

# Great Barrier Reef region

## Chapter 5

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*“Scientific consensus is that the declining quality of water entering the Great Barrier Reef is a major threat to the inshore ecosystems.”*

*Photo courtesy of Great Barrier Reef Marine Park Authority*



## 5.1 Profile

There are 35 major creek or river catchments adjacent to the Great Barrier Reef, ranging from small tidal creeks to the largest river basins on Australia's east coast—the Fitzroy and Burdekin (Furnas, 2003). These catchments are spread across six natural resource management regions from Cape York in the north to the Burnett Mary region in the south.

Climate and soil characteristics vary across the catchments, and the interactions of soil types, topography and land use lead to substantial differences in the water quality discharged from wet catchment and dry catchment rivers (EPA, 2008). Major land uses in the Great Barrier Reef region are shown

in Figure 5.1. Grazing is the dominant agricultural land use. Sugarcane and horticultural crops dominate in the high rainfall and coastal irrigation areas. Large sections of summer and winter rain-fed grain crops and irrigated cotton are prevalent in the inland areas of the Fitzroy region.

Although the coastal catchments adjacent to the Great Barrier Reef region are relatively sparsely populated and remote, extensive land modification has occurred over the past 200 years since European settlement (Furnas, 2003; Hutchings and Haynes, 2005). Recent science has highlighted the connection between expanding catchment activity in these adjacent catchments and declining water quality in the inshore waters of the Great Barrier Reef lagoon. Long term

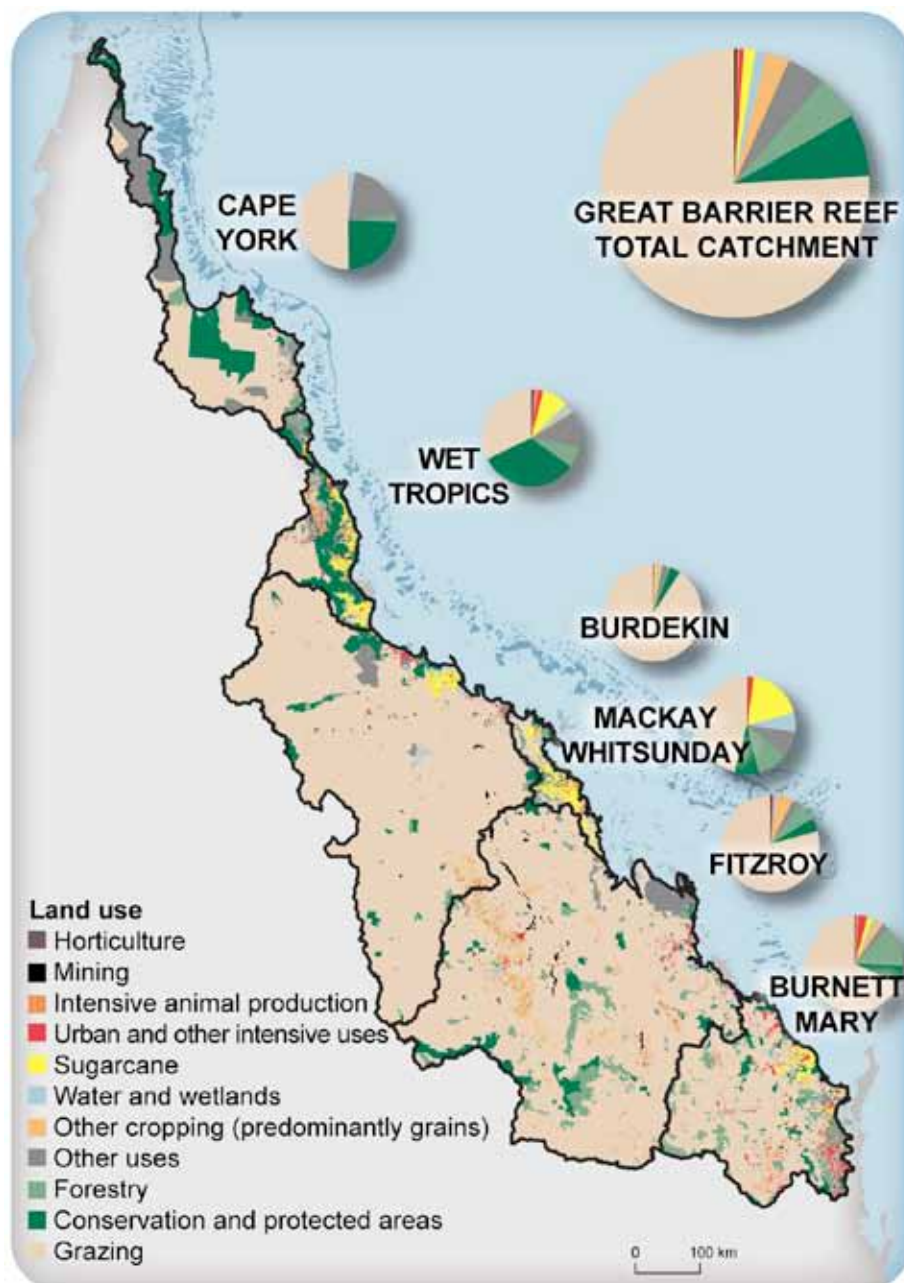


Figure 5.1 – Land use map of the Great Barrier Reef catchment.



monitoring and modelling has demonstrated that concentrations of nutrients are much higher in northern Queensland rivers adjacent to intensive agriculture than the relatively pristine rivers in Cape York (Mitchell et al., 2001); that sediment and nutrient exports to the Great Barrier Reef have increased significantly over the past 200 years (Furnas, 2003); and that flood events are critical in transporting these pollutants to the marine environment (Devlin et al., 2001). Monitoring has also shown that pesticides are being transported into river systems and the Great Barrier Reef at harmful concentrations during flood events (GBRMPA, 2009; Lewis et al., 2009). Inshore waters cover approximately eight per cent of the areas of the Great Barrier Reef Marine Park.

Scientific consensus is that the declining quality of water entering the Great Barrier Reef is a major threat to the inshore ecosystems (Department of the Premier and Cabinet, 2008). Figure 5.2 shows the key processes influencing water quality and ecosystem health in the Great Barrier Reef region. Flood events in the wet season deliver a large proportion of pollutants on to the Great Barrier Reef. Concentrations of dissolved inorganic nitrogen, dissolved inorganic phosphorus and suspended sediment are all many times higher during flood events than at other times and are well above natural loads.

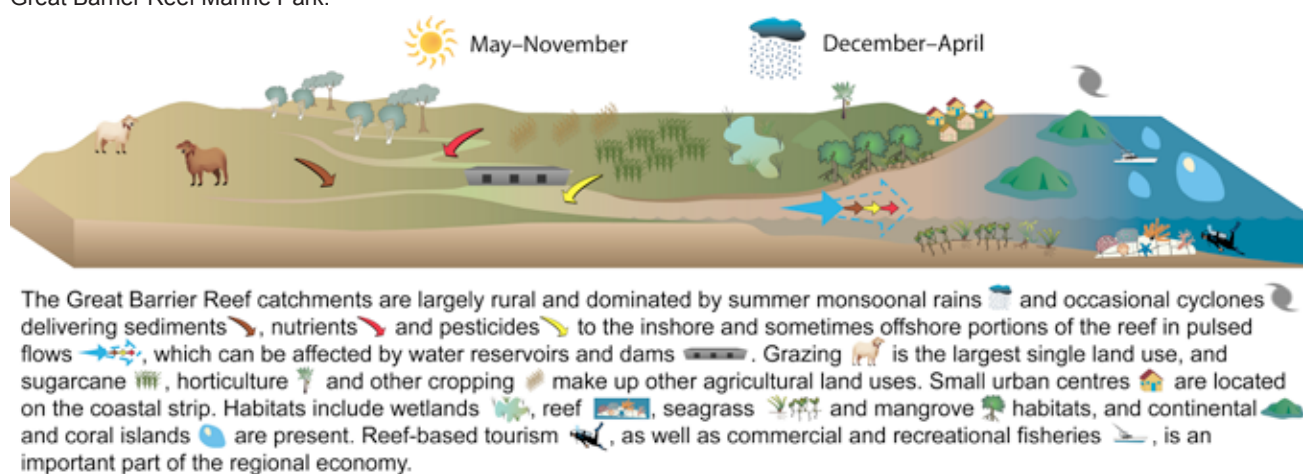


Figure 5.2 – Conceptual model showing the key processes influencing water quality and reef ecosystem health in the Great Barrier Reef region.

## 5.2 Adoption of improved management practices

### 5.2.1 Results

- Overall, cutting-edge (A) or best management (B) practices are used by 20 per cent of sugarcane growers, with 50 per cent using common (C) practices and 30 per cent using unacceptable (D) practices.
- Practices considered unacceptable by industry or community standards (D) are used by 34 per cent of sugarcane growers for nutrients.
- Fifty per cent of graziers across the Burdekin and Fitzroy regions are using (A or B) management practices that are likely to maintain land in good to very good condition or improve land in lesser condition.
- Twelve per cent of graziers in the Burdekin and Fitzroy regions are using (D) management practices that are likely to degrade land to poor condition.
- Overall, cutting-edge (A) or best management (B) practices for horticulture are used by 62 per cent of producers on 68 per cent of the land area.
- Practices considered unacceptable by industry or community standards (D) are used by 24 per cent of horticulture producers for nutrients, six per cent for herbicides and 11 per cent for soil.

The adoption of improved management practices for sugarcane, horticulture and grains is presented using the ABCD management practice framework, a suite of management practices that are recommended to maintain and/or improve water quality:

- A – Cutting-edge practice
- B – Best practice
- C – Common or code of practice
- D – Practices considered unacceptable by industry or community standards.

### 5.2.2 Sugarcane

As at 2008–2009, there are 4252 landholders growing sugarcane on 5653 square kilometers of land within the Great Barrier Reef region. The overall management practices (including nutrient, herbicide and soil) are shown in Figure 5.3 and Table 5.1. Adoption of specific nutrient, herbicide and soil management practices are also reported.

Cutting-edge (A) or best management (B) practices are used by 20 per cent of sugarcane growers on 22 per cent of the land area. Code of practice or common practices (C) are used by 50 per cent of sugarcane growers. Practices considered unacceptable by industry and community standards (D) are used by 30 per cent of growers.

Cutting-edge (A) or best management (B) practices are used by 36 per cent of sugarcane growers for nutrients and 19 per cent for soil.

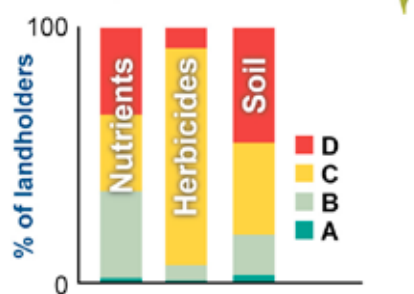
Practices considered unacceptable by industry or community standards (D) are used by 34 per cent of sugarcane growers for nutrients and 45 per cent for soil.

Cutting-edge (A) or best management (B) practices are used by only seven per cent of sugarcane growers for herbicides. The vast majority (85 per cent) are using practices for herbicides which are common practice or equivalent to code of practice (C). Practices considered unacceptable by industry or community standards (D) are used by only eight per cent of sugarcane growers for herbicides.

**Table 5.1 – ABCD sugarcane management practices for the Great Barrier Reef region.** (Source: modified from GHD, 2010a).

Combined management	A cutting-edge	B best practice	C code practice	D unacceptable practice
Number of cane growers	87	781	2145	1239
% of cane growers	2%	18%	50%	30%
Area (km <sup>2</sup> )	94	1149	2845	1564
% of area	2%	20%	50%	28%
Nutrient management	A cutting-edge	B best practice	C code practice	D unacceptable practice
Number of cane growers	84	1427	1279	1462
% of cane growers	2%	34%	30%	34%
Area (km <sup>2</sup> )	113	2091	1583	1865
% of area	2%	37%	28%	33%
Herbicide management	A cutting-edge	B best practice	C code practice	D unacceptable practice
Number of cane growers	51	252	3625	324
% of cane growers	1%	6%	85%	8%
Area (km <sup>2</sup> )	57	339	4805	452
% of area	1%	6%	85%	8%
Soil management	A cutting-edge	B best practice	C code practice	D unacceptable practice
Number of cane growers	127	665	1530	1930
% of cane growers	3%	16%	36%	45%
Area (km <sup>2</sup> )	113	1017	2148	2374
% of area	2%	18%	38%	42%

## Sugarcane practices



**Figure 5.3 – Adoption of improved sugarcane management practices using the ABCD management framework for the Great Barrier Reef region.**

### 5.2.3 Grazing

Within the combined Burdekin and Fitzroy regions there are an estimated 4418 landholders grazing cattle on 251,000 square kilometres of land.

Fifty per cent of graziers across the Burdekin and Fitzroy regions are using A or B management practices that are likely to maintain land in good to very good condition or improve land in lesser condition. Thirty-eight per cent of graziers in the combined regions are using (C) management practices that may maintain land in fair condition or gradually improve land in poor condition. Twelve per cent of graziers in the Burdekin and Fitzroy regions are using (D) management practices that are likely to degrade land to poor condition.

The Fitzroy region has 14 per cent of graziers using A practices compared to six per cent of graziers in the Burdekin region. A higher proportion of graziers in the Burdekin region are using C practices (49 per cent), compared to the Fitzroy region (35 per cent).

This report presents data on ABCD management practices, as distinct from ABCD land condition. However, these are management practices that impact upon land condition:

- A – Practices likely to maintain land in very good condition or improve land in lesser condition
- B – Practices likely to maintain land in good condition or improve land in lesser condition
- C – Practices that may maintain land in fair condition or gradually improve land in poor condition
- D – Practices likely to degrade land to poor condition.

**Table 5.2 – ABCD grazing management practices for the combined Burdekin and Fitzroy regions.**

Combined Burdekin and Fitzroy regions	A practices	B practices	C practices	D practices
Number of graziers	542	1656	1672	548
% of graziers	12%	38%	38%	12%
Area (km <sup>2</sup> )	24,186	89,489	106,398	31,407

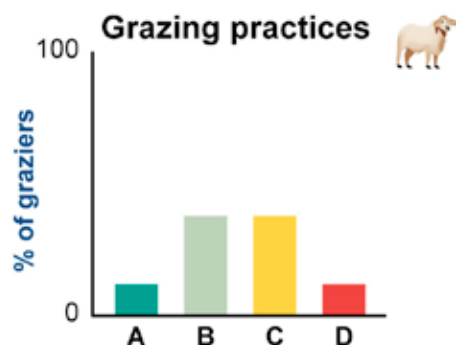


Figure 5.4 – Adoption of improved grazing management practices using the ABCD management framework for the Burdekin and Fitzroy regions.

### 5.2.4 Horticulture

There are approximately 970 producers growing horticultural crops on 668 square kilometres of land within the Great Barrier Reef region as at 2008–2009. The horticultural crops vary between regions, with major crops including bananas, paw paws, tomatoes, lychees, citrus, subtropical fruits and vegetables.

The overall management practices (including nutrient, herbicide and soil) are shown in Table 5.3. Adoption of specific nutrient, herbicide and soil management practices are also reported.

Cutting-edge (A) or best management (B) practices are used by 62 per cent of producers. Code of practice or common (C) practices are used by 24 per cent of producers. Practices considered unacceptable by industry or community standards (D) are used by 14 per cent of producers.

Cutting-edge (A) or best management (B) practices are used by 39 per cent of horticulture producers for nutrients, 78 per cent for herbicides and 70 per cent for soil.

Practices considered unacceptable by industry or community standards (D) are used by 24 per cent of horticulture producers for nutrients, six per cent for herbicides and 11 per cent for soil.

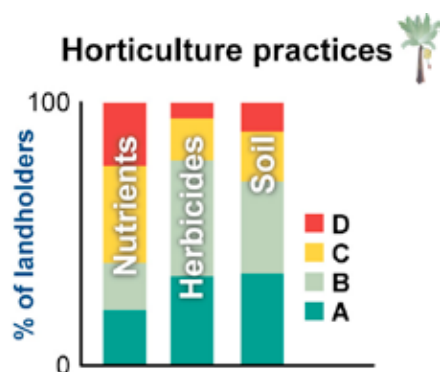


Figure 5.5 – Adoption of improved management practices for horticulture using the ABCD management framework for the Great Barrier Reef region.

The high adoption of A and B management practices in horticulture is most likely due to several factors. First, the Growcom Farm Management Systems database was the primary source of data used. This program is based on voluntary recruitment of horticultural growers, which possibly skews the results more toward A and B management. In addition, horticultural crops usually require precise management of nutrients and herbicides to achieve a profitable (i.e. marketable) crop. Also, achieving A and B soil management within horticultural tree crops, which by their nature are long term crops on permanent beds, is relatively easy to achieve.

Table 5.3 – ABCD horticulture management practices the Great Barrier Reef region. (Source: modified from Wallace S, 2010).

Combined management	A cutting-edge	B best practice	C code practice	D unacceptable practice
Number of horticulture producers	292	314	233	131
% of horticulture producers	30%	32%	24%	14%
Area (km <sup>2</sup> )	227	228	141	72
% of area	34%	34%	21%	11%
Nutrient management	A cutting-edge	B best practice	C code practice	D unacceptable practice
Number of horticulture producers	204	176	361	229
% of horticulture producers	21%	18%	37%	24%
Area (km <sup>2</sup> )	177	146	230	115
% of area	27%	22%	34%	17%
Herbicide management	A cutting-edge	B best practice	C code practice	D unacceptable practice
Number of horticulture producers	323	428	157	62
% of horticulture producers	34%	44%	16%	6%
Area (km <sup>2</sup> )	276	283	77	32
% of area	41%	42%	12%	5%
Soil management	A cutting-edge	B best practice	C code practice	D unacceptable practice
Number of horticulture growers	347	338	181	104
% of horticulture producers	35%	35%	19%	11%
Area (km <sup>2</sup> )	228	256	116	68
% of area	35%	38%	17%	10%

## 5.3 Catchment indicators

### 5.3.1 Results

- The total riparian area (area within 50 metres of the stream) in the Great Barrier Reef region as at 2008 is six million hectares, of which an estimated 100,000 hectares is likely to be susceptible to erosion (non-forested and low groundcover).
- There has been a loss of 30,000 hectares (0.49 per cent) of riparian vegetation between 2004 and 2008.
- The extent of wetlands (including vegetated freshwater swamps, lakes and mangrove/salt flats) across the Great Barrier Reef region as at 2005 is 720,000 hectares. Wetland loss since pre-European times is 14 per cent.
- Wetland loss from 2001 to 2005 was 883 hectares with up to eight per cent loss of vegetated freshwater swamps in some catchments.
- Many smaller coastal catchments with extensive lowlands have undergone widespread loss of vegetated freshwater swamps with less than 20 per cent of these original wetlands remaining in some catchments.
- The 2009 mean dry season groundcover for the grazing lands of the Great Barrier Reef region is 84 per cent, which is above the Reef Plan target of 50 per cent. This is due to higher than the historical average rainfall across many grazing areas.

### 5.3.2 Riparian vegetation

Well vegetated riparian areas play a role in stabilising river banks, which helps reduce erosion of sediments and particulate nutrients. Riparian areas also provide important ecological functions for stream ecosystems.

There are six million hectares of riparian areas across the Great Barrier Reef catchments. There are high proportions of forest and groundcover over most of the catchments' riparian areas. As at 2008, 4.7 million hectares (77.6 per cent) of riparian areas are forested, 1.2 million hectares (19.8 per cent) are non-forested but have high groundcover and 100,000 hectares (1.7 per cent) were non-forested and have low groundcover. The non-forested and low groundcover areas are likely to be susceptible to erosion and therefore sediment loss to streams. The Burdekin and Fitzroy regions have a higher proportion of areas of low riparian groundcover compared with other regions with 2.8 per cent and 2 per cent respectively.

Generally, clearing of forested riparian areas has been low overall (less than one per cent). From 2004 to 2008, 30,000 hectares (0.49 per cent) of forested riparian areas were cleared in the Great Barrier Reef catchments. The greatest proportion of clearing of forested riparian areas between 2004 and 2008 occurred in the Burnett Mary (1 per cent), followed by the Fitzroy (0.7 per cent) and Mackay Whitsunday (0.6 per cent) regions. The Cape York region (0.03 per cent) followed by the Wet Tropics (0.17 per cent) sustained the least amount of clearing of forested riparian areas between 2004 and 2008.

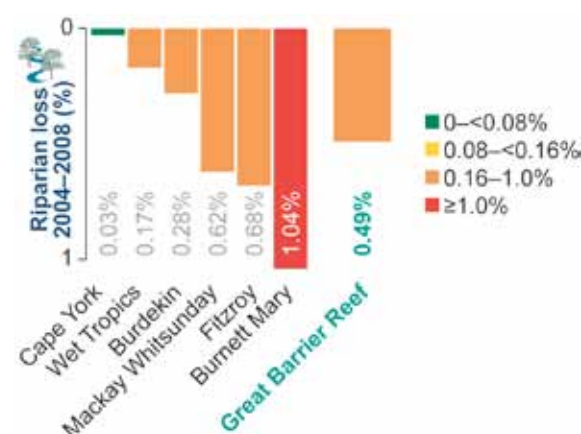


Figure 5.6 – Loss of forested riparian areas between 2004 and 2008 across the Great Barrier Reef regions.

Table 5.4 – Areas forested within the riparian buffer, non-forested with high groundcover (above or equal to 50 per cent), non-forested with low groundcover (below 50 per cent) for 2008 and the area cleared from 2004 to 2008.

Region	Total riparian buffer area (ha)	Forested		Non-forested high groundcover		Non-forested low groundcover		Missing data*	2004–2008 riparian clearing	
		Area (ha)	%	Area (ha)	%	Area (ha)	%		Area (ha)	%
Cape York	585,519	560,421	95.71	18,886	3.23	2083	0.34	0.71	198	0.03
Wet Tropics	469,606	426,772	90.88	36,361	7.74	1916	0.4	0.97	788	0.17
Burdekin	2,063,747	1,592,363	77.16	400,013	19.38	57,814	2.8	0.66	5834	0.28
Mackay Whitsunday	132,706	100,852	76.00	27,004	20.35	646	0.48	3.17	824	0.62
Fitzroy	1,881,612	1,331,269	70.75	496,123	26.37	38,237	2.03	0.85	12,702	0.68
Burnett Mary	879,403	651,410	74.07	210,841	23.98	3800	0.43	1.52	9185	1.04
<b>Total Great Barrier Reef</b>	<b>6,012,594</b>	<b>4,663,086</b>	<b>77.56</b>	<b>1,189,228</b>	<b>19.78</b>	<b>104,498</b>	<b>1.74</b>	<b>0.93</b>	<b>29,532</b>	<b>0.49</b>

\*Missing data refers to areas affected by cloud, cloud shadow, topographic shadow or areas of water within the riparian buffer.



### 5.3.3 Wetlands

Wetlands provide a natural filtration system to protect water quality. Disturbance or destruction of wetlands can result in increased sediment and nutrients flowing into streams and ultimately to the Great Barrier Reef lagoon.

#### Wetland types

As at 2005, there are approximately 720,000 hectares of wetlands mapped, which is approximately 1.7 per cent of the total area of the Great Barrier Reef catchments. Of these wetland areas:

- 250,000 hectares are vegetated freshwater swamps (palustrine wetlands). These areas occur with the greatest density in the small coastal catchments with extensive lowlands such as the Jeannie, Proserpine, Shoalwater, Burrum and the Mulgrave to Murray catchments in the Wet Tropics.
- 23,000 hectares are lakes (lacustrine wetlands).
- 446,000 hectares are mangroves/salt flats (estuarine wetlands). These wetlands occur in the greatest density in catchments such as the Jeannie, Johnstone, Haughton, O'Connell and Styx.

#### Extent of wetlands compared to pre-European times

Overall, 86 per cent of the total pre-European extent of wetlands remain across the Great Barrier Reef region. In terms of specific wetland types, 75 per cent of the pre-European extent of vegetated freshwater swamps remain across the Great Barrier Reef catchments. Loss of these vegetated freshwater swamps since pre-European times has been high in the Wet Tropics and Mackay Whitsunday regions, with 51 per cent and 47 per cent lost respectively. Many smaller coastal catchments with extensive lowlands have undergone widespread loss of freshwater swamps with greater than 80 per cent lost in catchments such as the Kolan, Pioneer, Calliope and Barron. This loss of wetlands has mainly occurred due to drainage, clearing and levelling of lowlands and parts of catchments associated with intensive agriculture. Over 90 per cent of pre-European mangroves and salt flats remain in most catchments, with the exception of the Burnett (78 per cent), Barron (71 per cent) and Pioneer (80 per cent). The Cape York (nil) and Burdekin (nine per cent) regions have had the least amount of wetlands lost since pre-European times.

Generally, there has been no great reduction in lakes compared to their pre-European extent while there has been a slight increase in lakes extent over the 2001–2005 period.

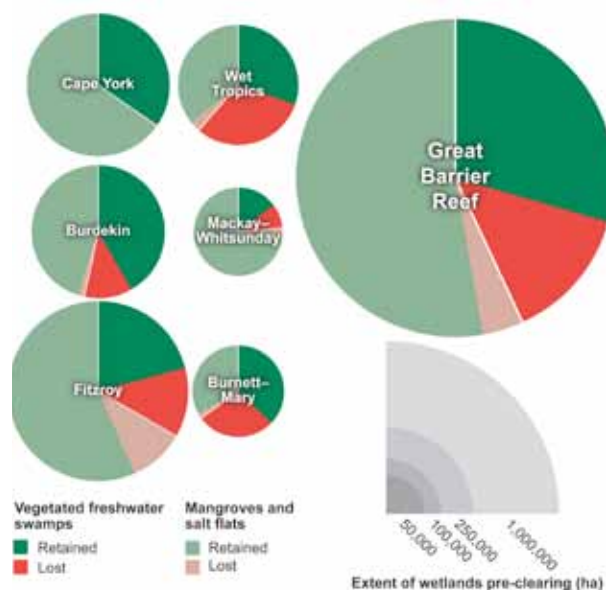


Figure 5.7 – Extent (hectares) and proportion of vegetated freshwater swamps and mangroves/salt flats remaining from pre-European extent.

#### Wetlands loss from 2001 to 2005

The combined loss of vegetated freshwater swamps and mangroves/salt flats between 2001 and 2005 was 0.12 per cent (over 800 hectares) across the Great Barrier Reef catchments. The loss of vegetated freshwater swamps between 2001 and 2005 was 0.27 per cent (approximately 640 hectares). There was a loss of vegetated freshwater swamps of greater than one per cent in the Kolan, Mossman, Mary and Murray catchments between 2001 and 2005. There was little reduction in the extent of mangroves and salt flats between 2001 and 2005.

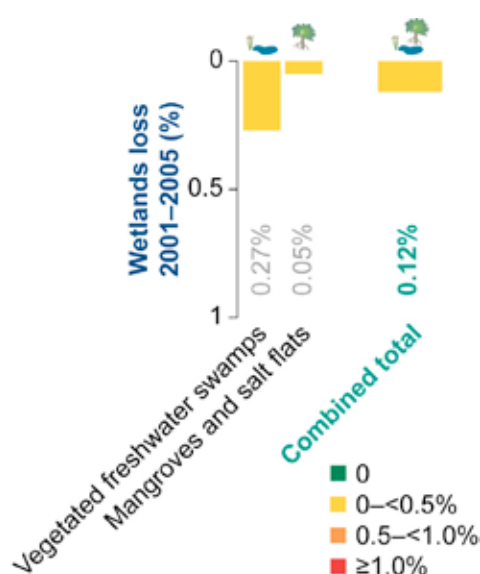


Figure 5.8 – Loss of vegetated freshwater swamps and mangroves/salt flats (between 2001 and 2005) for the Great Barrier Reef region.

**Table 5.5 – The extent of wetlands in 2005 and change between 2001 and 2005 across the Great Barrier Reef catchments for lakes, vegetated freshwater swamps and mangrove/salt flat wetlands.**

Region	Vegetated freshwater swamps			Lakes			Mangroves and salt flats			All wetlands		
	Extent 2005 (ha)	Extent (% pre-European)	Loss 2001–2005 (% of 2001)	Extent 2005 (ha)	Extent (% pre-European)	Loss 2001–2005 (% of 2001)	Extent 2005 (ha)	Extent (% pre-European)	Loss 2001–2005 (% of 2001)	Extent 2005 (ha)	Extent (% pre-European)	Loss 2001–2005 (% of 2001)
Cape York	59,135	100	0	6420	98	0	110,940	100	0	176,495	100	0
Wet Tropics	36,735	49	0.63	770	100	0	43,325	93	0.08	80,830	66	0.33
Burdekin	61,875	80	0.13	8180	99	0	66,855	98	0.03	136,910	91	0.07
Mackay Whitsunday	9695	53	0.05	205	100	0	47,780	96	0.02	57,680	88	0.03
Fitzroy	57,280	78	0.23	6965	88	-0.17	154,010	85	0.09	218,255	83	0.12
Burnett Mary	26,210	58	0.69	360	73	-7.04	23,385	95	0.05	49,955	70	0.36
<b>Total Great Barrier Reef</b>	<b>250,930</b>	<b>75</b>	<b>0.27</b>	<b>22,898</b>	<b>96</b>	<b>-0.1</b>	<b>446,295</b>	<b>93</b>	<b>0.05</b>	<b>720,125</b>	<b>86</b>	<b>0.12</b>

Note: The figures reported here pre-date the cessation of broad scale clearing of vegetation under the *Vegetation Management Act 1999* that occurred in December 2006 and the introduction of a State Planning Policy in 2010 to control earth works in wetlands of the region.

### 5.3.4 Groundcover in grazing lands

Groundcover was assessed in the grazing lands of the following areas:

- Burnett Mary
- Burdekin
- Fitzroy
- Herbert Catchment (in the Wet Tropics)
- Mackay Whitsunday.

Groundcover estimates can only be calculated for grazing lands with a foliage projective cover of less than 15 per cent. Foliage projective cover is defined as the percentage of ground area occupied by the vertical projection of foliage. This corresponds to 63 per cent of the grazing lands of the Great Barrier Reef catchments.

#### Late dry season groundcover

Groundcover is a critical attribute of the landscape, affecting soil processes and surface erosion. Low groundcover combined with heavy rainfall, often arising after overgrazing during periods of droughts or low rainfall, have led to catchment degradation in many Australian rangelands. Groundcover is influenced by a combination of factors including land use, land type, management practices and changes in climate.

The long term mean dry season groundcover for the grazing lands of the Great Barrier Reef catchments over the 1986–2009 period was 79 per cent, which is above the Reef Plan target of 50 per cent. The average groundcover in 2009 was higher than the historical average, increasing to 84 per cent. It is believed that this is a result of a number of recent wet years that have contributed to improved groundcover. However, the proportion

of the grazing area with groundcover of 50 per cent or greater in 2009 was similar to the long term mean (95 per cent).

Despite the generally higher cover, it appears that areas with low cover (less than 30 per cent) have increased in 2009, with 1.6 per cent coverage compared to the long term mean of one per cent. This is accompanied by a reduction in areas with medium groundcover (over 30 per cent and below 50 per cent) in 2009 with three per cent compared to the long term mean of 3.7 per cent. The Burdekin region had the greatest area below the 50 per cent groundcover target in 2009, with 6.3 per cent of the area below 50 per cent, including 2.3 per cent of the area below 30 per cent groundcover. A reduction in the area with groundcover over 30 per cent and below 50 per cent occurred in 2009 with three per cent compared to the long term mean of 3.7 per cent for grazing lands across the Great Barrier Reef. This may be the result of locally increased grazing activities but could also be related to flood-induced reduction in groundcover.



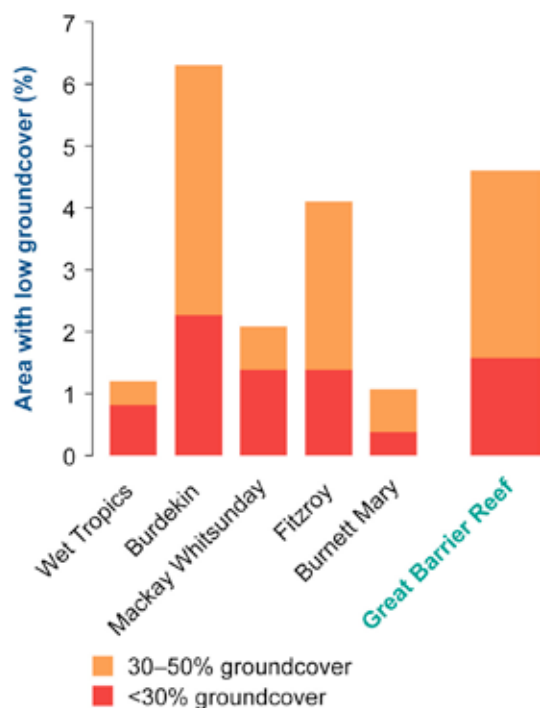


Figure 5.9 – Area with low groundcover (below 30 per cent and between 30 per cent and 50 per cent) for the Great Barrier Reef region and each dryland grazing area as at 2009.

Table 5.6 – Long term mean late dry season groundcover and 2009 groundcover showing the percentage of area below 30 per cent, 30 per cent to 50 per cent, and above 50 per cent for the regions and catchments.

Region	Total catchment area (km <sup>2</sup> )	Foliage projective cover < 15% (% of catchment)	Grazing (% of catchment)	Foliage projective cover < 15% grazing (% of grazing)	Long term mean groundcover index (%)	2009 groundcover index	Long term mean groundcover index (%)			Groundcover index 2009 (%)		
							Area < 30%	Area ≥ 30% < 50%	Area ≥ 50%	Area < 30%	Area ≥ 30% < 50%	Area ≥ 50%
Wet Tropics (Herbert catchment only)	9844	15.9	57.4	10.4	93.4	95.1	0.3	0.2	99.5	0.8	0.4	98.9
Burdekin	140,671	43.5	90.7	48.6	74.7	82.8	1.7	5.4	92.9	2.3	4.0	93.7
Mackay Whitsunday	8990	35.6	45.8	29.6	89.9	93.2	0.4	0.7	98.9	1.4	0.7	97.9
Fitzroy	155,741	50.6	79.1	55.0	79.4	82.5	0.7	3.0	96.3	1.4	2.7	95.9
Burnett Mary	53,024	34.2	69.4	41.3	87.5	92.3	0.1	0.6	99.3	0.4	0.7	98.9
<b>Total Great Barrier Reef</b>	<b>368,270</b>	<b>49.9</b>	<b>80.8</b>	<b>49.4</b>	<b>78.6</b>	<b>84.0</b>	<b>1.0</b>	<b>3.7</b>	<b>95.3</b>	<b>1.6</b>	<b>3.0</b>	<b>95.4</b>

## 5.4 Catchment loads

The baseline loads of total suspended solids, nitrogen, phosphorus and pesticides at the end of the catchment are estimated for individual regions and totalled for the Great Barrier Reef region, using monitoring and modelling data (Kroon et al., 2010). The load estimates are derived from an understanding of the land use and management practices from the period preceding Reef Plan 2009. The loads are presented as long term averages to account for the significant variability in the magnitude of flow events for a given river from year to year.

In future annual reports the baseline load estimates will be refined by using the latest catchment water quality modelling framework—Source Catchments. Source Catchments will be able to hindcast loads based on historical data and predict future loads based on combinations of future climatic and management scenarios.

### 5.4.1 Results

- **Although natural catchment loads occur, most of the loads to the Great Barrier Reef are from human activities.**
- **Annual total suspended solid loads are 17 million tonnes, of which 14 million tonnes are from human activity.**
- **The largest contribution of total suspended sediment load is from the Burdekin and the Fitzroy regions (4.7 and 4.1 million tonnes respectively), mainly derived from grazing lands.**
- **Agricultural fertiliser use is a key source of dissolved nitrogen and phosphorus runoff; annual loads of dissolved nitrogen are 31,000 tonnes of which 17,500 tonnes are from human activity.**
- **The highest total load of dissolved nitrogen is from the Wet Tropics region with 11,000 tonnes per year, of which 6300 tonnes are from human activity.**
- **All pesticides are from human activities. The total annual pesticide loads are approximately 28,000 kilograms and the highest loads are from the Mackay Whitsunday and Wet Tropics regions (approximately 10,000 kilograms each per year).**

### 5.4.2 Baseline catchment loads

The total loads leaving the catchments are significantly higher than in pre-European times (natural loads) (Kroon et al. 2010). The increase in loads due to human activity (anthropogenic loads) differs significantly across the load indicators and regions, reflecting local and regional differences in catchment land use and management, as well as local and regional topography, soil characteristics and rainfall.

The estimated total suspended solids load leaving the Great Barrier Reef catchments is 17 million tonnes per year, of which 14 million tonnes are from human activity. Most sediment originates from the extensive grazing lands of the dry (Burdekin and Fitzroy) catchments. The regions with the highest total suspended solids load are the Burdekin (4.7 million tonnes per

year) and the Fitzroy (4.1 million tonnes per year). The regions with the highest proportional increase compared to natural loads are the Burnett Mary (12 times the natural loads) and Burdekin (eight times the natural loads).

The estimated total nitrogen load leaving the Great Barrier Reef catchments is 80,000 tonnes per year, of which 66,000 tonnes are from human activity. The total nitrogen loads are similar across all regions apart from the Mackay Whitsunday region, which is lower. The regions with the highest proportional increase compared to natural loads are the Burnett Mary, Fitzroy and Mackay Whitsunday (all with approximately nine times the natural loads).

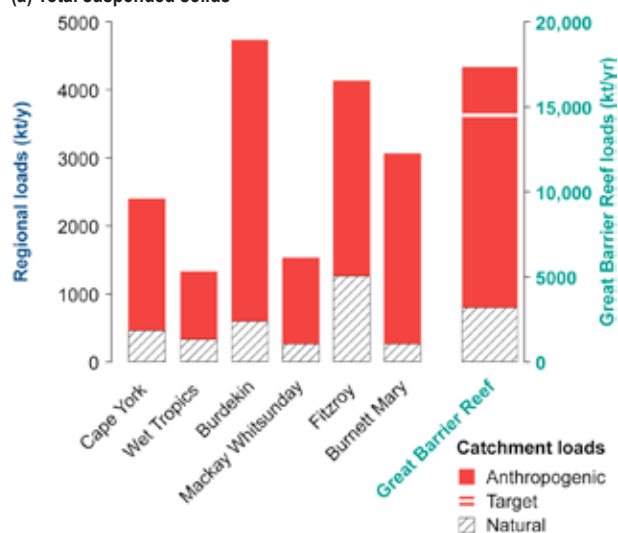
The estimated total phosphorus load leaving the Great Barrier Reef catchments is 16,000 tonnes per year, of which 14,000 tonnes are from human activity. The regions with the highest total phosphorus load are the Fitzroy (4100 tonnes per year) and the Burnett Mary regions (3100 tonnes per year). The regions with the highest proportional increase compared to natural loads are the Fitzroy (21 times the natural loads), Burnett Mary (15 times the natural loads), and Mackay Whitsunday (15 times the natural loads).

The estimated load of dissolved nitrogen leaving the Great Barrier Reef catchments is 31,000 tonnes per year, of which 17,000 tonnes are from human activity. The highest total load of dissolved nitrogen comes from the Wet Tropics region with 11,000 tonnes per year, of which 6300 tonnes are from human activity. The region with the highest proportional increase compared to natural loads is the Mackay Whitsunday region (four times the natural loads).

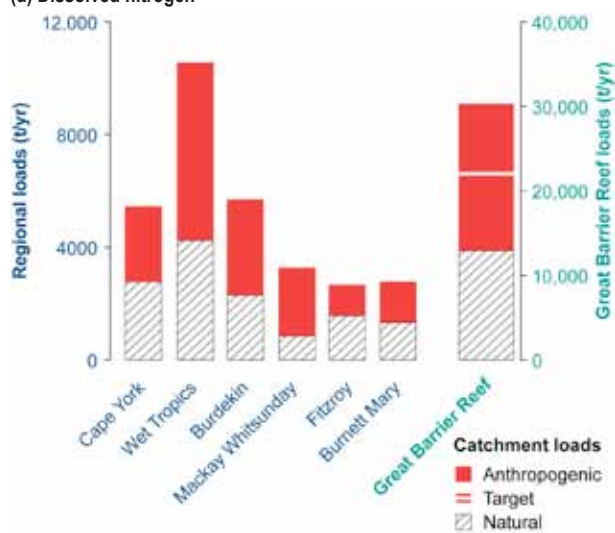
The estimated load of dissolved phosphorus leaving the Great Barrier Reef catchments is 2100 tonnes per year, of which 1300 tonnes per year are from human activity. The highest loads of dissolved phosphorus comes from the Wet Tropics region with 530 tonnes per year, of which 225 tonnes are from human activity. The region with the highest proportional increase compared to natural loads is the Mackay Whitsunday region (six times the natural loads).

The total photosystem inhibiting (PSII) pesticide load leaving the Great Barrier Reef catchments is an estimated 28,000 kilograms per year. Pesticides do not occur naturally in the environment, therefore this load is entirely from human activity. The highest estimated pesticide load is in the Wet Tropics and Mackay Whitsunday regions, each with 10,000 kilograms per year leaving the catchment. Of the pesticide residues most commonly found in surface waters in the Great Barrier Reef region, diuron, atrazine, ametryn and hexazinone derive largely from areas of sugarcane cultivation, while tebuthiuron is derived from rangeland beef grazing areas (Lewis et al., 2009). It is important to note that this estimate does not include several land uses known to leak photosystem inhibiting (PSII) pesticides (e.g. grazing, forestry, cotton, urban) and non-photosystem inhibiting (PSII) pesticides, indicating that the total pesticide pollutant load to the Great Barrier Reef is likely to be higher.

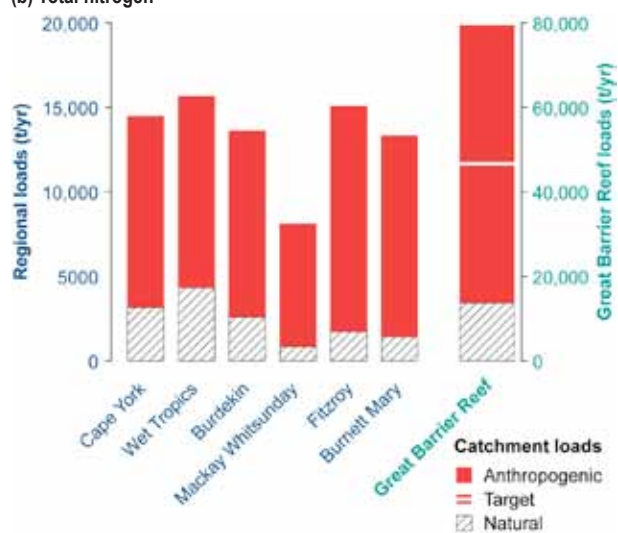
(a) Total suspended solids



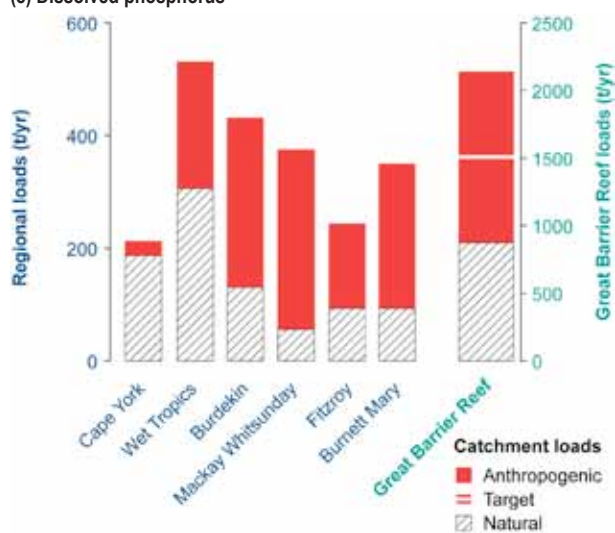
(d) Dissolved nitrogen



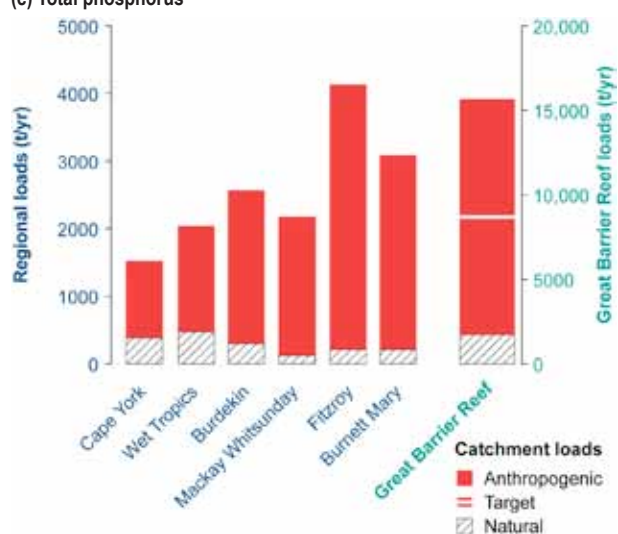
(b) Total nitrogen



(e) Dissolved phosphorus



(c) Total phosphorus



(f) Pesticides (PSII)

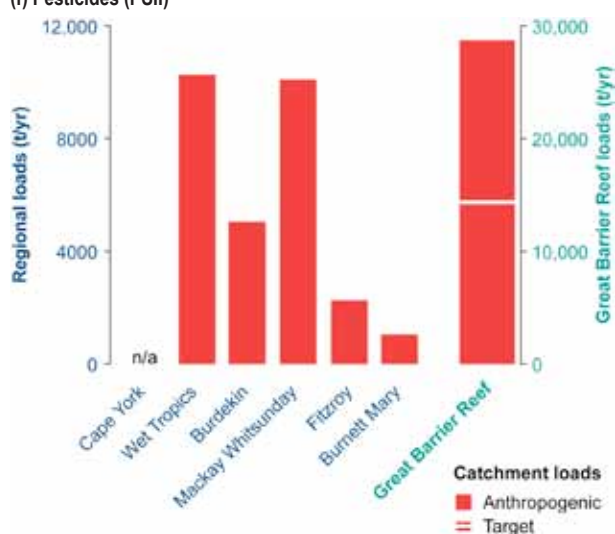


Figure 5.10 – Total and anthropogenic (caused by human activity) pollutant load estimates for the Great Barrier Reef and regions for (a) total suspended solids, (b) total nitrogen, (c) total phosphorus, (d) dissolved nitrogen, (e) dissolved phosphorus and (f) pesticides.



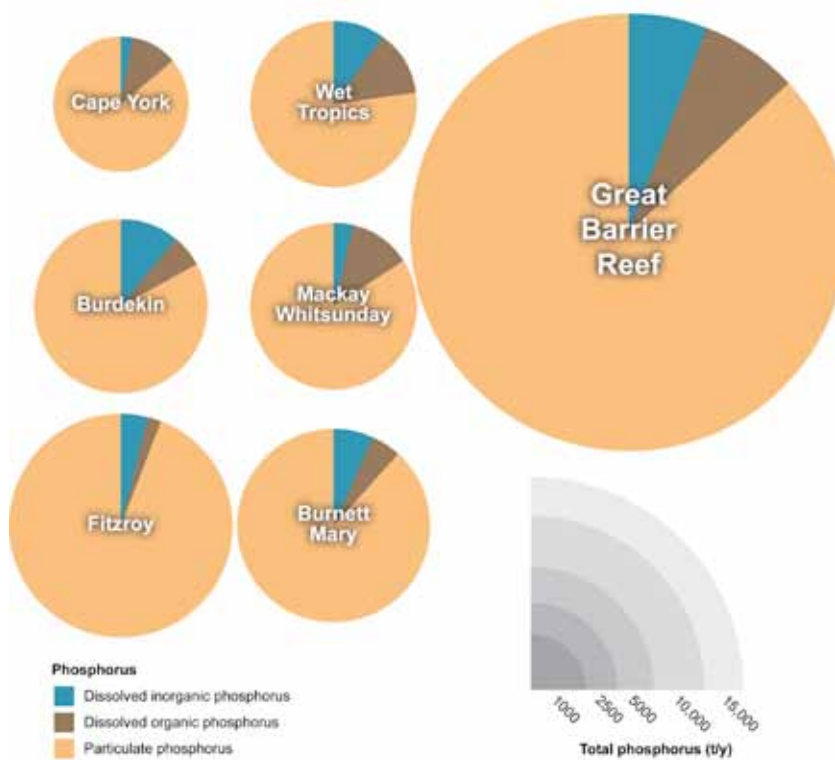
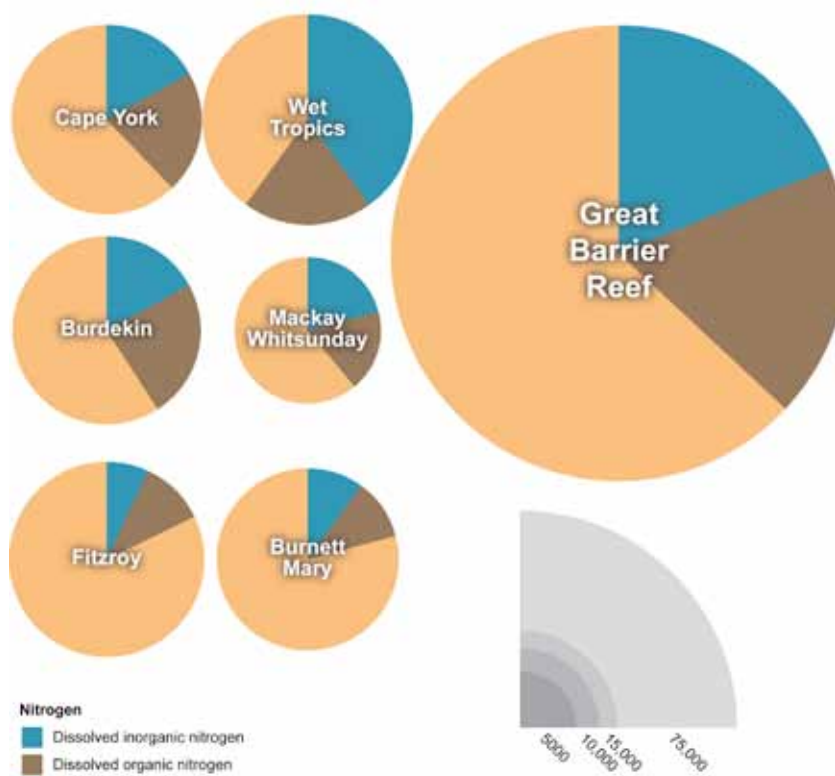


Figure 5.11 – The proportion of dissolved inorganic, dissolved organic and particulate forms of nitrogen and phosphorus leaving the Great Barrier Reef catchments.

Table 5.7 – Total and anthropogenic (caused by human activity) pollutant load estimates for the Great Barrier Reef and regions.

Catchment loads		Region						Total Great Barrier Reef
		Cape York	Wet Tropics	Burdekin	Mackay Whitsunday	Fitzroy	Burnett Mary	
TSS (kilotonnes/yr)	Natural	444	302	596	248	1259	263	3112
	Anthropogenic	1944	1058	4142	1294	2850	2813	14,101
	Total	2388	1360	4738	1542	4109	3076	17,213
TN (tonnes/yr)	Natural	2998	4400	2446	912	1672	1463	13,891
	Anthropogenic	11,340	11,176	11,139	7180	13,454	11,700	65,989
	Total	14,338	15,576	13,585	8092	15,126	13,163	79,880
DIN (tonnes/yr)	Natural	1281	1109	1096	387	770	660	5303
	Anthropogenic	1135	5972	1235	1359	337	699	10,737
	Total	2416	7081	2331	1746	1107	1359	16,040
DON (tonnes/yr)	Natural	1539	3138	1155	477	800	720	7829
	Anthropogenic	1518	350	2263	1093	785	729	6738
	Total	3057	3488	3418	1570	1585	1449	14,567
PN (tonnes/yr)	Natural	178	153	195	48	102	83	759
	Anthropogenic	8687	6872	8129	5164	12,332	10,272	51,456
	Total	8865	7025	8324	5212	12,434	10,355	52,215
DIN + DON (tonnes/yr)	Natural	2820	4247	2251	864	1570	1380	13,132
	Anthropogenic	2653	6322	3498	2452	1122	1428	17,475
	Total	5473	10,569	5749	3316	2692	2808	30,607
TP (tonnes/yr)	Natural	380	499	319	150	197	203	1748
	Anthropogenic	1136	1538	2236	2022	3945	2889	13,766
	Total	1516	2037	2555	2172	4142	3092	15,514
DIP (tonnes/yr)	Natural	48	88	20	14	13	23	206
	Anthropogenic	6	136	262	70	146	186	806
	Total	54	224	282	84	159	209	1012
DOP (tonnes/yr)	Natural	142	221	113	44	78	69	667
	Anthropogenic	19	89	38	244	8	72	470
	Total	161	310	151	288	86	141	1137
PP (tonnes/yr)	Natural	190	190	186	92	106	111	875
	Anthropogenic	1111	1573	1882	1841	3791	2631	12,829
	Total	1301	1763	2068	1933	3897	2742	13,704
DIP + DOP (tonnes/yr)	Natural	190	309	133	58	91	92	873
	Anthropogenic	25	225	300	314	154	258	1276
	Total	215	534	433	372	245	350	2149
PSII (kg/yr)	Natural	0	0	0	0	0	0	0
	Anthropogenic	ND	10,054	4911	10,019	2269	990*	28,243
	Total	ND	10,054	4911	10,019	2269	990*	28,243

TSS – total suspended solids, TN – total nitrogen, DIN – dissolved inorganic nitrogen, DON – dissolved organic nitrogen, PN – particulate nitrogen, TP – total phosphorus, DIP – dissolved inorganic phosphorus, DOP – dissolved organic phosphorus, PP – particulate phosphorus, PSII – photosystem (PSII) inhibiting herbicides.

ND – denotes lower than detectable.

\*Note: this load is based upon previous pesticide estimates compared to the other regions which use 2009 estimates.

## 5.5 Great Barrier Reef water quality and ecosystem health

Waters within 20 kilometres of the shore are at highest risk of degraded water quality. These waters are only approximately eight per cent of the Great Barrier Reef Marine Park, but support significant ecosystems as well as recreation, tourism and fisheries.

### 5.5.1 Results

- Significant rainfall events occurred between 2007 and 2009, which affected salinity levels, leading to localised coral bleaching and coral death on shallow, inshore reefs between Cairns and Townsville. Water temperatures were elevated for short periods but not long enough to sustain any widespread bleaching episodes.
- Inshore water quality is moderate overall. Concentrations of total suspended solids range from poor (Burdekin and Mackay Whitsunday regions) to very good (Burnett Mary region).
- Pesticides have been detected at all 13 inshore Great Barrier Reef monitoring sites over the past five years of monitoring. Overall concentrations were lowest in the Fitzroy region and highest in the Wet Tropics region.
- Monitoring during flood events over the past five years has detected pesticide concentrations above the guidelines at least 25 kilometres from the mouth of the Pioneer and O'Connell Rivers. Concentrations that may have short term effects on the health of marine plants have also been detected up to 50 kilometres from the coast.
- Inshore seagrasses are in moderate condition overall. Seagrass abundance is moderate and has declined over the past five to 10 years, associated with excess nutrients. The number of reproductive structures is poor or very poor in four of the six regions, indicating limited resilience to disturbance.
- Most inshore reefs are in good or moderate condition based on coral cover, macroalgal abundance, settlement of local corals and numbers of juvenile corals. Most inshore reefs have either high or increasing coral cover. However, corals in the Burdekin region are mostly in poor condition and have shown little recovery in the past four years.

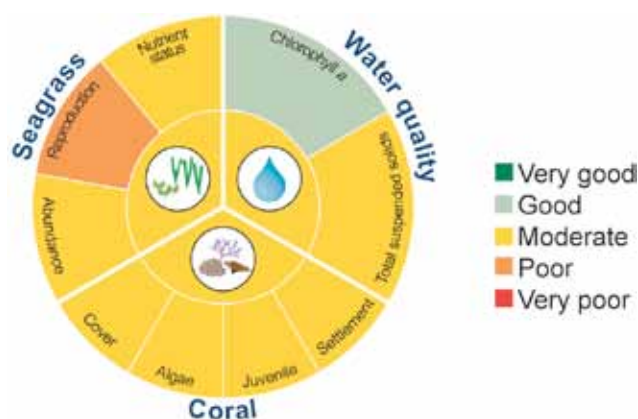


Figure 5.12 – Water quality and ecosystem health of the Great Barrier Reef showing the status of water quality, seagrass and corals.



## 5.5.2 Water quality

### Water quality: river flow and flood extent

The 2007–2009 period was unusual with regards to river flows in the Great Barrier Reef catchments. In 2007–2008, both the Burdekin and Fitzroy Rivers experienced extensive flooding, and the Burdekin River flooded again over the 2008–2009 wet season. In contrast, during the same two-year period, rivers of the Wet Tropics and Mackay Whitsunday regions (with the exception of the Herbert River) only experienced slightly above-average flow conditions without significant flooding occurring (Table 5.8). Freshwater discharge from the Great Barrier Reef catchments in 2008–2009 was two times the annual median flow, with the flow in the Burdekin River more than five times the annual median flow. The Herbert River was more than three times the annual median flow. Flow peaked in all Great Barrier Reef rivers between mid-February and mid-March 2009.

Flood plume movement across Great Barrier Reef marine waters is a consequence of the volume and duration of river (flood) flows, wind direction and velocity, as well as local marine current and tidal dynamics. Over the 2008–2009 wet season, flood plumes extended across inshore waters of the southern and northern Great Barrier Reef, but had a more limited influence on far northern Great Barrier Reef waters. Flood plumes lowered local water salinity and were associated with severe stress and localised coral bleaching and death on shallow, inshore reefs between Cairns and Townsville. While

these impacts are serious for affected reefs, damage from floodwaters was relatively minor on a reef-wide scale.

Tropical Cyclone Hamish, a category five system, tracked down the reef between 5 and 11 March 2009. Tropical Cyclone Hamish resulted in highly destructive winds over extensive offshore areas in the central to southern Great Barrier Reef. Although damage was reported reef-wide, the most severe damage occurred south of the Whitsunday group of islands. Most reef damage was sustained within 30 kilometres of the cyclone eye track. Within this area, damage was often severe on several sides of the reef, although most damage occurred on exposed windward sides of affected reefs. However, even on severely damaged reefs, pockets of untouched reef often remained. Scouring (tissue stripped off coral), coral breakage and macroalgal blooms were the most common type of impact caused by the cyclone.

### Water quality: water temperature

Extreme sea surface temperatures occurred in Great Barrier Reef waters during November and December 2008; however, prolonged monsoonal conditions from January 2009 onwards to the end of the wet season reduced temperature stress across most of the reef, keeping water temperatures below coral bleaching thresholds. As a result, mass coral bleaching did not occur over the 2008–2009 wet season, and only localised, minor temperature-induced bleaching was observed on reefs in the northern half of the Great Barrier Reef Marine Park.

**Table 5.8 – Annual freshwater discharge (in megalitres) for major Great Barrier Reef catchment rivers in 2008–2009. The median and mean annual flow is estimated from available long term time series for each river. Data was supplied by the Department of Environment and Resource Management. Long term medians were estimated from annual total flows (October to September).**

Region	River	Long term river discharge median (ML)	Long term river discharge mean (ML)	Total year discharge 2008–2009 (ML)	Difference between 2008–2009 flow and long term median (ML)	Relative magnitude between 2008–2009 flow and long term median
Cape York	Normanby	3,550,421	3,707,007	2,338,784	-1,211,637	0.66
Wet Tropics	Barron	692,447	795,275	779,456	87,009	1.13
	Mulgrave	719,625	743,399	688,515	-31,110	0.96
	Russell	1,049,894	1,051,743	1,212,230	162,337	1.16
	North Johnstone	1,845,338	1,797,648	1,986,776	141,438	1.08
	South Johnstone	810,025	801,454	1,043,893	233,868	1.29
	Tully	3,128,458	3,175,298	3,759,051	630,593	1.20
	Herbert	3,122,768	3,492,135	9,606,409	6,483,641	3.08
Burdekin	Burdekin	5,957,450	9,575,660	30,110,062	24,152,612	5.05
Mackay Whitsunday	Proserpine	35,736	70,568	63,263	27,527	1.77
	O'Connell	148,376	201,478	167,586	19,211	1.13
	Pioneer	731,441	648,238	931,808	200,367	1.27
	Plane	112,790	154,092	188,195	75,405	1.67
Fitzroy	Fitzroy	2,708,440	4,461,132	2,193,040	-515,400	0.81
Burnett	Burnett	147,814	217,511	12,079	-135,735	0.08
<b>Total</b>		<b>24,761,023</b>	<b>30,892,638</b>	<b>55,081,147</b>	<b>30,320,124</b>	<b>2.22</b>

### Water quality: chlorophyll *a* and suspended solids

Chlorophyll *a* is used as an indicator of nutrient loads in the marine system. Data analysed from satellite imagery showed that inshore waters in the Wet Tropics and Burdekin regions had elevated concentrations of chlorophyll *a* over the monitoring period (Table 5.9).

The satellite data also showed that highest concentrations of suspended solids were recorded at inshore areas of the Cape York, Burdekin and Mackay Whitsunday regions. High concentrations of suspended solids were also recorded in midshelf and offshore waters in the Mackay Whitsunday region. It should be noted that the Cape York remote sensed water quality data requires further validation.

**Table 5.9 – Summary of the exceedance of mean annual chlorophyll *a* and non-algal particulate matter as a measure of suspended solids using remote sensing data (retrieved from MODIS AQUA) for the inshore, midshelf and offshore waterbodies (1 May 2008–30 April 2009).**

Region	Chlorophyll <i>a</i> : relative area (%) of the waterbody where the annual mean value exceeds the water quality guideline value			Suspended solids: relative area (%) of the waterbody where annual mean value exceeds the water quality guideline value		
	Inshore	Midshelf	Offshore	Inshore	Midshelf	Offshore
Cape York	41	2	0	55	39	13
Wet Tropics	57	9	0	41	13	12
Burdekin	54	1	0	65	5	3
Mackay Whitsunday	24	3	0	74	42	50
Fitzroy	35	2	0	35	2	0
Burnett Mary	27	2	0	13	2	3

### Water quality: pesticides

Over the past five years of monitoring, time-integrated passive samplers have detected pesticides at all 13 inshore Great Barrier Reef monitoring sites. There are often clear differences in the types of pesticides detected between regions, which are often related to the type of agriculture practised (and types of pesticide applied) in adjacent catchments. Pesticides typically detected at inshore reef sites along the north Queensland coast include diuron, atrazine and hexazinone (Figure 5.13). Other chemicals detected regularly include simazine and tebuthiuron. Diuron is usually detected at the highest concentrations at most monitored sites, and concentrations of detectable pesticides are typically one to two orders of magnitude higher in the wet season compared with samples collected in the dry season. Pesticide monitoring in 2008–2009 detected average concentrations of pesticides below the guidelines at all monitored inshore reef sites, with clear differences between regions. Overall, average water concentrations of pesticides were lowest in the Fitzroy region (typically below two nanograms per litre) and highest in the Wet Tropics region, where the maximum average water concentrations of individual pesticides ranged from 2 to 15 nanograms per litre.

Although time-integrated passive samplers generally detect pesticide concentrations below ecosystem protection guidelines, spot sampling during flood events has detected concentrations above guidelines and above known effect concentrations (sublethal photosystem inhibition) for some organisms. The following case study discusses the results for flood plume monitoring conducted in the Mackay Whitsunday region (Lewis et al., 2009).

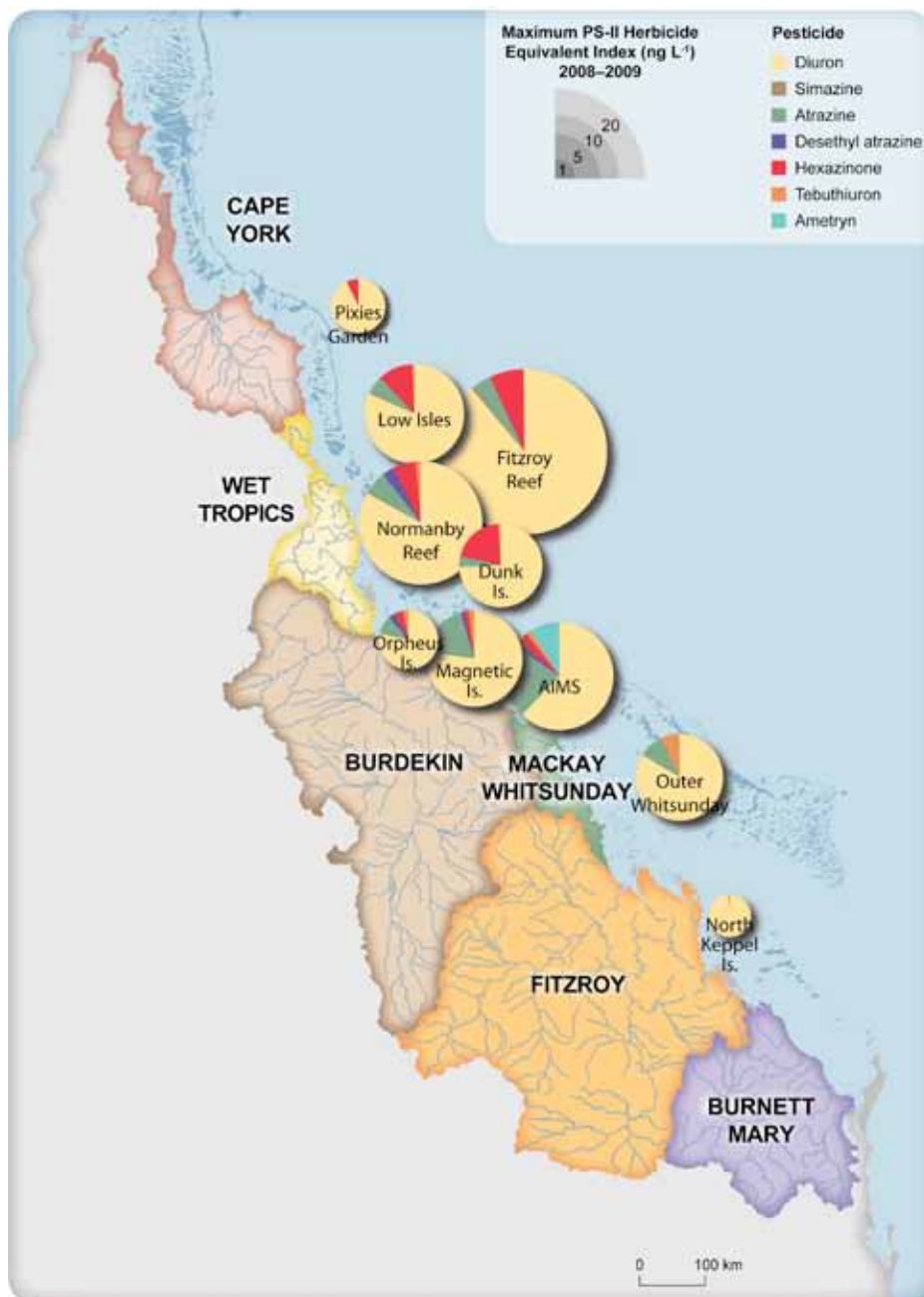


Figure 5.13 – Summary of maximum herbicide Diuron Equivalents (HEq), Great Barrier Reef, 2008–2009 from passive samplers (Source: Entox, UQ).



### Case Study: Pesticides in flood plumes in the Mackay Whitsunday region

Over 95 per cent of sediments, nutrients and pesticides are exported to the Great Barrier Reef during high river flow events that typically occur during the wet season months (January to March). The resulting flood plumes in the Great Barrier Reef lagoon carry the highest amounts of these terrestrial materials and hence have the most potential to directly impact marine ecosystems (Devlin and Brodie, 2005). Monitoring of flood plumes has been ongoing in the Great Barrier Reef for well over a decade, although the measurement of pesticide concentrations has only occurred in the past eight years. Flood plume pesticide monitoring data collected by a variety of research and monitoring programs (including Great Barrier Reef Marine Monitoring Program partners) is available for marine areas adjacent to the Tully and Murray Rivers, Russell-Mulgrave Rivers, Burdekin and Haughton Rivers, Pioneer and O'Connell Rivers, Fitzroy River and the Mary River. Pesticide monitoring during this time has revealed that several pesticides are regularly above levels of analytical detection. Some pesticide residues (diuron, atrazine and tebuthiuron) exceed concentrations that cause negative effects on marine plants or are above guideline values for the protection of the Great Barrier Reef Marine Park (Lewis et al., 2009). The highest herbicide concentrations are found at river mouths before they become diluted progressively offshore as the river waters mix with seawater. The pesticides most commonly

detected in the Great Barrier Reef inhibit the photosynthetic apparatus (PSII) of the target weed and have the capacity to impact on non-target organisms. Herbicide equivalent concentrations (PSII Herbicide Equivalent Index) have been calculated so that the herbicides that inhibit photosynthesis can be assessed additively.

Flood plume monitoring in the Mackay Whitsunday region has been conducted since 2005 by the Reef Rescue Marine Monitoring Program, Reef Catchments and Marine and Tropical Sciences Research Facility. The results of flood plume monitoring conducted in the Mackay Whitsunday region for the years 2005, 2007 and 2009 are shown in Figure 5.14. The herbicide equivalent concentration in at least one flood plume has exceeded ecosystem protection guidelines (over 900 nanograms per litre) at a distance at least 25 kilometres from the mouth of the Pioneer River (as shown in red in Figure 5.14). In addition, herbicide equivalent concentrations exceed known sublethal photosystem inhibition effect levels for either seagrass (Haynes et al., 2000: 100 nanograms per litre) or microalgae (Bengston-Nash, 2005: 50 nanograms per litre) in all monitored flood plumes, some for up to 50 kilometres from the mouths of both the Pioneer and O'Connell Rivers (as shown in yellow in Figure 5.14). This shows that herbicide residues in parts of inshore waters of the Great Barrier Reef lagoon are, at times, at concentrations known to have negative effects on marine plants.

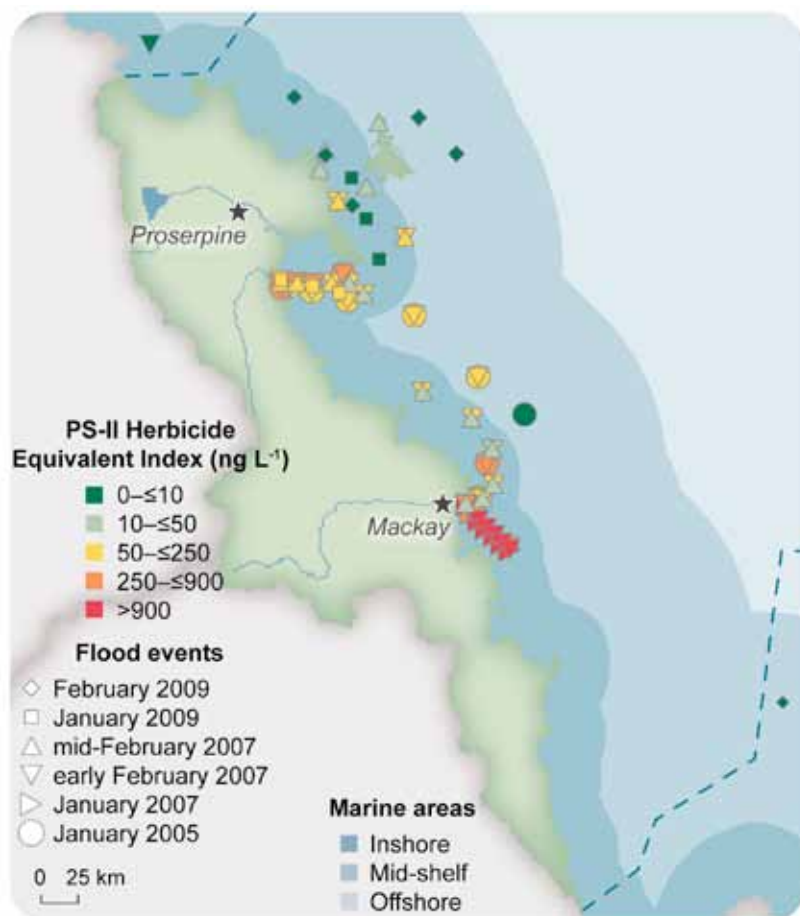


Figure 5.14 – Pesticides in flood plumes in the Mackay Whitsunday region.

### 5.5.3 Seagrass status

The types of seagrass species present in the Great Barrier Reef region vary between locations and habitats. Seagrass meadows located in inshore reef habitats tend to have more species than meadows at coastal or estuarine locations. Seagrass meadow cover (as a percentage of the substrate covered by plant material) also varies considerably between sites and locations at intertidal monitoring sites. At a Great Barrier Reef-wide scale, there is no evidence of long term sustained loss or gain in seagrass cover where monitoring has occurred, although considerable variation in cover exists between years and monitoring sites. This variation is natural inter-habitat variability and is also often a result of severe weather related impacts. Seagrass cover at some sites south of the Wet Tropics region is, however, considerably lower than the long term average for the Great Barrier Reef. Intertidal seagrass meadows in the Great Barrier Reef region also often have low or variable numbers of reproductive structures (Table 5.10). This suggests that many of these meadows may have reduced resilience to recover from future adverse environmental conditions such as flooding or mass sediment movements created by cyclonic conditions.

As bio-indicators of the environmental status of the inshore Great Barrier Reef, seagrass monitoring at intertidal sites indicates that there is a general trend of nutrient enrichment with plants growing in reducing light levels. Importantly, seagrass monitoring data from the Wet Tropics and the Burdekin regions suggests that many of these sites are showing increasing signs of nutrient saturated conditions, as seagrass tissue nitrogen levels in coastal habitats of these regions have consistently increased over the past 15 years.

### 5.5.4 Coral status

Coral reef communities are also highly variable along the length of the Great Barrier Reef. Monitoring of inshore reef communities over the past five years has provided valuable information about their condition (Figure 5.15).

Coral reef communities from the Daintree and Johnstone-Russell/Mulgrave sub-regions of the Wet Tropics have generally high coral cover (above 50 per cent) that has increased during periods without acute disturbance from cyclones and coral bleaching events. They have low macroalgae cover and relatively high densities of juvenile coral colonies.

In contrast, reefs in the Burdekin region have relatively high cover of macroalgae and moderate to low coral cover, with no clear evidence of increase in coral cover over the past five years. The limited recovery of coral cover in the Herbert Tully sub-region since Cyclone Larry in 2006 may be a consequence of riverine influence from regular flood events in the region.

The lack of recovery in the Burdekin region is concerning as there have been no obvious disturbances since coral bleaching impacted reefs in 2002, and the settlement of coral larvae in the region is low.

In the Mackay Whitsunday region, average coral cover is relatively high but has not increased despite a lack of acute disturbances in the region over the last five years. The cover of macroalgae is low and the relative density of juvenile colonies and settlement of spat is moderate relative to other monitoring regions.

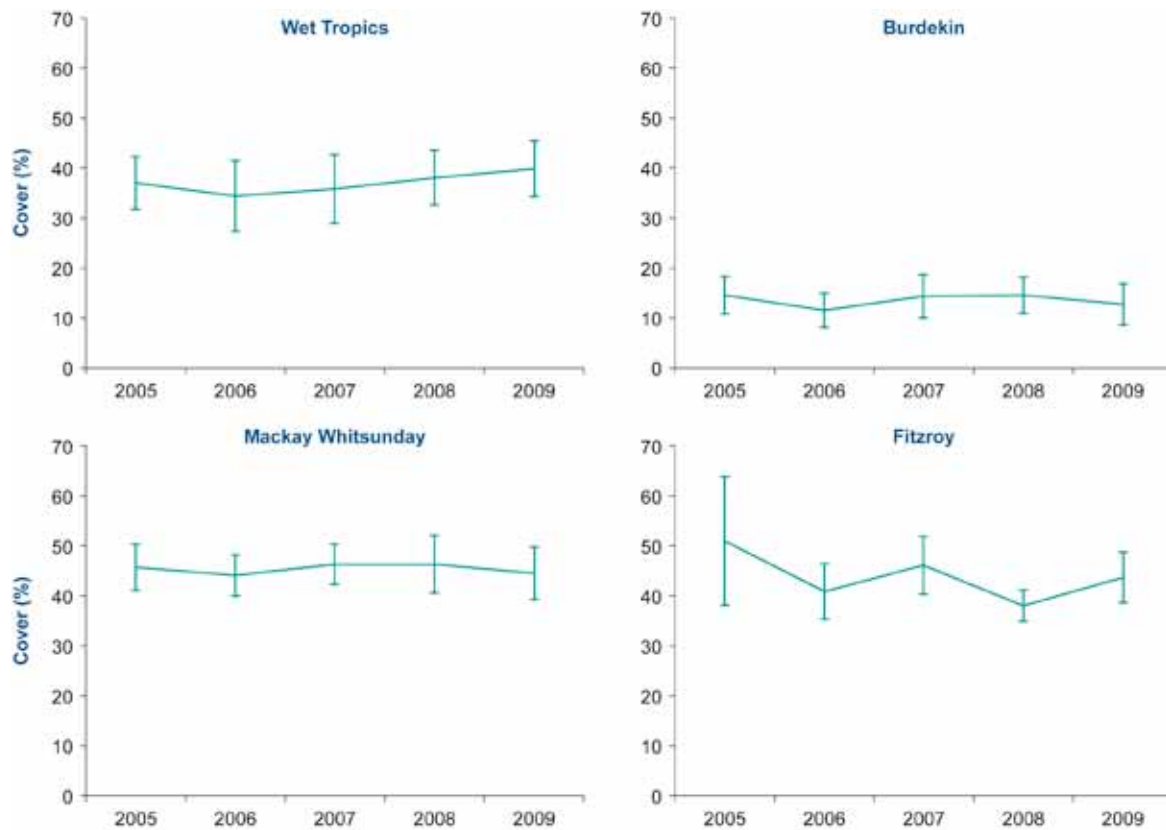
Corals in the Fitzroy region have been repeatedly affected by bleaching, causing substantial declines in coral cover in 1998, 2002 and 2006, but reefs have rapidly recovered from these past disturbances. Monitoring has found that reefs in the Fitzroy region have high cover (relative to other regions) and high (but variable) larvae settlement. However, these southern reefs also have high macroalgae cover and low juvenile coral colony densities. Recovery from disturbance in this region was usually by re-growth from fragments and not recruitment. It is currently unclear how resilient the Fitzroy region reefs would be to a disturbance that would cause widespread mortality.

Table 5.10 – Intertidal Great Barrier Reef seagrass abundance, reproductive health and nutrient status (2008–2009).

Region	Seagrass abundance	Reproductive status	Nutrient Status (C:P and N:P ratios*)	Overall status
Cape York	Moderate	Good	Good	Moderate
Wet Tropics	Moderate	Poor	Poor	Poor
Burdekin	Good	Poor	Moderate	Moderate
Mackay Whitsunday	Moderate	Very poor	Poor	Poor
Fitzroy	Good	Poor	Moderate	Moderate
Burnett Mary	Moderate	Very good	Moderate	Good

\*C:P is the ratio of carbon to phosphorus; N:P is the ratio of nitrogen to phosphorus.

## a) Coral cover



## b) Macroalgal cover

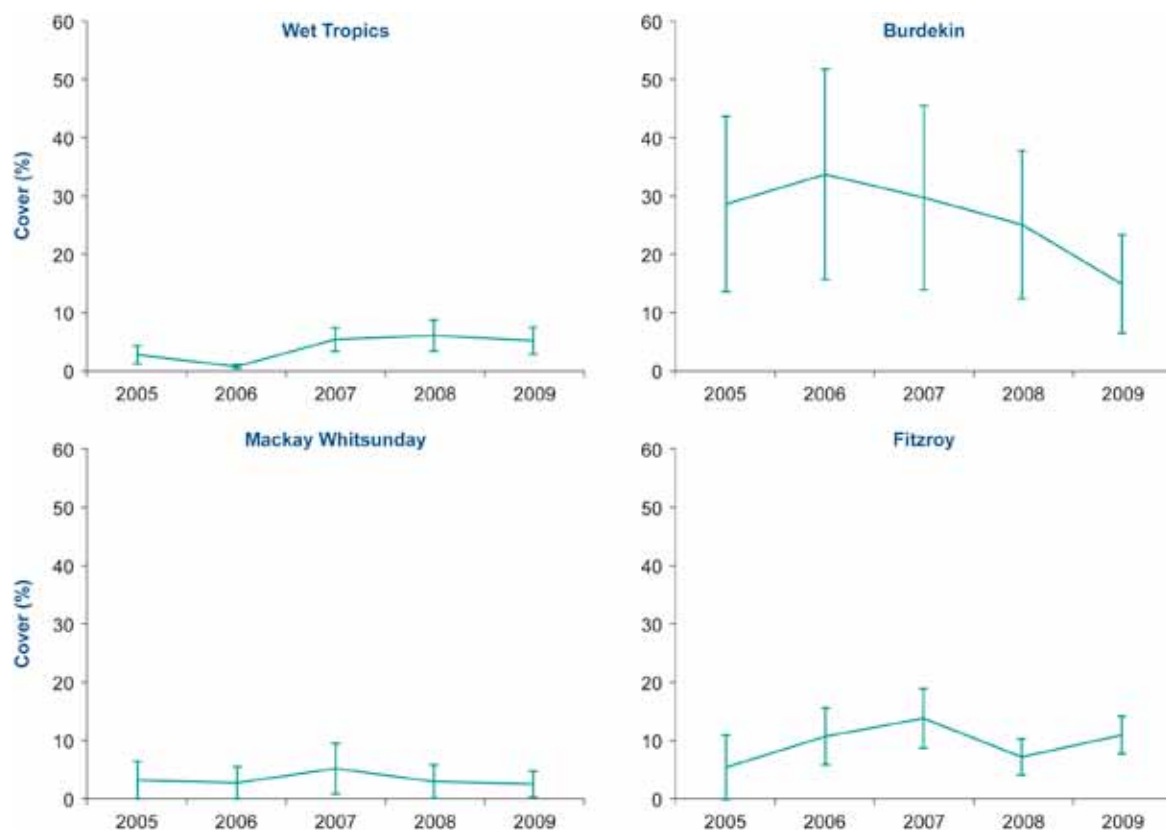


Figure 5.15 – Long term (2005–2009) trends in average ( $\pm$  standard error) hard coral (a) and macroalgal cover (b) for each natural resource management region (Source: Australian Institute for Marine Science). For each region, only reefs sampled in all years are included to ensure consistency among annual averages.