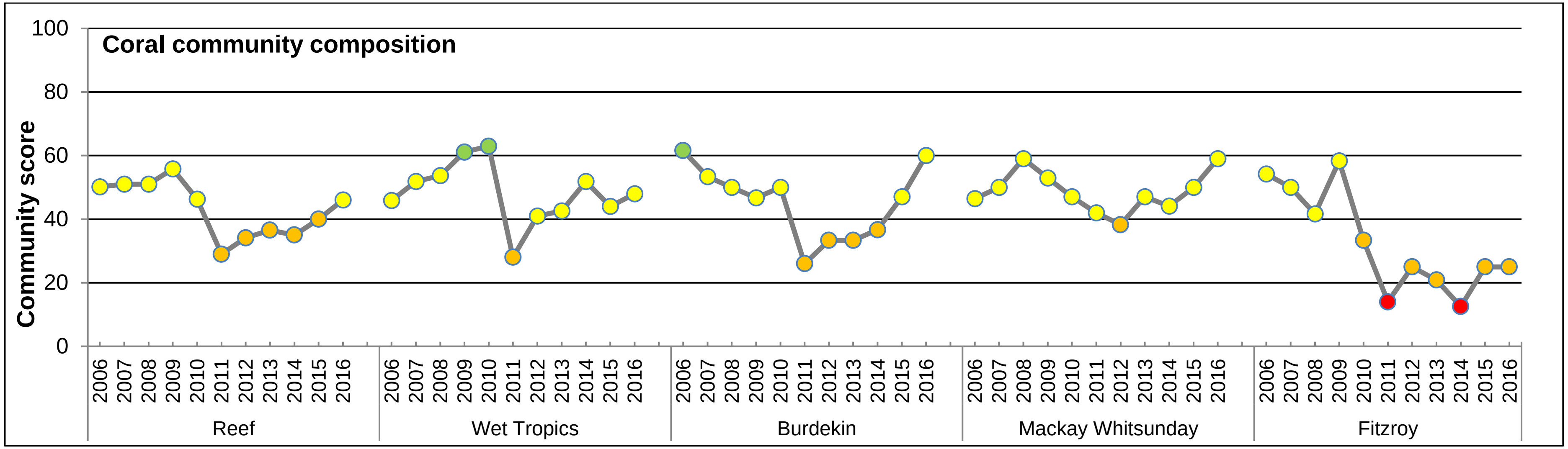


Figure 23: Trends in coral indicators (from top to bottom: coral cover, coral change, juvenile density, macroalgal cover, community composition) for the inshore Great Barrier Reef and NRM regions from 2006 to 2016. The overall score for Great Barrier Reef is the average of the component scores for the Wet Tropics, Burdekin, Mackay Whitsunday and Fitzroy regions. Monitoring data from the Marine Monitoring Program and the Australian Institute of Marine Science Long-term Monitoring Program is included. The coral change indicator is calculated as the average rate of increase in coral cover compared to modelled predictions over the preceding four years. Note that the time series for coral has been recalculated and trend graphs in previous Reef report cards are not comparable. Values are indexed scores scaled from 0 to 100; ■ = very good (81–100), ■ = good (61–80), ■ = moderate (41–60), ■ = poor (21–40), ■ = very poor (0–20). Note: Scores are unitless. Data source: Thompson et al., 2017

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