Results

Great Barrier Reef

Report Card 2014

Australian Government

Queensland Government

Management practice results

The updated 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.

The management practice targets set in Reef Plan 2009 related to adoption of improved management practices and were based on the best available evidence and designed to be ambitious. Since then, scientific knowledge and monitoring and modelling information has advanced significantly. The updated targets are equally ambitious and now refer to the attainment of **best management practice** systems, rather than improved practices.

Landholders manage complex farming systems made up of many diverse individual management practices. The revised 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.

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 this reason, Reef Plan 2013 continues to invest in programs which provide research and development to plug knowledge gaps, capacity building for landholders to acquire new skills and adopt new practices, and fiscal incentives to expedite farm equipment and infrastructure upgrades.

Best management practices in this context are defined in Reef Plan 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-low water quality risk. The 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- High risk (superseded or outdated practices)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 (innovative practices expected to result in further water quality benefits, but where commercial feasibility is not well understood)

The metrics used to describe progress toward 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 off-farm loss of soil, nutrients and pesticides. For the grazing industry, metrics refer to the adoption of practices that minimise soil loss through pasture (hillslope), streambank and gully erosion processes. Farm land estimated to be in the two lowest risk categories (best practice and innovative practices) is included in the area reported under best management practice systems.

Report Card 2014 details the area of land managed using best management practice systems as at June 2014.

Factors contributing to the degree of adoption during 2013-2014 were:

- A relatively short investment year. Both Queensland and Australian government investments transitioned to new and revised program arrangements coinciding with the commencement of Reef Plan 2013.
- An increased emphasis on extension to landholders. Acknowledging that best practice adoption is complex and challenging, there has been an increase in programs delivering capacity building extension, which aim to increase the rate of adoption of new practices through:

- providing support for on-farm research by farmers, trialling new practices and working out the best way to adopt
- working with facilitated landholder groups to develop local understanding of how new practices best fit into their farming system
- providing specific technical support to individual landholders in planning and implementing improved management systems
- delivering programmed learning (training) in certain areas.

These are known to be effective mechanisms for change. However, it is premature to report on the degree of change before it is understood and verified. It is expected that management practice adoption improvements stemming from these investments will be reported in future Report Cards.

For the sugarcane, horticulture and banana industries, there is a coaster metric describing progress toward best management practice *systems.* In the coasters, the wedges in the outer ring relate to the component priority practices. The relative size of the wedge indicates the potential influence of the practice on off-site water quality. There is also a bar graph displaying the proportion of area managed at each risk state (low to high).

For the grazing and grains industries, there is a bar graph displaying the proportion of area 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.

Colour codings used to indicate progress are below (the 90 per cent target split into four categories). The last category is included to show exceedance of the target (over 90 per cent).

Adoption progress categories and colour coding		
0-22 %	(red)	Very poor
23-45 %	(orange)	Poor
46-67 %	(yellow)	Moderate
68-89 %	(light green)	Good
90-100 %	(dark green)	Very good

Factors affecting agricultural industries in 2014

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' 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 briefly summarised below.

Sugarcane

The 2013-2014 year was an improvement for production area in much of the Wet Tropics, with the exception of the Herbert River area. Tropical Cyclone Ita caused some flooding and lodging in April 2014. Other regions experienced yields lower than the previous 10-year average, particularly the areas south of Proserpine that are more reliant on rainfall. Yields of around 90 to 95 per cent of the average were partially offset by generally high sugar contents.

Dry harvesting conditions were an important positive factor for crop performance in 2014-2015.

Horticulture
Ex-Tropical Cyclone Oswald was a severe setback for many horticulture producers in the Burnett Mary and Fitzroy regions in early 2013 and this continued to impact production well into 2013-2014. Tropical Cyclone Ita also caused some crop and infrastructure damage in the major production area around Bowen. Otherwise, production and market conditions were generally normal or favourable in most areas, especially for some of the staple annual crops.

Grains
The 2013-2014 season was favourable in most areas. Both summer and winter crop areas and yields were average with average market conditions. Dry summer conditions meant that the area planted to winter crops was modest.

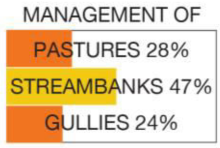
The use of tillage in Central Queensland grain farming systems has increased in recent years, largely due to the growing problem of some very difficult to control (especially in fallows) grass weeds. This has meant that tillage is again being seen as an option in what was previously a farming system dominated by zero tillage. These problematic weeds have also resulted in a wider range of herbicides being used.

Many growers have also introduced tillage again due to erosion damage caused by very wet seasons from 2010 to 2013.

Grazing
Much of the extensive grazing areas were drought declared by midway through 2014, the result of another relatively poor wet season in 2013-2014. The continued drought in the west of the state and subsequent over supply of cattle as a result of destocking saw low prices throughout much of the year.

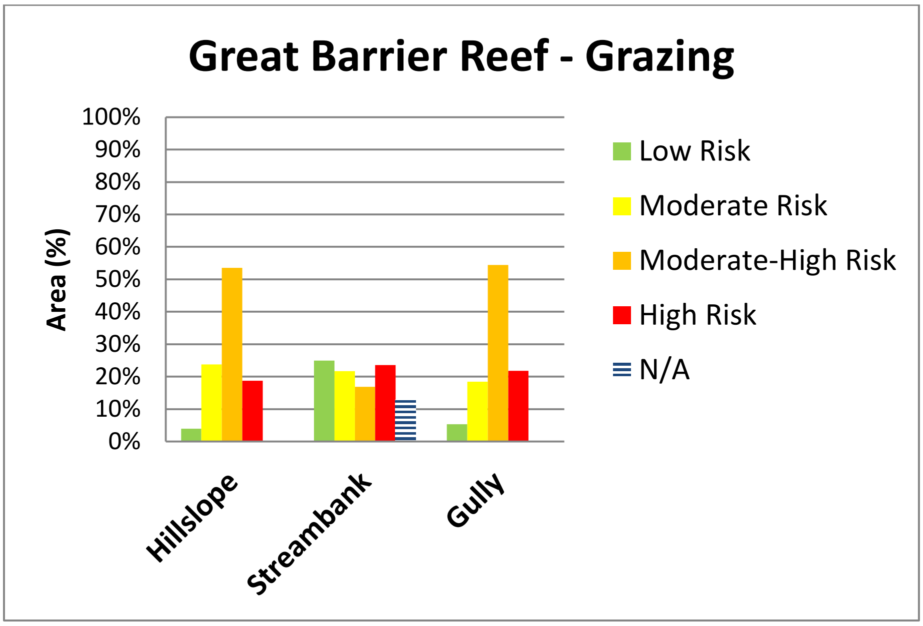
Great Barrier Reef-wide

Grazing



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

By June 2014, approximately 28 per cent of graziers were using best management systems for practices related to pasture (hillslope) erosion (8.6 million hectares), 47 per cent for practices relating to streambank erosion (14.5 million hectares) and 24 per cent for practices relating to gully erosion (7.4 million hectares). There are approximately 8545 graziers managing 322,891 square kilometres of land across the Great Barrier Reef catchment.



**The Not Applicable category represents those graziers without riparian areas to manage*.

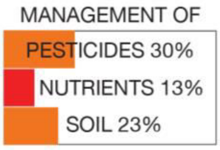
Major investments in the grazing sector are focused in the highest priority Fitzroy and Burdekin regions.

The Australian Government's Reef Programme co-funded on farm infrastructure improvements directly related to best practice adoption on 198 farms and over 130,000 hectares. Managers of an additional 305,000 hectares undertook specialist training in pasture monitoring and forage budgeting.

The Grazing BMP program, a partnership involving the Fitzroy Basin Association, AgForce and the Queensland Government, directly engaged 865 individual grazing businesses during 2013-2014. These businesses, managing over 3.4 million hectares, completed BMP modules on soil health and grazing land management which were directly relevant to runoff and soil loss.

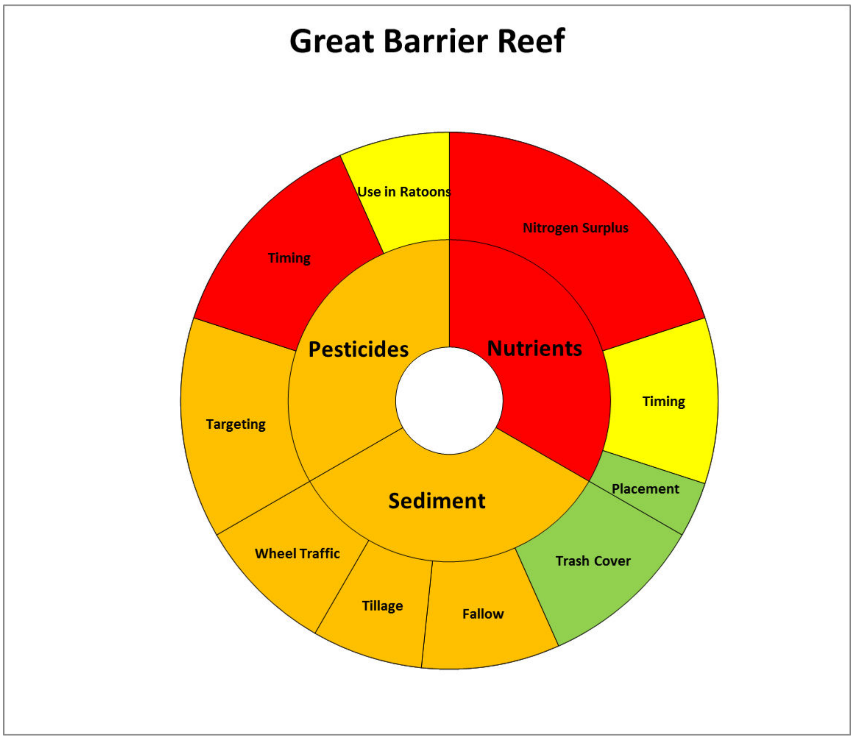
Queensland Government extension programs supporting the Grazing BMP engaged with 428 individual businesses managing over 8.3 million hectares of grazing land in the Fitzroy and Burdekin regions in 2013-2014.

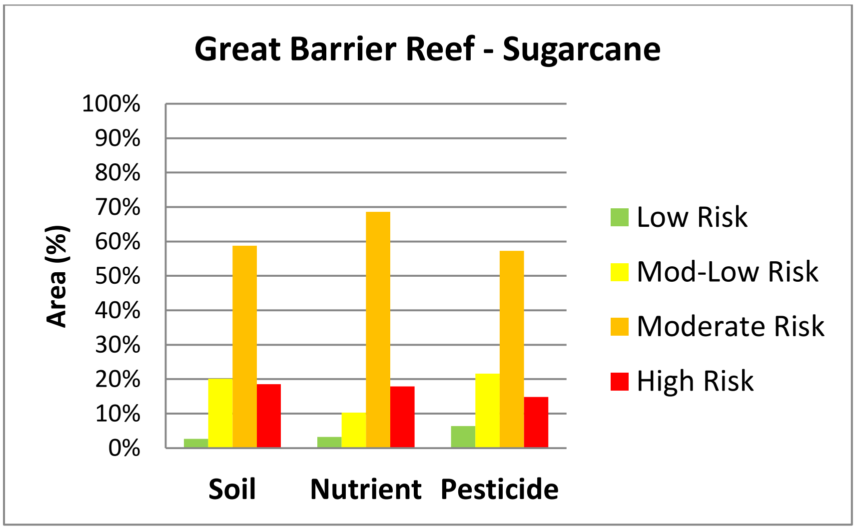
Sugarcane



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

By June 2014, best management practice systems were used by approximately 30 per cent of sugarcane growers for pesticides (123,000 hectares), 13 per cent for nutrients (60,000 hectares) and 23 per cent for soil (101,000 hectares). There are approximately 3777 sugarcane growers managing 4032 square kilometres of land across the Great Barrier Reef catchment.



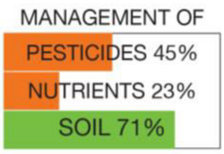


The major drivers of change in 2013-2014 in the sugarcane industry were:

- the Australian Government's Reef Programme directly funded on farm infrastructure and/or 1:1 extension with 465 growers managing over 97,000 hectares of land
- the Smartcane BMP program, an initiative of Canegrowers Ltd (with funding from the Queensland Government), facilitated farm management practice assessments with 512 growers managing over 93,000 hectares
- Queensland government extension services engaged with 585 growers managing approximately 76,000 hectares on issues related to nutrient, pesticide and soil reduction.

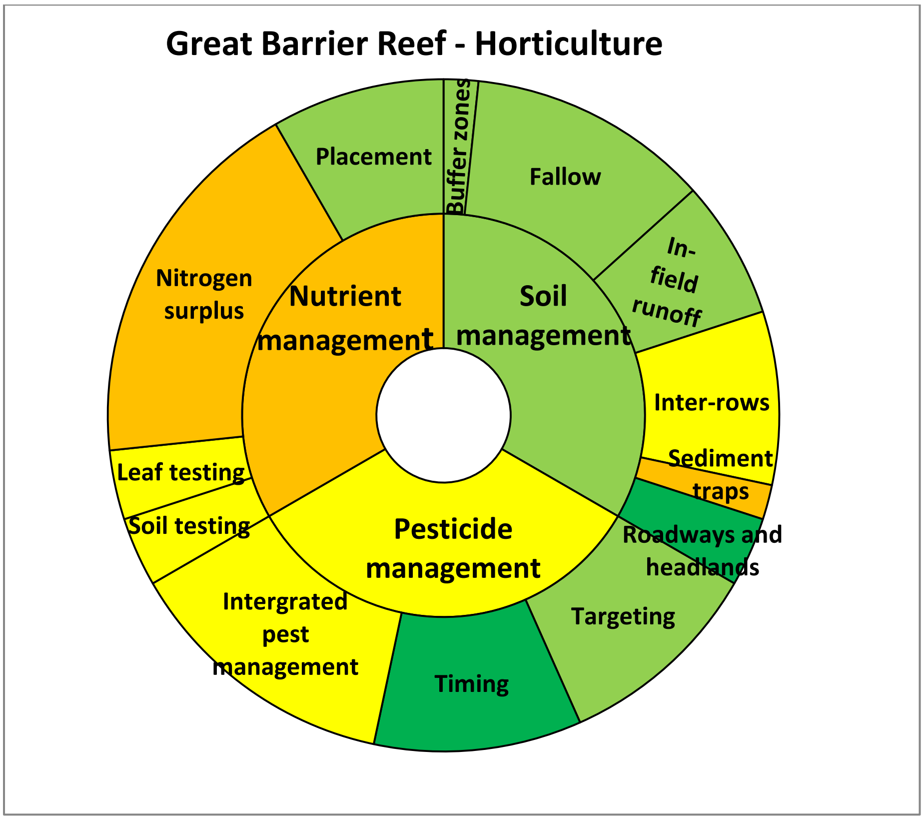
Both the Australian and Queensland governments also invested in extension services in priority sugarcane growing regions. These programs are expected to realise tangible results in terms of adoption of best practice systems in future reporting years.

Horticulture



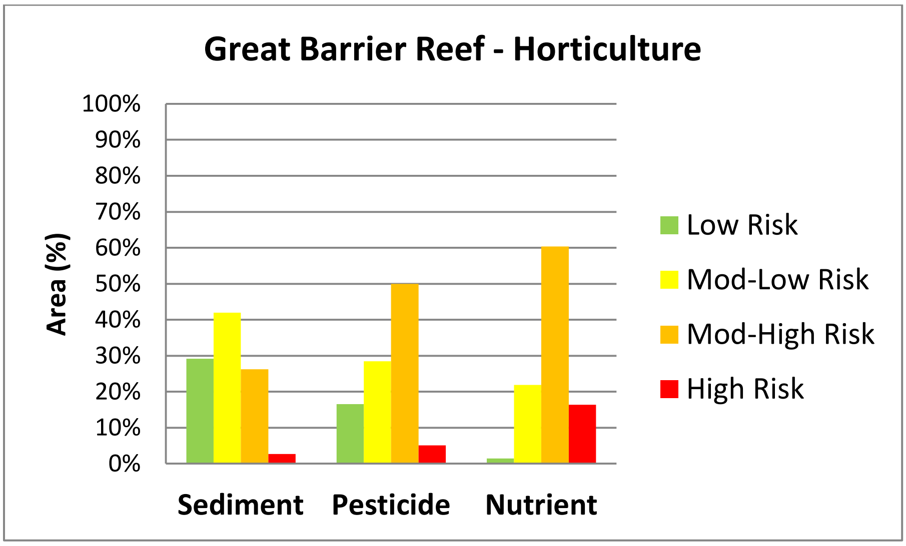
Target: 90 per cent of horticulture lands are managed using best management practice systems by 2018

By June 2014, best management practice systems were used by approximately 45 per cent of horticulture growers for pesticides (39,000 hectares), 23 per cent for nutrients (20,000 hectares) and 71 per cent for soil (61,000 hectares). There are approximately 970 horticulture producers farming 860 square kilometres of land in the Great Barrier Reef catchment.



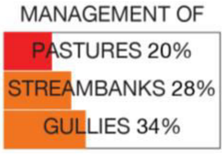
The major identified driver of change in the horticulture industry during 2013-2014 was the Australian Government's Reef Programme, delivered by regional Natural Resource Management organisations and Growcom, including:

- 19 growers implemented best management practice systems relating to soil (1593 hectares)
- five relating to nutrients (872 hectares)
- three relating to pesticides (2476 hectares)
- five relating to irrigation (399 hectares).



Cape York

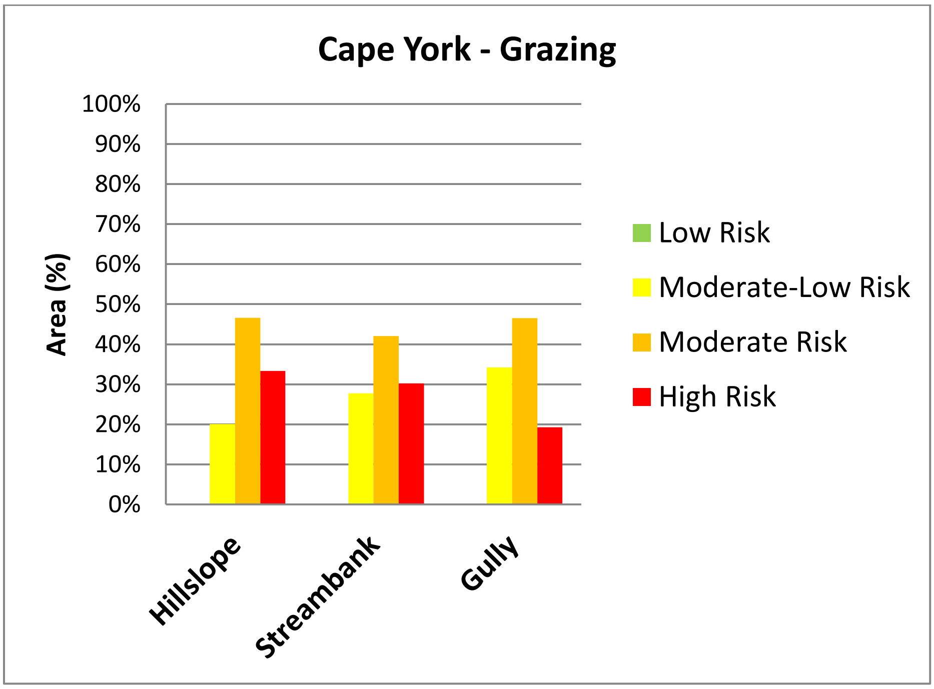
Grazing



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

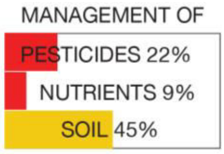
Management practice adoption efforts in the Cape York region have focused upon the Normanby River catchment. There are approximately 48 graziers managing 21,618 square kilometres of land in the Normanby River catchment.

There were no discrete management practice change investments in the Normanby during 2013-2014. As at June 2014, approximately 20 per cent of graziers were using best management for practices relating to pasture (hillslope) erosion (434,000 hectares), 28 per cent for practices related to streambank erosion (739,000 hectares), and 34 per cent for practices related to gully erosion (600,000 hectares).



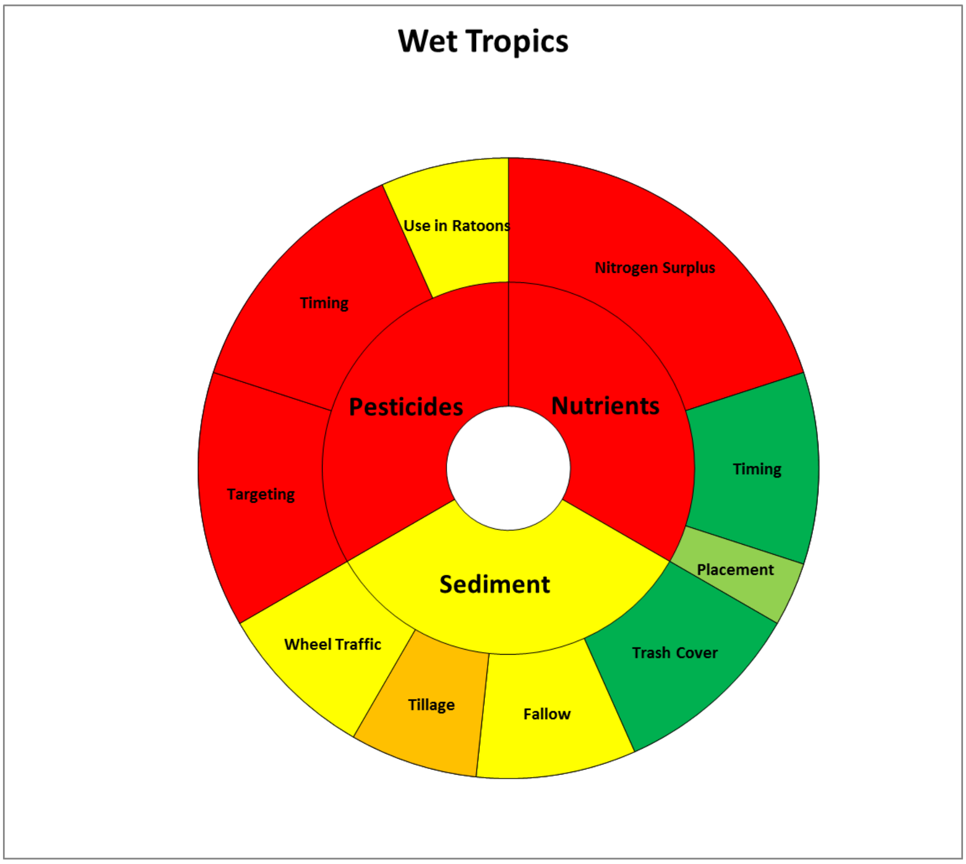
Wet Tropics

Sugarcane



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

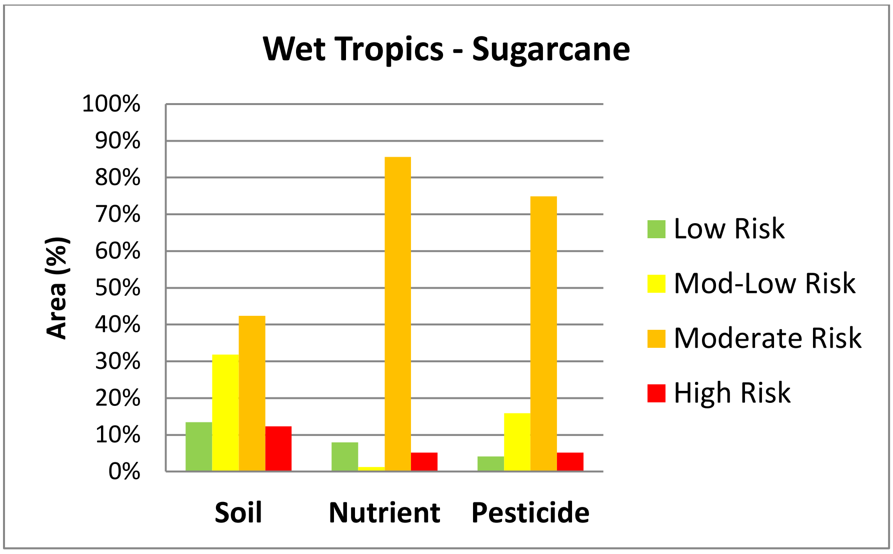
As at June 2014, best management practice systems were used by approximately 22 per cent of sugarcane growers for pesticides (27,000 hectares), nine per cent for nutrients (13,000 hectares) and 45 per cent for soil (62,000 hectares).There are approximately 1343 growers managing 1364 square kilometres of land in the Wet Tropics region.



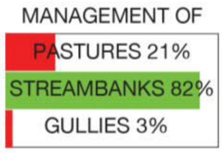
A total of 164 sugarcane growers managing 46,978 hectares improved various practices through collaboration with Terrain NRM and the Australian Government's Reef Programme including:

- 63 farms adopted improved controlled machinery traffic practices
- 30 farms adopted subsurface application of nitrogen fertiliser
- 37 growers set fertiliser rates based on expected yield potential and 14 growers moved toward altering rates for yield zones within blocks.
- 68 growers moved towards banding residual herbicides
- 40 growers changed from conventional to zonal tillage systems.

A further 22 growers adopted bandspraying and/or fertiliser rates based on expected paddock yield potential as a result of engagement with Queensland Government extension services.



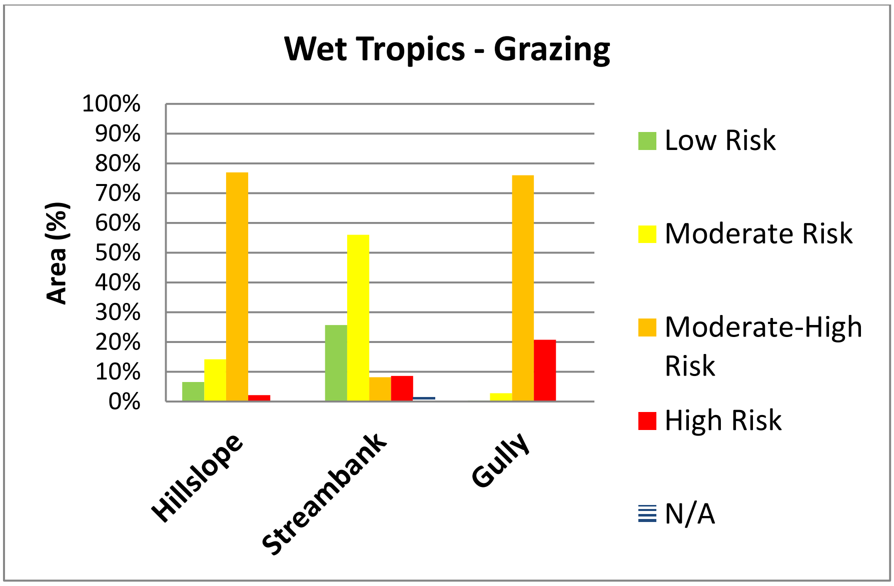
Grazing



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

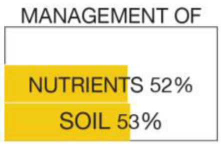
There were no discrete management practice change investments targeting water quality improvements in the grazing industry in the Wet Tropics region during 2013-2014. As at June 2014, approximately 21 per cent of graziers were using best management for practices relating to pasture (hillslope) erosion (147,000 hectares), 82 per cent for practices related to streambank erosion (573,000 hectares) and three per cent for practices related to gully erosion (21,000 hectares).

There are 935 graziers managing 6983 square kilometres 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.



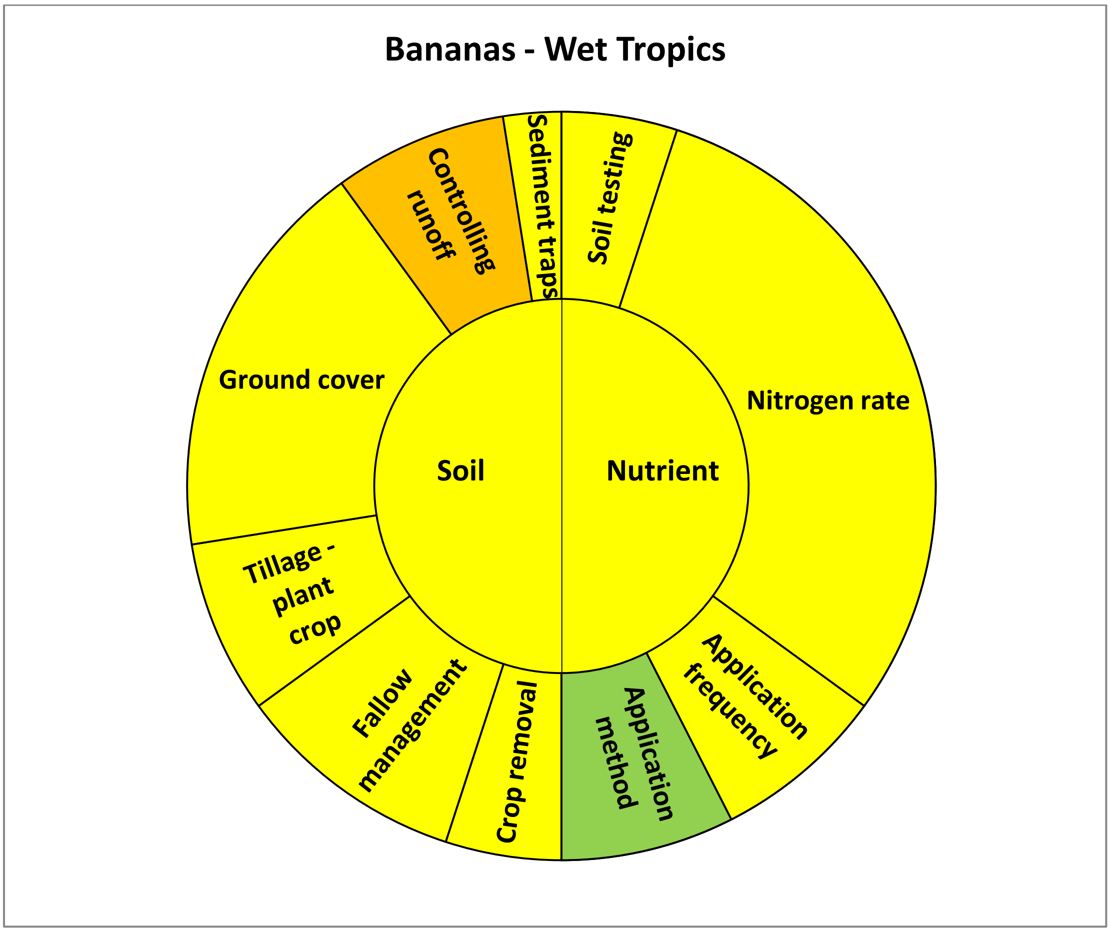
**The Not Applicable category represents those graziers without riparian areas to manage*.

Bananas

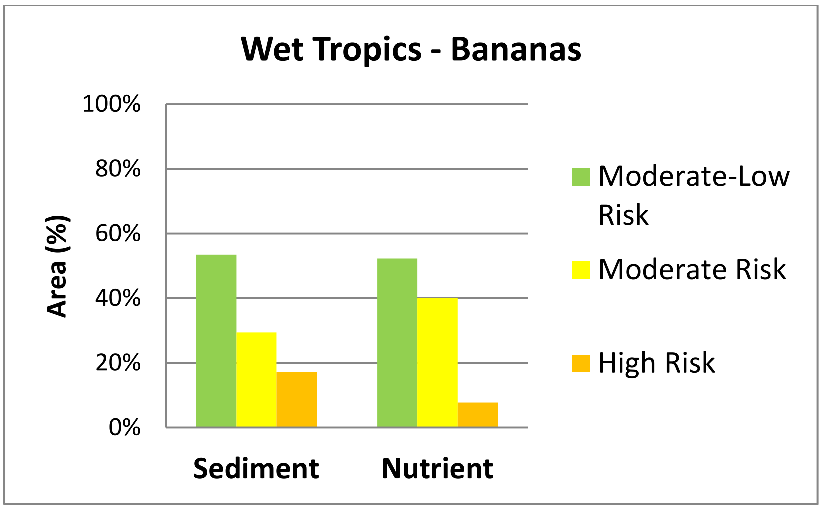


Target: 90 per cent of banana farming lands are managed using best management practice systems by 2018.

By June 2014, approximately 52 per cent of banana farming land was managed under best practice systems for nutrients (6500 hectares) and 53 per cent for soil (6700 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. There are approximately 260 growers managing 11,000 hectares of bananas in the Wet Tropics region.



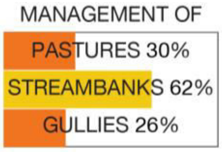
The main source of identified farm management practice change in 2013-2014 was the Australian Government's Reef Programme, facilitated by Terrain NRM. This program directly funded farm equipment and infrastructure improvements which resulted in 15 farms (1343 hectares) adopting best practice nutrient management and 13 farms (1099 hectares) adopting best practice soil management.



Wet Tropics - Bananas
100%
80%
60%
40%
20%
0%
Area (%)
Sediment
Nutrient
Moderate-Low Risk
Moderate Risk
High Risk

Burdekin

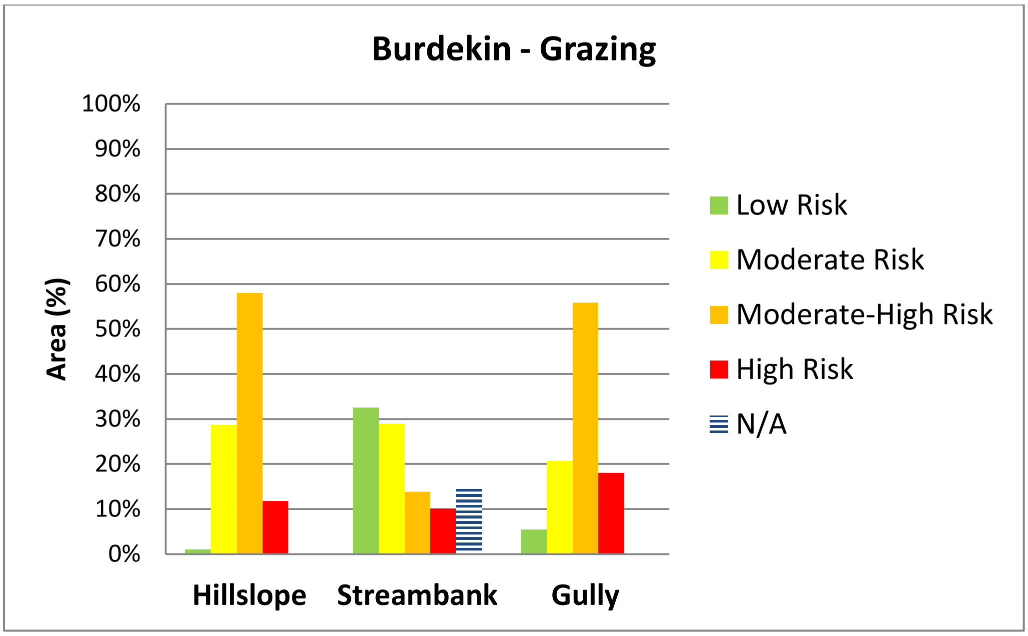
Grazing



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

By June 2014, approximately 30 per cent of graziers were best management practices relating to pasture (hillslope) erosion (3.7 million hectares), 62 per cent for practices related to streambank erosion (7.6 million hectares) and 26 per cent for practices related to gully erosion (3.2 million hectares).

There are approximately 983 graziers managing 135,753 square kilometres of land in the Burdekin region.

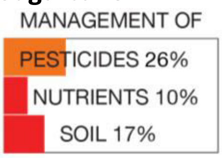


**The Not Applicable category represents those graziers without riparian areas to manage*.

NQ Dry Tropics (funded by the Australian Government's Reef Programme) directly assisted 45 graziers to adopt best practice, with co-funded management improvements on over 35,000 hectares of grazing land.

The Grazing BMP program and associated Queensland Government extension support worked with 215 graziers on over 1.8 million hectares of grazing land in assessing farm management practices and identifying potential actions to improve. Many of these grazing businesses have implemented management changes which will be reported in future cards.

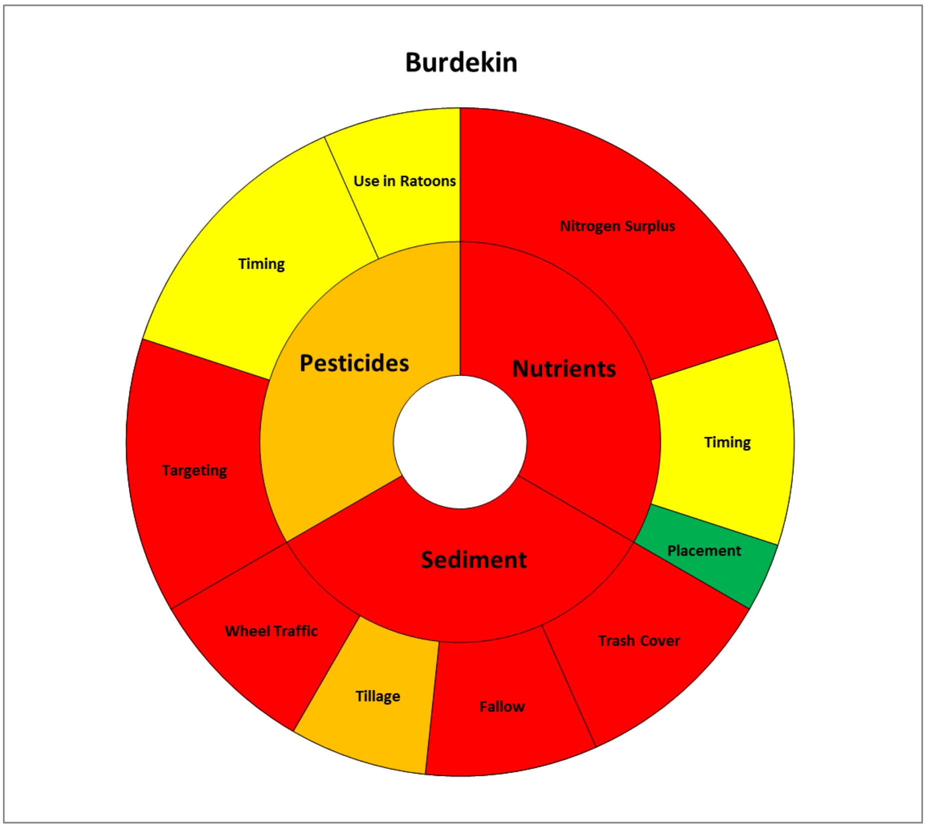
Sugarcane



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

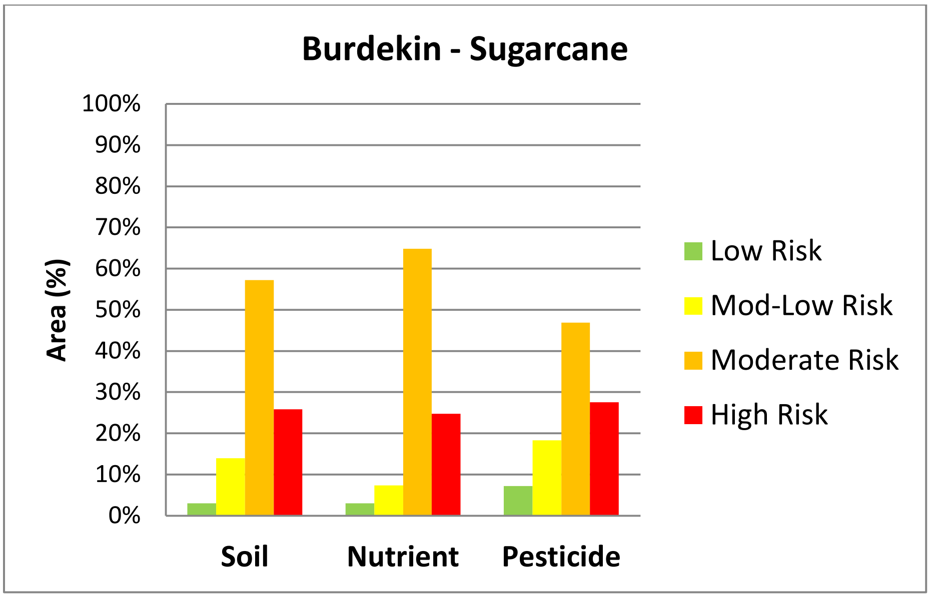
By June 2014, approximately 26 per cent of sugarcane land was managed using best management practice systems for practices relating to pesticides (21,000 hectares), 10 per cent for nutrients (9000 hectares) and 17 per cent for soil (14,000 hectares).

There are 556 growers managing 829 square kilometres of land in the Burdekin region.

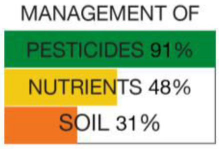


A total of 39 sugarcane growers implemented on farm management changes through collaboration with NQ Dry Tropics and the Australian Government's Reef Programme, for example:

- 22 growers improved irrigation management on 3274 hectares. Irrigation is the primary driver of off-farm nutrient and pesticide transport on sugarcane farms in the Burdekin region. 19 of these growers constructed or modified irrigation recycling pits to capture and reuse irrigation tailwater.
- six growers improved their capability to fine tune nutrient applications over 1688 hectares
- six growers improved their pesticide application capability over 1258 hectares
- three growers improved soil management over an area of 2144 hectares.

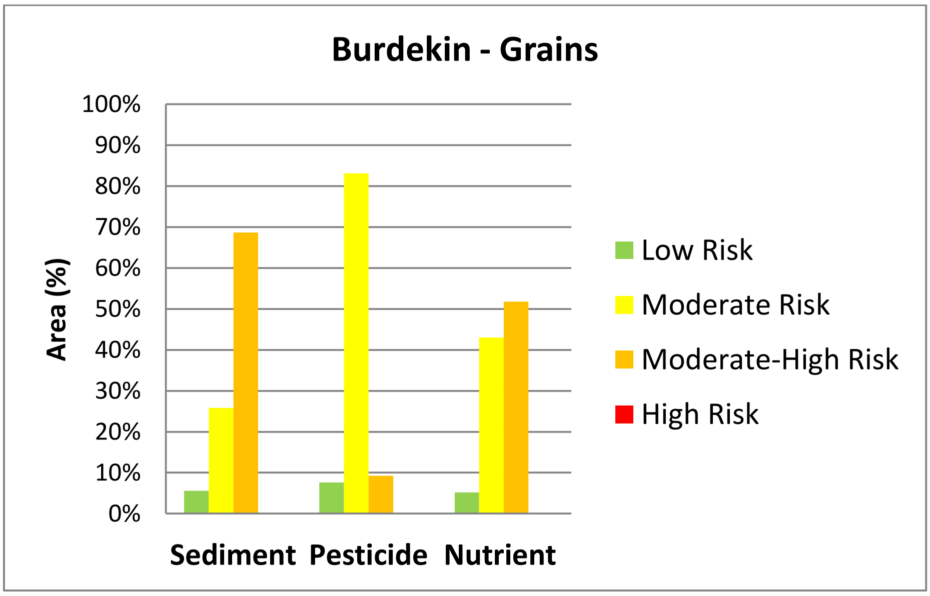


Grains



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

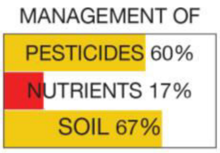
By June 2014, best management systems were used on approximately 91 per cent of grain farming land for pesticides (112,000 hectares), 48 per cent for nutrients (59,000 hectares) and 31 per cent for soil (39,000 hectares). There are approximately 44 growers managing 123,000 hectares under grain crops in the Burdekin region.



On farm management changes were implemented through Reef Programme grants and the Grains BMP for:

- nutrients on 1564 hectares
- soil on 1850 hectares
- pesticides on 11,040 hectares.

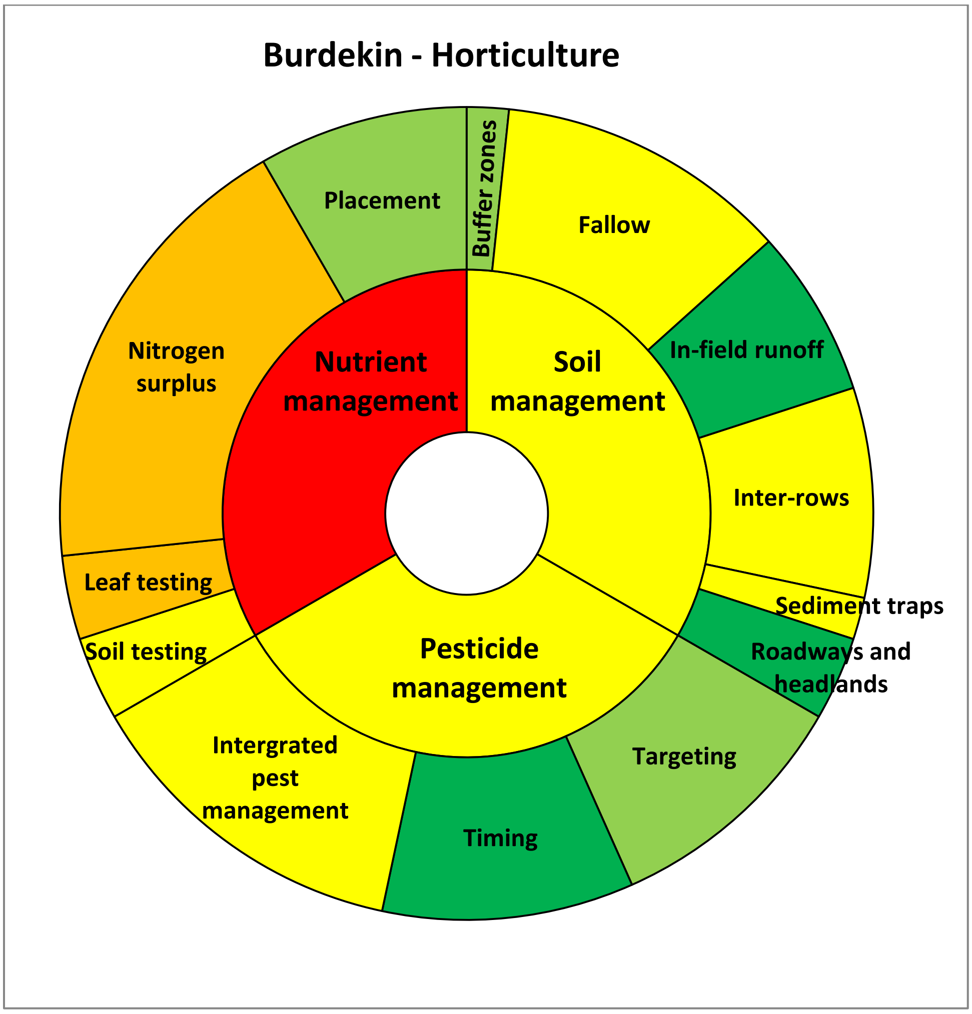
Horticulture



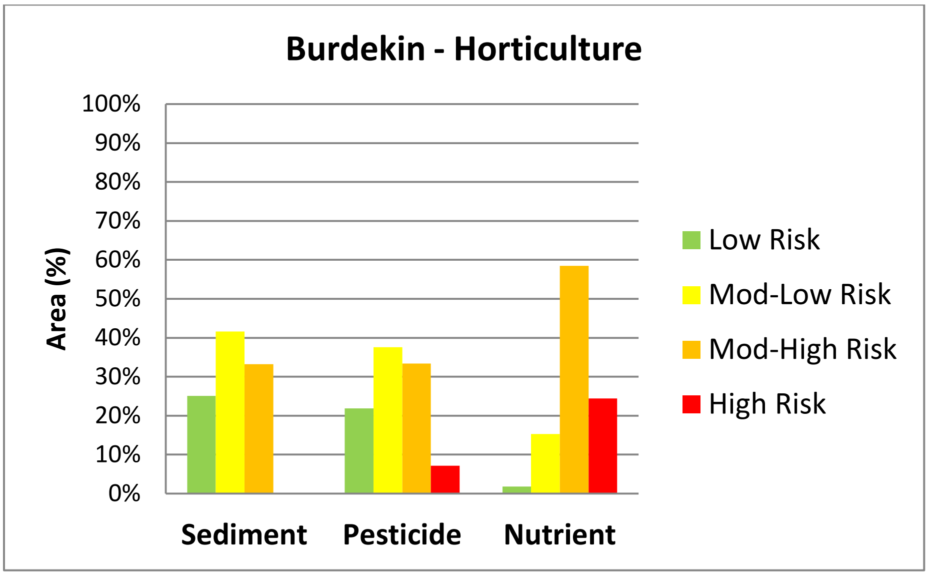
Target: 90 per cent of horticulture lands are managed using best management practice systems by 2018.

By June 2014, best management practice systems were used by approximately 60 per cent of horticulture growers for pesticides (14,900 hectares), 17 per cent for nutrients (4300 hectares) and 67 per cent for soil (16,700 hectares).

There are approximately 200 horticulture producers farming 250 square kilometres of land in the Burdekin region.

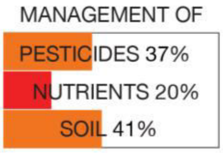


A total of 10 horticulture producers in the Burdekin region improved management practices over 3268 hectares during 2013-2014, with the assistance of NQ Dry Tropics and financial incentives through the Australian Government's Reef Programme.


Burdekin - Horticulture
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Area (%)
Sediment
Pesticide
Nutrient
Low Risk
Mod-Low Risk
Mod-High Risk
High Risk

Mackay Whitsunday

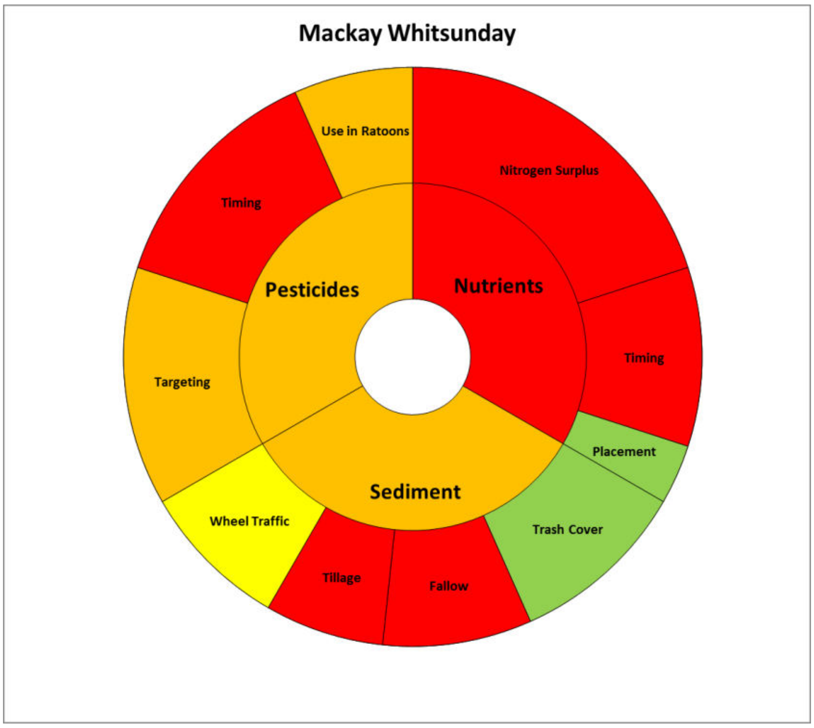
Sugarcane



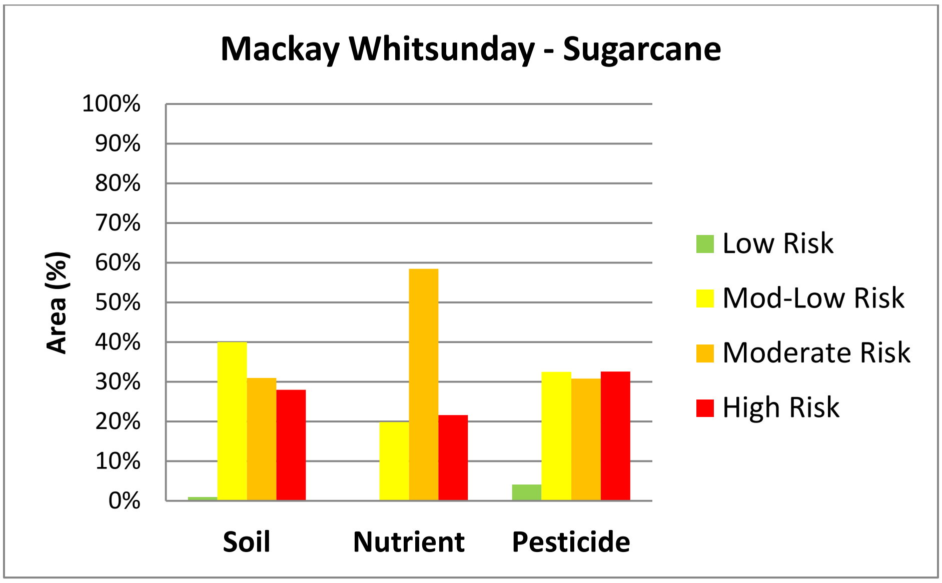
Target: 90 per cent of sugarcane lands are managed using best management practice systems by 2018.

As at June 2014, approximately 37 per cent of sugarcane farming land was managed using best management for practices relating to pesticides (50,000 hectares), 20 per cent for nutrients (27,000 hectares) and 41 per cent for soil (56,000 hectares).

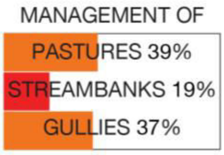
There are 1380 growers managing 1362 square kilometres of land in the Mackay Whitsunday region.



Seven sugarcane growers were identified as adopting best management practices during 2013-2014. The vast majority of investment occurred through the Australian Government's Reef Programme, focusing on 1:1 extension with growers to develop improved nutrient and pesticide management systems. A further 380 sugarcane growers (over a third of the industry in this region) were directly involved in this program during 2013-2014. Many of these growers will have management changes to report in future years (2014-2015) as new knowledge and skills attained through participation in extension begin to result in land management improvements. Many of these growers are trialling nitrogen fertiliser rates based on their own expected farm yield potential.

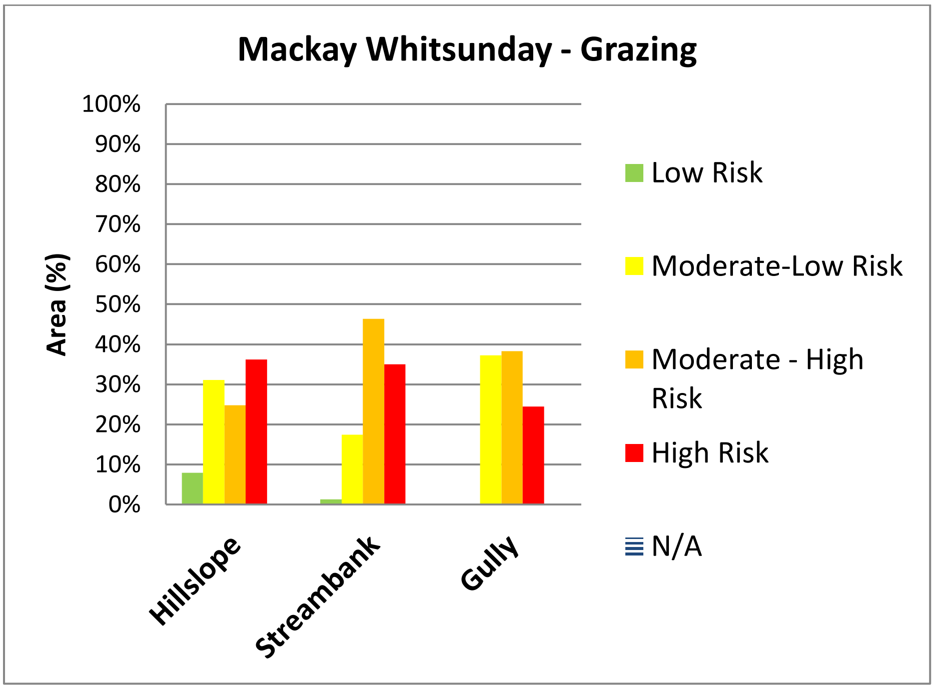


Grazing



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

By June 2014, approximately 39 per cent of graziers were using best management practice systems for practices related to surface (hillslope) erosion (119,000 hectares), 19 per cent for practices relating to streambank erosion (57,000 hectares) and 37 per cent for practices relating to gully erosion (113,000 hectares). There are approximately 416 graziers managing 3038 square kilometres of land in the Mackay Whitsunday region.



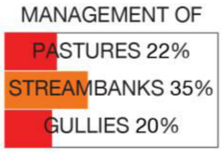
**The Not Applicable category represents those graziers without riparian areas to manage.*

A total of 29 graziers in the Mackay Whitsunday region improved their grazing land management practices with the assistance of Reef Catchments and the Australian Government's Reef Programme, for example:

- 15 graziers improved the protection of streambanks over 795 hectares through the construction of riparian fencing and off stream watering points for livestock
- eight graziers improved fencing infrastructure over 2334 hectares to enable grazing management of different land types
- five graziers implemented erosion control measures on 77 hectares of land.

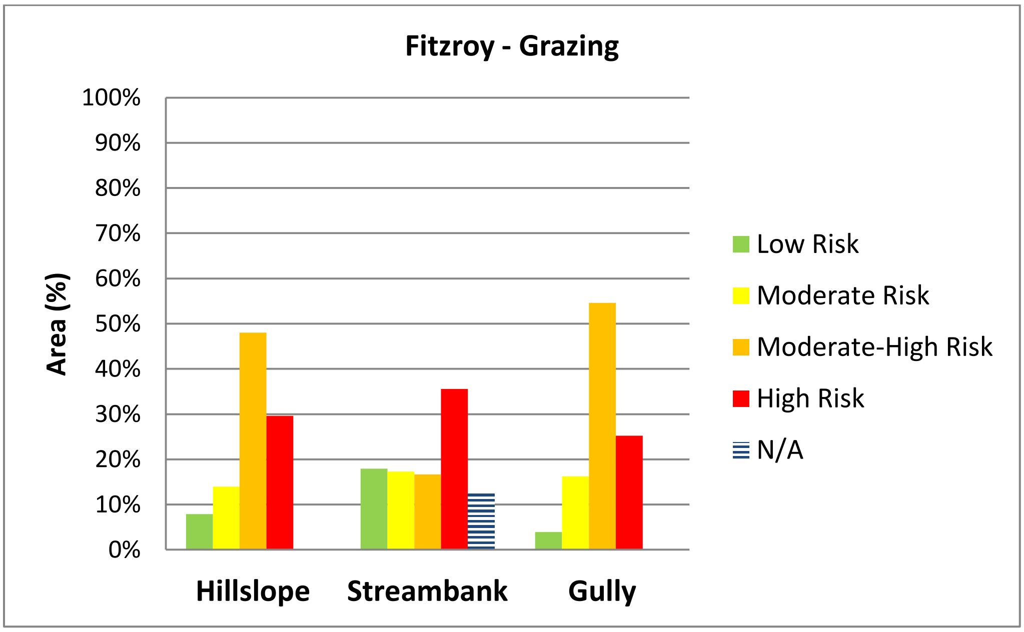
Fitzroy

Grazing



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

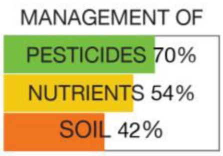
By June 2014, approximately 22 per cent of graziers were using best management practices for practices relating to surface (hillslope) erosion (2.8 million hectares), 35 per cent for practices relating to streambank erosion (4.5 million hectares) and 20 per cent for practices relating to gully erosion (2.6 million hectares). There are approximately 3666 graziers managing 126,880 square kilometres of land in the Fitzroy region.



**The Not Applicable category represents those graziers without riparian areas to manage*.

A total of 81 graziers adopted best practice through collaboration with the Fitzroy Basin Association (funded through the Australian Government's Reef Programme), which co-funded management improvements on over 88,000 hectares of grazing land. The Grazing BMP program and associated Queensland Government extension support worked with 650 graziers on over 1.5 million hectares of grazing land to assess farm management practices and identify potential actions to improve. Many of these grazing businesses have implemented management changes which will be reported in future cards.

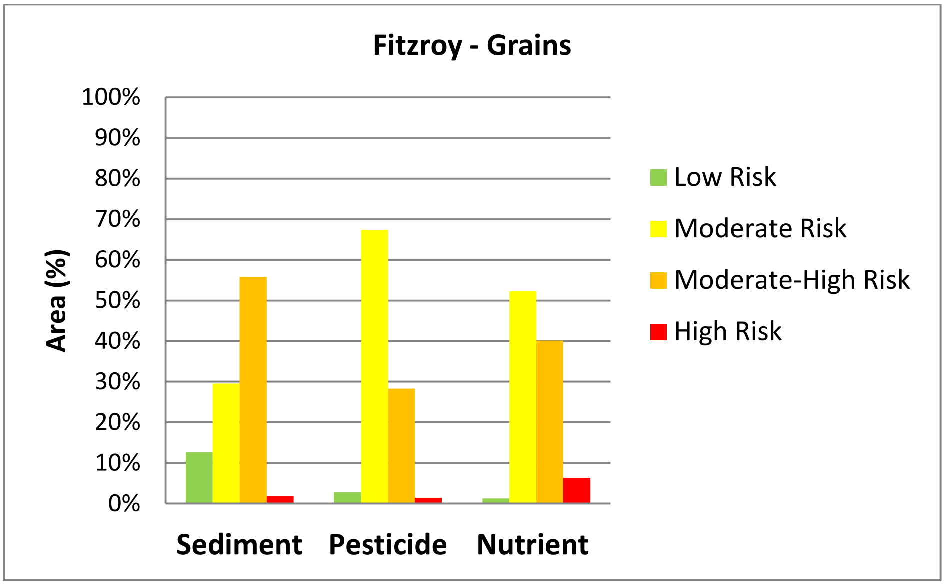
Grains



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

By June 2014, best management systems were used by approximately 70 per cent of grain growers for pesticides (643,000 hectares), 54 per cent for nutrients (490,000 hectares) and 42 per cent for soil (387,000 hectares).

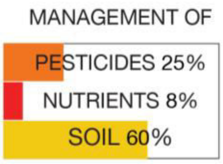
There are approximately 600 grain growers managing 9146 square kilometres of land in the Fitzroy region.



A total of 16 grain growers implemented best practice improvements through working directly with the Grains BMP program and the Australian Government's Reef Programme including:

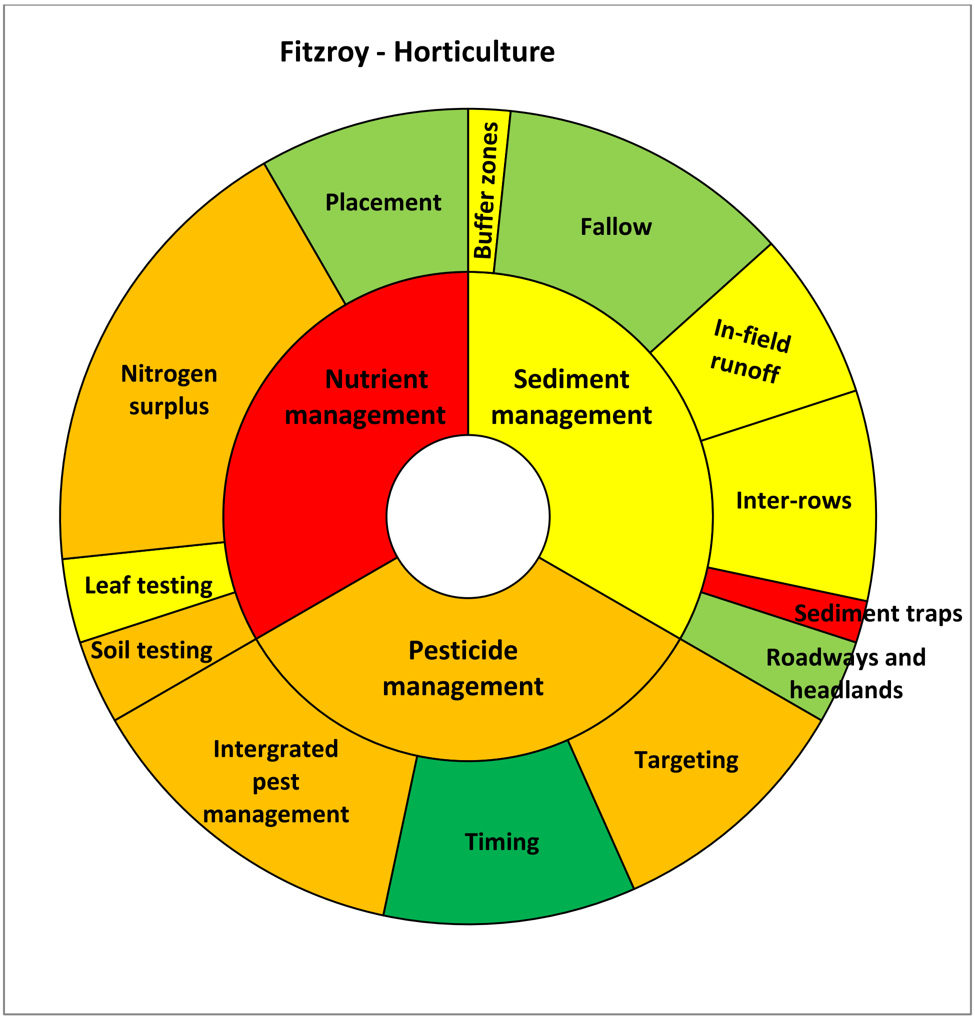
- nutrient management improvements occurred over four farms and 1774 hectares
- 12 farmers installed and/or modified contour banks and other erosion control structures over 3928 hectares of grain farming land. These structures are critical in preventing the transport of very fine sediments into streams.
- five farmers adopted best practice controlled traffic systems over 2559 hectares of land through machinery modifications and accurate machine guidance systems. These practices reduce runoff and soil loss, and also reduce the total rate of nutrient and pesticides applied due to reducing machine overlap.

Horticulture

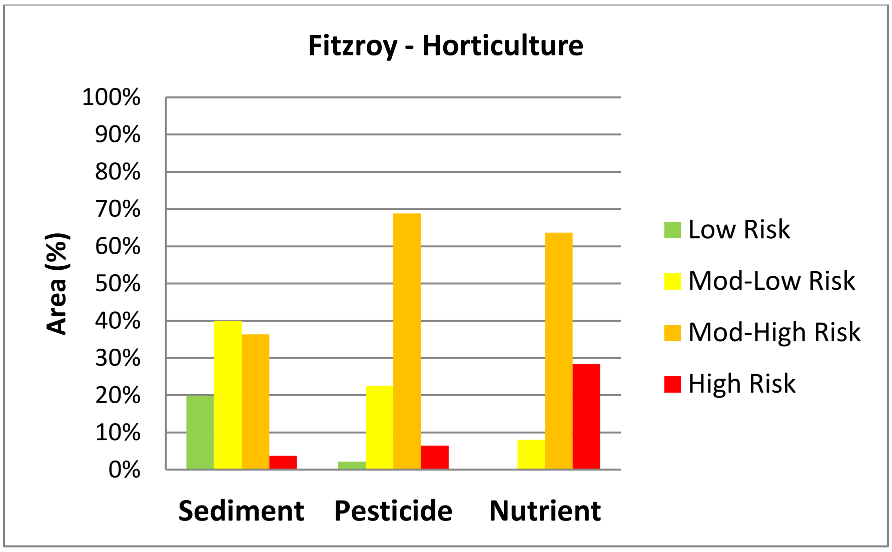


Target: 90 per cent of horticulture lands are managed using best management practice systems by 2018

By June 2014, best management practice systems were used by approximately 25 per cent of horticulture growers for pesticides (1900 hectares), eight per cent for nutrients (600 hectares) and 60 per cent for soil (4600 hectares)**.** There are approximately 100 horticulture producers farming 77 square kilometres of land in the Fitzroy region.

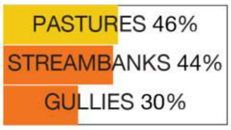


The Fitzroy Basin Association facilitated, through the Australian Government's Reef Programme, farm management improvements on eight farms and 1816 hectares of horticultural land during 2013-2014.



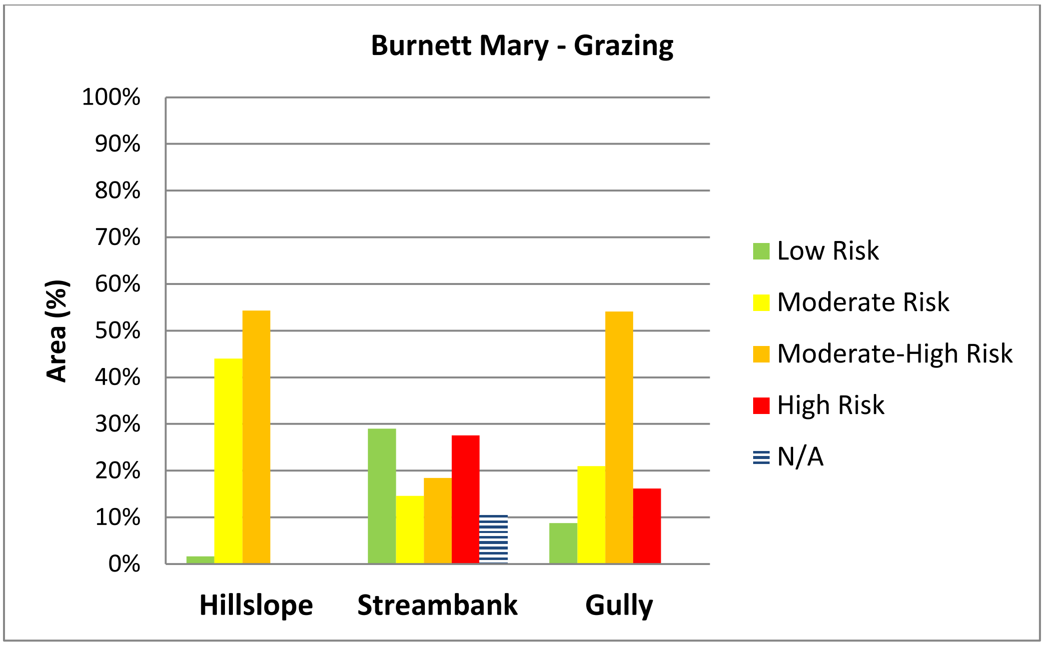
Burnett Mary

Grazing



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

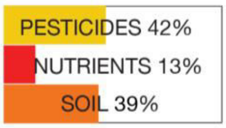
By June 2014, approximately 46 per cent of graziers were using best practice systems for practices relating to surface (hillslope) erosion (1.3 million hectares), 44 per cent for practices relating to streambank erosion (1.25 million hectares) and 30 per cent for practices relating to gully erosion (850,000 hectares). There are approximately 2495 graziers managing 28,618 square kilometres of land in the Burnett Mary region.



**The Not Applicable category represents those graziers without riparian areas to manage*.

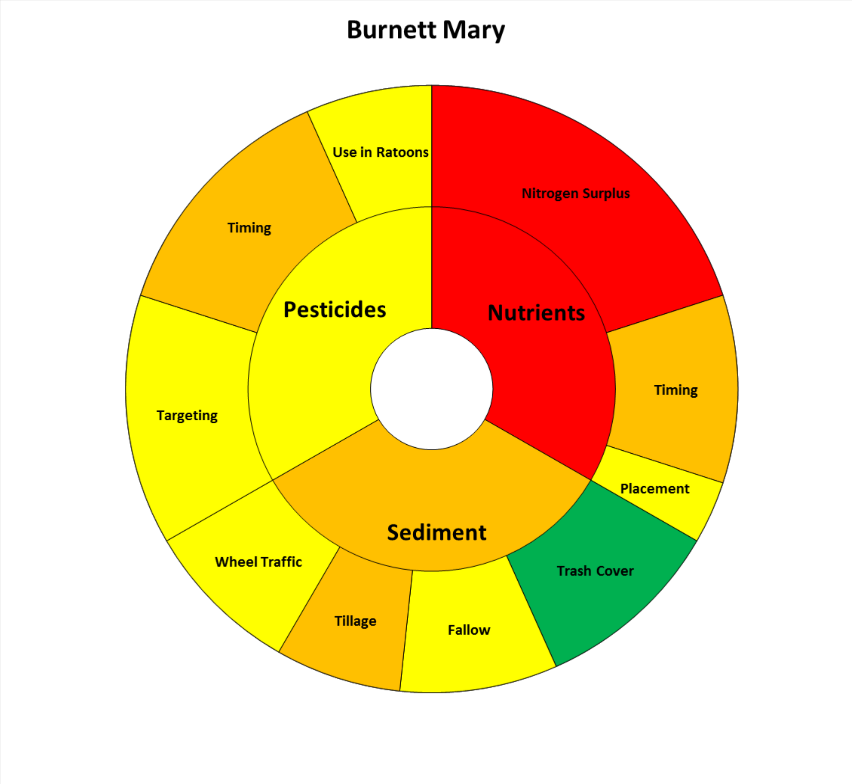
A total of 42 graziers implemented best practice on 3115 hectares of grazing lands through collaboration with the Burnett Mary Regional Group and the Australian Government's Reef Programme. The majority of these projects involved excluding livestock from vulnerable stream frontages.

Sugarcane



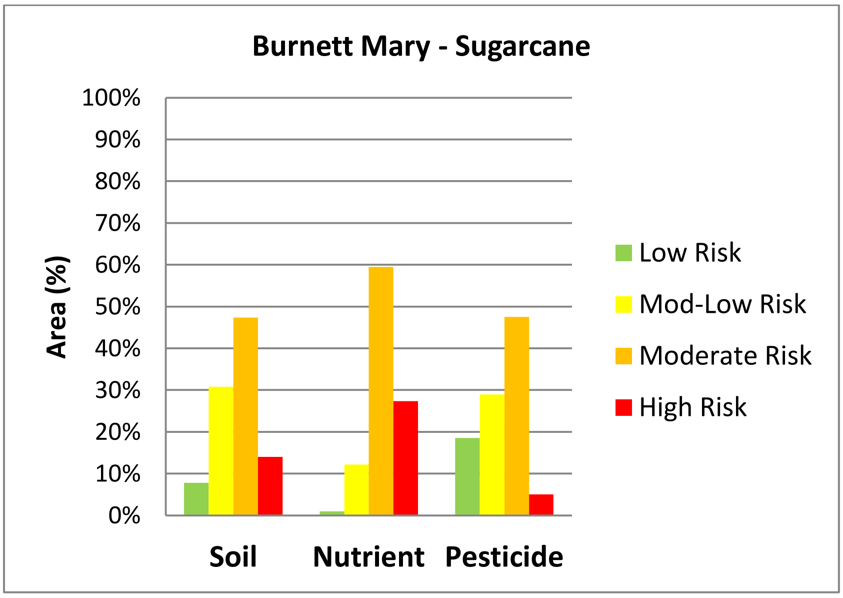
Target: 90 per cent of sugarcane lands are managed using best management practice systems by 2018.

As at June 2014, approximately 42 per cent of sugarcane growers were using best management for practices relating to pesticides (41,000 hectares), 13 per cent for nutrients (11,000 hectares) and 39 per cent for soil (33,000 hectares). There are approximately 498 growers managing 476 square kilometres of land in the Burnett Mary region.

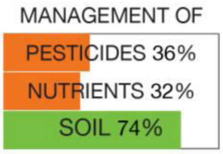


A total of 35 sugarcane growers adopted improved practices on 4163 hectares of land through collaboration with the Burnett Mary Regional Group and the Australian Government's Reef Programme, for example:

- eight growers adopted varying degrees of controlled traffic through adopting machine GPS guidance across 773 hectares
- seven growers improved water use efficiency and reduced potential for off farm transport of pollutants over 349 hectares
- pesticide management practices were improved on six farms and 1096 hectares
- nutrient application practices were improved on six farms and 1173 hectares
- two growers adopted reduced tillage regimes over 534 hectares.

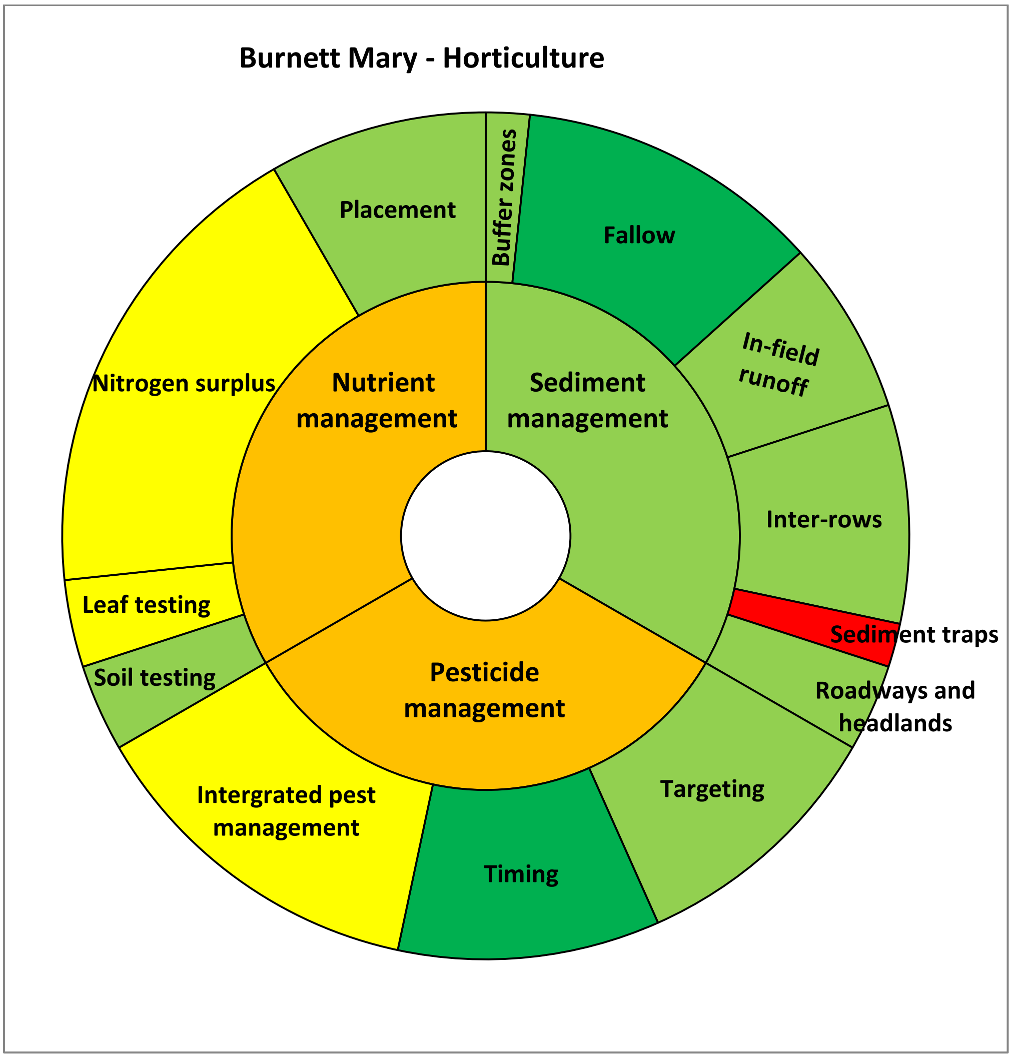


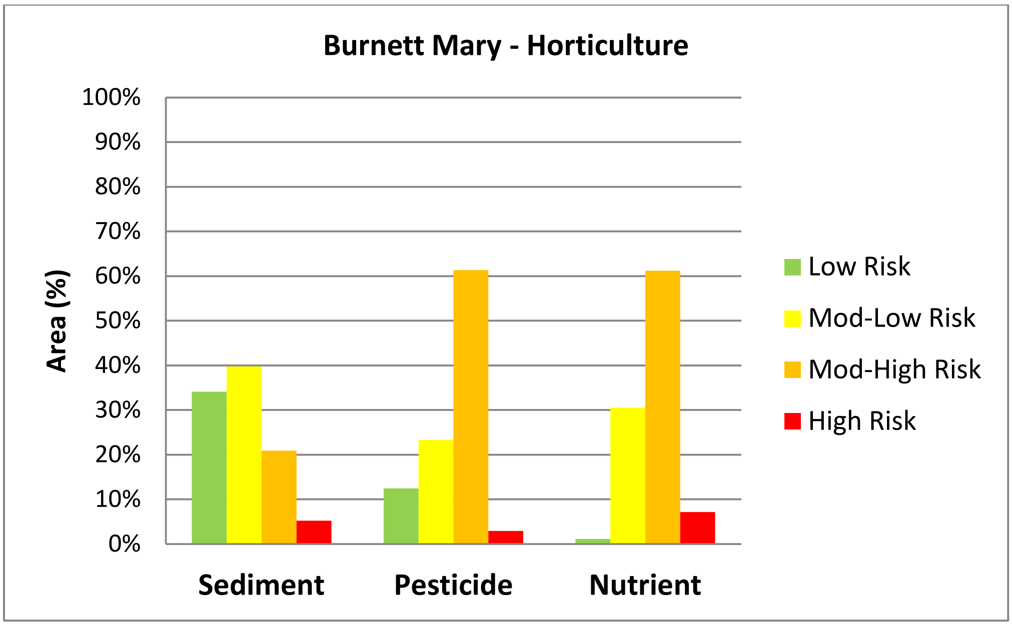
Horticulture



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

As at June 2014, best management practice systems were used by approximately 36 per cent of horticulture growers for pesticides (8200 hectares), 32 per cent for nutrients (7300 hectares) and 74 per cent for soil (17,000 hectares). There are approximately 280 horticulture producers farming around 230 square kilometres of land in the Burnett Mary region. The area under horticulture in this region can vary considerably due to rotations between sugarcane and annual vegetable crops.




Burnett Mary - Horticulture
Area (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Sediment
Pesticide
Nutrient
Low Risk
Mod-Low Risk
Mod-High Risk
High Risk

Ground cover results

The updated ground cover target in the Reef Water Quality Protection Plan 2013 (Reef Plan) is:
"Minimum 70 per cent late dry season ground cover on grazing lands."

The target was increased from 50 per cent (in Reef Plan 2009) based on a range of independent studies which indicated that a ground cover level of 70 per cent was required to minimise erosion by water.

Mean late dry season ground cover in 2013-2014 for the Great Barrier Reef grazing lands was above the target at 77 per cent. Mean annual rainfall in 2014 was below the 27-year mean for all regions except for the Wet Tropics and Cape York. Large parts of western Queensland were drought declared during mid-to-late 2013 and 2014 and this included some areas of the Burdekin and Fitzroy regions. Generally drier conditions across the Great Barrier Reef led to reductions in mean ground cover, although the localised effects may have been more pronounced in some areas.

Scoring system

- Very good
- Good
- Moderate
- Poor
- Very poor
- No data

Great Barrier Reef-wide

77%

Target: 70 per cent late dry season ground cover.
Very good progress: Late dry season mean ground cover across grazing lands was 77 per cent. The 27-year mean ground cover was 79 per cent.

All regions had mean ground cover levels above the target ranging from 73 per cent (Burdekin) to 88 per cent (Mackay Whitsunday) in 2014. The area below the 70 per cent target was 25 per cent in 2014, compared to 23 per cent over the 27-year period (Table 1).

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

Region	27-year mean ground cover (%)	2014 mean ground cover (%)	Area with less than 70% ground cover averaged over past 27 years	Area with less than 70% ground cover in 2014 (%)
Cape York	85	84	13	16
Wet Tropics	87	85	6	7
Burdekin	75	73	33	36
Mackay Whitsunday	89	88	5	5
Fitzroy	79	78	20	20
Burnett Mary	86	81	7	12
Total Great Barrier	79	77	23	25

The ground cover distribution for the Great Barrier Reef provides a visual representation of the results (Figure 1). The proportion of the catchment with less than 70 per cent cover is labelled (25%) and shaded blue. Distribution of the long-term mean ground cover levels is displayed as the dashed line and the 2014 distribution of ground cover levels is the solid line. The median of the long-term mean and 2014 cover are presented, with the actual median value in 2014 (79%) shown in red.

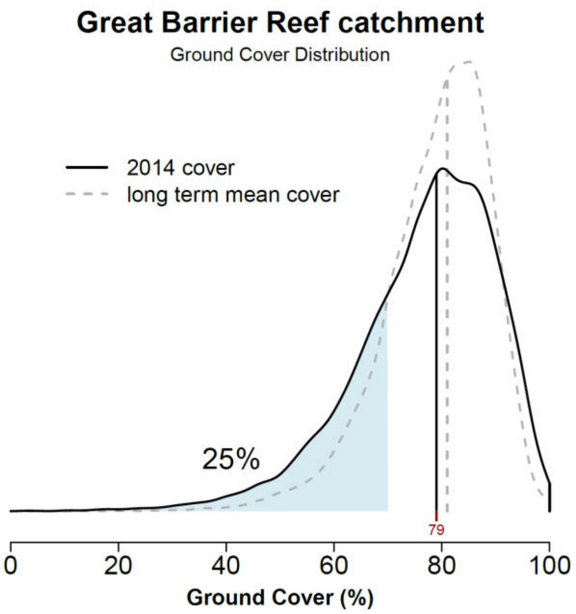


Figure 1: Great Barrier Reef ground cover distribution.

Ground cover changes over time

Mean ground cover across the Great Barrier Reef region has been declining over the past four years, from 92 per cent in 2010 to 77 per cent in 2014. Very high rainfall in 2010 and 2011 resulted in a very high proportion of the region being above 70 per cent ground cover and subsequent drier years have 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 was just over 70 per cent and the percentage of area with mean ground cover below 70 per cent ranged from 37 to 41 per cent (Figures 2 and 3). There was low annual rainfall in the preceding years.

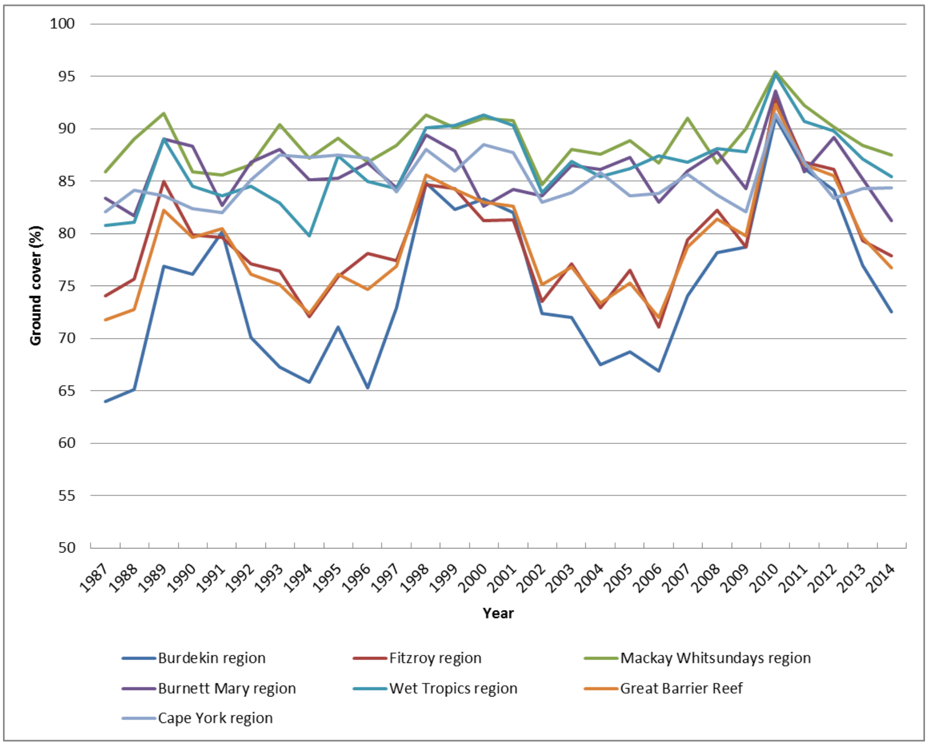


Figure 2: Mean late dry season ground cover in the Great Barrier Reef regions from 1987 to 2014. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

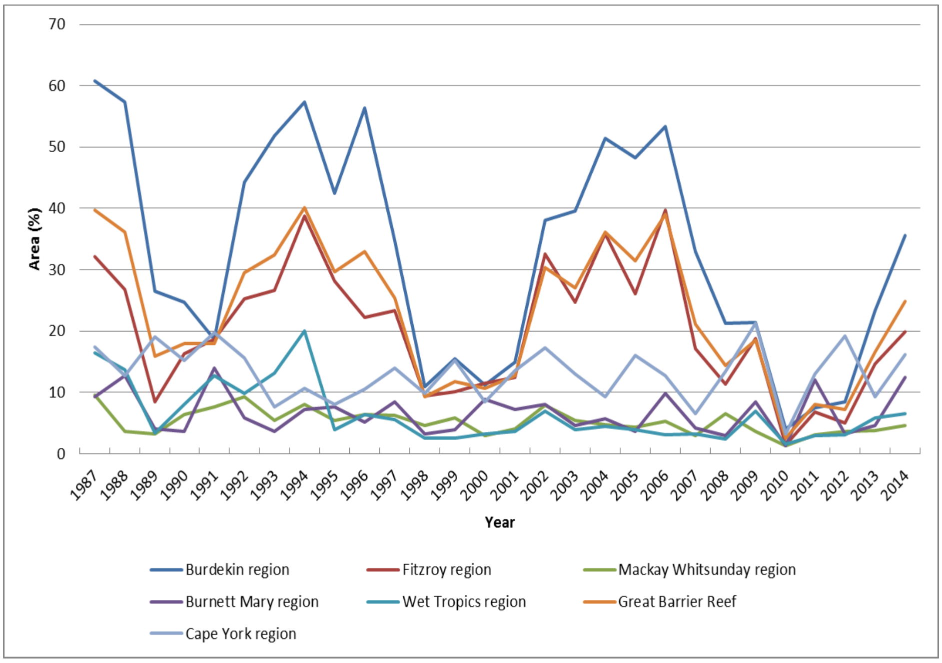


Figure 3: Percentage of the Great Barrier Reef regions with ground cover below 70 per cent from 1987 to 2014.

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 27-years. In addition, the area with mean ground cover below 70 per cent in these regions has been below 22 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. In these regions, mean ground cover declines in drier years and the area below 70 per cent ground cover increases. In general, in these regions, a more extended time lag follows the end of a wet period before the region has large areas of low ground cover. Furthermore, ground cover returns to high levels comparatively quickly following rain at the end of a dry period. This may be due to a range of factors including stocking rates during wet and dry periods, localised climate effects, land type, land condition and pasture composition.

Mean rainfall for 2014 in the Great Barrier Reef region was 714 millimetres, 99 millimetres below the long-term mean of 813 millimetres (Figure 4).

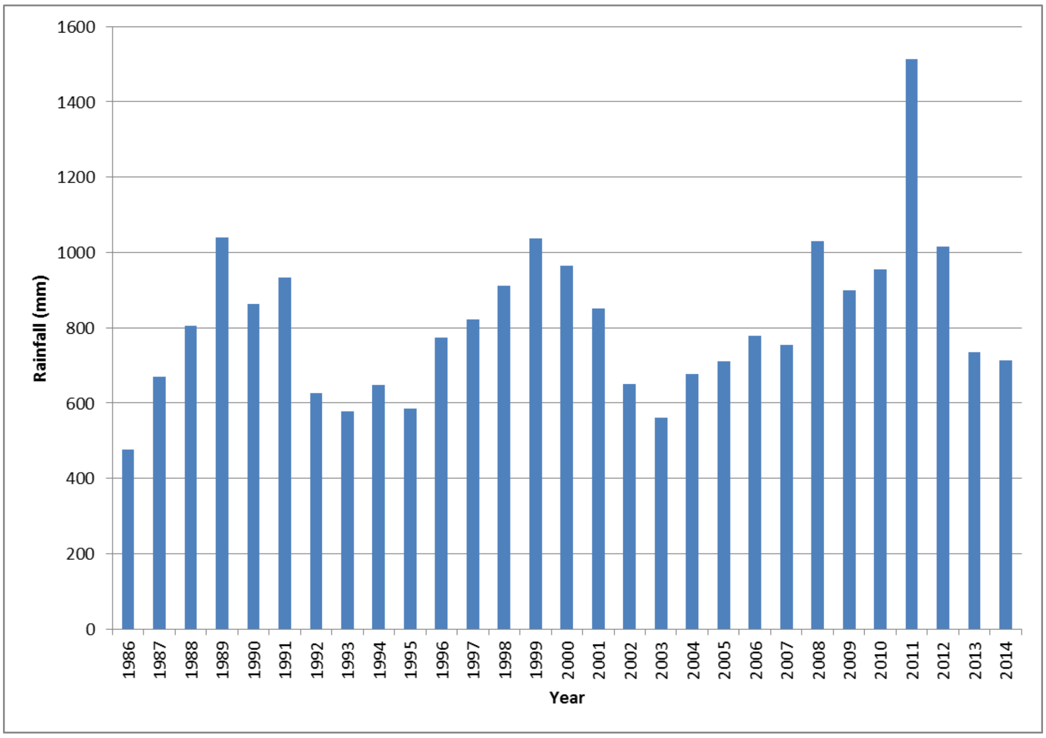


Figure 4: Mean annual rainfall in the Great Barrier Reef region from 1986 to 2014. Note that a year is from September to September to align with late dry season reporting.

Although ground cover is above the target for each of the regions, sediment loads are affected by localised sources such as gully scalds and streambank erosion.

Ground cover in the regions

Figure 5 displays the percentage of ground cover for each of the regions and their catchments.

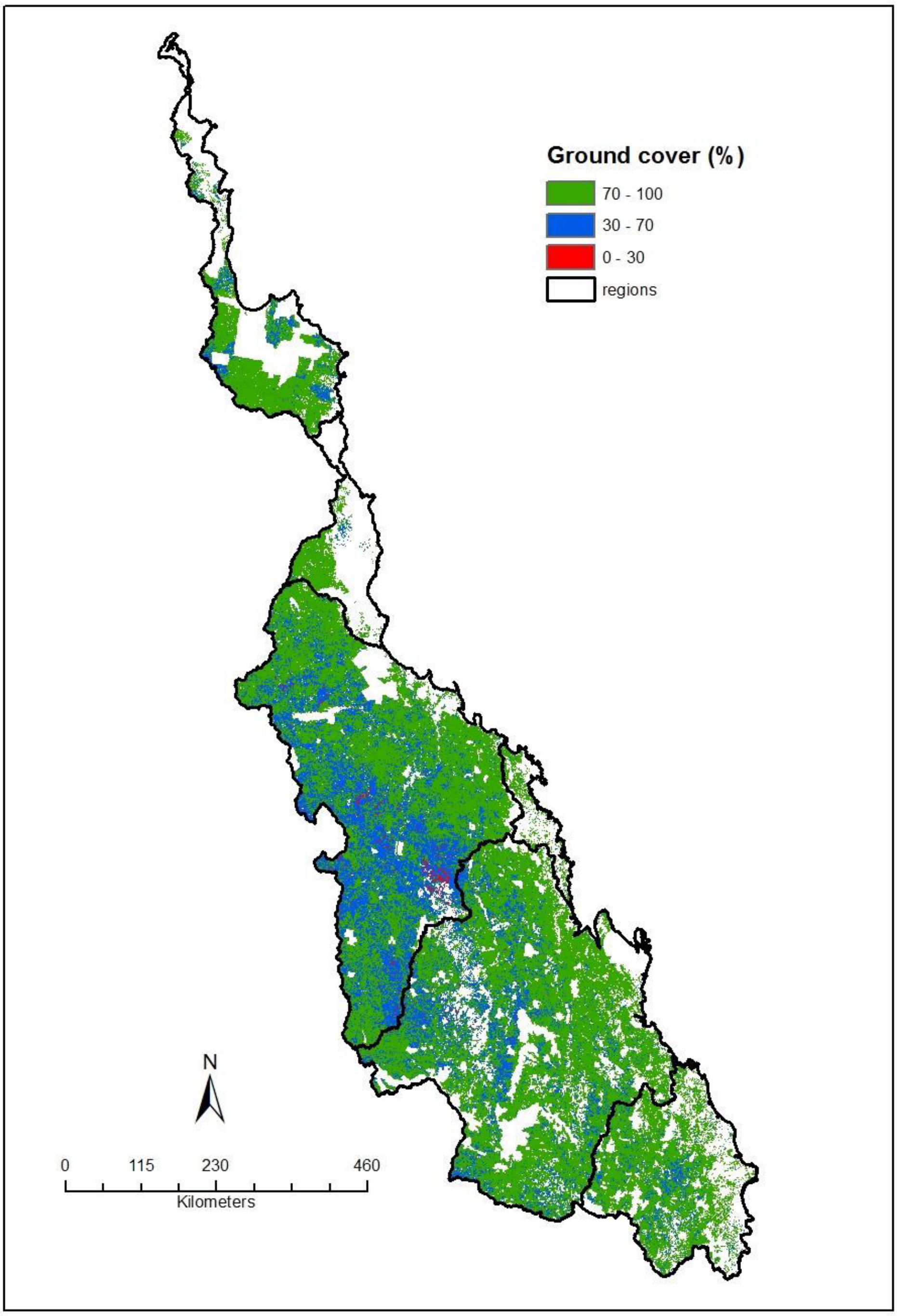


Figure 5: Percentage of ground cover for each of the regions and their catchments.

The map of ground cover deciles (Figure 6) compares the spring 2014 cover to the long-term cover (1988 to 2012) for the spring season. Red on the map refers to cover being the lowest level in that time period (lowest deciles) while blue shows cover that is at the highest levels (or deciles) in that time period. This may be used as a guide to indicate areas of concern or improvement.

Parts of the southern Fitzroy, eastern Burnett Mary, central and northern Burdekin, and patches of the Wet Tropics and Cape York regions had very low cover compared to long-term levels of ground cover in those areas. There was very high cover (compared to the long-term levels) in parts of the northern and eastern Fitzroy, southern Cape York and patches of the Burdekin regions.

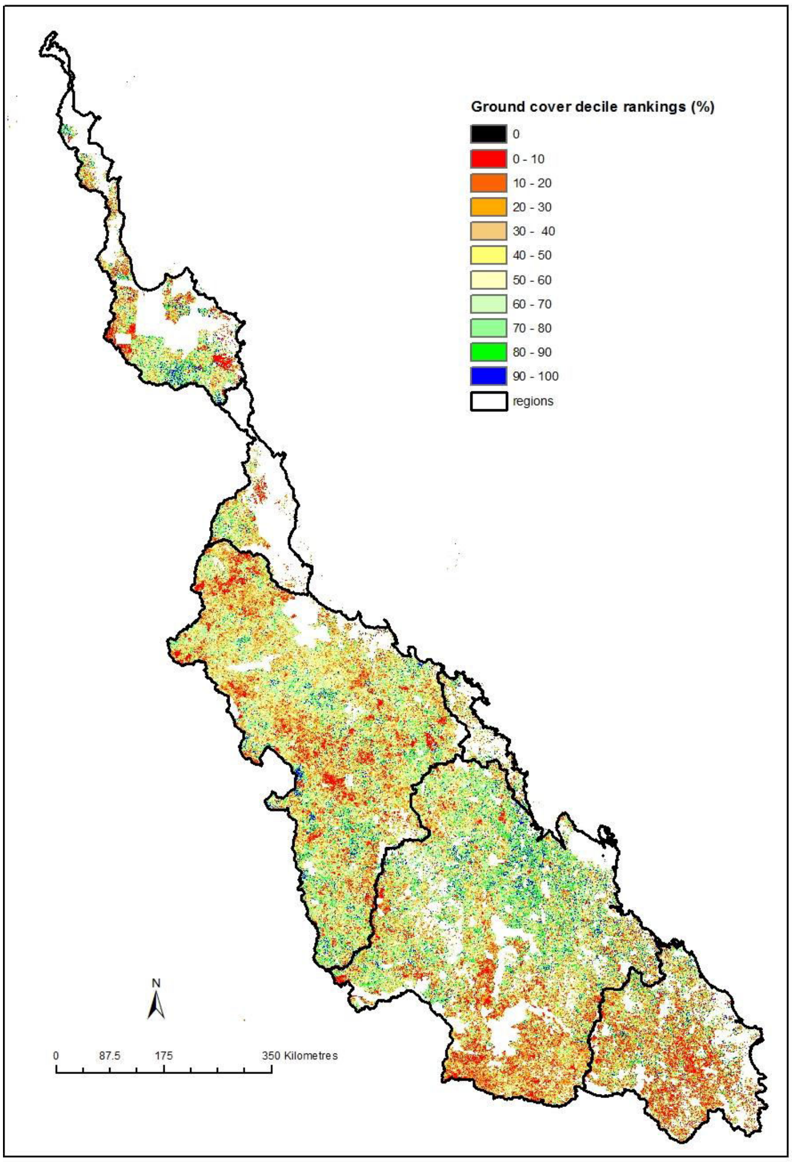


Figure 6: Map of ground cover deciles comparing spring 2014 cover to long-term cover (1988–2012).

Cape York

84%

Target: 70 per cent late dry season ground cover.

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

Table 2: Ground cover results for the Cape York region and catchments

Catchment	27-year mean ground cover (%)	2014 mean ground cover (%)	Area with less than 70% ground cover averaged over past 27 years (%)	Area with less than 70% ground cover in 2014 (%)
Olive-Pascoe	85	85	16	19
Lockhart	85	83	16	20
Normanby	86	86	12	11
Jeannie	81	75	22	38
Endeavour	86	75	12	45
Stewart	85	81	17	25
Cape York region (excluding Jacky Jacky	85	84	13	16

The ground cover distribution for Cape York provides a visual representation of the results (Figure 7). The proportion of the catchment with less than 70 per cent cover is labelled (16%) and shaded blue. Distribution of the long-term mean ground cover levels is displayed as the dashed line and the 2014 distribution of ground cover levels is the solid line. The median of the long-term mean and 2014 cover are presented, with the actual median value in 2014 (89%) shown in red.

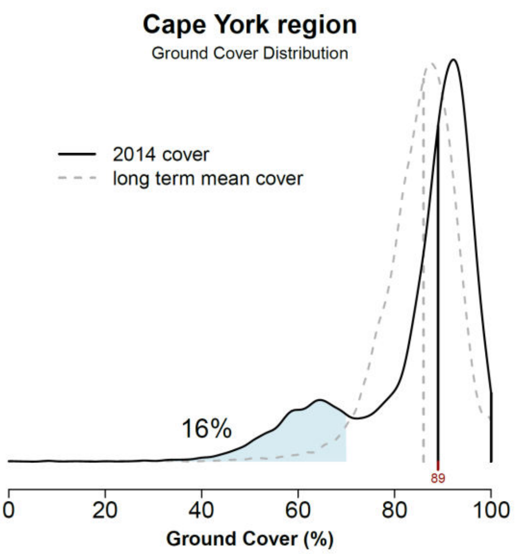


Figure 7: Cape York ground cover distribution.

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

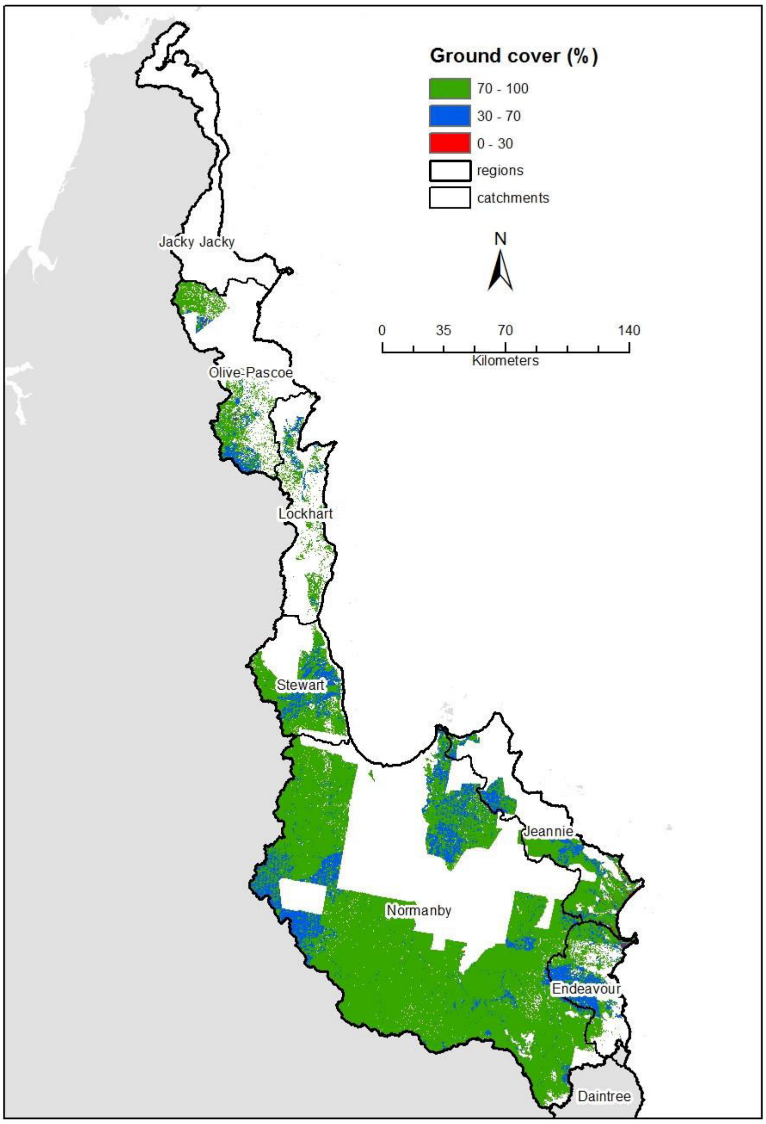


Figure 8: Percentage of ground cover for the Cape York region and catchments.

The Cape York region had consistently high mean ground cover from 1987 to 2014 with a mean ground cover level of 85 per cent (Figure 9). The proportion of grazing lands under target of 70 per cent was 16 per cent in 2014 and 13 per cent for the 27-year period (Table 2 and Figure 7).

This proportion has fluctuated quite considerably, particularly for individual catchments. For example, the area below the 70 per cent target in the Jeannie catchment was 15 per cent in 1990 and 45 per cent in 1991 (Figure 10). A large fire occurred during 1991, causing significant loss of ground cover.

Fire also affected 2014 ground cover levels in some catchments in the Cape York region. For example, the Endeavour catchment has a 27-year mean of 86 per cent ground cover with 12 per cent under the 70 per cent target. In 2014, mean ground cover dropped to 75 per cent and the area under 70 per cent cover increased to 45 per cent due to fire.

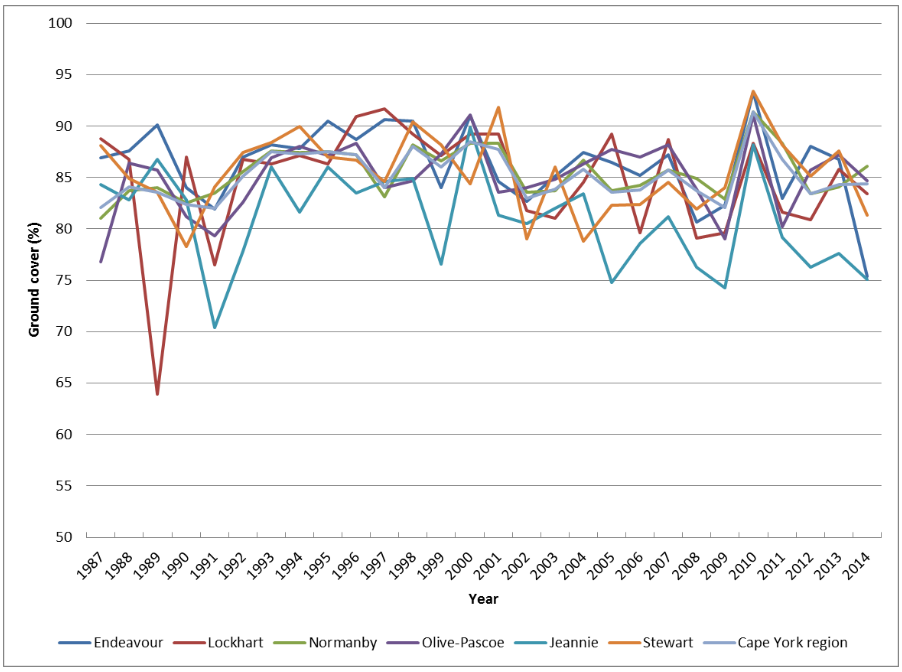


Figure 9: Mean late dry season ground cover in the Cape York region and catchments from 1987 to 2014. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

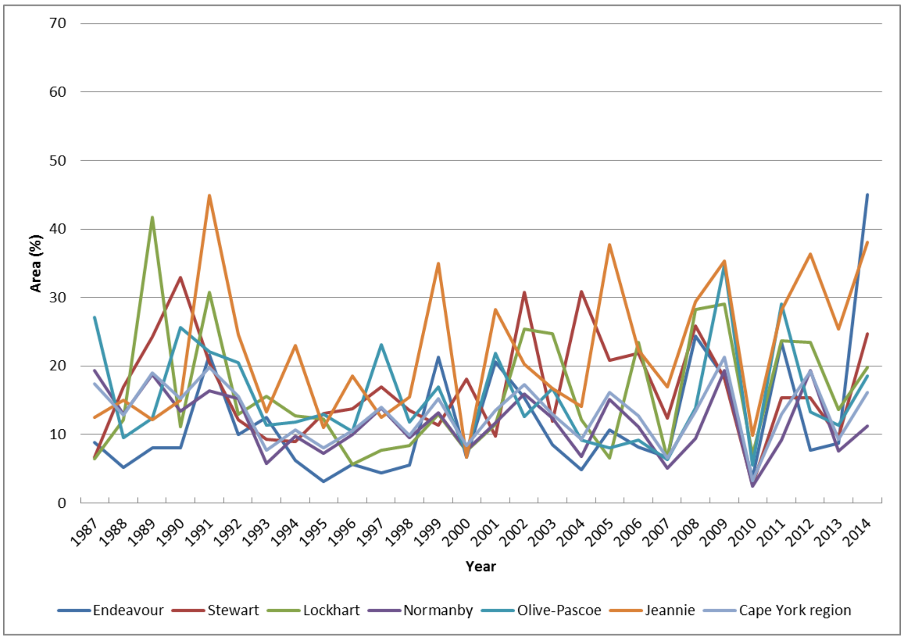


Figure 10: Percentage of the Cape York region and catchments with ground cover below 70 per cent from 1987 to 2014.

The map of ground cover deciles (Figure 11) compares the spring 2014 cover to the long term cover (1988 to 2012) for the spring season. Only the assessable areas (i.e. areas classified as grazing) are shown. Red on the map refers to cover being the lowest level in that time period (lowest deciles) while blue shows cover that is at the highest (or deciles) in that time period. This may be used as a guide to indicate areas of concern or improvement. The large areas of red shown in the Endeavour and Normanby catchments are largely a result of the fires that occurred in 2014.

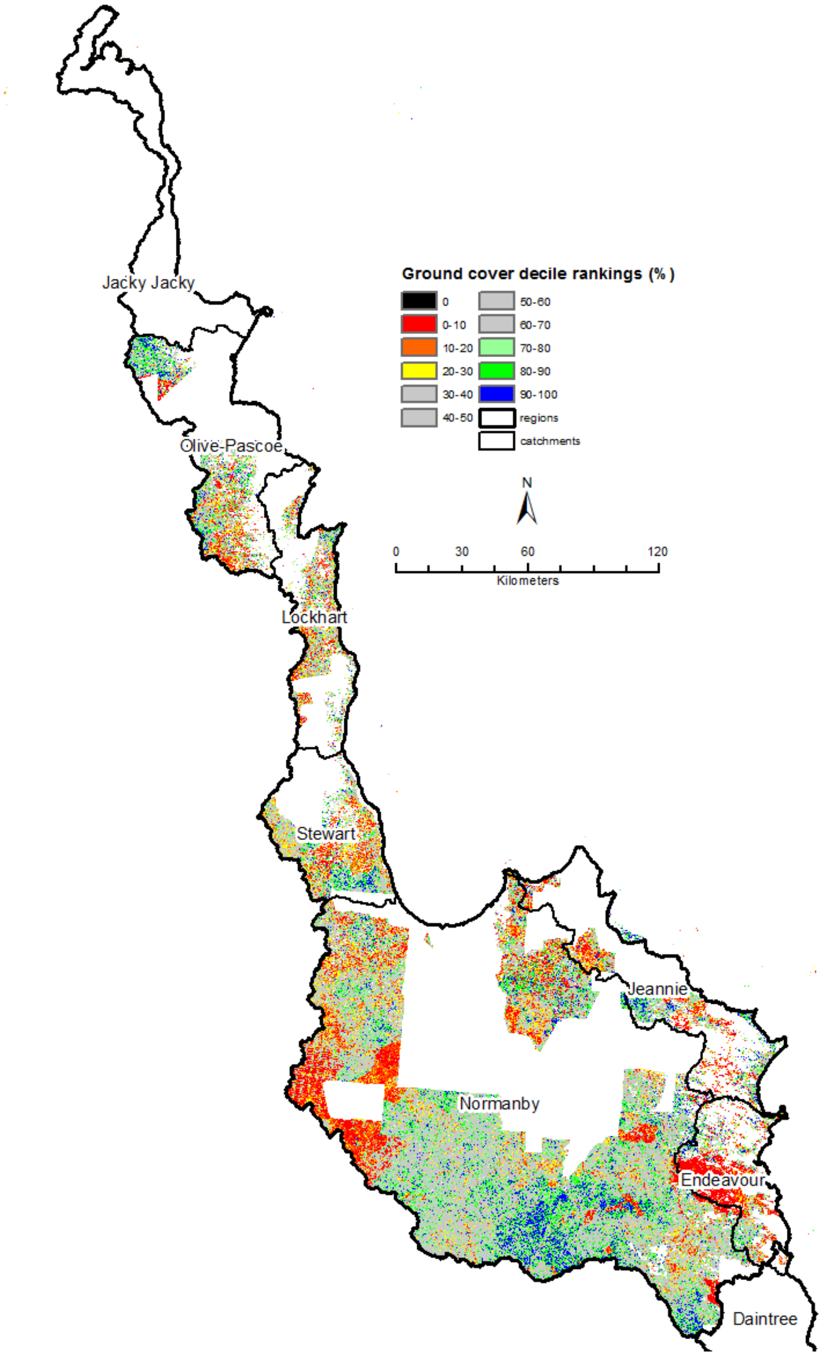


Figure 11: Map of ground cover deciles for the Cape York region.

The Cape York region is the third wettest region with 1278 millimetres mean annual rainfall. Rainfall was above the mean in 2014 (1545 millimetres) (Figure 12).

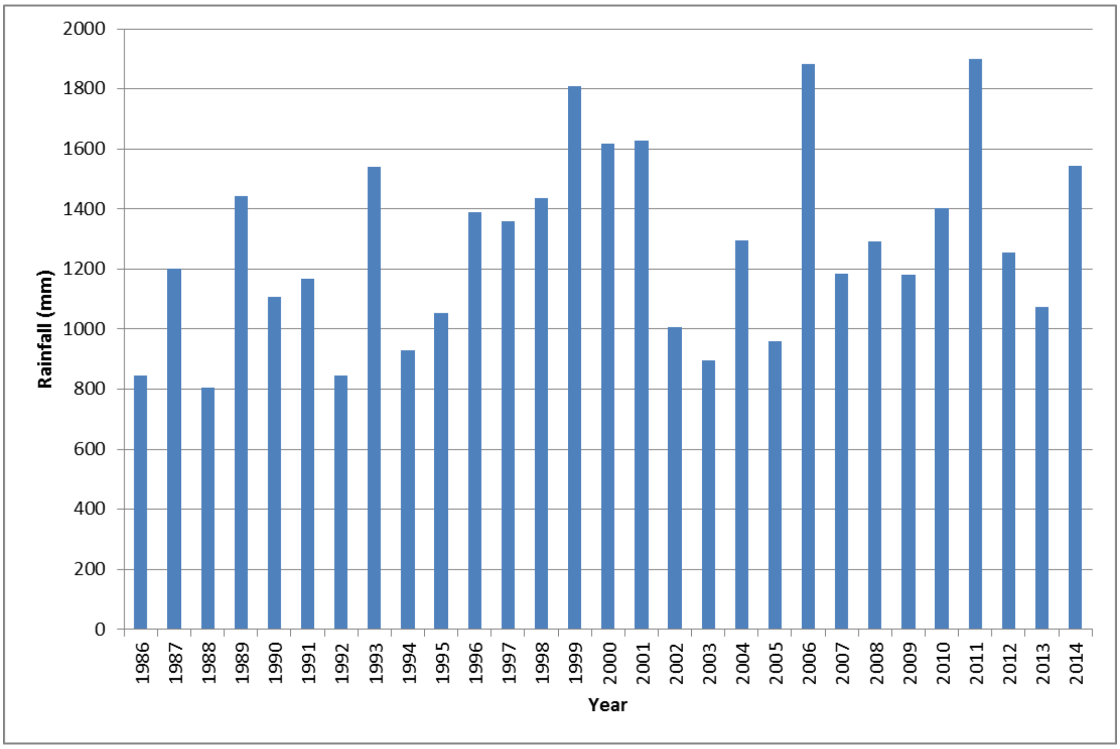


Figure 12: Mean annual rainfall for the Cape York region from 1986 to 2014. Note that a year is from September to September to align with late dry season reporting.

Wet Tropics

85%

Target: 70 per cent late dry season ground cover.

Very good progress: Late dry season mean ground cover across grazing lands was 85 per cent.

Table 3: Ground cover results for the Wet Tropics region and catchments

Catchment	27-year mean ground cover (%)	2014 mean ground cover (%)	Area with less than 70% ground cover averaged	Area with less than 70% ground cover in 2014 (%)
Herbert	87	87	6	3
Johnstone	79	67	18	61
Barron	86	83	9	14
Wet Tropics region (Herbert, Johnstone and	87	85	6	7

The ground cover distribution for the Wet Tropics provides a visual representation of the results (Figure 13). The proportion of the catchment with less than 70 per cent cover is labelled (7%) and shaded blue. Distribution of the long-term mean ground cover levels is displayed as the dashed line and the 2014 distribution of ground cover levels is the solid line. The median of the long-term mean and 2014 cover are presented, with the actual median value in 2014 (88%) shown in red.

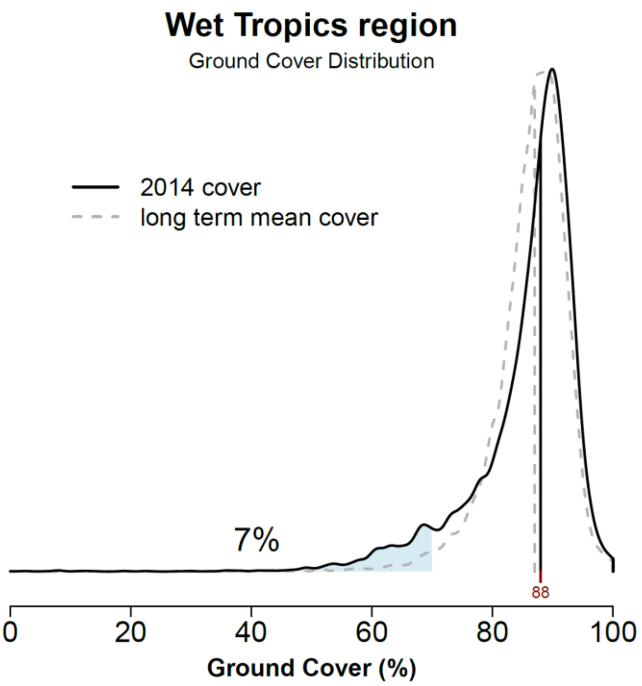


Figure 13: Wet Tropics ground cover distribution.

Figure 14 shows the percentage of ground cover for the Wet Tropics region and catchments.

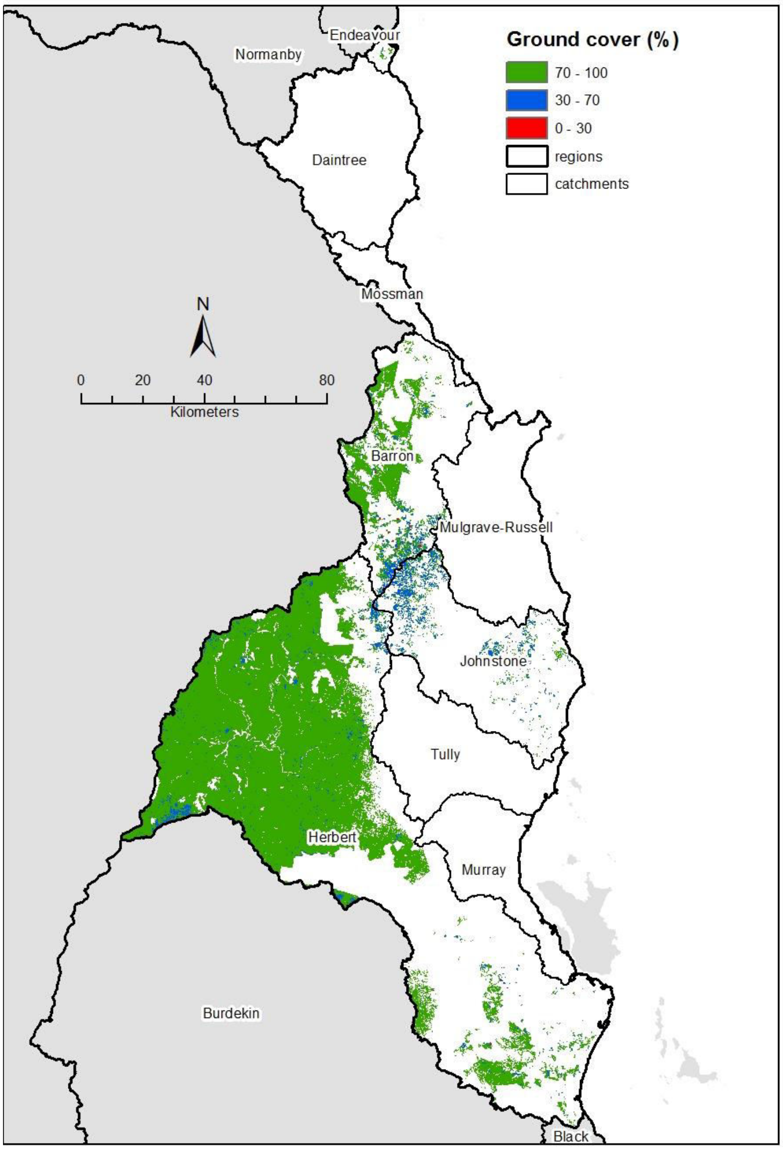


Figure 14: Percentage of ground cover for the Wet Tropics region and catchments.

The Wet Tropics region had consistently high mean ground cover from 1987 to 2014 with a mean of 87 per cent. Minimum mean ground cover for the monitoring period was 80 per cent in 1994. The proportion of grazing lands under the target was also consistently low with a mean of six per cent over the 27-year period and seven per cent in 2014 (Table 3 and Figure 13). Results are only reported for the Herbert, Barron and Johnstone catchments as the other catchments in the Wet Tropics have less than 10 per cent assessable area.

The Herbert and Barron catchments are well above the target for the 27-year mean and 2014 results; however, the Johnstone dropped to 67 per cent mean ground cover in 2014 (Figure 15). Likewise, the area under the 70 per cent target fluctuates in the Johnstone and has risen considerably in 2014 (Figure 16). A total of 61 per cent of the Johnstone catchment had less than 70 per cent cover in 2014, with the majority falling between 50 and 70 per cent.

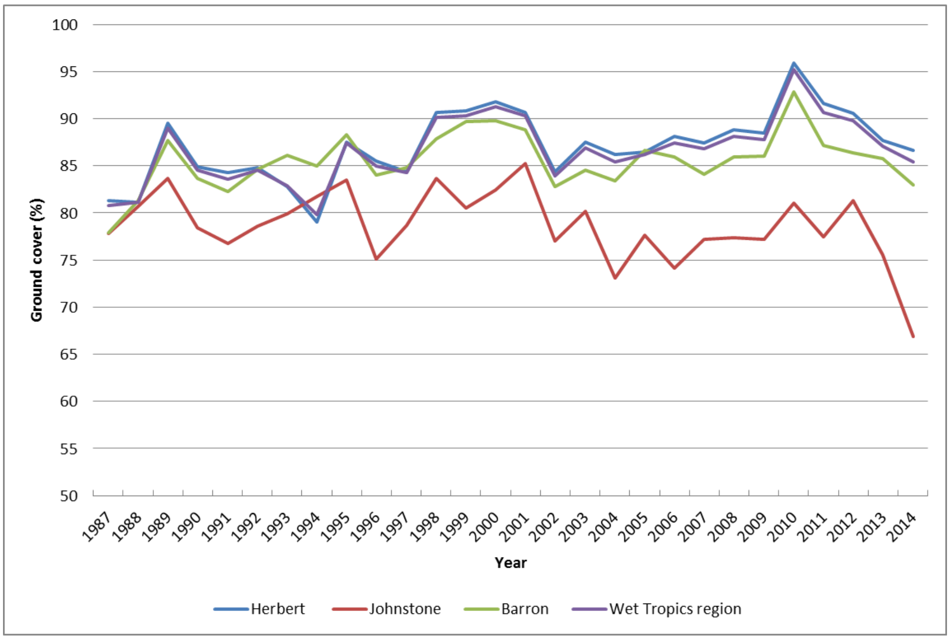


Figure 15: Mean late dry season ground cover in the Wet Tropics region and catchments from 1987 to 2014. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

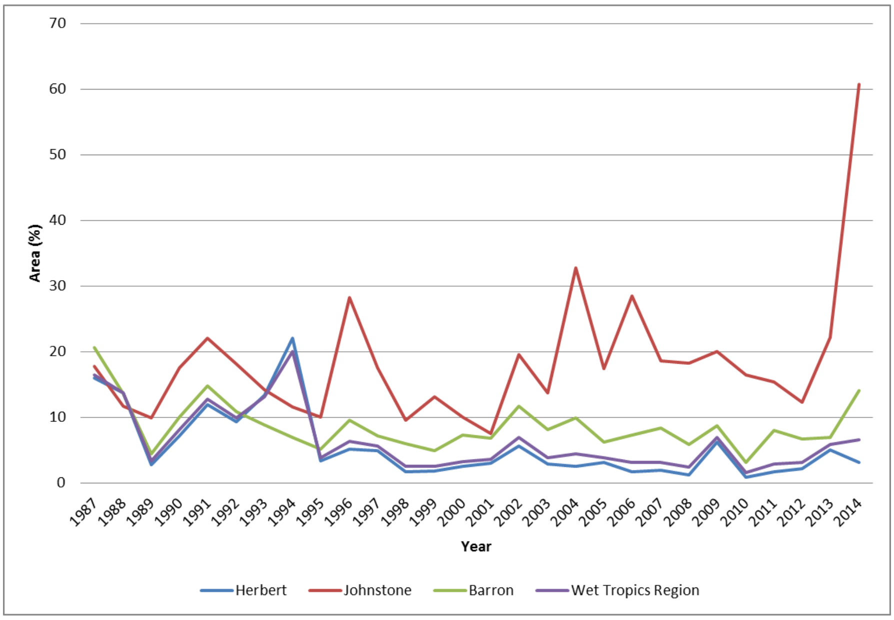


Figure 16: Percentage of the Wet Tropics region and catchments with ground cover below 70 per cent from 1987 to 2014.

The map of ground cover deciles (Figure 17) compares the spring 2014 cover to the long term cover (1988 to 2012) for the spring season. Only the Herbert, Barron and Johnstone catchments were reported on as the other catchments in the Wet Tropics had less than 10 per cent assessable area. Red on the map refers to cover being the lowest level in that time period (lowest deciles) while blue shows cover that is at the highest (or deciles) in that time period. This may be used as a guide to indicate areas of concern or improvement. The area of red in the Johnstone shows the decrease in mean ground cover recorded for 2014.

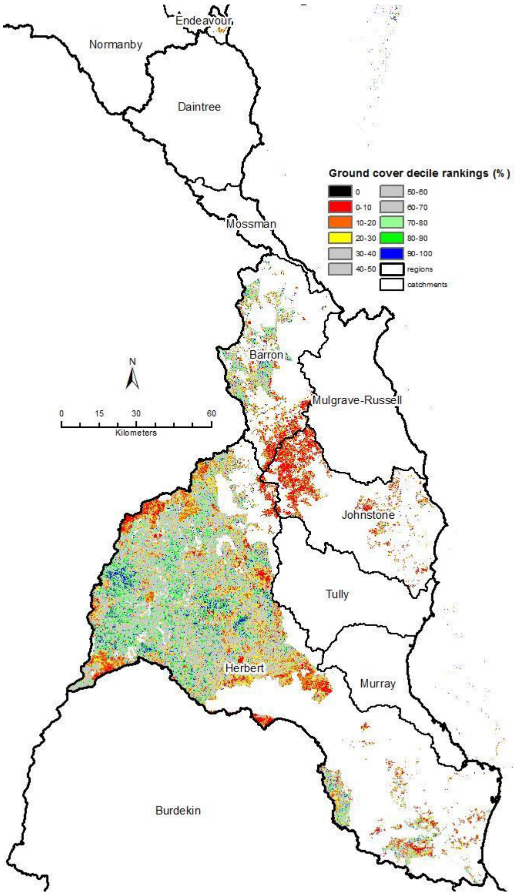


Figure 17: Map of ground cover deciles for the Wet Tropics region.

The Wet Tropics region is the wettest region (1909 millimetres mean annual rainfall). Rainfall was above the mean in 2014 (2031 millimetres) (Figure 18).

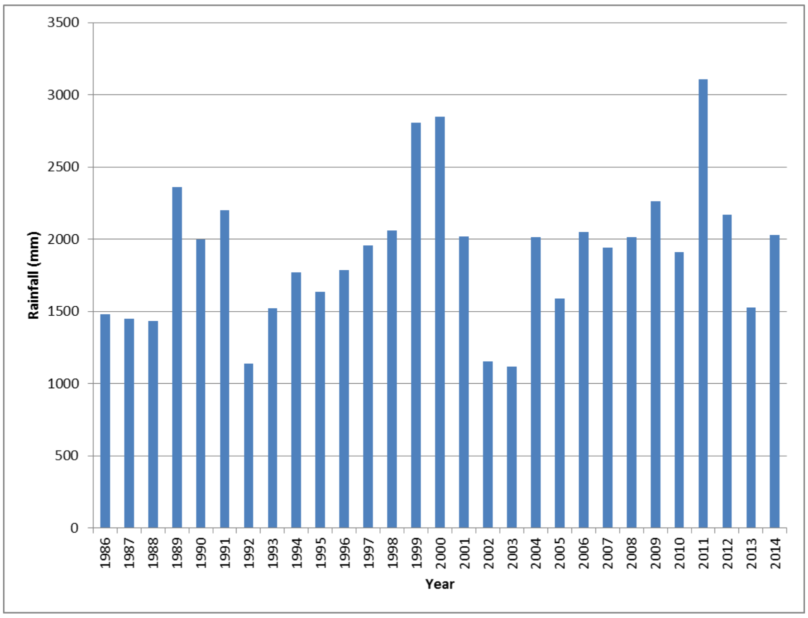


Figure 18: Mean annual rainfall for the Wet Tropics region from 1986 to 2014. Note that a year is from September to September to align with late dry season reporting.

Burdekin

73%

Target: 70 per cent late dry season ground cover.
Very good progress: Late dry season mean ground cover across grazing lands was 73 per cent.

Table 4: Ground cover results for the Burdekin region and catchments

Catchment / region	27-year mean ground cover (%)	2014 mean ground cover (%)	Area with less than 70% ground cover averaged	Area with less than 70% ground cover in 2014 (%)
Black	87	85	10	10
Burdekin	74	72	34	37
Don	84	84	12	6
Haughton	81	79	17	14
Ross	83	83	15	10
Burdekin region	75	73	33	36

The ground cover distribution for the Burdekin provides a visual representation of the results (Figure 19). The proportion of the catchment with less than 70 per cent cover is labelled (36%) and shaded blue. Distribution of the long-term mean ground cover levels is displayed as the dashed line and the 2014 distribution of ground cover levels is the solid line. The median of the long-term mean and 2014 cover are presented, with the actual median value in 2014 (75%) shown in red.

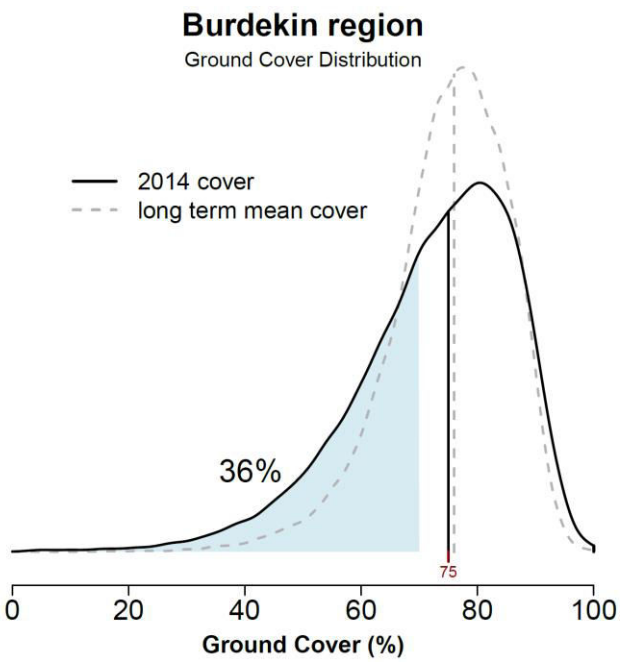


Figure 19: Burdekin ground cover distribution.

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

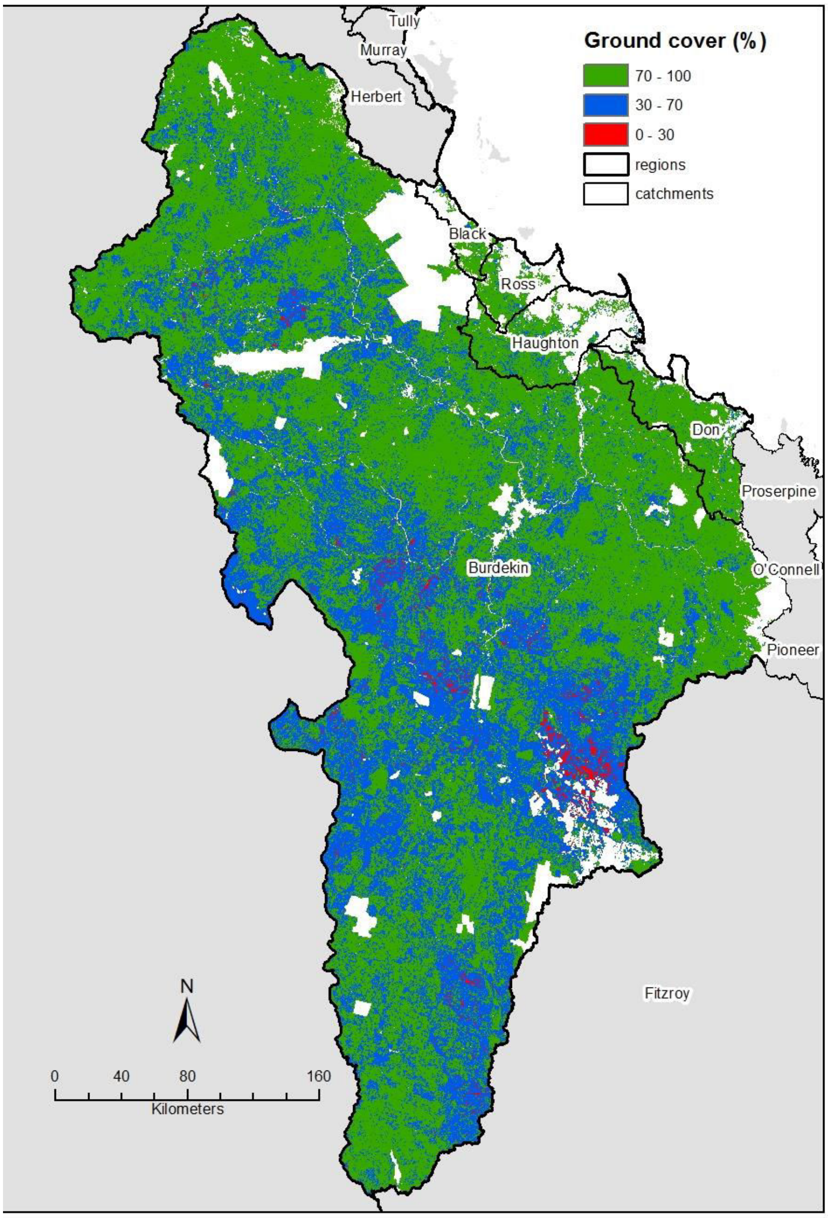


Figure 20: Percentage of ground cover for the Burdekin region and catchments.

While mean ground cover was 75 per cent for the 27-year period and 73 per cent for 2014 (Table 4 and Figure 19), ground cover levels in the Burdekin region fluctuate significantly over time. For example, in 1988 mean late dry season ground cover was 65 per cent, while the following year it was 77 per cent (Figure 21). The Belyando, Suttor and Cape sub-catchments were just below or at the 70 per cent target for 2014.

The area with ground cover less than 70 per cent also varies greatly. Increases in the area with less than 70 per cent ground cover correspond to low mean late dry season ground cover and below mean annual rainfall. For example, in 1988, 57 per cent of the reporting area had ground cover less than 70 per cent (Figure 22).

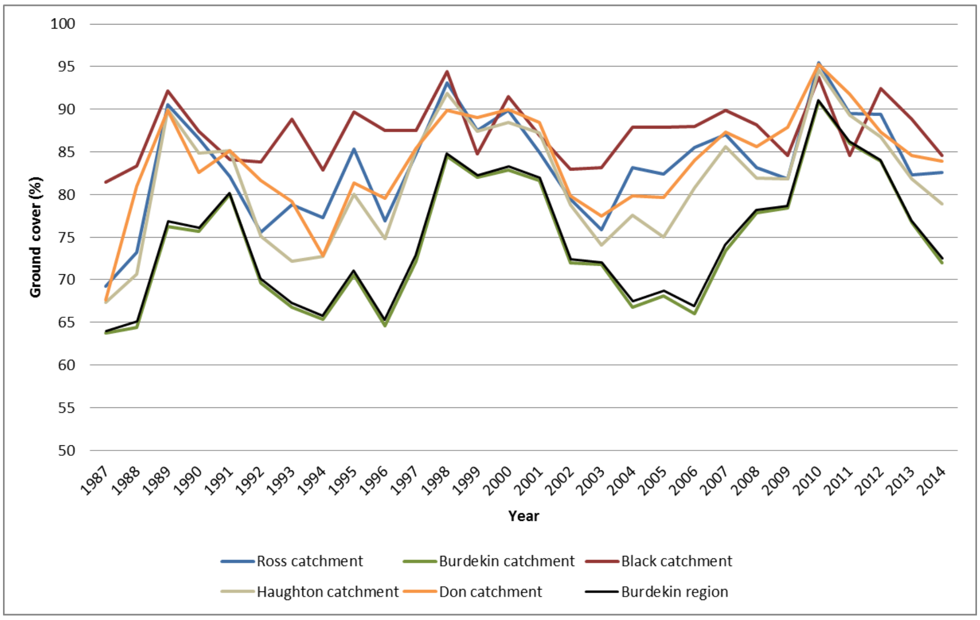


Figure 21: Mean late dry season ground cover in the Burdekin region and catchments from 1987 to 2014. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

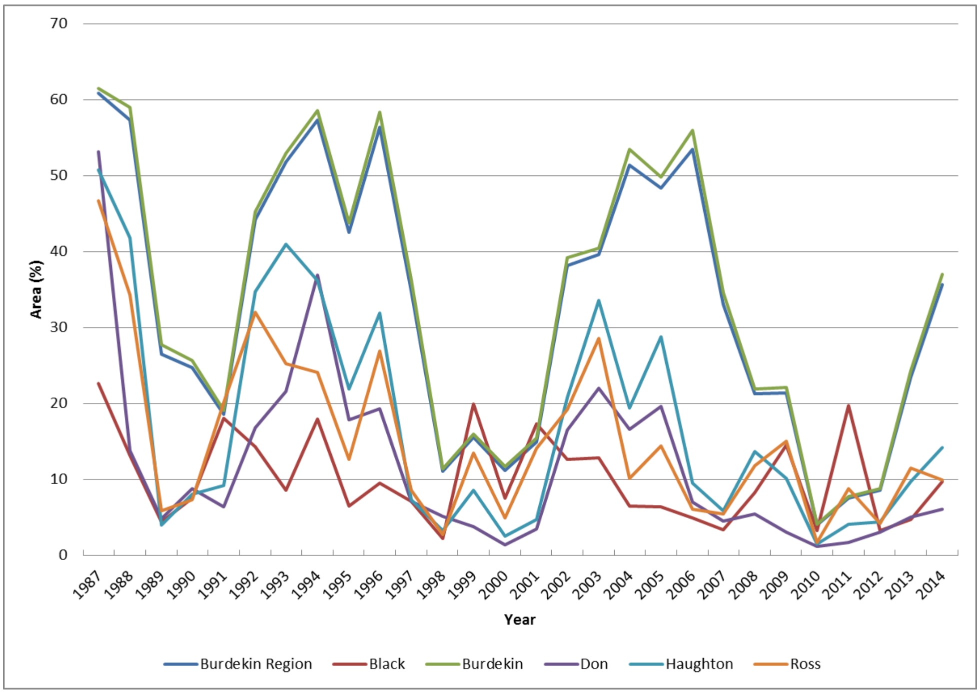


Figure 22: Percentage of the Burdekin region and catchments with ground cover below 70 per cent from 1987 to 2014.

The map of ground cover deciles (Figure 23) compares the spring 2014 cover to the long term cover (1988 to 2012) for the spring season. Red on the map refers to cover being the lowest level in that time period (lowest deciles) while blue shows cover that is at the highest (or deciles) in that time period. This may be used as a guide to indicate areas of concern or improvement.

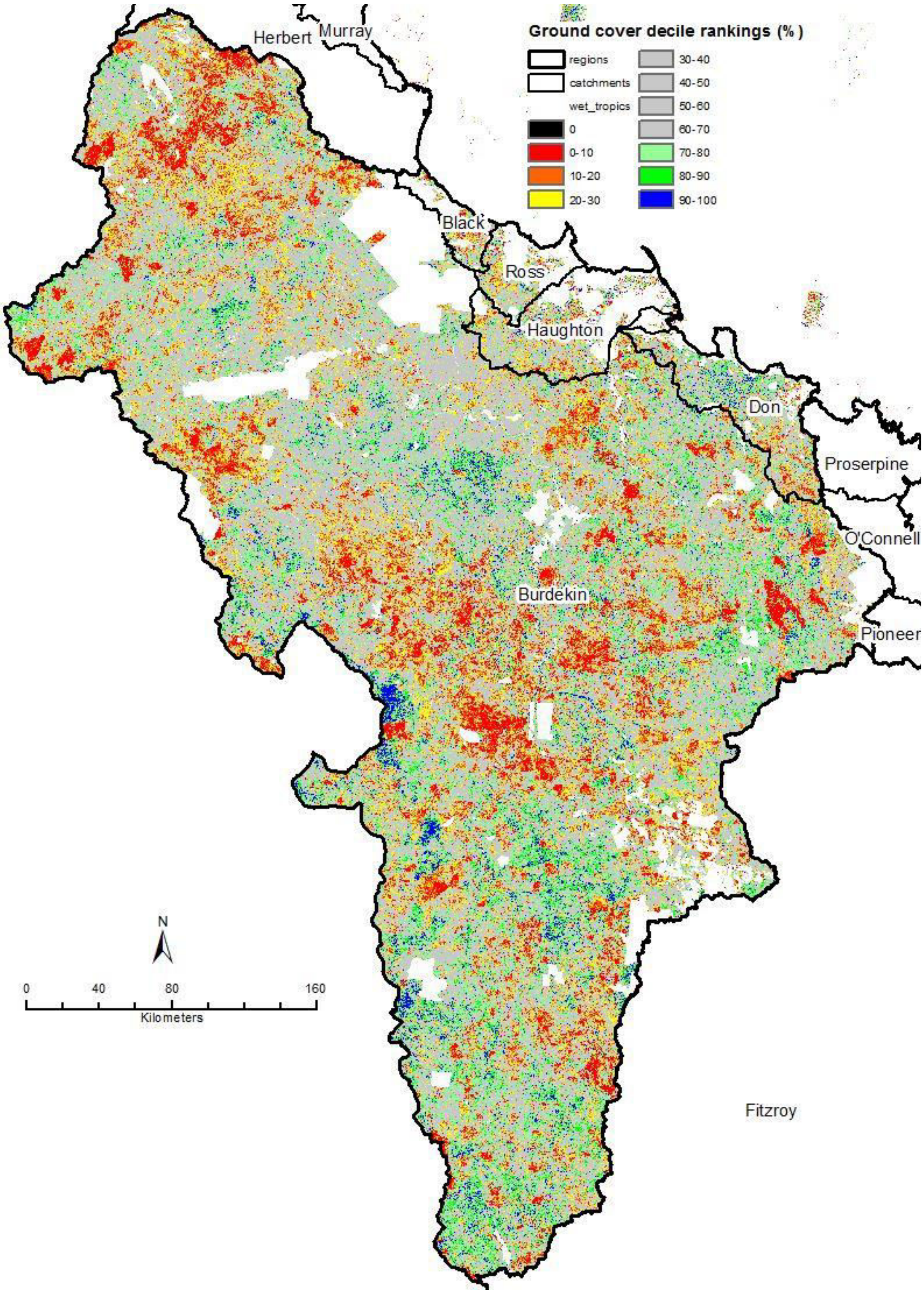


Figure 23: Map of ground cover deciles for the Burdekin region.

The Burdekin region is the driest region (648 millimetres mean annual rainfall). Rainfall was below the mean in 2014 (513 millimetres) (Figure 24).

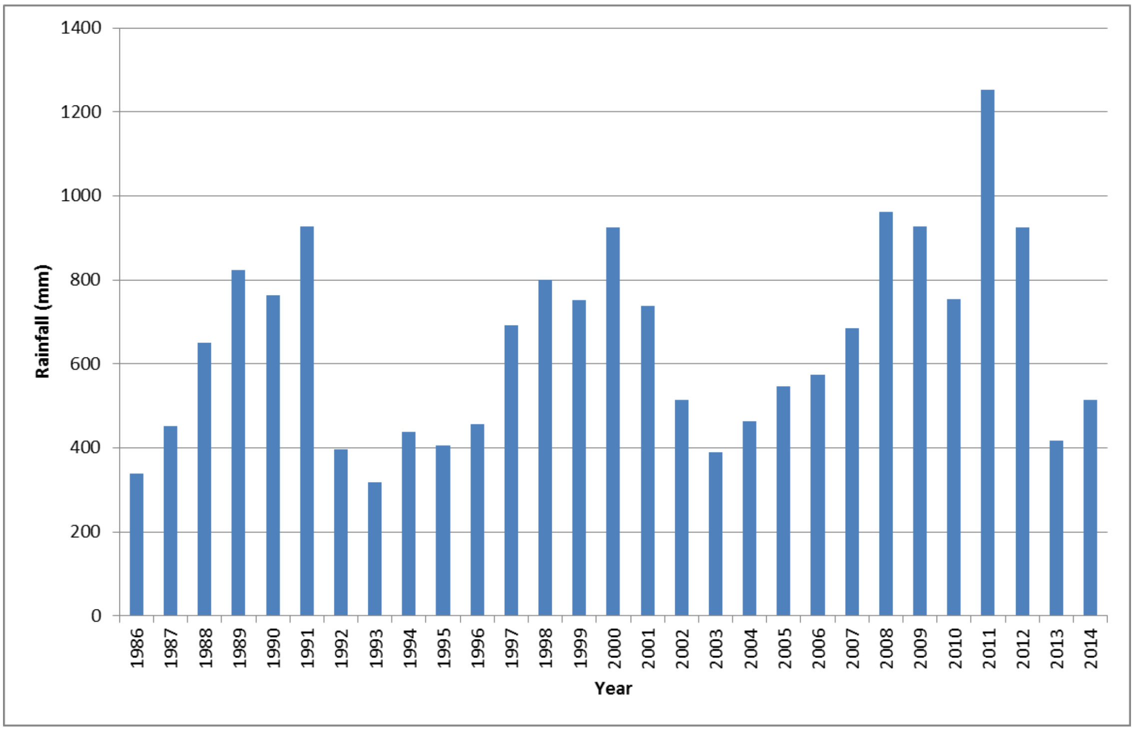


Figure 24: Mean annual rainfall for the Burdekin region from 1986 to 2014. Note that a year is from September to September to align with late dry season reporting.

Mackay Whitsunday

88%

Target: 70 per cent late dry season ground cover.
Very good progress: Late dry season mean ground cover across grazing lands was 88 per cent.

Table 5: Ground cover results for the Mackay Whitsunday region and catchments

Catchment / region	27-year mean ground cover (%)	2014 mean ground cover (%)	Area with less than 70% ground cover averaged over past	Area with less than 70% ground cover in 2014 (%)
O'Connell	90	88	4	4
Pioneer	91	91	3	3
Plane Creek	89	87	6	6
Proserpine	87	87	7	4
Mackay Whitsunday region	89	88	5	5

The ground cover distribution for the Burdekin provides a visual representation of the results (Figure 25). The proportion of the catchment with less than 70 per cent cover is labelled (5%) and shaded blue. Distribution of the long-term mean ground cover levels is displayed as the dashed line and the 2014 distribution of ground cover levels is the solid line. The median of the long-term mean and 2014 cover are presented, with the actual median value in 2014 (90%) shown in red.

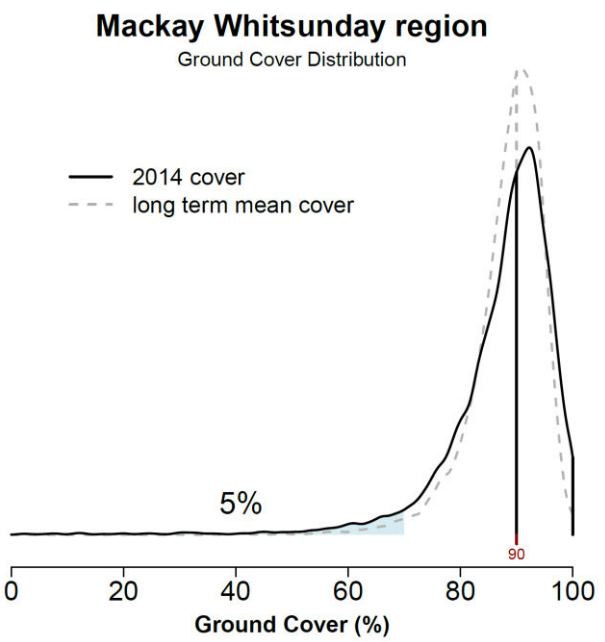


Figure 25: Mackay Whitsunday ground cover distribution.
The percentage of ground cover for the Mackay Whitsunday region and catchments is shown in Figure 26.

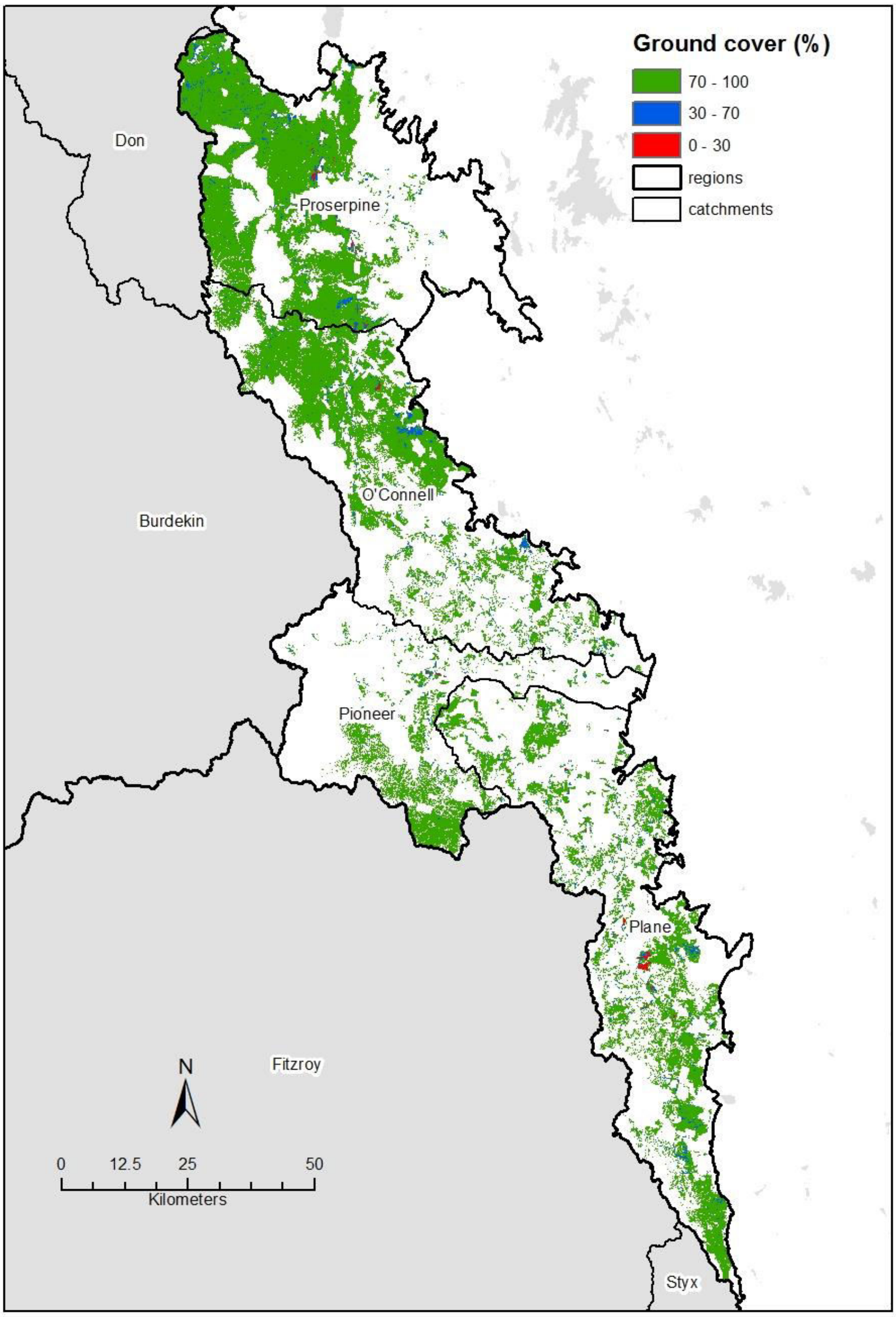


Figure 26: Percentage of ground cover for the Mackay Whitsunday region.

During the past 27 years, the Mackay Whitsunday region has had consistently high mean annual ground cover levels ranging from 85 per cent to 95 per cent (Figure 27). The area with ground cover less than 70 per cent has also been consistently low across all years, with a mean of five per cent for both the 27-year period and 2014 (Table 5, Figures 25 and 28).

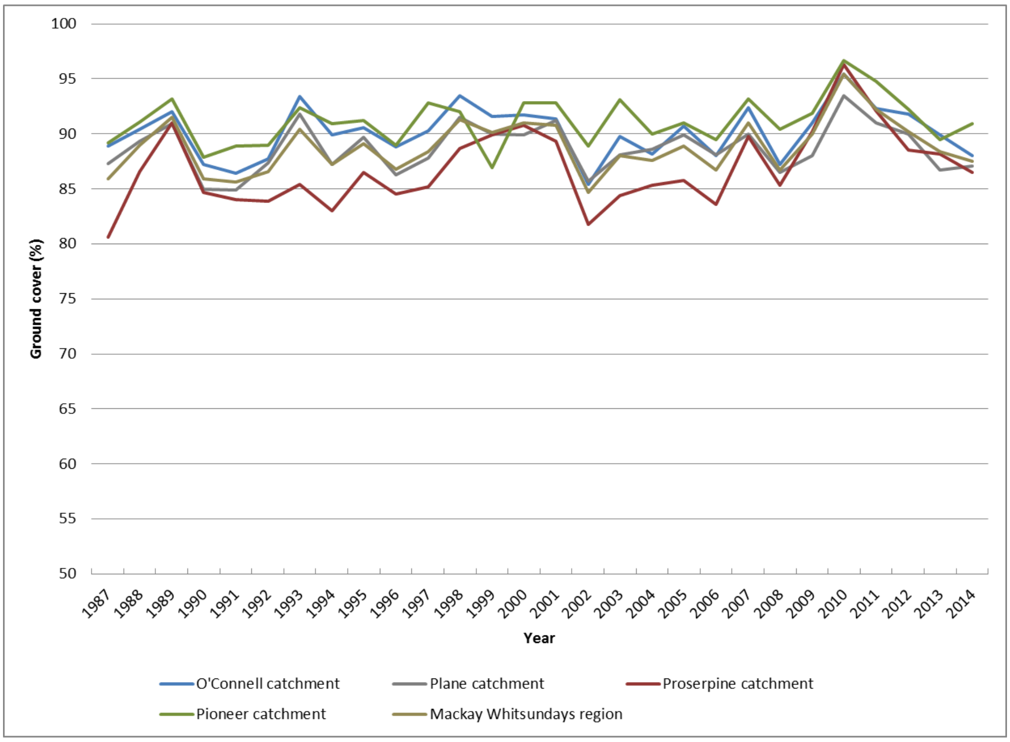


Figure 27: Mean late dry season ground cover in the Mackay Whitsunday region and catchments from 1987 to 2014. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

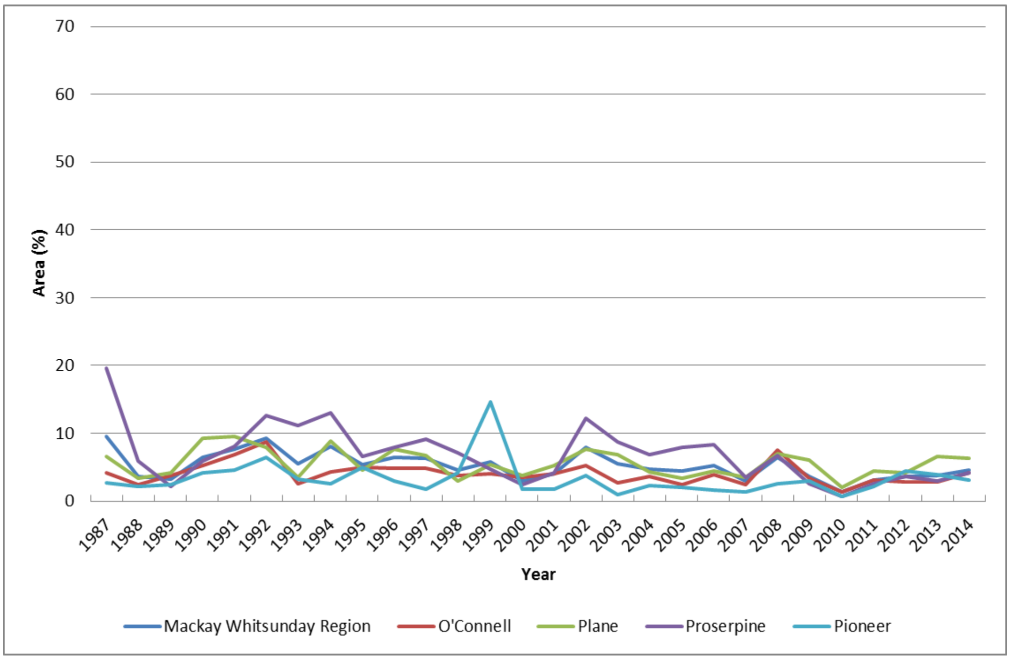


Figure 28: Percentage of the Mackay Whitsunday region and catchments with ground cover below 70 per cent from 1987 to 2014.

The map of ground cover deciles (Figure 29) compares the spring 2014 cover to the long term cover (1988 to 2012) for the spring season. Red on the map refers to cover being the lowest level in that time period (lowest deciles) while blue shows cover that is at the highest (or deciles) in that time period. This may be used as a guide to indicate areas of concern or improvement.

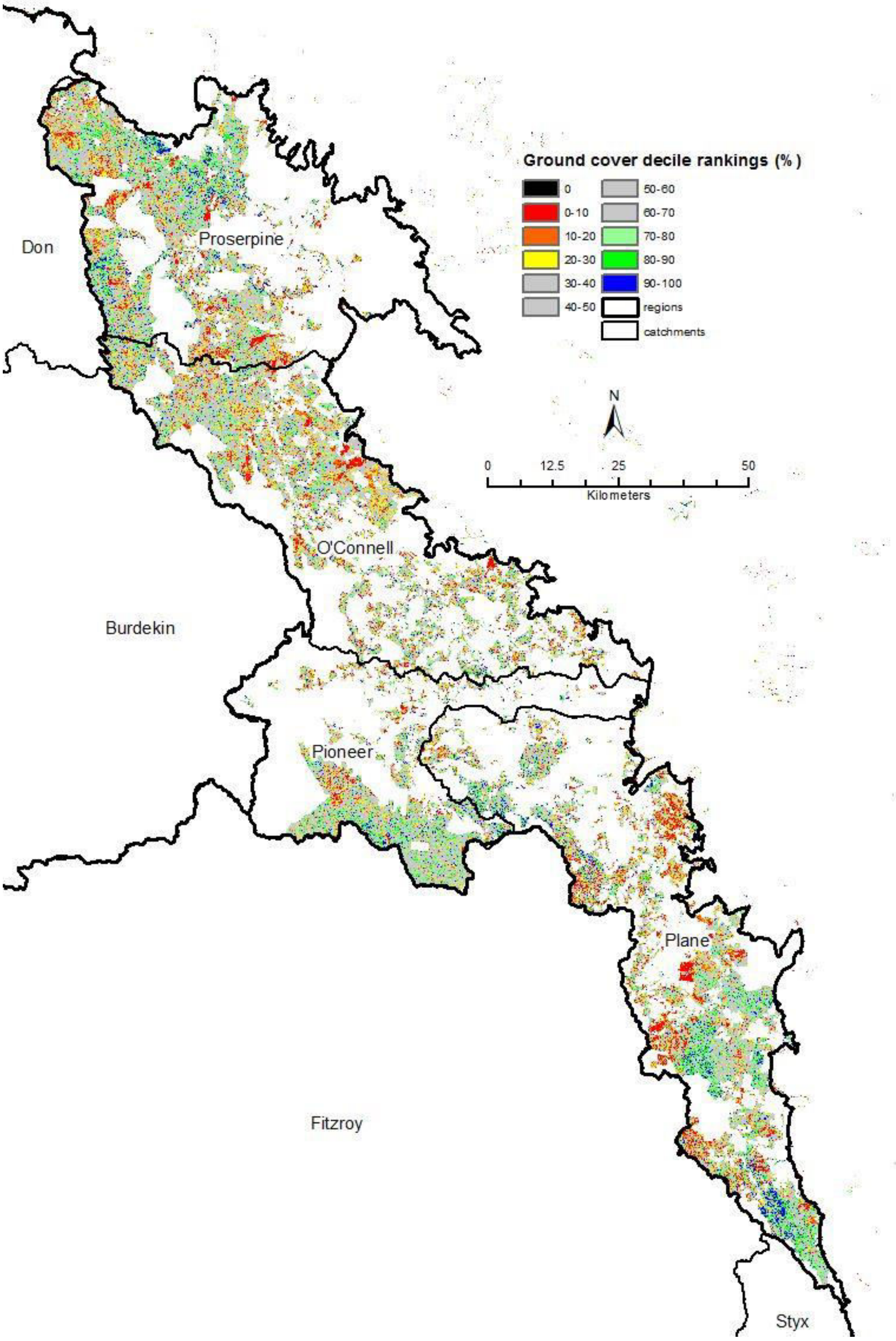


Figure 29: Map of ground cover deciles for the Mackay Whitsunday region.

The Mackay Whitsunday region is the second wettest region (1540 millimetres mean annual rainfall). Rainfall was below the mean in 2014 (1393 millimetres) (Figure 30).

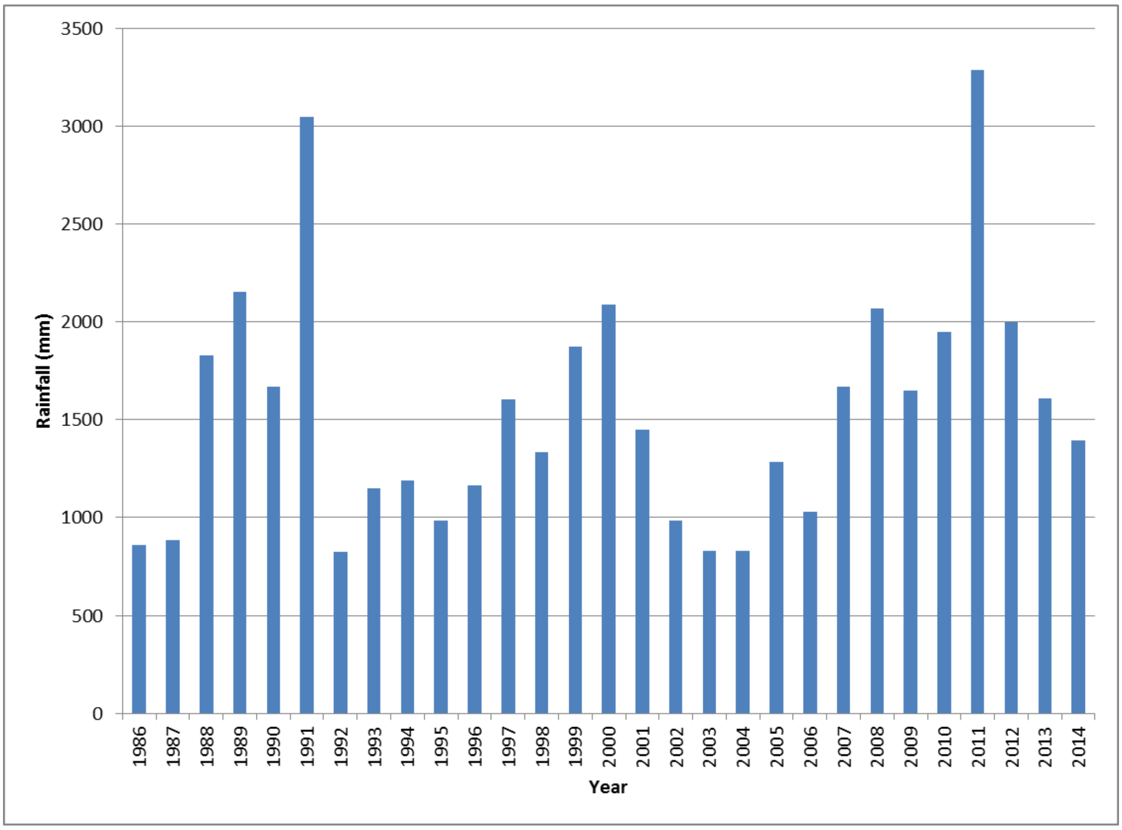


Figure 30: Mean annual rainfall for the Mackay Whitsunday region from 1986 to 2014. Note that a year is from September to September to align with late dry season reporting.

Fitzroy

78%

Target: 70 per cent late dry season ground cover.
Very good progress: Late dry season mean ground cover across grazing lands was 78 per cent.

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

Catchment / region	27-year mean ground cover (%)	2014 mean ground cover (%)	Area with less than 70% ground cover averaged over past	Area with less than 70% ground cover in 2014 (%)
Boyne	87	87	6	5
Calliope	87	86	6	6
Fitzroy	79	77	21	21
Shoalwater	86	89	10	3
Styx	86	91	9	2
Water Park	87	85	8	9
Fitzroy region	79	78	20	20

The ground cover distribution for the Fitzroy provides a visual representation of the results (Figure 31). The proportion of the catchment with less than 70 per cent cover is labelled (20%) and shaded blue. Distribution of the long-term mean ground cover levels is displayed as the dashed line and the 2014 distribution of ground cover levels is the solid line. The median of the long-term mean and 2014 cover are presented, with the actual median value in 2014 (79%) shown in red.

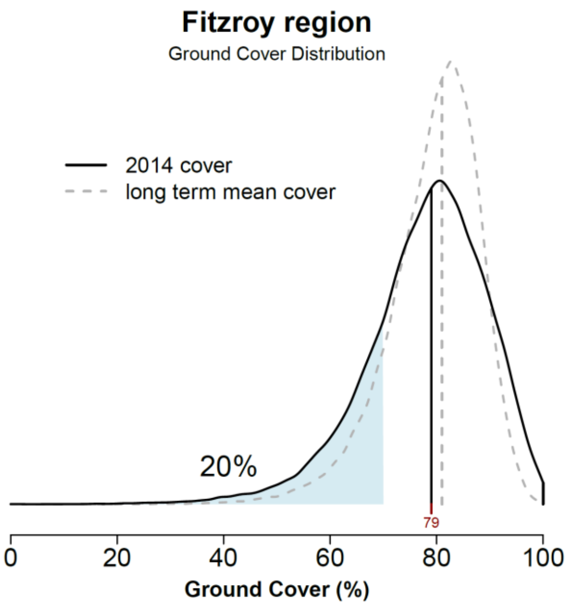


Figure 31: Fitzroy ground cover distribution.

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

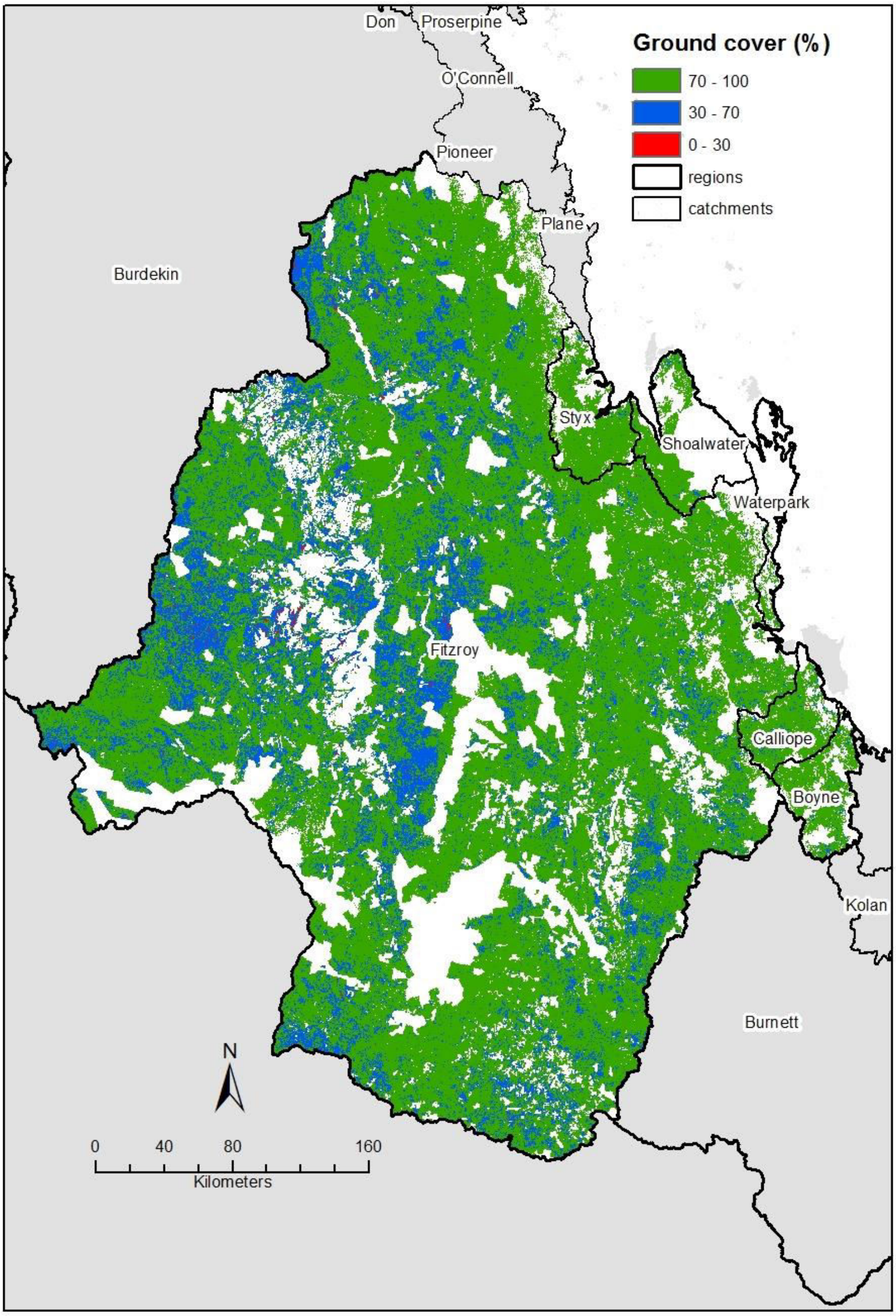


Figure 32: Percentage of ground cover for the Fitzroy region.

Mean ground cover in the Fitzroy region fluctuates considerably over time. For example, in 2006 mean ground cover was 71 per cent, while in 2008 it was 82 per cent and in 2010 it was 93 per cent (Figure 33).

The area with ground cover less than 70 per cent was 20 per cent for both the 27-year period and 2014 (Table 5 and Figure 31), but this also varies greatly. Increases in the area with less than 70 per cent ground cover correspond to low mean late dry season ground cover and below mean annual rainfall. For example, in 1994 mean ground cover was 72 per cent, the area with ground cover below 70 per cent was 39 per cent and mean annual rainfall had been declining since 1989 (Figures 34 and 36). Mean rainfall in 1993 was 396 millimetres, more than 250 millimetres lower than the region's mean annual rainfall from 1986 to 2014.

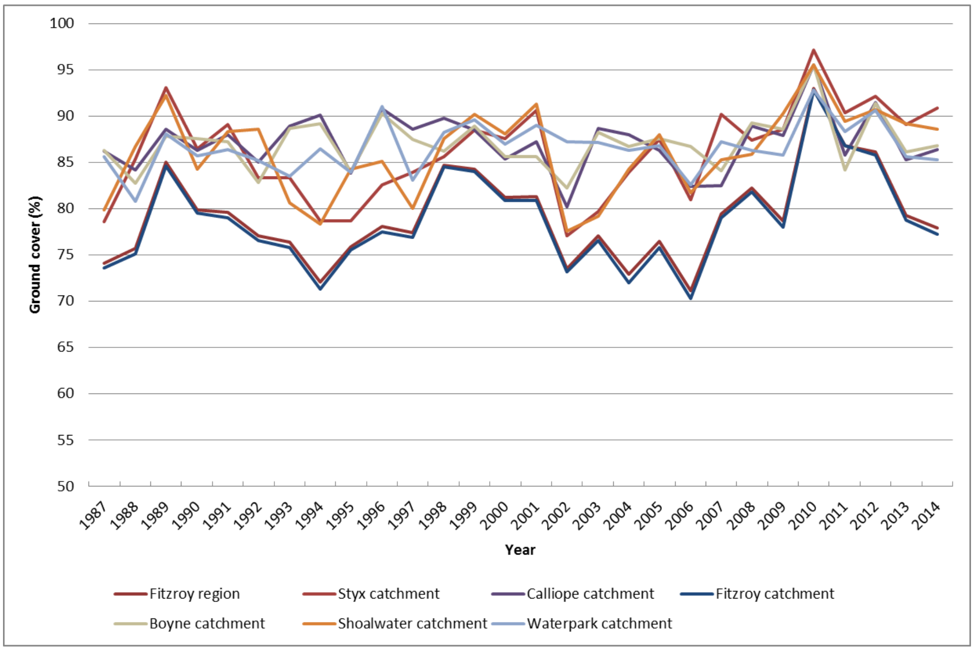


Figure 33: Mean late dry season ground cover in the Fitzroy region and catchments from 1987 to 2014. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

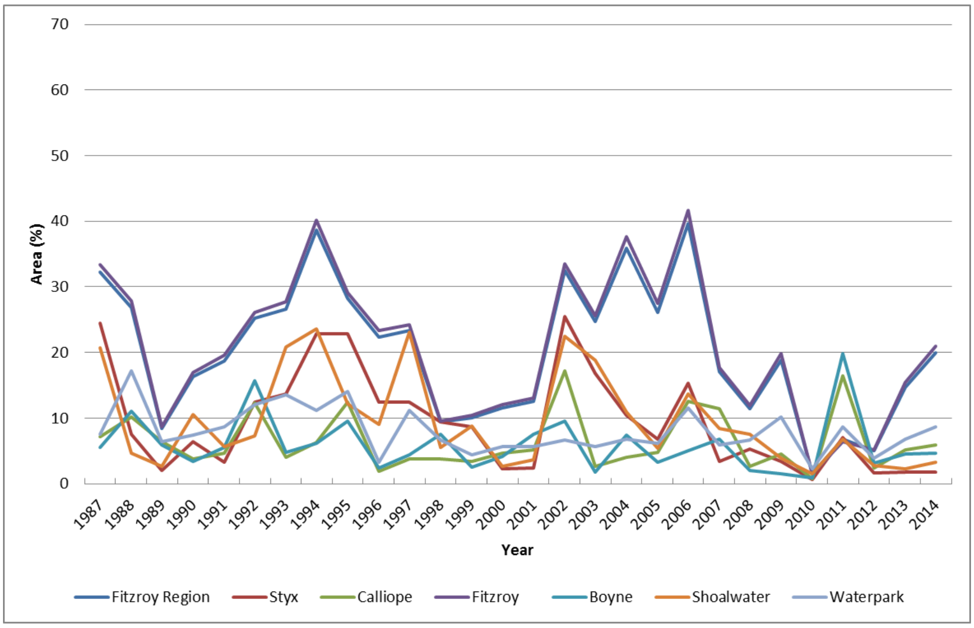


Figure 34: Percentage of the Fitzroy region and catchments with ground cover below 70 per cent from 1987 to 2014.

The map of ground cover deciles (Figure 35) compares the spring 2014 cover to the long term cover (1988 to 2012) for the spring season. Red on the map refers to cover being the lowest level in that time period (lowest deciles) while blue shows cover that is at the highest (or deciles) in that time period. This may be used as a guide to indicate areas of concern or improvement.

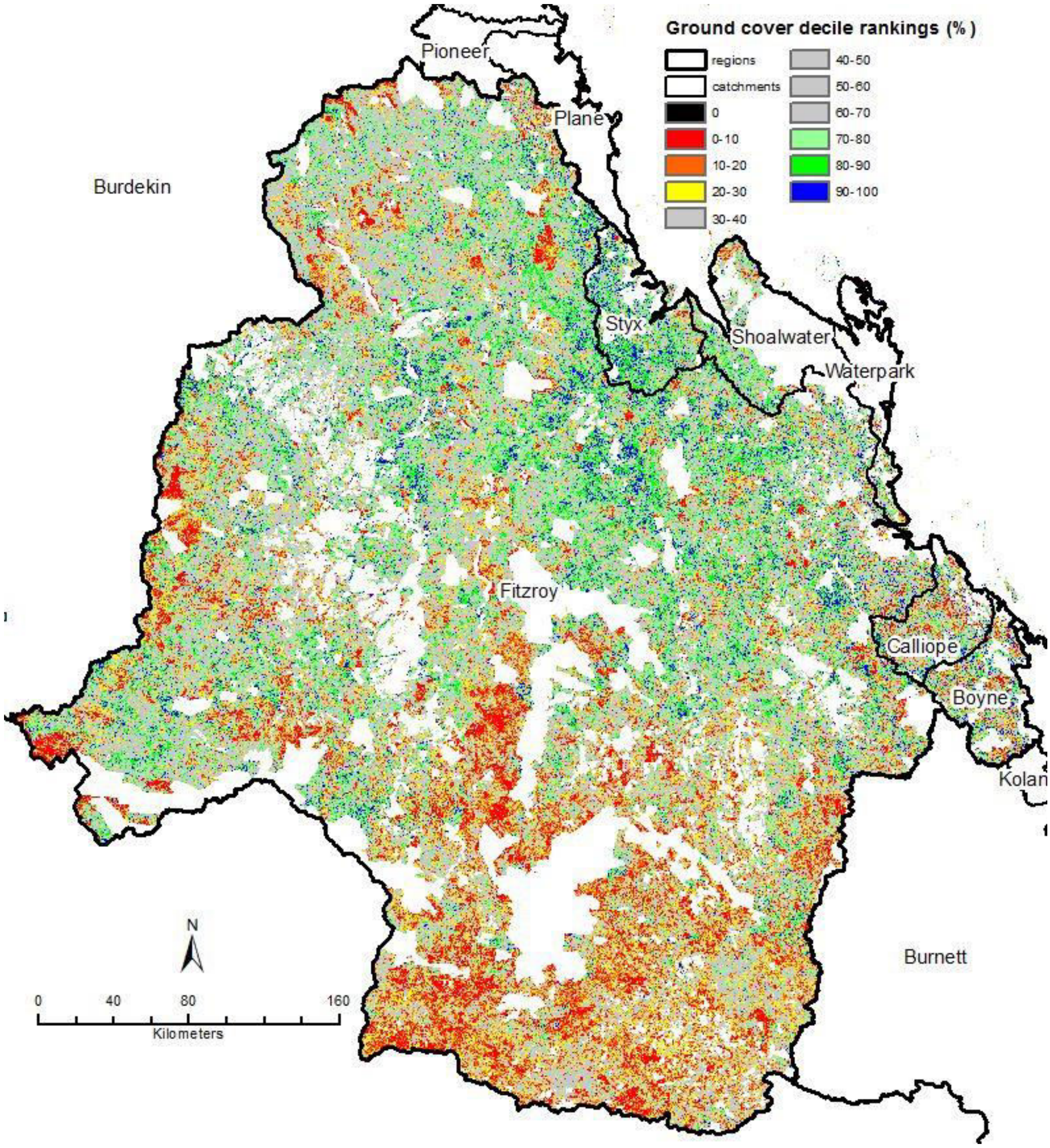


Figure 35: Map of ground cover deciles for the Fitzroy region.

The Fitzroy region is the second driest of the regions (656 millimetres mean annual rainfall). Rainfall was below the mean in 2014 (517 millimetres) (Figure 36).

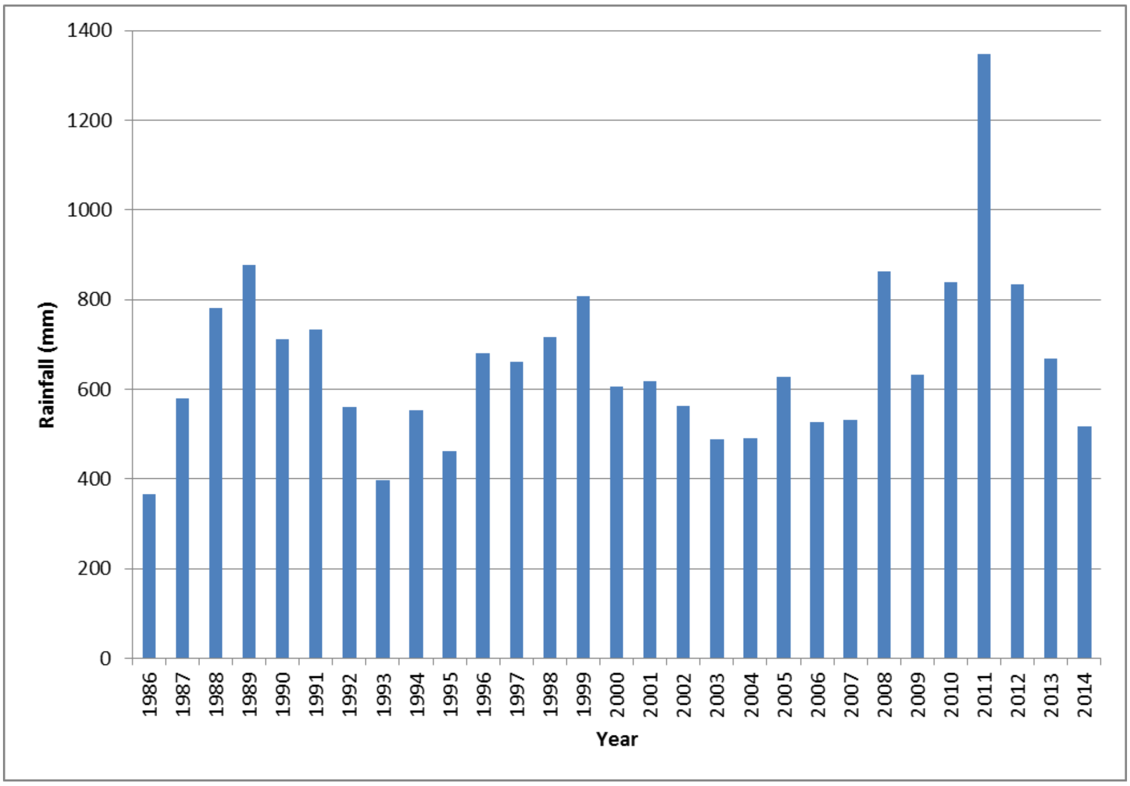


Figure 36: Mean annual rainfall for the Fitzroy region from 1986 to 2014. Note that a year is from September to September to align with late dry season reporting.

Burnett Mary

81%

Target: 70 per cent late dry season ground cover.
Very good progress: Late dry season mean ground cover across grazing lands was at the lowest level (81 per cent) since recording began 27 years ago.

Table 7: Ground cover results for the Burnett Mary region and catchments

Catchment / region	27-year mean ground cover (%)	2014 mean ground cover (%)	Area with less than 70% ground cover averaged	Area with less than 70% ground cover in 2014 (%)
Baffle	89	88	6	4
Burnett	85	80	7	14
Burrum	87	85	9	9
Kolan	88	85	4	6
Mary	88	83	5	8
Burnett Mary region	86	81	7	12

The ground cover distribution for the Burnett Mary provides a visual representation of the results (Figure 37). The proportion of the catchment with less than 70 per cent cover is labelled (12%) and shaded blue. Distribution of the long-term mean ground cover levels is displayed as the dashed line and the 2014 distribution of ground cover levels is the solid line. The median of the long-term mean and 2014 cover are presented, with the actual median value in 2014 (83%) shown in red.

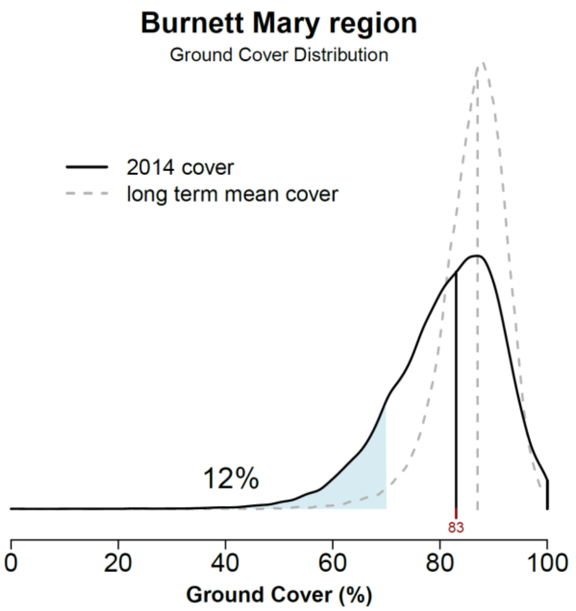


Figure 37: Burnett Mary ground cover distribution.

Figure 38 shows the percentage of ground cover for the Burnett Mary region and catchments.

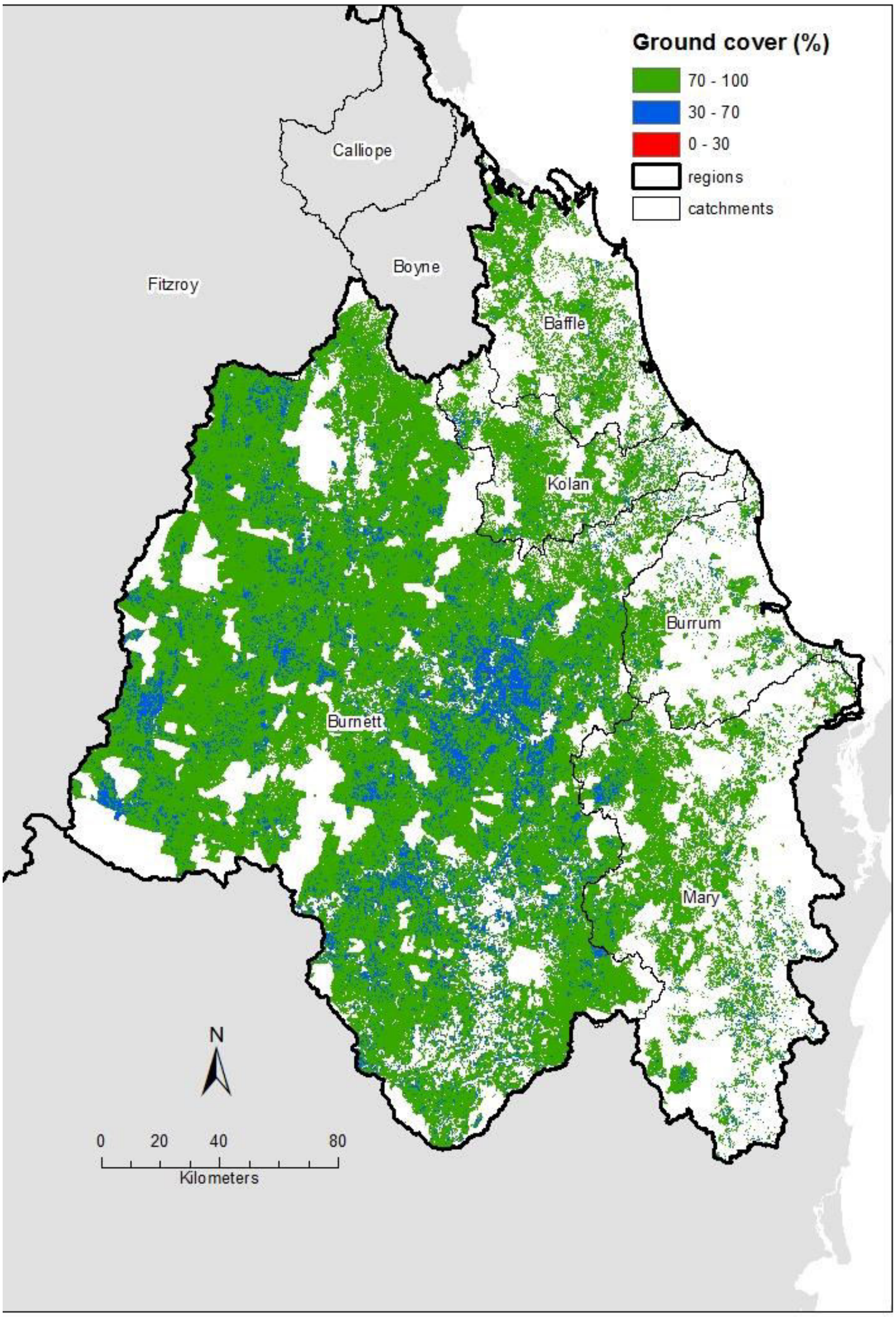


Figure 38: Percentage of ground cover for the Burnett Mary region.

Over the past 27 years, the Burnett Mary region has had a consistently high mean annual ground cover of 86 per cent with a minimum of 81 per cent in 2014. The highest level of ground cover was in 2010 (94 per cent) (Figure 39).

The area with ground cover less than 70 per cent has been consistently low across all years, with a 27-year mean of seven per cent, and a mean of 12 per cent in 2014 (Table 7 and Figures 37 and 40). The highest value was recorded in 1991 (14 per cent). This corresponded with low rainfall, more than 250 millimetres below the mean annual rainfall.

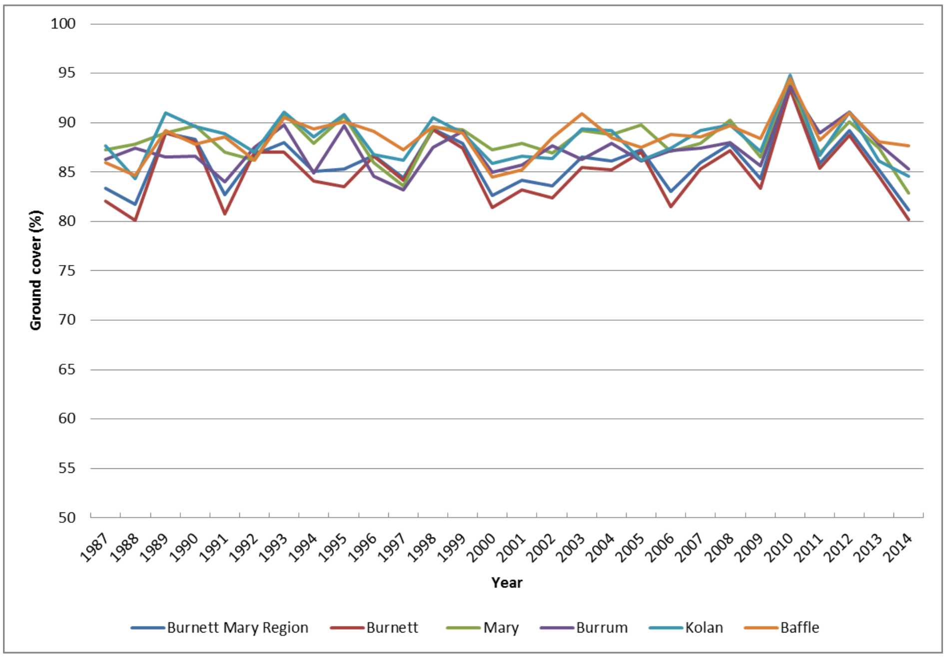


Figure 39: Mean late dry season ground cover in the Burnett Mary region and catchments from 1987 to 2014. Note the scale on the y-axis is between 50 per cent and 100 per cent ground cover.

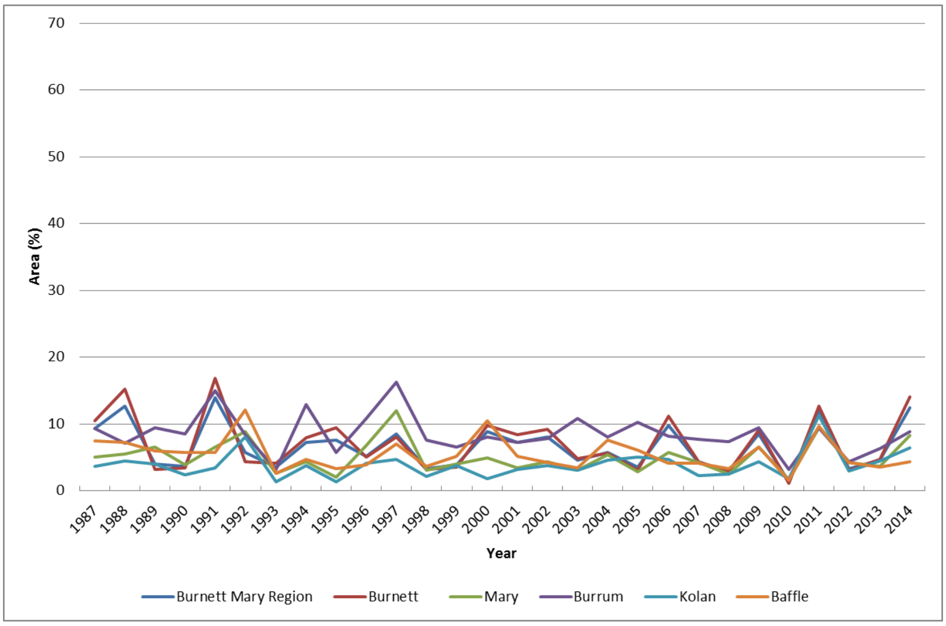


Figure 40: Percentage of the Burnett Mary region and catchments with ground cover below 70 per cent from 1987 to 2014.

The map of ground cover deciles (Figure 41) compares the spring 2014 cover to the long term cover (1988 to 2012) for the spring season. Red on the map refers to cover being the lowest level in that time period (lowest deciles) while blue shows cover that is at the highest (or deciles) in that time period. This may be used as a guide to indicate areas of concern or improvement. Although the mean ground cover for 2014 is high across all of the catchments in this region, it is lower than previous years in many areas (as indicated by the large amount of red in the decile rankings).

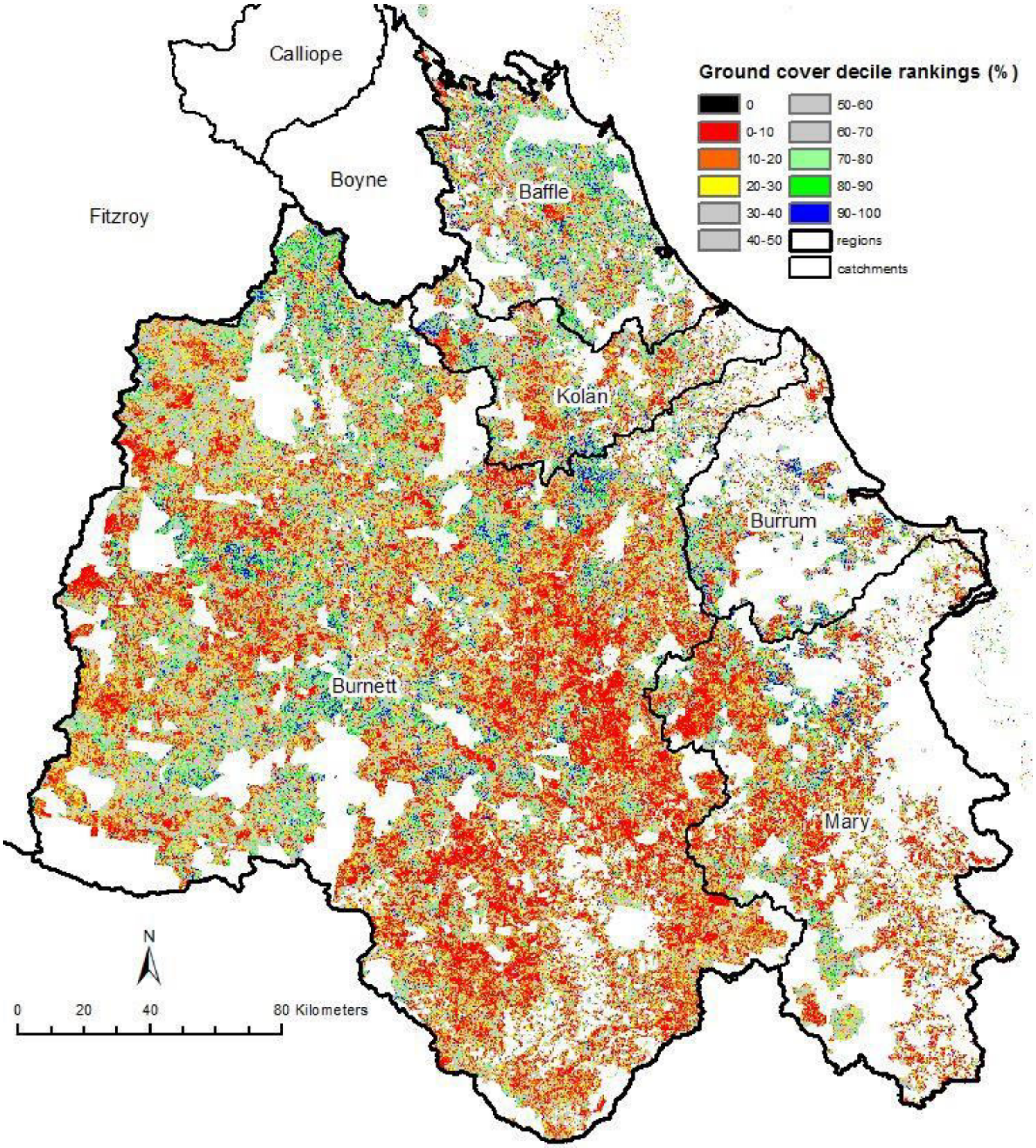


Figure 41: Map of ground cover deciles for the Burnett Mary region.

Mean annual rainfall for the Burnett Mary region is 797 millimetres. Rainfall was below the mean in 2014 (551 millimetres) (Figure 42).

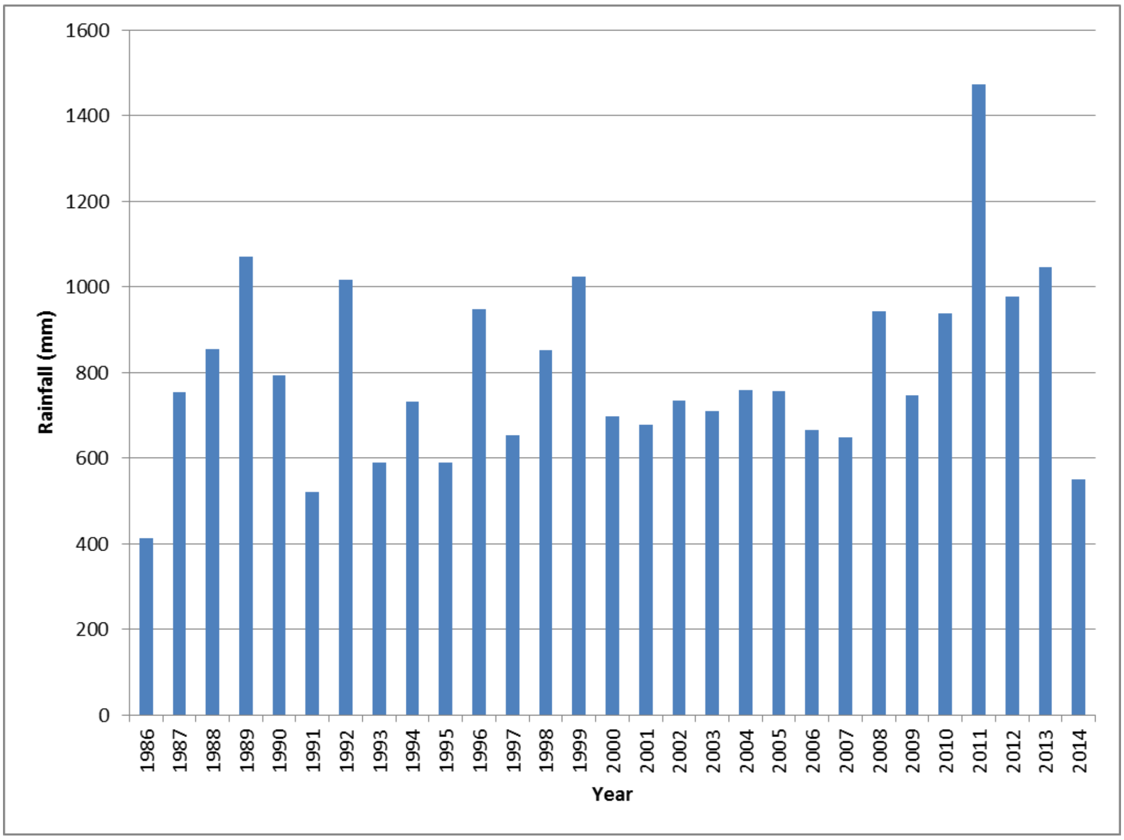


Figure 42: Mean annual rainfall for the Burnett Mary region from 1986 to 2014. Note that a year is from September to September to align with late dry season reporting.

Wetland extent results

The updated wetlands target in the Reef Water Quality Protection Plan 2013 is:
"There is **no net loss** of the extent, and an improvement in the ecological processes and environmental values, of **natural wetlands**."

The 2009 wetlands target was revised to allow the values and ecological processes of wetlands to be monitored, rather than just extent.

A separate case study outlines the new wetland monitoring pilot project to report on the wetland *environmental values and processes*.

The *extent* of wetlands is updated every four years (2001, 2005, 2009 and 2013). The below results assess changes in wetland extent for the current reporting period (2009-2013) against previous results and historical loss (pre-European).

A description of the various wetland types is covered in the wetland extent methods.

Scoring system

- Very good
- Good
- Moderate
- Poor
- Very poor
- No data

Great Barrier Reef-wide

330ha loss
(<0.1%)

Target: There is no net loss of the extent of natural wetlands.

Good progress: There was a loss of 330 hectares (less than 0.1 per cent) of natural wetland extent across the Great Barrier Reef between 2009 and 2013.

Wetland losses also occurred between 2001 and 2005, and 2005 and 2009. Rates of wetland loss between 2009 and 2013 were lower in most regions than for previous periods. An exception was an increase in the loss of mangroves and salt-flats in the Calliope catchment within the Fitzroy region.

Overall loss of vegetated freshwater swamps has continued since 2001, but at a slowing rate in most regions. Their extent declined by 59 hectares (less than 0.1 per cent) between 2009 and 2013 across the Great Barrier Reef catchment. There was a small increase in the rate of loss of vegetated freshwater swamps in the Fitzroy catchment between 2009 and 2013 compared to 2005 to 2009.

The Fitzroy and Burnett Mary regions had the highest proportional loss of wetlands between 2009 and 2013 (0.1 per cent).

Wetland systems extent

Approximately 737,500 hectares of wetlands were mapped in the Great Barrier Reef catchment in 2013, which is approximately 1.7 per cent of the total area. Of these wetland areas there are approximately:

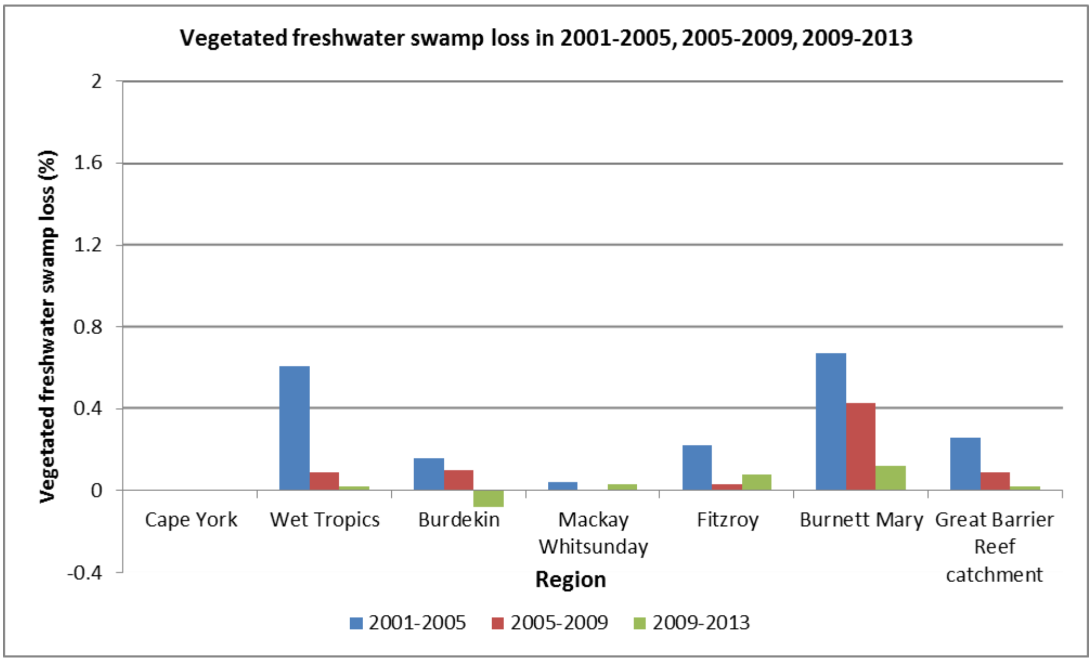
281,600 hectares of vegetated freshwater swamps (palustrine wetlands) with 77 per cent comprising natural wetlands. These areas occur in the greatest density in the small coastal catchments with extensive lowlands such as Jacky Jacky Creek in the Cape York region, Russell-Mulgrave and Murray Rivers in the Wet Tropics, Water Park Creek and Shoalwater Creek in the Fitzroy region

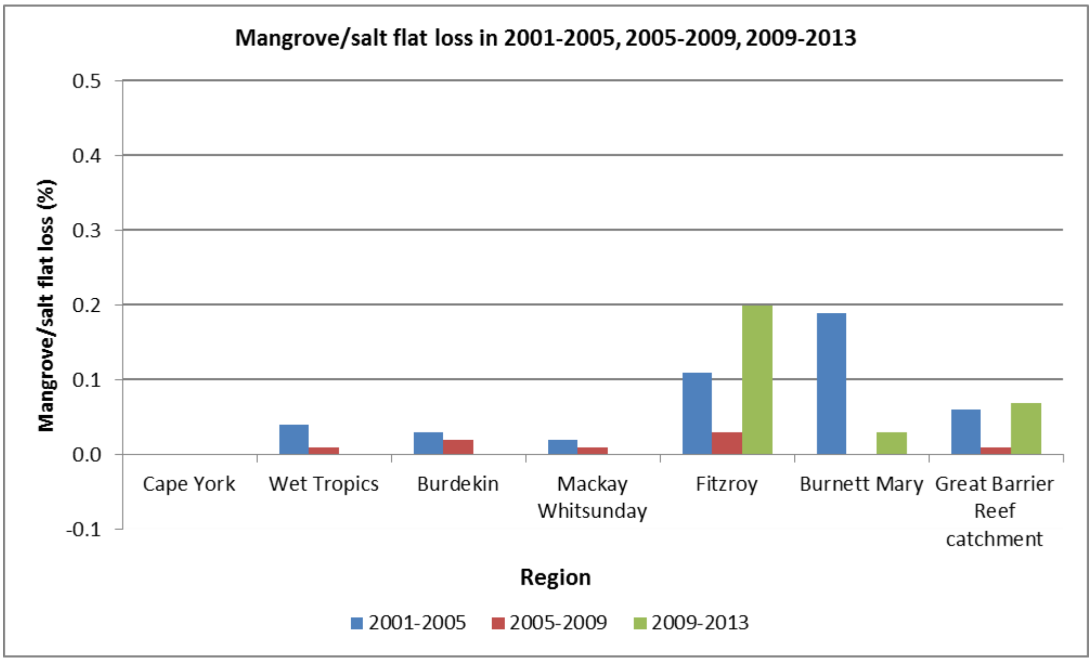
22,400 hectares of lakes (lacustrine wetlands) with 83 per cent comprising natural wetlands

433,500 hectares of mangroves/salt flats (estuarine wetlands) with 99.6 per cent comprising natural wetlands. These areas occur in the greatest density in catchments such as Water Park Creek, Styx, Shoalwater, Murray, Jacky Jacky Creek, Haughton, Ross and Plane Creek.

In addition to the above natural and modified wetlands, there were 167,000 hectares of artificial and highly modified wetlands (e.g. dams) mapped across the Great Barrier Reef catchments in 2013. These non-natural wetlands are excluded from the wetland target in the Reef Water Quality Protection Plan 2013.

Recent change in extent





Wetland loss has continued since 2001, although the rates of loss between 2009 and 2013 were generally lower than during previous periods. The two major exceptions were an increase in the rate of loss of mangroves and salt-flats in the Calliope catchment, and a small increase in the rate of loss of vegetated freshwater swamps in the Fitzroy catchment.

The rate of loss of vegetated freshwater swamps fell to less than 0.1 per cent (59 hectares) between 2009 and 2013, compared to 0.1 per cent (293 hectares) between 2005 and 2009, and 0.3 per cent (728 hectares) between 2001 and 2005. Only the Mossman catchment recorded more than a one per cent loss of vegetated freshwater swamps between 2009 and 2013.

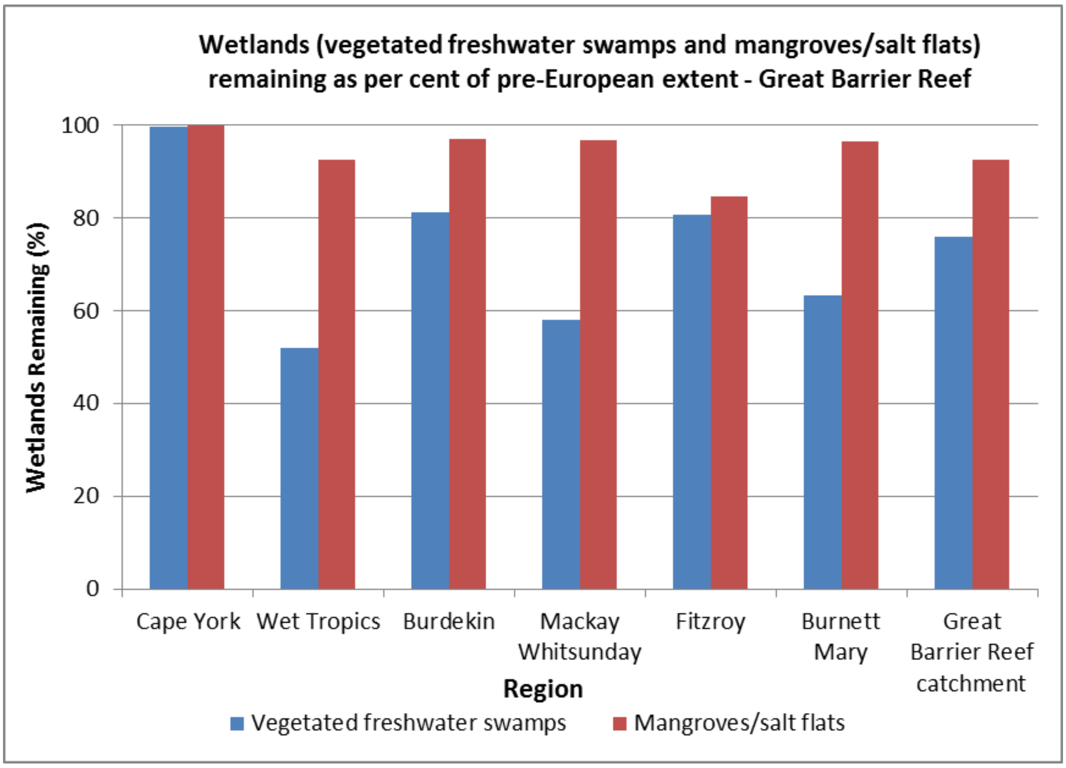
The loss of mangroves/salt flats was 296 hectares (less than 0.1 per cent) between 2009 and 2013, significantly more than the 60 hectares lost (less than 0.1 per cent) between 2005 and 2009. The only catchment that recorded loss of more than one per cent of its mangroves/salt flats between 2009 and 2013 was the Calliope catchment (3.6 per cent).

Lacustrine wetlands increased by 223 hectares between 2001 and 2013. These increases are associated with modifications to existing wetlands by levees, bunds and similar structures that cause wetland expansion. Similar modifications are associated with small increases in vegetated freshwater swamps between 2005 and 2013. There was no change in natural lakes between 2001 and 2013.

There was also an increase in artificial and highly modified wetlands of 18,470 hectares between 2001 and 2013 across the Great Barrier Reef catchments.

Although wetland extent change is typically very small, it is considered indicative of genuine trends in wetland extent, rather than being within the margin of error in the mapping. This is primarily because the mapping method focusses on detecting change relative to the 2001 baseline year. This approach is designed to give reliable indications of change in wetland extent, and each detected change is verified using manual checking of imagery and other data. Each release of wetland mapping incorporates improved data for all previous years (e.g. version 4 mapping includes updated pre-clearing, 2001, 2005, 2009 and 2013 data), so the reported changes in wetland extent are not artefacts of random differences in mapping between years.

Historical change in extent



In 2013, 85 per cent of the total pre-European extent of all wetlands remained across the Great Barrier Reef catchments, including 76 per cent of the pre-European extent of vegetated freshwater swamps.

Loss of vegetated freshwater swamps compared to pre-European extent has been high in the Wet Tropics (48 per cent), Mackay Whitsunday (42 per cent) and Burnett Mary (37 per cent) regions. Many smaller coastal catchments with extensive lowlands have undergone widespread loss of freshwater swamps with more than 80 per cent lost in the Kolan, Pioneer and Calliope catchments. This loss is mainly due to drainage, clearing and levelling associated with intensive agriculture or urban use.

Over 90 per cent of pre-European extent of mangroves and salt flats remain in most catchments, except for the Barron, Mulgrave, Russell, Pioneer, Boyne, Fitzroy, Shoalwater, Burnett and Kolan catchments.

The Cape York region has lost the least amount of wetlands (less than one per cent) from pre-European extent.

Generally there has been no significant reduction in lakes compared to their pre-European extent.

Cape York

No loss

Target: There is no net loss of the extent of natural wetlands.
Very good progress: There was no loss of natural wetland extent in the Cape York region between 2009 and 2013.

There has been very little historical loss of wetlands compared to pre-European extent in the Cape York region and no change in extent between 2005 and 2013. The vast majority (98.6 per cent) of vegetated freshwater swamps and lakes are made up of natural (unmodified) wetlands.

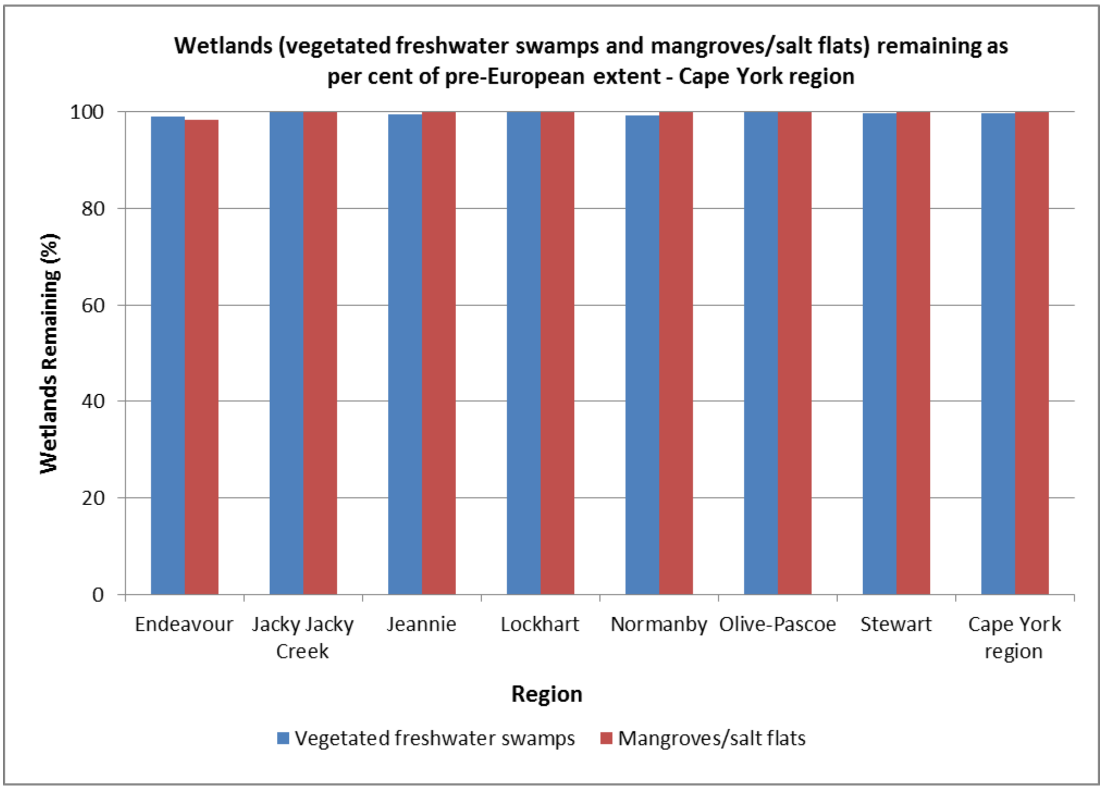
Wetland systems extent

Approximately 170,800 hectares of wetlands were mapped in the Cape York region in 2013. Of these wetland areas there are approximately:

- 55,500 hectares of vegetated freshwater swamps (palustrine wetlands) with the greatest density in the Jacky Jacky catchment
- 6200 hectares of lakes (lacustrine wetlands)
- 111,000 hectares of mangroves/salt flats (estuarine wetlands) with the greatest density in the Jacky Jacky, Jeannie and Lockhart catchments.

Historical and recent change in extent

The Cape York region recorded very little historical loss of wetlands compared to pre-European extent; no change in extent between 2005 and 2013 and a very minor reduction in extent (less than one hectare) between 2001 and 2005.



Wet Tropics

9ha loss
(<0.1%)

Target: There is no net loss of the extent of natural wetlands.
Good progress: There was a loss of nine hectares (less than 0.1 per cent) of all wetlands across the Wet Tropics region between 2009 and 2013. The rate of loss of all wetlands in the Wet Tropics region has continued to decline.

Wetland systems extent

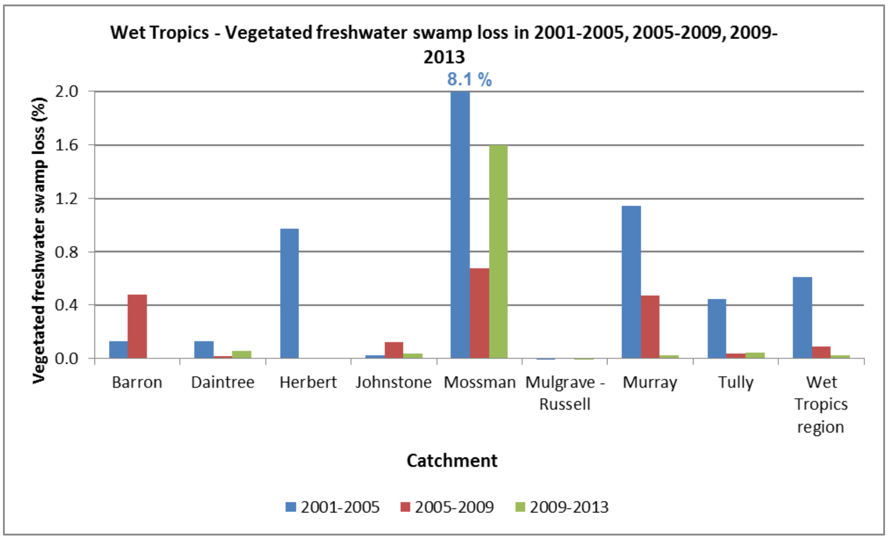
Approximately 80,000 hectares of wetlands were mapped in the Wet Tropics region in 2013. Of these wetland areas there are approximately:

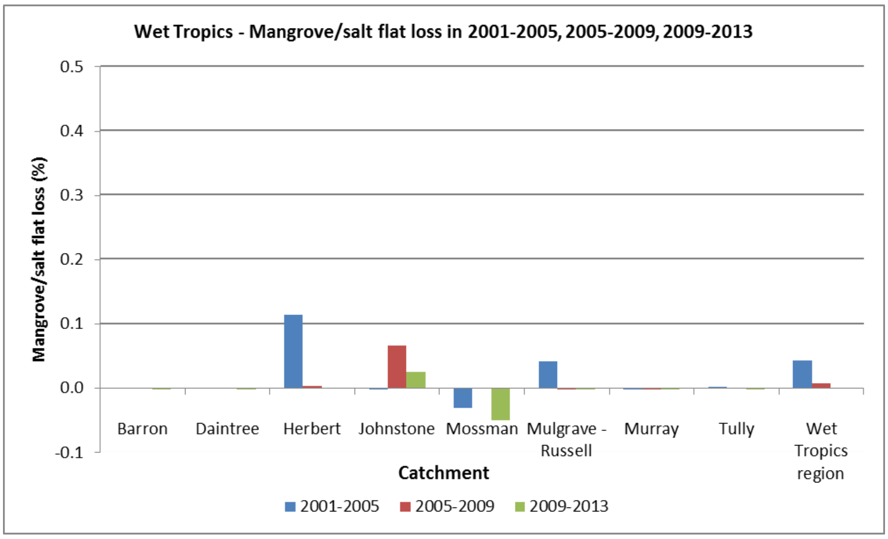
37,100 hectares of vegetated freshwater swamps (palustrine wetlands) with the greatest density in the Murray, Herbert and Russell-Mulgrave catchments

450 hectares of lakes (lacustrine wetlands)

42,500 hectares of mangroves/salt flats (estuarine wetlands) with the greatest density in the Murray and Herbert catchments.

Recent change in extent



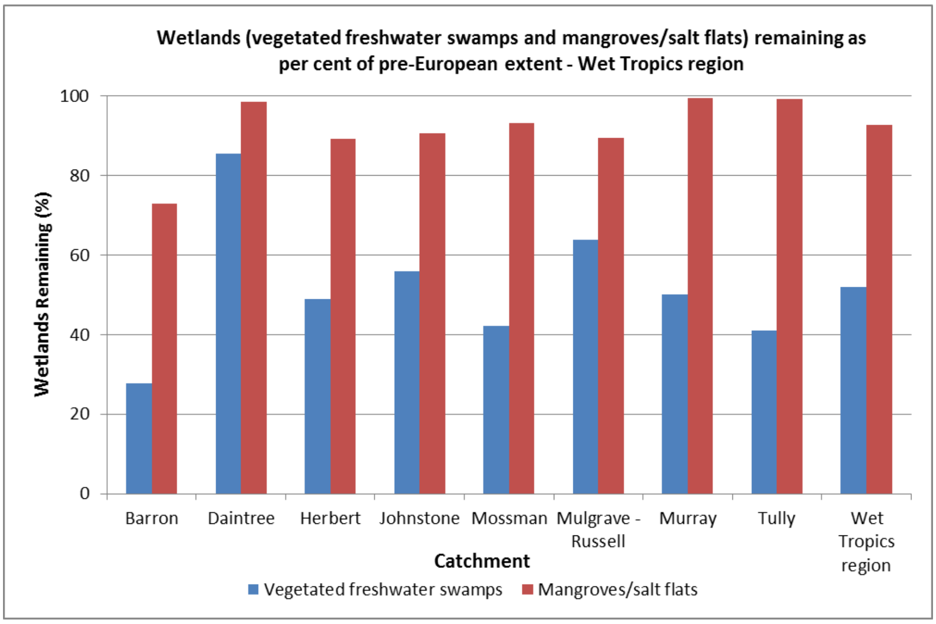


The rate of loss of all natural wetlands in the Wet Tropics has declined since 2001. Less than 0.1 per cent (nine hectares between 2009 and 2013 and 38 hectares between 2005 and 2009) of wetlands were lost following a 0.3 per cent loss (240 hectares) between 2001 and 2005. The rate of loss of vegetated freshwater swamps has also continued to decline, falling to less than 0.1 per cent (nine hectares) between 2009 and 2013 from 0.1 per cent (34 hectares) between 2005 and 2009 and nearly 0.6 per cent (225 hectares) between 2001 and 2005.

The Mossman catchment recorded the highest proportional rate of loss of vegetated freshwater swamps of all reef catchments between 2009 and 2013 (1.6 per cent). The small extent of vegetated freshwater swamps in this catchment means that the relatively small loss of three hectares represents a large proportional loss. In comparison, the much larger loss of 93 hectares in the Fitzroy catchment represented a loss of only 0.2 per cent due to the large extent of vegetated freshwater swamps in the Fitzroy catchment (42,624 hectares).

There was no change in the mapped extent of mangroves/salt flats in the Wet Tropics region between 2009 and 2013, following small reductions between 2005 and 2009 (three hectares, less than 0.1 per cent) and 2001 and 2005 (18 hectares, less than 0.1 per cent).

Historical change in extent



The Wet Tropics region recorded the highest regional historical loss of all wetlands compared to pre-European extent (33 per cent), and has also lost a larger proportion of its vegetated freshwater swamps (48 per cent) than any other region.

The Barron catchment has had significant historical loss of vegetated freshwater swamps with only 28 per cent of the pre-European extent remaining in 2013. Ninety-three per cent of pre-European extent of mangroves/salt flats remains in the region, although the Barron catchment has only 73 per cent remaining.

Burdekin

61ha gain (<0.01%)

Target: There is no net loss of the extent of natural wetlands.
Very good progress: There was a net gain of 61 hectares (less than 0.01 per cent) of extent of all natural wetlands across the Burdekin region between 2009 and 2013. Note: increases are due to modification through bunding.

Wetland systems extent

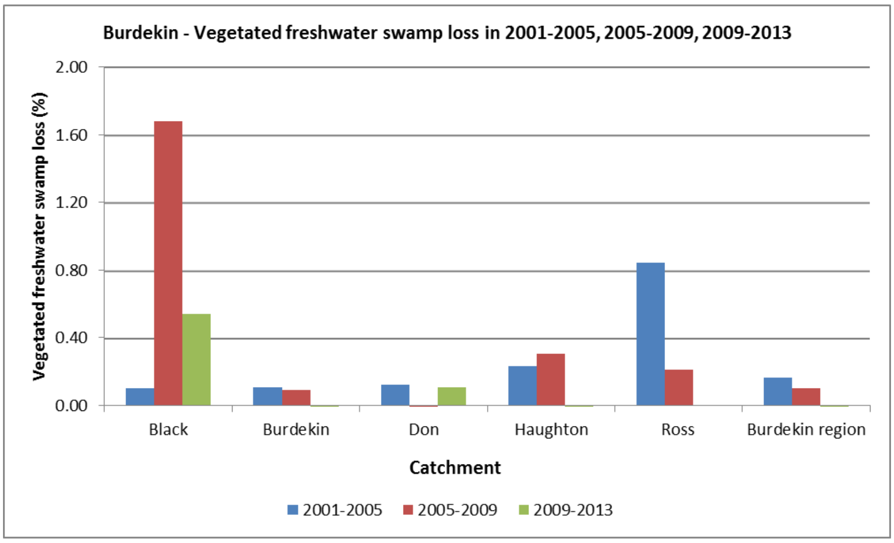
Approximately 144,100 hectares of wetlands were mapped in the Burdekin region in 2013. Of these wetland areas there are:

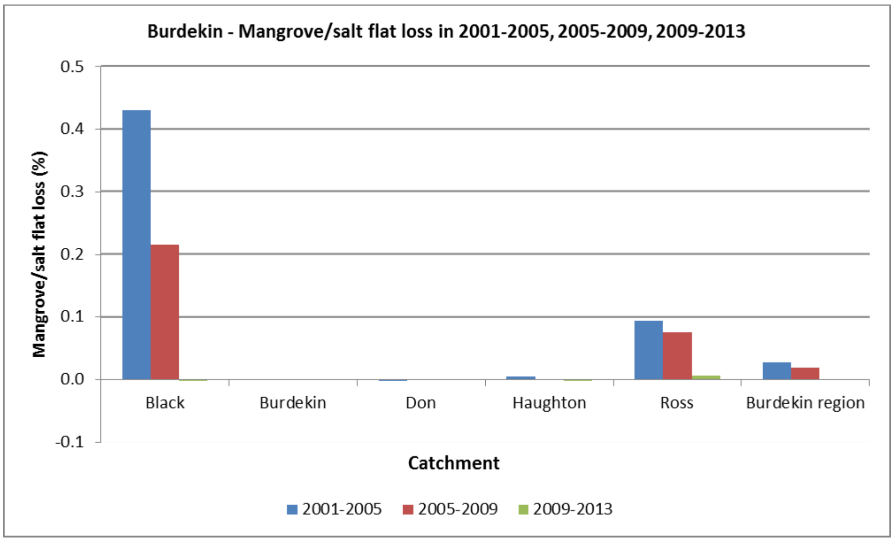
69,300 hectares of vegetated freshwater swamps (palustrine wetlands) with the greatest density in the Ross and Haughton catchments

8500 hectares of lakes (lacustrine wetlands)

66,300 hectares of mangroves/salt flats (estuarine wetlands) with the greatest density in the Haughton, Ross and Don Catchments.

Recent change in extent

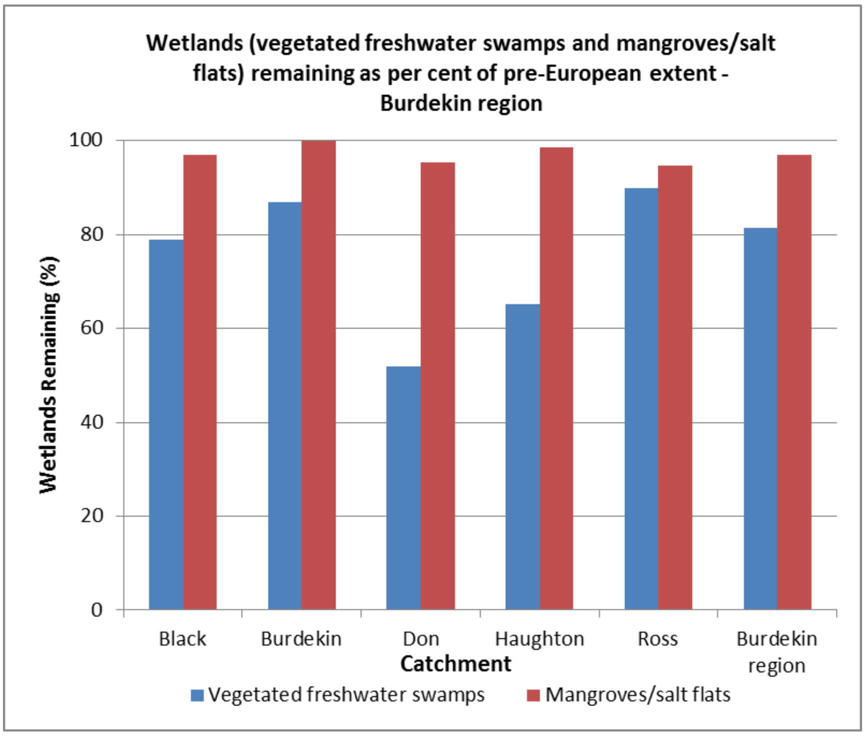




There was an overall net gain in extent of all natural wetlands of 61 hectares (less than 0.01 per cent) between 2009 and 2013, following losses of 30 hectares (less than 0.1 per cent) between 2005 and 2009, and 66 hectares (less than 0.1 per cent) between 2001 and 2005. Increases in extent through hydrological modification of lakes or freshwater vegetated swamps of more than 50 hectares occurred in all time periods. There was a net gain of 57 hectares (0.1 per cent) of vegetated freshwater swamps between 2009 and 2013 due to modification and bunding, following losses of 69 hectares (0.1 per cent) between 2005 and 2009, and 114 hectares (0.2 per cent) between 2001 and 2005.

Only one hectare (less than 0.1 per cent) of mangroves/salt flats was lost between 2009 and 2013, down from 12 hectares (less than 0.1 per cent) between 2005 and 2009 and 18 hectares (less than 0.1 per cent) between 2001 and 2005. There were small increases in lakes (associated with local hydrological modifications), gaining five hectares (0.1 per cent) between 2009 and 2013, 52 hectares (0.6 per cent) between 2005 and 2009, and 67 hectares (0.8 per cent) between 2001 and 2005.

Historical change in extent



Eighty-eight per cent of the pre-European extent of all wetlands remains. Historically, 19 per cent of vegetated freshwater swamps have been lost from pre-European extent across the region with 48 per cent and 35 per cent lost in the Don and Haughton catchments respectively. Over 97 per cent of the pre-European extent of mangroves/salt flats remains across all catchments in the region.

Mackay Whitsunday

5ha gain (<0.1%)

Target: There is no net loss of the extent of natural wetlands.
Very good progress: There was a small gain of five hectares (less than 0.1 per cent) in the extent of all natural wetlands in the Mackay Whitsunday region between 2009 and 2013 following a trend of small losses between 2001 and 2009. Note: increases are due to modification through bunding.

Wetland systems extent

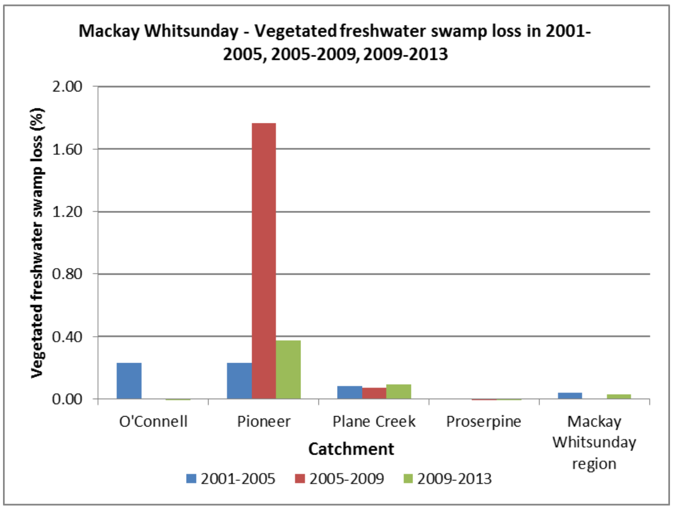
Approximately 57,100 hectares of wetlands were mapped in the Mackay Whitsunday region in 2013. Of these wetland areas there are:

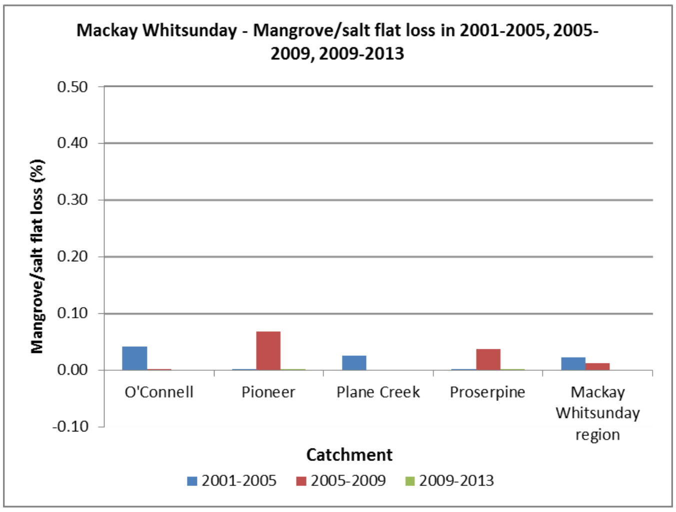
10,100 hectares of freshwater swamps (palustrine wetlands) with the greatest density in the Proserpine Creek catchment

280 hectares of lakes (lacustrine wetlands) with the greatest density in the Proserpine catchment

46,700 hectares of mangroves/salt flats (estuarine wetlands) with the greatest density in the Plane catchment.

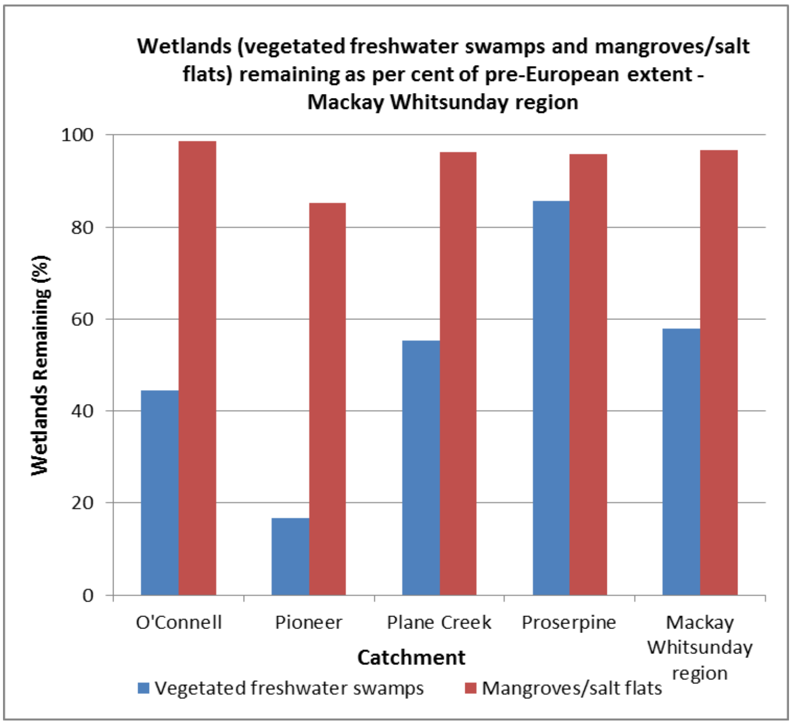
Recent change in extent





There was a small gain of five hectares (less than 0.1 per cent) in the extent of all natural wetlands in the Mackay Whitsunday region between 2009 and 2013, following losses of six hectares (less than 0.1 percent) between 2005 and 2009, and 15 hectares (less than 0.1 per cent) between 2001 and 2005. The loss of vegetated freshwater swamps since 2001 has been slow, always less than four hectares over each four-year reporting period (less than 0.1 per cent). There was no loss of mangroves/salt flats between 2009 and 2013, following losses of six hectares (less than 0.01 per cent) between 2005 and 2009, and 11 hectares (less than 0.01 per cent) between 2001 and 2005. Lakes recorded no change between 2001 and 2013 except for an eight hectare gain (46.2 per cent) in the Plane Creek catchment between 2009 and 2013.

Historical change in extent



Ninety per cent of the pre-European extent of all wetlands remains in the Mackay Whitsunday region. However, historically 42 per cent of the pre-European extent of vegetated freshwater swamps has been lost. The Pioneer and O‘Connell catchments have had significant historical loss of vegetated freshwater swamps with 83 per cent and 56 per cent of pre-European extent lost respectively. Ninety-seven per cent of the pre-European extent of mangroves/salt flats remains.

Fitzroy

348ha loss (0.1%)

Target: There is no net loss of the extent of natural wetlands.
Good progress: There was a loss of 348 hectares (0.1 per cent) in the extent of all natural wetlands across the Fitzroy region between 2009 and 2013. This was the greatest loss in extent across all regions.

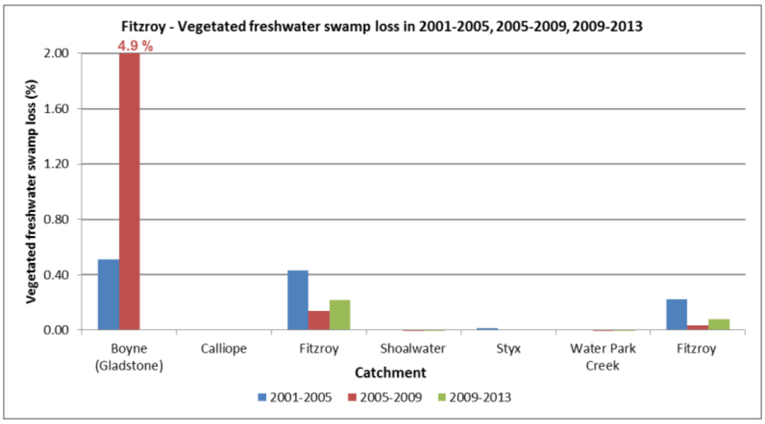
The Calliope catchment recorded the highest area and percentage loss of any wetland type across all Great Barrier Reef catchments, losing 284 hectares (3.5 per cent) of mangroves/salt flats between 2009 and 2013.

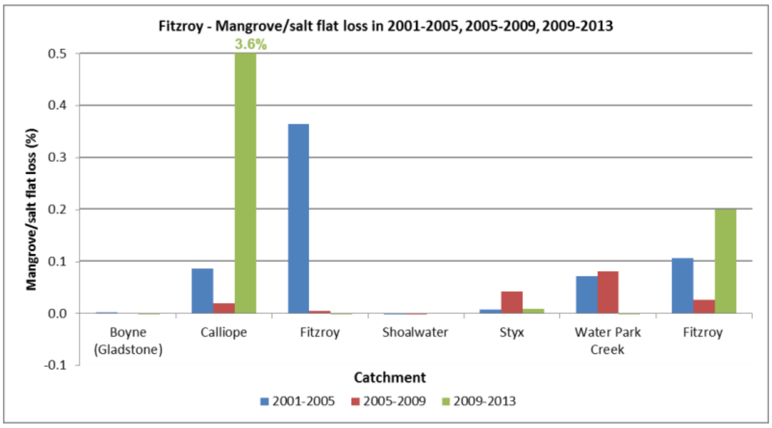
Wetland systems extent

Approximately 229,400 hectares of wetlands were mapped in the Fitzroy region in 2013. Of these wetland areas there are:

- 79,500 hectares of vegetated freshwater swamps (palustrine wetlands) with the greatest density in the Water Park Creek and Shoalwater catchments. The Shoalwater and Styx catchments have more than 94 per cent of their vegetated freshwater swamps comprised of former estuarine wetlands modified by bunding to convert them into fresh water systems
- 6500 hectares of lakes (lacustrine wetlands)
- 143,400 hectares of mangroves/salt flats (estuarine wetlands) with the greatest density in the Water Park Creek, Shoalwater and Styx catchments.

Recent change in extent





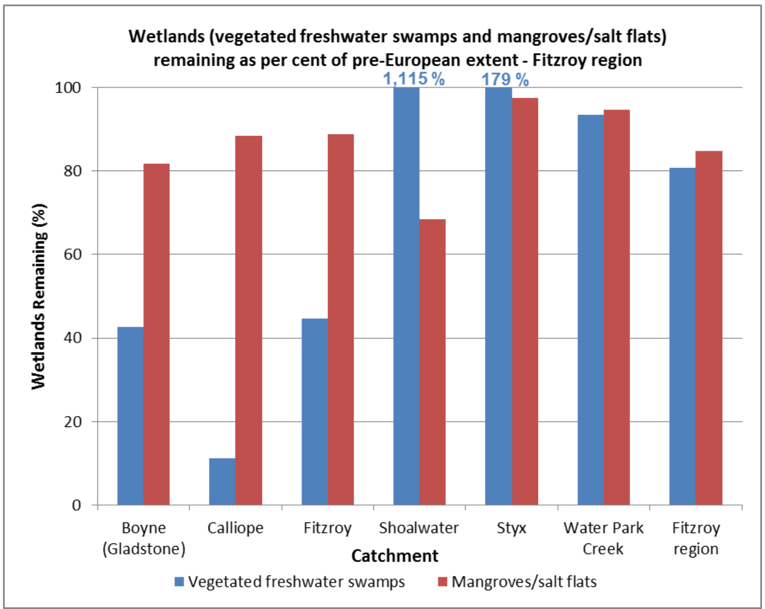
The Fitzroy region recorded the highest regional loss of extent across all wetlands of 348 hectares (0.1 per cent) between 2009 and 2013, following losses of 79 hectares (less than 0.1 per cent) between 2005 and

2009 and 302 hectares (0.15 per cent) between 2001 and 2005. However, the rate of loss was the same as the Burnett Mary region.

Loss of vegetated freshwater swamps was 68 hectares (0.1 per cent) between 2009 and 2013, following losses of 60 hectares (less than 0.1 per cent) between 2005 and 2009 and 185 hectares (0.2 per cent) between 2001 and 2005.

Loss of mangroves/salt flats increased dramatically to 287 hectares (0.2 per cent) between 2009 and 2013 from a loss of 39 hectares (less than 0.1 per cent) between 2005 and 2009 and 153 hectares (0.1 per cent) between 2001 and 2005. This 287 hectare loss, of which 284 hectares were lost in the Calliope catchment (3.6 per cent), was the highest recorded loss in area and percentage for any wetland system across the Great Barrier Reef catchments and all reporting periods.

Historical change in extent



Eighty four per cent of the pre-European extent of all wetlands remains. Historically, 19 per cent of the pre-European extent of vegetated freshwater swamps has been lost. However, this figure is influenced by significant increases prior to 2001 in vegetated freshwater swamps in the Shoalwater (greater than 13,000 hectares, 1115 per cent) and Styx (500 hectares, 179 per cent) catchments. These increases were caused by large scale conversion of estuarine wetlands to freshwater wetlands by damming or bunding, which is a common practice in many coastal catchments.

The Calliope catchment has experienced the highest historical loss of vegetated freshwater swamps with 89 per cent of pre-European extent lost. The Boyne (Gladstone) and Fitzroy catchments have also experienced historical loss of vegetated freshwater swamps in excess of 50 per cent. Eighty-five per cent of the pre-European extent of mangroves/salt flats remains across the region. This relatively high historical loss is associated with the conversion of mangroves/salt flats to freshwater swamps mainly in the Shoalwater catchment (32 per cent lost).

Burnett Mary

39ha loss
(0.1%)

Target: There is no net loss of the extent of natural wetlands.
Good progress: There was a loss of 39 hectares (0.1 per cent) in the extent of all natural wetlands across the Burnett Mary region between 2009 and 2013. This was largely made up of losses of freshwater swamps which have continued to decline in extent since 2001.

Wetland systems extent

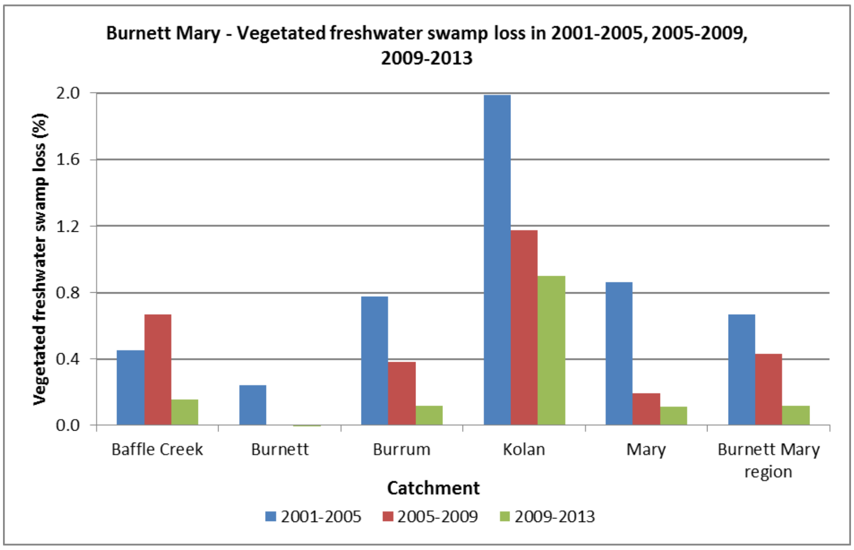
Approximately 54,000 hectares of wetlands were mapped in the Burnett Mary region in 2013. Of these wetland areas there are:

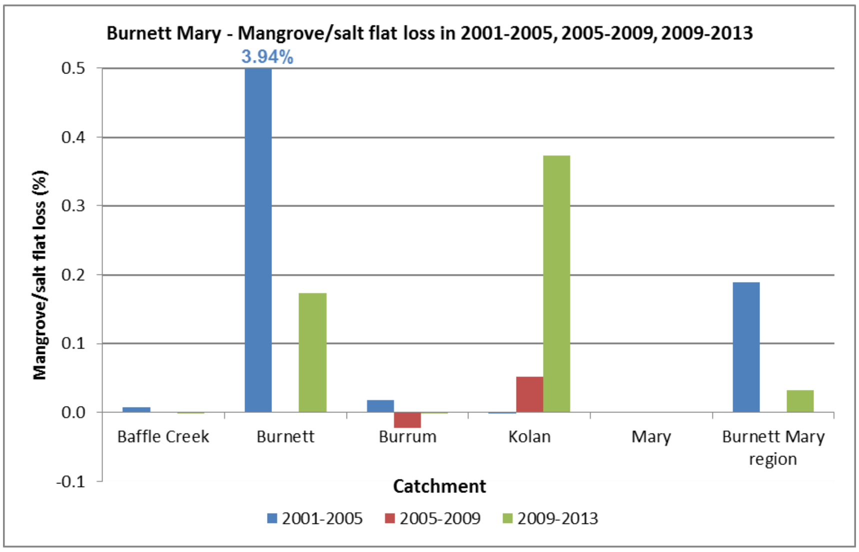
30,000 hectares of vegetated freshwater swamps (palustrine wetlands) with the greatest density in the Burrum and Baffle catchments

440 hectares of lakes (lacustrine wetlands)

23,600 hectares of mangroves/salt flats (estuarine wetlands) with the greatest density in the Baffle catchment.

Recent change in extent

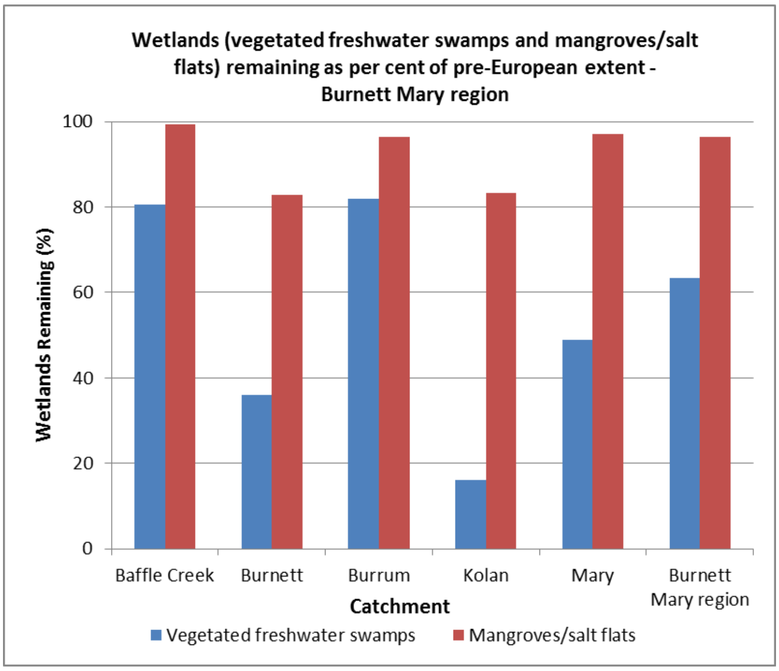




The rate of loss of extent across all wetlands continued to decline, down to 39 hectares (0.1 per cent) between 2009 and 2013, compared with 125 hectares (0.2 percent) between 2005 and 2009, and 200 hectares (0.4 per cent) between 2001 and 2005. The Burnett Mary region recorded the greatest proportional loss of wetlands between 2009 and 2013, along with the Fitzroy region. Losses were mainly from vegetated freshwater swamps which declined by 35 hectares (0.1 per cent) between 2009 and 2013, compared to losses of 128 hectares (0.4 per cent) between 2005 and 2009, and 200 hectares (0.7 per cent) between 2001 and 2005.

Small increases in the extent of natural lakes (less than five hectares) were recorded between 2005 and 2013 following a 30 hectare increase (8.3 per cent) between 2001 and 2005. These increases are associated with modifications due to earth works. There was a small loss of less than 10 hectares (less than 0.01 per cent) of mangroves/salt flats between 2009 and 2013 following no loss between 2005 and 2009 and a loss of 45 hectares (0.2 per cent) between 2001 and 2005.

Historical change in extent



Seventy four per cent of the pre-European extent of all wetlands remains in the Burnett Mary region. The Kolan catchment has the highest recorded historical loss of all wetlands (59 per cent). Thirty-seven per cent of the pre-European extent of vegetated freshwater swamps has been lost. The Kolan, Burnett and Mary catchments recorded substantial historical loss of vegetated freshwater swamps with 16, 36 and 49 per cent of pre-European extent remaining respectively. This loss is particularly prevalent in the lowlands of these catchments. Ninety-six per cent of mangroves/salt flats pre-European extent remains.

Riparian results

The riparian vegetation target in the Reef Water Quality Protection Plan 2013 (Reef Plan) is:
"The extent of riparian vegetation is increased by 2018."

Between 2009 and 2013, there was an increase in vegetation loss in the riparian areas of the Great Barrier Reef region compared to 2005 to 2009. In 2013, 78 per cent of riparian areas in the Great Barrier Reef region remained forested.

Scoring system

- Very good
- Good
- Moderate
- Poor
- Very poor
- No data

Great Barrier Reef-wide

30,980ha loss (0.4%)

Target: The extent of riparian vegetation is increased by 2018.
Moderate progress: There was a loss of 30,980 hectares (0.4%) of riparian vegetation across the Great Barrier Reef between 2009 and 2013.

A riparian area is defined as an area within a 100m of a mapped stream or riverine wetland. Approximately 7.4 million hectares of riparian areas were mapped in the Great Barrier Reef region which represents approximately 17 per cent of the total Great Barrier Reef region area. The regions with the largest amount of riparian areas are the Burdekin (2.4 million hectares) and Fitzroy (2.2 million hectares) regions (Figure 1).

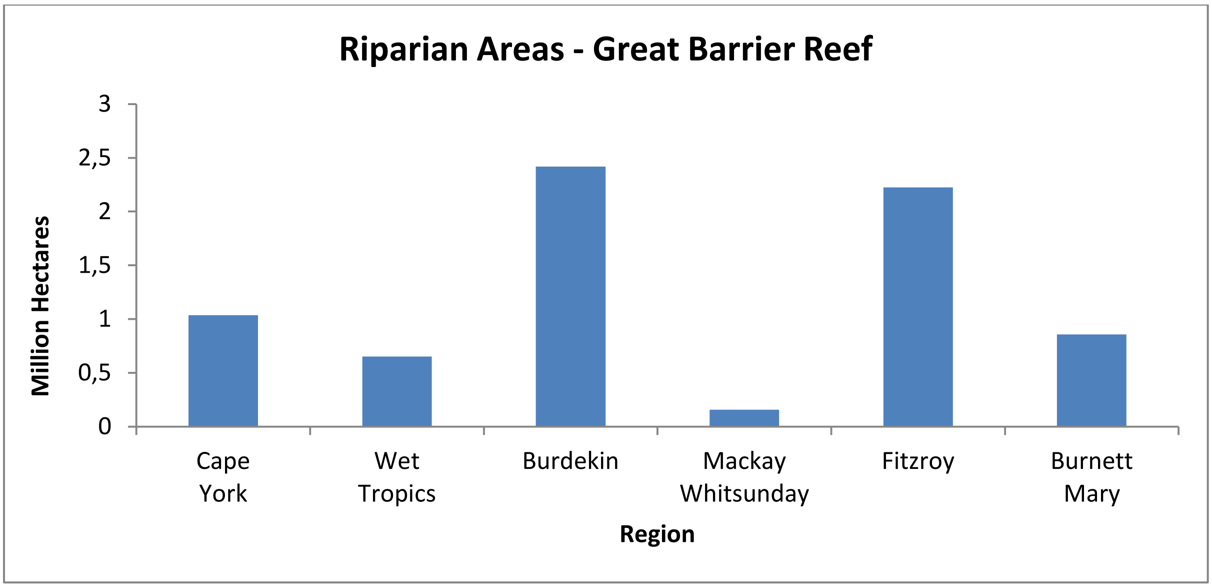


Figure 1: Number of hectares mapped as riparian areas within the Great Barrier Reef region.

Changes in extent of riparian vegetation

Extent of modification to riparian forests since European settlement

The historical loss of riparian forest for the Great Barrier Reef region is estimated to be about 19 per cent (1.4 million hectares) of the pre-European extent. The greatest estimated historical loss has occurred in the Fitzroy region (27 per cent, 609,400 hectares) (Figure 2). Cape York has had very little historical riparian forest loss. Note these figures have been rounded due to the uncertainty associated with estimating pre-European forest extent. The figures provide an indication of the relative level of modification in each region.

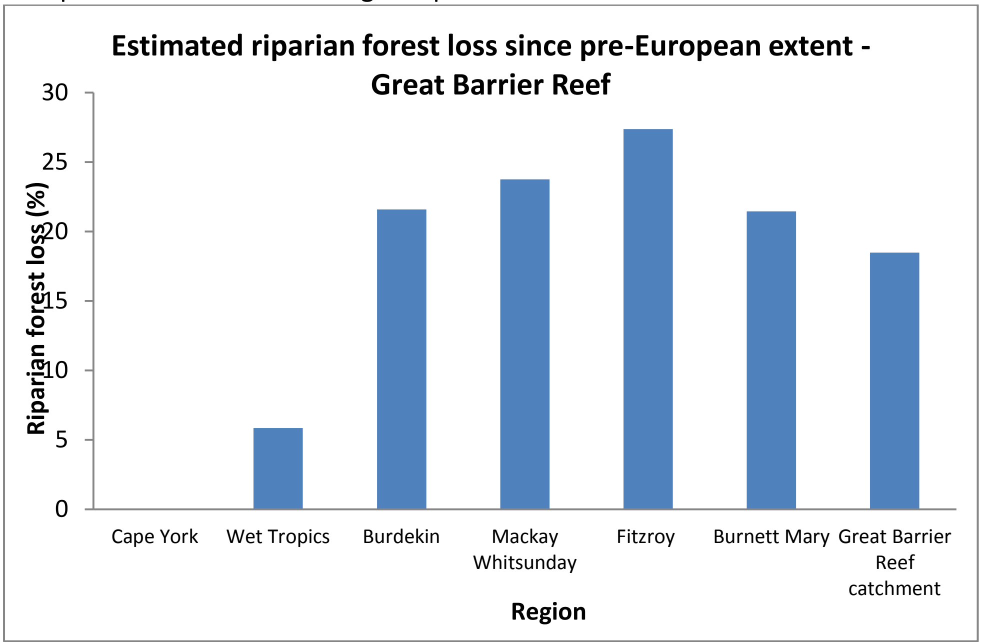


Figure 2: Proportion of riparian forest loss in the Great Barrier Reef region since pre-European settlement.

Recent loss of riparian vegetation

From 2000 to 2010 there was a consistent decrease in riparian vegetation loss from 32,515 hectares (0.44 per cent) in 2000 to 3,764 hectares (0.05 per cent) by 2010. However, since then, riparian vegetation loss has increased to 11,677 hectares (0.16 per cent) in 2013 (Figure 3).

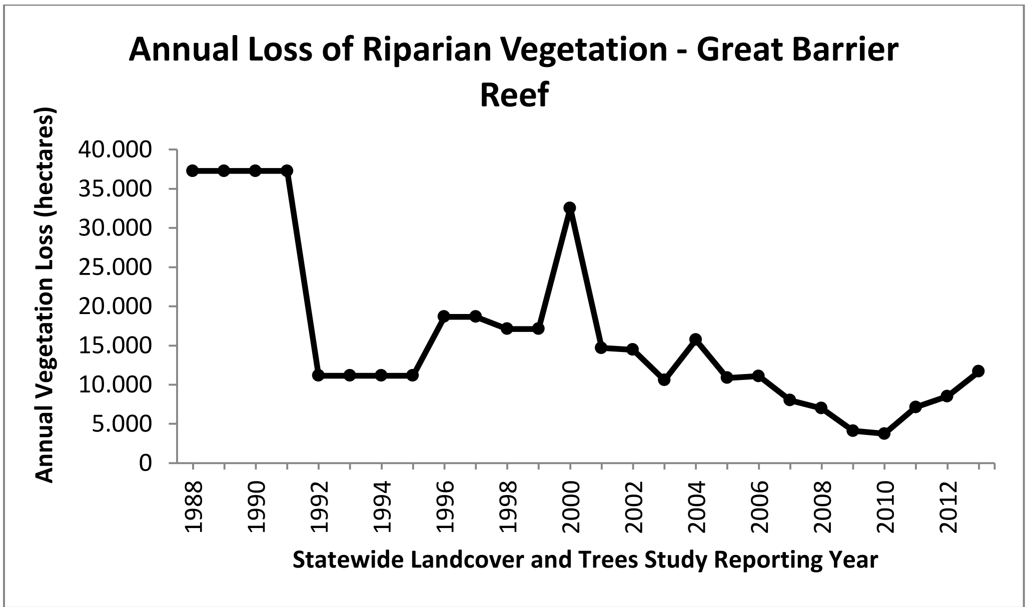


Figure 3: Riparian vegetation loss from 1988 to 2013 as reported by the Statewide Landcover and Trees Study for the Great Barrier Reef region.

The rate of loss of riparian vegetation increased between 2009 and 2013 (0.42 per cent; 30,980 hectares) up from 0.38 per cent (28,162 hectares) between 2005 and 2009 (Figure 4). This followed a loss of 0.7 per cent (51,274 hectares) between 2001 and 2005.

The Fitzroy region had the largest increase in the loss of riparian vegetation from 0.4 per cent (9,938 hectares) between 2005 and 2009 to 0.7 per cent (14,777 hectares) between 2009 and 2013. This resulted in the Fitzroy region having the highest proportion of riparian vegetation loss along with the Burnett Mary region. The Fitzroy region also had the highest rate of loss (1.2 per cent; 25,670 hectares) between 2001 and 2005.

While the Burnett Mary region had the highest rate of loss between 2009 and 2013 (0.7 per cent, 6027 hectares), it also recorded the greatest reduction in the rate of loss down from 0.91 per cent (8,877 hectares) between 2005 and 2009, a decrease of 2,850 hectares. This was down from one per cent (9410 hectares) between 2001 and 2005.

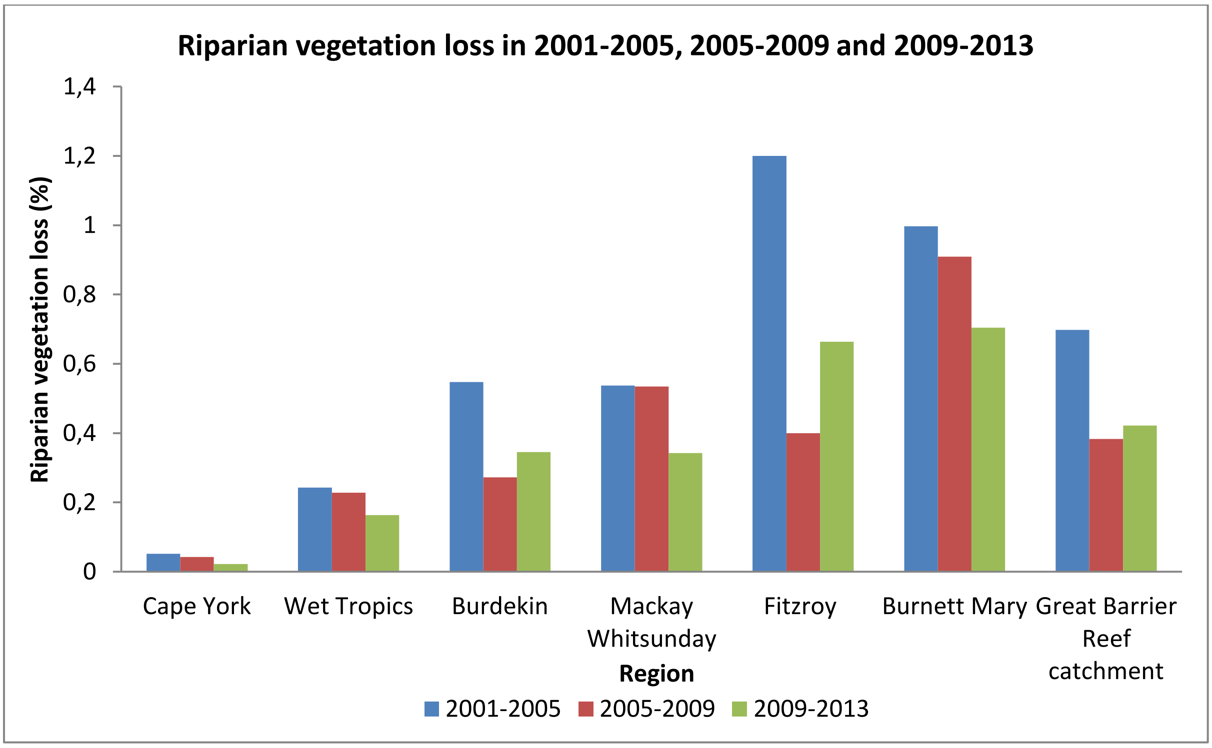


Figure 4: Riparian vegetation loss as a percentage of the total riparian area from 2001 to 2013 summarised into three periods (2001-2005, 2005-2009 and 2009-2013) for the Great Barrier Reef region as reported by the Statewide Landcover and Trees Study.

Landscape metrics

The patch size and connectivity index describes the size and connectivity of riparian forest patches. The patch size and connectivity index value increases as vegetation patches become larger and more connected. The normalised patch density value provides a measure of the linear connectivity of riparian forest along the stream network. A low value indicates high linear connectivity.

In 2013, the Great Barrier Reef region had a riparian forest patch size and connectivity index of 82.6 and a normalised patch density value of 6.1 (Figure 5). The Cape York region had the highest patch size and connectivity index (98.1) and the lowest normalised patch density value (0.11). This shows that within the Cape York region, forest patches are generally large, well-connected and continuous along the streams. The Wet Tropics region also had relatively high connectivity.

The least connected riparian forest patches were found in the Fitzroy (patch size and connectivity index of 71.8 and normalised patch density value of 9.6) and Burdekin (patch size and connectivity index of 73.5 and normalised patch density value of 12.8) regions. Both these regions had many small, non-continuous patches of riparian forest.

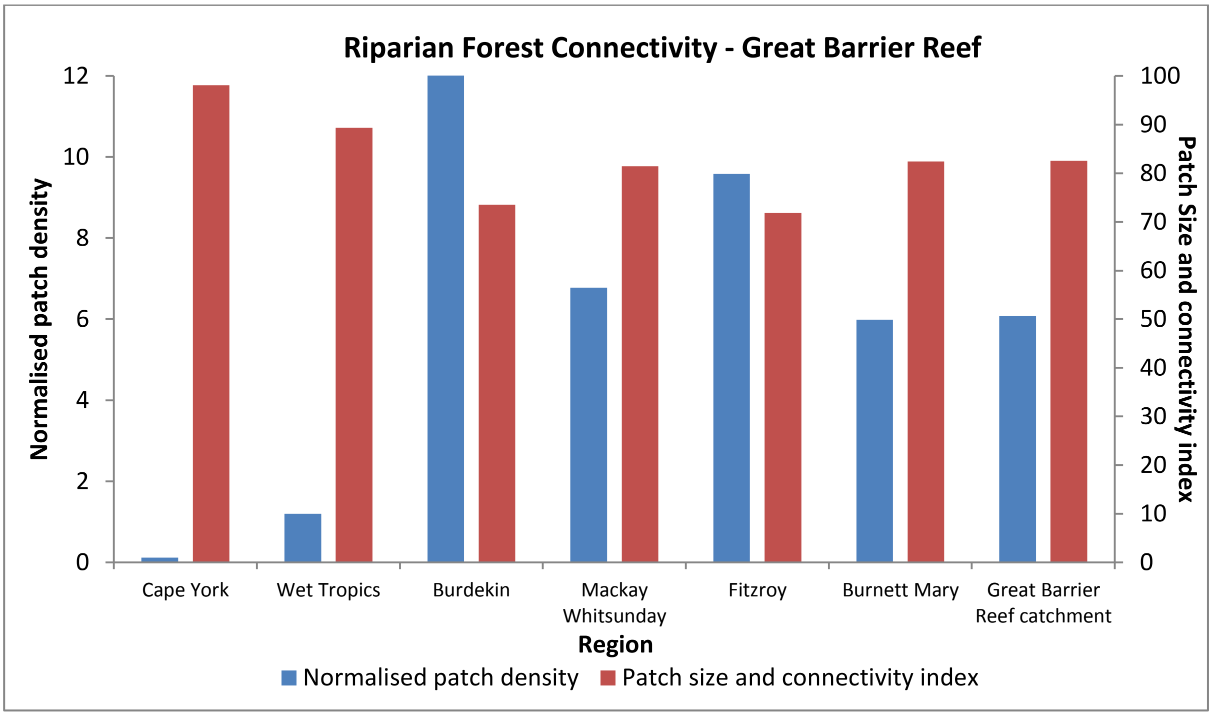


Figure 5: Normalised patch density and patch size and connectivity index for the Great Barrier Reef region.

Proportions of riparian vegetation

In 2013, approximately 78 per cent (5.7 million hectares) of riparian areas were forested (Figure 6), 5.4 per cent (395,610 hectares) were classed as non-forested and had less than 70 per cent ground cover, and 0.2 per cent (15,258 hectares) with ground cover 30 per cent. The Burdekin and Fitzroy regions had the greatest areas of less than 70 per cent ground cover in non-forested riparian areas. Parts of these regions were impacted by drier conditions in 2013 which may have resulted in lower ground cover levels.

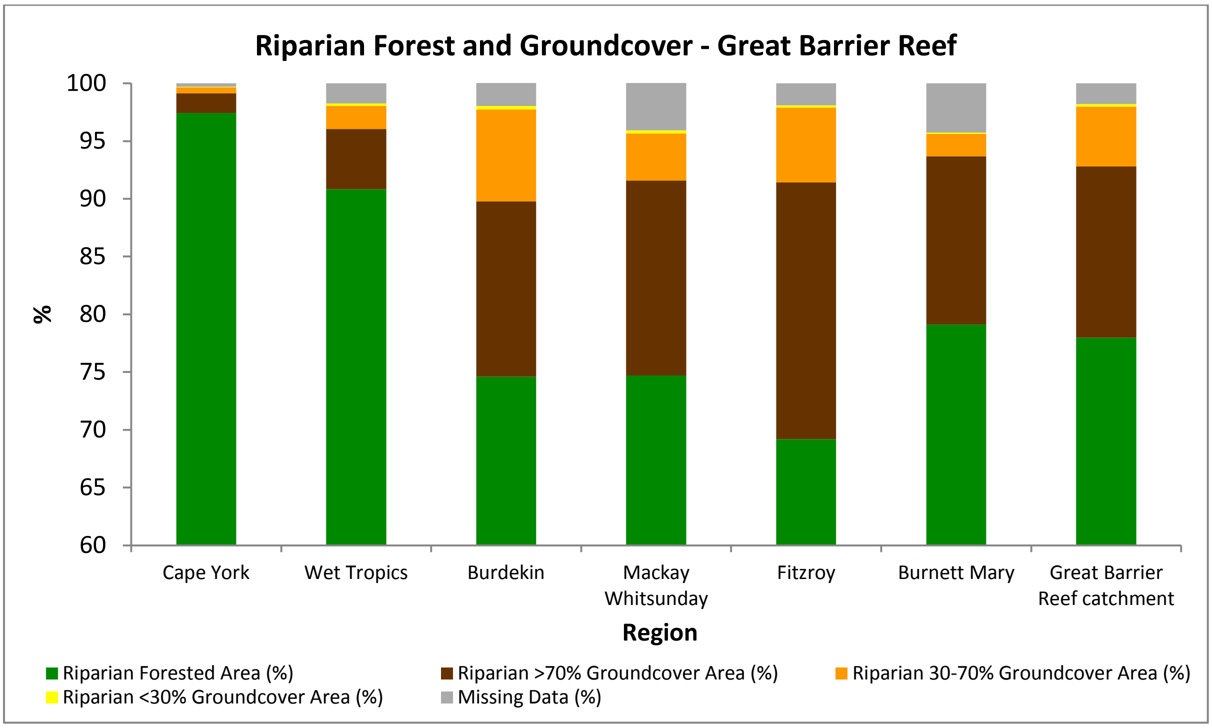


Figure 6: The proportion of forest, ground cover greater than 70 per cent, ground cover between 30 and 70 per cent, ground cover less than 30 per cent and missing data for riparian areas within the Great Barrier Reef region.

Cape York

226ha loss (0.02%)

Target: The extent of riparian vegetation is increased by 2018.

Good progress: There was a loss of 226 hectares (0.02 per cent) of riparian vegetation across the Cape York region between 2009 and 2013.

Approximately 1.04 million hectares of riparian areas were mapped within the Cape York region. The catchment with the largest amount of riparian areas was the Normanby River catchment with 344,313 hectares (Figure 7).

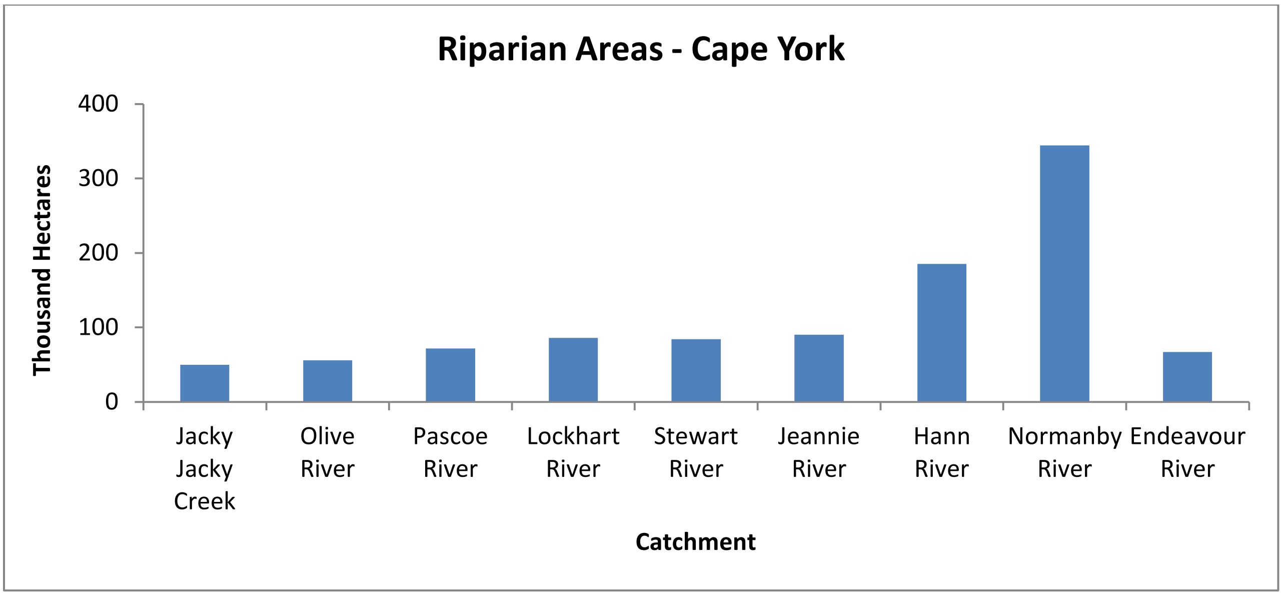


Figure 7: Number of hectares mapped as riparian areas within the Cape York region.

Changes in extent of riparian vegetation

Extent of modification to riparian forests since European settlement

There has been minimal change in riparian forest within the Cape York region since European settlement. This region has had the least proportion of riparian forest loss of all the Great Barrier Reef regions since European settlement.

Recent loss of riparian vegetation

Since 1988, there has been minimal change in riparian forest extent with an annual loss below 250 hectares (0.01 per cent) (Figure 8).

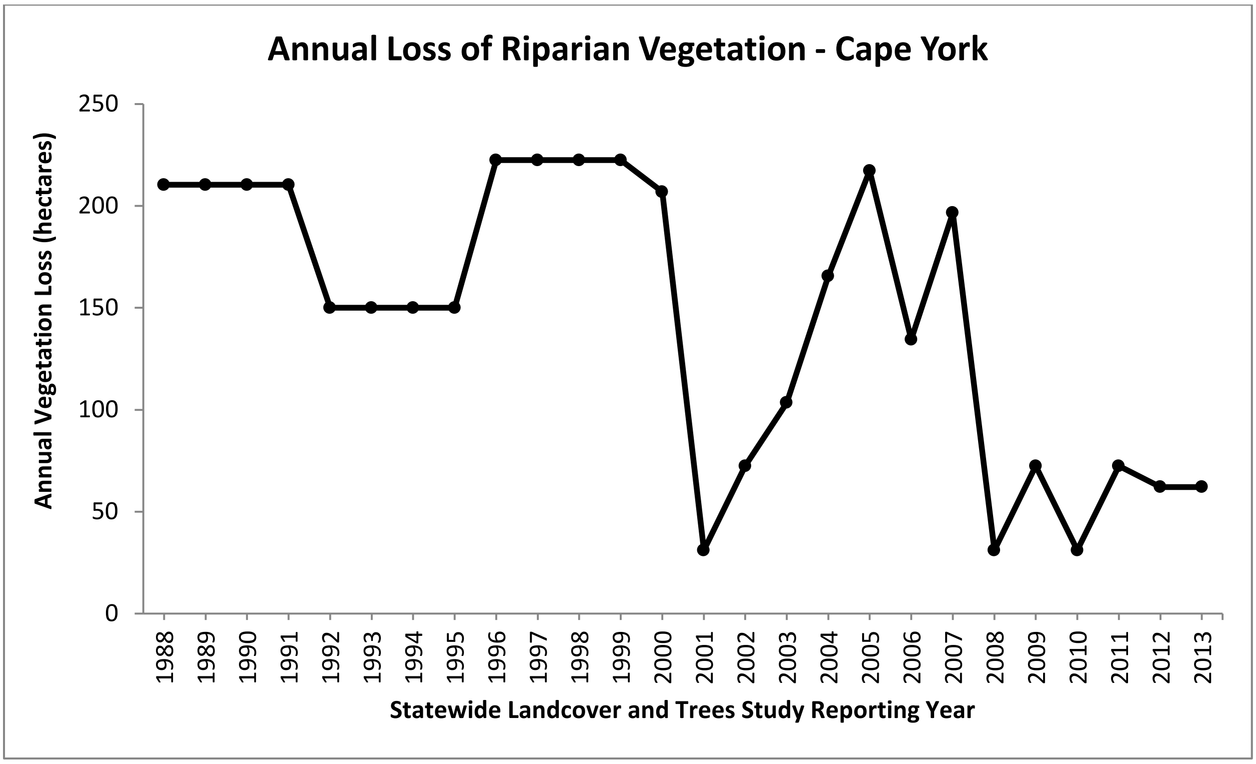


Figure 8: Riparian vegetation loss from 1988 to 2013 as reported by the Statewide Landcover and Trees Study for the Cape York region.

Only 0.02 per cent (240 hectares) of riparian vegetation loss occurred between 2009 and 2013 (average annual vegetation loss of 0.006 per cent) (Figure 9). This compares to 0.04 per cent (434 hectares) of loss between 2005 and 2009 (average annual loss of 0.01 per cent) and 0.05 per cent between 2001 and 2005 (average annual loss of 0.01 per cent).

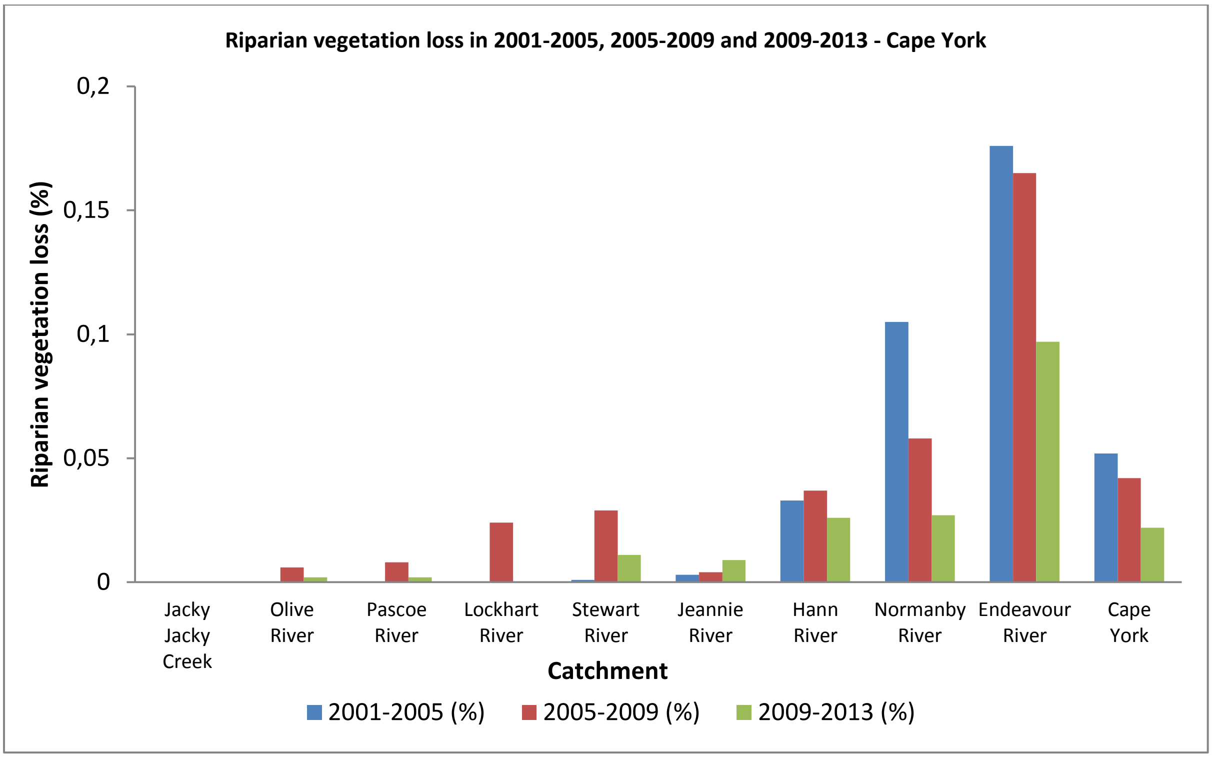


Figure 9: Riparian vegetation loss from 2001 to 2013 summarised into three periods (2001-2005, 2005-2009 and 2009-2013) for the Cape York region.

Landscape metrics

The patch size and connectivity index describes the size and connectivity of riparian forest patches. The patch size and connectivity index value increases as vegetation patches become larger and more connected. The normalised patch density value provides a measure of the linear connectivity of riparian forest along the stream network. A low value indicates high linear connectivity.

In 2013, the Cape York region had the highest riparian forest connectivity with a patch size and connectivity index of 98.1 and a normalised patch density value of 0.11 (Figure 10). All catchments within the Cape York region had high riparian forest connectivity.

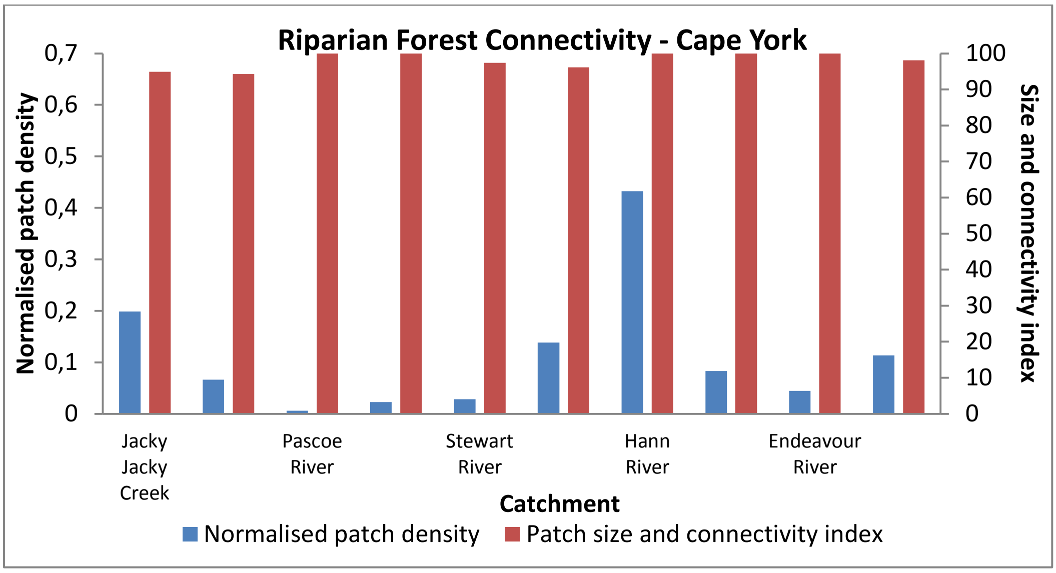


Figure 10: Normalised patch density and connectivity index for the Cape York region.

Proportions of riparian vegetation

In the Cape York region, 97.4 per cent (one million hectares) of riparian areas were forested, 0.6 per cent (5837 hectares) of riparian areas were non-forested with ground cover less than 70 per cent and 0.05 per cent (538 hectares) had ground cover less than 30 per cent (Figure 11). In this region, low ground cover areas are mainly associated with naturally bare river beds and coastal sand dunes.

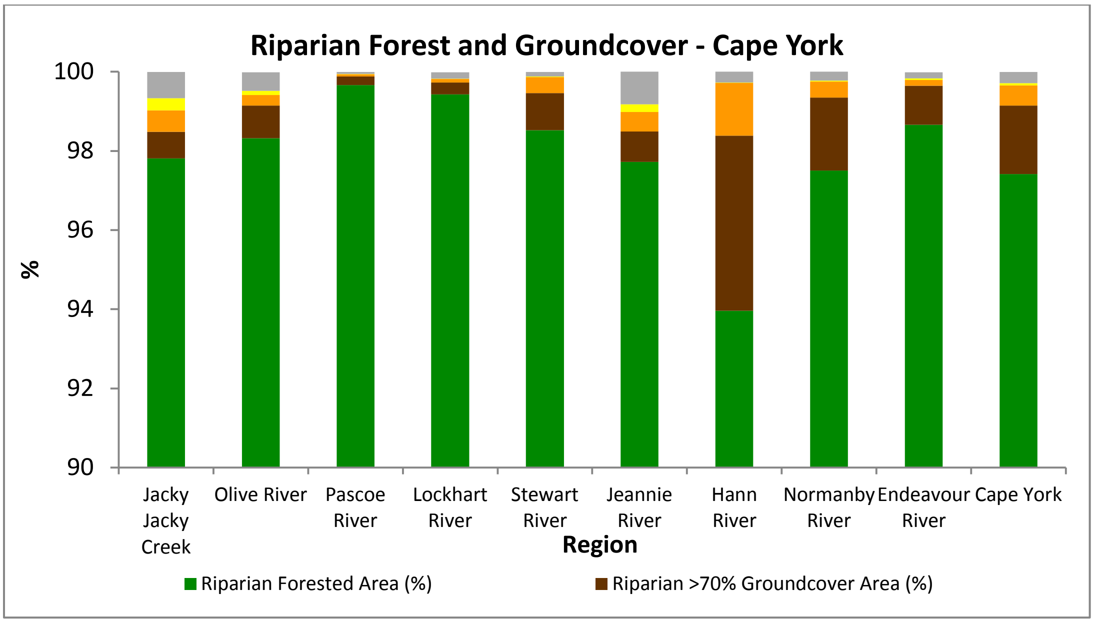


Figure 11: The proportion of forest, ground cover greater than 70 per cent, ground cover between 30 and 70 per cent, ground cover less than 30 per cent and missing data for riparian areas within the Cape York region.

Wet Tropics

1060ha loss (0.2%)

Target: The extent of riparian vegetation is increased by 2018.
Moderate progress: There was a loss of 1060 hectares (0.2 per cent) of riparian vegetation across the Wet Tropics region between 2009 and 2013.

Approximately 651,690 hectares of riparian areas were mapped in the Wet Tropics region (Figure 12). The catchment with the largest amount of riparian areas was the Herbert River catchment with 261,194 hectares. The Freshwater Creek catchment had the smallest amount of riparian areas (4186 hectares).

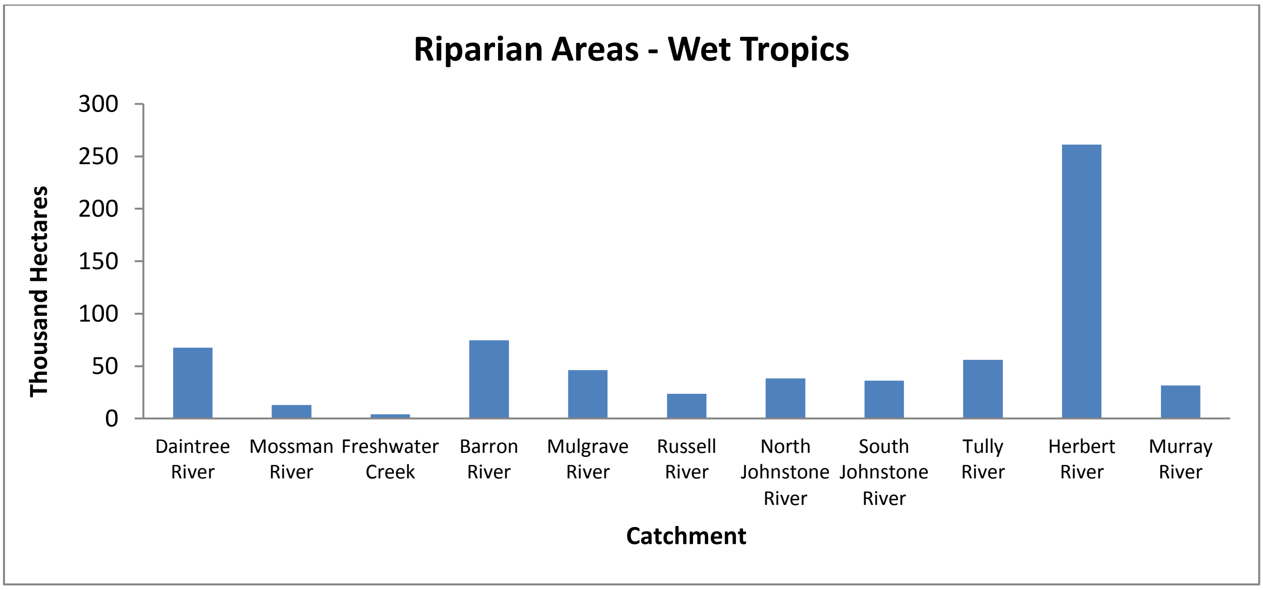


Figure 12: Number of hectares mapped as riparian areas within the Wet Tropics region.

Changes in extent of riparian vegetation

Extent of modification to riparian forests since European settlement
An estimated six per cent (38,000 hectares) of riparian forests has been lost from pre-European extent, with the South Johnstone River catchment losing the largest proportion (13 per cent, 4600 hectares) (Figure 13). The catchment with the least amount of riparian forest loss compared to pre-European extent was the Daintree River catchment with virtually no loss.

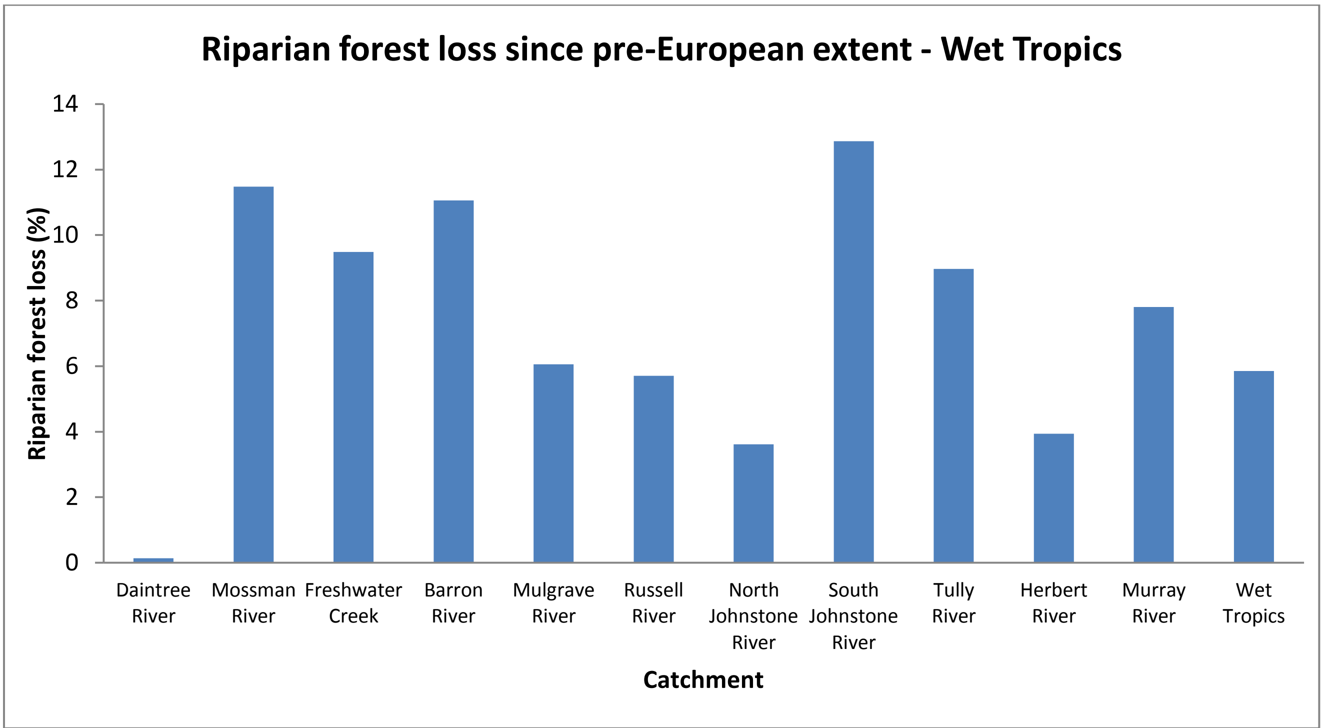


Figure 13: Proportion of riparian forest loss in the Wet Tropics region since pre-European settlement.

Recent loss of riparian vegetation
Since 1988, the annual loss of riparian vegetation in the Wet Tropics region has generally been falling from over 1000 hectares (0.16 per cent) to 55 hectares (0.01 per cent) in 2010. However, this increased to 370 hectares (0.06 per cent) in 2013 (Figure 14).

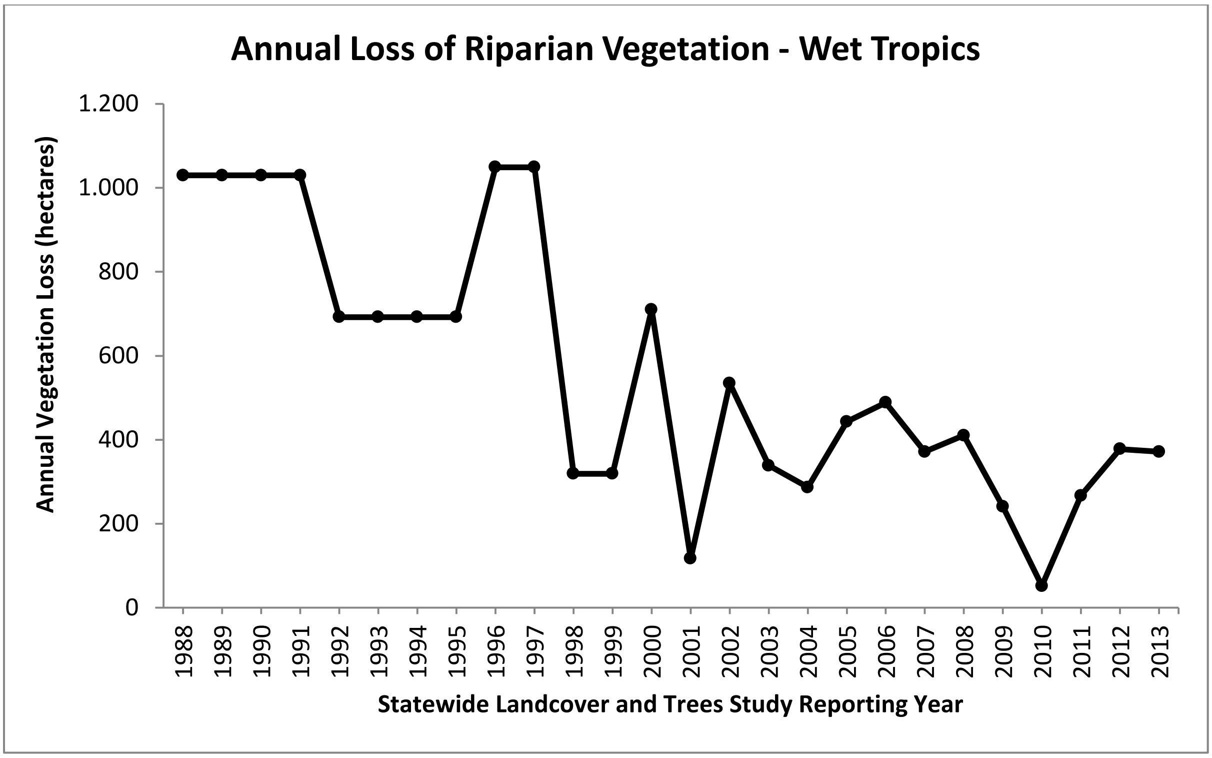


Figure 14: Riparian vegetation loss from 1988 to 2013 as reported by the Statewide Landcover and Trees Study for the Wet Tropics region.

The rate of loss of riparian vegetation has remained consistent at 0.2 per cent (1060 hectares from 2009 to 2013, 1488 hectares from 2005 to 2009 and 1582 hectares from 2001 to 2005). The Murray catchment had the highest riparian vegetation loss with 1.4 per cent (426 hectares) between 2009 and 2013. This was a 0.5 per cent increase compared to 2005 to 2009 but 0.06 per cent lower than 2001 to 2005 (Figure 15). This catchment consists of a large amount of plantation forestry which is where most of the vegetation loss is detected.

The Daintree River catchment had the lowest amount of riparian vegetation loss (four hectares, 0.01 per cent between 2009 and 2013 and eight hectares, 0.01 per cent 2005 and 2009).

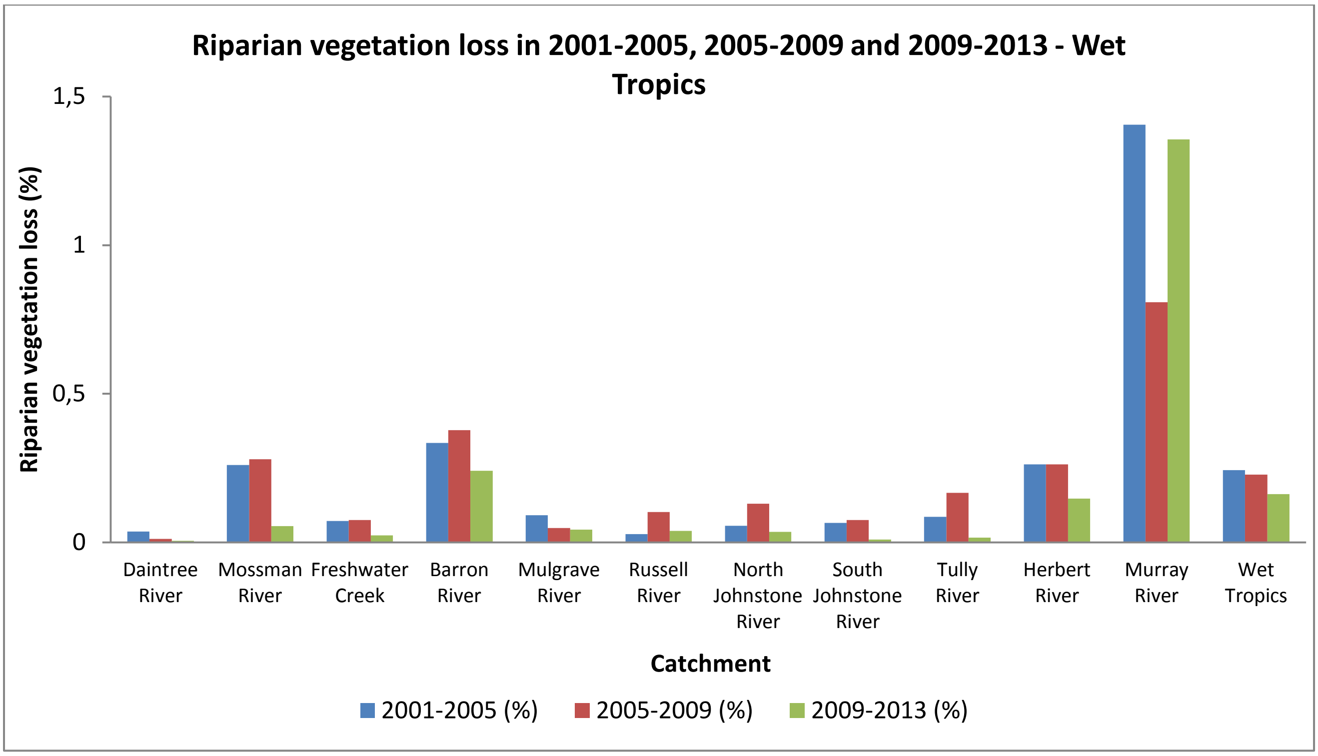


Figure 15: Riparian vegetation loss from 2001 to 2013 summarised into three periods (2001-2005, 2005-2009 and 2009-2013) for the Wet Tropics region.

Landscape metrics

The patch size and connectivity index describes the size and connectivity of riparian forest patches. The patch size and connectivity index value increases as vegetation patches become larger and more connected. The normalised patch density value provides a measure of the linear connectivity of riparian forest along the stream network. A low value indicates high linear connectivity.

In 2013, the Wet Tropics region had a patch size and connectivity index of 89.4 and a normalised patch density value of 1.2 (Figure 16). The Mulgrave River and Daintree River catchments were the most connected with a patch size and connectivity index of 100 and 91 respectively and a normalised patch density value of 0.7 and 0.05 respectively. The least connected catchments were Freshwater creek (patch size and connectivity index 79.8, normalised patch density 0.7), Mossman River (patch size and connectivity index 84.5, normalised patch density 3) and South Johnstone River (patch size and connectivity index 84.7, NPD 2.3).

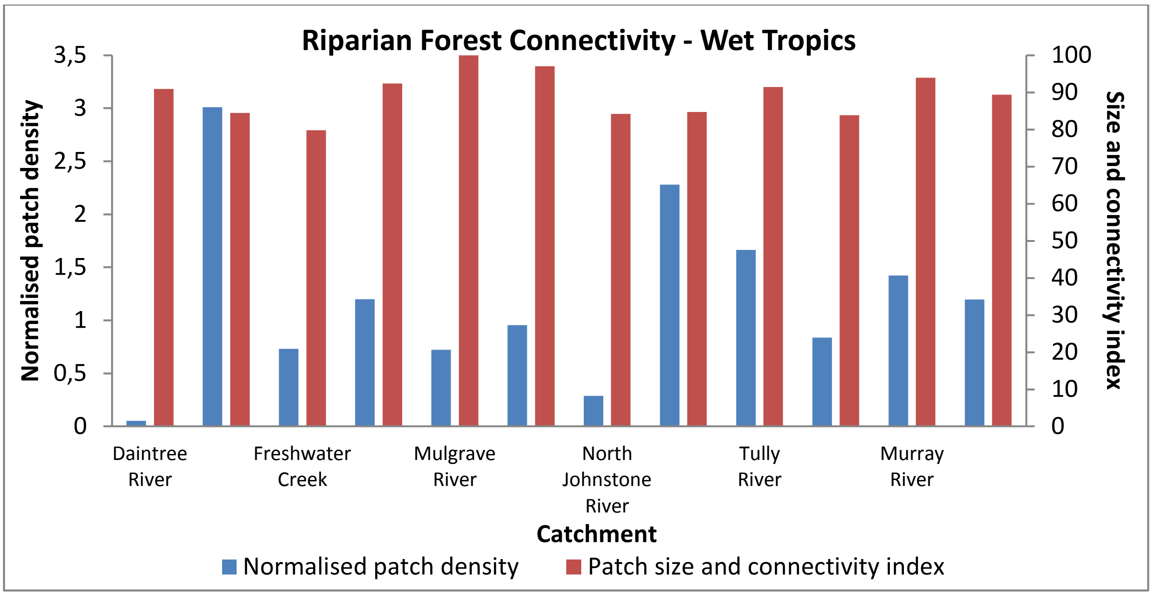


Figure 16: Normalised patch density and riparian patch size and connectivity index for the Wet Tropics region.

Proportions of riparian vegetation

In the Wet Tropics region, the forested areas represented approximately 90.8 per cent (592,025 hectares) of the riparian area in 2013 (Figure 17). The lowest proportion occurred in the South Johnstone River catchment (85.5 per cent, 30,794 hectares) and the Daintree River catchment had the highest proportion (98.7 per cent, 66,563 hectares).

Approximately 2.2 per cent (14,564 hectares) of riparian areas were non-forested and had ground cover less than 70 per cent and 0.2 per cent (1398 hectares) had ground cover less than 30 per cent. The highest proportion of ground cover less than 70 per cent occurred in the South Johnstone River with 4.2 per cent (1516 hectares). Freshwater Creek had the highest proportion of ground cover less than 30 per cent with 0.87 per cent (36 hectares) followed by Mossman River with 0.84 per cent (108 hectares). Ground cover less than 30 per cent within the Freshwater Creek catchment occurs within the urban areas of Cairns.

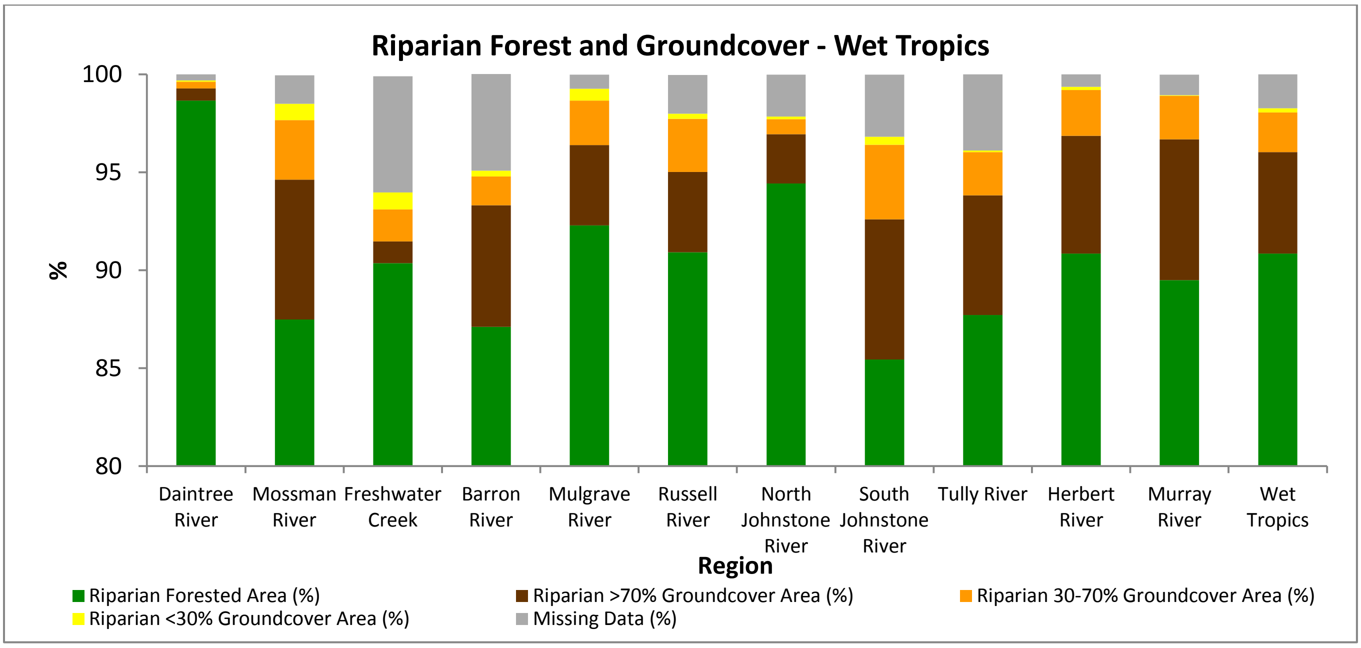


Figure 17: The proportion of forest, ground cover greater than 70 per cent, ground cover 30 – 70 per cent, ground cover less than 30 per cent and missing data for riparian areas within the Wet Tropics region.

Burdekin

8351ha loss (0.3%)

Target: The extent of riparian vegetation is increased by 2018.
Moderate progress: There was a loss of 8351 hectares (0.3%) of riparian vegetation across the Burdekin region between 2009 and 2013.

The Burdekin region has the largest mapped area of riparian areas in the Great Barrier Reef region with approximately 2.42 million hectares (Figure 18). The Suttor (928,934 hectares) and Upper Burdekin (821,143 hectares) catchments make up the majority of the riparian areas in this region

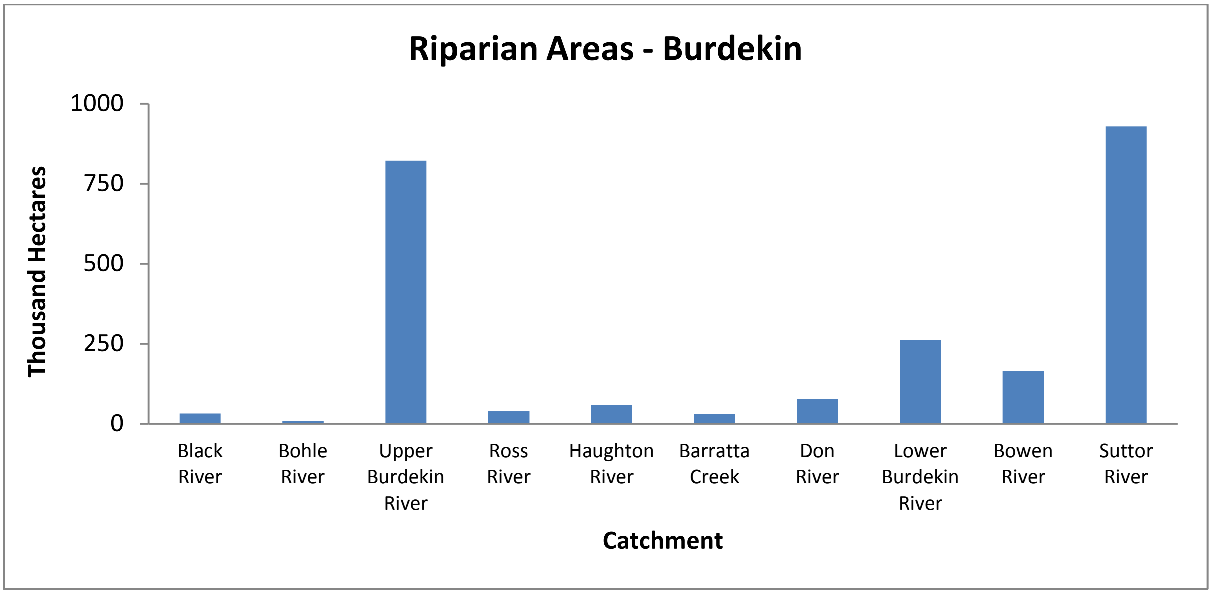


Figure 18: Number of hectares mapped as riparian areas within the Burdekin region.

Changes in extent of riparian vegetation

Extent of modification to riparian forests since European settlement
An estimated 21.6 per cent (522,544 hectares) of riparian forest has been lost from pre-European extent (Figure 19) in the Burdekin region. The Ross River has lost the greatest proportion of riparian forest compared to pre-European extent (34 per cent, 13,300 hectares). The Black River has lost the least (5 per cent, 1500 hectares).

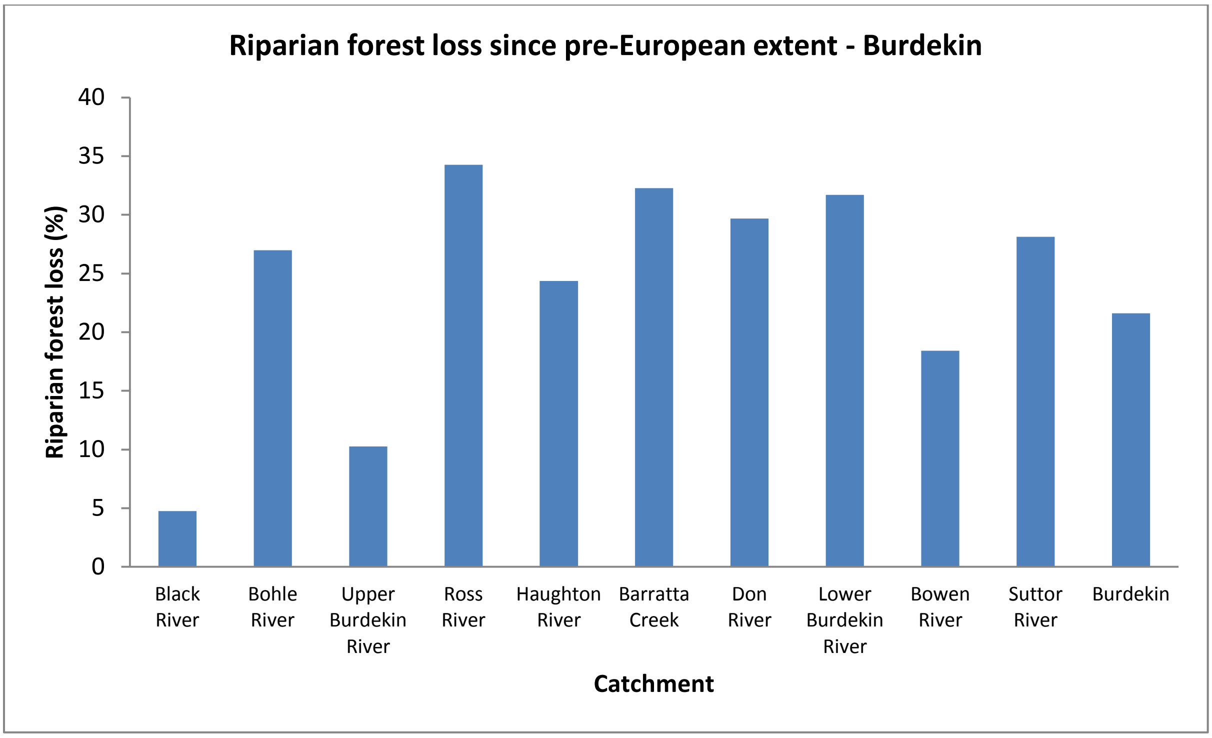


Figure 19: Proportion of riparian forest loss in the Burdekin region since pre-European settlement.

Recent loss of riparian vegetation

Since 2001, riparian vegetation loss had decreased from 5710 hectares (0.24 per cent) to 786 hectares (0.03 per cent) in 2010 but this increased to 3381 hectares (0.14 per cent) in 2013 (Figure 20).

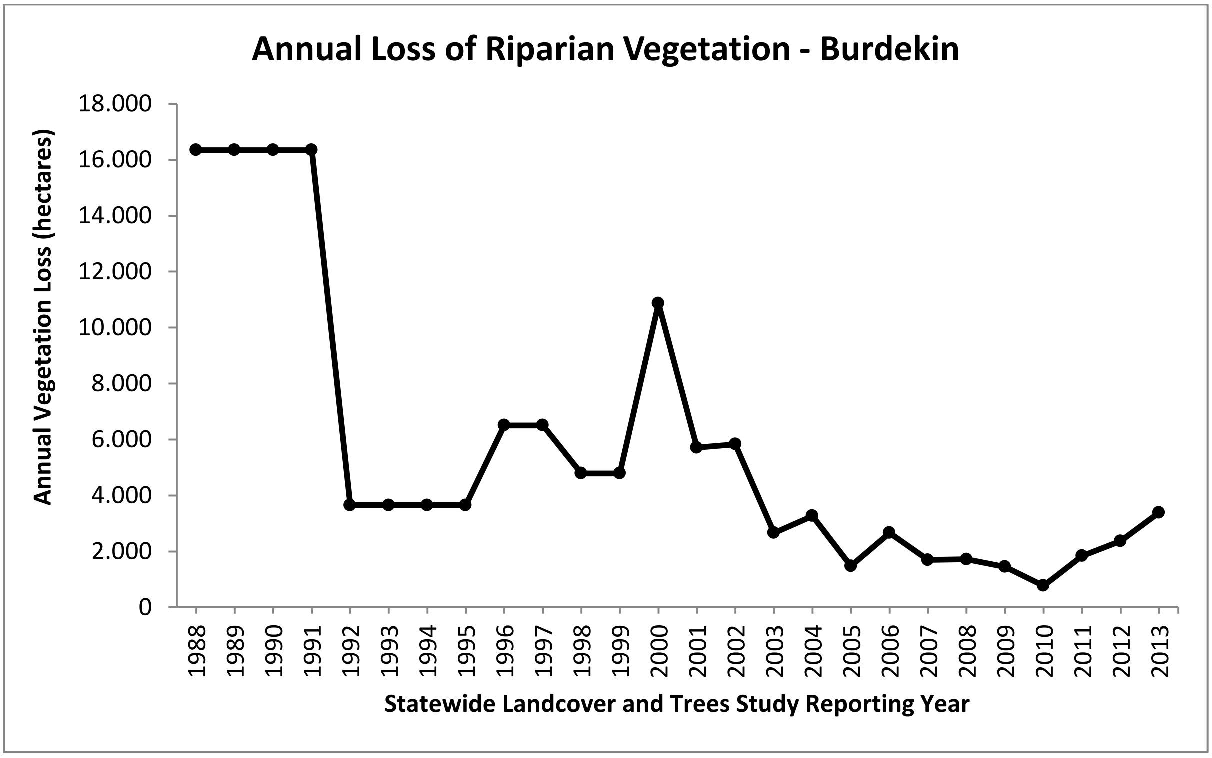


Figure 20: Riparian vegetation loss from 1988 to 2013 as reported by the Statewide Landcover and Trees Study for the Burdekin region.

The rate of loss of riparian vegetation was 0.35 per cent (8351 hectares) between 2009 and 2013 compared to 0.27 per cent (6583 hectares) between 2005 and 2009. This compares to 0.55 per cent (13,222 hectares) between 2001 and 2005 (Figure 21). The Don River and Suttor River catchments had an increase in riparian vegetation loss from 2009 to 2013 compared with 2005 to 2009. The Bohle River catchment saw the largest decrease in riparian vegetation loss when comparing 2005 to 2009 (3.6 per cent; 284 hectares) and 2009 to 2013 (1.2 per cent; 91 hectares) but still had the highest proportion of riparian vegetation loss.

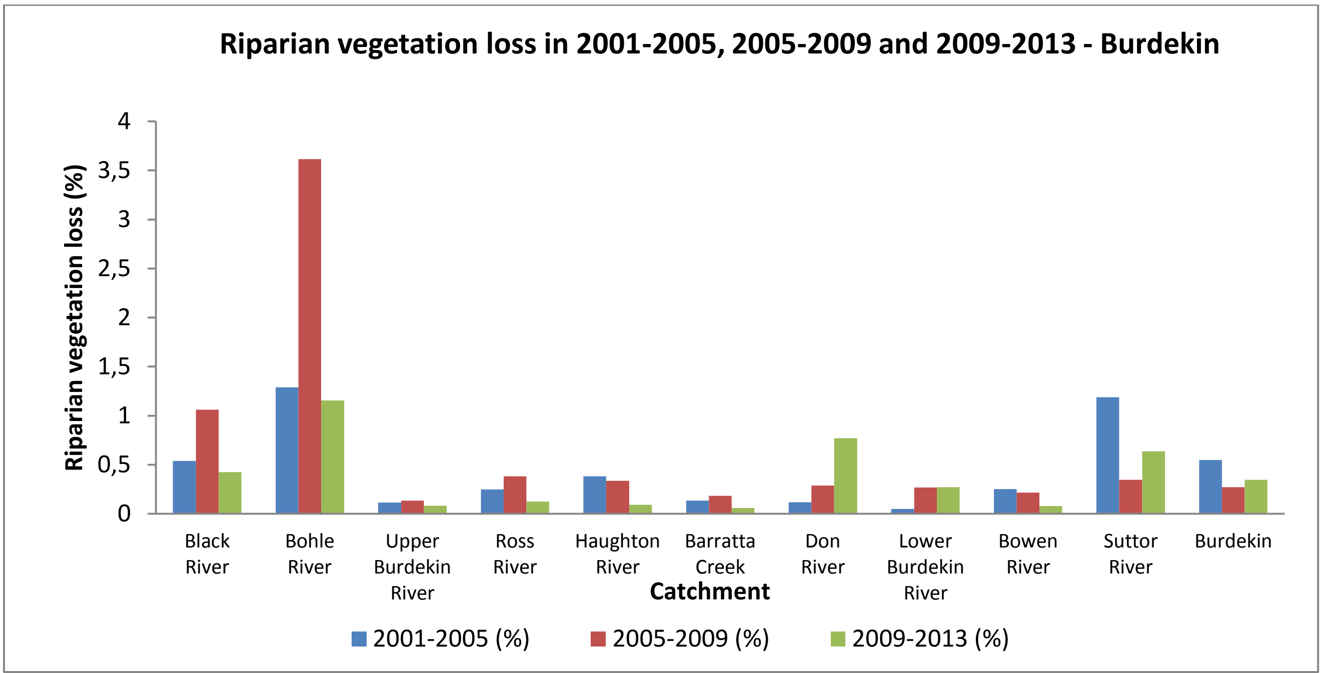


Figure 21: Riparian vegetation loss from 2001 to 2013 summarised into three periods (2001-2005, 2005-2009 and 2009-2013) for the Burdekin region.

Landscape metrics

The patch size and connectivity index describes the size and connectivity of riparian forest patches. The patch size and connectivity index value increases as vegetation patches become larger and more connected. The normalised patch density value provides a measure of the linear connectivity of riparian forest along the stream network. A low value indicates high linear connectivity.

The Burdekin region had a patch size and connectivity index of 73.5 and a normalised patch density value of 12.8 (Figure 22). The catchments with the highest connectivity are the Black River catchment with a patch size and connectivity index of 88 and a normalised patch density of 0.6 and the Haughton River catchment with a patch size and connectivity index of 83 and a normalised patch density of 8.8. The catchments which have the least connected riparian forests are the Lower Burdekin River (patch size and connectivity index of 61.6 normalised patch density of 16.1) and Barratta Creek (patch size and connectivity index of 73.1 and normalised patch density of 30).

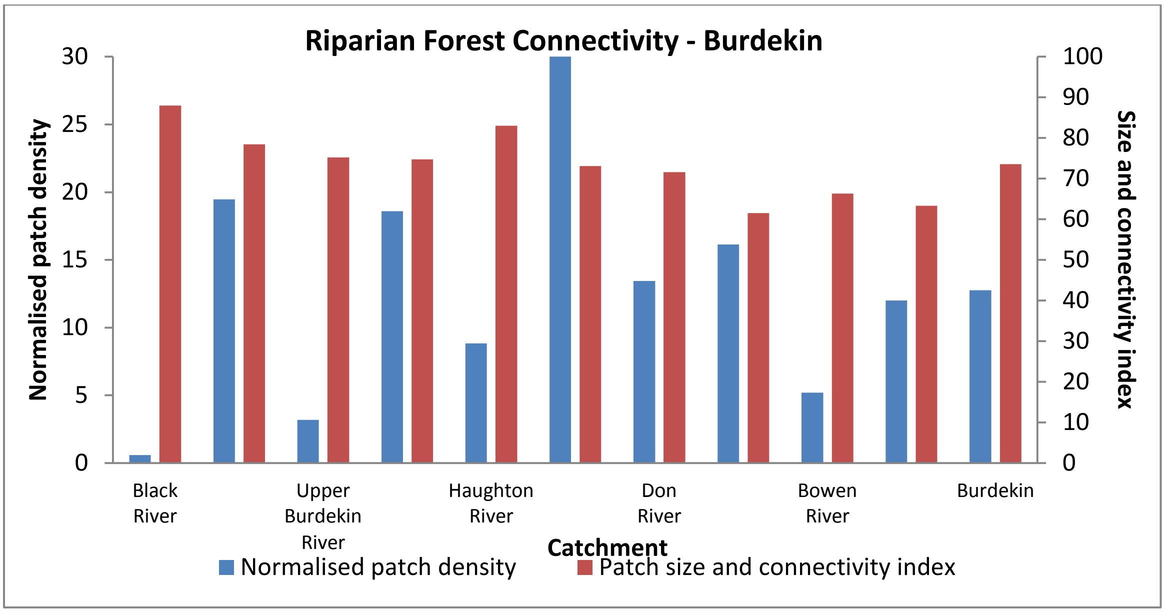


Figure 22: Normalised patch density and riparian patch size and connectivity index for the Burdekin region.

Proportion of riparian vegetation

In 2013, the forested riparian area was approximately 74.6 per cent (1.81 million hectares) (Figure 23) with the Black River catchment containing the highest proportion (93.5 per cent, 29,249 hectares). The Barratta Creek catchment had the lowest proportion of riparian forests with 56.6 per cent (17,158 hectares).

Approximately 8.26 per cent (199,733 hectares) of riparian areas were non-forested with ground cover less than 70 per cent and 0.3 per cent (7125 hectares) had ground cover less than 30 per cent. The Burdekin region had the highest proportion of ground cover less than 70 per cent and less than 30 per cent potentially leading to lower bank stability and an increased risk of erosion.

The Bohle River catchment had the highest proportion of ground cover less than 70 per cent (14.1 per cent, 1112 hectares) and less than 30 per cent (2.2 per cent, 176 hectares). However, this catchment covers a small area. In comparison, the Suttor catchment had 2572 hectares (0.3 per cent) of ground cover less than 30 per cent.

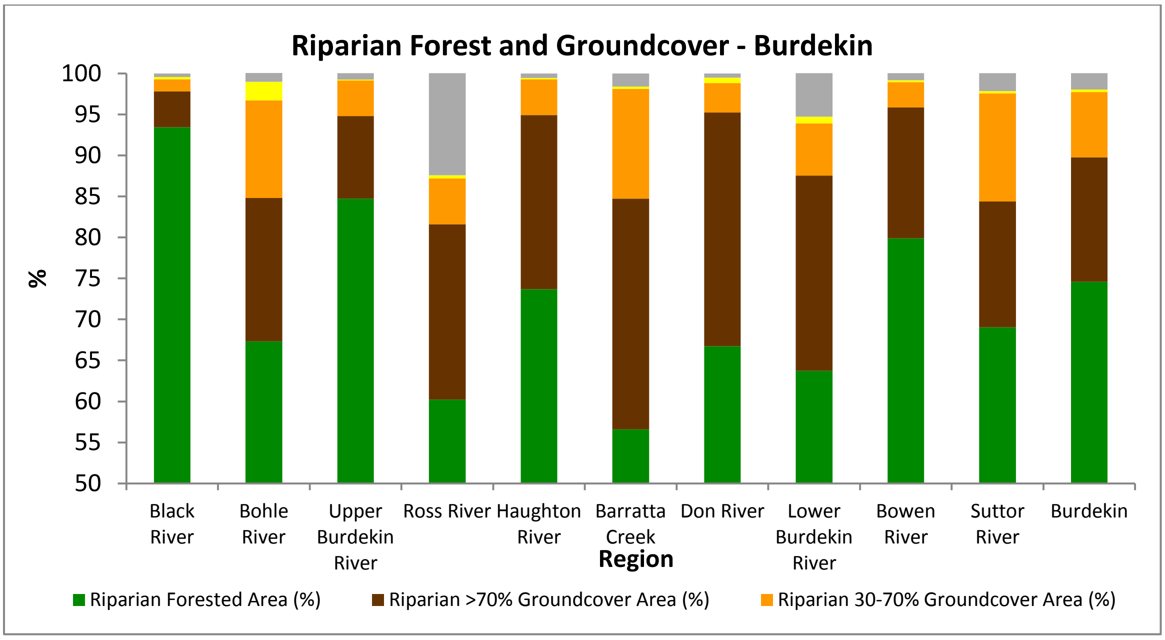


Figure 23: The proportion of forest, ground cover greater than 70 per cent, ground cover between 30 and 70 per cent, ground cover less than 30 per cent and missing data for riparian areas within the Burdekin region.

Mackay Whitsunday

539ha loss (0.3%)

Target: The extent of riparian vegetation is increased by 2018.
Moderate progress: There was a loss of 539 hectares (0.3%) of riparian vegetation across the Mackay Whitsunday region between 2009 and 2013.

Approximately 157,743 hectares of riparian areas were mapped in the Mackay Whitsunday region (Figure 24). The catchment with the largest amount of riparian areas was the Proserpine River with 42,689 hectares. The Pioneer River catchment contained the smallest amount with 34,198 hectares of riparian areas.

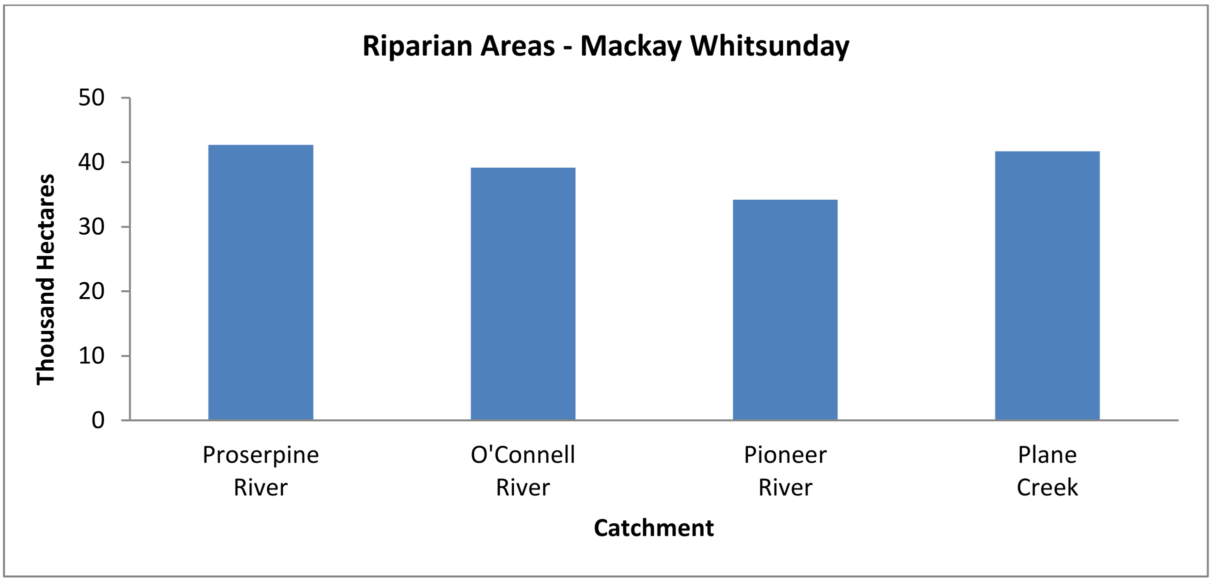


Figure 24: Number of hectares mapped as riparian areas within the Mackay Whitsunday region.

Changes in extent of riparian vegetation

Extent of modification to riparian forests since European settlement
Approximately 23.8 per cent (37,473 hectares) of riparian forest has been lost from pre-European extent (Figure 25) in the Mackay Whitsunday region. The largest proportional loss occurred in the Plane Creek catchment with 29.6 per cent (12,323 hectares). The Pioneer River catchment lost the lowest proportion of riparian forest compared to pre-European extent (20 per cent, 6840 hectares).

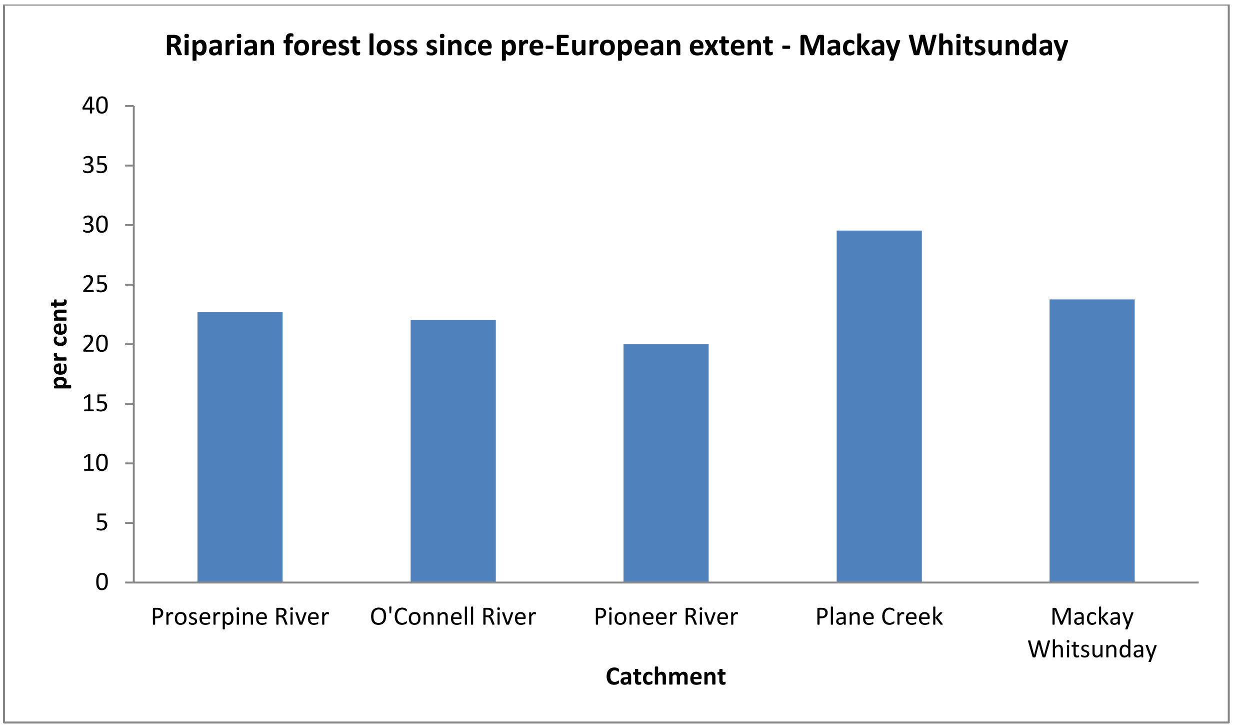


Figure 25: Proportion of riparian forest loss in the Mackay Whitsunday region since pre-European settlement.

Recent loss of riparian vegetation

Riparian vegetation loss in the Mackay Whitsunday region has generally been falling since 1988 from 1262 hectares (0.8 per cent) to 61 hectares (0.04 per cent) in 2010 but this increased to over 180 hectares (0.12 per cent) in 2013 (Figure 26).

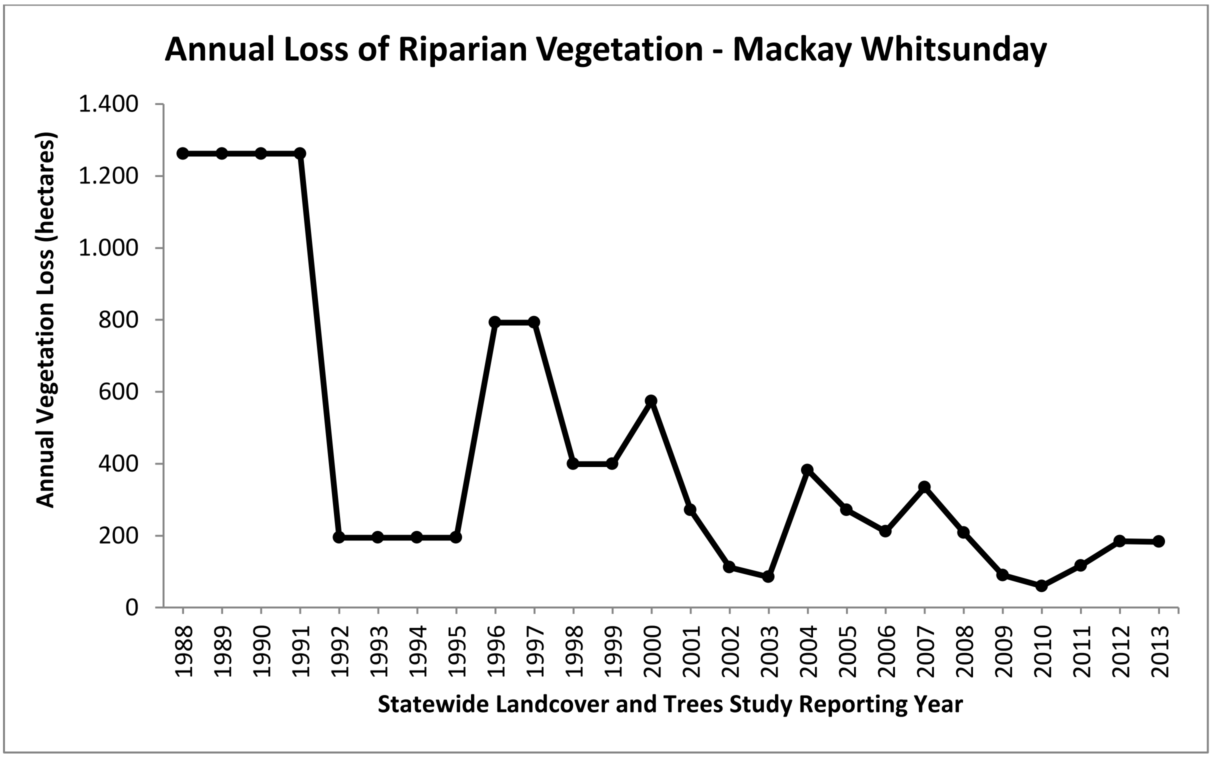


Figure 26: Riparian vegetation loss from 1988 to 2013 as reported by the Statewide Landcover and Trees Study for the Mackay Whitsunday region.

The rate of loss of riparian vegetation was 0.3 per cent (539 hectares) between 2009 and 2013 down from 0.5 per cent (843 hectares between 2005 and 2009 and 848 hectares between 2001 and 2005) (Figure 27). All Mackay Whitsunday catchments recorded a decrease in loss of riparian vegetation between 2009 and 2013 compared to 2005 to 2009. The O'Connell River catchment had the highest rates of riparian vegetation loss in all periods whereas the Pioneer River catchment had the lowest.

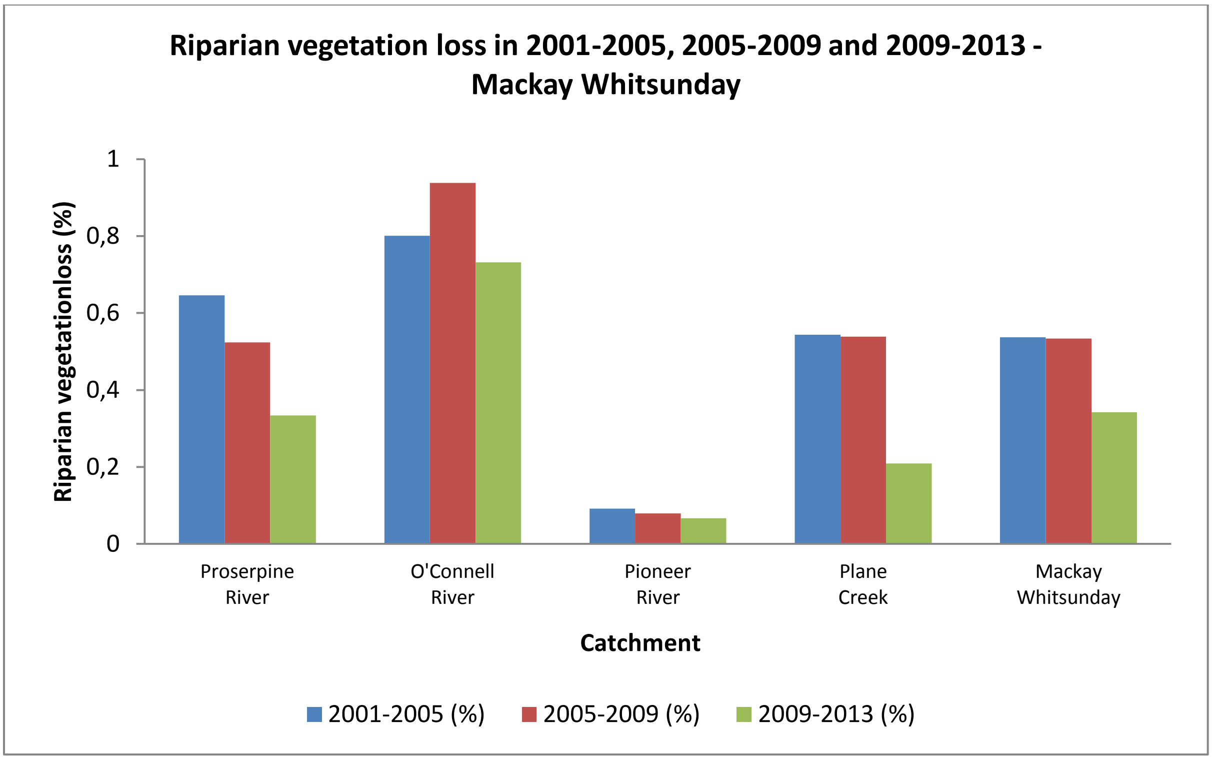


Figure 27: Riparian vegetation loss from 2001 to 2013 summarised into three periods (2001-2005, 2005-2009 and 2009-2013) for the Mackay Whitsunday region.

Landscape metrics

The patch size and connectivity index describes the size and connectivity of riparian forest patches. The patch size and connectivity index value increases as vegetation patches become larger and more connected. The normalised patch density value provides a measure of the linear connectivity of riparian forest along the stream network. A low value indicates high linear connectivity.

In 2013, the Mackay Whitsunday region scored a patch size and connectivity index of 81.5 and a normalised patch density value of 6.8 (Figure 28). All four catchments in this region had very similar scores except for Plane Creek catchment which had a normalised patch density value of 11.3 indicating this catchment is slightly less connected than the other catchments.

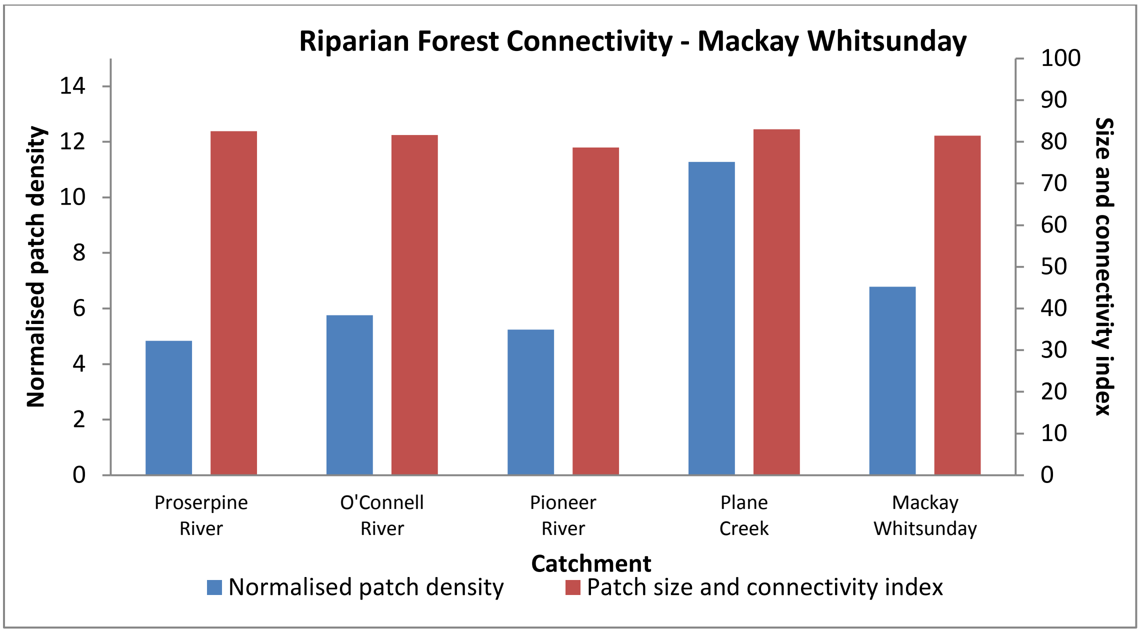


Figure 28: Normalised patch density and riparian patch size and connectivity index for the Mackay Whitsunday region.

Proportions of riparian vegetation

In 2013, the forested riparian area was approximately 74.7 per cent (117,853 hectares) (Figure 29). The O'Connell catchment had the highest proportion with 77.7 per cent (30,421 hectares) and Plane Creek had the lowest with 69.6 per cent (29,015 hectares).

In the Mackay Whitsunday region, 4.4 per cent (6876 hectares) of riparian areas were non-forested with ground cover less than 70 per cent and 0.3 per cent (461 hectares) had ground cover less than 30 per cent, potentially leading to lower bank stability and an increased risk of erosion. Plane Creek had the highest proportion of ground cover less than 70 per cent (6.8 per cent, 2816 hectares) and less than 30 per cent (0.7 per cent, 282 hectares).

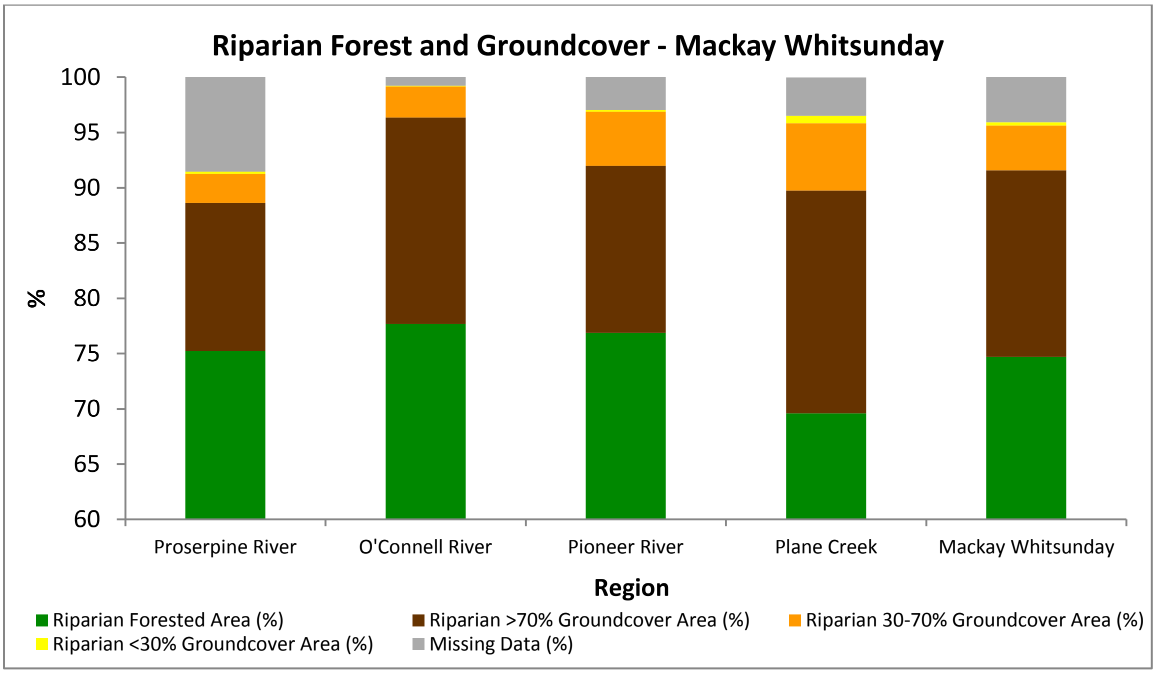


Figure 29: The proportion of forest, ground cover greater than 70 per cent, ground cover between 30 and 70 per cent, ground cover less than 30 per cent and missing data for riparian areas within the Mackay Whitsunday region.

Fitzroy

14,777ha loss (0.7%)

Target: The extent of riparian vegetation is increased by 2018.
Poor progress: There was a loss of 14,777 hectares (0.7%) of riparian vegetation across the Fitzroy region between 2009 and 2013.

Approximately 2.2 million hectares of riparian areas were mapped in the Fitzroy region (Figure 30). The Dawson River catchment had the highest amount of riparian areas (656,870 hectares).

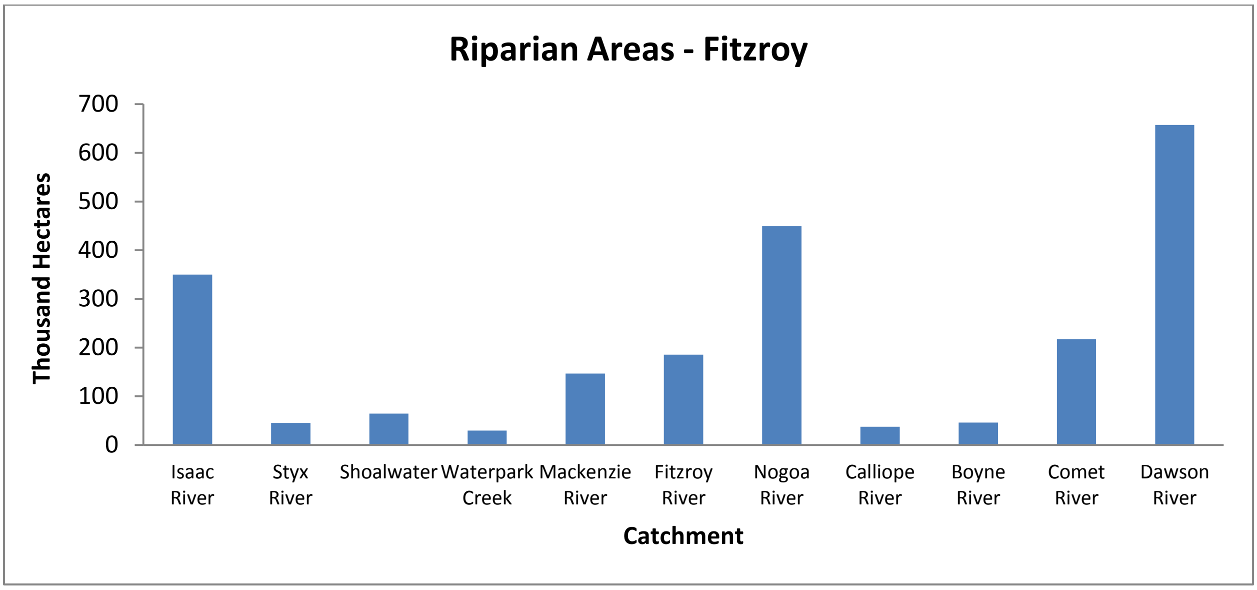


Figure 30: Number of hectares mapped as riparian areas within the Fitzroy region.

Changes in extent of riparian vegetation

Extent of modification to riparian forests since European settlement
Approximately 27 per cent (609,400 hectares) of riparian forest has been lost from pre-European extent (Figure 31). Approximately 37 per cent of forested riparian areas have been lost in the Dawson River catchment and 36 per cent in the Mackenzie River catchment. In the Waterpark Creek catchment, there has been no reported loss of riparian forest extent compared to pre-European levels.

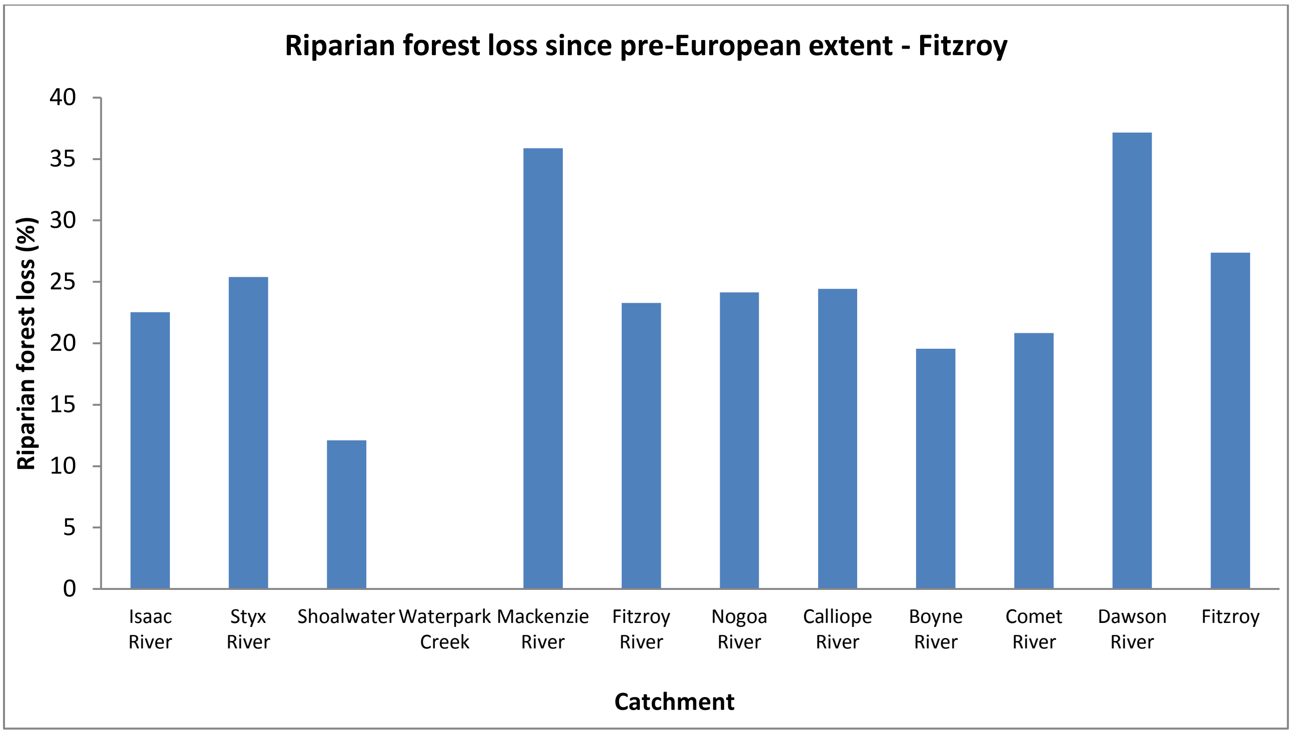


Figure 31: Proportion of riparian forest loss in the Fitzroy region since pre-European settlement.

Recent loss of riparian vegetation

Since 2000, the annual riparian vegetation loss has decreased from 16,704 hectares (0.75 per cent) to 1304 hectares (0.06 per cent) in 2009 but has increased to 5912 hectares (0.27 per cent) in 2013 (Figure 32).

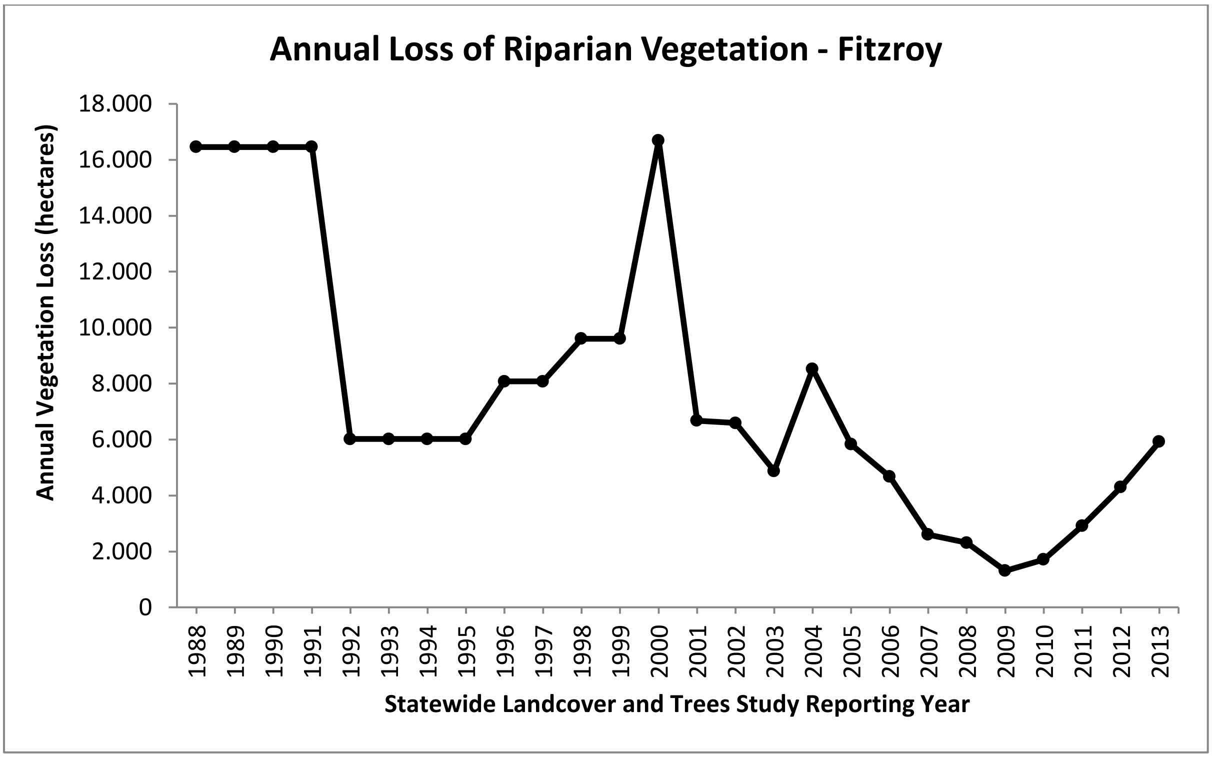


Figure 32: Riparian vegetation loss from 1988 to 2013 as reported by the Statewide Landcover and Trees Study for the Fitzroy region.

The rate of riparian vegetation loss was 0.7 per cent (14,777 hectares) between 2009 and 2013 compared to 0.5 per cent (9,938 hectares) between 2005 and 2009 and 1.2 per cent (25,670 hectares) between 2001 and 2005 (Figure 33). There was a high level of riparian vegetation loss in the Mackenzie River catchment with 1.2 per cent (1778 hectares). The loss of riparian vegetation in the Isaac, Mackenzie, Fitzroy, Nogoa, Comet and Dawson catchments increased from 2005 to 2009 to 2009 to 2013.

The loss of riparian vegetation in the Waterpark catchment was predominantly related to plantation forestry which had returned to forested by 2013.

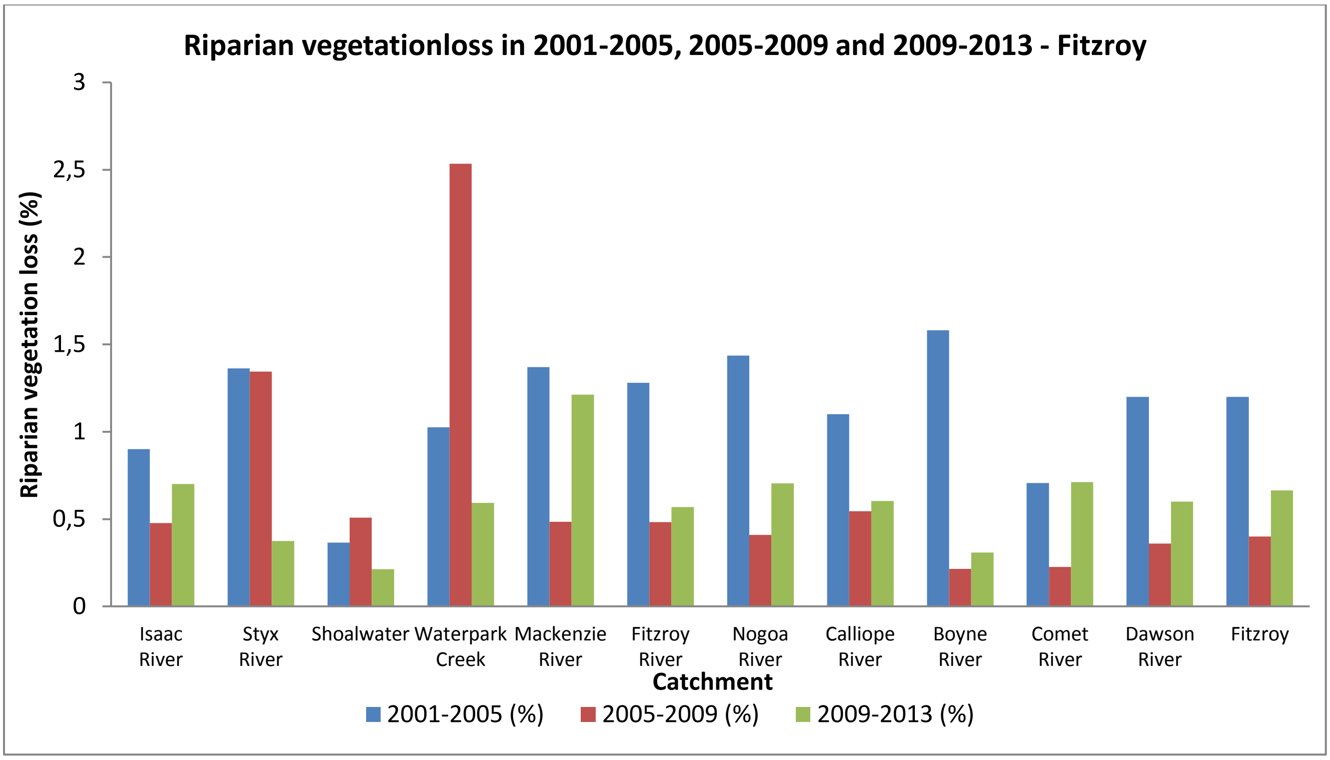


Figure 33: Riparian vegetation loss from 2001 to 2013 summarised into three periods (2001-2005, 2005-2009 and 2009-2013) for the Fitzroy region.

Landscape metrics

The patch size and connectivity index describes the size and connectivity of riparian forest patches. The patch size and connectivity index value increases as vegetation patches become larger and more connected. The normalised patch density value provides a measure of the linear connectivity of riparian forest along the stream network. A low value indicates high linear connectivity.

In 2013, the Fitzroy region scored a patch size and connectivity index of 71.8 and a normalised patch density value of 9.6. The Waterpark Creek and Boyne River catchments had the highest riparian forest connectivity with a patch size connectivity index of 90.8 and 86.1 respectively and a normalised patch density value of 0.8 and 2.9 respectively (Figure 34). The catchment with the least connected riparian forests was the Dawson River catchment (patch size and connectivity index of 48.7, normalised patch density of 18.9) followed by the Mackenzie River catchment (patch size and connectivity index of 59.3, normalised patch density of 19.6).

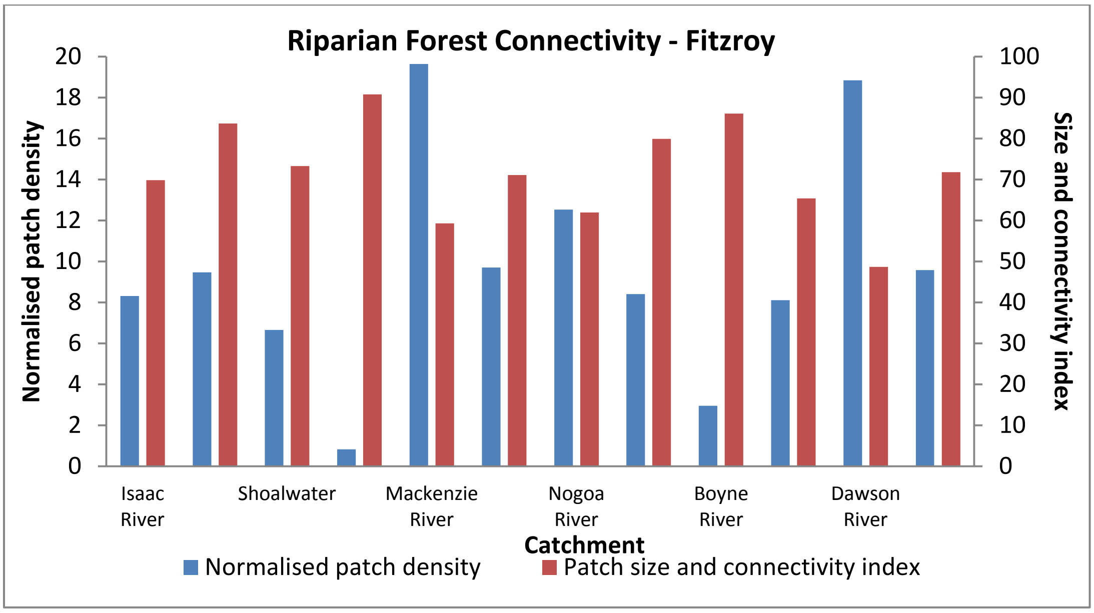


Figure 34: Normalised patch density and riparian patch size and connectivity index for the Fitzroy region.

Proportions of riparian vegetation

In 2013, the forested riparian area was approximately 69.2 per cent (1.5 million hectares) (Figure 35). The catchment with the highest proportion of forested riparian areas was Waterpark Creek catchment with 96.6 per cent (28,185 hectares). The Dawson River catchment had the lowest proportion with 62.2 per cent (408,590 hectares).

In the Fitzroy region, 6.7 per cent (149,940 hectares) of riparian areas were non-forested with ground cover less than 70 per cent and 0.2 per cent (4801 hectares) had ground cover less than 30 per cent. The Nogoa River catchment had the highest proportion of ground cover less than 70 per cent (12.8 per cent, 57,422 hectares) and the Isaac River catchment had the highest proportion of ground cover less than 30 per cent (0.5 per cent, 1875 hectares).

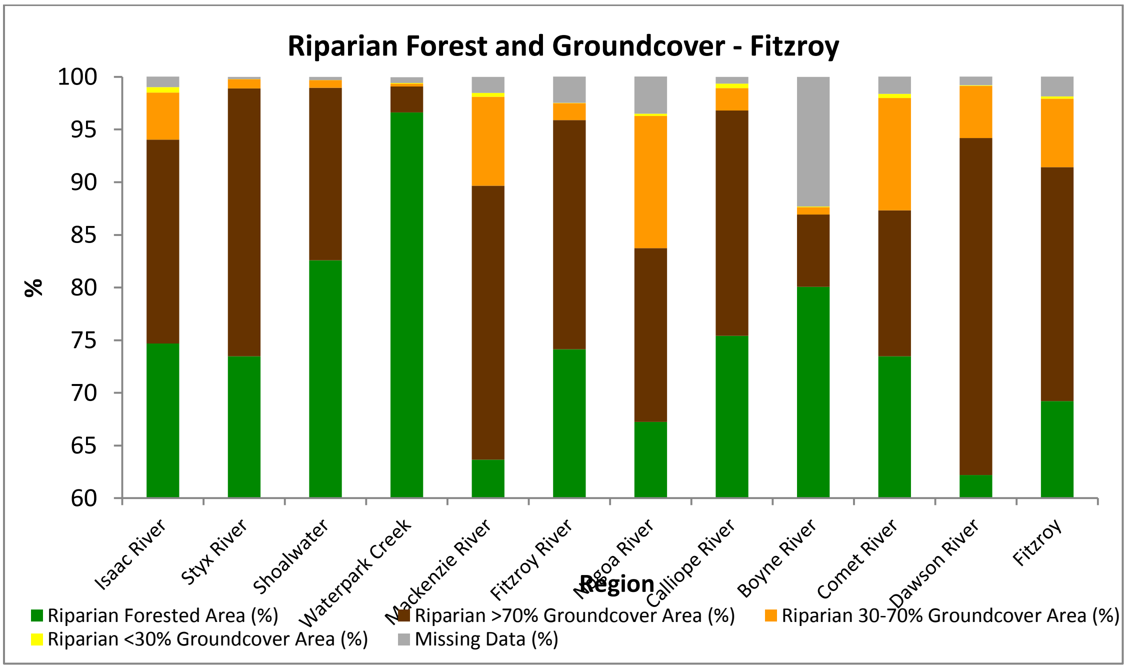


Figure 35: The proportion of forest, ground cover greater than 70 per cent, ground cover between 30 and 70 per cent, ground cover less than 30 per cent and missing data for riparian areas within the Fitzroy region.

Burnett Mary

6027ha loss (0.7%)

Target: The extent of riparian vegetation is increased by 2018.
Poor progress: There was a loss of 6027 hectares (0.7%) of riparian vegetation across the Burnett Mary region between 2009 and 2013.

Approximately 855,754 hectares of riparian areas were mapped in the Burnett Mary region (Figure 36). The Boyne Auburn Rivers catchment had the largest area (185,048 hectares) of riparian areas in the region.

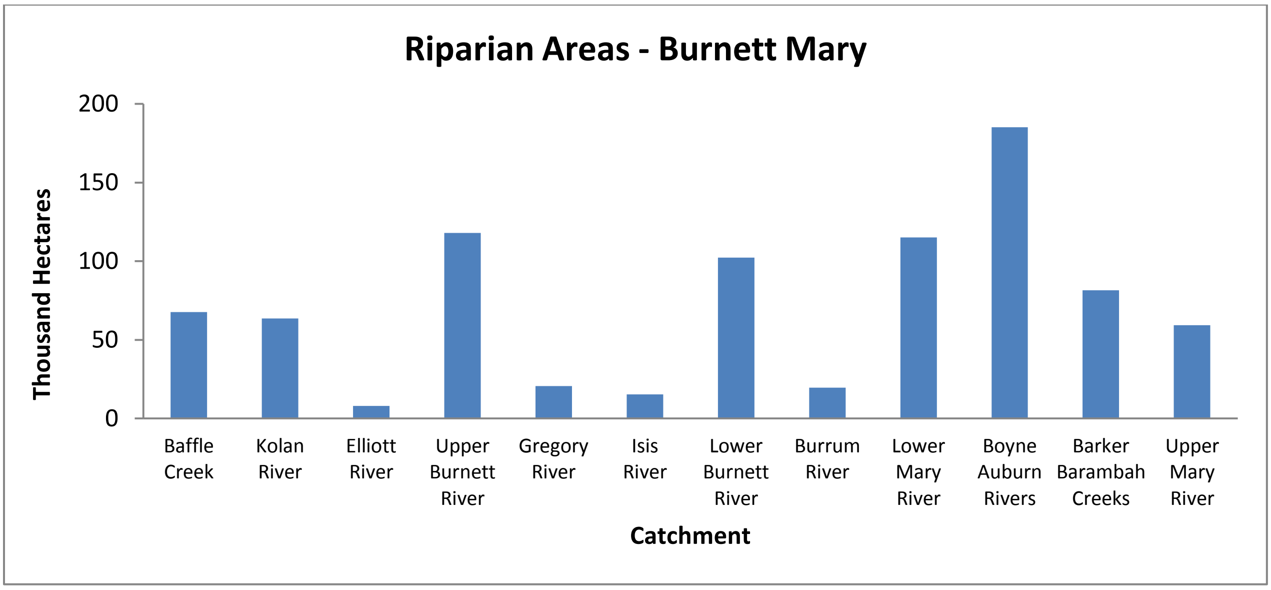


Figure 36: Number of hectares mapped as riparian areas within the Burnett Mary region.

Changes in extent of riparian vegetation

Extent of modification to riparian forests since European settlement
Approximately 22 per cent (183,500 hectares) of riparian forest has been lost from pre-European extent with the highest proportion of loss in the Barker Barambah Creeks catchment (33 per cent, 27,200 hectares) (Figure 37). The Isis River catchment has lost the least amount of riparian forest compared to pre-European extent (three per cent, 490 hectares).

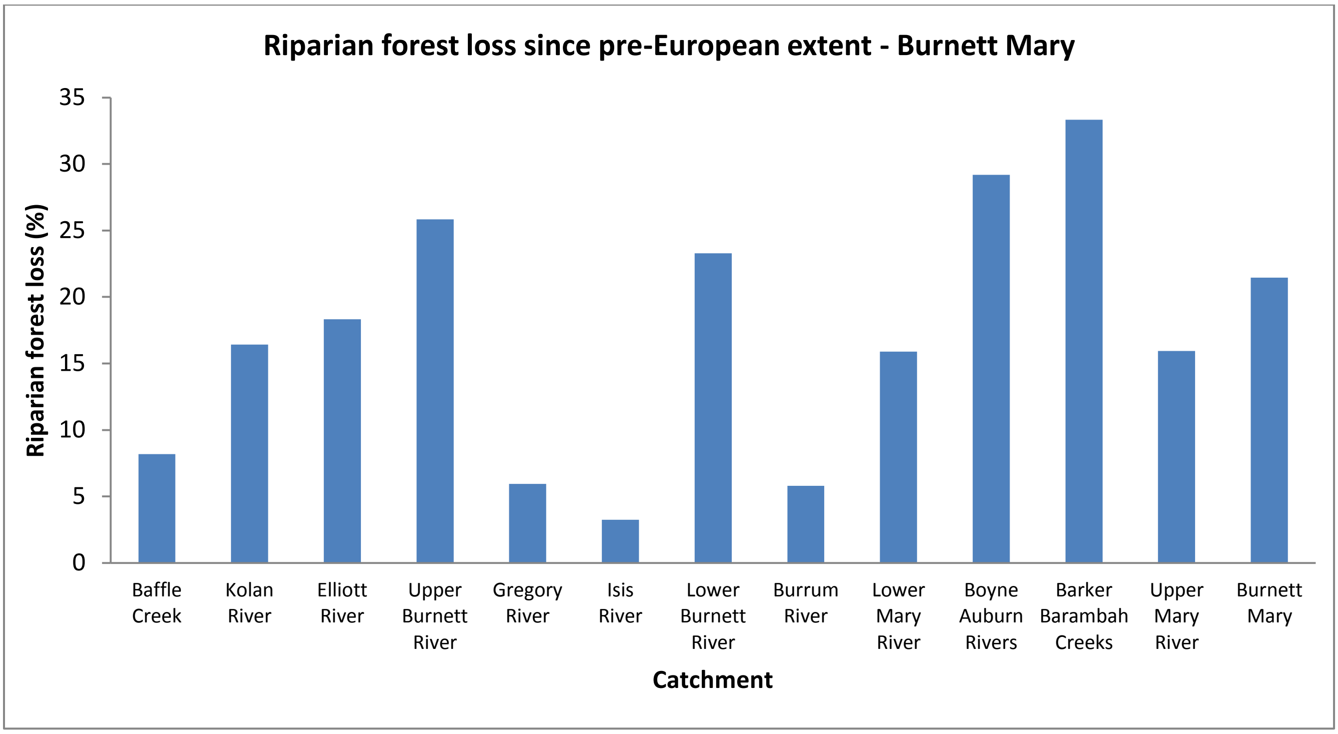


Figure 37: Proportion of riparian forest loss in the Burnett Mary region since pre-European settlement.

Recent loss of riparian vegetation

Since 2004, riparian vegetation loss has generally been falling from 2598 hectares (0.4 per cent) to 952 hectares (0.1 per cent) in 2009. However, an increased amount of riparian forest has been lost in recent years with 1769 hectares lost (0.2 per cent) in 2013 (Figure 38).

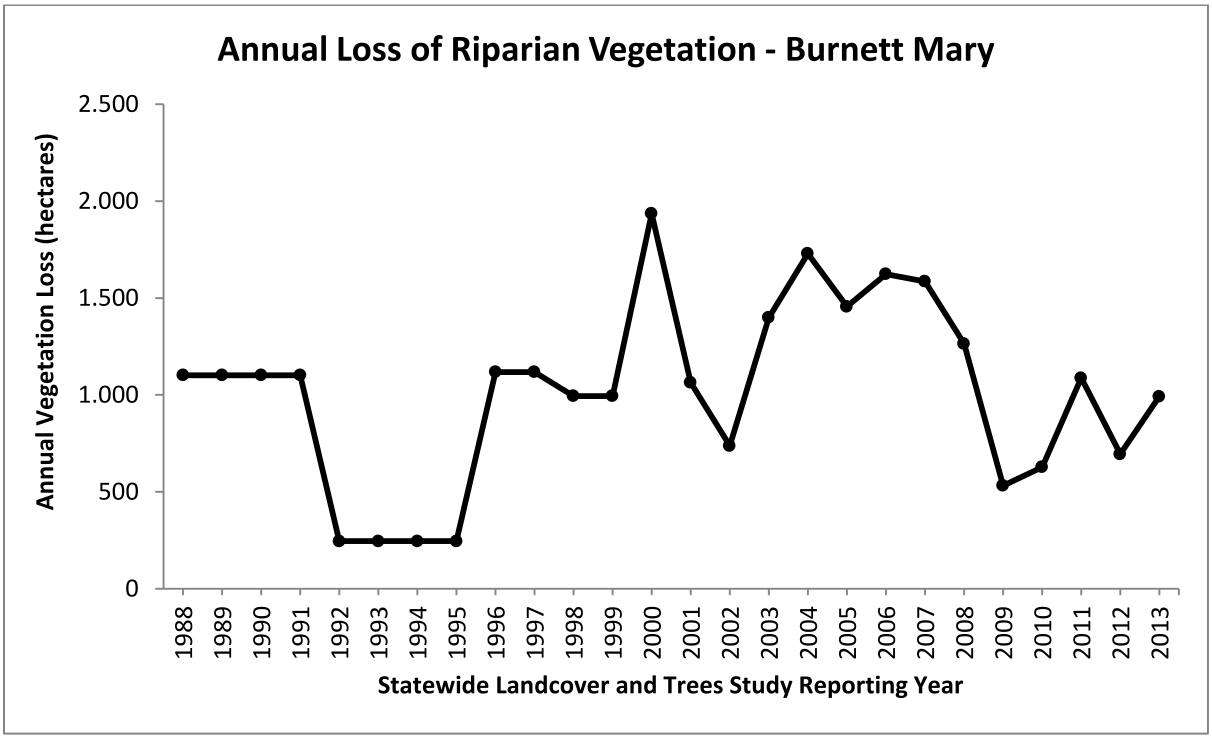


Figure 38: Riparian vegetation loss from 1988 to 2013 as reported by the Statewide Landcover and Trees Study for the Burnett Mary region.

Between 2009 and 2013, the Burnett Mary region had 0.7 per cent (6027 hectares) of riparian vegetation loss (Figure 39). This was down from one per cent loss (8877 hectares) between 2005 and 2009 and 1.1 per cent (9410 hectares) between 2001 and 2005. Between 2009 and 2013, the Elliott River catchment had the highest proportion of riparian vegetation loss (1.2 per cent, 96 hectares) followed by the Baffle Creek catchment (1.1 per cent, 763 hectares). Most catchments had a decrease in loss of riparian vegetation except for the Lower Burnett River, Barker Barambah Creeks and Upper Mary River catchments.

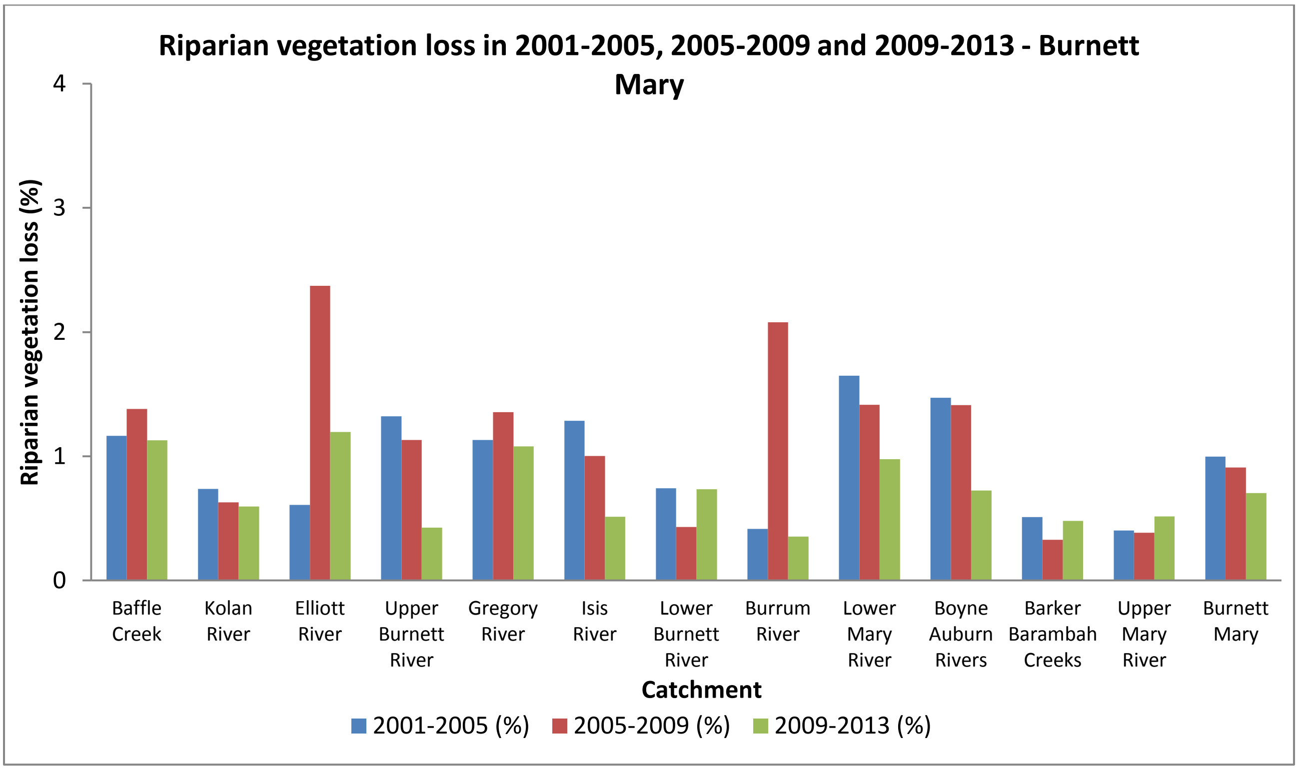


Figure 39: Riparian vegetation loss from 2001 to 2013 summarised into three periods (2001-2005, 2005-2009 and 2009-2013) for the Burnett Mary region.

Landscape metrics

The patch size and connectivity index describes the size and connectivity of riparian forest patches. The patch size and connectivity index value increases as vegetation patches become larger and more connected. The normalised patch density value provides a measure of the linear connectivity of riparian forest along the stream network. A low value indicates high linear connectivity.

In 2013, the catchments with the highest riparian forest connectivity in the Burnett Mary region were the Isis River and Gregory River catchments with a patch size and connectivity index of 100 (Figure 40). The Isis River catchment scored a normalised patch density value of 0.2 and the Gregory catchment scored 0.6. The catchment with the least connected riparian forests was the Barker Barambah Creeks catchment with a patch size and connectivity index of 53.6 and a normalised patch density value of 19.7.

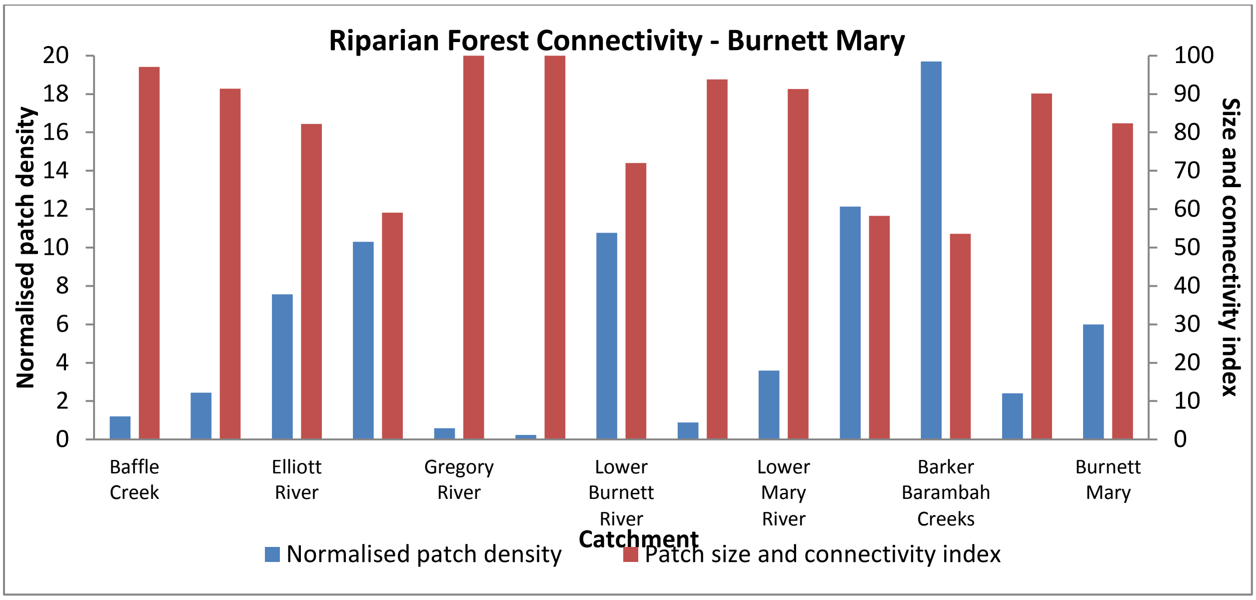


Figure 40: Normalised patch density and riparian patch size and connectivity index for the Burnett Mary region.

Proportions of riparian vegetation

In 2013, the forested riparian area was approximately 77.7 per cent (664,653 hectares) (Figure 41). The Isis River catchment had the highest proportion of forested riparian areas (96.7 per cent, 14,748 hectares). The catchment with the lowest proportion of forested riparian areas was the Barker Barambah catchment (65.4 per cent, 53,291 hectares).

In the Burnett Mary region, 2.2 per cent (18,660 hectares) of riparian areas were non-forested with ground cover less than 70 per cent and 0.1 per cent (936 hectares) had ground cover less than 30 per cent. The catchment with the highest proportion of non-forested riparian areas with ground cover less than 70 per cent was the Barker Barambah Creeks catchment (4.2 per cent, 3395 hectares). The Elliott River catchment had the highest proportion of non-forested riparian areas with ground cover less than 30 per cent (1.6 per cent, 130 hectares).

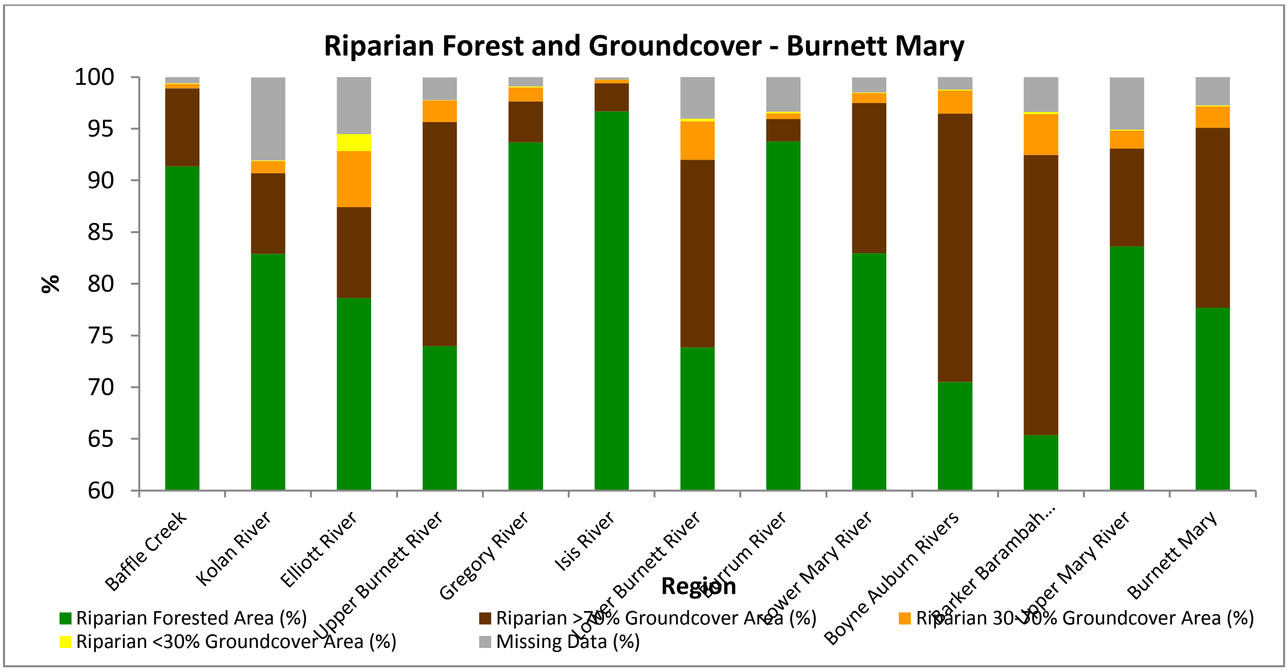


Figure 41: The proportion of forest, ground cover greater than 70 per cent, ground cover between 30 and 70 per cent, ground cover less than 30 per cent and missing data for riparian areas within the Burnett region.

Catchment pollutant loads results

The Catchment pollutant loads 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 per cent 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 have been refined from those set in 2009 and 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 nitrogen target has changed from total nitrogen to dissolved inorganic nitrogen and the sediment target was expanded to include particulate nutrients (particulate nitrogen and particulate phosphorus). The pesticide target was increased and now reports on overall toxic loads – previously the toxicity of individual pesticides was not taken into account.

As the catchment loads targets are reported as cumulative progress since 2009, the results have been recalculated for this period.

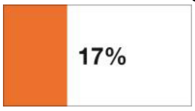
Scoring system

Very good
Good
Moderate
Poor
Very poor
No data

Great Barrier Reef-wide

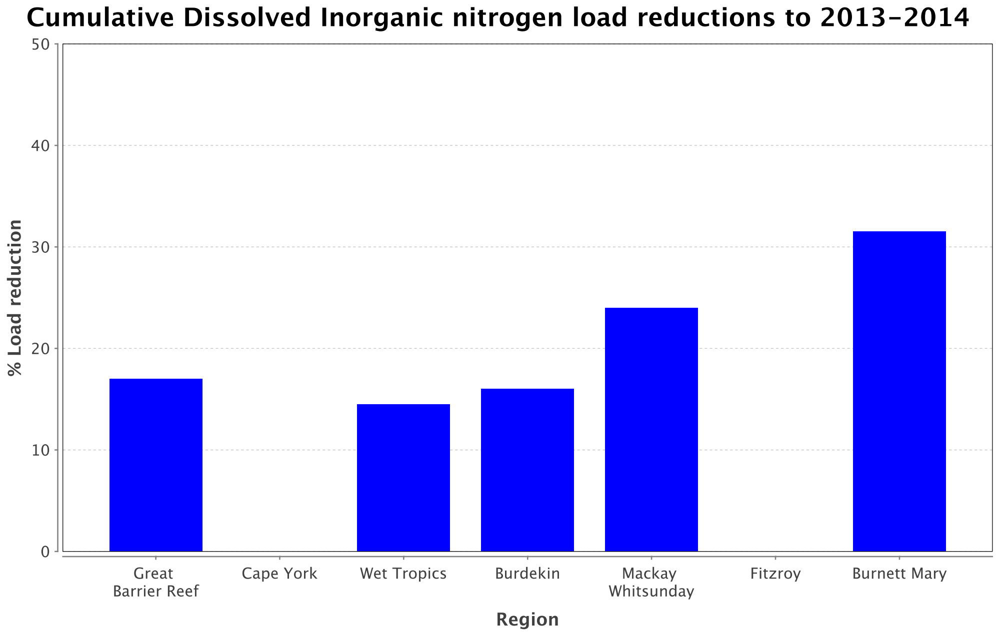
Catchment modelling has been used to estimate the long term annual load reductions due to the adoption of improved management practices. The model is run over a fixed climate period to account for climate variability.

Dissolved inorganic nitrogen



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

Poor progress: The estimated annual average dissolved inorganic nitrogen load leaving catchments reduced by 17 per cent by June 2014. The greatest reduction (31.5 per cent) was from the Burnett Mary region.

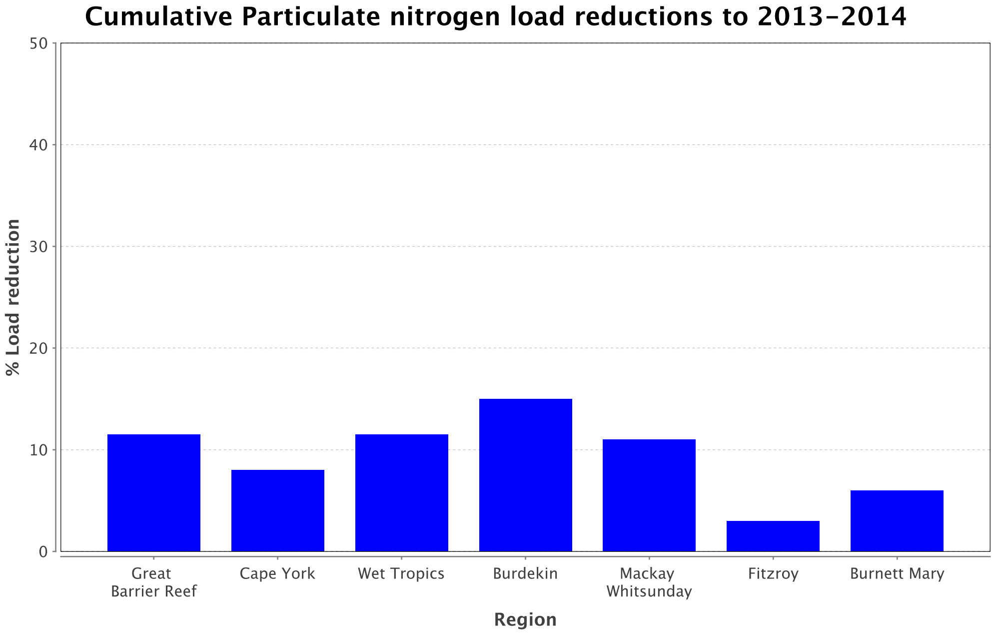


Note: Dissolved inorganic nitrogen reductions are only modelled for regions where sugarcane is grown.

Particulate nitrogen

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

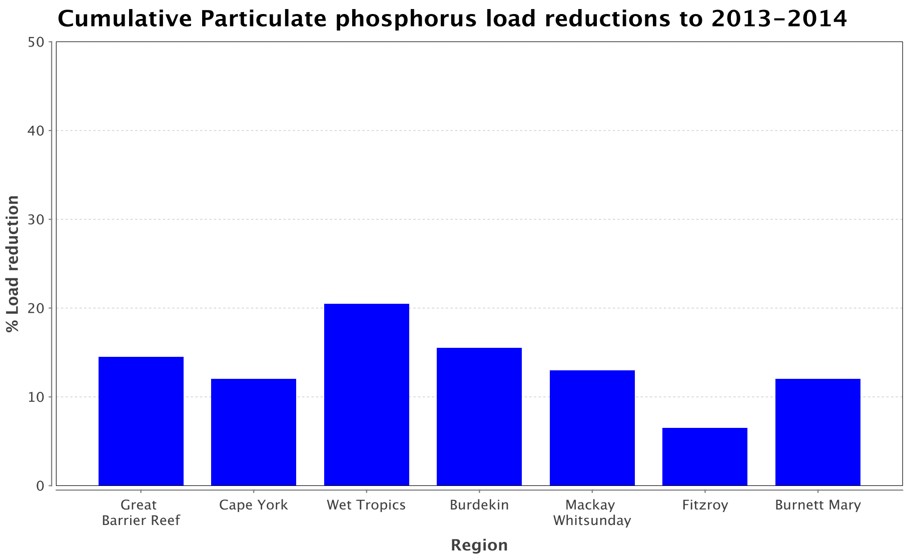
Good progress: The estimated average annual particulate nitrogen load leaving catchments reduced by 11.5 per cent by June 2014. The greatest reduction was from the Burdekin region with 15 per cent.



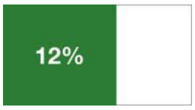
Particulate phosphorus

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

Very good progress: The estimated average annual particulate phosphorus load leaving catchments reduced by 14.5 per cent by June 2014. The greatest reduction was from the Wet Tropics region which achieved the target with an estimated 20.5 per cent reduction.

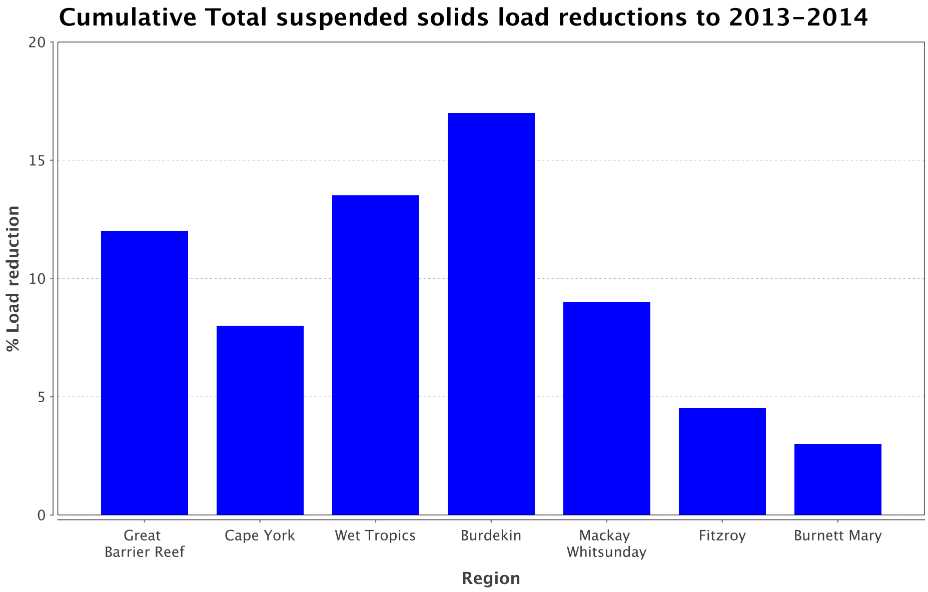


Sediment

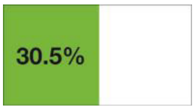


Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment in priority areas by 2018.

Very good progress: The estimated average annual sediment load leaving catchments reduced by 12 per cent by June 2014. The greatest reduction was from the Burdekin region with 17 per cent.

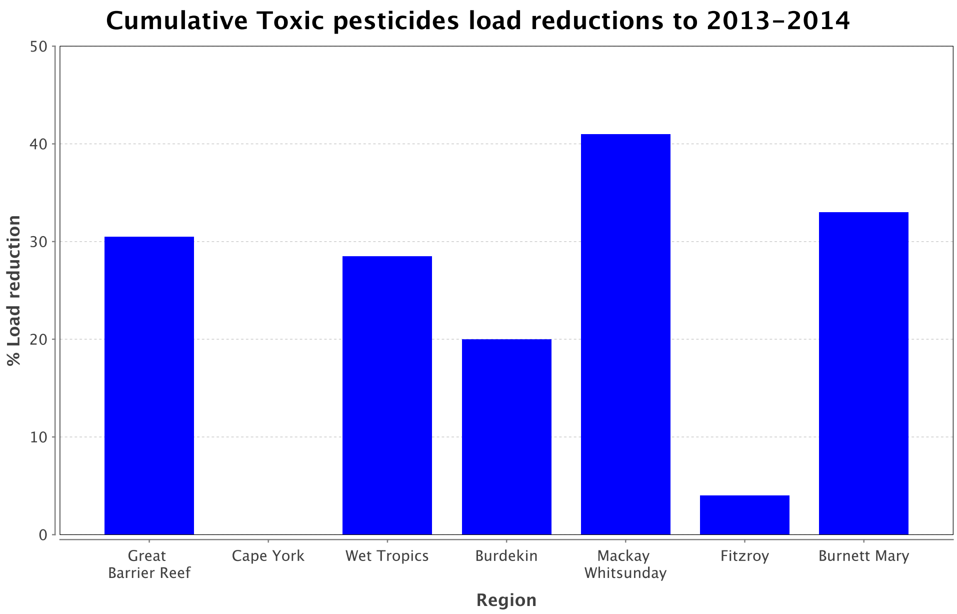


Pesticides



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

Good progress: The estimated annual average toxic pesticide load leaving catchments reduced by 30.5 per cent by June 2014.



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

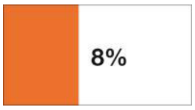
Cape York

No investment occurred in the Cape York region in 2013-2014. All load reductions are the same as the results up to June 2013.

Dissolved inorganic nitrogen

Dissolved inorganic nitrogen reductions are not modelled in regions without sugarcane.

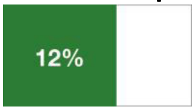
Particulate nitrogen



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

Poor progress: The estimated average annual particulate nitrogen load leaving catchments remained at eight per cent by June 2014.

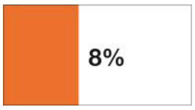
Particulate phosphorus



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

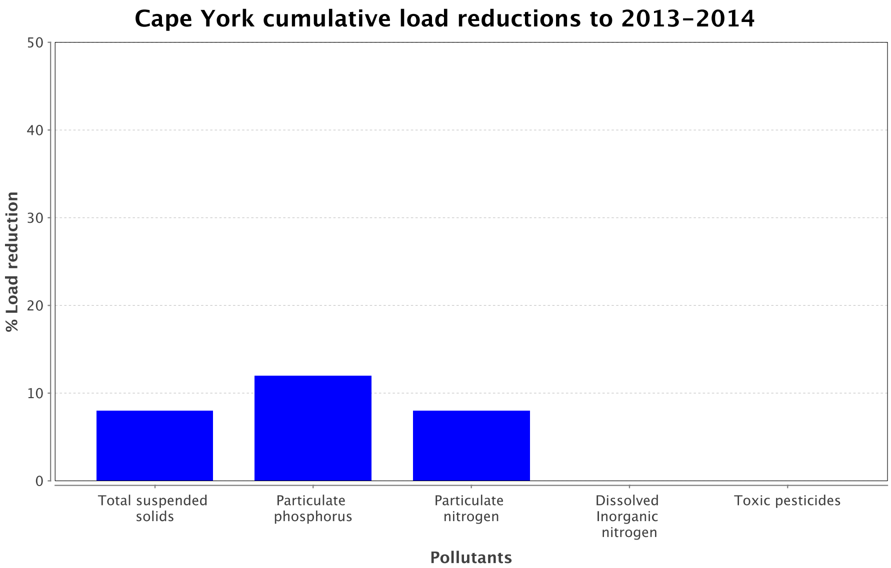
Very good progress: The estimated average annual particulate phosphorus load leaving catchments remained at 12 per cent by June 2014.

Sediment



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

Poor progress: The estimated average annual sediment load leaving catchments remained at eight per cent by June 2014.



Note:

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

Wet Tropics

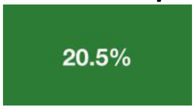
Dissolved inorganic nitrogen

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 reduced by 14.5 per cent by June 2014.

Particulate nitrogen

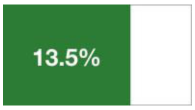
Target: At least a 20 per cent reduction in anthropogenic end of catchment loads of particulate nutrients in priority areas by 2018.
Good progress: The estimated annual average particulate nitrogen load leaving catchments reduced by 11.5 per cent by June 2014.

Particulate phosphorus



Target: At least a 20 per cent reduction in anthropogenic end of catchment loads of particulate nutrients in priority areas by 2018.
Very good progress: The estimated annual average particulate phosphorus load leaving catchments reduced by 20.5 per cent by June 2014, exceeding the target.

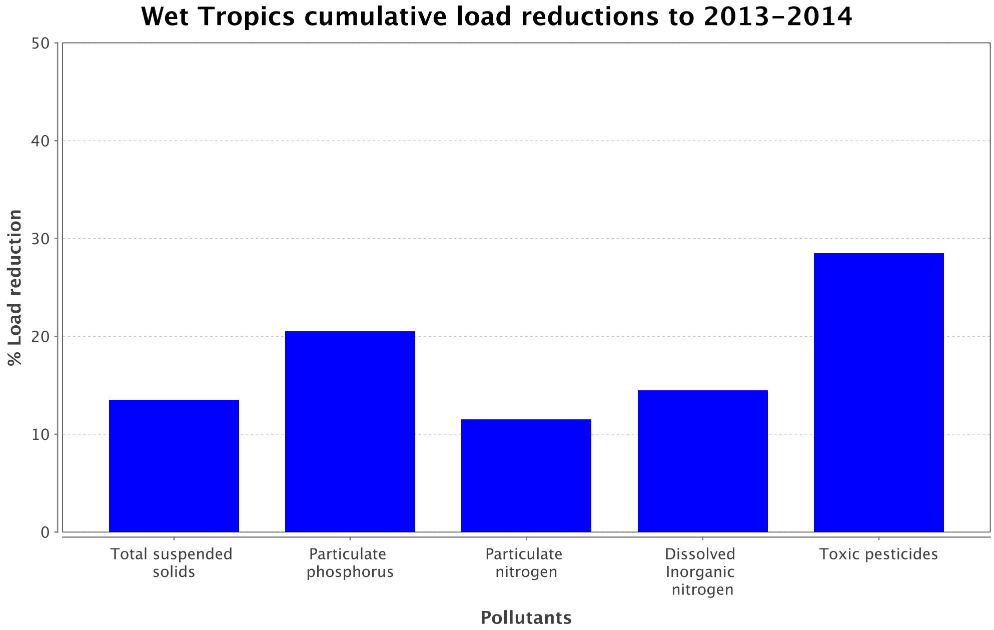
Sediment



Target: At least a 20 per cent reduction in anthropogenic end of catchment loads of sediment in priority areas by 2018.
Very good progress: The estimated annual average total suspended sediment load leaving catchments reduced by 13.5 per cent by June 2014.

Pesticides

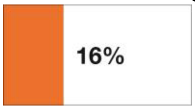
Target: At least a 60 per cent reduction in end-of-catchment pesticide loads in priority areas by 2018.
Moderate progress: The estimated annual average toxic pesticide load leaving catchments reduced by 28.5 per cent by June 2014.



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

Burdekin

Dissolved inorganic nitrogen



Target: At least a 50 per cent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas by 2018.
Poor progress: The estimated annual average dissolved inorganic nitrogen load leaving catchments reduced by 16 per cent by June 2014.

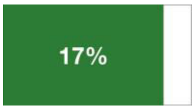
Particulate nitrogen

Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas by 2018.
Very good progress: The estimated annual average particulate nitrogen load leaving catchments reduced by 15 per cent by June 2014.

Particulate phosphorus

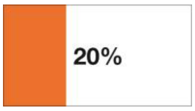
Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas by 2018.
Very good progress: The estimated annual average particulate phosphorus load leaving catchments reduced by 15.5 per cent by June 2014.

Sediment

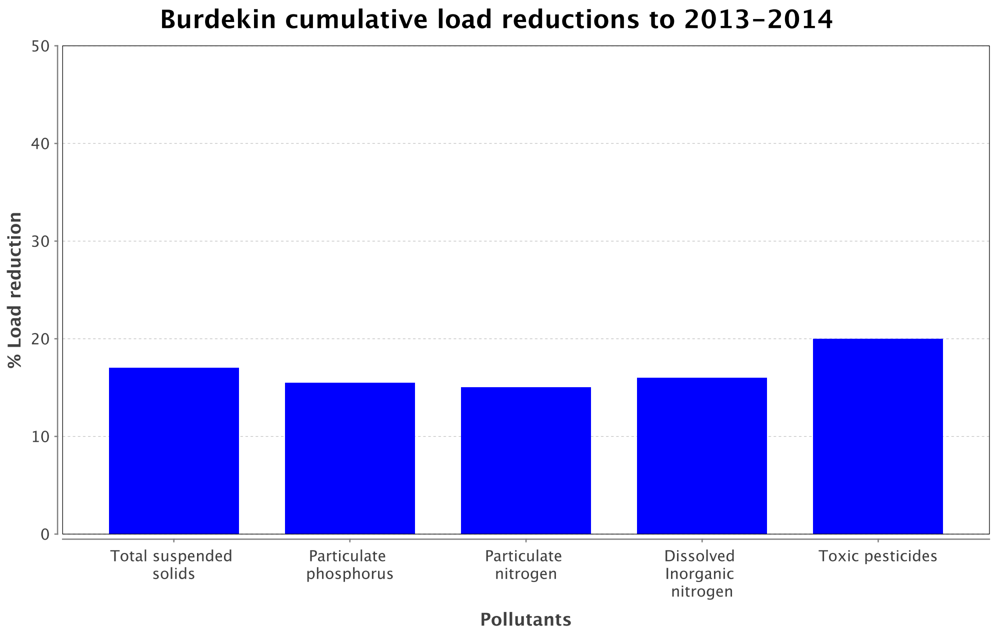


Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment in priority areas by 2018.
Very good progress: The estimated annual average total suspended sediment load leaving catchments reduced by 17per cent by June 2014.

Pesticides



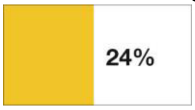
Target: At least a 60 per cent reduction in end of catchment pesticide loads in priority areas by 2018.
Poor progress: The estimated annual average toxic pesticide load leaving catchments reduced by 20 per cent by June 2014.



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

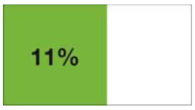
Mackay Whitsunday

Dissolved inorganic nitrogen



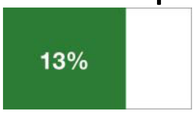
Target: At least a 50 per cent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas by 2018.
Moderate progress: The estimated annual average dissolved inorganic nitrogen load leaving catchments reduced by 24 per cent by June 2014.

Particulate nitrogen



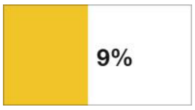
Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas by 2018.
Good progress: The estimated annual average particulate nitrogen load leaving catchments reduced by 11 per cent by June 2014.

Particulate phosphorus



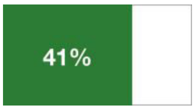
Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas by 2018.
Very good progress: The estimated annual average particulate phosphorus load leaving catchments reduced by 13 per cent by June 2014.

Sediment

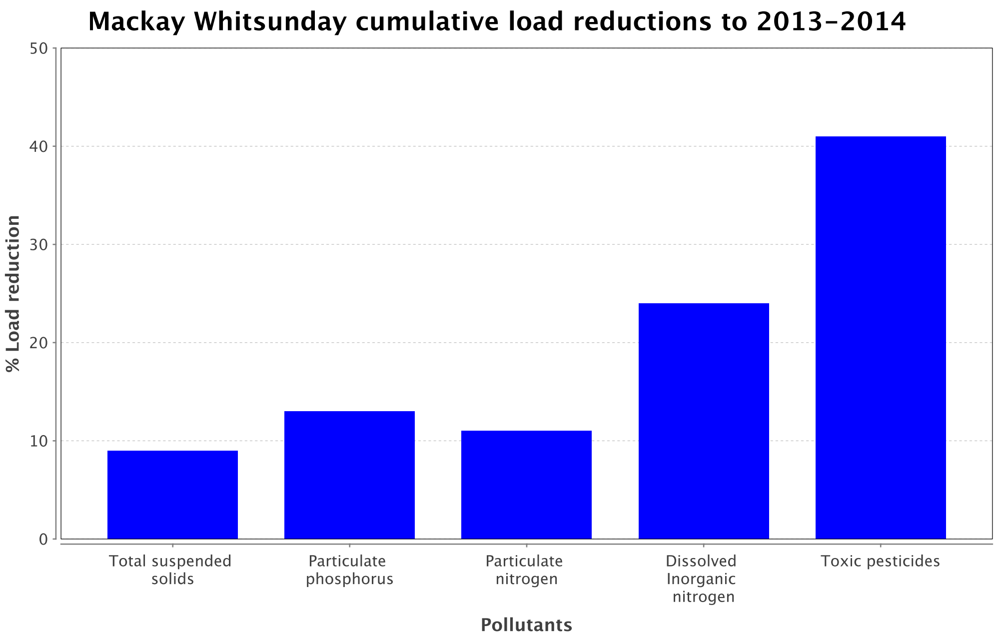


Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment in priority areas by 2018.
Moderate progress: The estimated annual average total suspended sediment load leaving catchments reduced by nine per cent by June 2014.

Pesticides



Target: At least a 60 per cent reduction in end-of-catchment pesticide loads in priority areas by 2018.
Very good progress: The estimated annual average toxic pesticide load leaving catchments reduced by 41 per cent by June 2014.



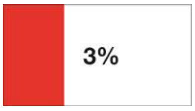
Note: Land management changes in the horticulture industry have not been modelled.

Fitzroy

Dissolved inorganic nitrogen

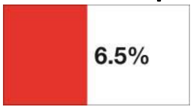
Dissolved inorganic nitrogen reductions are not modelled in regions without sugarcane.

Particulate nitrogen



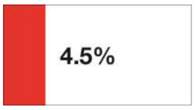
Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas by 2018.
Very poor progress: The estimated annual average particulate nitrogen load leaving catchments reduced by three per cent by June 2014.

Particulate phosphorus



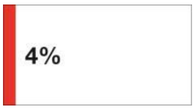
Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas by 2018.
Very poor progress: The estimated annual average particulate phosphorus load leaving catchments reduced by 6.5 per cent by June 2014.

Sediment

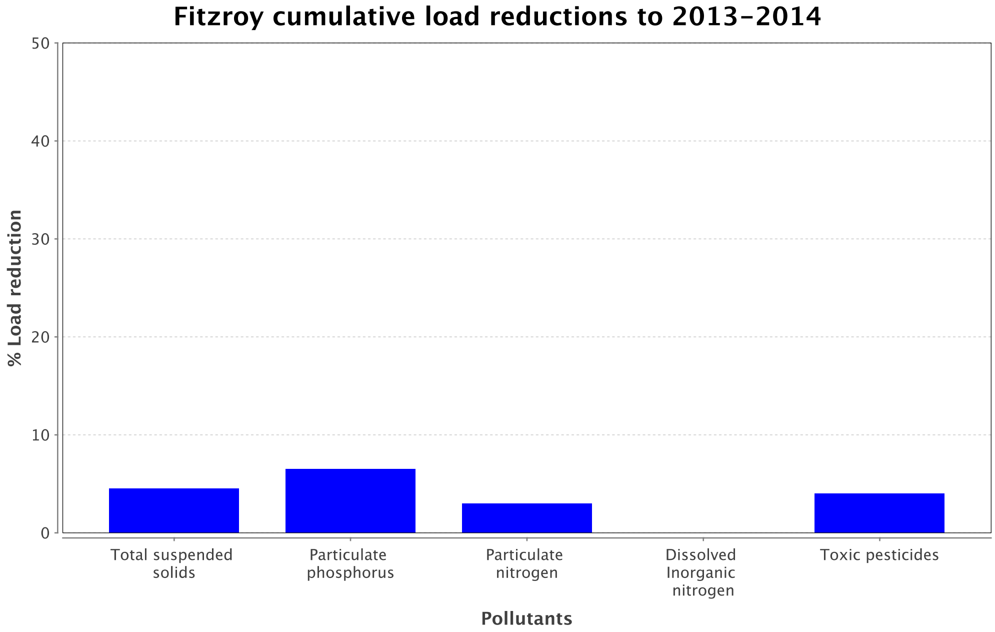


Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment in priority areas by 2018.
Very poor progress: The estimated annual average total suspended sediment load leaving catchments reduced by 4.5 per cent by June 2014.

Pesticides



Target: At least a 60 per cent reduction in end-of-catchment pesticide loads in priority areas by 2018.
Very poor progress: The estimated annual average toxic pesticide load leaving catchments reduced by four per cent by June 2014. This does not include pesticide reductions from improved grazing practices.



Note:

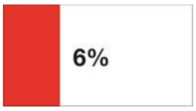
- Dissolved inorganic nitrogen reductions are only modelled for regions with significant sugarcane areas.
- Land management changes in horticulture have not been modelled.

Burnett Mary

Dissolved inorganic nitrogen

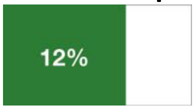
Target: At least a 50 per cent reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen loads in priority areas by 2018.
Very good progress: The estimated annual average dissolved inorganic nitrogen load leaving catchments reduced by 31.5 per cent by June 2014.

Particulate nitrogen



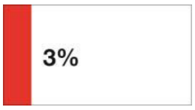
Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas by 2018.
Very poor progress: The estimated annual average particulate nitrogen load leaving catchments reduced by six per cent by June 2014.

Particulate phosphorus



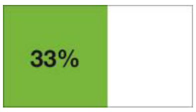
Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas by 2018.
Very good progress: The estimated annual average particulate phosphorus load leaving catchments reduced by 12 per cent by June 2014.

Sediment

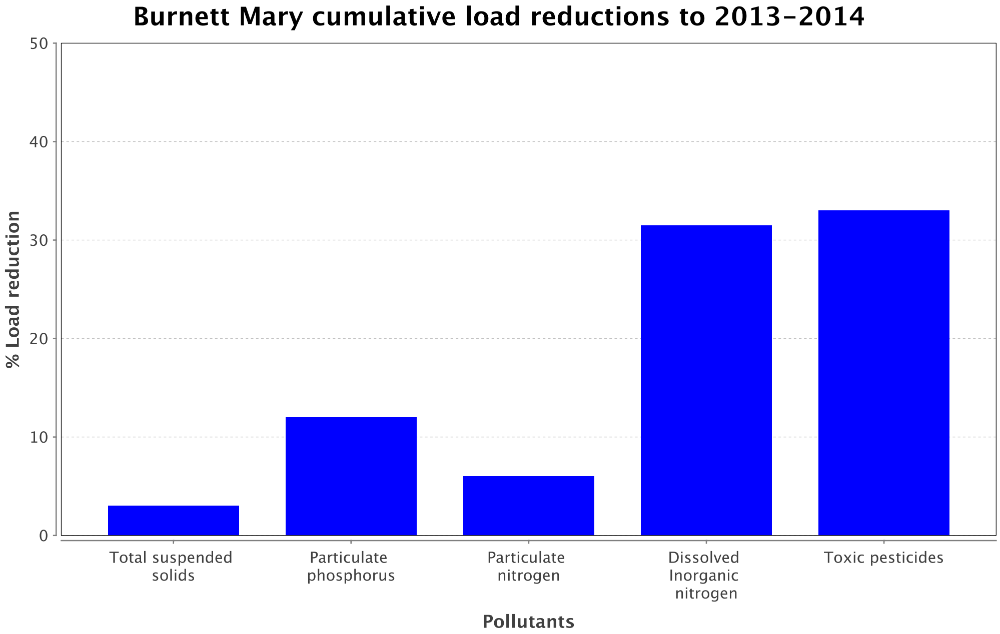


Target: At least a 20 per cent reduction in anthropogenic end-of-catchment loads of sediment in priority areas by 2018.
Very poor progress: The estimated annual average total suspended sediment load leaving catchments reduced by three per cent by June 2014.

Pesticides



Target: At least a 60 per cent reduction in end of catchment pesticide loads in priority areas by 2018.
Good progress: The estimated annual average toxic pesticide load leaving catchments reduced by 33 per cent by June 2014.



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

Marine results

The long-term goal of the Reef Water Quality Protection Plan 2013 (Reef Plan) is:
"To ensure that by 2020 the quality of water entering the reef from adjacent catchments has no detrimental impact on the health and resilience of the Great Barrier Reef."

Improvements in land management practices will take time to translate into improved marine condition as there are significant time lags between implementation and measurable outcomes in these natural systems. Inshore marine condition is also strongly influenced by severe weather events, such as tropical cyclones and floods, which have had an impact on all regions in recent years.

The marine results focus mainly on the inshore area of the Great Barrier Reef. Water quality at mid and outer shelf sites is generally good to very good overall because it is less influenced by river discharge.

Introduction
The Great Barrier Reef receives runoff from 35 major catchments, which drain 424,000 square kilometres of coastal Queensland. The far northern part of the reef region is relatively sparsely populated; however, the southern part of the catchment from Port Douglas to Bundaberg is more heavily populated and includes six major urban centres (GBRMPA, 2013). Since European settlement, agricultural development in the catchment has resulted in significant loss, modification and fragmentation of terrestrial habitats that support the reef, which has affected the health of the many inshore ecosystems (GBRMPA, 2012). Increasing pressure from human activities continues to have an adverse impact on the quality of water entering the reef lagoon, particularly during the wet season. Flood waters deliver loads of nutrients and sediments to the reef that are well above natural levels and many times higher than in non-flood waters (Devlin et al., 2015; Waters et al., 2014; Thompson et al., 2013). Pesticides, which are manufactured chemicals with no natural level, are detected year-round in reef waters (Gallen et al., 2014). The main source of excess nutrients, fine sediments and pesticides from reef catchments is agriculture, although some progress has been made in addressing this through Reef Plan 2013.

Disturbances affecting the Great Barrier Reef
The health and resilience of the reef is affected by a range of short-term acute and longer term chronic disturbances including:

- catchment runoff
- floods
- cyclones
- crown-of-thorns starfish outbreaks
- elevated sea surface temperatures.

A resilient coral community has high rates of coral recruitment and growth, which compensate for losses from acute disturbances (e.g. cyclones) in combination with chronic environmental pressures (e.g. poor water quality). Over time, chronic pressures may decrease the resilience of the reef ecosystem by slowing or inhibiting recovery from acute disturbances. The impact of disturbances on the reef depends on their frequency, duration and severity, as well as the state of the ecosystem (GBRMPA 2014; Osborne et al., 2011). Multiple acute disturbances in close succession usually have a combined negative effect on reef resilience that is greater than the effect of each disturbance in isolation. Importantly, reducing one stress will often help the ecosystem recover from or resist the impact of other pressures. For example, improving water quality is expected to improve the resilience of corals to the effects of climate change.

Between 2006 and 2014, repeated disturbances had a considerable and widespread impact on the water quality and ecosystem health of the inshore area. For example, tropical cyclones severely reduced coral cover at some reefs in all regions (Tropical Cyclone Larry in 2006, Tropical Cyclone Hamish in 2009 and Tropical Cyclone Yasi in 2011), and in combination with flooding, caused the near-loss of some seagrass communities. There are signs of seagrass recovery at locations that have been relatively free from disturbances in subsequent years.

However, marine ecosystem health remains vulnerable and it may take many years for complex communities to re-establish.

The Strategic Assessment Report (GBRMPA, 2013) and Outlook Report (GBRMPA, 2014) concluded that the overall outlook for the reef is ‘poor’, and the health of the reef ecosystem is declining in inshore areas south of Cooktown. For example, coral cover on mid-shelf reefs along the developed coast of the central and southern Great Barrier Reef has declined to less than 50 per cent of what it was in 1985, while coral cover in the northern Great Barrier Reef is in better condition (De’ath et al., 2012). Outbreaks of the coral-eating crown-of-thorns starfish are one of the main direct causes of the decline in coral cover reef-wide and the link between outbreaks and poor water quality, especially the level of nutrients in flood waters, has been greatly strengthened (Fabricius et al., 2010; Furnas et al., 2013; The State of Queensland, 2013).

The area at highest risk from degraded water quality and its flow-on effects is the inshore region (Alvarez-Romero et al., 2013), which makes up approximately eight per cent of the Great Barrier Reef Marine Park. Inshore seagrass and coral reef ecosystems support significant ecological communities and the inshore region is the area most used by recreational visitors, commercial tourism operators and some commercial fisheries. Management interventions to improve land management practices are having a positive effect on water quality (Reef Water Quality Protection Plan Secretariat 2014); however, it will take time and the continued effort of all stakeholders for the marine ecosystem to recover and return to good health (GBRMPA, 2013; The State of Queensland, 2013).

Impacts of catchment runoff

Reef ecosystems and the catchments are part of a dynamic, interconnected system (GBRMPA, 2012) and the relationship between land use, water quality and ecosystem health indicators (e.g. coral cover and seagrass abundance) is relatively well understood. Nutrient enrichment, turbidity, sedimentation and pesticides all affect the resilience of the reef, degrading coral reefs and seagrass meadows at local and regional scales (Brodie et al., 2012; The State of Queensland, 2013). Pollutants may also interact to have a combined negative effect on reef resilience that is greater than the effect of each pollutant in isolation. For example, excess nutrients and reduced light levels characteristic of turbid flood waters combine to increase the level of stress on seagrasses (Collier et al., 2012; McKenzie et al., 2015), and differences in tolerance between species of coral to nutrient enrichment and sedimentation can lead to tissue death and changes in community composition (Fabricius, 2005; Fabricius, 2011; Weber et al., 2012). Since 2009, there has been a modelled decrease in the loads of main pollutants entering the reef lagoon.

Floods

There were few floods over the summer of 2013-2014, as the level of rainfall in the reef catchment was low to average. However, Tropical Cyclone Ita caused some flooding in the Wet Tropics, mainly from the Herbert River.

Monitoring in 2013-2014 showed that the Cape York and Wet Tropics regions had near-average river discharges and monitored loads of sediment and nitrogen (Figure 1). All other regions had significantly lower than average discharge which resulted in markedly below average monitored sediment and nitrogen loads. The highest pesticide loads were from the Wet Tropics and Mackay Whitsunday regions.

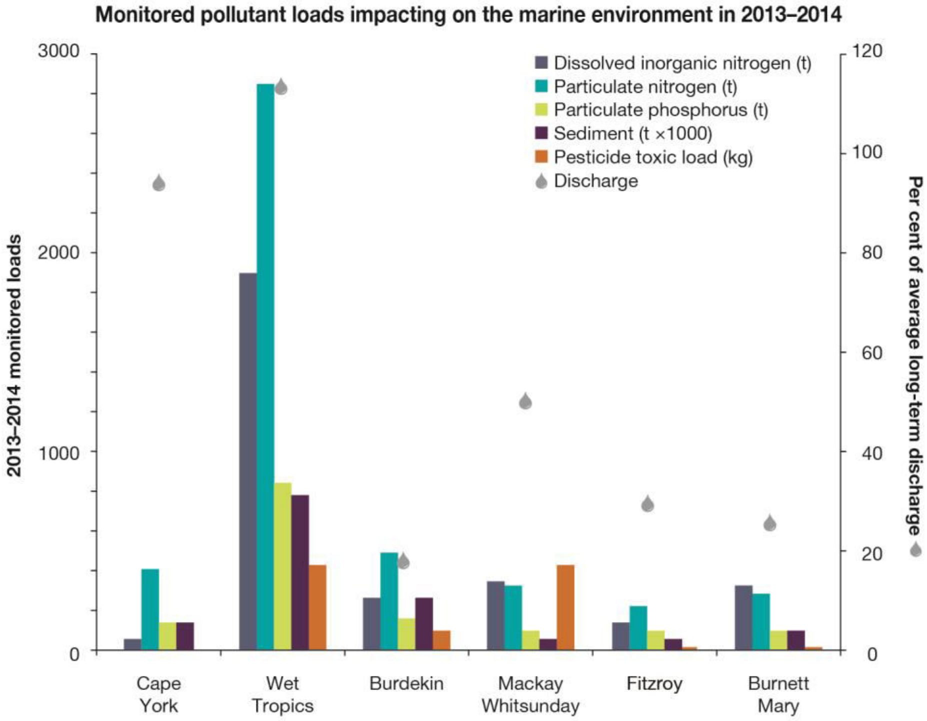


Figure 1: Long-term discharge and combined annual monitored pollutant loads from major rivers in each region. Note: pesticides are not monitored in Cape York. Source: Data supplied by the Queensland Department of Science, Information Technology and Innovation

Cyclones

Two tropical cyclones traversed parts of the reef in 2013-2014: Tropical Cyclone Dylan (Category 2) which made landfall between Bowen and Proserpine and Tropical Cyclone Ita (Category 4) which made landfall north of Cooktown. The most significant impacts were associated with Tropical Cyclone Ita, which weakened from Category 5 to 4 when it made landfall on 11 April 2014. The Great Barrier Reef Marine Park Authority's Eye on the Reef monitoring network recorded some damage to coral reefs in the Cairns to Cooktown region that was attributed to the high winds and heavy rainfall associated with this event. There were minor impacts on seagrass meadows in areas north of Cairns due to physical damage from waves, as well as exposure to low salinity, high sediments and turbidity from the flood plumes.

Since 2005, many areas of the reef have been affected by cyclonic activity including very destructive Category 4 or 5 cyclones (Figure 2). For example, about 13 per cent of the reef, representing a 300 kilometre stretch from Cairns to Townsville, was exposed to Tropical Cyclone Yasi's destructive or very destructive winds in February 2011.

Cyclones may cause extreme physical damage to the reef structure and other benthic communities, such as seagrass meadows. The combined paths of all cyclones since 2005 have exposed 80 per cent of the Great Barrier Reef Marine Park to gale force winds or above. Recent estimates attribute 48 per cent of total coral mortality recorded between 1985 and 2012 to cyclones and storms (De'ath et al., 2012). There have been no large-scale assessments of the impacts of cyclones on seagrass communities; however, localised monitoring after Tropical Cyclone Yasi suggests they play a significant role in redistributing marine sediments by scouring the seafloor and removing benthic communities including seagrass (http://www.gbrmpa.gov.au/__data/assets/pdf_file/0016/14308/GBRMPA-ExtremeWeatherAndtheGBR-2010-11.pdf). The effect of multiple severe cyclones and floods on the health of the inshore area is still evident today (McKenzie et. al., 2015; Thompson et al., 2013). For example, extensive loss of seagrass across the southern part of the reef resulted in a large number of dugong and turtle deaths, and the population of dugongs remains at a record low (http://www.gbrmpa.gov.au/outlook-for-the-reef/extreme-weather/dugong-and-turtle-strandings).

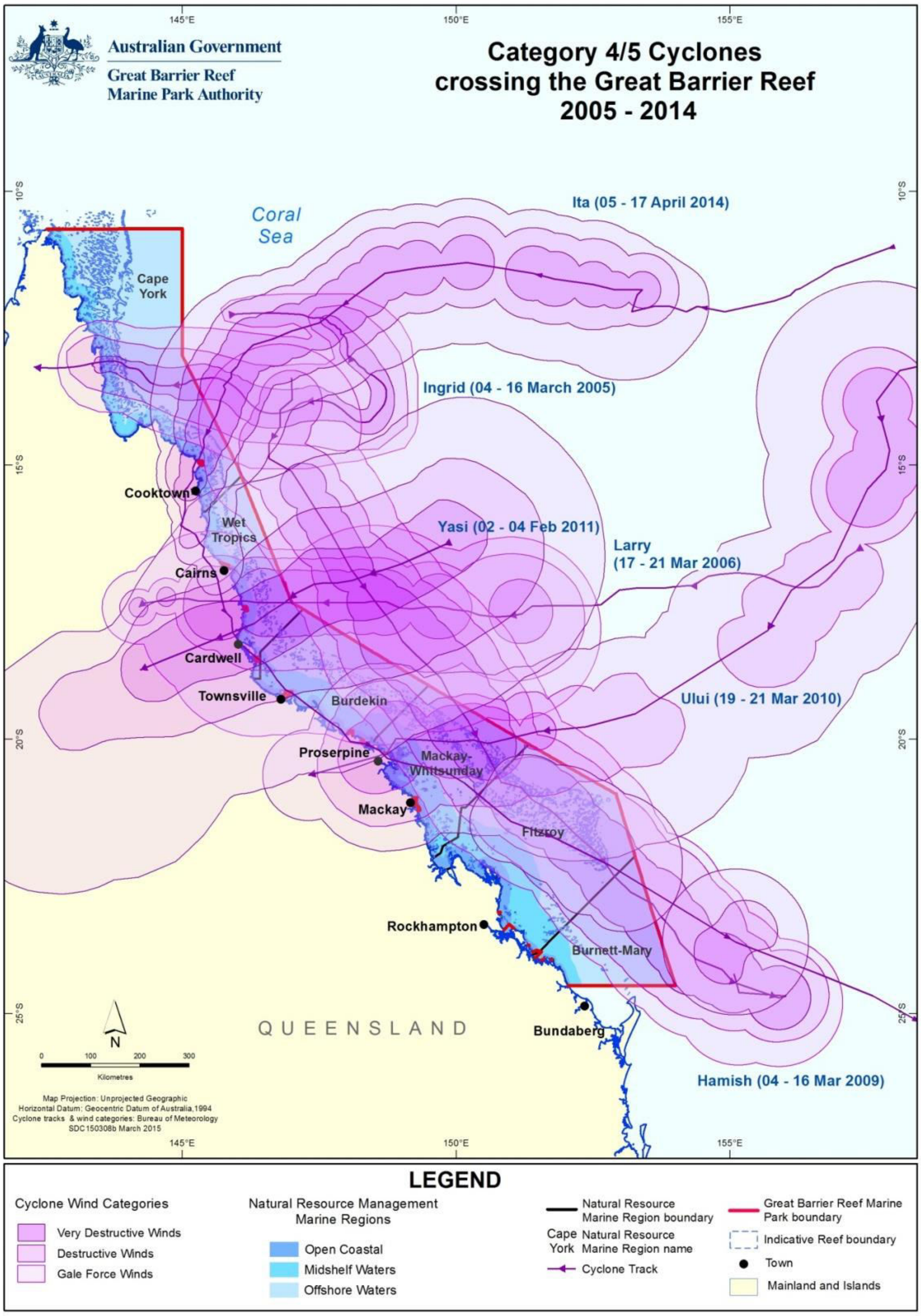


Figure 2: Extent of the Great Barrier Reef affected by Category 4 or 5 cyclones in the nine year period 2005-2014.

Crown-of-thorns starfish

In 2013-2014, outbreaks of the coral-eating crown-of-thorns starfish were recorded at 14 per cent of reefs monitored by the Australian Institute of Marine Science Long Term (Reef) Monitoring Program (Figure 3). Densities in the 'initiation zone' from Lizard Island to Cairns were at the highest levels since 1986 (Miller and Sweatman, 2013). The initiation zone is where primary outbreaks of crown-of-thorns starfish are thought to originate following exposure to excess nutrients in runoff (Fabricius et al., 2010; Furnas et al., 2013a). There are three previously documented outbreaks of crown-of-thorns starfish in the reef since the 1960s: from 1962 to 1976, 1978 to 1990 and 1993 to 2005. The latest, ongoing outbreak commenced in 2011 (http://www.aims.gov.au/docs/research/biodiversity-ecology/threats/cots-animation.html). Evidence for the link between the onset of the current outbreak and poor water quality, specifically high nutrients loads, has been greatly strengthened after the multiple floods and severe weather events from 2009 to 2011 (Fabricius et al., 2010; The State of Queensland, 2013).

Crown-of-thorns starfish have had a major impact on the reef (Osborne et al., 2011). An analysis of long-term monitoring data attributed 42 per cent of the decline in coral cover between 1985 and 2012 to the starfish (De'ath et al. 2012). Most outbreaks occur on mid-shelf reefs, beginning along the narrow northern shelf between Cairns and Lizard Island (the 'initiation zone') and then move to southern reefs as larvae are transported by the East Australian Current. The Swains Reefs in the Fitzroy region have had infestations of crown-of-thorns starfish for most of the past three decades, as a result of the regional oceanography and high density of coral reefs.

An active outbreak of crown-of-thorns starfish occurs when the starfish consume coral tissue faster than corals can grow. This is generally considered to be more than about 15 starfish per hectare when coral cover is moderate to high (Moran and De'ath, 1992). However, many of the inshore and mid-shelf reefs affected by multiple severe weather events in recent years have lower coral cover and, therefore, reduced capacity to cope with these levels of starfish.

In addition to improving the quality of water entering the reef, the Australian Government is committed to protecting coral cover at high value tourism sites by funding a crown-of-thorns starfish management program, which involves lethally injecting the coral-eating starfish (http://www.gbrmpa.gov.au/about-the-reef/animals/crown-of-thorns-starfish/what-is-the-short-term-strategy). The management program has been underway since 2012 and is a collaborative effort involving the Association of Marine Park Tourism Operators, Queensland Parks and Wildlife Service, the Great Barrier Reef Marine Park Authority, and the Reef and Rainforest Research Centre. Broad-scale surveillance of crown-of-thorns starfish populations on individual reefs helps to direct efforts and resources where they are most needed.

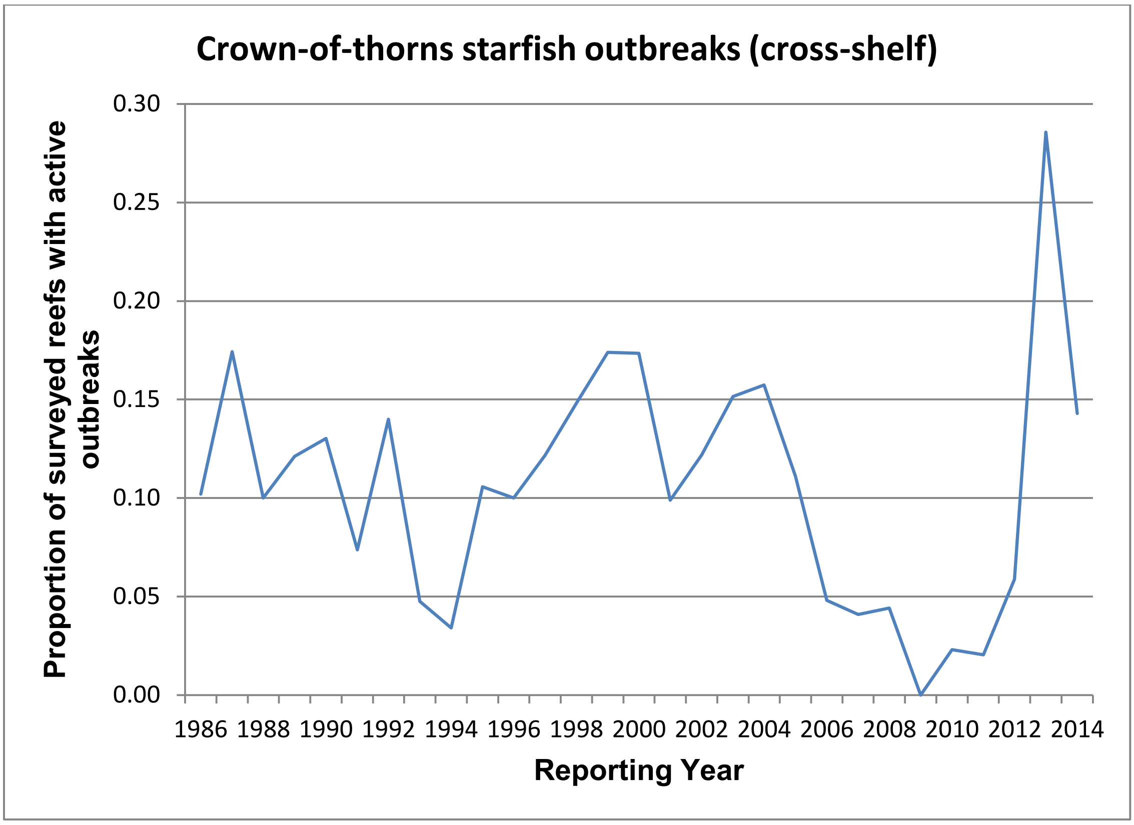


Figure 3: Extent of the crown-of-thorns starfish outbreaks in the Great Barrier Reef from 1985 to 2014. Data source: Australian Institute of Marine Science Long-term Monitoring Program. Note that the same reefs are not necessarily surveyed every year and some of the outbreaks of crown-of-thorns starfish overlap in time.

Elevated sea surface temperatures

Coral bleaching across the reef in 2013-2014 was low, with minor impacts observed at some reefs in the Cape York, Wet Tropics and Mackay Whitsunday regions (Figure 4). In 2013-2014, the method for assessing accumulated heat stress changed and Figure 4 is not directly comparable with maps in previous reports.

Coral bleaching generally occurs when accumulated temperature stress, measured as degree heating days over the summer months, exceeds a threshold of about 60 to 100 degree heating days (Maynard, 2010). However, other factors that affect sea surface temperatures can influence where bleaching occurs, such as cyclones, rainfall and currents.

An increase in the long-term average temperature of reef waters is narrowing the gap between a regular summer and a coral bleaching season, with an increase in the frequency of mass bleaching events over the past two decades (Johnson and Marshall, 2007; Lough, 2007; GBRMPA, 2014). Major coral bleaching events caused by unusually warm water temperatures were not recorded in the Great Barrier Reef Marine Park before 1998, when bleaching occurred globally. Similar conditions returned in 2002 and to a lesser extent in 2006, and caused substantial loss of coral cover (De'ath et. al., 2012). Prolonged exposure to elevated seawater temperatures may also increase the susceptibility of corals to disease (Bruno et. al., 2007; GBRMPA, 2014).

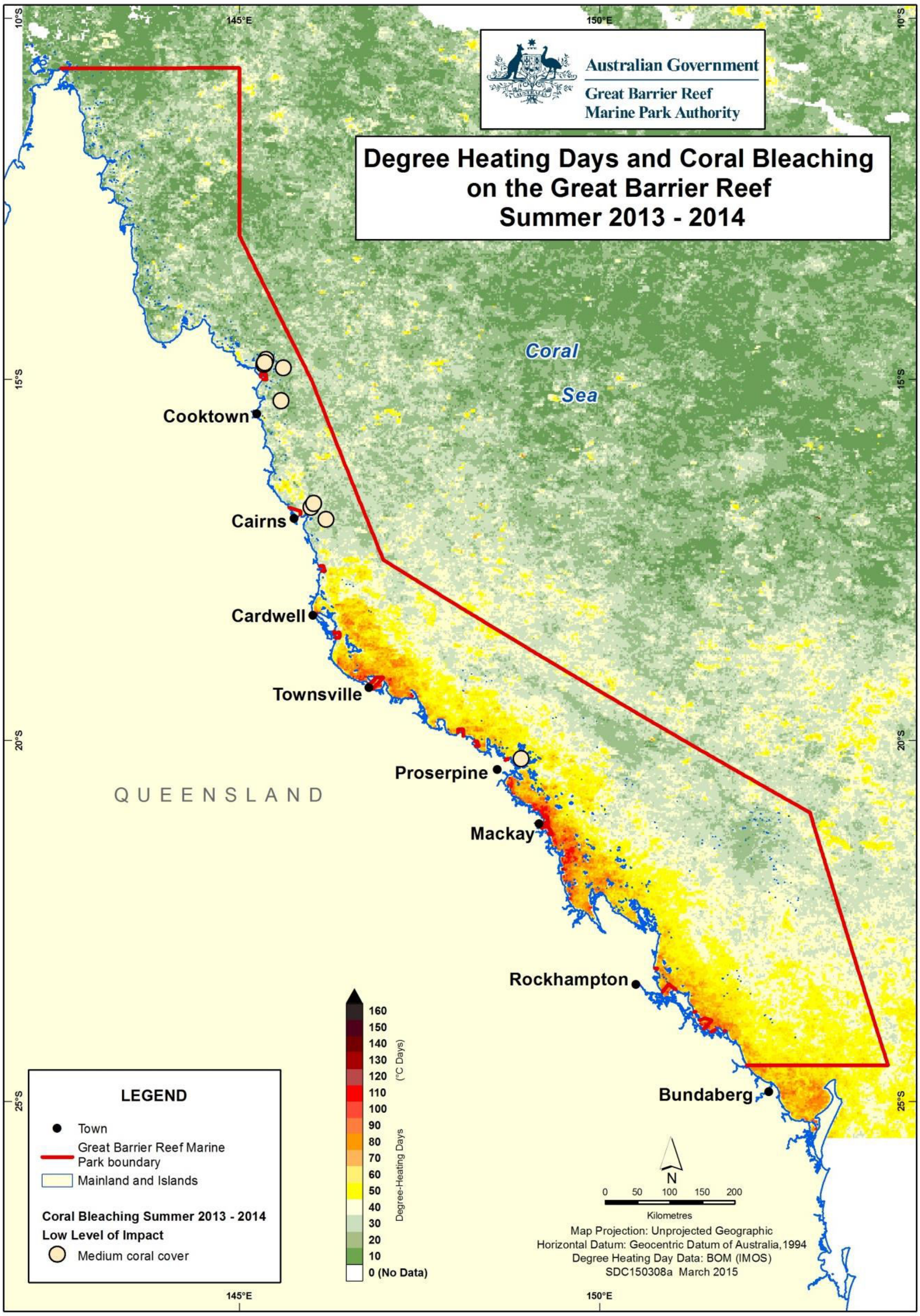


Figure 4: Water temperature as degree heating days and areas where coral bleaching occurred in 2013-2014. Areas where bleaching occurred are indicated by circles proportional to the level of impact and coral cover.

Influence of climate change

The intensity of disturbances to the reef is set to increase under future climate change projections (The State of Queensland 2013). The average seawater temperature on the reef could be about 2.5 degrees Celsius warmer than the present average by 2100 (Garnaut, 2008; Outlook 2014). It is also predicted that reef waters will become more acidic, sea levels will continue to rise, patterns of ocean circulation will change and weather events will become more extreme (Intergovernmental Panel on Climate Change, 2007). The extent and persistence of damage to the reef will largely depend on the rate and magnitude of change in the world's climate and on the resilience of the reef ecosystem (GBRMPA, 2014). This has important implications for the future management of the Great Barrier Reef and level of pollutants in run-off entering the reef lagoon. For example, modelling suggests the upper thermal bleaching limit of corals is correlated with exposure to dissolved inorganic nitrogen and reducing the output of dissolved inorganic nitrogen may enhance the resilience of inshore corals (Woodridge, 2009).

The future is not easily forecast, but there is strong evidence that improving the quality of water entering the Great Barrier Reef lagoon will increase the natural resilience of reef ecosystems to climate change.

Great Barrier Reef-wide

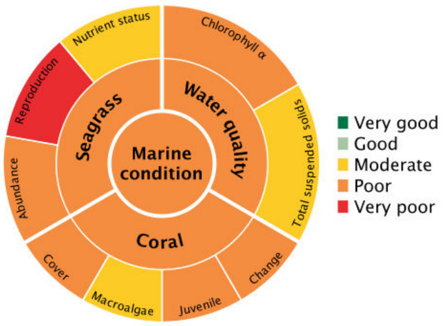


Figure 5: Overall condition of the inshore marine environment. The overall condition of the inshore marine environment remained poor in 2013-2014 (Figure 5). Inshore water quality was poor, except Mackay Whitsunday which was moderate. Pesticides were detected year round at all sites monitored across the reef. Inshore seagrass showed signs of recovery at locations that were relatively free from disturbances in recent years, but remained in poor condition overall. Inshore coral reefs have continued to improve since 2011-2012 when their condition reached its lowest point due to impacts by repeated disturbances. However, they remained in poor condition overall. Improvements in coral condition were mainly due to increases in the number of juvenile corals in all regions in 2013-2014.

Water quality

Inshore water quality for the Great Barrier Reef (assessed by remote sensing of chlorophyll *a* and total suspended solids) was poor in 2013-2014 (Figure 6). The overall poor score reflects the cumulative impact of above-median discharge from many rivers over multiple years and the continued re-suspension of finer sediment by wind and waves. Concentrations of chlorophyll *a* and total suspended solids were poor and moderate respectively in 2013-2014.

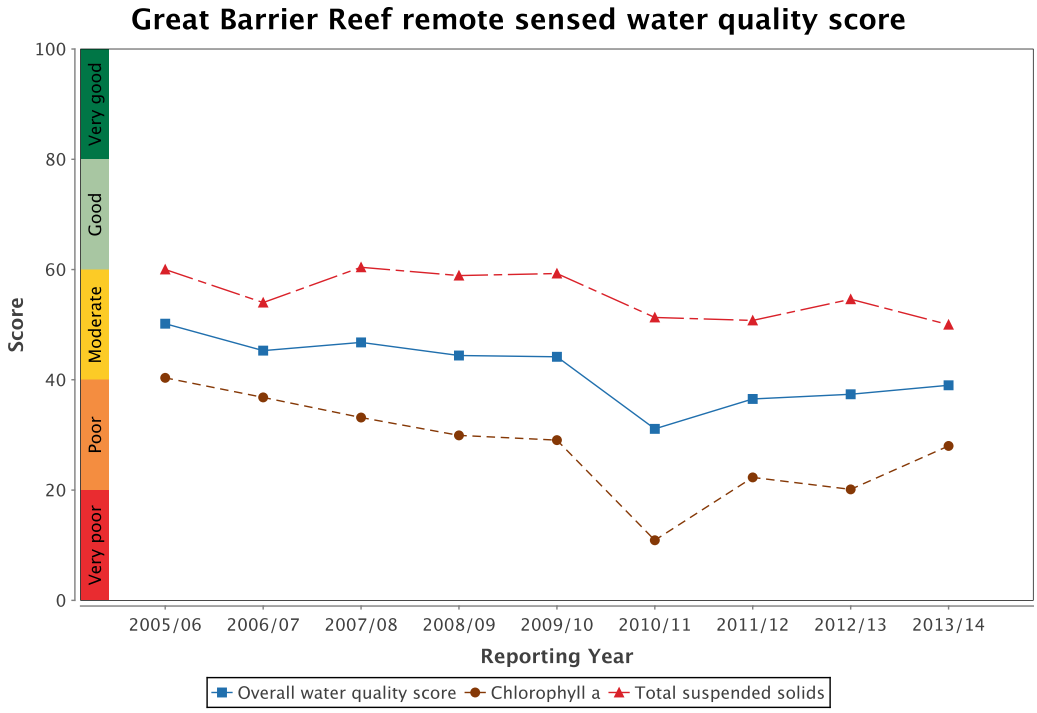


Figure 6: Trend in water quality from 2005-2014. The overall water quality score is also separated into component scores for concentrations of chlorophyll *a* and total suspended solids.

In 2013-2014, as in previous years, remote sensing of water quality showed a clear gradient of improvement from inshore areas that are more frequently exposed to flood waters to mid-shelf and offshore areas that are more distant from terrestrial inputs.

The inshore area of all regions had annual mean chlorophyll *a* concentrations that exceeded the Great Barrier Reef Water Quality Guidelines, with some areas approaching close to 100 per cent exceedance (from 61 per cent in the Mackay Whitsunday region to 91 per cent in the Burnett Mary region in 2013-2014) (Figure

7). While some exceedance of the guidelines is expected during the wet season, these high concentrations of chlorophyll *a* are indicative of high nutrient loading from the catchments.

Concentrations of total suspended solids also exceeded the Great Barrier Reef Water Quality Guidelines during the year. This reflected the input of sediment to the lagoon from repeated flood events in recent years and the continual re-suspension of finer sediment particles by wind and wave action (from 30 per cent in the Burnett Mary region to 52 per cent in the Burdekin region in 2013-2014) (Figure 8). Regions where the Great Barrier Reef Water Quality Guidelines were exceeded had water quality scores ranging from moderate to poor depending on the magnitude of exceedance.

Note that the time-series for water quality has been recalculated and trend graphs in previous reports are not comparable. Remote sensing data for Cape York and the Burnett Mary regions is not validated with any field data so there is a high degree of uncertainty in those scores. In the other four regions, more detailed, site specific water quality information is available, which is assessed against the Great Barrier Reef Water Quality Guidelines. The site specific water quality data is not included in the water quality scores because a method needs to be developed to integrate the different datasets. However, the in-situ water quality monitoring is important because it provides an overall assessment of water quality at each of the 20 water quality sampling locations, which is based on a three-year rolling average.

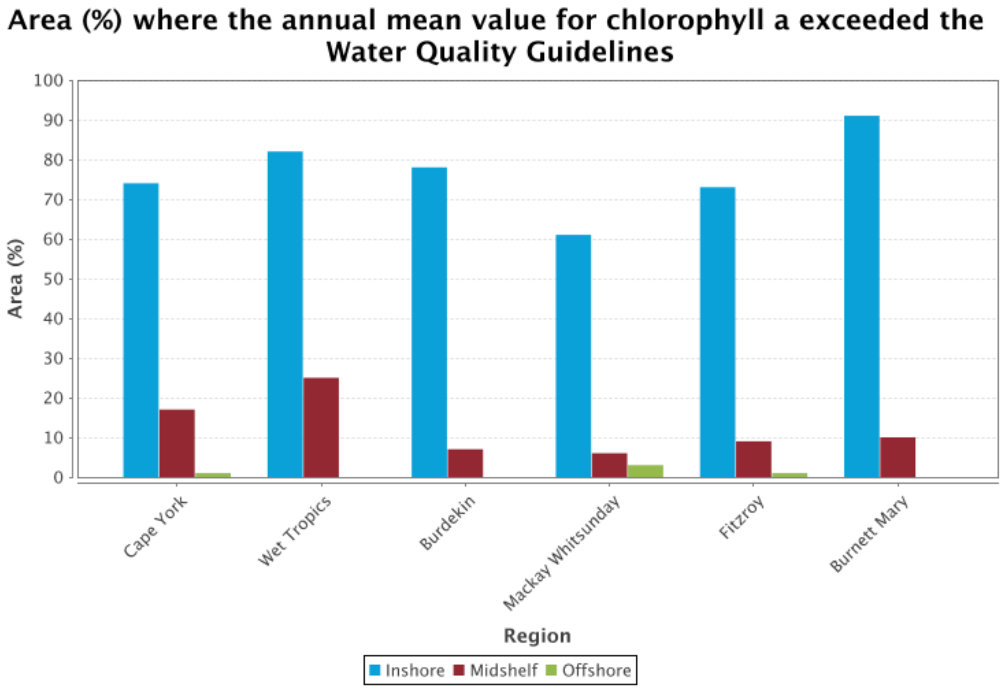


Figure 7: Relative area (%) of the inshore, mid-shelf and offshore water bodies where the annual mean value for chlorophyll *a* exceeded the Barrier Reef Water Quality Guidelines from 1 May 2013 to 30 April 2014.

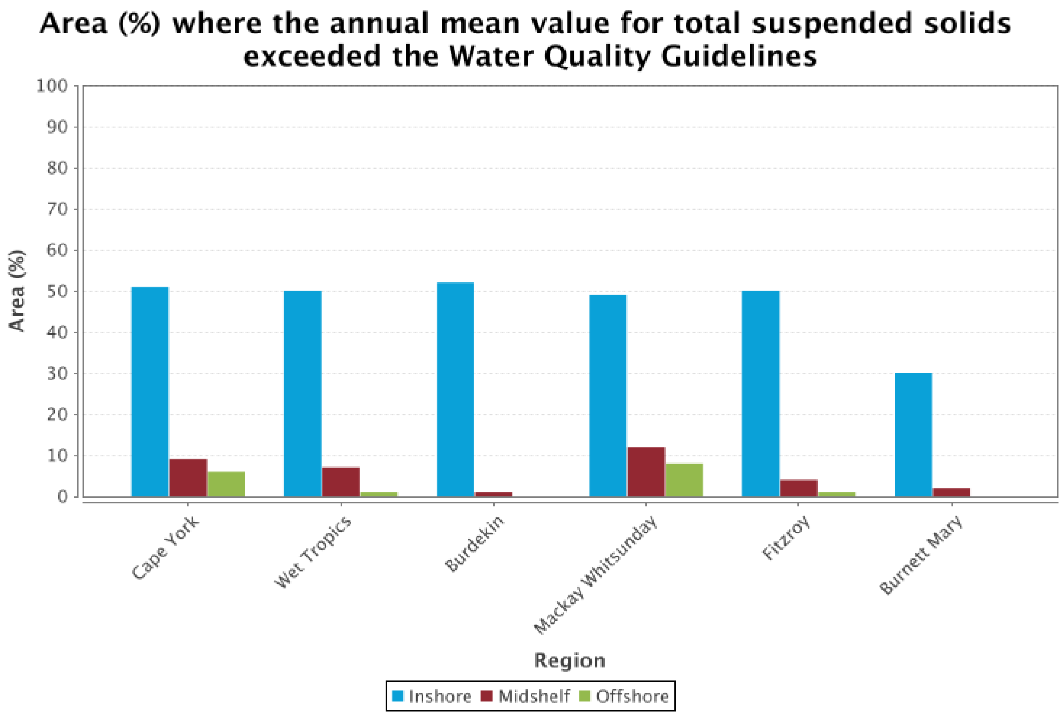


Figure 8: Relative area (%) of the inshore, mid-shelf and offshore water bodies where the annual mean value for total suspended sediment exceeded the Great Barrier Reef Water Quality Guidelines from 1 May 2013 to 30 April 2014.

Pesticides

Pesticides were detected at all sites in 2013-2014 with high variability in the profiles and concentrations between regions and seasons. The most frequently detected pesticides in inshore waters are those that inhibit photosynthesis (Photosystem II inhibiting (PSII) e.g., diuron, atrazine, hexazinone, simazine and tebuthiuron). An index has been developed using PSII herbicide equivalent concentrations to assess the potential combined toxicity of these pesticides relative to the Great Barrier Reef Water Quality Guidelines. The PSII herbicide equivalent concentration incorporates the relative potency and abundance of individual PSII herbicides compared to a reference PSII herbicide, diuron. 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 corresponds to the greatest impact and is equivalent to the Great Barrier Reef Water Quality Guideline for diuron for 99 per cent species protection. Recent research indicates that persistent concentrations of pesticides below guideline levels may have a longer-term, chronic impact on some marine organisms and the pesticide index is being revised.

Elevated PSII herbicide equivalent concentrations generally coincided with periods of high flow from the major rivers in the wet season. Two grab samples collected at the Tully and Russell-Mulgrave River mouths had concentrations of diuron and metolachlor that exceeded Interim Working Levels of the Australian and New Zealand Environment Conservation Council and Agricultural and Resource Management Council of Australia and New Zealand Guidelines, respectively. However, in 2013-2014, no PSII herbicide equivalent concentrations were detected above Great Barrier Reef Water Quality Guideline levels (Category 1) at any of the monitored sites.

Even though there were few exceedances of the Great Barrier Reef Water Quality Guidelines, biologically relevant concentrations of PSII herbicides (Category 4) were present at one of the 12 monitored sites in the Mackay Whitsunday region (Figure 9). Flood waters from the Russell-Mulgrave, Tully and Herbert rivers, located in the Wet Tropics region, also had concentrations of PSII herbicides (Categories 2 to 4) that suppress photosynthesis in marine species, which were mostly attributed to the presence of diuron.

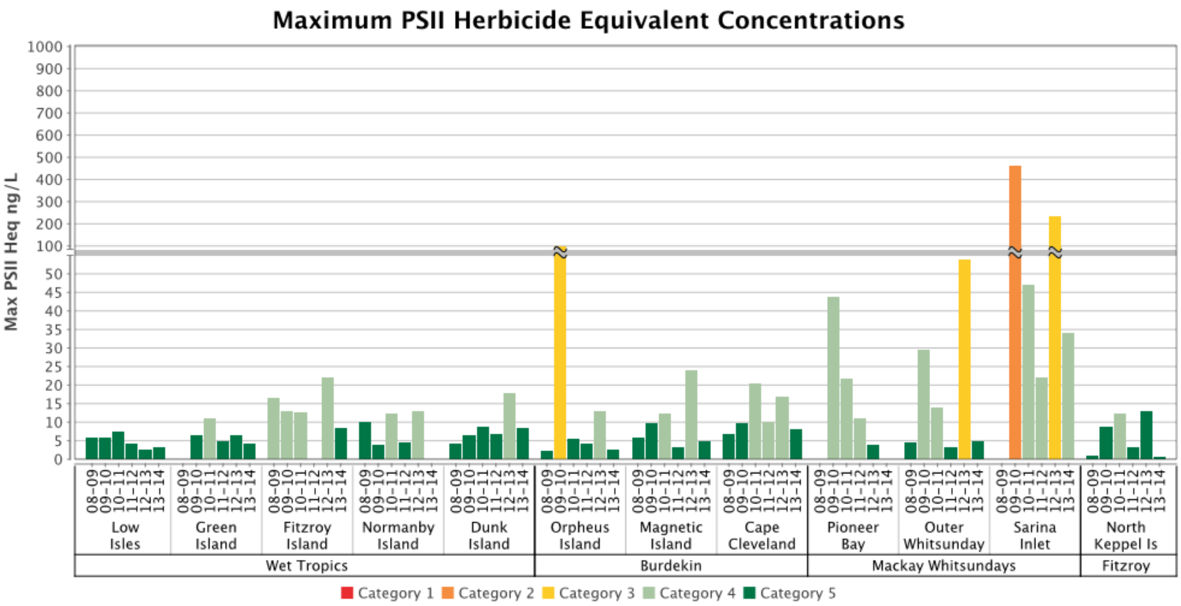


Figure 9: Maximum PSII herbicide equivalent concentrations at all sites monitored in the reef in 2013-2014.

Herbicide equivalent concentrations provide a single reporting parameter for PSII herbicides with a similar mode of action on photosynthesis. However, they may obscure differences in the abundance of individual herbicides detected in different regions because they also consider the potency of each herbicide. For example, a herbicide detected at a high concentration may have a low potency (with respect to the reference diuron) and thus the contribution to the overall PSII inhibition is very small. Therefore, the concentrations of individual herbicides are also presented below. The types of pesticides detected in each region are often related to the land management activities in adjacent catchments.

The most prevalent pesticide detected across the reef in 2013-2014 was diuron (heavily used in the sugarcane industry), which was the main contributor to the PSII herbicide equivalent index. Diuron was detected at the majority of sites in the Wet Tropics, Burdekin, Mackay Whitsunday and Fitzroy regions (Figure 10). However, concentrations of diuron were lower than those in 2012-2013. Atrazine and hexazinone were also frequently detected. A range of other pesticides were detected across the reef including tebuthiuron, metolachlor, the industrial chemical galaxolie and the insecticide imidacloprid.

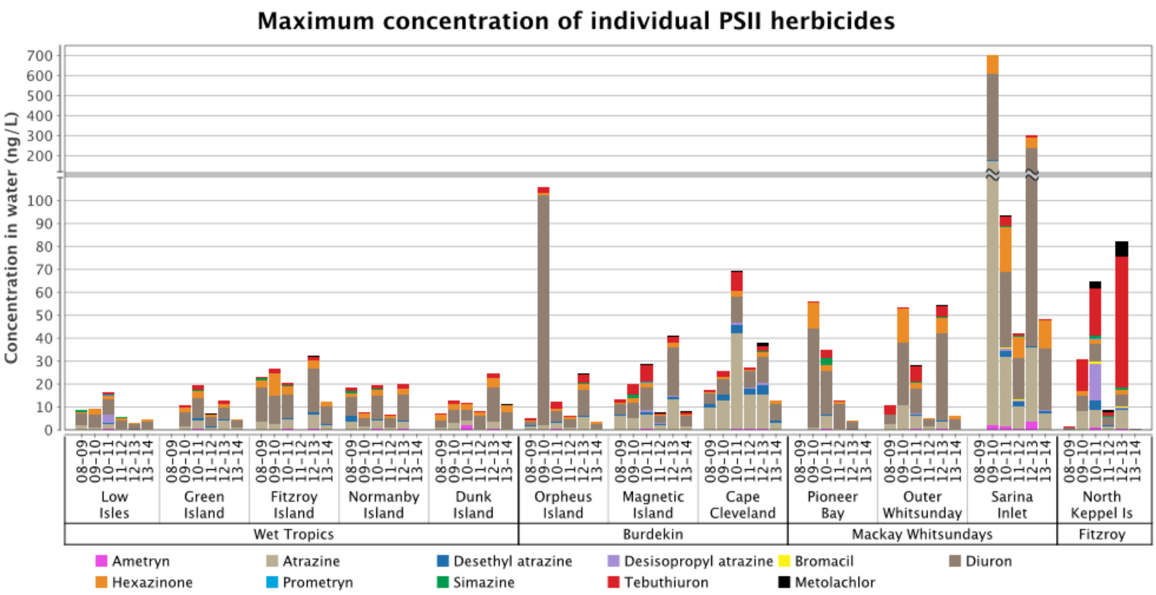


Figure 10: Maximum concentration of individual PSII herbicides at all sites monitored across the reef in 2013-2014 compared to the previous five years.

Seagrass
The overall reef-wide condition of inshore seagrass meadows remained poor in 2013-2014. Seagrass abundance and reproductive effort were poor and very poor, respectively, while nutrient status improved to moderate (Figure 11).

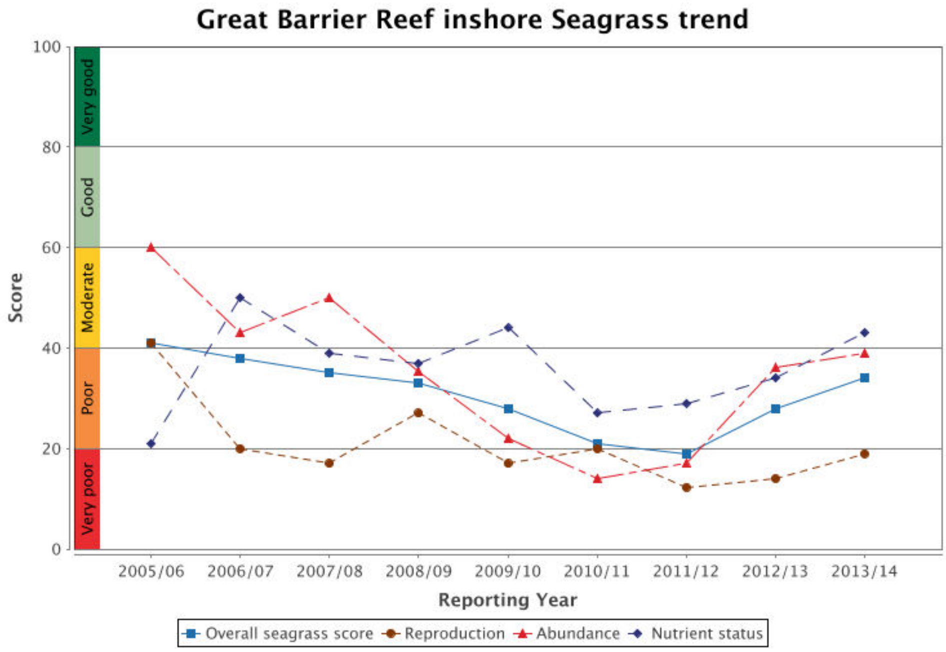


Figure 11: Trend in seagrass condition from the inshore Great Barrier Reef from 2005-2006 to 2013-2014. The overall seagrass score is also separated into component scores for reproduction, abundance and nutrient status.

The abundance of seagrass meadows improved slightly in all regions in 2013-2014 except for the Fitzroy region where seagrass abundance continued to decline. The Burdekin region had the greatest improvement in abundance from poor to moderate. Recovery was mainly of fast-growing pioneer species and it may take many years for meadows to fully recover their more complex foundational community structure. Reproductive effort increased in the Wet Tropics, Burdekin, Mackay Whitsunday and Fitzroy regions, with the largest improvements in the Burdekin region. Reproductive effort can reflect the capacity of local meadows to recover from environmental disturbances and the very low score overall indicates seagrass remain in vulnerable condition. Nutrient content of seagrass tissue improved in all regions except the Wet Tropics region where it declined from moderate to poor in 2013-2014.

The slow recovery of seagrass continues to have an impact on populations of dugongs and turtles. The rate of dugong and turtle strandings, which increased significantly after the 2011 floods, has returned to normal for dugongs (although from a much lower population base). However, the rate of turtle deaths (turtles are more sedentary in their behaviour) has remained higher than the historical stranding rates prior to 2011 (Great Barrier Reef Marine Park Authority 2014).

Coral
The overall reef-wide condition of inshore coral reefs remained poor in 2013-2014 (Figure 12). This reflects the general loss of coral cover from many inshore areas of the reef following repeated disturbances, as well as a low recovery potential of many reefs and a high level of macroalgae at some sites. However, although still rated as poor, the overall score for corals has continued to improve from a low point reached in 2011-2012, except in the Fitzroy region. This is due to improvements in the coral health indicators for coral cover, the rate of coral cover increase (change) and the density of juvenile corals in recent years.

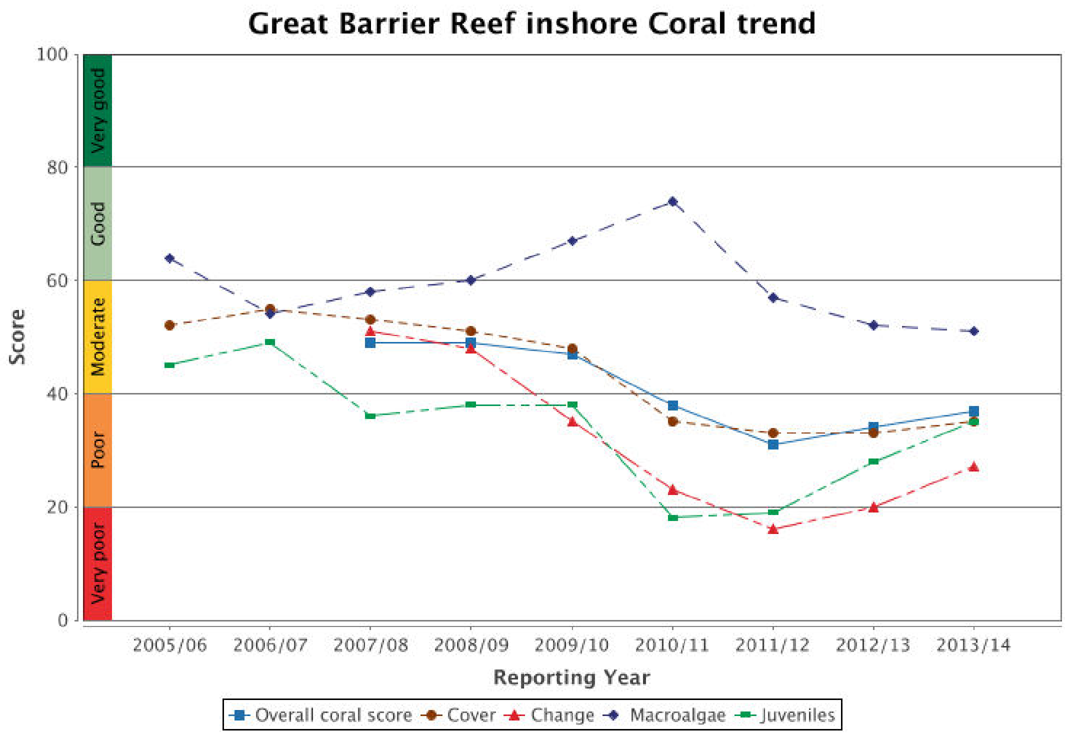


Figure 12: Trends in coral condition from the inshore Great Barrier Reef from 2007-2008 to 2013-2014. The overall coral score is also separated into component scores for cover, change, macroalgae and juveniles.

The overall decline in coral scores through to 2011-2012 reflects responses to a range of different regional pressures affecting coral communities. Generally, these pressures include both acute disturbances associated with tropical cyclones as well as the chronic influence of poor water quality, particularly following major flood events.

In several regions, a high incidence of coral disease followed high discharge from local rivers, demonstrates a link between runoff and ongoing stress to coral communities. Similarly, increased turbidity and sedimentation from repeated flood events are likely to have had a negative impact on coral recruitment by smothering and limiting the amount of light available to newly settled corals. Further, macroalgae, which competes with the coral for space, can rapidly occupy space made available by the removal of corals due to disturbances such as cyclones, especially when nutrient availability is high. These responses can result in lower rates of recovery, consistent with the low scores for the coral change indicator through to 2011-2012.

Recent increases in the density of juvenile corals and the rate of change in coral cover, along with a very slight increase in coral cover, indicate some recovery from the multiple impacts of recent years. While this recovery indicates a degree of resilience in coral communities, the continued increase in macroalgae in some regions is of concern.

While coral data collection began in 2005, the coral change indicator is calculated as the average rate of increase in coral cover compared to modelled predictions over the preceding three years, so the overall coral score and coral change trend graphs start in 2007-2008.

Cape York

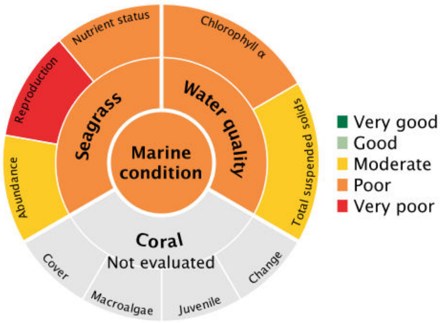


Figure 13: Overall marine condition adjacent to the Cape York region.

Overall marine condition in Cape York was poor in 2013-2014 (Figure 13). Inshore water quality was poor and inshore seagrass remained in poor condition. There is no coral monitoring in the inshore waters of the Cape York region under the Marine Monitoring Program. However, some sites monitored in the southern section by the Australian Institute of Marine Science indicated that coral communities in Cape York were in relatively good condition.

Water quality

There is no comprehensive, ongoing in situ water quality monitoring in the Cape York region. Estimates of chlorophyll *a* and total suspended solids are derived from remote sensing only (Figure 14), which requires further field validation and, therefore, the estimates have relatively low reliability compared to other regions. In 2012-2013, a first step was made towards addressing this issue with researchers completing an intensive field campaign in Princess Charlotte Bay. These field observations will be used to ground-truth the satellite's information for future report cards.

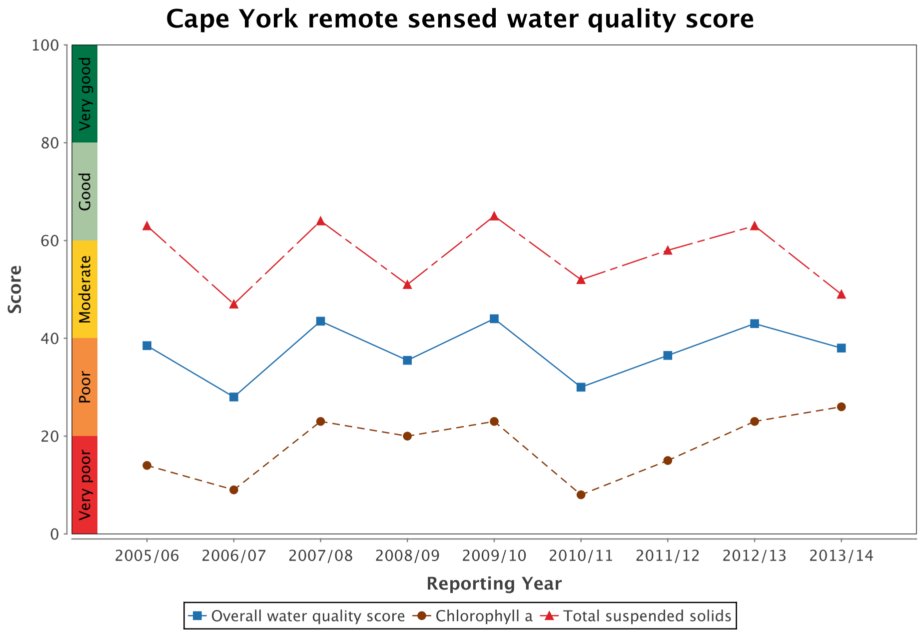


Figure 14: Trend in water quality from 2005-2014. The water quality score is also separated into component scores for concentrations of chlorophyll *a* and total suspended solids.

Inshore water quality in Cape York (assessed by remote sensing) was poor in 2013-2014 and has varied from poor to moderate since 2005-2006, with no clear correlation with freshwater discharge from local rivers. However, Cape York is influenced by discharge from southern rivers that carry nutrients and sediment northward. The two water quality indicators, chlorophyll *a* and total suspended solids, varied similarly over time and were poor and moderate, respectively.

Chlorophyll *a* exceeded the Great Barrier Reef Water Quality Guidelines for 79 per cent of the inshore area in the dry season. However, in the wet season, the Great Barrier Reef Water Quality Guidelines were exceeded for 71 per cent of the inshore area, mainly around river mouths and embayments. Total suspended solids exceeded the Great Barrier Reef Water Quality Guidelines for 33 and 44 per cent of the inshore area, in the dry and wet seasons, respectively.

No sampling in flood plumes or routine monitoring of pesticides occurred in 2013-2014 in the Cape York region.

The marine environment in the Cape York region is relatively pristine compared to other regions. However, increasing pressure for development and the associated impacts on water quality mean that Cape York is a high priority for intensifying monitoring efforts and validating remote sensing.

Seagrass

The condition of inshore seagrass in the Cape York region remained poor in 2013-2014 and has been highly variable since 2005-2006 (Figure 15). This is due to the complex and highly variable environment and the impact of significant rain events and cyclones on seagrass abundance and reproductive effort. In previous report cards, the assessment was based on only one sampling location, Archer Point. However, additional monitoring locations were established in the Cape York region in 2012 at Stanley Island, Farmer Island, Bathurst Head and Shelbourne Bay (Figure 16) and these results included in Report Card 2014.

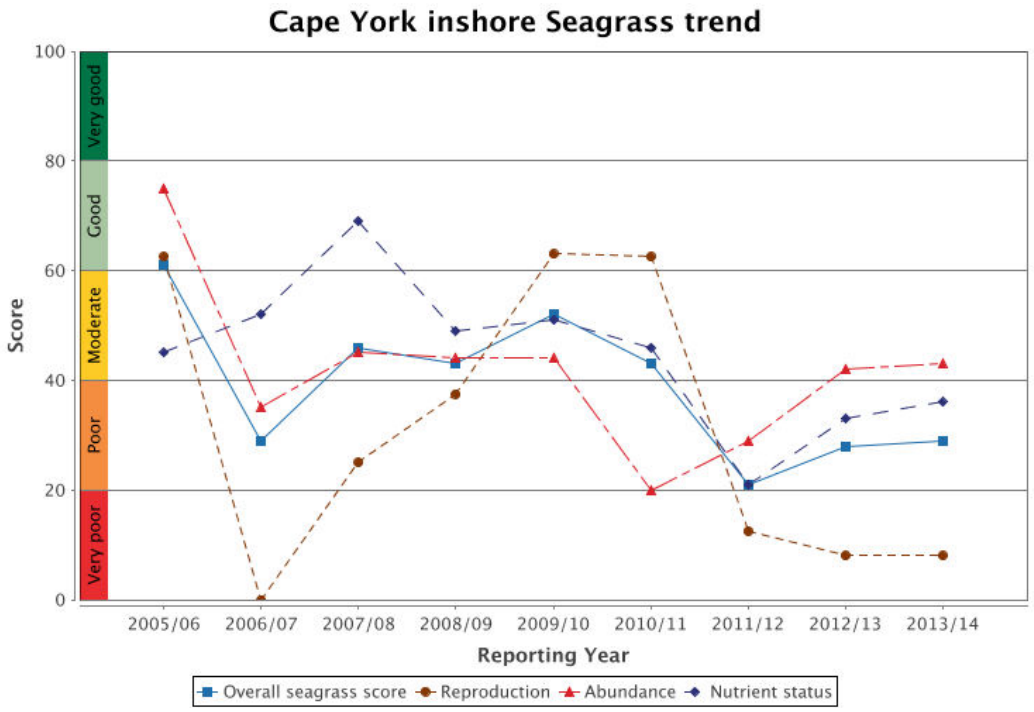
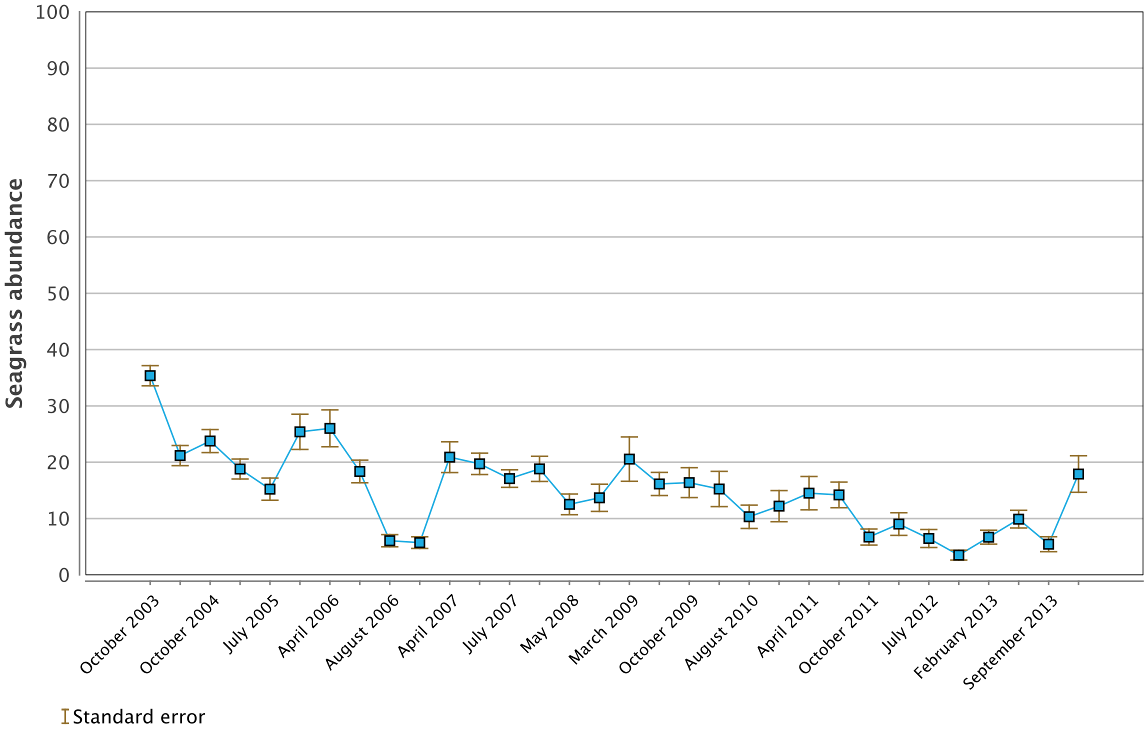


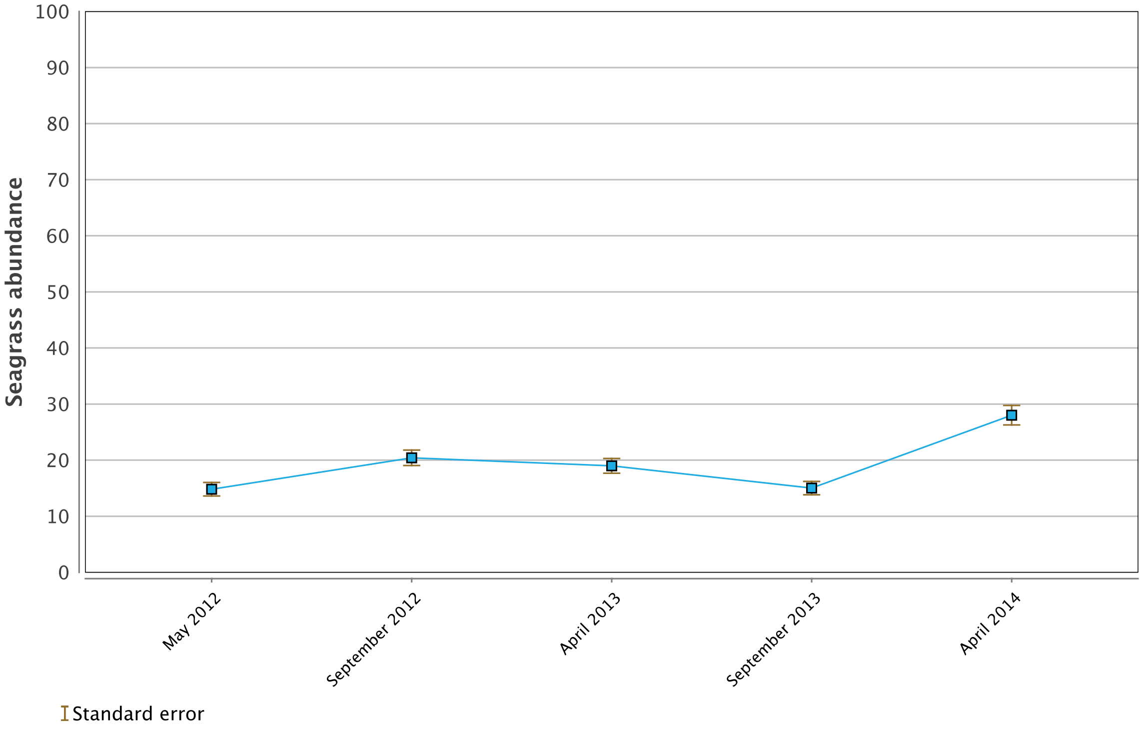
Figure 15: Trend in seagrass condition in the Cape York region from 2005-2006 to 2013-2014. The overall seagrass score is also separated into component scores for reproduction, abundance and nutrient status.

Dominant influences on seagrass communities in the Cape York region include disturbance from waves/swell and associated sediment movement on reef communities, while temperature extremes and runoff also influence coastal communities. Seagrass abundance was moderate overall in 2013-2014. It is difficult to compare the 2013-2014 scores with previous years because of the additional sites. However, at the long-term intertidal reef habitat (Archer Point) there have been modest increases in abundance since Tropical Cyclone Yasi in 2010-2011. Reproductive effort remained very poor in 2013-2014, indicating communities may have a low capability to recover from future environmental disturbances. Nutrient ratios of seagrass tissue were again poor in 2013-2014, which may reflect local water quality conditions relative to the amount of light available for growth.

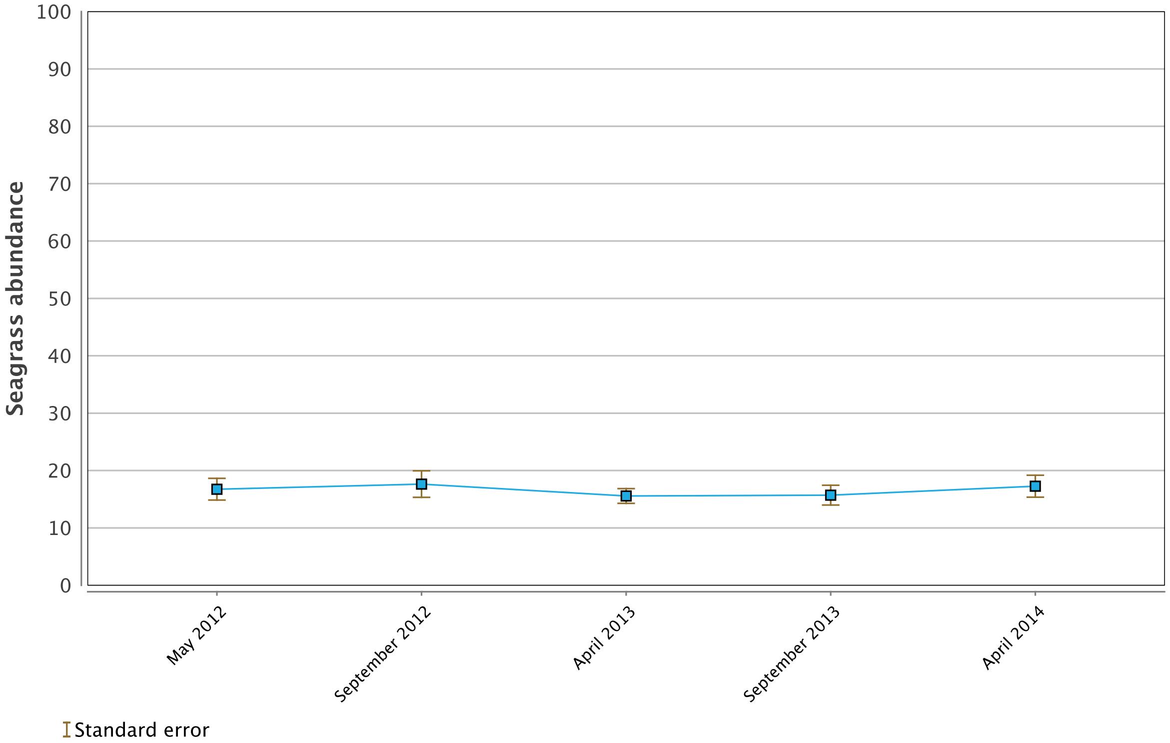
Seagrass abundance at inshore intertidal reef habitat at Archer Point in the Cape York region



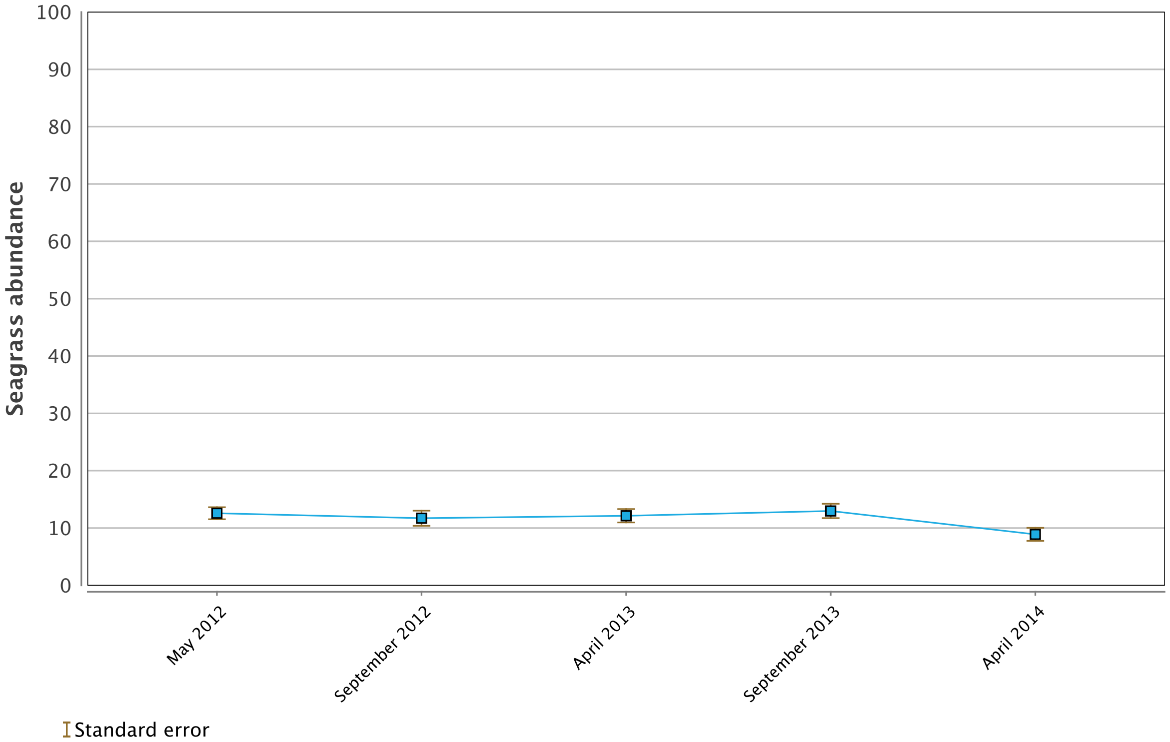
Seagrass abundance at inshore intertidal coastal habitat at Bathurst Head in the Cape York region



Seagrass abundance at inshore intertidal reef habitat at Farmer Island in the Cape York region



Seagrass abundance at inshore intertidal coastal habitat at Shelbourne Bay in the Cape York region



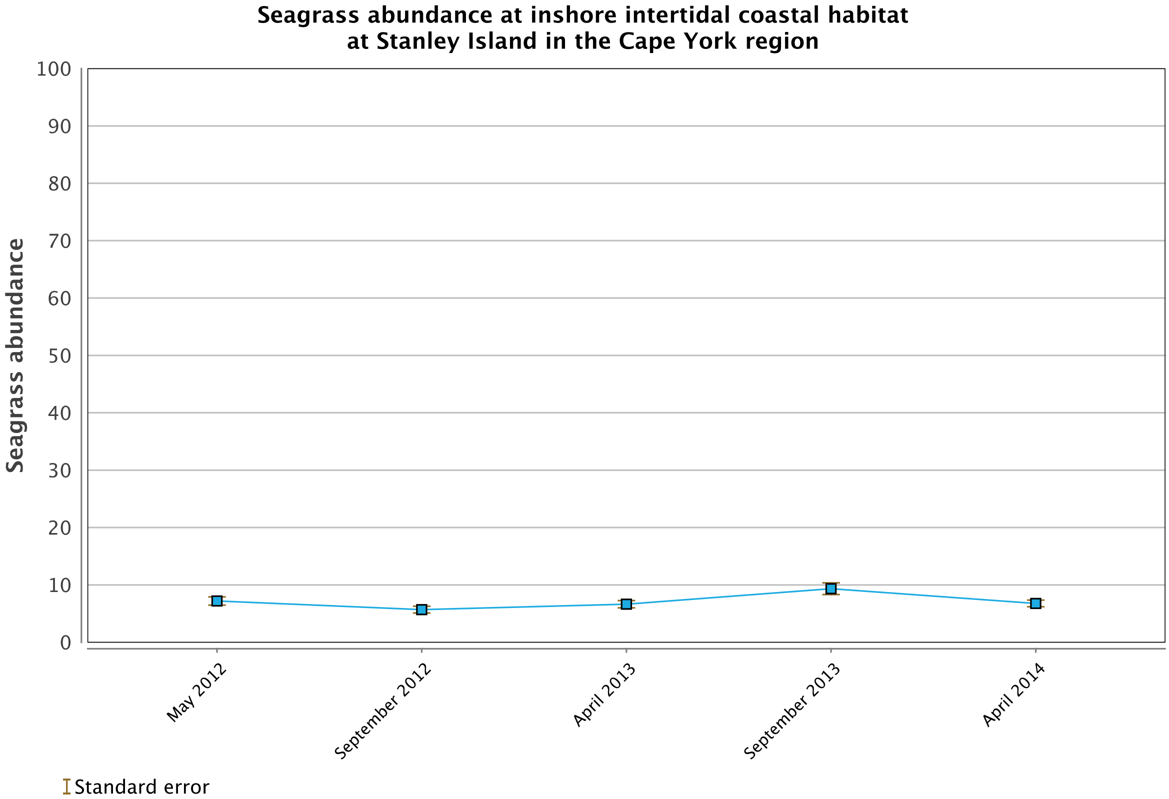


Figure 16: Seagrass abundance at Archer Point, Bathurst Head, Farmer Island, Shelbourne Bay and Stanley Island.

Coral

No coral monitoring occurs in the inshore waters of the Cape York region under the Marine Monitoring Program. In 2012, the Australian Institute of Marine Science published a report that indicated mid-shelf and offshore coral communities in Cape York were healthy, having recovered to early 1980s condition following impacts of cyclones, crown-of-thorns starfish and bleaching over the intervening years. This was the only region in the reef where an increase in coral cover was observed (De'ath et al., 2012).

Wet Tropics

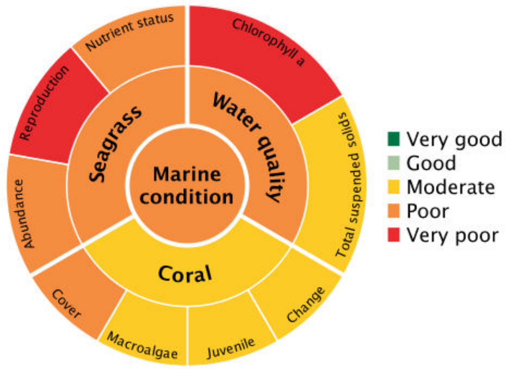


Figure 17: Overall marine condition adjacent to Wet Tropics region.

Overall marine condition in the Wet Tropics remained poor in 2013-2014 (Figure 17). Inshore water quality was poor. Biologically relevant concentrations of PSII herbicides were detected in flood waters from the Russell-Mulgrave, Tully and Herbert rivers. Inshore seagrass was in poor condition, whereas coral reefs improved from poor to moderate condition. Improvements in coral condition were mainly due to increases in coral change and the number of juvenile corals.

Water quality

Inshore water quality (assessed by remote sensing of chlorophyll *a* and total suspended solids) was poor in 2013-2014 (Figure 18). Scores for chlorophyll *a* were consistently worse than those for total suspended solids in all monitoring years.

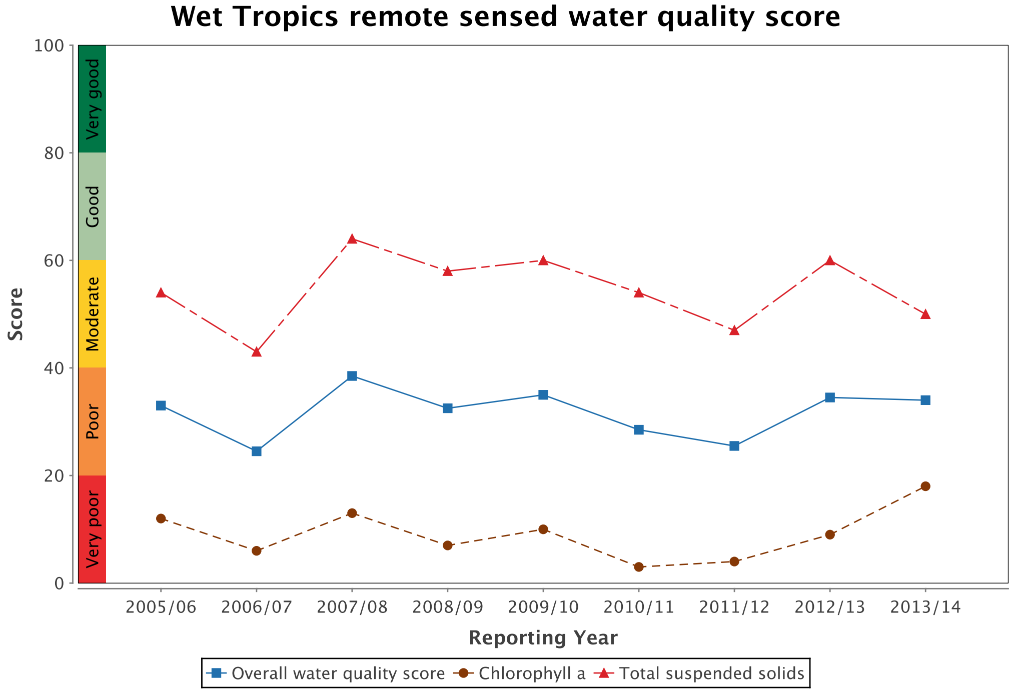


Figure 18: Trend in water quality from 2005-2014. The water quality score is also separated into component scores for concentrations of chlorophyll *a* and total suspended solids.

Chlorophyll *a* was very poor in 2013-2014. Concentrations exceeded the Great Barrier Reef Water Quality Guidelines for 85 and 83 per cent of the inshore area in the dry and wet seasons, respectively, in 2013-2014. Total suspended solids were moderate in 2013-2014; however, concentrations exceeded the guidelines for 37 and 41 per cent of the inshore area in the dry and wet seasons, respectively. Note that the time-series for water quality has been recalculated and trend graphs in previous reports are not comparable.

Water quality across the region showed a clear gradient of improvement from inshore to offshore waters, as the inshore area is more frequently exposed to flood waters. This gradient was supported by long-term assessments of water quality at specific sites, with variability between sites reflecting local hydrodynamic conditions and biological processes. Site specific water quality data is not included in the water quality scores because a method needs to be developed to integrate the different datasets. While the overall trends are consistent between the two methods, the scores are not directly comparable.

Site-specific water quality was good or very good at eight of 11 sites in the region, three of which are located in the mid-shelf water body (Figure 19). However, water quality at the three sites closest to river mouths draining from highly developed catchments was moderate or poor. Concentrations of chlorophyll *a* exceeded the Great Barrier Reef Water Quality Guidelines while particulate phosphorus and total suspended solids approached the guidelines in 2013-2014. These site-specific water quality scores are calculated using a long-term integrated assessment of four indicators of water quality relative to the Great Barrier Reef Water Quality Guidelines (GBRMPA 2010).

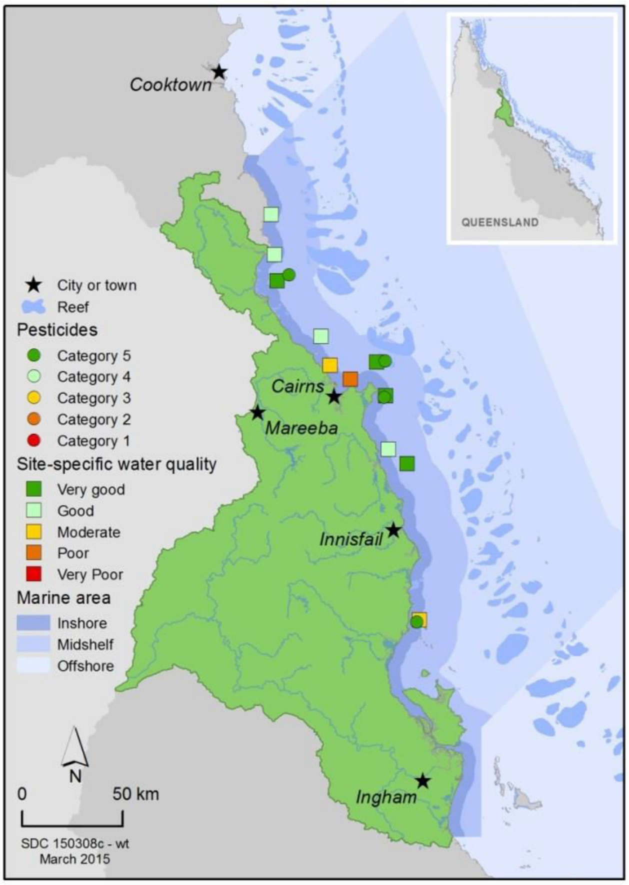


Figure 19: Scores for site-specific water quality and pesticides at fixed monitoring sites in the Wet Tropics region.

Concentrations of photosystem II (PSII) herbicides were below those known to have any effects on plants or animals based on toxicity or a reduction in photosynthesis (Category 5) at all sites in the Wet Tropics including Low Isles, Green Island, Fitzroy Island and Dunk Island. However, two grab samples from the Tully and Russell Mulgrave River mouths had concentrations of diuron and metolachlor that exceeded the Interim Working Levels of the Australian and New Zealand Environment Conservation Council Guidelines and Agriculture and Resource Management Council of Australia and New Zealand Guidelines, with concentrations ranging from Category 2 to Category 4.

The most frequently detected PSII herbicides in the Wet Tropics region were diuron, atrazine and hexazinone. There was a range of other herbicides and insecticides detected in 2013-2014 including ametryn, the breakdown products of atrazine, simazine, tebuthiuron, metolachlor, imidacloprid, galaxolide and tonalid. In 2013-2014, concentrations of PSII herbicides during the wet season were either equivalent to or less than concentrations detected in 2012-2013.

Seagrass

The overall condition of inshore seagrass in the Wet Tropics region remained poor in 2013-2014 and has generally been poor since 2005-2006 (Figure 20). This is due to complex interactions between the three indicators of seagrass condition (abundance, reproductive effort and nutrient status) which are highly variable between years and habitats. In previous report cards, the scores for seagrass condition were based only on intertidal seagrass sites. However, from 2008 onwards, additional data became available for subtidal seagrass communities at Low Isles, Green Island and Dunk Island (Figure 21) and these results are included in Report Card 2014.

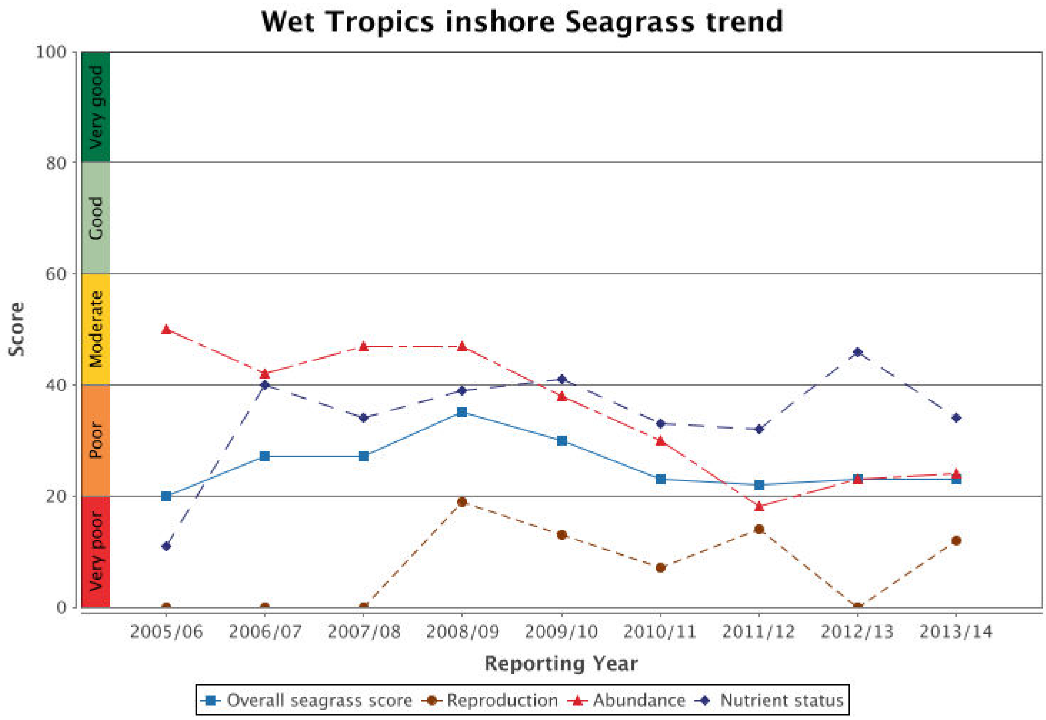
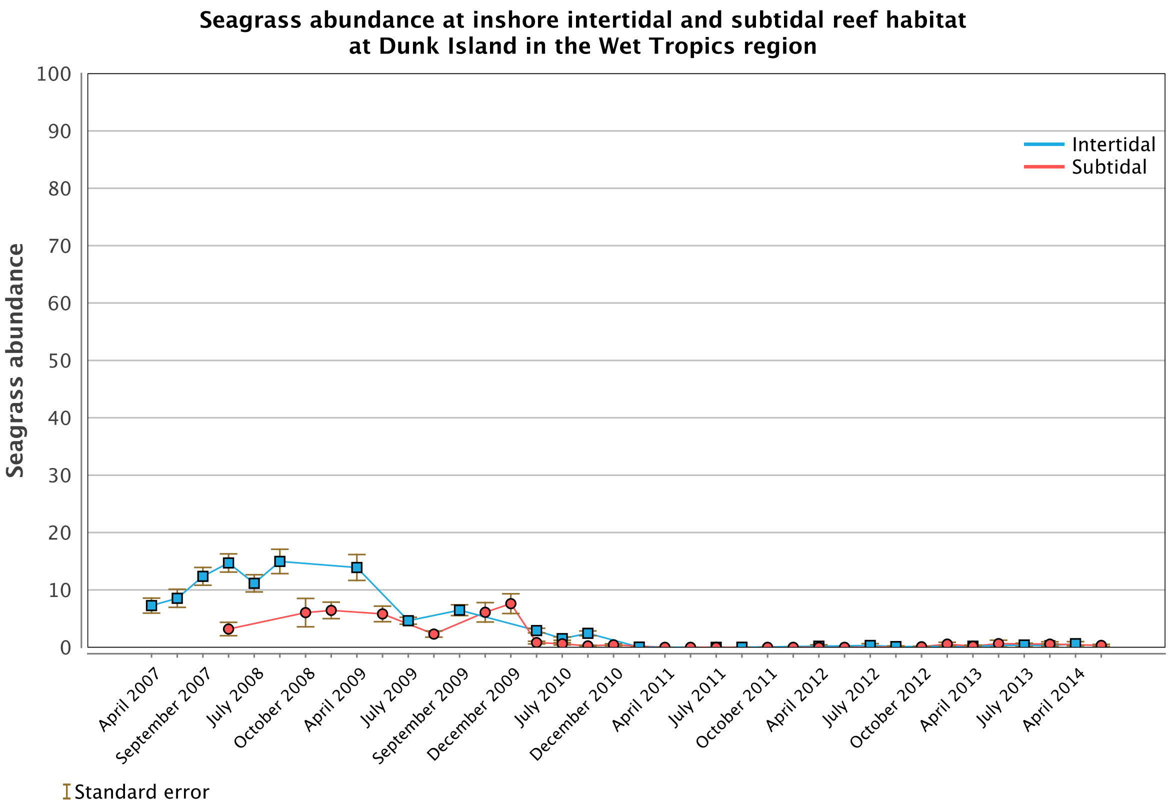
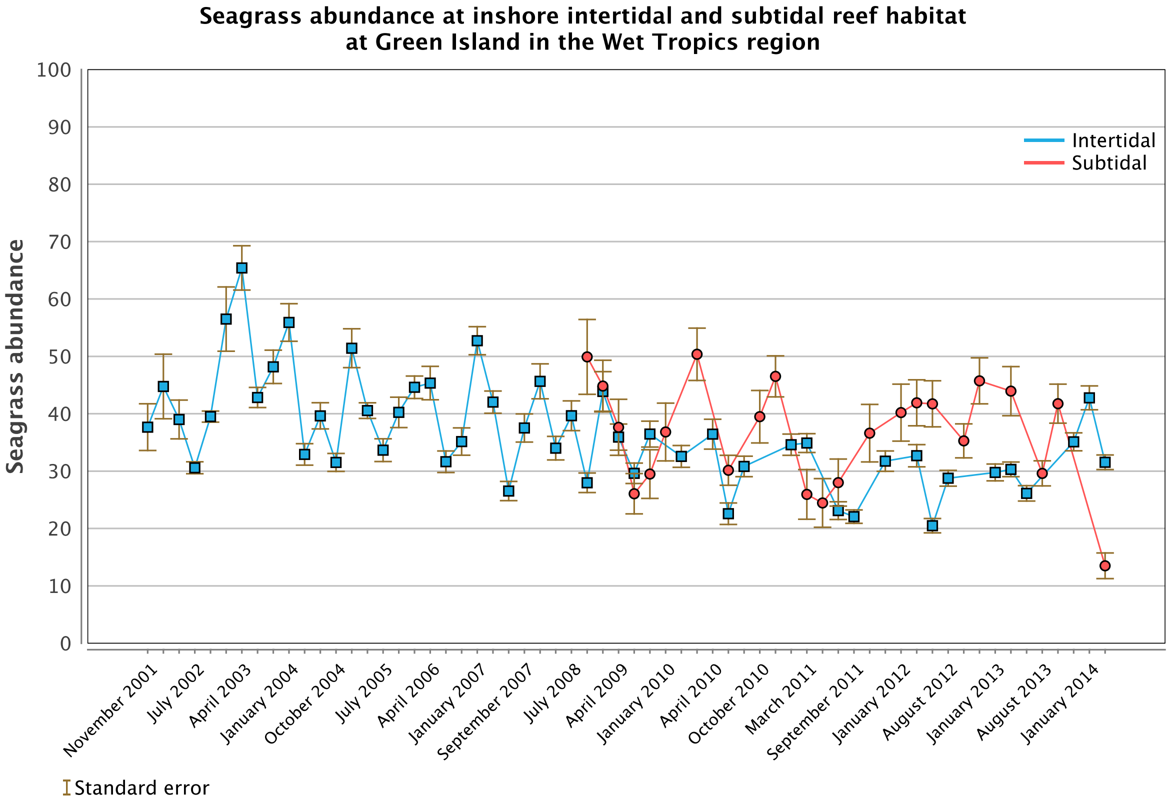


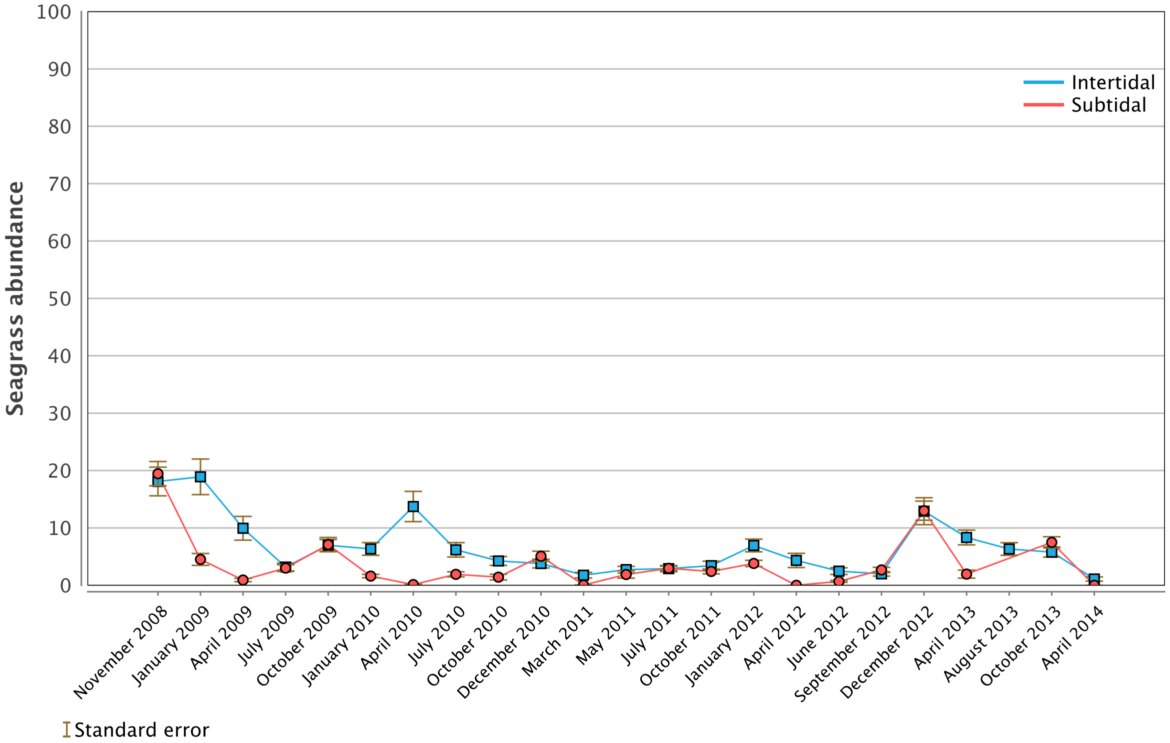
Figure 20: Trend in seagrass condition in the Wet Tropics region from 2005-2006 to 2013-2014. The overall seagrass score is also separated into component scores for reproduction, abundance and nutrient status.

Dominant influences on seagrass communities in the Wet Tropics region include elevated temperatures, seasonal run-off and disturbances from wave action and associated sediment movement. The abundance of inshore seagrass in both coastal and reef habitats in the Wet Tropics remained poor overall. Reproductive effort across the region increased marginally, but remained very poor in 2013-2014. The low levels of abundance coupled with very low reproductive effort indicate meadows are at risk of degradation from further impacts and will take many years to fully recover even if conditions were optimal. Leaf tissue nutrient ratios were poor overall and may provide an integrated assessment of the quality of the surrounding waters relative to the amount of light available for growth. Supporting evidence (e.g. cover of epiphytes and isotopic signatures) suggests that levels of anthropogenically derived nitrogen are present in inshore areas of the region.

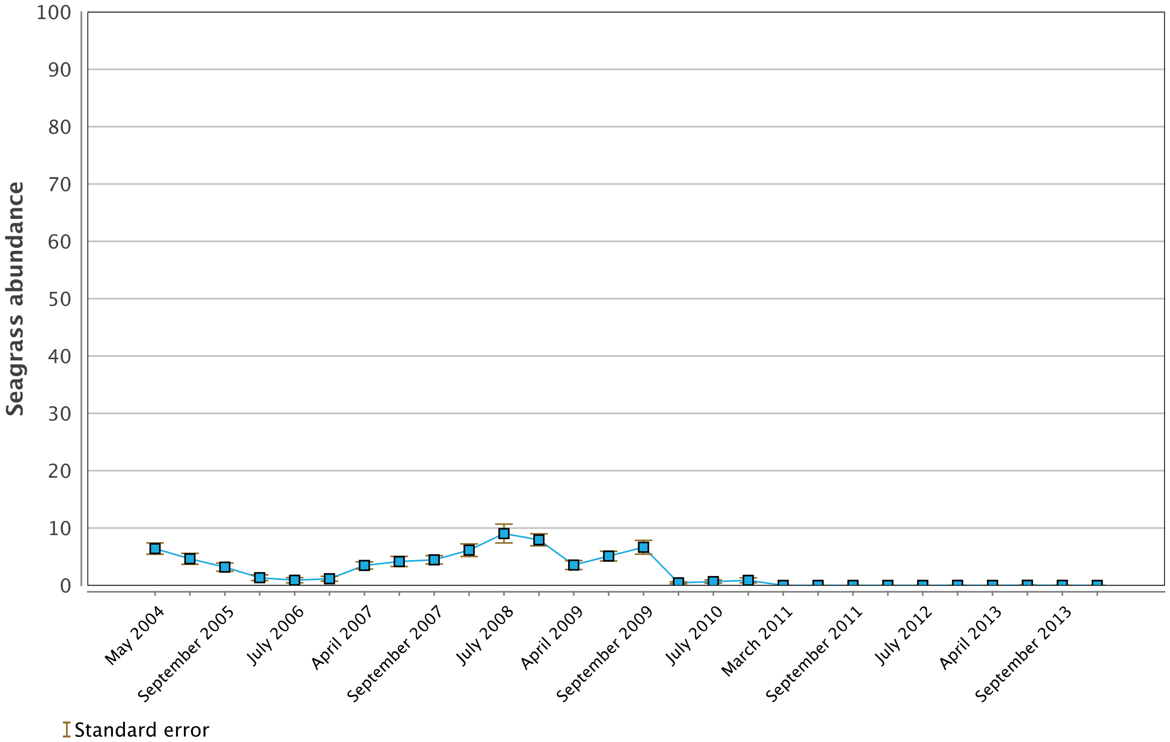

Seagrass abundance at inshore intertidal and subtidal reef habitat
at Dunk Island in the Wet Tropics region
Seagrass abundance
100
90
80
70
60
50
40
30
20
10
0
Intertidal
Subtidal
April 2007
September 2007
July 2008
October 2008
April 2009
July 2009
September 2009
December 2009
July 2010
December 2010
April 2011
July 2011
October 2011
April 2012
July 2012
October 2012
April 2013
July 2013
April 2014
Standard error


Seagrass abundance at inshore intertidal and subtidal reef habitat
at Green Island in the Wet Tropics region
Seagrass abundance
100
90
80
70
60
50
40
30
20
10
0
Intertidal
Subtidal
November 2001
July 2002
April 2003
January 2004
October 2004
July 2005
April 2006
January 2007
September 2007
July 2008
April 2009
January 2010
April 2010
October 2010
March 2011
September 2011
January 2012
August 2012
January 2013
August 2013
January 2014
Standard error

Seagrass abundance at inshore intertidal and subtidal reef habitat at Low Island in the Wet Tropics region



Seagrass abundance at inshore intertidal coastal habitat at Lugger Bay in the Wet Tropics region



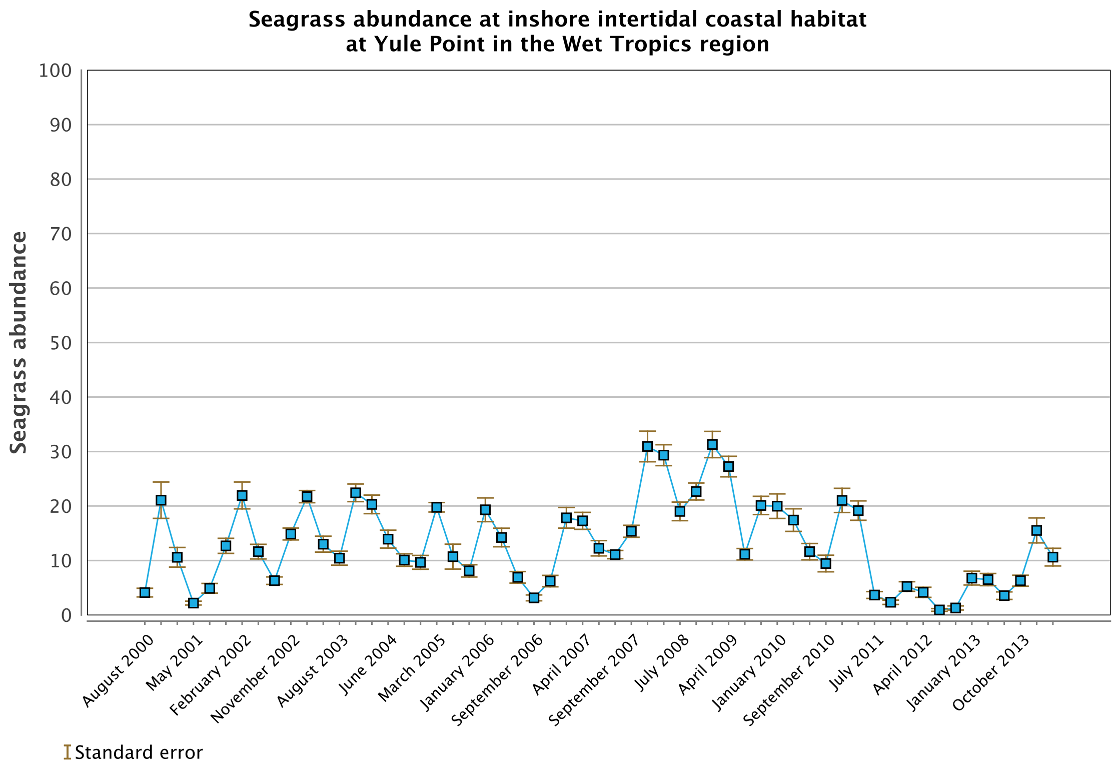


Figure 21: Seagrass abundance at Dunk Island, Green Island, Low Island, Lugger Bay and Yule Point.

Coral

The overall condition of inshore coral reefs in the Wet Tropics improved from poor in 2012-2013 to moderate in 2013-2014 (Figure 22). In the Barron Daintree sub-region of the northern Wet Tropics, coral reef communities were in poor condition as a result of the recent impacts of Tropical Cyclone Ita. Coral communities in the Johnstone Russell-Mulgrave area remained in moderate condition, while those in the more southerly Herbert Tully area improved from poor to moderate in 2012-2013.

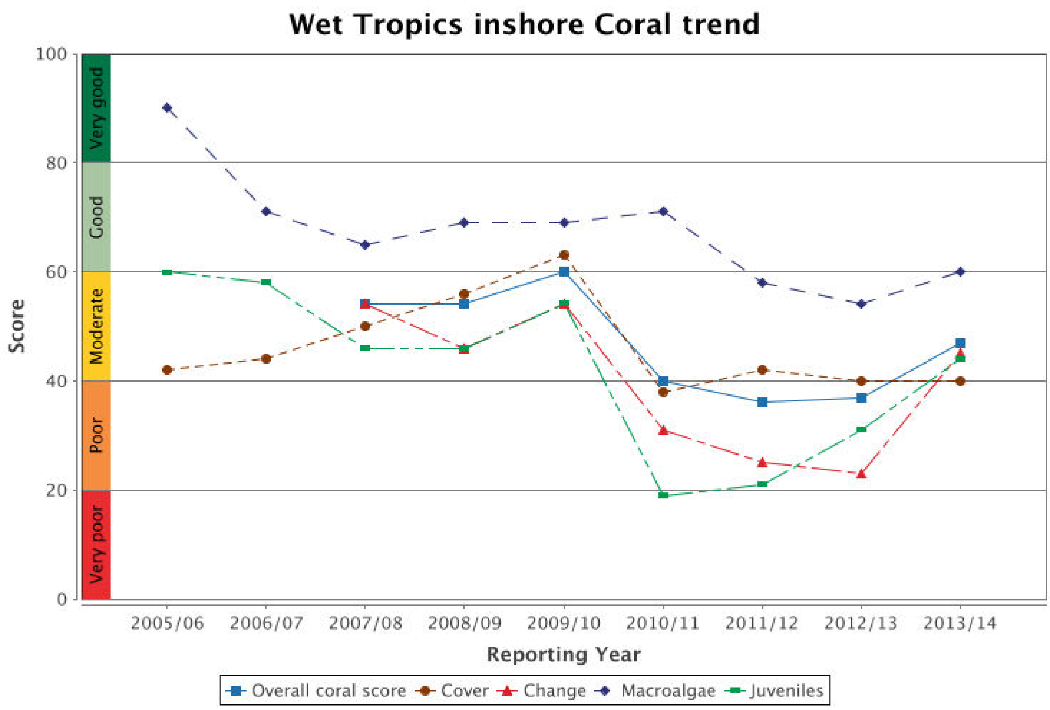
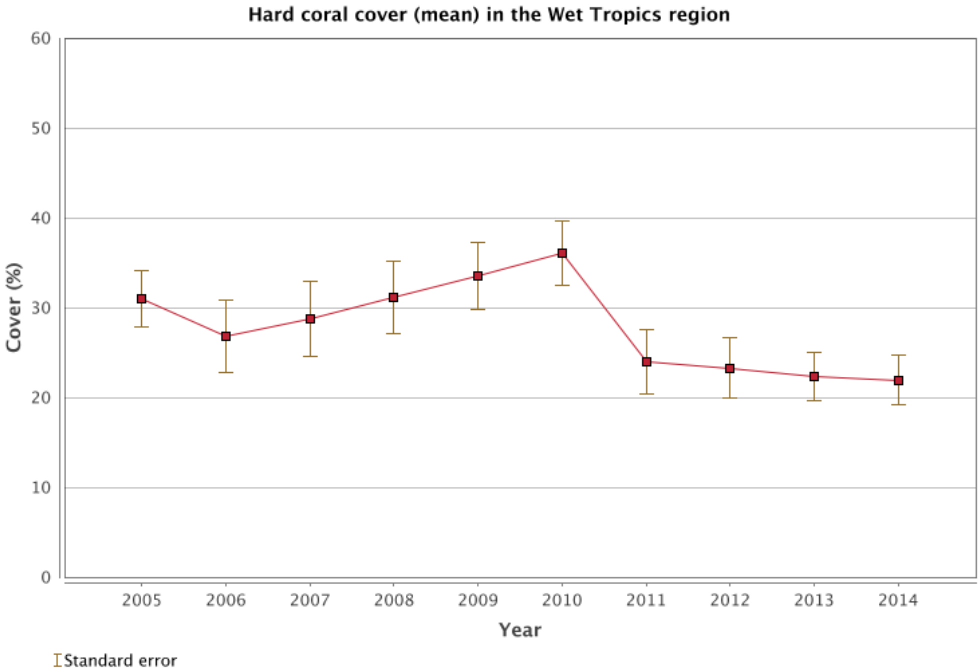


Figure 22: Trends in coral condition in the Wet Tropics region from 2007-2008 to 2013-2014. The overall coral score is also separated into component scores for cover, change, macroalgae and juveniles.

Since 2000, the Wet Tropics region has been repeatedly affected by high freshwater flows, high levels of coral disease, outbreaks of crown-of-thorns starfish, coral bleaching, and strong wind and wave action from severe storms and cyclones. Coral cover remained in poor condition overall in 2013-2014. Indicators for the rate of increase in coral cover (change), juvenile density and macroalgae cover all improved from poor in 2012-2013 to moderate in 2013-2014 (Figure 23). These results indicate coral communities in the Wet Tropics region have the potential to recover further if milder weather conditions persist.



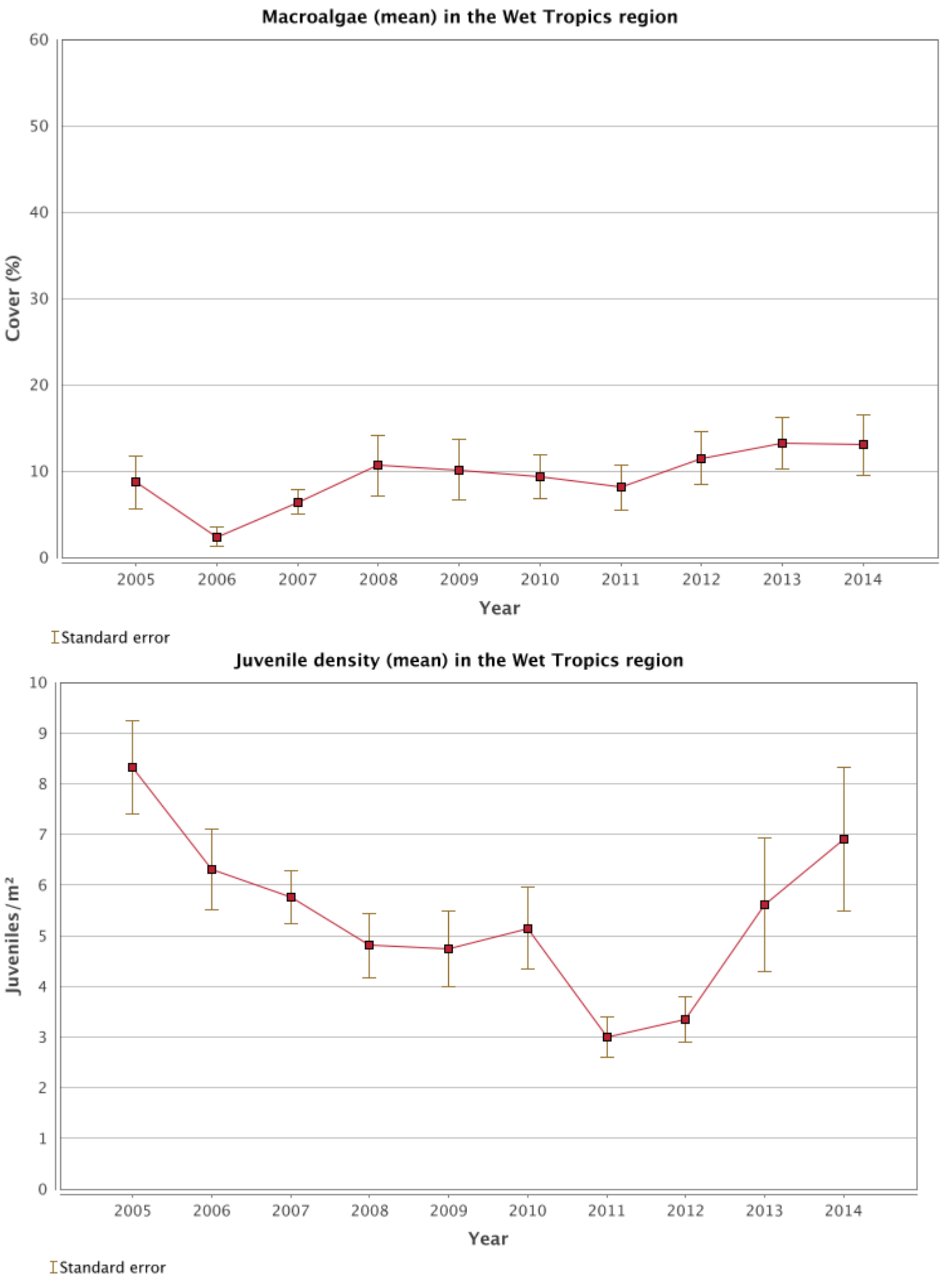


Figure 23: Average cover of hard corals, cover of macroalgae and density of hard coral juveniles in the Wet Tropics region from 2005 to 2014.

Burdekin

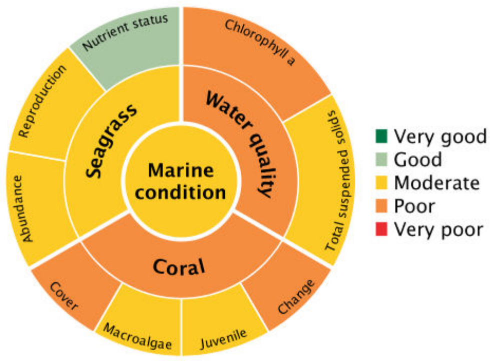


Figure 24: The overall marine condition adjacent to Burdekin region.

Overall marine condition in the Burdekin improved from poor to moderate in 2013-2014 (Figure 24). However, inshore water quality was poor. Inshore seagrass improved from poor to moderate, while coral reefs remained in poor condition with early signs of recovery. Improvements in seagrass and coral condition were a result of improvements in all ecosystem health indicators.

Water quality

Inshore water quality (assessed by remote sensing of chlorophyll *a* and total suspended solids) was poor in 2013-2014. Chlorophyll *a* and total suspended solids were poor and moderate, respectively (Figure 25).

Concentrations of chlorophyll *a* exceeded the Great Barrier Reef Water Quality Guidelines for 87 and 67 per cent of the inshore area in the dry and wet seasons, respectively, in 2013-2014. Concentrations of total suspended solids exceeded the guidelines for 43 and 47 per cent of the inshore area in the dry and wet seasons, respectively, in 2013-2014. Note that the time-series for water quality has been recalculated and trend graphs in previous reports are not comparable.

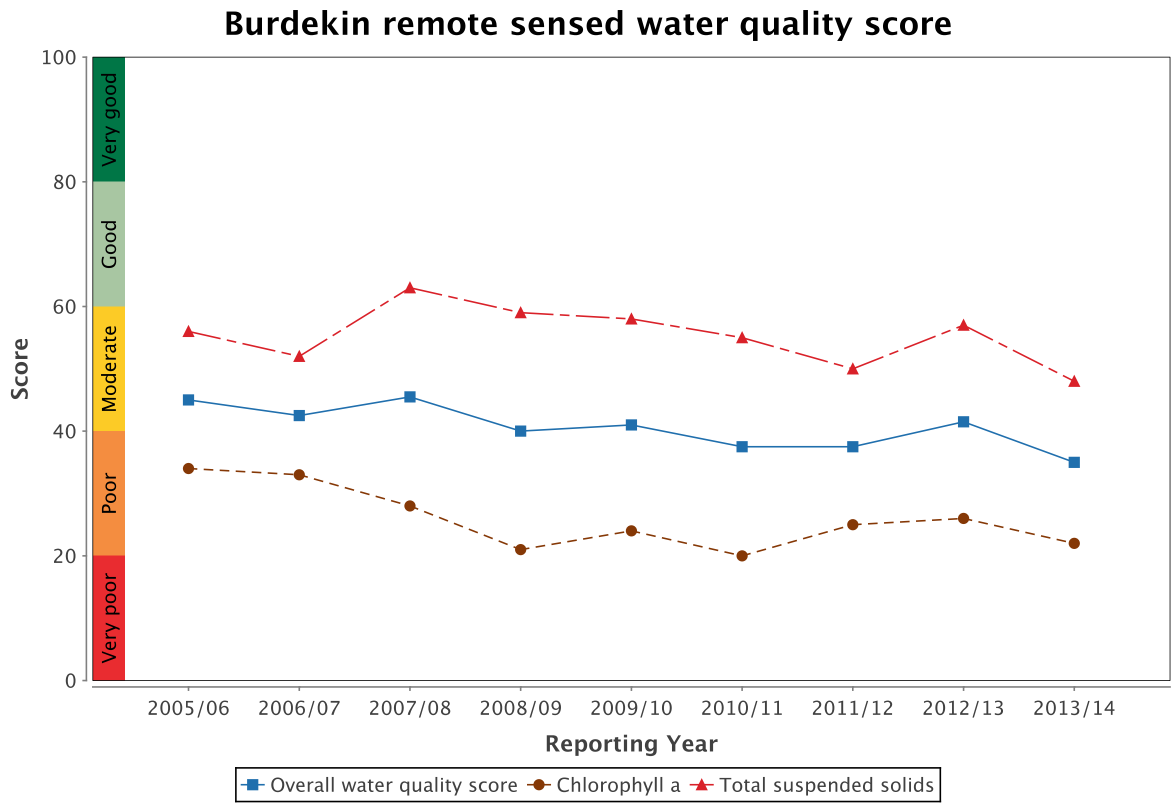


Figure 25: Trend in the water quality from 2005-2014. The overall water quality score is also separated into component scores for concentrations of chlorophyll *a* and total suspended solids.

Water quality across the region showed a clear gradient of improvement from inshore areas more frequently exposed to flood waters to offshore areas. This gradient was supported by long-term assessments of water quality at specific sites, with variability between sites reflecting local hydrodynamic conditions and biological processes. Site specific water quality data is not included in the water quality scores because a method needs to be developed to integrate the different datasets. While the overall trends are consistent between the two methods, the scores are not directly comparable.

Site-specific water quality was good and very good at the two mid-shelf sites and moderate at Magnetic Island in the inshore region (Figure 26). The water quality scores for this region have been stable over the past four years. However, there have been slight increases in concentrations of chlorophyll *a,* total suspended solids, particulate nitrogen and particulate phosphorus since 2011-2012. The site-specific water quality scores are a long-term integrated assessment of four water quality indicators relative to the Great Barrier Reef Water Quality Guidelines (GBRMPA 2010).

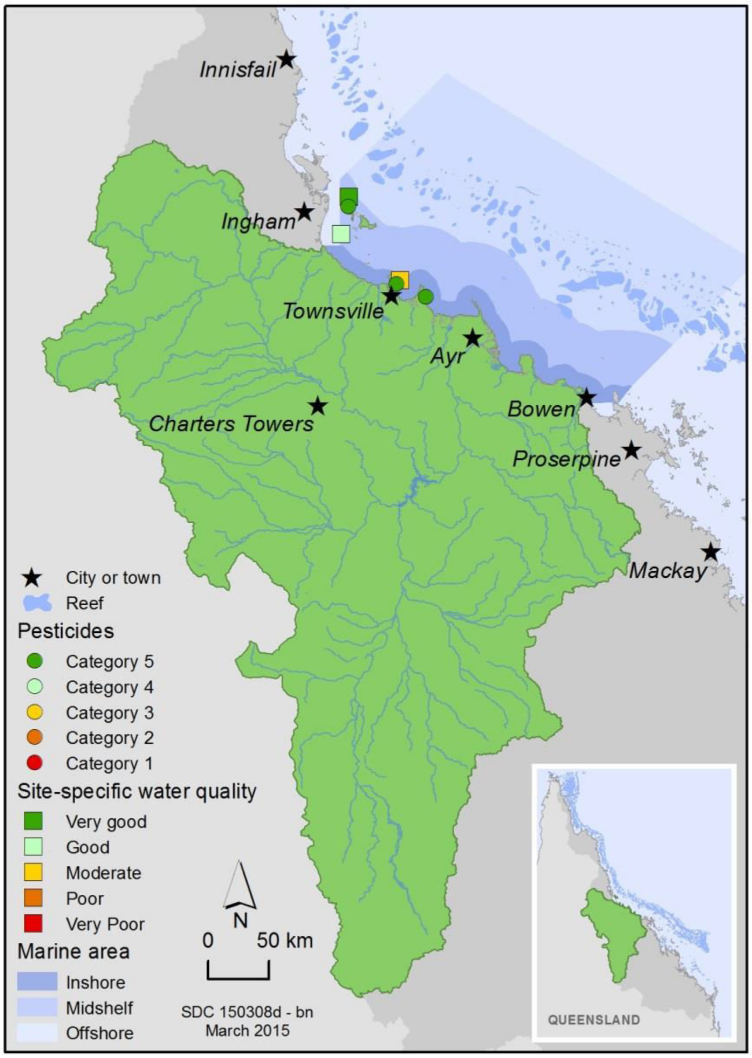


Figure 26: Scores for site-specific water quality and pesticides at fixed monitoring sites in the Burdekin region.

In 2013-2014, concentrations of photosystem II (PSII) herbicides at Orpheus Island, Magnetic Island and Cape Cleveland improved from Category 4 to Category 5 at all sites when compared to concentrations in 2012-2013.

The most frequently detected pesticides in the Burdekin region were atrazine and its breakdown products and diuron. The highest PSII herbicide concentrations were detected in grab samples from the Herbert River transect. A range of other pesticides were detected in the Burdekin region including hexazinone, ametryn, prometryn, simazine, tebuthiuron, bromacil, terbutyrn, metolachlor, imazapic, imidacloprid, galaxolide, tonalid and diazinon.

Seagrass
The overall condition of inshore seagrass in the Burdekin region improved from poor in 2012-2013 to moderate in 2013-2014 (Figure 27). The improvement in condition was a result of increases in abundance, reproductive effect and nutrient status. In previous report cards, the scores for seagrass condition were based only on intertidal seagrass sites. However, additional data became available for a subtidal seagrass site at Magnetic Island and an intertidal seagrass site in Jerona within Bowling Green Bay from 2008 and 2012 onwards, respectively (Figure 28) and these results included in Report Card 2014.

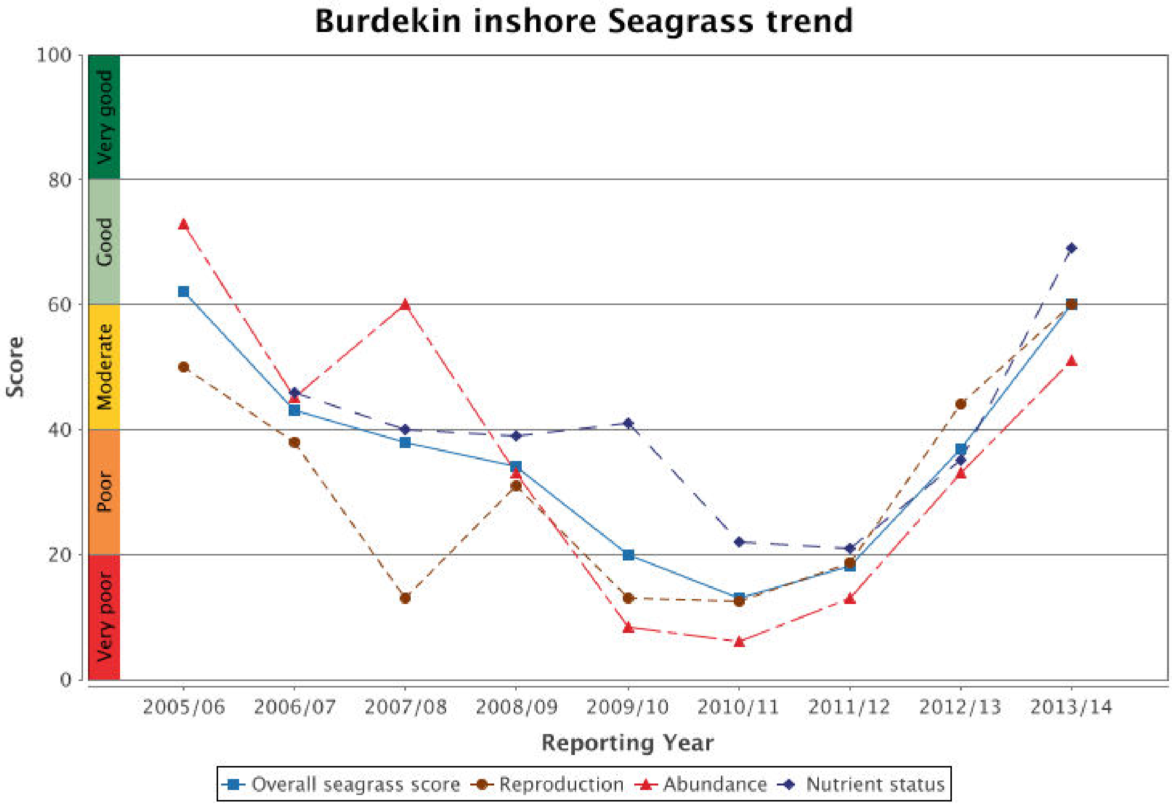
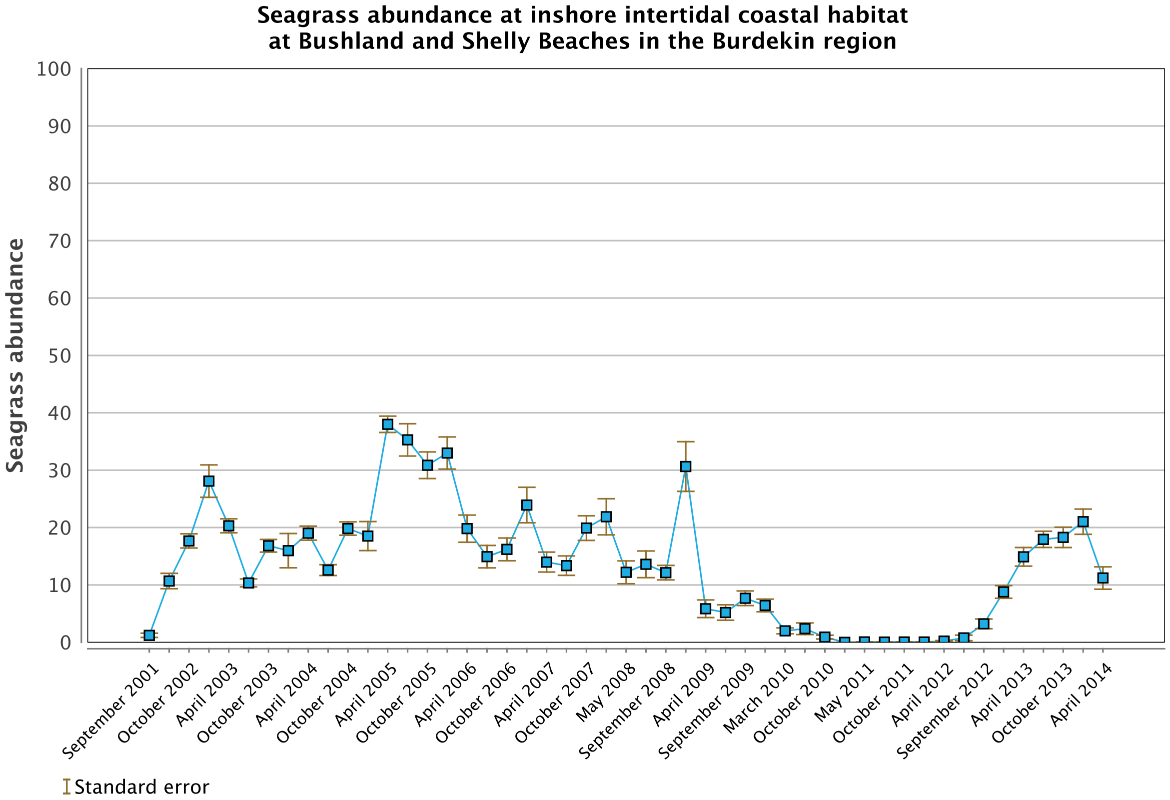
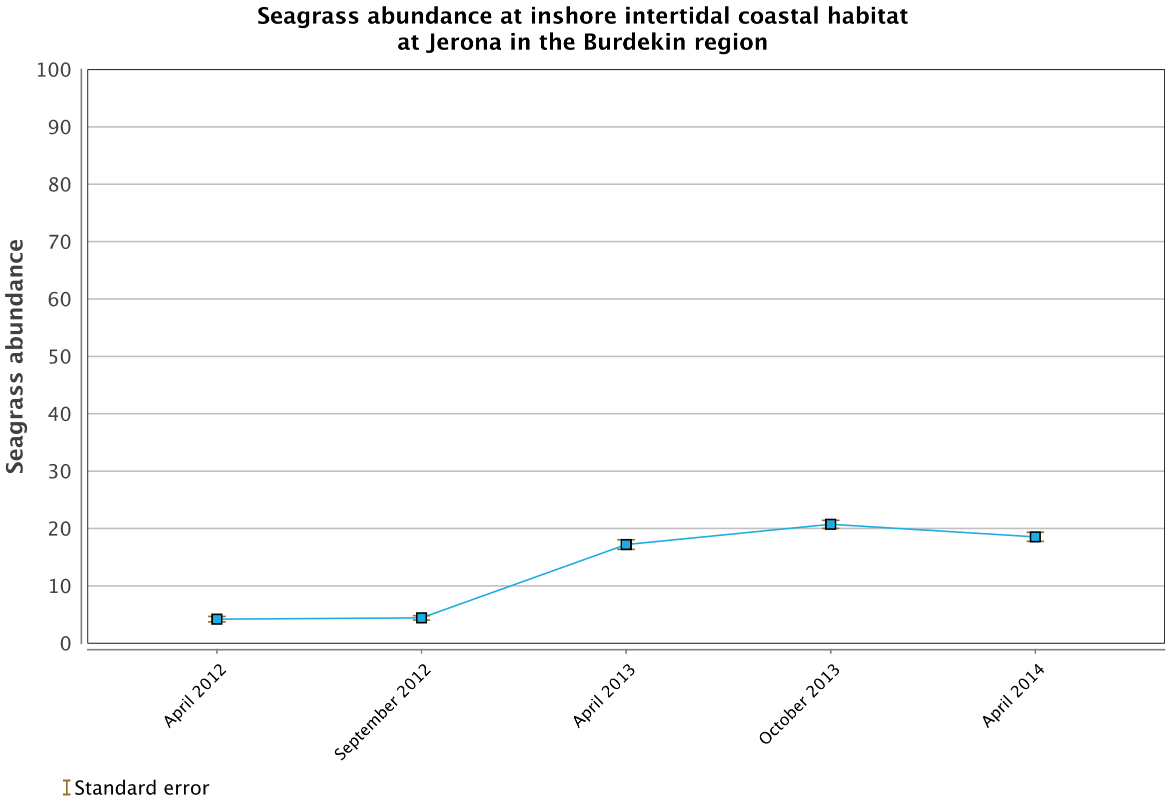


Figure 27: Trend in seagrass condition in the Burdekin region from 2005-2006 to 2013-2014. The overall seagrass score is also separated into component scores for reproduction, abundance and nutrient status.

Seagrass monitoring was conducted in coastal and reef habitats primarily influenced by wind-driven turbidity and the pulsed delivery of nutrients and sediment. Seagrass abundance across the region improved from poor in 2012-2013 to moderate in 2013-2014 and is at its highest levels since 2007-2008. Reproductive effort also improved, but remained moderate in 2013-2014, suggesting the capacity of seagrass to recover from future disturbances may be improving across the region. The nutrient status of seagrass tissue improved markedly in 2013-2014 from poor to good. However, although nutrient status has improved, supporting evidence (e.g., cover of epiphytes and isotopic signatures) suggests there are levels of anthropogenically derived nitrogen in inshore areas of the region.


Seagrass abundance at inshore intertidal coastal habitat at Bushland and Shelly Beaches in the Burdekin region
Seagrass abundance
100
90
80
70
60
50
40
30
20
10
0
September 2001
October 2002
April 2003
October 2003
April 2004
October 2004
April 2005
October 2005
April 2006
October 2006
April 2007
October 2007
May 2008
September 2008
April 2009
September 2009
March 2010
October 2010
May 2011
October 2011
April 2012
September 2012
April 2013
October 2013
April 2014
Standard error


Seagrass abundance at inshore intertidal coastal habitat at Jerona in the Burdekin region
Seagrass abundance
100
90
80
70
60
50
40
30
20
10
0
April 2012
September 2012
April 2013
October 2013
April 2014
Standard error

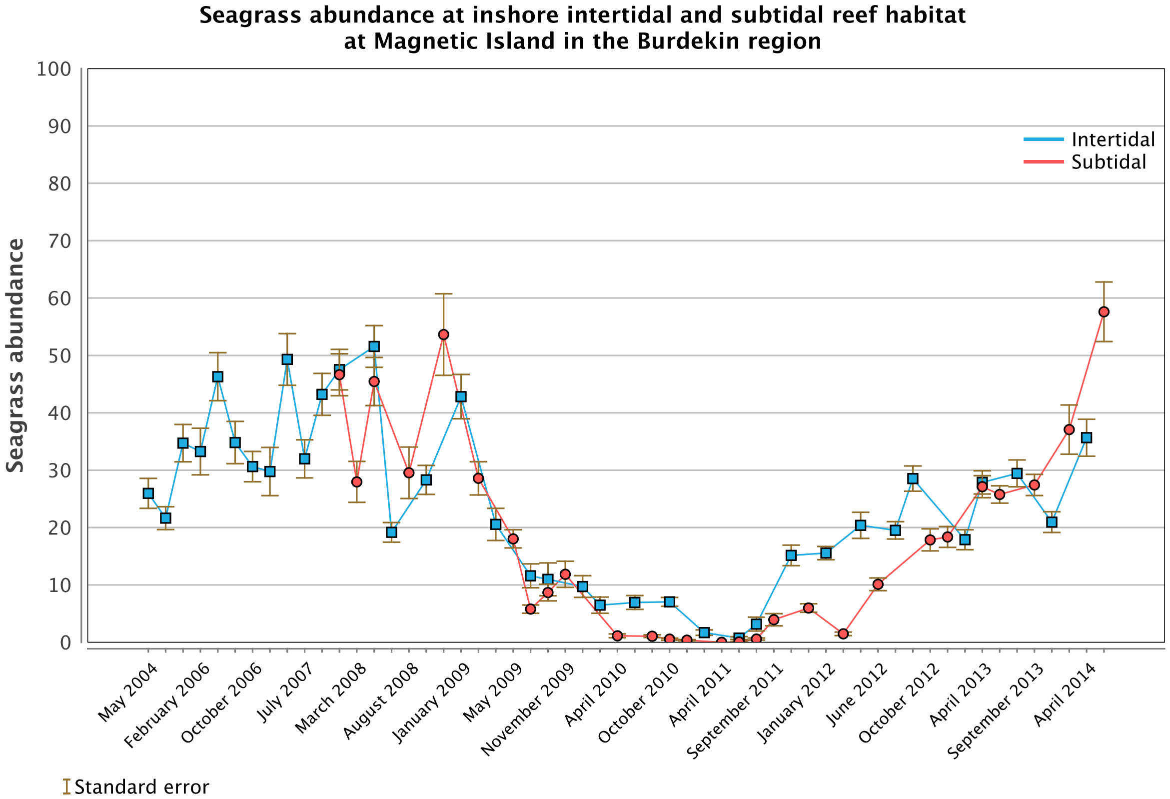


Figure 28: Seagrass abundance at Bushland and Shelly Beaches, Jerona and Magnetic Island.

Coral

The overall condition of inshore coral reefs in the Burdekin region improved slightly in 2013-2014 to levels comparable to 2010-2011 before Tropical Cyclone Yasi. However, they remained in poor condition (Figure 29).

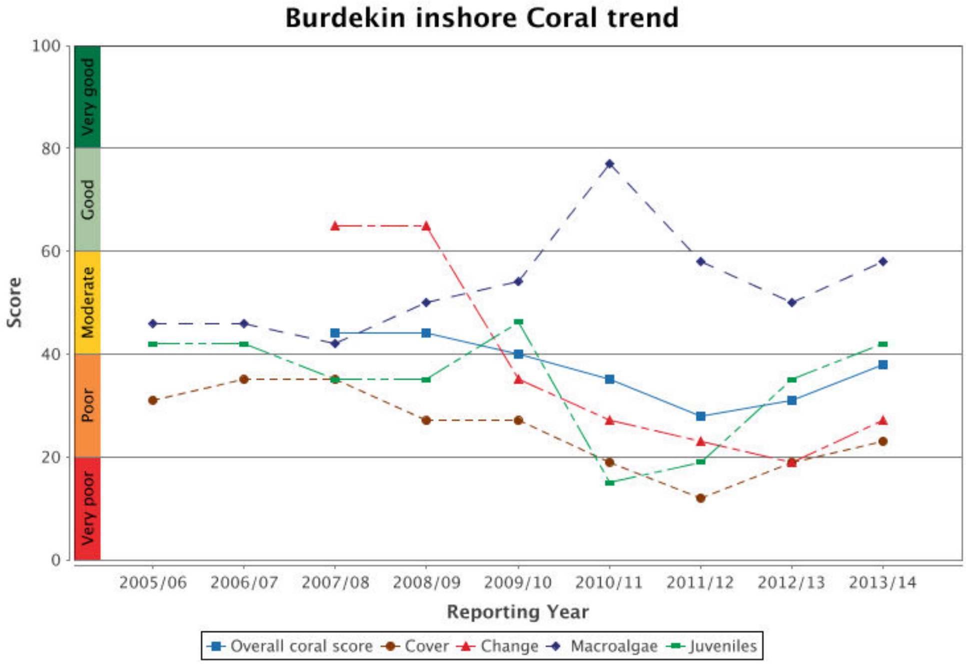
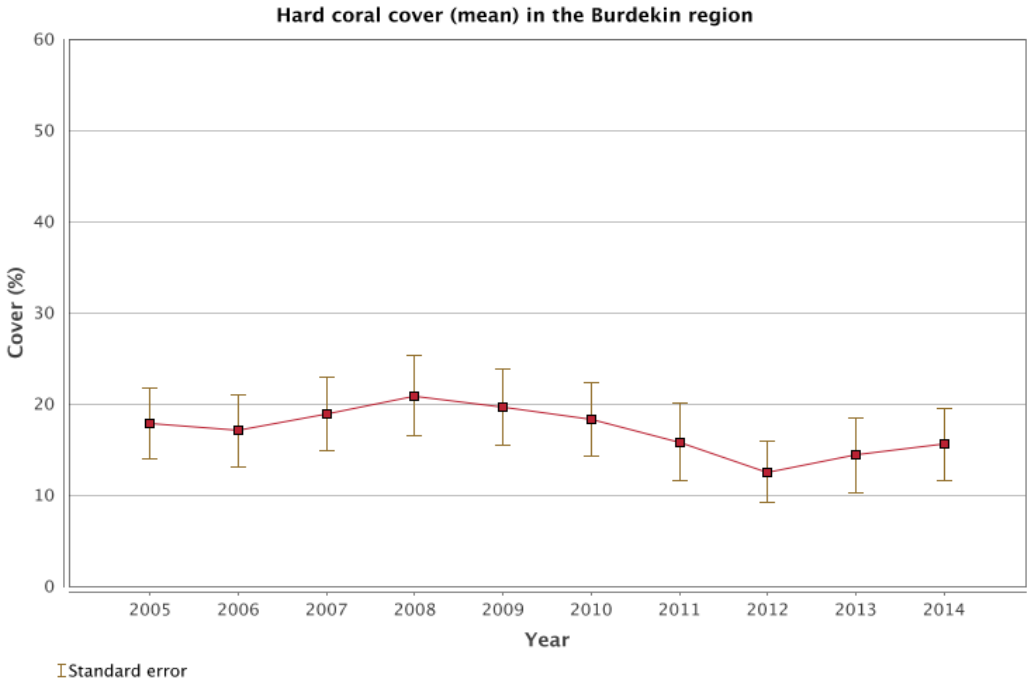


Figure 29: Trends in coral condition in the Burdekin region from 2007-2008 to 2013-2014. The overall coral score is also separated into component scores for cover, change, macroalgae and juveniles.

Coral cover across the Burdekin region improved from very poor to poor in 2013-2014, indicating some recovery of reefs from the repeated disturbances since 2006 such as Tropical Cyclones Larry and Yasi. This improvement reflects the increasing densities of juvenile corals and improvements in the rate of coral cover increase (change) at some reefs (Figure 30). In 2013-2014, the indicator for macroalgae cover also improved slightly, indicating more favourable conditions for coral settlement and survival. Notably, there has also been a reduction in coral disease in line with reduced flooding of the Burdekin River. Although, slight improvements in coral condition have been observed in 2013-2014, greater and prolonged periods free from disturbance are needed for substantial recovery of coral in the Burdekin region.



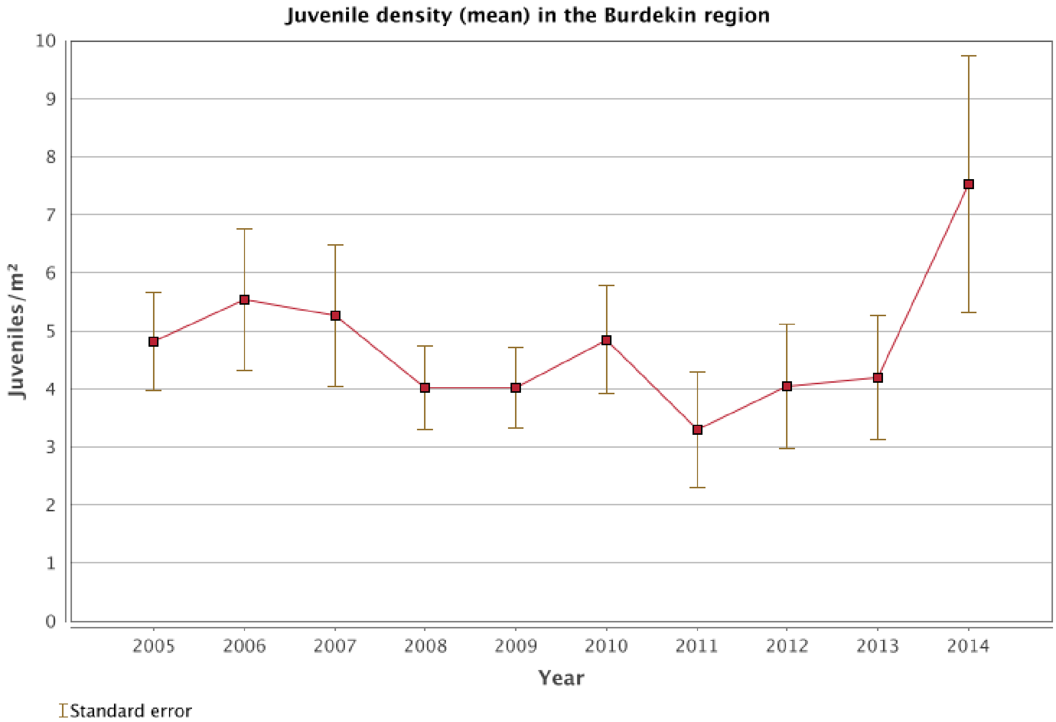


Figure 30: Average cover of hard corals, cover of macroalgae and density of hard coral juveniles in the Burdekin region from 2005 to 2013.

Mackay Whitsunday

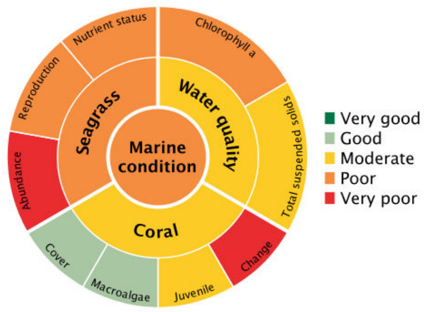


Figure 31: The overall marine condition adjacent to Mackay Whitsunday region.

Overall marine condition in the Mackay Whitsunday remained poor in 2013-2014 (Figure 31). Inshore water quality was moderate. Biologically relevant concentrations of PSII herbicides were present at one routine monitoring site. Inshore seagrass improved from very poor to poor and coral reefs remained in moderate condition in 2013-2014.

Water quality

Inshore water quality (assessed by remote sensing of chlorophyll *a* and total suspended solids) was moderate in 2013-2014 (Figure 32). Chlorophyll *a* was poor, with concentrations exceeding the Great Barrier Reef Water Quality Guidelines for 81 and 46 per cent of the inshore area, in the dry and wet seasons, respectively. Total suspended solids were moderate, with concentrations exceeding the Great Barrier Reef Water Quality Guidelines for 45 and 29 per cent of the inshore area, in the dry and wet seasons, respectively. Note that the time-series for water quality has been recalculated and trend graphs in previous reports are not comparable.

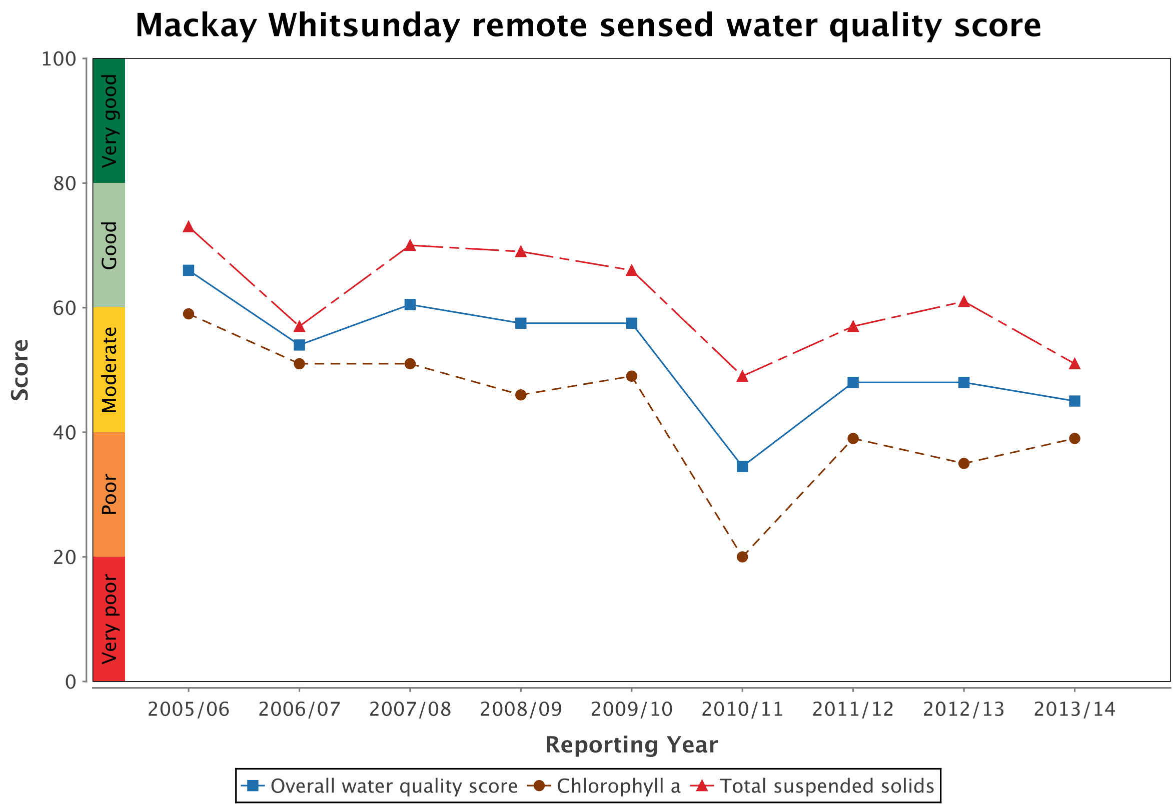


Figure 32: Trend in water quality Index from 2005-2014. The overall water quality score is also separated into component scores for concentrations of chlorophyll a and total suspended solids.

Water quality across the region showed a clear gradient of improvement from inshore areas more frequently exposed to flood waters than offshore areas. This gradient was supported by long-term assessments of water quality at specific sites with variability between sites reflecting local hydrodynamic conditions and biological processes. Site specific water quality data is not included in the water quality scores because a method needs to be developed to integrate the different datasets. While the overall trends are consistent between the two methods, the scores are not directly comparable.

Site-specific water quality was moderate at Daydream Island, poor at Pine Island and good at Double Cone Island in 2013-2014 (Figure 33). All indicators of water clarity including total suspended solids, Secchi depth and turbidity exceeded the Great Barrier Reef Water Quality Guidelines in 2013-2014, especially at Pine and Daydream Islands which are more frequently exposed to flood plumes. The water quality scores are a long-term integrated assessment of four indicators of water quality relative to the Great Barrier Reef Water Quality Guidelines (GBRMPA 2010).

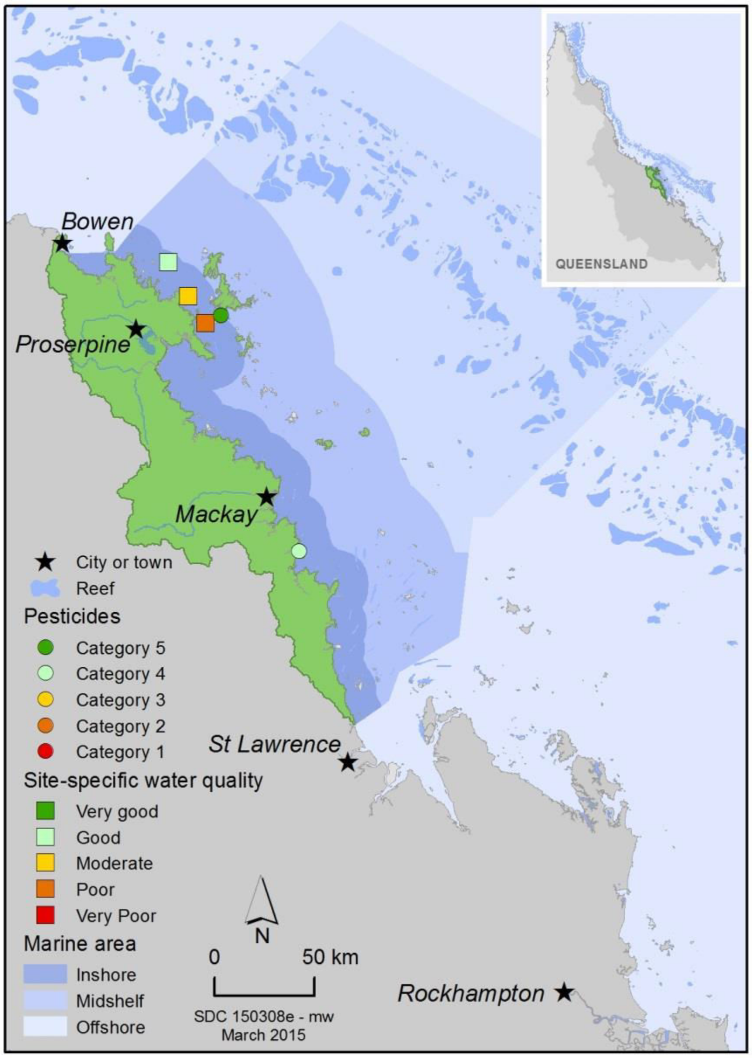


Figure 33: Scores for site-specific water quality and pesticides at fixed monitoring sites in the Mackay Whitsunday region.

In 2013-2014, concentrations of photosystem II (PSII) herbicides were detected at biologically relevant concentrations (Category 4) at Sarina Inlet, but were below those known to have any effects on plants or animals based on toxicity or a reduction in photosynthesis (Category 5) at the outer Whitsunday site. Concentrations of herbicides at both sites have decreased compared to 2012-2013 concentrations, reflecting lower flows in the wet season compared to previous recorded discharges. Sarina Inlet consistently has the highest concentrations of PSII herbicides compared to all other sites monitored across the Great Barrier Reef. This reflects a combination of local pesticide usage patterns, land management practices and the proximity of the passive samplers to river discharge.

The most frequently detected PSII herbicides in the Mackay Whitsunday region were diuron, atrazine and tebuthiuron. Other pesticides detected include ametryn, hexazinone, prometryn, simazine, bromacil, terbutyrn, metolachlor, imazapic, imidacloprid, galaxolide, chlorphyrifos, tonalid and diazinon.

Seagrass
The overall condition of inshore seagrass in the Mackay Whitsunday region improved from very poor to poor in 2013-2014, reaching levels comparable to those in 2009-2010 (Figure 34).

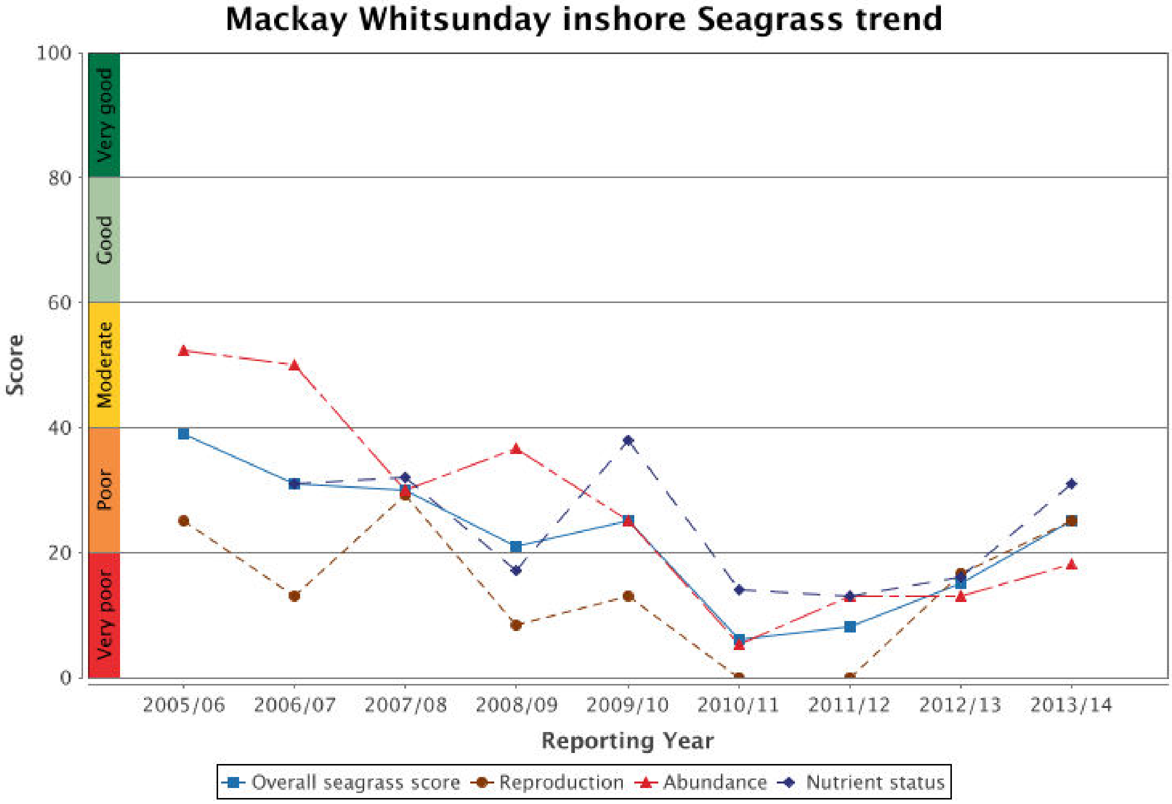
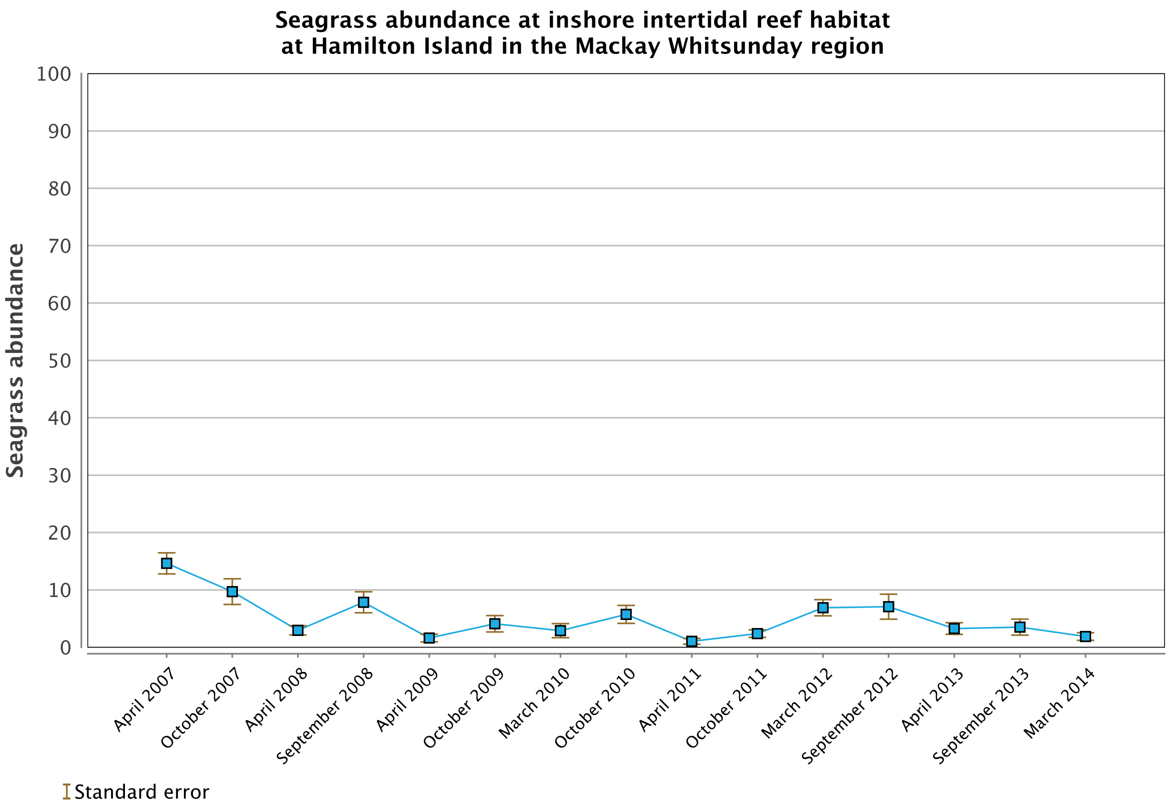
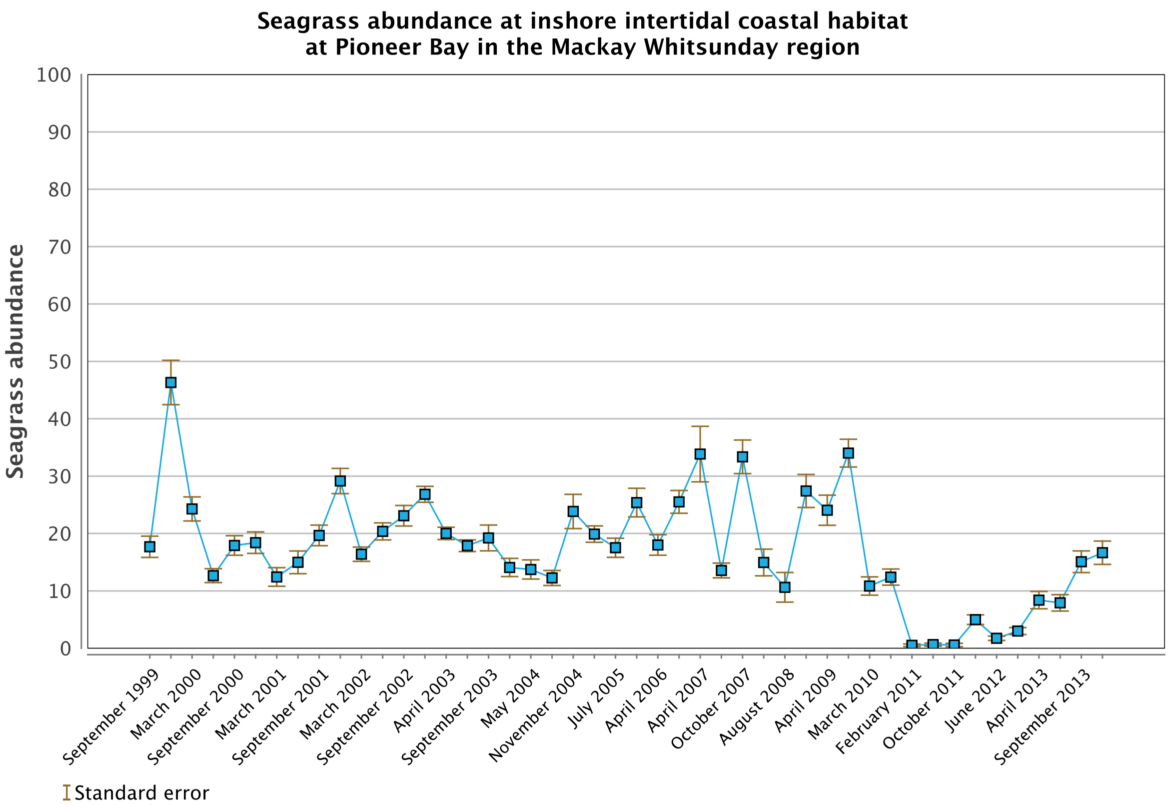


Figure 34: Trend in seagrass condition in the Mackay Whitsunday region from 2005-2006 to 2013-2014. The overall seagrass score is also separated into component scores for reproduction, abundance and nutrient status.

Seagrass meadows were monitored at coastal, estuarine and fringing reef locations in the Mackay Whitsunday region(Figure 35). Key environmental drivers of seagrass communities in this region include a high tidal range, exposure at very low tides and variable catchment run-off. Seagrass abundance remained very poor in 2013-2014, but has been gradually improving across the region from record low levels in 2010-2011 following Tropical Cyclone Yasi. Reproductive effort improved from very poor to poor in 2013-2014; however, long-term trends in this region suggest that seagrass is still in a vulnerable state with low resistance and reduced capacity to recover from any further large disturbances. Nutrient status improved from very poor to poor in 2013-2014 and may provide an integrated assessment of the quality of the surrounding waters relative to the amount of light available for growth. Although nutrient status has improved, supporting evidence (e.g., isotopic signatures) suggest that there are levels of anthropogenically derived nitrogen in inshore areas of the region.


Seagrass abundance at inshore intertidal reef habitat at Hamilton Island in the Mackay Whitsunday region
Seagrass abundance
100
90
80
70
60
50
40
30
20
10
0
April 2007
October 2007
April 2008
September 2008
April 2009
October 2009
March 2010
October 2010
April 2011
October 2011
March 2012
September 2012
April 2013
September 2013
March 2014
Standard error


Seagrass abundance at inshore intertidal coastal habitat at Pioneer Bay in the Mackay Whitsunday region
Seagrass abundance
100
90
80
70
60
50
40
30
20
10
0
September 1999
March 2000
September 2000
March 2001
September 2001
March 2002
September 2002
April 2003
September 2003
May 2004
November 2004
July 2005
April 2006
April 2007
October 2007
August 2008
April 2009
March 2010
February 2011
October 2011
June 2012
April 2013
September 2013
Standard error

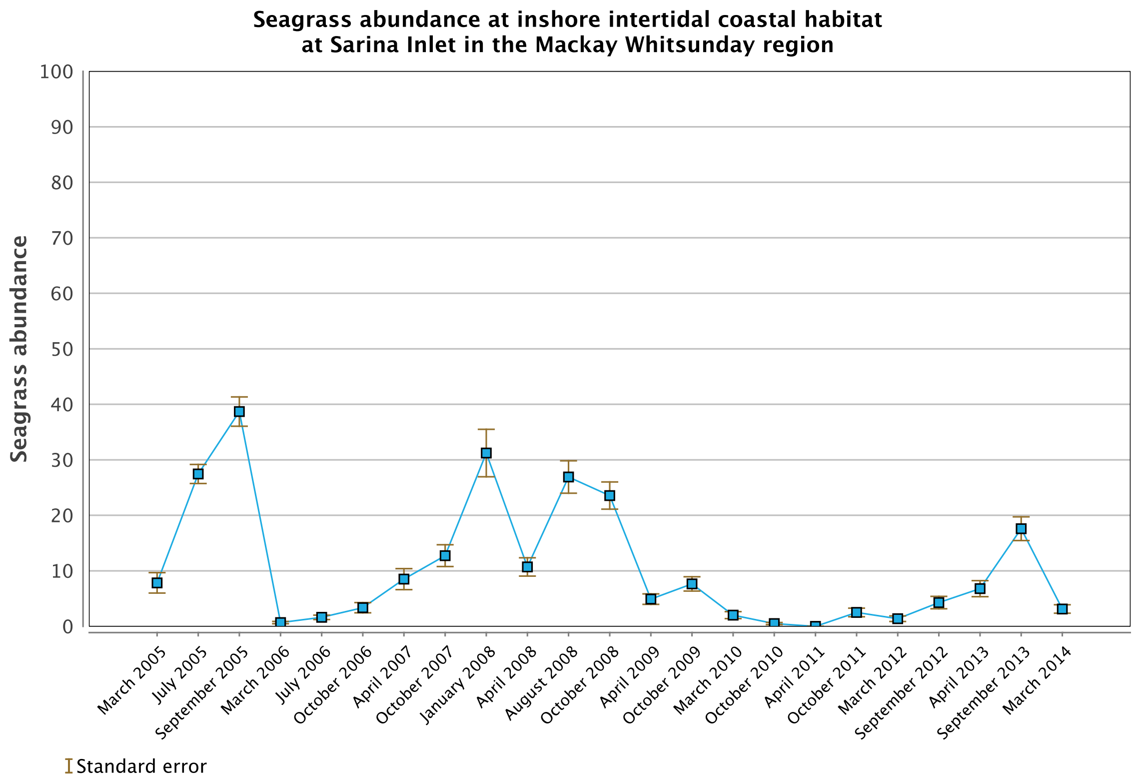


Figure 35: Seagrass abundance at Hamilton Island, Pioneer Bay and Sarina Inlet.

Coral

The overall condition of inshore coral reefs in the Mackay Whitsunday region has remained moderate since 2009-2010 (Figure 36).

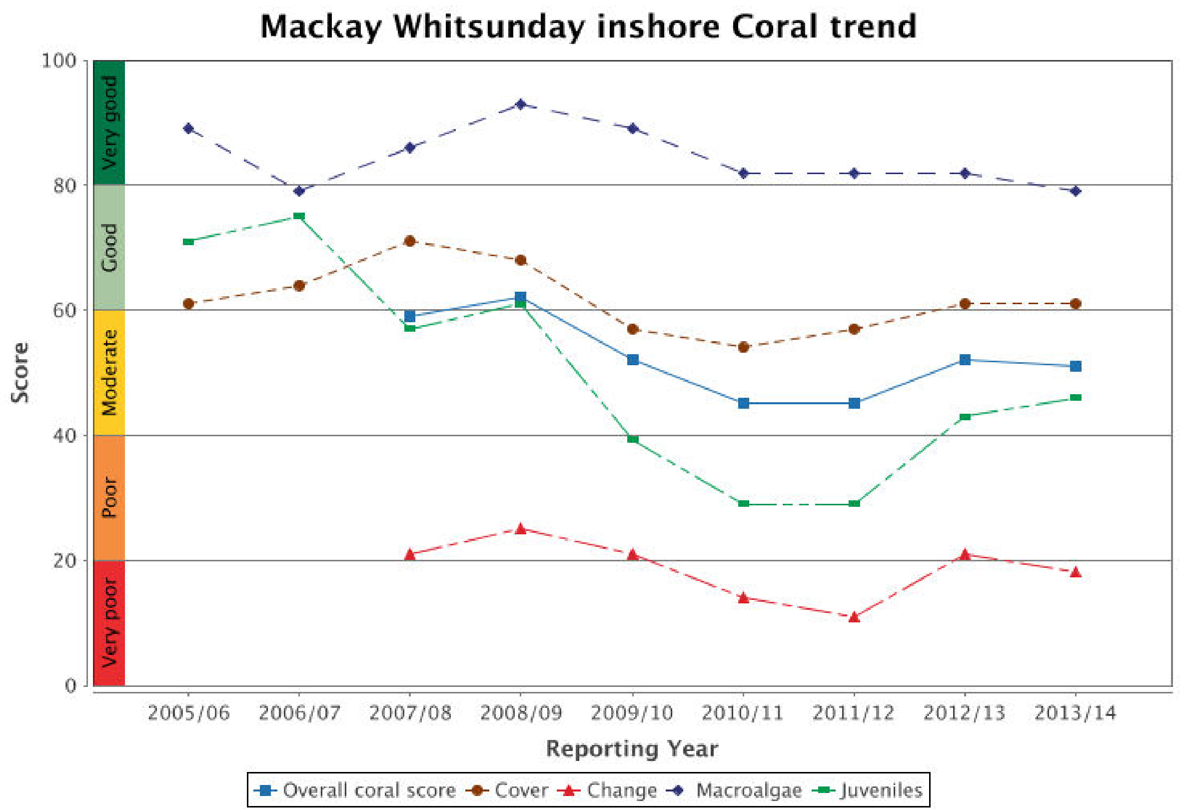
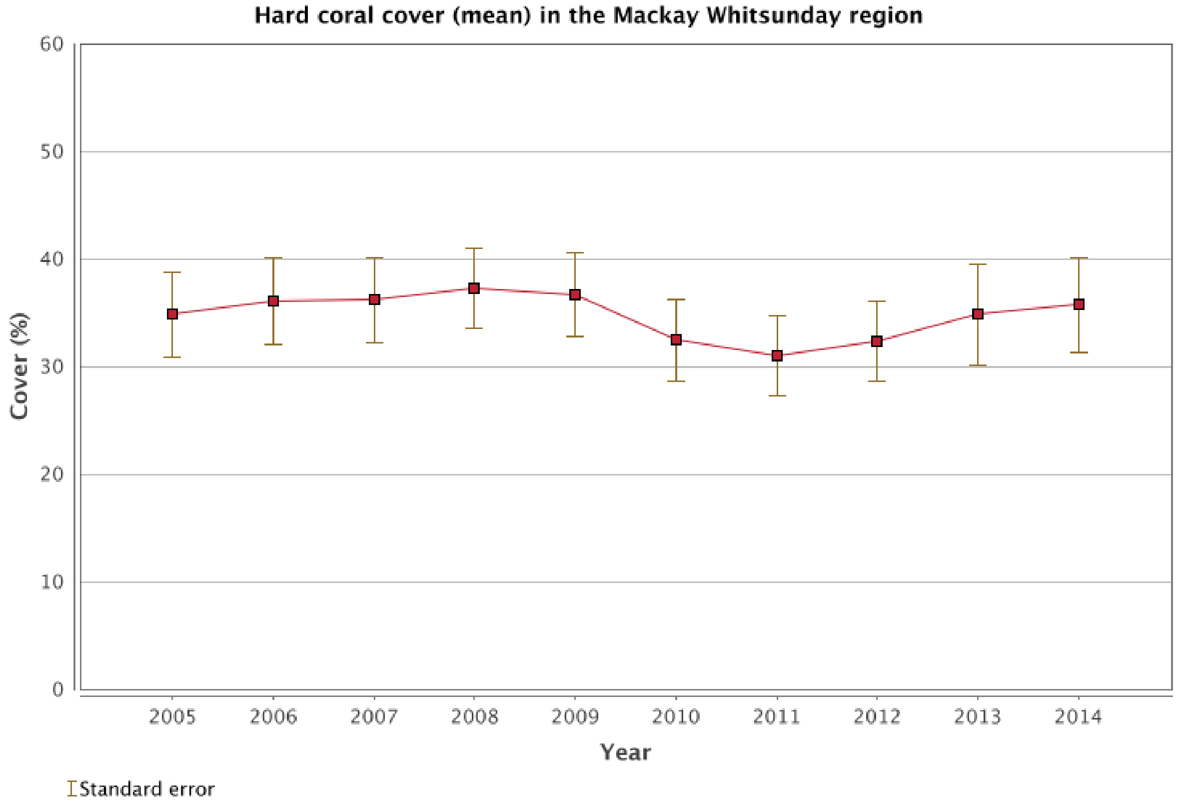
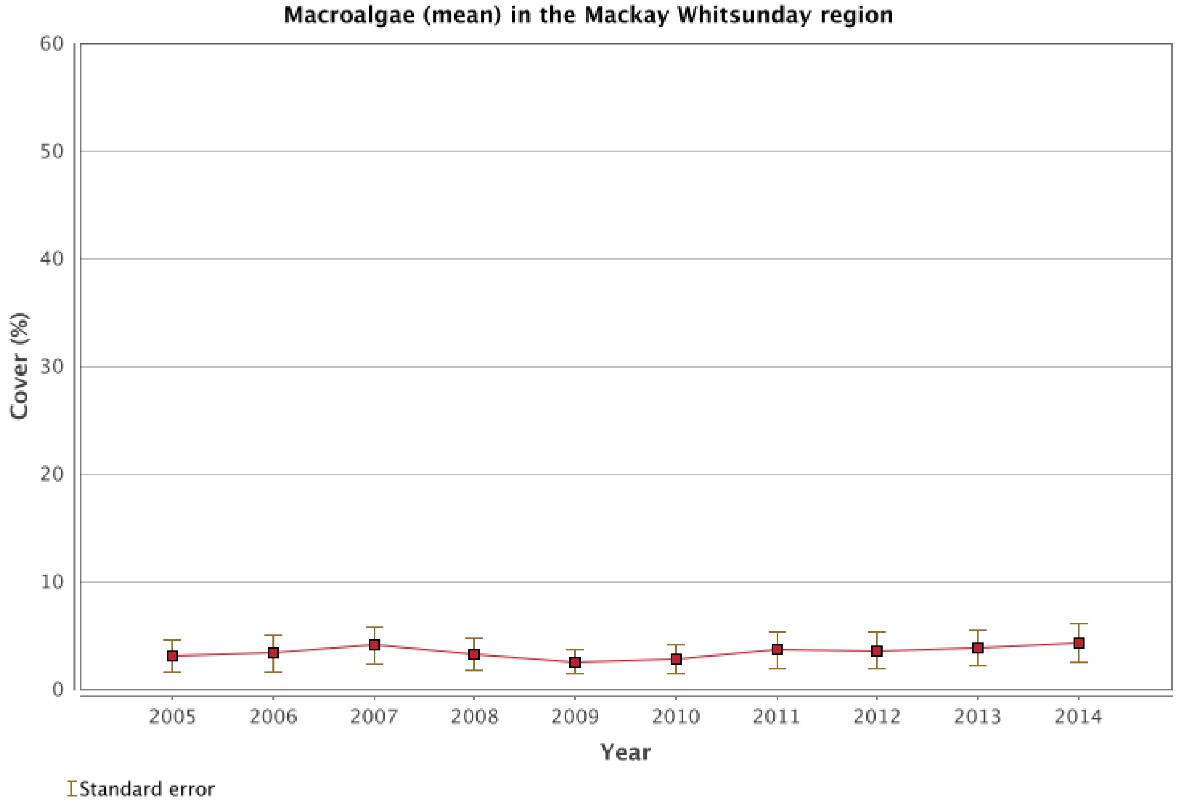


Figure 36: Trends in coral condition in the Mackay Whitsunday region from 2007-2008 to 2013-2014. The overall coral score is also separated into component scores for cover, change, macroalgae and juveniles.

Coral cover remained in good condition in 2013-2014 reflecting both the limited incidence of severe disturbances in recent years and the predominance of coral species tolerant of high turbidity and nutrient levels. There were slight increases in juvenile densities and the cover of macroalgae was good. The coral change indicator was very poor in 2013-2014, indicating some uncertainty about resilience of coral communities should the region experience further disturbances (Figure 37).





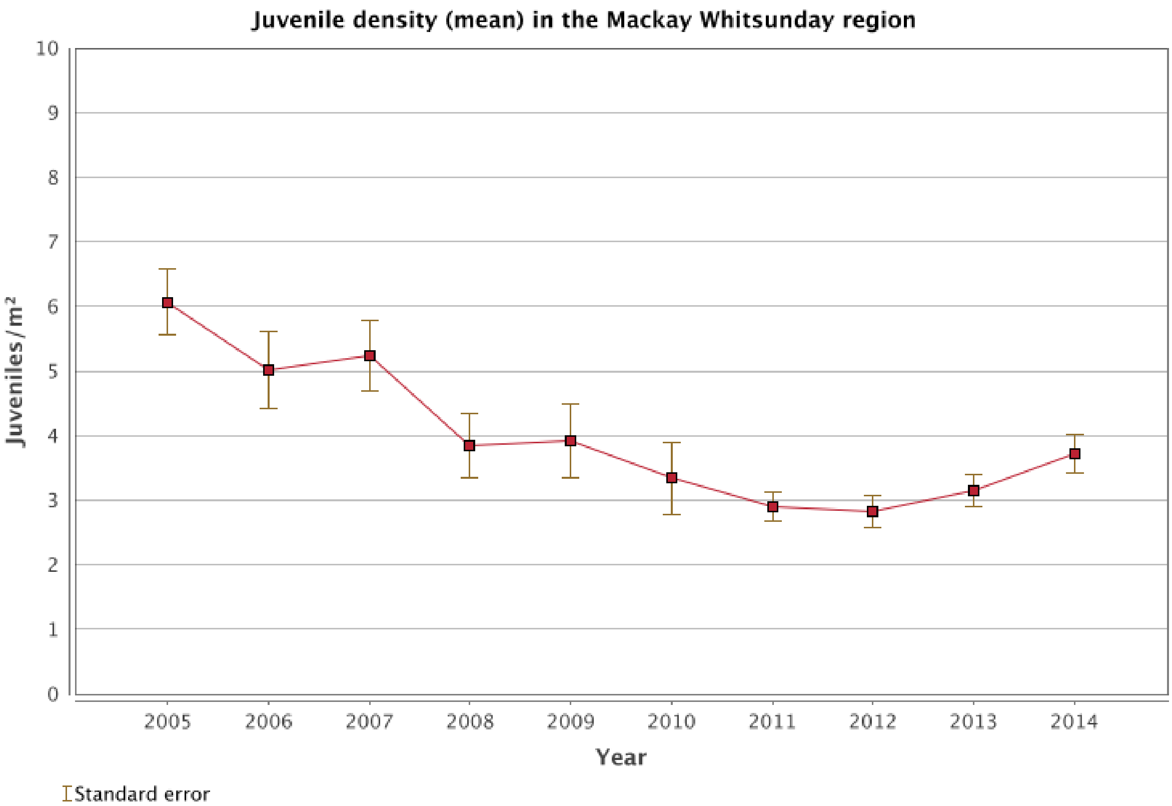


Figure 37: Average cover of hard corals, cover of macroalgae and density of hard coral juveniles in the Mackay Whitsunday region from 2005 to 2014.

Fitzroy

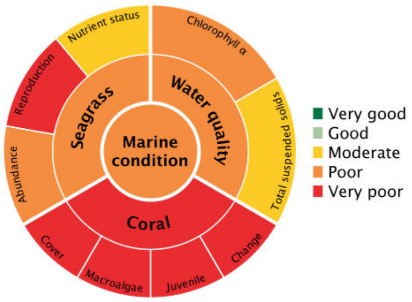


Figure 38: The overall marine condition adjacent to Fitzroy region. Overall marine condition in the Fitzroy remained poor in 2013-2014 (Figure 38). Inshore water quality was poor and inshore seagrass remained in poor condition. Coral reefs have remained in very poor condition since 2011-2012 following multiple disturbances.

Water quality

Inshore water quality (assessed by remote sensing of chlorophyll *a* and total suspended solids) in the Fitzroy region was poor in 2013-2014 (Figure 39). Changes in inshore water quality have been driven by relatively larger fluctuations in chlorophyll *a* compared to total suspended solids.

Chlorophyll *a* was poor in 2013-2014. Concentrations of chlorophyll *a* exceeded the Great Barrier Reef Water Quality Guidelines for 82 and 63 per cent of the inshore area in the dry and wet seasons, respectively, in 2013-2014. Total suspended solids were moderate in 2013-2014. However, concentrations exceeded the guidelines for 47 and 45 per cent of the inshore area in the dry and wet seasons, respectively, in 2013-2014. Note that the time-series for water quality has been recalculated and trend graphs in previous reports are not comparable.

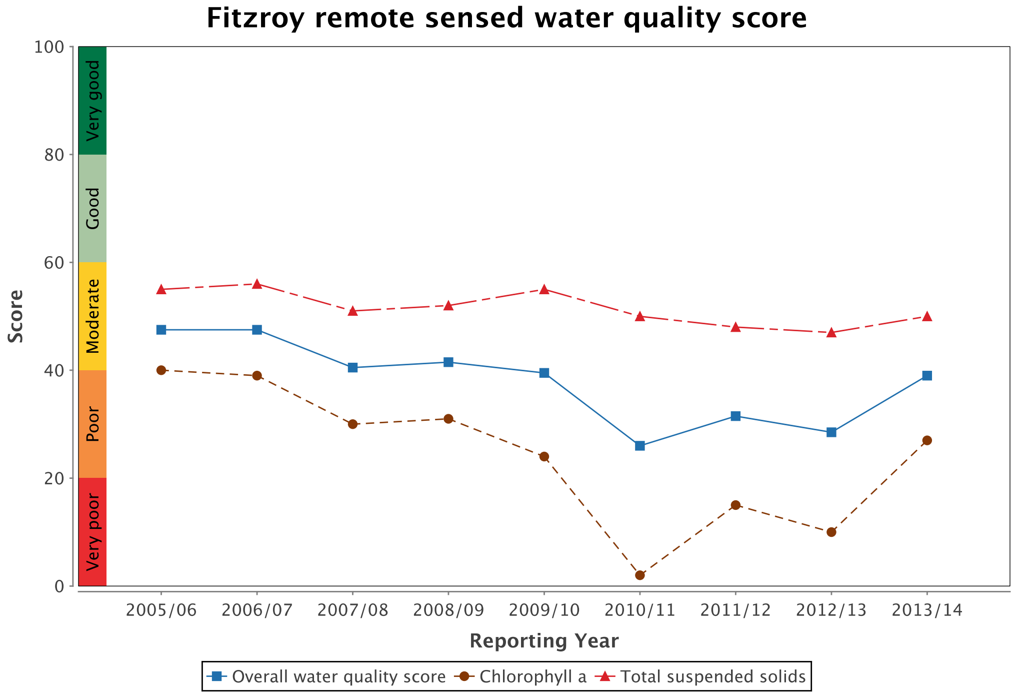


Figure 39: Trend in water quality from 2005-2014. The overall water quality score is also separated into component scores for concentrations of chlorophyll a and total suspended solids.

Water quality across the region showed a clear gradient of improvement from inshore areas more frequently exposed to flood waters than offshore areas. This gradient was supported by long-term assessments of water quality at specific sites, with variability between sites reflecting local hydrodynamic conditions and biological processes. Site specific water quality data is not included in the water quality scores because a method needs to be developed to integrate the different datasets. While the overall trends are consistent between the two methods, the scores are not directly comparable.

Site-specific water quality was poor at Pelican Island, good at Humpy Island and very good at Barren Island, reflecting increasing distance away from river influence (Figure 40). The water quality scores are a long-term integrative assessment based on four indicators of water quality relative to the Great Barrier Reef Water Quality Guidelines (GBRMPA 2010).

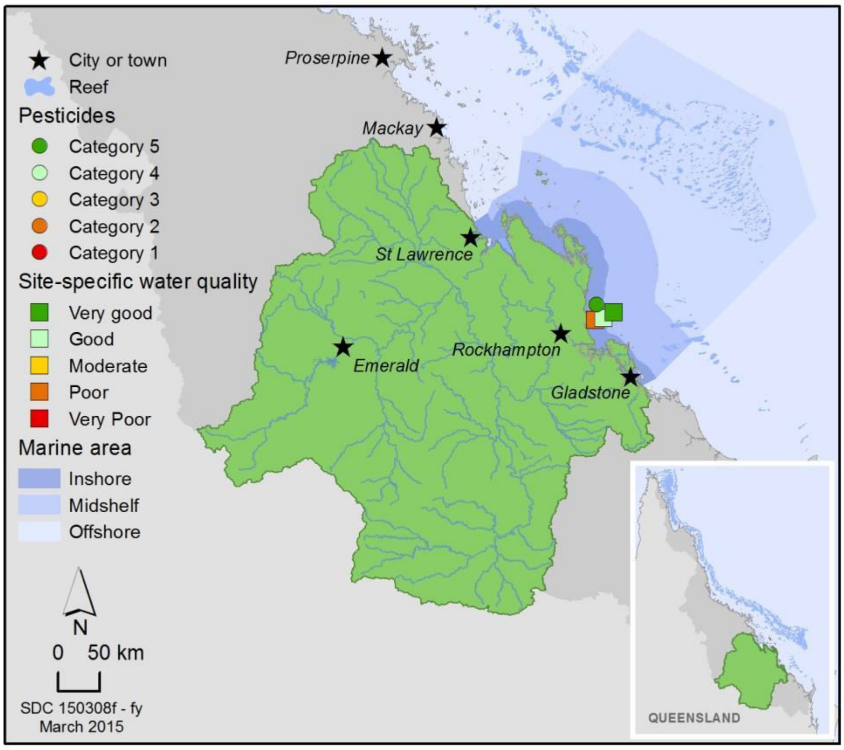


Figure 40: Scores for site-specific water quality and pesticides at fixed monitoring sites in the Fitzroy region.

At North Keppel Island, concentrations of photosystem II (PSII) herbicides were below those known to have any effects on plants or animals based on toxicity or a reduction in photosynthesis (Category 5). This concentration is the lowest detected at any monitoring site since sampling commenced in 2005. The herbicides detected with the greatest frequency include atrazine, diuron and tebuthiuron. Other pesticides detected include hexazinone, metolachlor, imazapic and imidacloprid.

Seagrass
The condition of inshore seagrass in the Fitzroy region remained poor in 2013-2014 and was a result of different and complex interactions between the three health indicators (Figure 41).

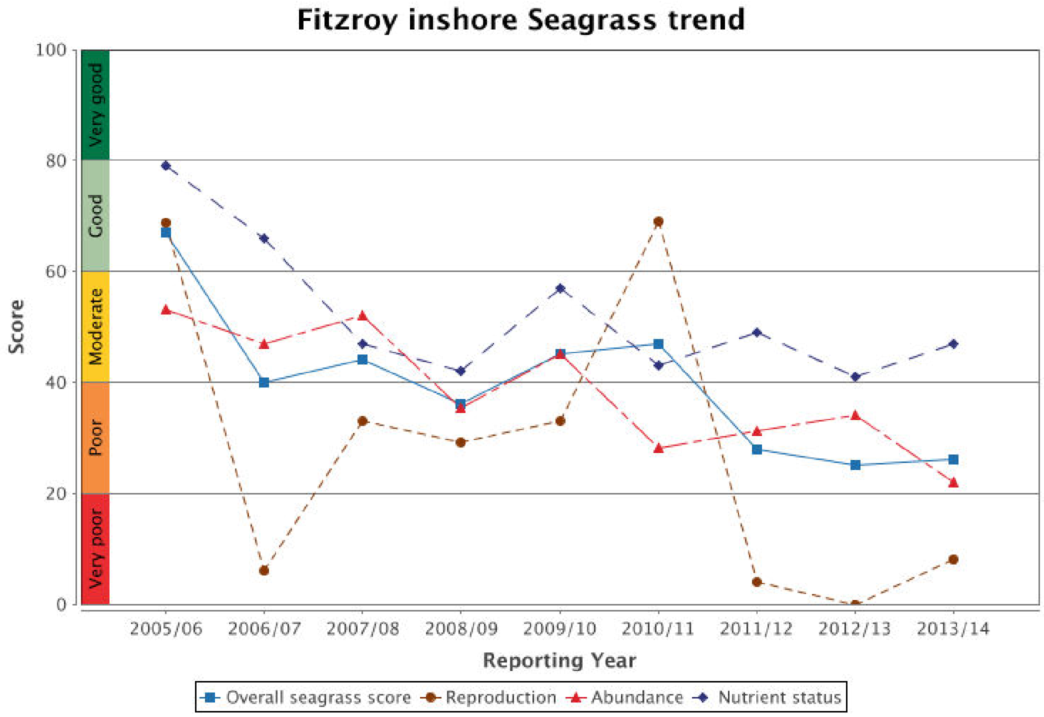
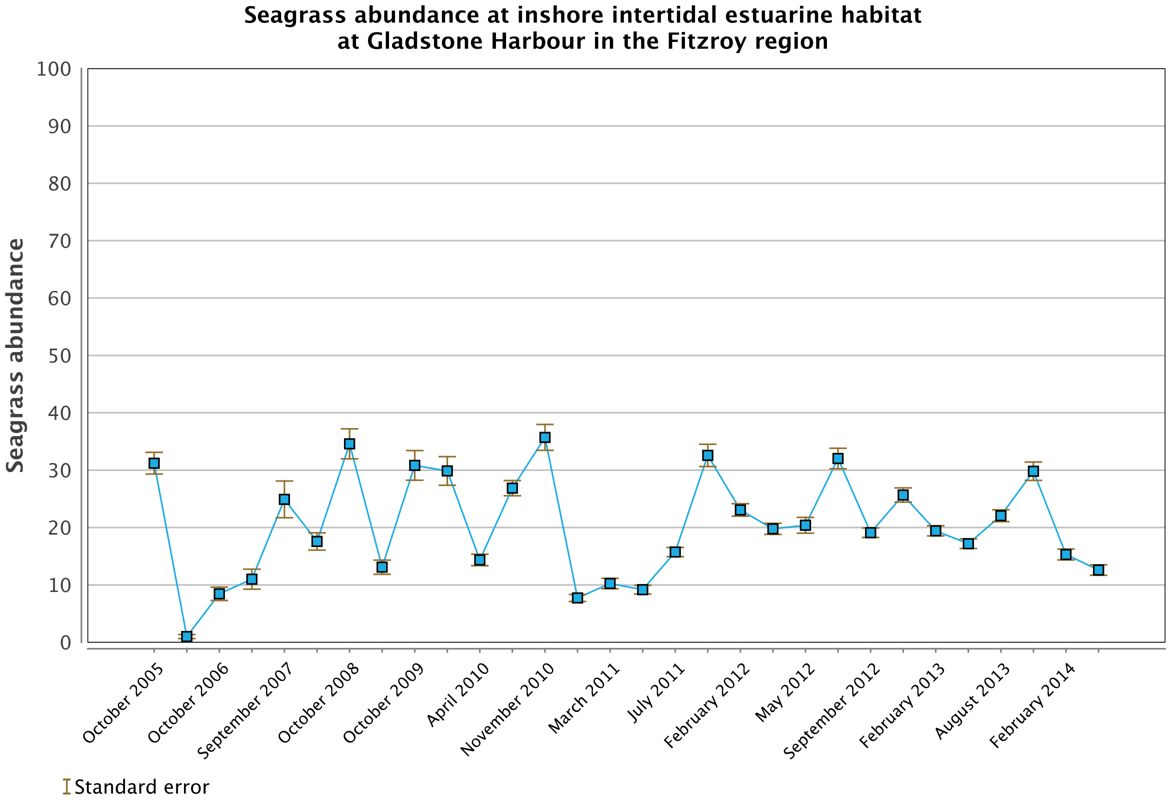
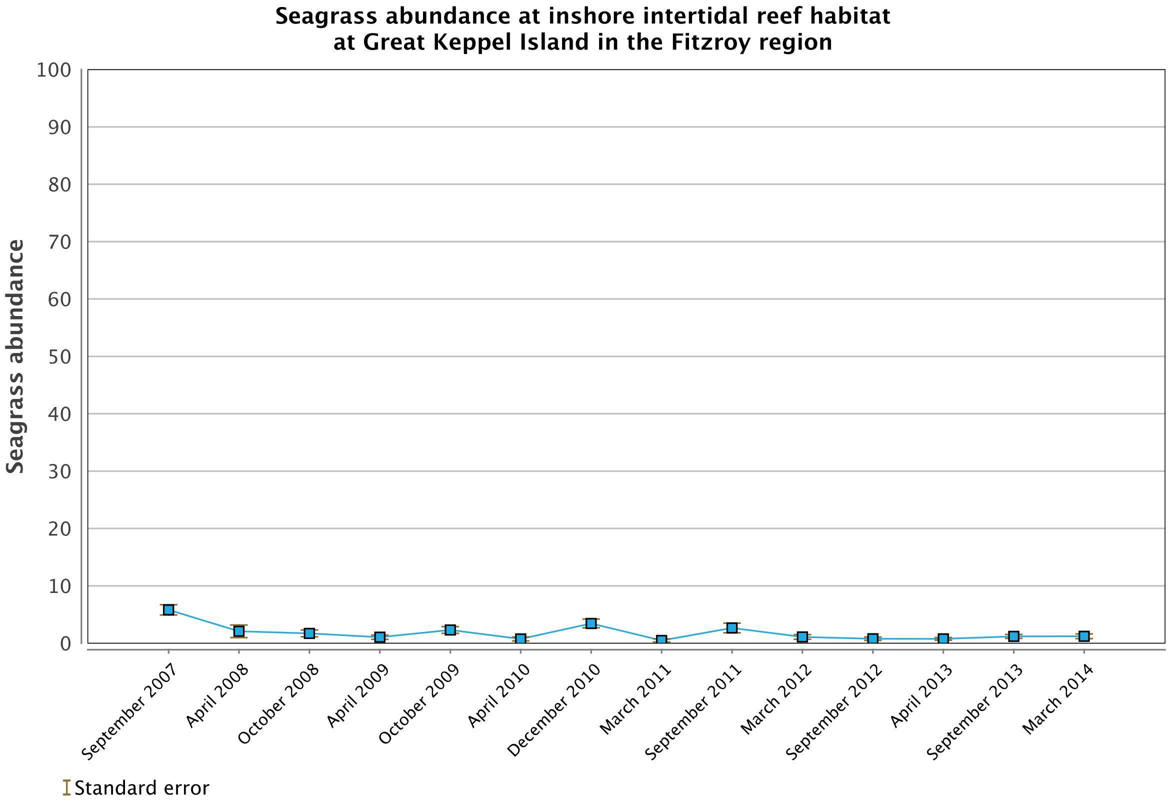


Figure 41: Trend in seagrass condition in the Fitzroy region from 2005-2006 to 2013-2014. The overall seagrass score is also separated into component scores for reproduction, abundance and nutrient status.

Seagrass meadows were monitored at coastal, estuarine and fringing reef locations in the Fitzroy region. Key environmental drivers in the region include exposure at very low tide and high turbidity. Seagrass abundance declined in 2013-2014 but remained poor. Reproductive effort improved but remained very poor. The nutrient status of seagrass tissue was moderate overall and variations between habitats reflected differences in nutrient and light availability. Seagrass meadows across the region are still recovering from years of repeated environmental disturbances and they will be unable to withstand further impacts until abundance and community composition recover to long-term average levels (Figure 42).


Seagrass abundance at inshore intertidal estuarine habitat
at Gladstone Harbour in the Fitzroy region
Seagrass abundance
100
90
80
70
60
50
40
30
20
10
0
October 2005
October 2006
September 2007
October 2008
October 2009
April 2010
November 2010
March 2011
July 2011
February 2012
May 2012
September 2012
February 2013
August 2013
February 2014
Standard error


Seagrass abundance at inshore intertidal reef habitat
at Great Keppel Island in the Fitzroy region
Seagrass abundance
100
90
80
70
60
50
40
30
20
10
0
September 2007
April 2008
October 2008
April 2009
October 2009
April 2010
December 2010
March 2011
September 2011
March 2012
September 2012
April 2013
September 2013
March 2014
Standard error

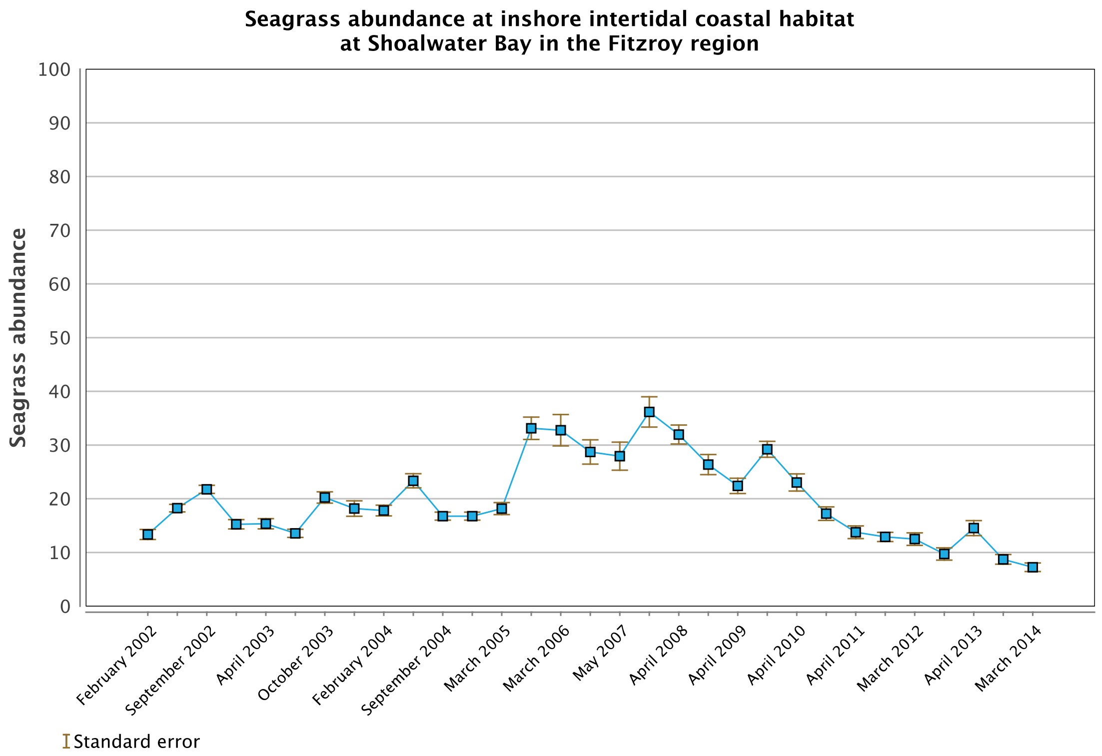


Figure 42: Seagrass abundance at Gladstone Harbour, Great Keppel Island and Shoalwater Bay.

Coral

The overall condition of inshore coral reefs in the Fitzroy region declined slightly in 2013-2014 but they remained in very poor condition (Figure 43). The influence of repeated and intense flooding, extreme temperatures and a series of severe storms since 2008 has contributed to the ongoing decline in coral reef condition.

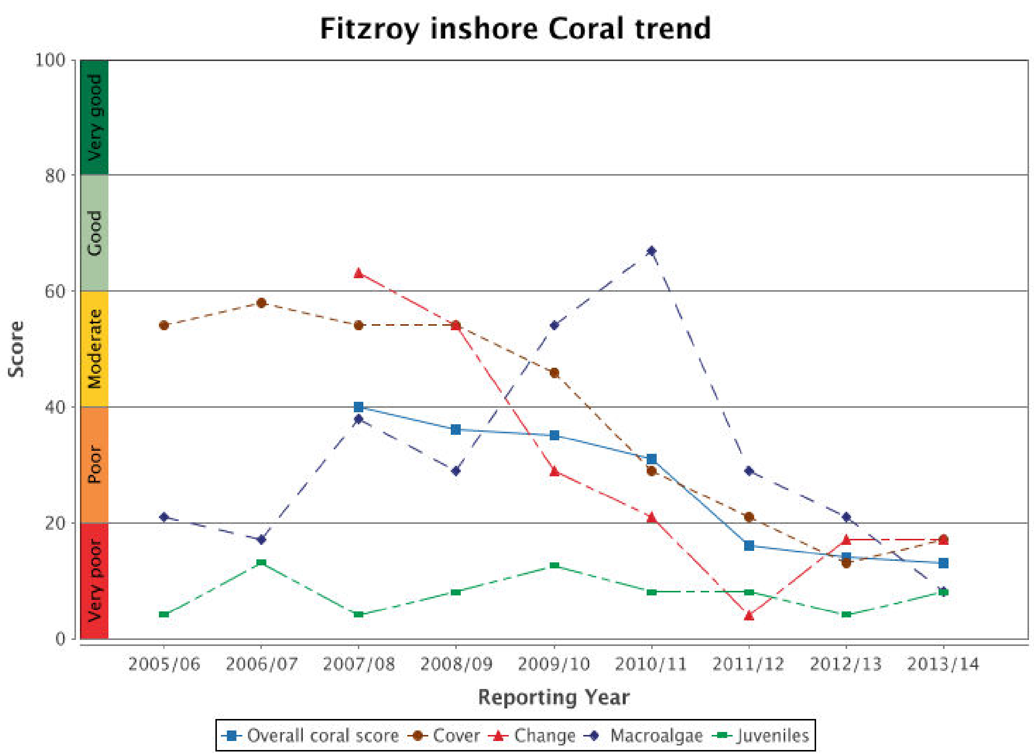
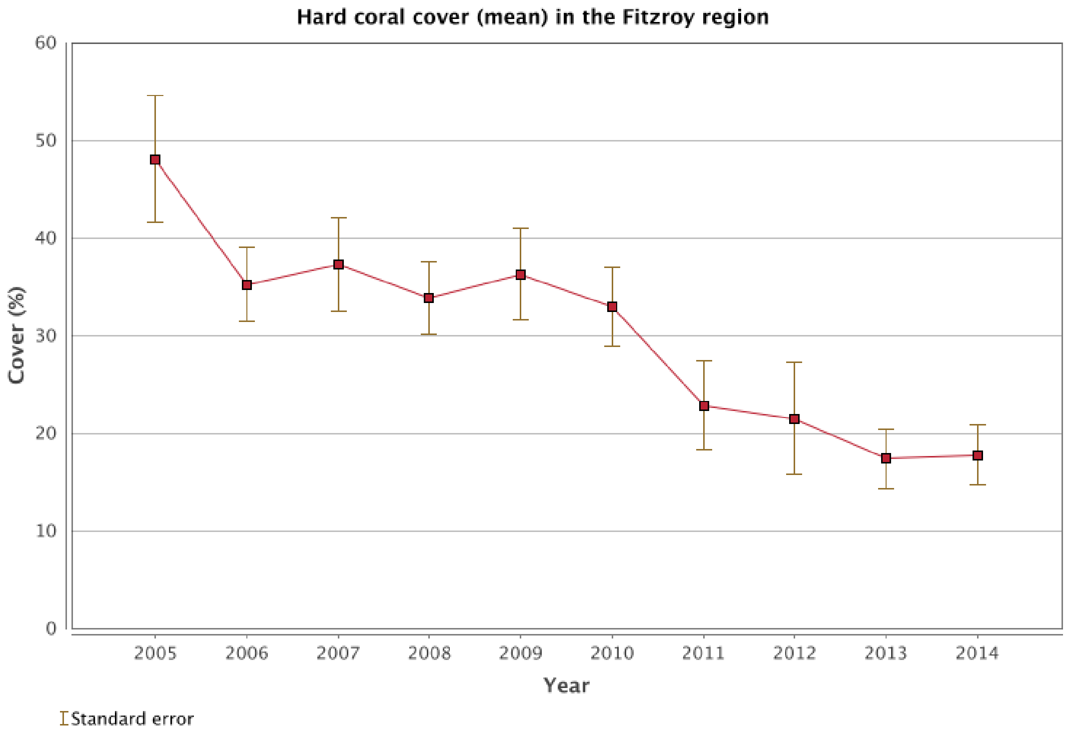
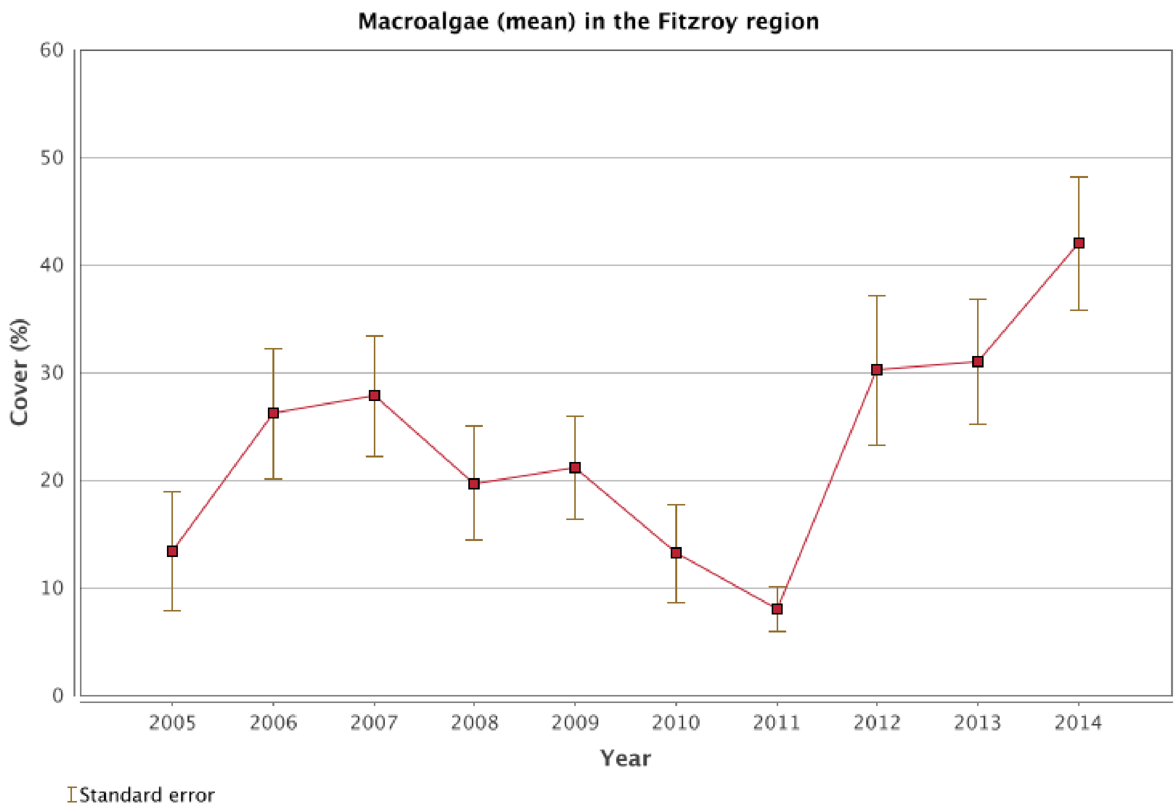


Figure 43: Trends in coral condition in the Fitzroy region from 2007-2008 to 2013-2014. The overall coral score is also separated into component scores for cover, change, macroalgae and juveniles.

Coral health indicators for coral cover, coral change and juvenile densities remained very poor in 2013-2014 (Figure 44). Levels of macroalgae continued to increase resulting in very poor condition in 2013-2014. High incidences of coral disease were observed in the Fitzroy region following major floods, demonstrating a link between poor water quality and chronic stress on coral communities.





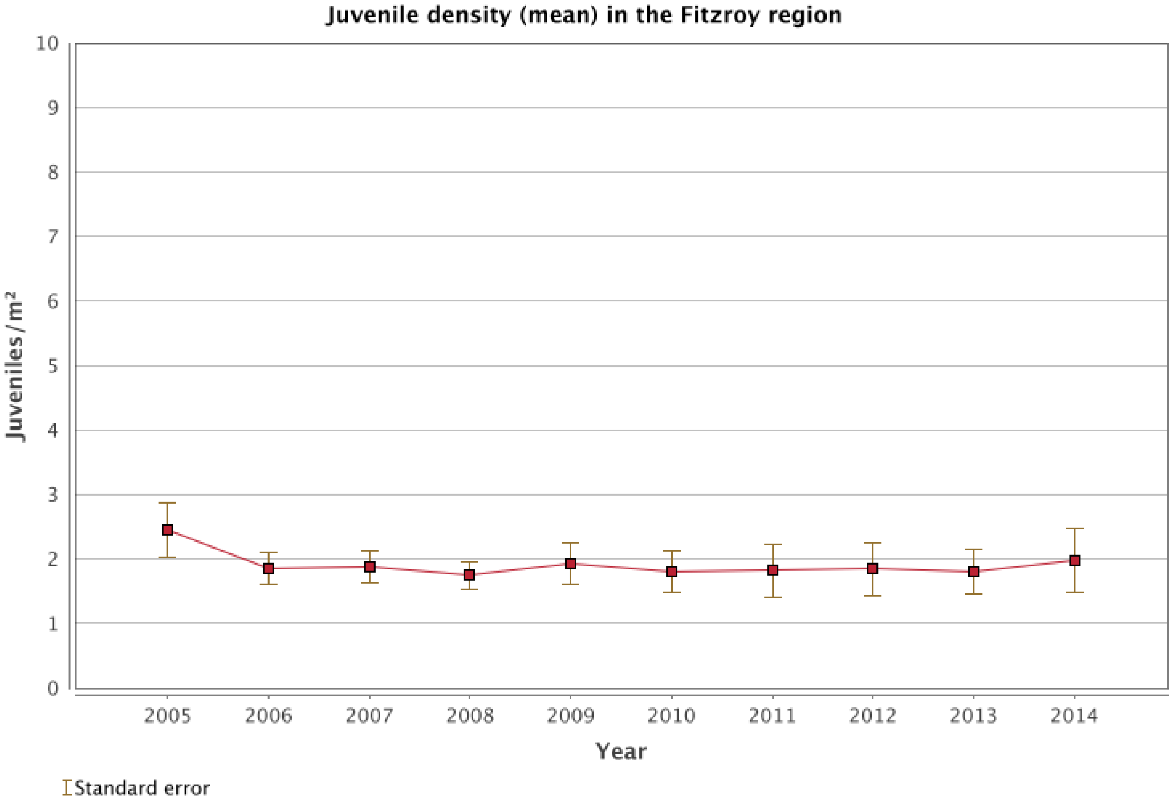


Figure 44: Average cover of hard corals, cover of macroalgae and density of hard coral juveniles in the Fitzroy region from 2005 to 2014.

Burnett Mary

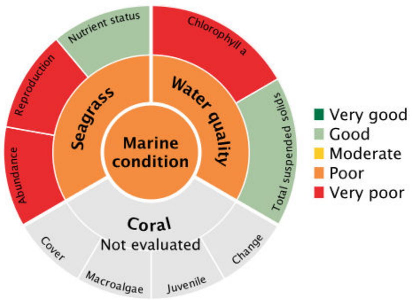


Figure 45: The overall marine condition adjacent to Burnett Mary region.

Overall marine condition in the Burnett Mary remained poor in 2013-2014 (Figure 45). Inshore water quality was poor and inshore seagrass improved from very poor to poor. No coral monitoring occurs in the Burnett Mary region through the Marine Monitoring Program.

Water quality

There is no comprehensive, ongoing in situ water quality monitoring in the Burnett Mary region. Estimates of chlorophyll *a* and total suspended solids are derived from remote sensing only, which requires further field validation, and therefore estimates have relatively low reliability compared to other regions.

The water quality score is composed of very different ratings for chlorophyll *a* and total suspended solids. Inshore water quality (assessed by remote sensing of chlorophyll *a* and total suspended solids) in the Burnett Mary region was poor in 2013-2014 (Figure 46). The continued decline was driven by relatively large changes in chlorophyll *a*, while total suspended solids remained stable, which is a consequence of the recent large-scale flood events.

Chlorophyll *a* was very poor in 2013-2014. Concentrations exceeded the Great Barrier Reef Water Quality Guidelines for 94 and 65 percent of the inshore area in the dry and wet seasons, respectively, in 2013-2014. Total suspended solids were good in 2013-2014; however, concentrations exceeded the guidelines for 25 and 18 per cent of the inshore area in the dry and wet seasons, respectively.

There is no routine monitoring of pesticides in the Burnett Mary region.

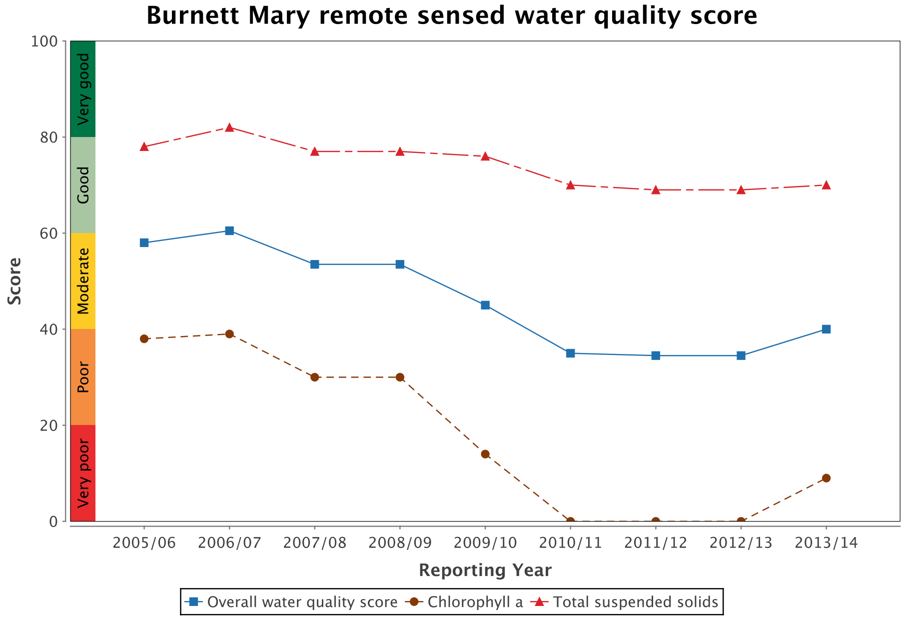


Figure 46: Trend in water quality from 2005-2014. The overall water quality score is also separated into component scores for concentrations of chlorophyll a and total suspended solids.

Seagrass

The overall condition of inshore seagrass in the Burnett Mary region improved from very poor to poor in 2013-2014 for the first time in five years. This improvement was largely a result of improvements in tissue nutrient status from poor in 2012-2013 to good in 2013-2014 (Figure 47). However, seagrass meadows are in a vulnerable state with reduced capacity to recover from any further large disturbances because abundance and reproductive effort remained very poor.

Note that leaf tissue nutrients may provide an integrated assessment of the quality of the surrounding waters relative to the amount of light available for growth. Although there have been improvements in nutrient status, supporting evidence (e.g., cover of epiphytes and isotopic signatures) suggests there are levels of anthropogenically derived nitrogen in inshore areas of the region.

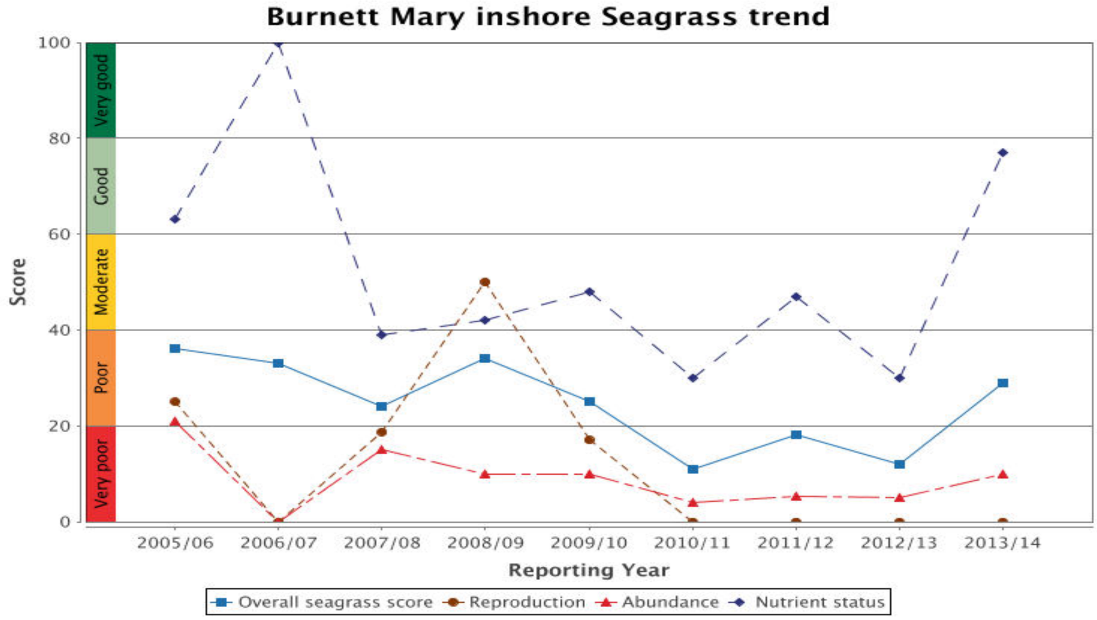
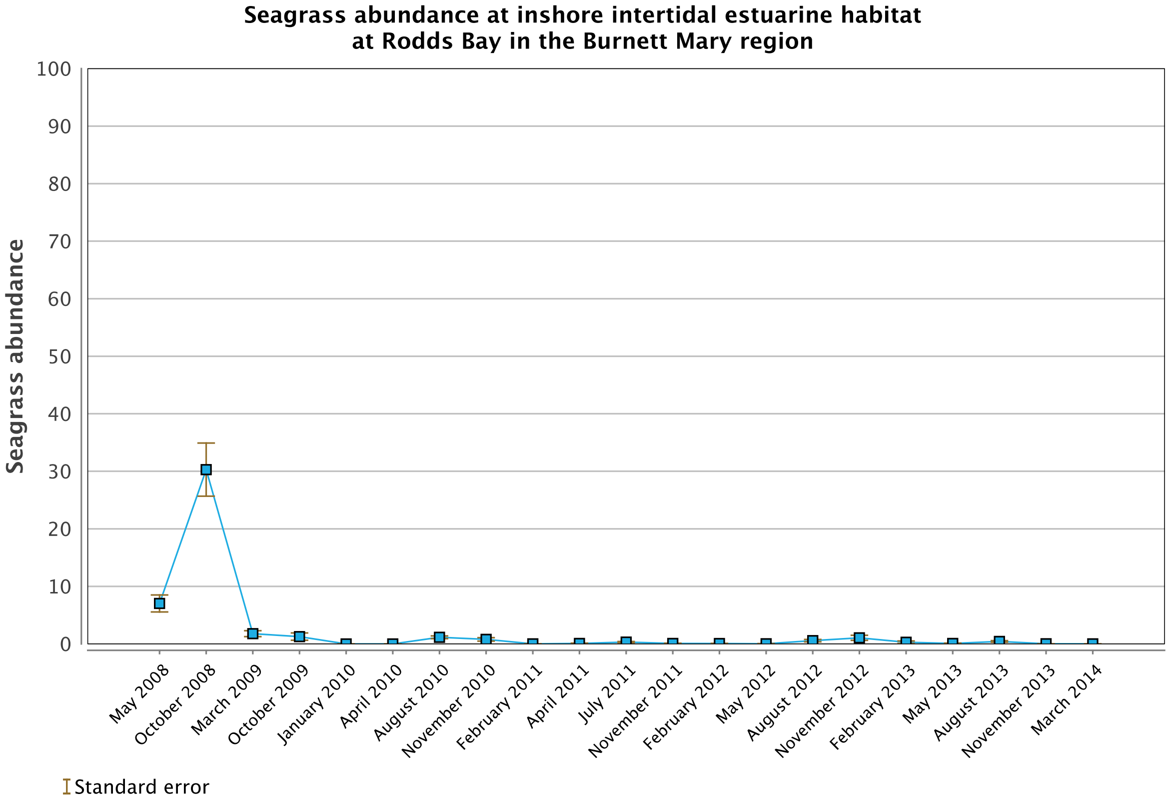


Figure 47: Trend in seagrass condition in the Burnett Mary region from 2005-2006 to 2013-2014. The overall seagrass score is also separated into component scores for reproduction, abundance and nutrient status.

Seagrass is monitored at estuarine sites at Rodds Bay and Urangan, in the north and south of the Burnett Mary region, respectively (Figure 48). The main environmental factors influencing seagrass community composition at these sites are wind, waves, elevated temperatures, land-based runoff and turbid waters.



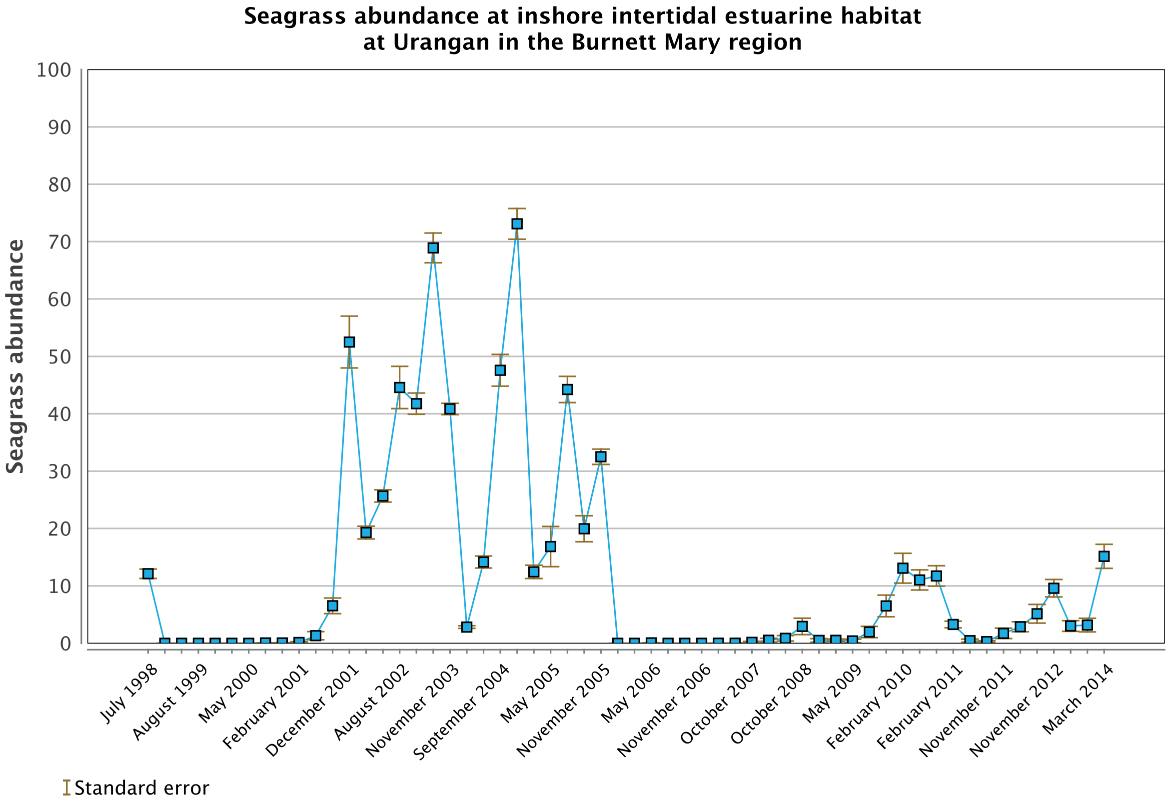


Figure 48: Seagrass abundance at Rodds Bay and Urangan.

References

Álvarez-Romero, J.G., Devlin, M., Teixeira da Silva, E., Petus, C., Ban, N.C., Pressey, R.L., Kool, J., Roberts, J.J., Cerdeira-Estrada, S., Wenger, A.S., Brodie, J., 2013. A novel approach to model exposure of coastal-marine ecosystems to riverine flood plumes based on remote sensing techniques. Journal of Environmental Management 119, 194-207.

Brodie, J.E., Kroon, F.J., Schaffelke, B., Wolanski, E.C., Lewis, S.E., Devlin, M.J., Bohnet, I.C., Bainbridge, Z.T., Waterhouse, J., Davis, A.M., 2012. Terrestrial pollutant runoff to the Great Barrier Reef: An update of issues, priorities and management responses. Marine Pollution Bulletin 65, 81-100.

Bruno, J.F., Selig, E.R., Casey, K.S., Page, C.A., Willis, B., Harvell, C.D., Sweatman, H., Melendy, A.M., 2007. Thermal stress and coral cover as drivers of coral disease outbreaks. PLoS Biology 5, e124.

Collier, C.J., Waycott, M., Giraldo-Ospina, A., 2012. Responses of four Indo-West Pacific seagrass species to shading. Marine Pollution Bulletin 65, 342-354.

De'ath G, Fabricius KE, Sweatman H, Puotinen M (2012) The 27-year decline of coral cover on the Great Barrier Reef and its causes. Proceedings of the National Academy of Sciences 190(44):17995-17999.

Fabricius, K.E., 2005. Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. Mar. Pollut. Bull. 50, 125-146.

Fabricius, K.E., Okaji, K., De'ath, G., 2010. Three lines of evidence to link outbreaks of the crown-of-thorns seastar Acanthaster planci to the release of larval food limitation. Coral Reefs 29, 593-605.

Fabricius, K.E., 2011. Factors determining the resilience of coral reefs to eutrophication: a review and conceptual model, in Dubinsky, Z., Stambler, N. (Eds.), Coral Reefs: An Ecosystem in Transition. Springer, Dordrecht, pp. 493-508.

Furnas, M., Brinkman, R., Fabricius, K., Tonin, H., Schaffelke, B., 2013. Chapter 1: Linkages between river runoff, phytoplankton blooms and primary outbreaks of crown-of-thorns starfish in the Northern GBR. In: Assessment of the relative risk of water quality to ecosystems of the Great Barrier Reef: Supporting Studies. A report to the Department of the Environment and Heritage Protection, Queensland Government, Brisbane. TropWATER Report 13/30, Townsville, Australia.

Gallen, C., Devlin, M., Paxman, C., Mueller, J. (2014) Pesticide monitoring in inshore waters of the Great Barrier Reef using both time-integrated and event monitoring techniques (2013 - 2014). The University of Queensland, The National Research Centre for Environmental Toxicology (Entox).

Garnaut, R., 2008. The Garnaut climate change review, 634.

Great Barrier Reef Marine Park Authority (GBRMPA), 2010. Water quality guidelines for the Great Barrier Reef Marine Park.

Great Barrier Reef Marine Park Authority (GBRMPA), 2012. Informing the outlook for Great Barrier Reef coastal ecosystems, GBRMPA, Townsville.

Great Barrier Reef Marine Park Authority (GBRMPA), 2013. Great Barrier Reef Strategic Assessment Report, GBRMPA, Townsville, Qld.

Great Barrier Reef Marine Park Authority (GBRMPA), 2014. Great Barrier Reef outlook report 2014, GBRMPA, Townsville, Qld.

Intergovernmental Panel on Climate Change, 2007. Climate change 2007 synthesis report. Summary for policymakers, 22p.

Johnson, J.E. and Marshall, P.A. (eds) 2007, Climate change and the Great Barrier Reef: a vulnerability assessment, Great Barrier Reef Marine Park Authority and Australian Greenhouse Office.

Lough, J. 2007, Climate and climate change on the Great Barrier Reef, in Climate change and the Great Barrier Reef: A Vulnerability Assessment, eds J.E. Johnson and P.A. Marshall, Great Barrier Reef Marine Park Authority and Australian Greenhouse Office, Townsville, pp. 15-50.

Maynard, J.A. 2010, Evaluation of thermal stress thresholds at the Australian Institute of Marine Science (AIMS) Long-Term Monitoring Program (LTMP) sites and Eye on the Reef tourism sites. Maynard Marine Consulting, Inc., Australia, <http://edocs.gbrmpa.gov.au/RefWorks/2001.

McKenzie, L.J., Collier, C., Langlois L., Yoshida, R., Smith, N. and Waycott, M. 2015, Reef Rescue Marine Monitoring Program: Inshore seagrass, annual report for the sampling period 1st July 2013 – 31st May 2014. TropWater, James Cook University, Cairns. 226pp.

Miller, I.R. and Sweatman, H. 2013. The status of crown-of-thorns starfish populations on the Great Barrier Reef from AIMS surveys. Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns.

Moran, P.J.; and De'ath, G, 1992, Estimates of the abundance of the crown-of-thorns starfish Acanthaster planci in outbreaking and non-outbreaking populations on reefs within the Great Barrier Reef, Marine Biology 113, pp 509-515.

Osborne, K., Dolman, A.M., Burgess, S.C., Johns, K.A., 2011. Disturbance and the dynamics of coral cover on the Great Barrier Reef (1995–2009). PLoS ONE 6, e17516.

Reef Water Quality Protection Plan Secretariat 2014, Great Barrier Reef report card 2012 and 2013, Reef water quality protection plan. Report card key findings, Reef Water Quality Protection Plan Secretariat, Brisbane.

The State of Queensland 2013, Scientific Consensus Statement 2013. Land use impacts on Great Barrier Reef water quality and ecosystem condition.

Thompson A, Lønborg C, Logan M, Costello P, Davidson J, Furnas M, Gunn K, Liddy M, Skuza M, Uthicke S, Wright M and Zagorskis I, Schaffelke B (2013) Reef Rescue Marine Monitoring Program. Annual Report of AIMS Activities 2012 to 2013– Inshore water quality and coral reef monitoring. Report for the Great Barrier Reef Marine Park Authority. Australian Institute of Marine Science, Townsville.146 pp.

Weber, M., de Beer, D., Lott, C., Polerecky, L., Kohls, K., Abed, R., Ferdelman, T., Fabricius, K., 2012. A series of microbial processes kills corals exposed to organic-rich sediments. Proceedings of the National Academy of Sciences of the United States of America 109, E1558-E1567.