Australian Government

Great Barrier Reef Marine Park Authority

Informing the Outlook

for Great Barrier Reef coastal ecosystems

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Cover: Mouth of the Ross River, with the river winding through Townsville suburbs in the background, photograph by Julie Jones.

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The data used to undertake the spatial analysis of coastal ecosystems was provided by the Queensland Government though the Department of Environment and Heritage Protection (formally the Department of Environment and Resource Management). The conceptual models in this report have been developed by Paul Groves © Great Barrier Reef Marine Park Authority based upon scientific information contained within Vulnerability Assessments and created using symbols from the IAN symbols library at www.ian.umecs.edu/symbols.

Australian Government

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Executive summary

Great Barrier Reef coastal ecosystems (coastal ecosystems) in and adjacent to the Great Barrier Reef are the critical habitats that connect the land and sea. Healthy coastal ecosystems are critical for the long term health of the reef.

Fourteen coastal ecosystems have been identified as important to the functioning of the Great Barrier Reef: coral reefs, lagoon floor, islands, open water, seagrasses, coastline, estuaries, freshwater wetlands, forested floodplain, heath and shrublands, grass and sedgelands, woodlands, forests and rainforests. These coastal ecosystems provide the interconnections that support the physical, biological and biogeochemical process that underpin the ecosystem health of the Great Barrier Reef World Heritage (the World Heritage Area).

Coastal ecosystems and inshore biodiversity are sensitive to changes caused by modification to the natural environment, in particular land clearing and/or development. Despite considerable management efforts, several Great Barrier Reef inshore species are at risk or their numbers are declining due to pressure from human use of the environment, and these risks are compounded by the impacts of climate change. In particular, within the Great Barrier Reef there has been approximately 25 – 50 per cent decline in coral cover, primarily on reefs in the central part of the World Heritage Area that have been subjected to multiple pressures. These pressures include declining water quality, extreme weather events and increasingly frequent outbreaks of crown of thorns starfish.

These pressures are impacting both flora and fauna. For example, seagrass meadows along parts of the developed coast have been impacted by the combination of floods, cyclones and declining water quality. Significant range contractions and population declines of some fauna species have occurred as a result of past pressures. These include fishing and coastal clearing which have lead to the degradation of coastal wetlands, and the modification and barriers to water flow in local waterways. It is likely that the speartooth shark has become extinct from waterways on the east coast of Australia, as the last verified specimen was recorded in Princess Charlotte Bay in 1983.

Maintaining and restoring the coastal ecosystems and their functions in and adjacent to the Great Barrier Reef is essential to halting and reversing these declines and maintaining the Outstanding Universal Value of the World Heritage Area.

This report *'Informing the Outlook for Great Barrier Reef coastal ecosystems'* (henceforth referred to as 'the Report') is a technical report, it is the first step toward assessing the coastal ecosystems at various geographic scales and understanding their importance for maintaining the health and resilience of the World Heritage Area. The Report identifies the coastal ecosystems that have been modified and natural corridors and essential connections to the Great Barrier Reef for flora and fauna that have been lost or compromised as a result of over more than one hundred and fifty years of catchment clearing and coastal development.

The Report has identified a gradient in the differences in loss or modification of coastal ecosystems as one travels from south to north in the Great Barrier Reef catchment. Significantly more coastal ecosystems have been lost or modified in the Burnett Mary, Fitzroy and Mackay Whitsunday regions compared to the Cape York, Wet Tropics or Burdekin Dry Tropics regions. Finer (basin) scale assessments have revealed the pressures on coastal ecosystems is greatest in the coastal zone and in areas within close proximity to the coast with increasing numbers of, urban areas and its supporting infrastructure such as roads, rail and ports.

Major landuses in the Great Barrier Reef catchment (catchment) include grazing, intensive agriculture, urban areas, water supply, road and rail infrastructure, mining, ports and industry. Grazing occurs over 74 per cent of the catchment but these areas have been subjected to coastal ecosystem modification, including extensive broadscale clearing of forests, woodlands and forested floodplains to support grazing. This has resulted in a significant increase in erosion and sediment loss into rivers, streams and freshwater wetlands that eventually discharge into the Great Barrier Reef. There has been a four to five fold increase in sediment input into the Great Barrier Reef, resulting in direct impacts on inshore biodiversity.

Although intensive agriculture occurs in only five per cent of the catchment, it is isolated to the lower coastal floodplain and has resulted in a significant loss of forested floodplain and freshwater wetland ecosystems in the coastal zone. These areas have been identified as critical for many of the ecological processes (e.g. groundwater recharge and discharge, water, nutrient and sediment cycling and regulation, habitat and feeding areas, recruitment and nursery areas for ecologically important flora and fauna) which support and protect the health of the Great Barrier Reef. These areas also provide crucial links for fish species such as barramundi, mangrove jack and freshwater sawfish which may use both freshwater and saltwater ecosystems during their lifecycle.

Coastal ecosystems are also subject to indirect pressure from activities occurring further from the coast, agriculture, grazing and mining being the dominant activities historically. In recent years, as a result of the booming resource sector, mining and liquid natural gas extraction have increased, and although the footprint of the mine or extraction well may often be relatively small, the impact of the supporting resources and infrastructure can lead to fragmentation and modification or loss of coastal ecosystems. The need to increase the capacity of ports and associated infrastructure (road and rail links) to export resources has resulted in a demand to expand existing ports and a desire to open new port areas to support increased shipping in the World Heritage Area. These actions have the potential to directly impact a range of coastal ecosystems including, estuaries, coastlines, lagoon floor, water column, seagrasses and islands and the inshore biodiversity that rely on these areas such as Australian snubfin dolphin, marine turtles, dugongs and sharks if not strategically and effectively managed.

Lower floodplain connectivity and function is also affected by multiple, smaller scale activities. For example, bunding has been placed in many estuarine ecosystems to minimise tidal influence to extend intensive agriculture or to provide grazing additional areas as ponded pastures. The impact of these actions are often not immediately apparent but when considered cumulatively the repercussions include loss of coastal ecosystems and function, declines in water quality, exposed acid sulphate soils, weed invasion and decline in natural productivity and biodiversity. The main modification comprises loss of forested floodplains, freshwater wetlands, and estuarine areas, especially saltmarshes. These coastal ecosystems are critical for primary production, carbon sequestration and sediment and nutrient removal and recycling.

The *Great Barrier Reef Outlook Report 2009* highlighted that coastal development is increasing the loss of coastal habitats that support the health and resilience of the Great Barrier Reef. Human populations are projected to increase within the Great Barrier Reef catchment and Great Barrier Reef Region placing greater pressure on the coastal ecosystems that support them. Integrated planning, knowledge and compliance in managing coastal development were highlighted as poor and requiring improvement.

This Report undertook a further assessment of current management and identifies substantial actions that have been taken in the last decade or so to protect remaining coastal ecosystems. These actions range from new laws to prevent further land clearing and to protect wetlands, to major initiatives such as the *Reef Water Quality Protection Plan* that is improving agricultural land management and halting and reversing the decline in Great Barrier Reef water quality. However, it is clear that many of the changes generated by past development happened before much of the contemporary legislation and improved management practices were in place. These legacy issues are probably the most difficult to address.

The Report has identified that in order to restore and protect coastal ecosystems and manage for future coastal development, there is a need to understand the coastal processes and aquatic connectivity at a basin scale (or finer). Further analysis and planning is now required at the basin scale in order to identify additional actions that can be taken to restore the lost connectivity and functioning of these vital coastal ecosystems.

Future time series analysis of the extent of remnant vegetation will help to build a clearer picture of the extent of change in coastal ecosystems. These data, when used in conjunction with Queensland's land use data and current research, provide a basis for better management and planning decisions for the Great Barrier Reef catchment that protect the long term health and resilience of the Great Barrier Reef.

This report and the associated framework and methodology provide a tool for use in:

- integrated natural resource management (NRM) and planning
- engaging communities and stakeholders
- supporting future planning and management to build ecosystem resilience in a changing climate
- improving knowledge of coastal ecosystems and the interconnections that strengthen the physical, biological and biogeochemical process that support the health of the Great Barrier Reef.

Management of coastal ecosystems spans a range of jurisdictions and the Great Barrier Reef Marine Park Authority will continue to work in partnership with Australian and Queensland government departments and agencies, local government, regional bodies, industries, research institutions and the community to build on the findings of this Report to increase our understandings and knowledge about the role of coastal ecosystems and the management actions and strategies that can be implemented to restore and protect them.

Contents

Vision for the Great Barrier Great Barrier Reef World Heritage Area

The Great Barrier Reef was inscribed as a World Heritage Property in 1981 for its outstanding universal value. It is recognised worldwide for its amazing biodiversity, beauty, integrity and vast scale.

> ***An ecosystem is a dynamic complex of plant, animal and micro-organism communities and the non-living environment interacting as a functional unit.***
> ***(source: Millennium Ecosystem Assessment, 2005)***

The Great Barrier Reef World Heritage Area (World Heritage Area) supports Aboriginal and Torres Strait Islander tradition and culture. It also supports a wide range of highly valued economic and socially important activities including fishing, tourism, shipping, defence and research. These activities contribute in the order of $5.4 billion to the Australian economy.[1]

In 1994 the Australian and Queensland governments, together with Traditional Owners and stakeholders developed a 25 year vision for the World Heritage Area which envisaged a "healthy environment which maintains its diversity of species and habitats and its ecological integrity and resilience, parts of which are in pristine condition".[2] It also recognised sustainable multiple use as a key element of this vision and the need to have "integrated management of activities which take into account the ecological relationship between the Great Barrier Reef and adjacent areas" supported by an "informed, involved and committed community".[2]

The 25 year vision for the World Heritage Area remains central to the effective management of the World Heritage Area.

25 year vision: The Great Barrier Reef World Heritage Area will have...

A healthy environment: an area which maintains its diversity of species and habitats, and its ecological integrity and resilience, parts of which are in pristine condition.

Sustainable multiple use: non-destructive activities which can continue forever, that is, in such a way that maintains the widest range of opportunities for appropriate sustainable use, and does not adversely affect the ecological integrity of its natural systems.

Maintenance and enhancement of values: the continuation and enhancement of diverse aesthetic, ecological, economic, cultural and social values, providing for the aspirations of residents, users, Aboriginals and Torres Strait Islanders and the global community.

Integrated management: management of activities which takes into account the ecological relationship between the area and other adjacent areas, particularly the mainland.

Knowledge-based but cautious decision making in the absence of information: decisions based on a commitment to research, monitoring and review using data and experience from all sources and erring on the side of caution in the absence of information.

An informed, involved, committed community.

(Source: 25 year Strategic Plan Vision for the Great Barrier Reef World Heritage Area, 1994)

1. Introduction

The Great Barrier Reef is recognised as one of the largest, most intact and complex ecosystems on Earth. Its amazing diversity supports tens of thousands of marine and terrestrial species, many of which have recognised global significance. Management of the Great Barrier Reef recognises that this natural asset exists within a rich social, cultural and economic environment which utilises many of these natural resources to enrich the wellbeing and enjoyment of international, Australian, Queensland and local communities.

The *Great Barrier Reef Outlook Report 2009* (Outlook 2009)[3] captured current knowledge of the Great Barrier Reef ecosystem, its use, its management and its vulnerability to the pressures it is facing now and into the future. Although the *Outlook Report 2009* identified coastal development as one of the highest risks to the Great Barrier Reef, and assessed the Great Barrier Reef Marine Park Authority's (GBRMPA) effectiveness in managing that risk as lowest of all management categories, it did not provide sufficient detailed analysis to help plan a strategic way forward to improve the situation.

Coastal ecosystems connect the land to the sea. This report assessed the coastal ecosystems connecting the 35 basins forming the Great Barrier Reef catchment (the catchment) to the Great Barrier Reef World Heritage Area (the World Heritage Area). This provides an understanding of the coastal ecosystems that have the potential to influence its health and resilience. The Report identifies changes to the coastal and inshore ecosystems since European settlement, and assesses the implications for the Great Barrier Reef.

This Report has been developed to provide further detail necessary to inform the future management of the World Heritage Area, catchment and the inshore species reliant on a healthy environment and in particular the management of Great Barrier Reef. It describes how the inshore marine, coastal and catchment ecosystems are interconnected and reliant on one another for their functions, and illustrates how species that form part of the amazing biodiversity of the World Heritage Area live in and move between these ecosystems throughout their life cycles.

A legacy of past land use practices has led to degradation of coastal ecosystems and water quality, and very marked declines in inshore biodiversity. Agricultural and urban expansion, mining and development of ports and related infrastructure occurring in the catchment and along the coast are further impacting inshore biodiversity. These development pressures must be considered in the context of declining water quality from catchment runoff, historic and some remaining impacts of fishing, climate change and recent cyclones and the extreme weather events of 2010–2011. The management challenge is to ensure that current activities are ecologically sustainable, and that management actions are in place to restore the ecological functions of coastal ecosystems affected by human and extreme weather events.

This Report documents the present distribution, status, use and the cumulative pressures on coastal ecosystems at the catchment and basin scales. It presents vulnerability assessments for each of the coastal ecosystem types, which describe the status of and pressures on these coastal ecosystems and outlines the management actions in place and further actions required to address those pressures.

The management challenge is not only to ensure that any future development in and adjacent to the Great Barrier Reef World Heritage Area is ecologically sustainable. A legacy of past development and land use practices has led to degradation of Great Barrier Reef coastal ecosystems and water quality, and very marked declines in inshore biodiversity. Management actions are also required to halt and reverse those declines and restore the ecological functions of coastal ecosystems.

1.1. Scope of the report

The World Heritage Area extends 2300 km along the Queensland Coast from the tip of Cape York in the north to approximately Bundaberg in the south, extending seaward to the outer boundary of the Great Barrier Reef Marine Park (Marine Park). It encompasses an area of 348,000 km^2. The adjacent catchment encompasses an area of 424,000 km^2 and contains a diverse range of terrestrial, freshwater and estuarine ecosystems including tropical rainforests, drier tropical and subtropical woodlands, forests and forested floodplains, freshwater wetlands, heathlands and grasslands and a variety of coastline communities including sandy beaches and rocky headlands, extensive mangroves, saltmarshes and mudflats.

Management and protection of the coastal ecosystems that support the health and resilience of the Great Barrier Reef is challenged by complex factors originating beyond the jurisdictional boundaries of the Great Barrier Reef. Therefore, it is relevant that this Report looks beyond the boundaries of the Great Barrier Reef and assesses the coastal ecosystems and the current land use of the 35 basins forming the catchment that is connected to the World Heritage Area.

The area examined in this report includes ecosystems extending from the inshore marine area of the Marine Park, which covers approximately 10 per cent of Reef waters, to the upper extent of the catchment (figure 1.1).

This Report seeks to provide an assessment of the coastal ecosystems and the role they play in maintaining the health and resilience of the World Heritage Area and its adjacent catchment. The findings of this Report will be used to inform the Outlook Report 2014. Additionally the report and the associated framework and methodology provide a tool for use in:

- integrated Natural Resource Management (NRM) and planning
- engaging communities and stakeholders
- supporting future planning and management to build ecosystem resilience in a changing climate
- improving knowledge of coastal ecosystems and the interconnections that sustain the physical, biological and biogeochemical processes that support the health of the Great Barrier Reef.

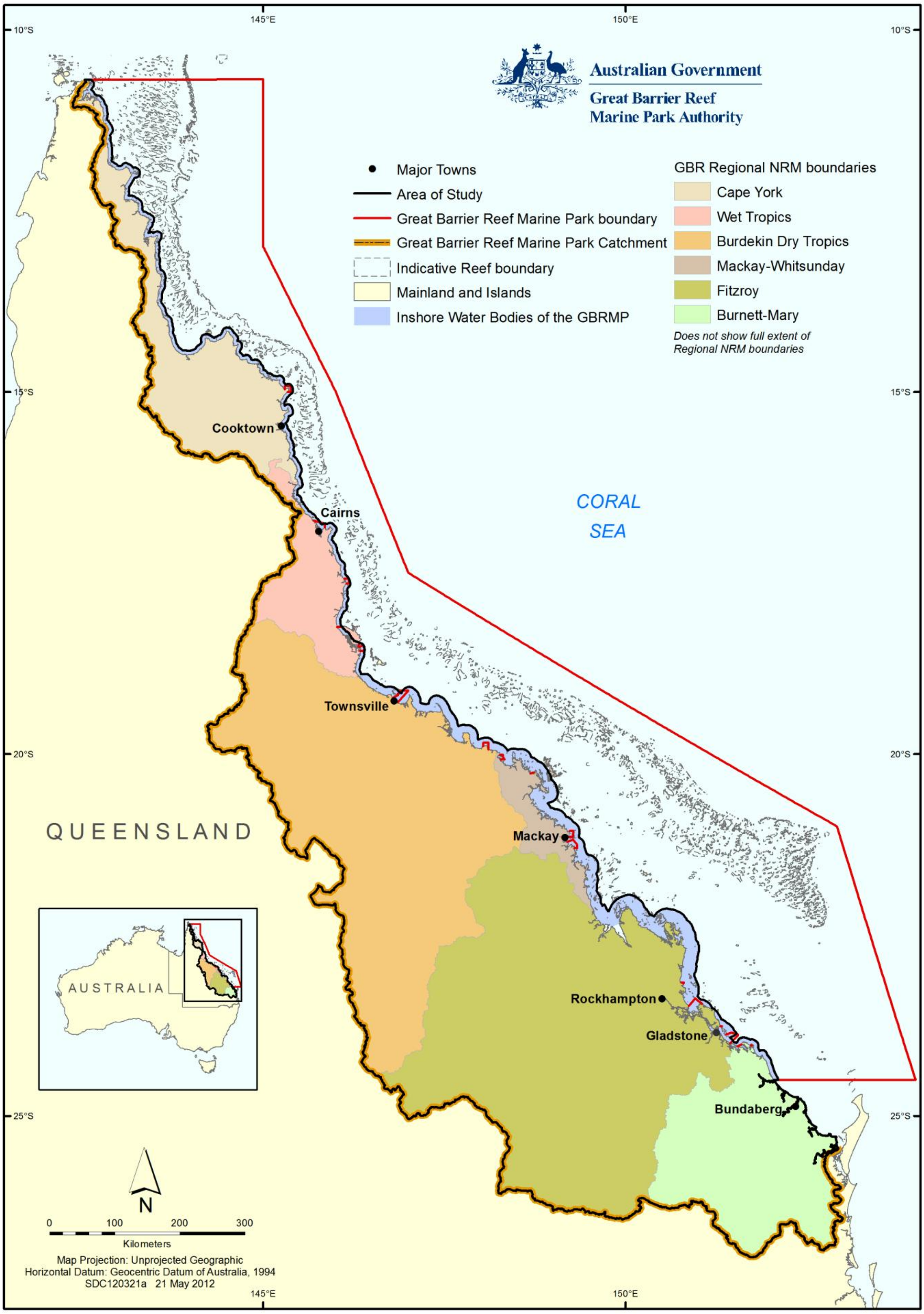

Figure 1.1: Areas of interest within the catchment and inshore waters.

1.2. Key terminology

Basins:	An extent or an area of land where surface water channels to a hydrological network and discharges at a single point i.e. river, stream, creek.
Coastal zone:	Area of coast as defined by the Queensland Coastal Plan 2011.
Coastal Ecosystem:	Inshore, coastal and adjacent catchment ecosystems that connect the land and sea and have the potential to influence the health and resilience of the Great Barrier Reef. For this study, this includes the Great Barrier Reef catchment and 10% of the Reef waters seawards of the coastline
Ecosystem:	A dynamic complex of plant, animal and micro-organism communities and the non-living environment interacting as a functional unit. (source: Millennium Ecosystem Assessment 2005)
Ecosystem function:	The interactions between organisms and the physical environment, such as nutrient cycling, soil development and water budgeting.
Inshore marine areas:	Include (but not limited to) those areas extending up to 20 km offshore from the coast and which correspond to enclosed coastal and open coastal water bodies as described in the *Water Quality Guidelines for the Great Barrier Reef Marine Park (2010)*.
Great Barrier Reef catchment (catchment):	The 35 river basins in Queensland which drain into the Great Barrier Reef (table 1.1).
Natural Resource Management (NRM) regions:	A group of basins managed by non government organisations (NRM bodies) within Queensland (table 1.1).
Natural Resource Management (NRM) bodies:	Non government organisations funded through Commonwealth grants to run environmental and sustainable agriculture programs
Non Remnant:	Vegetation that does not meet the criteria of remnant vegetation as defined under the Vegetation Management Act 1999.
Pre-clear:	Queensland government reconstruction of regional ecosystems to represent vegetation pre-European settlement.
Post-clear:	Queensland mapping of the state of regional ecosystems that occurred in 1999 and 2009.
Remnant vegetation:	Vegetation that meets all of following criteria: • 50 per cent of the predominant canopy cover that would exist if the vegetation community were undisturbed • 70 per cent of the height of the predominant canopy that would exist if the vegetation community were undisturbed • composed of the same floristic species that would exist if the vegetation community were undisturbed.
Regional Ecosystem:	Regional ecosystems (REs) are vegetation communities that are consistently associated with a particular combination of geology, land form and soil in a bioregion. The Queensland Herbarium has mapped the remnant extent of regional ecosystems for much of the State using a combination of satellite imagery, aerial photography and on-ground studies. Each regional ecosystem has been assigned a conservation status which is based on its current remnant extent (how much of it remains) in a bioregion. Some areas of Cape York have not been mapped.
Vulnerability:	The degree to which a system or species is susceptible to, or unable to cope with, adverse effects of pressures. Vulnerability is a function of the character, magnitude, and rate of variation or change to which a system or species is exposed, its sensitivity, and its adaptive capacity.

Table 1.1: Regional breakdown of the scale of assessments used to analyse coastal ecosystems and land use. (Refer to section four)

	NRM regions	Basins	
Great Barrier Reef catchment	**Cape York NRM region** (managed by Cape York NRM)	Jacky Jacky	Coastal zone as defined by Queensland State Coastal Management Plan 2011
		Olive-Pascoe	
		Lockhart	
		Stewart	
		Normanby	
		Jeanie	
		Endeavour	
	Wet Tropics NRM region (managed by Terrain)	Daintree	
		Mossman	
		Barron	
		Mulgrave-Russell	
		Johnstone	
		Tully	
		Murray	
		Herbert	
	Burdekin Dry Tropics NRM region (managed by NQ Dry Tropics)	Black	
		Ross	
		Haughton	
		Burdekin	
		Don	
	Mackay-Whitsunday NRM region (managed by Reef Catchments)	Proserpine	
		O'Connell	
		Pioneer	
		Plane	
	Fitzroy NRM region (managed by Fitzroy Basin Association)	Styx	
		Shoalwater	
		Waterpark	
		Fitzroy	
		Calliope	
		Boyne	
	Burnett-Mary NRM region (managed by Burnett Mary Regional Group)	Baffle	
		Kolan	
		Burnett	
		Burrum	
		Mary	

1.3. Addressing long term declines in coastal habitats and inshore biodiversity

The *Outlook Report 2009* identified coastal development, declining water quality, climate change and some fishing activities as among the major issues putting the long term health and resilience of Great Barrier Reef ecosystems at risk. All of these pressures affect coastal ecosystem functions. Coastal development and declining water quality are not solely Great Barrier Reef-based pressures, and in fact predominantly originate from our use of the adjacent land. While the Australian and Queensland governments, who are responsible for the Great Barrier Reef's management, have put in place an array of tools to protect its values, its long-term outlook in 2009 was still assessed as poor. This is, in part, because the Great Barrier Reef ecosystem is made up of many complex components, including estuarine and marine ecosystems (for example mangroves, seagrasses and inshore coral reefs) that are closely linked to adjacent coastal ecosystems (such as freshwater wetlands, coastlines, and floodplains). These coastal and inshore systems are the ones most at risk from development pressures and the ones that have been significantly modified or affected by development in the past.

A review of landscape health in 2001 identified significant areas of the southern and central catchment, and associated marine systems, as being subject to continental landscape health stress.[4] The review highlighted there are strong biological, bio-physical and ecological links across the landscape, from catchment to reef, and that activities in the catchment affect the coastal floodplain, rivers and estuarine systems and can dictate the health of these systems. An assessment completed in 2002 by the Land and Water Audit identified that over half of the Great Barrier Reef's 35 basins (catchments, rivers and estuarine systems) were in a poor condition, and that only in the area north of Cooktown were basins in a relatively good condition.[5]

The impacts of recent extreme weather (figure 1.2), including the result of unprecedented losses of seagrass, dugongs and marine turtles from the urban coast of the Great Barrier Reef have highlighted the fragility of the inshore ecosystems along the developed parts of the Great Barrier Reef coast. These extreme weather events, which occurred in late 2010 and early 2011, led to an extensive reduction or loss of seagrass meadows between Cairns and Hervey Bay.[6] This resulted in the number of reported dugong deaths more than doubling in the southern Great Barrier Reef, when compared with all other years since stranding records (records of injured or deceased species of interest that wash up on beaches) commenced in the mid 1990s. There were 189 dugong deaths reported in 2011, compared with 87 for the previous year. The stranding of green turtles was also significantly higher compared with previous years. As of 3 April 2012, reported deaths in 2011 were 1526 compared to 821 in the previous year, based on unpublished data collected by the former Department of Environment and Resource Management (DERM).

While the loss of dugongs in 2011 is unprecedented in recent times, historically the dugong population along the urban or developed coast had already been reduced by approximately 90 per cent since the early 1960s.[7] Similarly, while the scale of the seagrass decline in 2011 was also unprecedented[8], the Reef Water Quality Protection Plan (Reef Plan) Marine Monitoring Program reports for 2008–2009 and 2009–2010,[9,10] have reported an ongoing decline in the health of Great Barrier Reef seagrass meadows in parts of the developed coast over the past five to six years of monitoring.

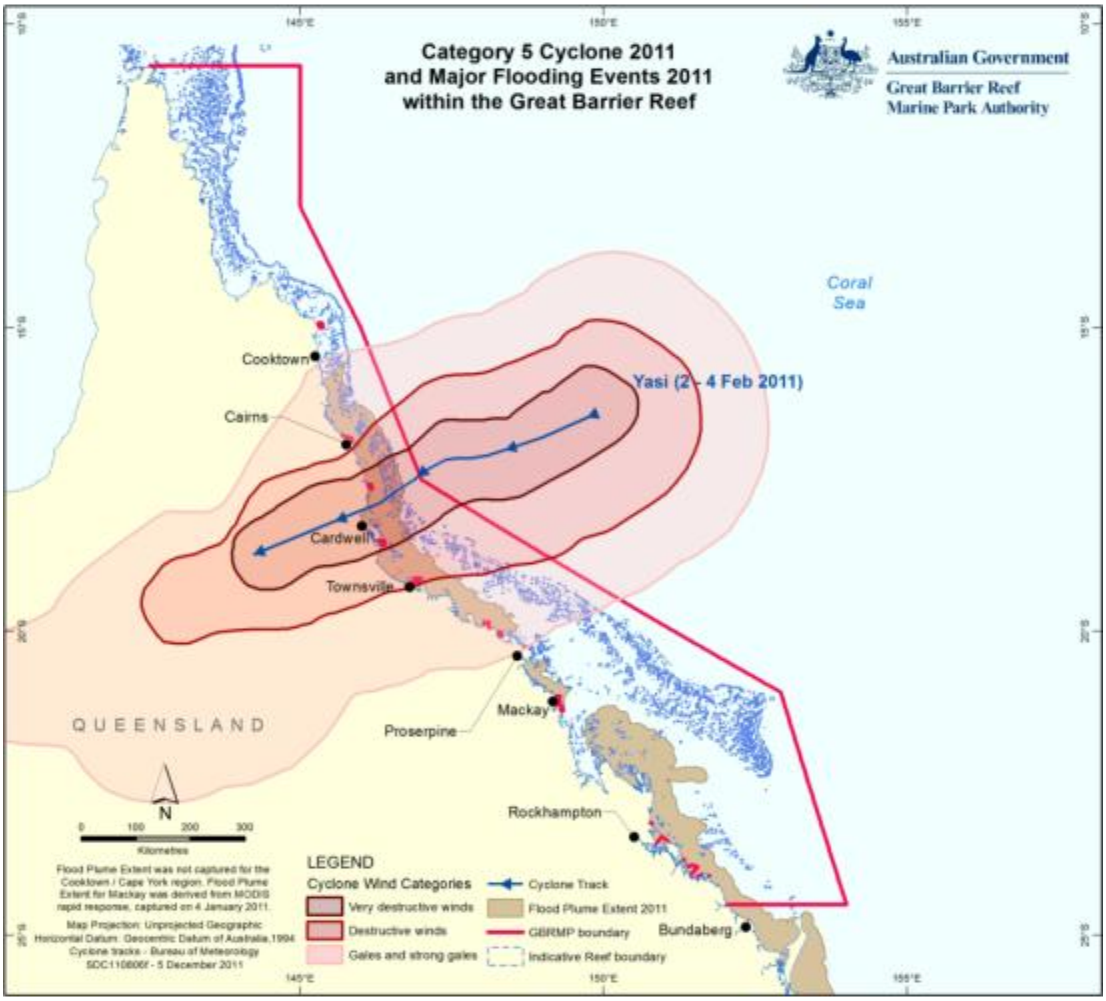

Figure 1.2: Track path of cyclone Yasi overlaid with the major flood plume extents that occurred in 2011

Changes to coastal and inshore ecosystems date back to before the decline in dugong along the urban coast, which has been apparent from at least the 1960s. Recently scientists have used sediment cores taken from inshore reef flats to assess changes in coral communities over more than 800 years. This research found that the predominant *Acropora* species coral assemblages at Pelorus Island (in the Palm Group located just north of Townsville) had remained stable for more than 800 years, until the 1930s when a collapse of these *Acropora* occurred and the reefs declined to monospecific assemblages.[11] Researchers have concluded that these changes are a direct result of changes to water quality following large scale vegetation clearing on the adjacent coast.

Cumulative pressures, including changes to coastal and inshore ecosystems have also affected a range of other species. For example, significant range contractions and population declines have occurred for the freshwater and green sawfish, which led to both being listed as vulnerable species under the *Environment Protection and Biodiversity Conservation Act 1999*. Most concerning of all, is that it is possible that the speartooth shark, listed as critically endangered under the *Environment Protection and Biodiversity Conservation Act 1999*, is now possibly extinct on the east coast of Australia. Not a single specimen was found when recent surveys were undertaken to determine the east coast population of the speartooth shark, which means the last verified specimen was recorded in 1983 from the Bizant River, which flows into Princess Charlotte Bay.[12] Each of these species is dependent on coastal habitats, including riverine and estuarine systems. The widespread introduction of mono-filament fishing nets is thought to be the major contributor to the decline of these two species. Elsewhere the modification of estuarine and inshore ecosystems is also likely to have been a significant contributor.

One of the main reasons inshore species are particularly vulnerable is that they often have life history traits and behaviours which predispose them to exposure to human-related threats. Many have relatively long lives with a reliance on a small home range. This is a trait exhibited by the recently described Australian snubfin dolphin. Recent evidence also suggests commonly fished species such as king threadfin salmon and grey mackerel also exist as discrete local populations at spatial scales of less than 100 km. These localised inshore populations are particularly susceptible to cumulative impacts associated with declining water quality, coastal development and intensive localised fishing pressure.

Despite being right on our doorstep, little is known about many inshore species and their habitat requirements or even their population status.[3,13] Inshore waters are often turbid, making scientific surveys very challenging. Nevertheless, in today's terms it seems inconceivable that a large marine mammal like the Australian snubfin dolphin is so poorly known that its conservation status cannot even be assessed under the *Environment Protection and Biodiversity Conservation Act 1999*, but this is the case for this species. What we do know is that this inshore specialist feeds on fish and squid in shallow waters (less than 5 metres deep), and is typically found in bays with large river systems surrounded by extensive estuarine systems draining into them. Research has shown that these dolphins generally live in small groups (around 100 animals per embayment), maintain very small home ranges (less than 200 km^2), with little or no interchange of animals from nearby bays. This maintenance of small home ranges means this inshore species is particularly susceptible to localised extinction, especially from human-related threats that are often land based.

Since European settlement, the variability in the nature of landscapes (topography, soils and rainfall patterns) has driven variability in land use patterns and practices, and as a consequence there have been more significant changes to the catchment in certain areas. This report seeks to assess the extent of those changes, their implications for the World Heritage Area, and the management strategies in place or required to halt and reverse the declines in inshore biodiversity.

1.4. Climate change

Climate change will exacerbate the pressures on coastal ecosystems over the coming decades. The House of Representatives Report *Managing our coastal zone in a changing climate: the time to act is now*[14] concluded that:

- *coasts are experiencing the adverse consequences of hazards related to climate and sea-level rise (very high confidence)*
- *coasts will be exposed to increasing risks, including coastal erosion, over coming decades due to climate and sea-level rise (very high confidence)*
- *the impact of climate change on the coast will be exacerbated by increasing human-induced pressures (very high confidence)*
- *adaptation costs for vulnerable coasts are much less than the costs of inaction (high confidence)*
- *the unavoidability of sea-level rise, even in the longer- term, frequently conflicts with present-day human development patterns and trends (high confidence).*

Queensland is second only to New South Wales in terms of the extent of built infrastructure in the identified coastal hazard areas as well as having highly valuable natural coastal resources likely to be affected by climate change, if management of the coast does not allow for the natural coastal processes to occur.[15]

Climate change forecasts for Queensland's regions show by 2070 there will be a trend of increasing air temperatures, including an increase in the number of days over 35 degrees celsius which is likely to have repercussions for fire regimes across the catchment. [16] [17] Rainfall changes with likely overall decreases with extended periods between events, and increases in evaporation rates may change fire regimes and further exacerbate loss of ground cover during dry periods.

Extreme events are likely to increase in intensity, with storm surges penetrating further inland and cyclones occurring further south. This will greatly increase the risk to ecosystems and infrastructure in low-lying areas.[17] Five severe cyclones have impacted the Great Barrier Reef since 2005, with four of those making landfall and impacting upon coastal ecosystems. The Great Barrier Reef ecosystem has evolved under a natural regime of cyclones and floods, so in many ways severe weather is 'normal'. However, data collected between 1995 and 2009 shows 33.8 per cent of all coral mortality recorded in long-term monitoring of the Great Barrier Reef by the Australian Institute of Marine Science is attributable to storm damage[18]. An additional 5.6 per cent of coral mortality has been attributed to coral bleaching.[18] Bleaching is largely the result of extreme seasonal sea surface temperature anomalies but it is also occasionally associated with extensive flooding that creates a freshwater lens. This sits on top of the heavier seawater, which extends out into the inshore environment and can result in coral mortality.

Severe cyclones and increased sea surface temperature anomalies are predicted to occur more frequently as the climate warms, bringing a future where the recovery potential of coral reefs and seagrass meadows becomes increasingly important. Chronic stresses from reduced water quality can hinder recovery of damaged seabed communities. Therefore, the combined effect of increased flooding, increased temperatures and more severe storms means efforts to restore the natural resilience of important habitats such as coral reefs and seagrass meadows are more important than ever before. Despite its size, in the last decade there have been few areas of the Great Barrier Reef that have not been affected by flooding and cyclonic events (figure 1.3).

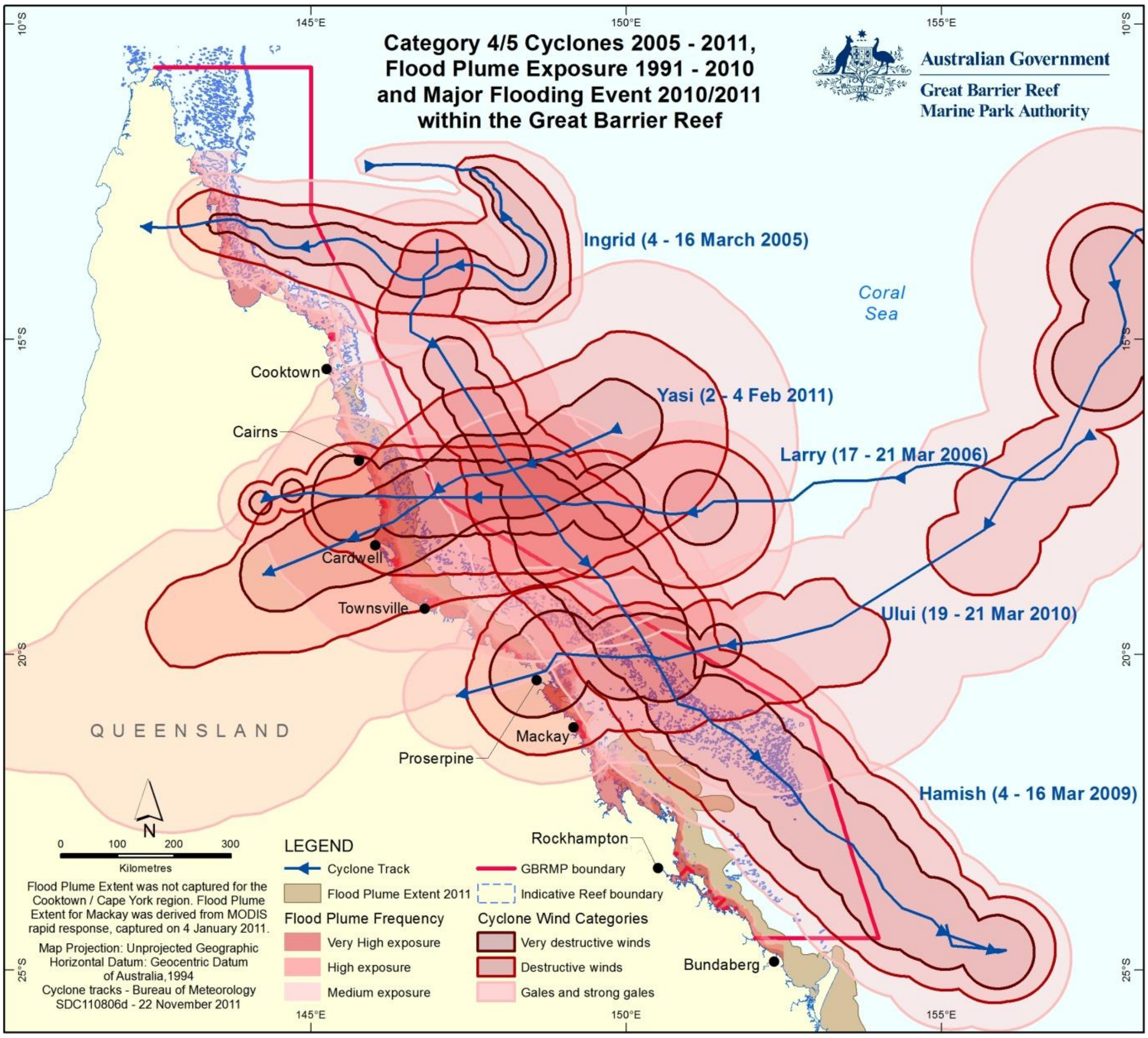

Figure 1.3: Area of the Great Barrier Reef affected by the cumulative impacts of major cyclones in the last six years overlaid with the major flood plume extents over the last two decades.[6]

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2. Process for reviewing the outlook for Great Barrier Reef coastal ecosystems

The process for reviewing the implications of increasing coastal development pressures on the long – term health and resilience of the Great Barrier Reef is outlined in figure 2.1. This process evolved from the results and recommendations arising from the *Outlook Report 2009*[1], the Reef Water Quality Protection Plan[2] and the Queensland Wetlands Program[3].

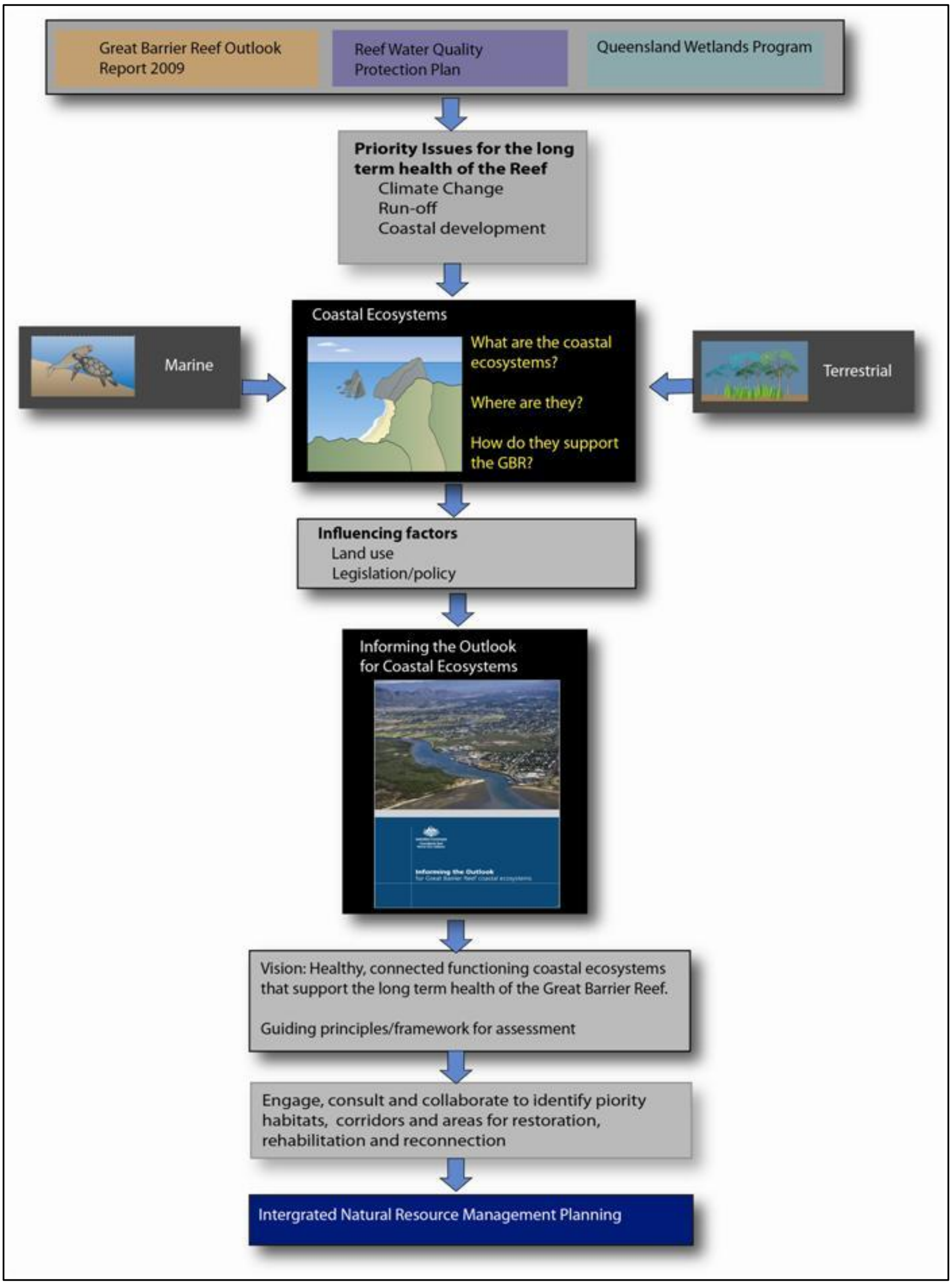

Figure 2.1: Drivers, methods and planned outcomes for considering the effects of coastal ecosystems on the health and resilience of the Great Barrier Reef.

This review was a multi-step process that began with a literature assessment, workshops with experts to define functional coastal ecosystems and to develop a conceptual understanding of these ecosystems' ecological functions. Data from the Representative Areas Program (the basis of the re-zoning of the Marine Park in 2004) was used for the marine assessment. Workshops with experts in coastal ecosystem functionality categorised the catchment into broad ecosystem types. Further expert workshops provided advice on how the ecosystem functions would change with land use modifications, and the consequential environmental, social, cultural and economic implications.

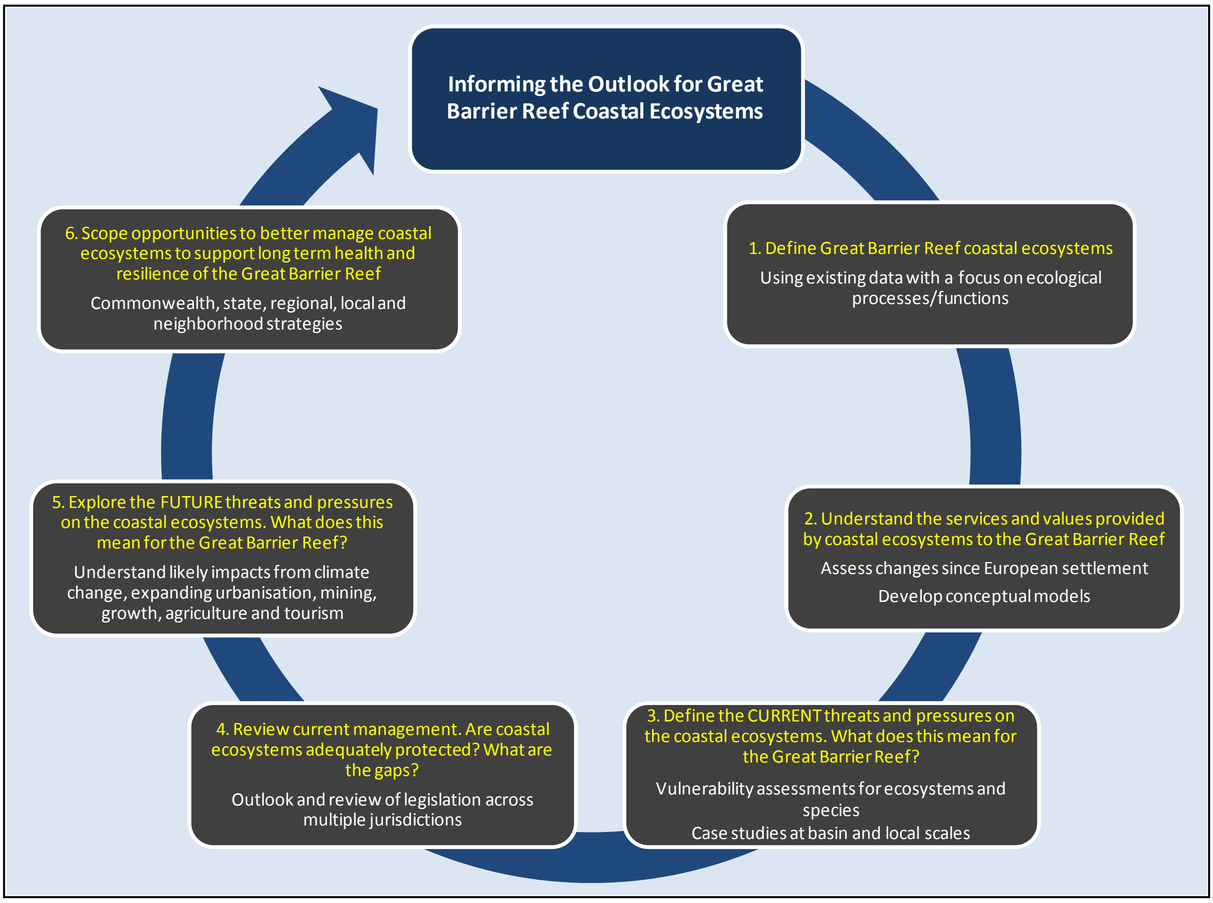

Figure 2.2: Methods and tools used for defining and assessing functions of coastal ecosystems and assessing threats, pressures and management.

The methodology used to undertake the assessment is represented diagrammatically at figure 2.2. Key components of the work included:

- In June 2010, the Great Barrier Reef Marine Park Authority (GBRMPA) organised a workshop that brought together ecosystem experts to identify functional coastal ecosystems and the ecological roles they play in sustaining the health of the Great Barrier Reef ecosystem and species. A key product of this workshop was the development of a conceptual model (refer to section 3, figure 3.3).
- Spatial data available from the Queensland Department of Environment and Heritage Protection (formerly the Department of Environment and Resource Management) has been assessed based on the State's Regional Ecosystems (REs) which are defined as vegetation communities that are consistently associated with a particular combination of geology, landform and soil in a bioregion. Coastal ecosystems have been grouped based on this information in order to:
  - map the pre-clear (pre-European) extent of coastal ecosystems
  - map and compare the current extent of those functional coastal ecosystems
  - determine and map the current land use that are the drivers of change to catchment and coastal ecosystem functions.

- Coastal ecosystems were then mapped across the 35 river basins that make up the catchment including the inshore waters of the Great Barrier Reef to assess how these ecosystems have been changed or modified by human activities. Four spatial scales were used: the catchment, the regional NRM areas, the basins and the coastal zone area (as defined by the State Coastal Management Plan 2011) within each of the NRM areas. This enabled assessments to be undertaken at a variety of scales from Great Barrier Reef wide, through the NRM region, individual basins and lastly to specifically defined areas, for example the coastal zone (from the coast 5 km or 10 AHD, whichever is further).
- In August 2011, the agency and the former Department of Environment and Resource Management jointly organised a 2nd Expert Ecological Advisory Workshop bringing together experts to develop an integrated understanding of current ecosystem function, including exploring the implications of modifying these functions.
- The agency has completed vulnerability assessments for each of the coastal ecosystems. These vulnerability assessments document our present knowledge of their distribution, status and function; the pressures (or drivers of change) they are experiencing and the risk or hazard they pose to the ecosystem and existing management arrangements. These vulnerability assessments have been summarised in the report and will be available at www.gbrmpa.gov.au.

The assessment of coastal ecosystems also draws on the work of the draft *Great Barrier Reef Biodiversity Conservation Strategy 2012* (in press) as it relates to inshore biodiversity. Vulnerability assessments developed to guide the implementation of the Biodiversity Strategy have identified the most at-risk habitats, species and groups of species in the World Heritage Area.

2.1. Spatial data analysis

The Marine Park extends approximately 2300km along the Queensland coastline. Thirty five basins (smaller catchments) make up the Great Barrier Reef catchment, covering a land area of approximately 424,000 square kilometres. Water moving over the land is collected, stored, used and eventually discharged through a network of interconnected rivers, creeks and streams at the coast, eventually making its way to the Great Barrier Reef. Landuse in the catchment influences the quantity and quality of water received by the Marine Park.

In response to the *Outlook Report 2009*, the agency embarked on a project to gather and synthesise information to better understand how the health of the Great Barrier Reef is supported and influenced by coastal ecosystems. To define the coastal ecosystems the project needed to:

1. use existing spatial data that was current, verified, maintained and updated for the whole catchment.
2. use spatial data that supports current Queensland legislation and regulatory mechanisms that manage, protect and conserve ecosystems in the catchment.
3. build upon the existing Queensland Wetlands Program mapping.
4. develop a repeatable methodology for describing coastal catchment ecosystems.

Regional ecosystem mapping

The Queensland Herbarium has mapped the remnant extent of regional ecosystems for the state of Queensland using a combination of satellite imagery, aerial photography and on-ground studies[4]. Regional ecosystems are vegetation communities that are consistently associated with a particular combination of geology, land form and soil in a bioregion. This mapping provides a spatial representation of the pre-clear and current extent of regional ecosystems. The comparison of these layers provides a reporting mechanism for monitoring regional ecosystem vegetation change in the catchment and was used to map the coastal ecosystems. This data is available online at a www.ehp.qld.gov.au/ecosystems/biodiversity/regional-ecosystems/maps/index.php and is updated every two years.

A repeatable methodology has been developed for grouping coastal ecosystems based on the regional ecosystem data from the Queensland Government. This methodology will allow updated data to be re-analysed and compared to previous regional ecosystem mapping. Having a time-series of the extent of remnant vegetation will help to build a clearer picture of the role these coastal ecosystems play in the long term health and resilience of the Great Barrier Reef. The detailed methodology for mapping coastal ecosystems can be found in Appendix I.

Queensland land use mapping

The Queensland Land Use Mapping Program (QLUMP) is a collaborative project between the Department of Environment and Heritage Protection and the Bureau of Rural Sciences and is part of the Australian Collaborative Land Use Mapping Program. The project uses remote sensing data. Information for the catchment is available for 1999 and 2009, with data available for some basins for 2004.[5]

Land use information is grouped by the mapping program into six primary categories, they are then grouped into secondary and tertiary classifications. For example, under the primary classification *Conservation and Natural Environments*, there are secondary classifications of *Nature Conservation, Managed Resource Protection* and *Other Minimal Use*. Under the secondary classification of *Other Minimal Use,* there are four tertiary classifications: *Defence, Stock Route, Residual Native Cover* and *Rehabilitation.*[6]

For this analysis, the mapping program categories were re-grouped to better reflect the ecological functions that these modified landscapes provide for the Great Barrier Reef. For example, within the program's primary category *Water*, the tertiary categories of *River Conservation, Marsh/Wetland Conservation* and *Estuary/Coastal Waters Conservation* were removed and placed under the primary classification *Conservation and Natural Environments.* This separated the conservation element from the other tertiary categories of *Production* and *Intensive Uses* that resided within the primary category W*ater.*

Other land use classifications were isolated from the primary classifications so their impact could be more readily identified. These included the secondary classifications of *Forestry, Grazing, Sugar, Intensive Animal Production, Urban Residential, Mining* and *Ports*. The tertiary classifications of *Marsh/Wetland Production, Lake Production* and *Estuary/Coastal Waters Production* were also isolated and grouped under a new secondary classification *Water – Production Ponded Pastures.* This also applied to *Lake, River, Marsh/Wetland* and *Estuary/Coastal waters Intensive Use* tertiary classifications – these were grouped into a new secondary classification *Water – Intensive Uses*.

A repeatable methodology has been developed for grouping the data based upon their influences on coastal ecosystems. This methodology allows updated data to be reanalysed and compared to previous years. Having a time series of the extent of land use change will help to build a clearer picture of the impacts these changes have on coastal catchment ecosystems, and the flow-on affects for the long-term health and resilience of the Great Barrier Reef.

The detailed methodology for mapping changes in land use can be found in Appendix I.

2.2. Vulnerability assessments

To support the development of this report, vulnerability assessments were completed for the key coastal ecosystems identified in this report. These vulnerability assessments used the components of previous work[7] (figure 2.3) and were used to:

- document the present distribution of the ecosystem.
- document the major pressures on and key sources of vulnerability for each ecosystem.
- document their ecological role and function, ecosystem services and connections and how these influence the health and resilience of the Great Barrier Reef.
- identify present management tools and appropriate and practical management actions that could be taken to mitigate risk and enhance ecosystem resilience for the long term benefit of the Great Barrier Reef.

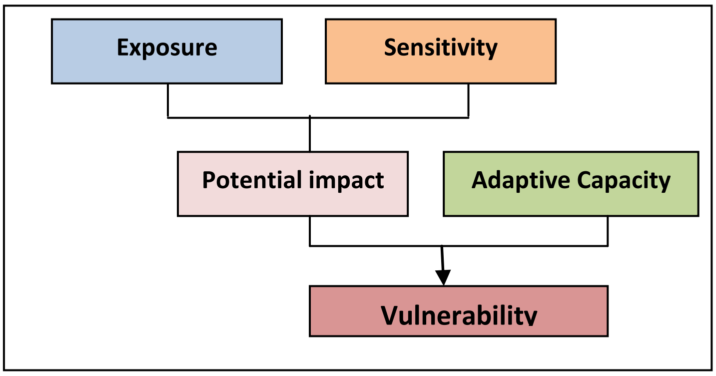

Figure 2.3: The key components of Vulnerability Assessments

- identify gaps in management effectiveness, including deficiencies in legislation and policy, and those areas where additional research is required for making informed decisions.

Vulnerability assessments were prepared based on the best available information. They were peer reviewed by natural resource managers and researchers who were considered to be authorities on that particular ecosystem. More information on coastal ecosystems is summarised in section 5 of this report and the full vulnerability assessments will be available at www.gbrmpa.gov.au

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3. Categorising Great Barrier Reef coastal ecosystems

The Great Barrier Reef inshore ecosystems are made up of many complex components, including estuarine and marine ecosystems such as mangroves, seagrasses and inshore coral reefs, which are closely linked to adjacent coastal ecosystems. These include coastal freshwater wetlands, coastlines and forested floodplains (figure 3.1). These coastal ecosystems are interconnected and reliant on one another for their ongoing health and resilience. Species that form part of the amazing biodiversity of the Great Barrier Reef live in and move between these ecosystems throughout their life cycles.

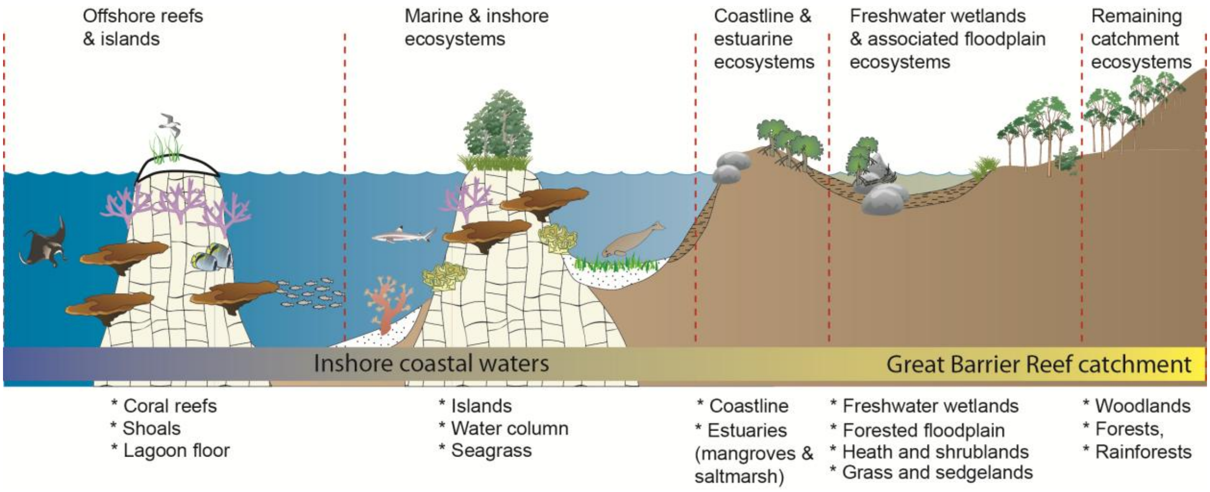

Figure 3.1: Broad groupings of coastal ecosystems illustrating the general level of importance for the ongoing health and resilience of the Great Barrier Reef

Coastal ecosystems are not easily separated and defined, as functionally they are all connected one way or another. Each component provides specific ecological functions that together make up and support the health and resilience of the ecosystem as a whole. Notwithstanding these complexities and inter-relationships, experts were able to identify broad relationships that provided a basis for categorising coastal ecosystems into 14 distinct components. These are coral reefs, lagoon floor, islands, water column (pelagic), seagrass, coastline, estuaries, freshwater wetlands, forested floodplains, heath and shrublands, grass and sedgelands, woodlands, forests and rainforests (figure 3.2). Further expert workshops identified the level and nature of the ecological functions provided by each coastal ecosystem (table 3.1).

Defining Coastal Ecosystems

Workshops conducted with a range of experts developed a methodology to categorise catchment, coastal and inshore ecosystems in terms of the services and functions they provide for the Great Barrier Reef.

Spatial data available from the Queensland Department of Environment and Resource Management was grouped based on the combination of geology, land form, soil and vegetation that are consistently associated with each category of ecosystem type.

While these ecosystems can be categorised into many different groupings, this review focused on understanding the functions and the services of these ecosystems from the perspective of the health and resilience of the Great Barrier Reef. With this in mind, workshops with marine, estuarine and terrestrial ecosystem experts developed a natural state conceptual model of the range of ecosystem functions that support the biodiversity of the World Heritage Area (figure 3.3). The conceptual model was then used as the basis for categorising the Great Barrier Reef coastal, catchment and inshore ecosystems and assessing the ecological functions and services of those ecosystems to the cumulative impacts of development. Further information on the workshops can be found at www.gbrmpa.gov.au.

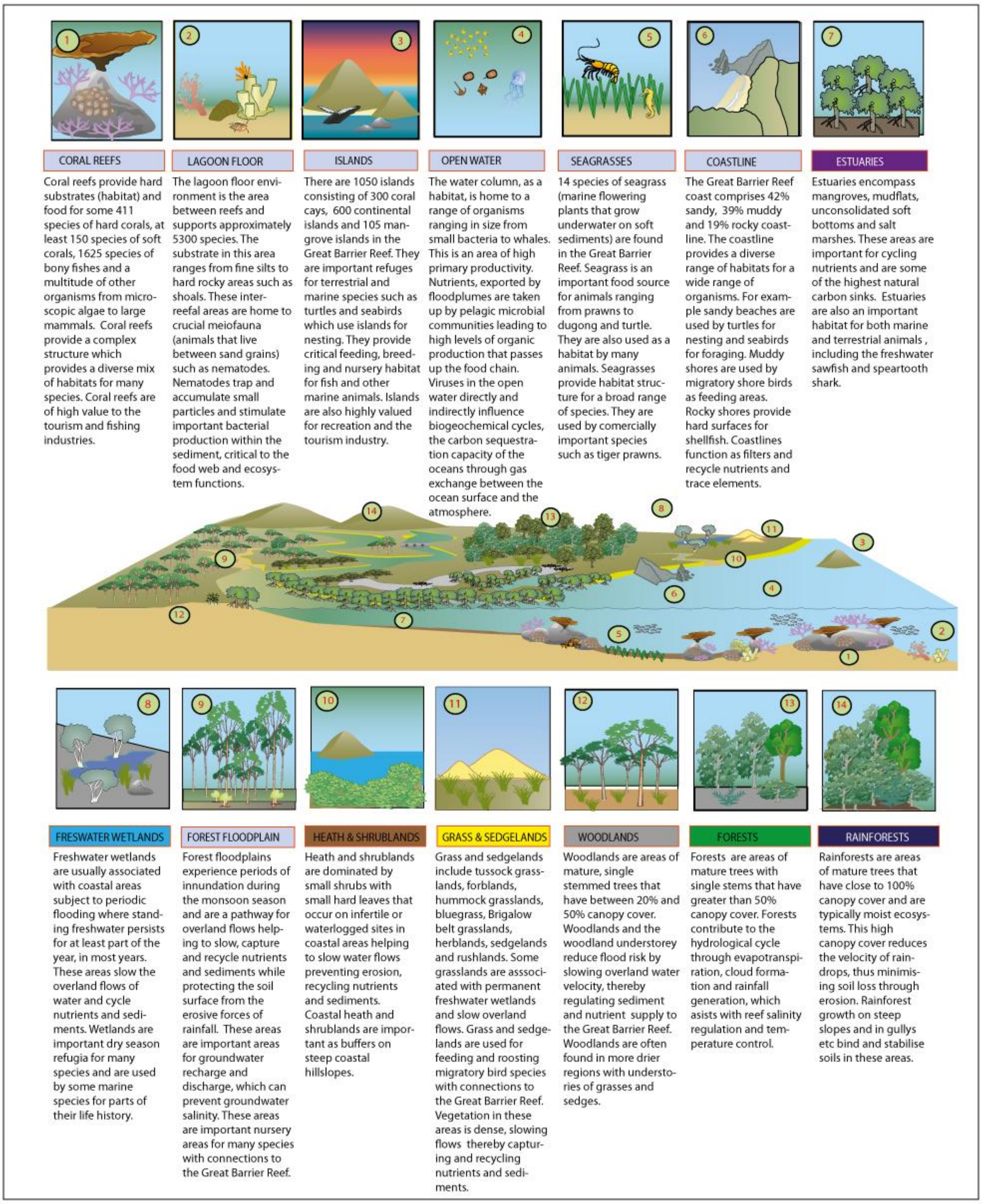

Figure 3.2: Categorisation and description of some of the ecological functions provided by coastal ecosystems[1]

Table 3.1: Ecological processes of natural and modified coastal ecosystems linked to the health and resilience of the Great Barrier Reef. Islands have been excluded as they vary considerably between island types

Process	Ecological Service	Coral Reefs	Lagoon floor	Open water	Seagrass	Coastline	Estuaries	Freshwater wetlands	Forest floodplain	Heath and shrublands	Grass and sedgelands	Woodlands	Forests	Rainforests
Physical processes- transport and mobilisation														
Recharge/discharge	Detains water						MH	H	✓					
	Flood mitigation						M	✓	H		L			
	Connects ecosystems						✓	H	H					
	Regulates water flow (groundwater, overland flows)	H	L		✓	✓	MH	H	✓		L	MH	MH	H
Sedimentation/ erosion	Traps sediment	M	MH	ML	M		H	H			L	MH	MH	MH
	Stabilises sediment from erosion		✓		M	H	✓	✓	✓	✓	L	MH	MH	M
	Assimilates sediment					✓	✓	H				MH	MH	H
	Is a source of sediment							M				MH	MH	
Deposition and mobilisation processes	Particulate deposition & transport (sed/nutr/chem. etc)							H						
	Material deposition & transport (debris, DOM, rock etc)							H						
	Transports material for coastal processes							H						
Biogeochemical Processes – energy and nutrient dynamics														
Production	Primary production	✓	✓	H	H	✓	H	H				M	M	H
	Secondary production				H	✓	H	✓						
Nutrient cycling (N, P)	Detains water, regulates flow of nutrients							H						
	Source of (N,P)				M	L	H					M	M	H
	Cycles and uptakes nutrients	L	H	H	M	L	H	MH		✓	✓			
	Regulates nutrient supply to the reef				M	L	H	M	H			M	M	H
Carbon cycling	Carbon source				M	L	H	H						H
	Sequesters carbon	✓	H	L	M	L	H	H	✓					
	Cycles carbon	L	H	H	M	L	H					H	H	H

Decomposition	Source of Dissolved Organic Matter						H	H						H
Oxidation-reduction	Biochar source											H	H	
	Oxygenates water		H	H		L	✓							
	Oxygenates sediments		✓		M	L	✓							
Regulation processes	pH regulation				M			H						
	PASS management						H	H						
	Salinity regulation													
	Hardness regulation							H						
	Regulates temperature					✓	✓	✓	✓					ML
Chemicals/heavy metal modification	Biogeochemically modifies chemicals/heavy metals	L			M		✓	H						
	Flocculates heavy metals						✓	H						
Biological processes (processes that maintain animal/plant populations)														
Survival/reproduction	Habitat/refugia for aquatic species with reef connections	H	M	L	✓	H	H	H		✓				
	Habitat for terrestrial spp with connections to the reef	H						H						
	Food source		✓		H	✓	✓	✓		H				
	Habitat for ecologically important animals	H	✓		H	L	H			✓	✓			
Dispersal/ migration/ regeneration	Replenishment of ecosystems – colonisation (source/sink)	H			H	M	H	H						
	Pathway for migratory fish							H						
Pollination														
Recruitment	Habitat contributes significantly to recruitment	H			H	H	H	H		H				

Capacity of natural coastal ecosystems to provide ecological services for the Great Barrier Reef[1]

H – High capacity for this system to provide this service, M – medium capacity for this system to provide this service, L- low capacity for this system to provide this service, N – No capacity for this system to provide this service, X- Not applicable, ✓– service is provided but capacity unknown. Boxes with no data indicate a lack of information available. Note that the capacity shown for modified systems assumes periods of low hydrological flow.

The functions coastal ecosystems provide for the Great Barrier Reef include: physical processes such as sediment and water distribution and cycling; biogeochemical processes such as nutrient and chemical cycling and biological processes such as habitat and food provisioning.

Coastal ecosystems are functional ecosystems that range from those with strong and direct links for the functions they provide to the Great Barrier Reef, such as river discharges of freshwater, to systems that are more remote with less direct but nevertheless critical links, such as highland rainforests preventing hill slope soil loss. There are three broad groupings based upon their level of influence on reef health. Those ecosystems with greatest influence are located on the Great Barrier Reef coast (coastline and estuarine ecosystems) that form the boundary between terrestrial and marine ecosystems. The second group of ecosystems are those that are part of the coastal floodplain adjacent to and linked to the Great Barrier Reef coast (freshwater wetlands and associated floodplain ecosystems). These are ecosystems that are directly linked to the marine environment permanently or intermittently by water. Lastly the ecosystems that make up the bulk of the catchment but have less direct links to, and thus less influence on the health of the Great Barrier Reef, make up the last group (the remaining catchment ecosystems).

Islands in the Great Barrier Reef form a specific component of coastal ecosystems. They are made up of a range of coastal ecosystems and are sometimes home to the only intact remnant of the broader mainland bioregional ecosystems in the World Heritage Area. More detailed information on each of the fourteen coastal ecosystems (figure 3.2) can be found in section five and also in the Vulnerability Assessments that have been prepared for each coastal ecosystem.

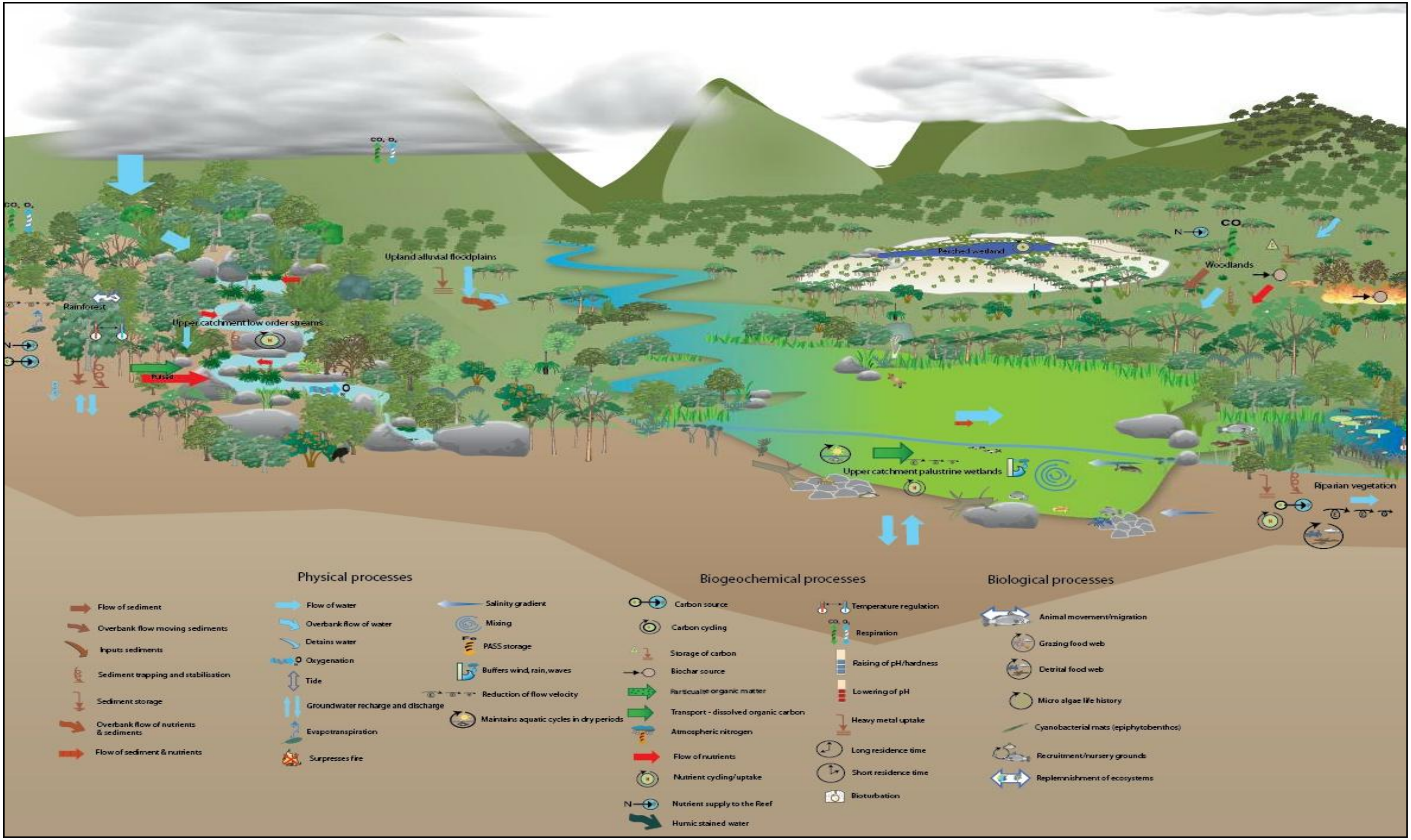

Figure 3.3: Upper catchment component of a conceptual model showing some of the processes provided by coastal ecosystems that support the health and resilience of the Great Barrier Reef. This model was developed in an expert scientific advisory workshop for a hypothetical unmodified catchment.[1]

3.1. Ecosystem connectivity and dependencies – case studies

A well-known example of the broad habitat requirements of some Great Barrier Reef species is the lifecycle movements of fish, such as barramundi, from aquatic floodplain ecosystems to marine ecosystems and vice versa. A case study of the life cycle of barramundi shows the importance of the variety of coastal ecosystems and their relationship to the life cycle of a fish (figure 3.5). Throughout the year, barramundi commonly use different coastal ecosystems at different times of their life. Other well-known examples of these lifecycle relationships are available for the red emperor,[2] mangrove jack[3] (figure 3.6) and a species that has suffered a very significant decline — the freshwater sawfish (figure 3.7). Another example of this connectivity between species and distinct and quite separate coastal ecosystems is the pied imperial pigeon — pigeons roost on islands within the Great Barrier Reef at night and feed in mainland rainforests during the day, creating important biological linkages between systems (figure 3.8).

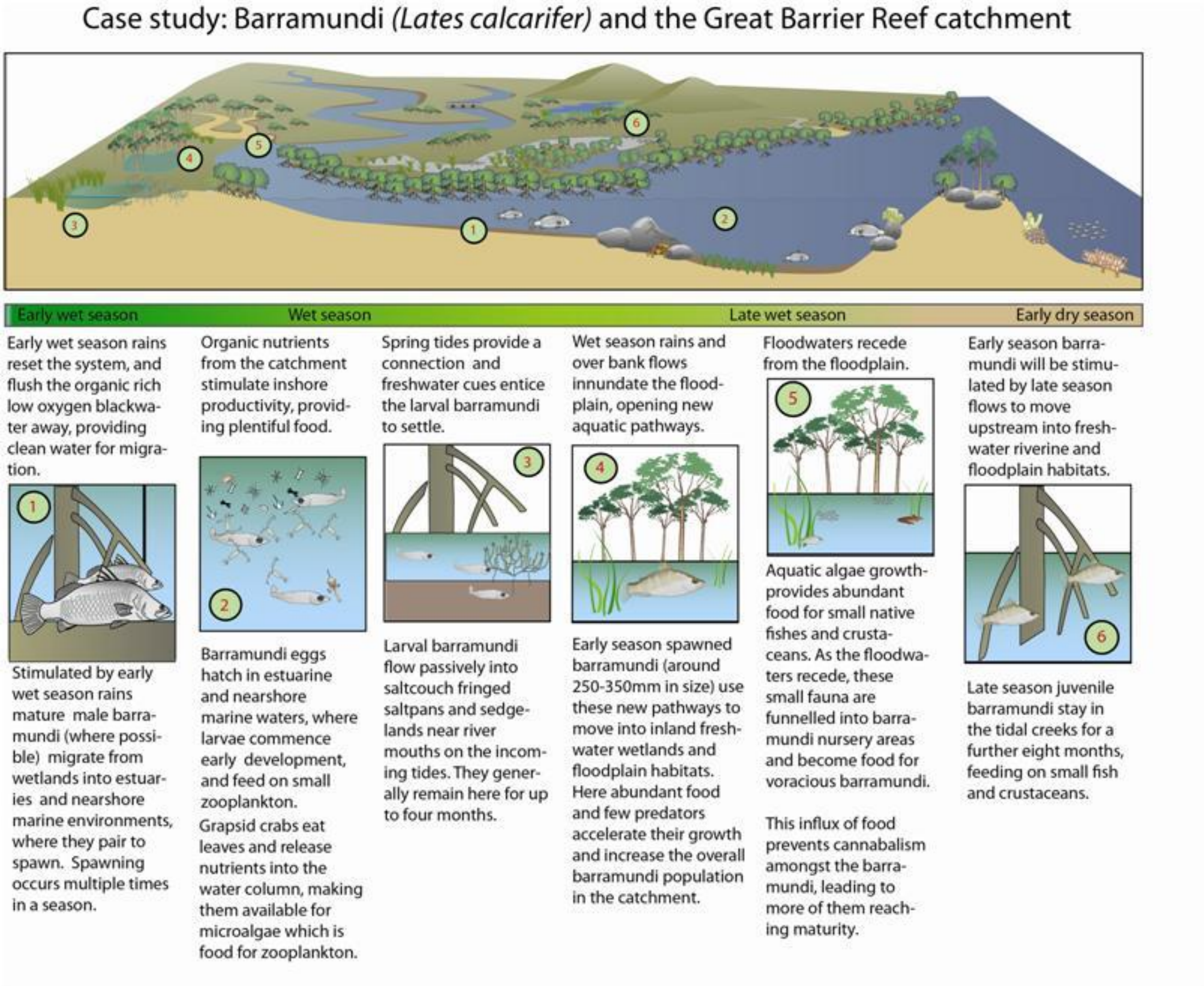

Figure 3.5: Lifecycle of the barramundi and its links to Great Barrier Reef coastal ecosystems [14,5]

Many species that form part of the amazing biodiversity of the World Heritage Area rely on, live in, and move between coastal and marine ecosystems throughout their life cycle. Well-known examples::

- Barramundi that start off their lifecycle as males living variously on flooded coastal plains and in freshwater wetlands, use wet season floods to move to estuaries and inshore marine environments to pair with females and spawn. They return to freshwater ecosystems as fry and begin the cycle again.
- Freshwater sawfish pups born in estuaries move upstream into deep freshwater waterholes for the first seven years of their life before returning to estuarine and marine waters to breed.
- Many mangrove jack larvae settle in estuaries prior to migrating upstream into freshwater streams to mature. Adult mangrove jack may then move out through the estuarine system and to the Great Barrier Reef to breed.
- Red emperor juveniles shelter and feed in coastal seagrass meadows before moving offshore across the lagoon floor towards shoals and the Great Barrier Reef where they breed. Fry move back into coastal areas to feed and grow.
- Another example of this connectivity between species and distinct and quite separate coastal ecosystems is the pied imperial pigeon. Pigeons roost on islands within the Great Barrier Reef at night and feed in mainland rainforests during the day, creating important biological linkages between systems.

These are just five of many examples of the interdependencies between Great Barrier Reef coastal and marine ecosystems.

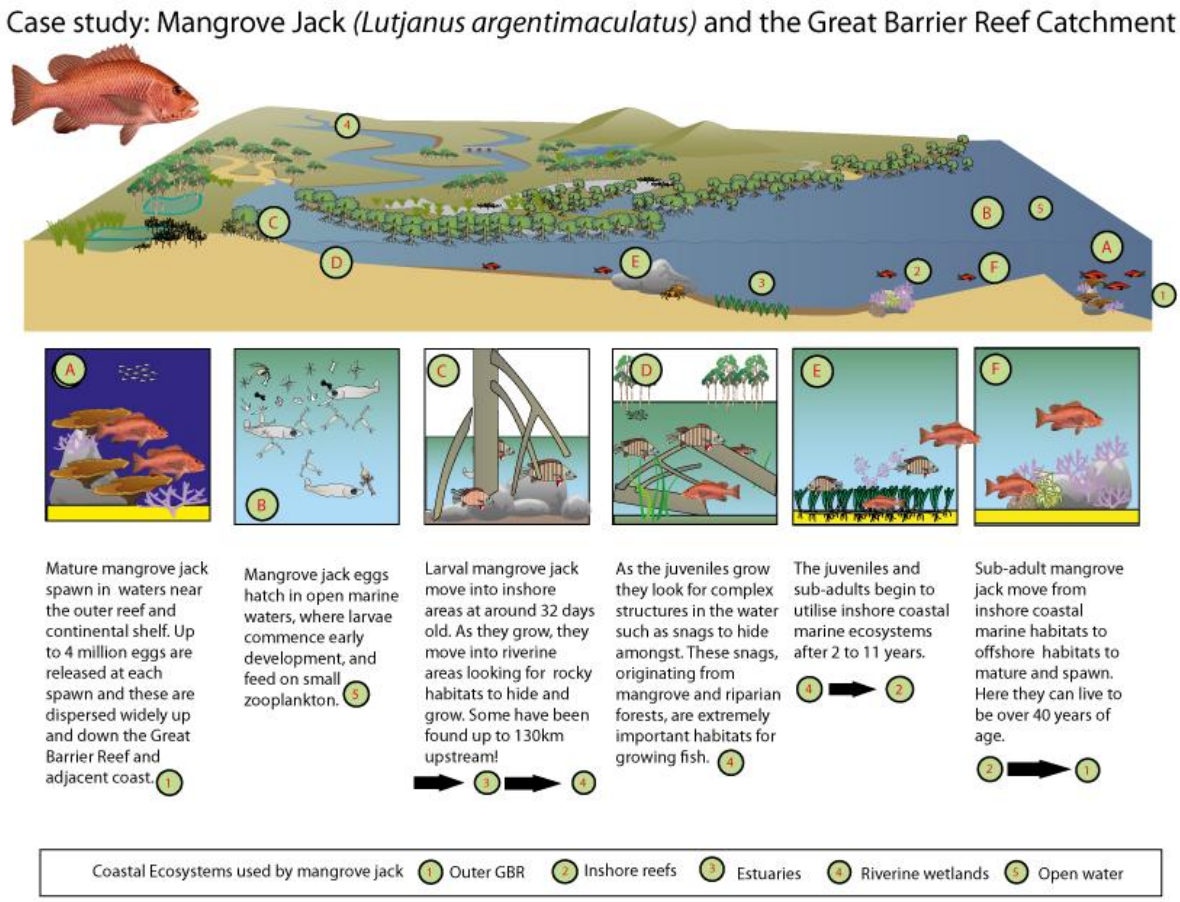

Figure 3.6: How mangrove jack move from the freshwater reaches in the upper catchment out to the outer Great Barrier Reef during their lifetime[1]

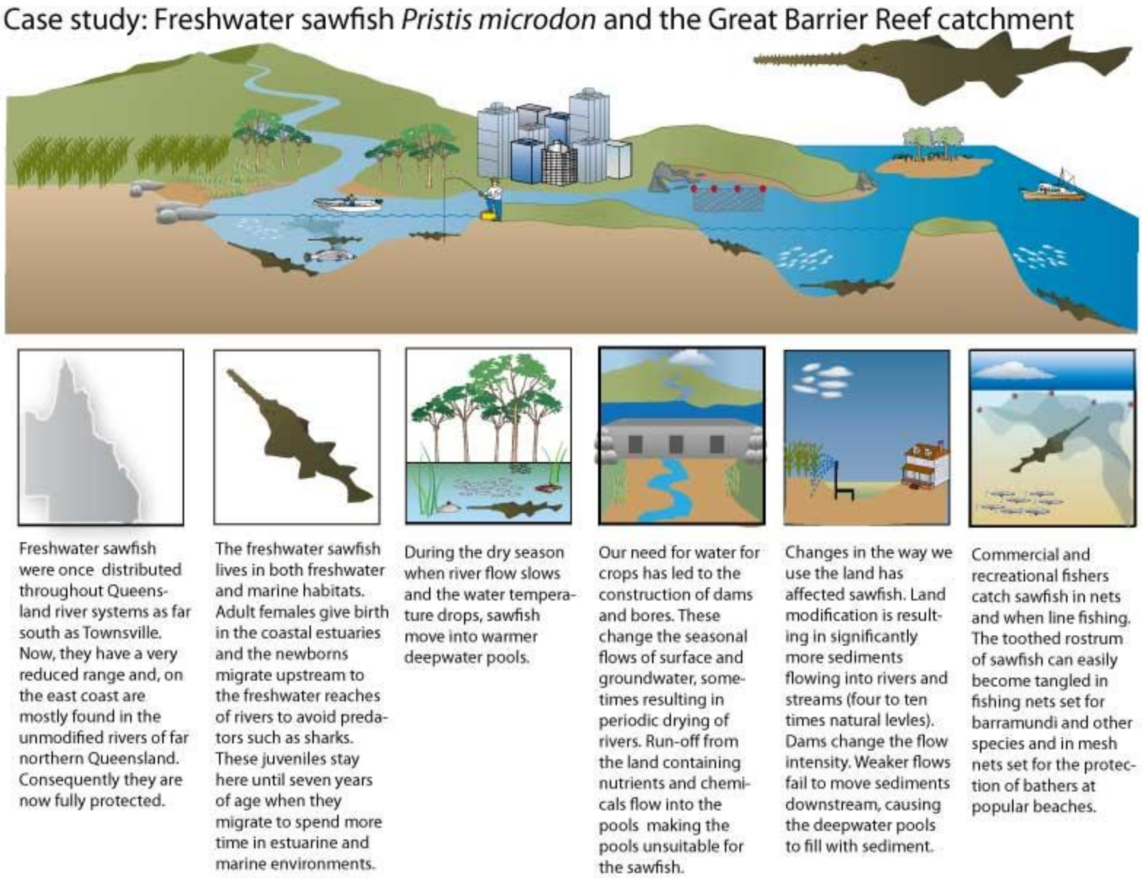

Figure 3.7: A conceptual model showing how the freshwater sawfish uses the coastal freshwater ecosystems[16,7,8,9,10]

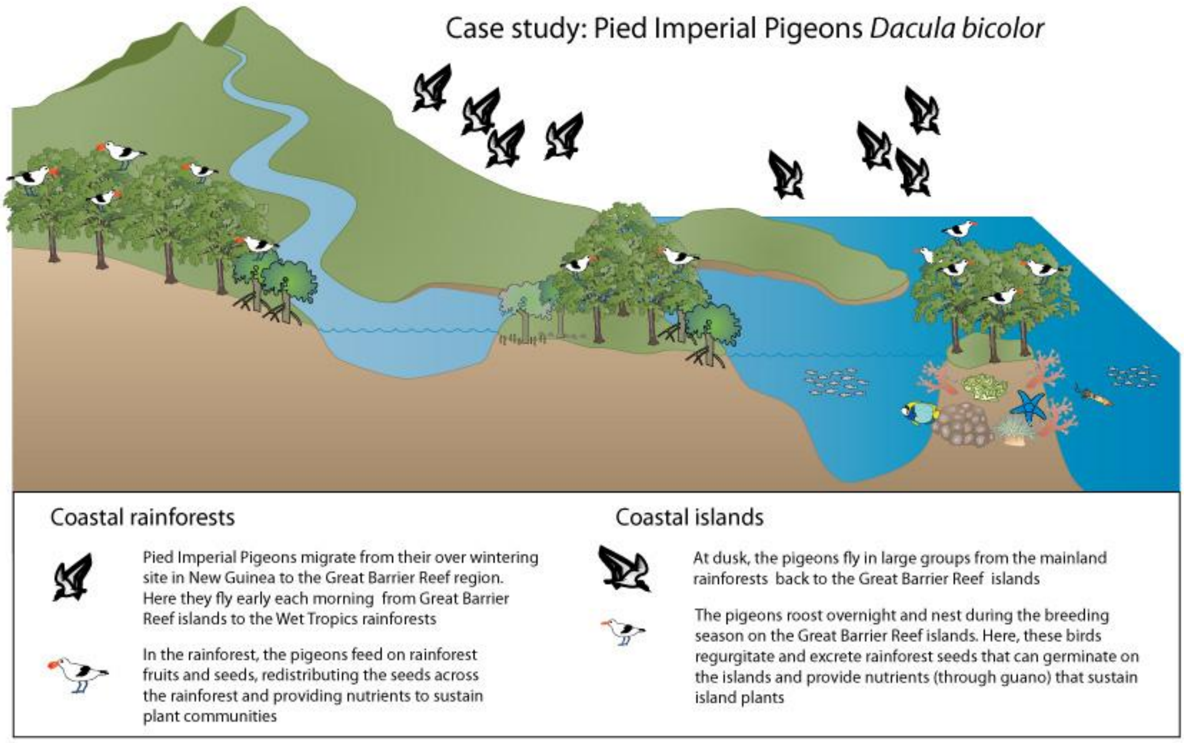

Figure 3.8: How rainforest species, in this case pied imperial pigeons, use the catchment and Reef[1]

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4. Assessment of coastal ecosystems – status and trends

Ecosystems with links to the Great Barrier Reef were mapped using Queensland's Regional Ecosystem data and displayed as pre-European (figure 4.1) and 2006 (figure 4.2). This provides a basis to assess and calculate the extent to which they have changed or been modified by human activities since European settlement. The mapping also enabled assessments to be undertaken at a variety of scales including the entire catchment, each NRM region and the 35 individual river basins that make up the catchment and specifically defined areas such as the coastal zone.

Overall, sixty per cent of pre-clear vegetation classified as remnant vegetation remains intact in the great Barrier Reef catchment (table 4.1). Much of Cape York's catchment ecosystems remain intact and these make up around one third of the total area of currently intact catchment ecosystems. By contrast, other regions have experienced significant reductions to the extent of some ecosystems across their catchments. For example, the Wet Tropics NRM region has seen substantial loss of native grasslands and freshwater wetlands across the entire region (greater than 55 per cent) and a high loss of forests and woodlands in several basins, especially on the floodplain (see the regional summaries in section 4.2). Thus, regional or basin scale status of coastal ecosystems is highly variable and in some cases there has been very substantial ecosystems loss or modification. Note that the figures shown for remaining coastal ecosystem extent do not reflect the intrinsic health and functioning of these ecosystems.

Figure 4.3 shows the percentage of each terrestrial coastal ecosystem that has been modified or cleared, the percentage that now remains, and the proportion of the remaining (post-clear) ecosystems that are now protected as conservation parks, national parks and state forests. This analysis highlights the variability in the level of representation of the various ecosystems in the protected area estate, both regionally and functionally. For example, some ecosystem types such as rainforests have relatively high levels of protection provided to them, and overall 11 per cent of the catchment's terrestrial coastal ecosystems are protected in conservation tenures. In comparison, 33 per cent of the Great Barrier Reef has this same level of protection with a minimum of 20 per cent for each bioregion.

At the basin level, the cumulative impacts from a range of development activities have in some instances resulted in less than 10 per cent of the original extent of some critical ecosystems remaining. For example, up to 90 per cent of coastal wetlands, floodplain forests and woodlands have been lost or significantly modified, while a considerable number are below 30 per cent (refer to section 4.2).

Information is not available on the historic extent of inshore marine ecosystems. Notwithstanding that historic photographic records show significant loss of coral communities on coastal reef flats[1], these systems have not been subjected to the same level of direct broadscale disturbance that has affected the extent and distribution of coastal ecosystems.

Table 4.1: Changes in the extent of coastal ecosystems for the whole catchment

Coastal Ecosystems	Total Area (km^2) Pre-European settlement	Total Area (km^2) Current	Percentage remaining and condition statement
Coral reefs	Unknown but more extensive than today	2600	Extent of loss of coastal fringing reefs unknown. Around50% decline in coral cover over the central reefs in the past two decades.
Lagoon floor	20,456	20,456	100 per cent remaining. Affected by poor water quality and fishing (trawling) in some areas.
Islands	Unknown vegetation. Mapping only completed for larger islands	Not calculated, but around 1050 islands of three types	More than 30 per cent national parks. Around 5 per cent of islands extensively modified by developments.
Open water	7200km^3	7200 km^3	Around 60 per cent of inshore waters regularly exceed Great Barrier Reef Marine Park water quality guidelines
Seagrasses	Unknown but believed to be more extensive than today	5668	Around1 per cent cleared for port development. Water quality is affecting coastal seagrass communities south of Cooktown, although the extent of loss is unknown.
Coastline	7752km	7752km	Around1 per cent of coastline is directly impacted by reclamations, groynes, jetties etc.
Estuaries (Mangroves and tidal saltmarshes)	4339	3969	91 per cent although some 30 per cent of tidal saltmarshes are affected by bunding.
Freshwater wetlands	1431	1238	87 per cent, with the health and condition varying between individual wetlands.
Forested floodplain	24597	12655	51 per cent with grazing occurring within some areas
Heath and shrublands	5351	5026	94 per cent condition unknown
Grass and sedgelands	12,364	5989	48 per cent condition unknown
Forests	239,608	145,380	61 per cent condition unknown
Woodlands	105,123	64,592	61 per cent with grazing occurring within some woodlands
Rainforests	26,886	16,744	62 per cent

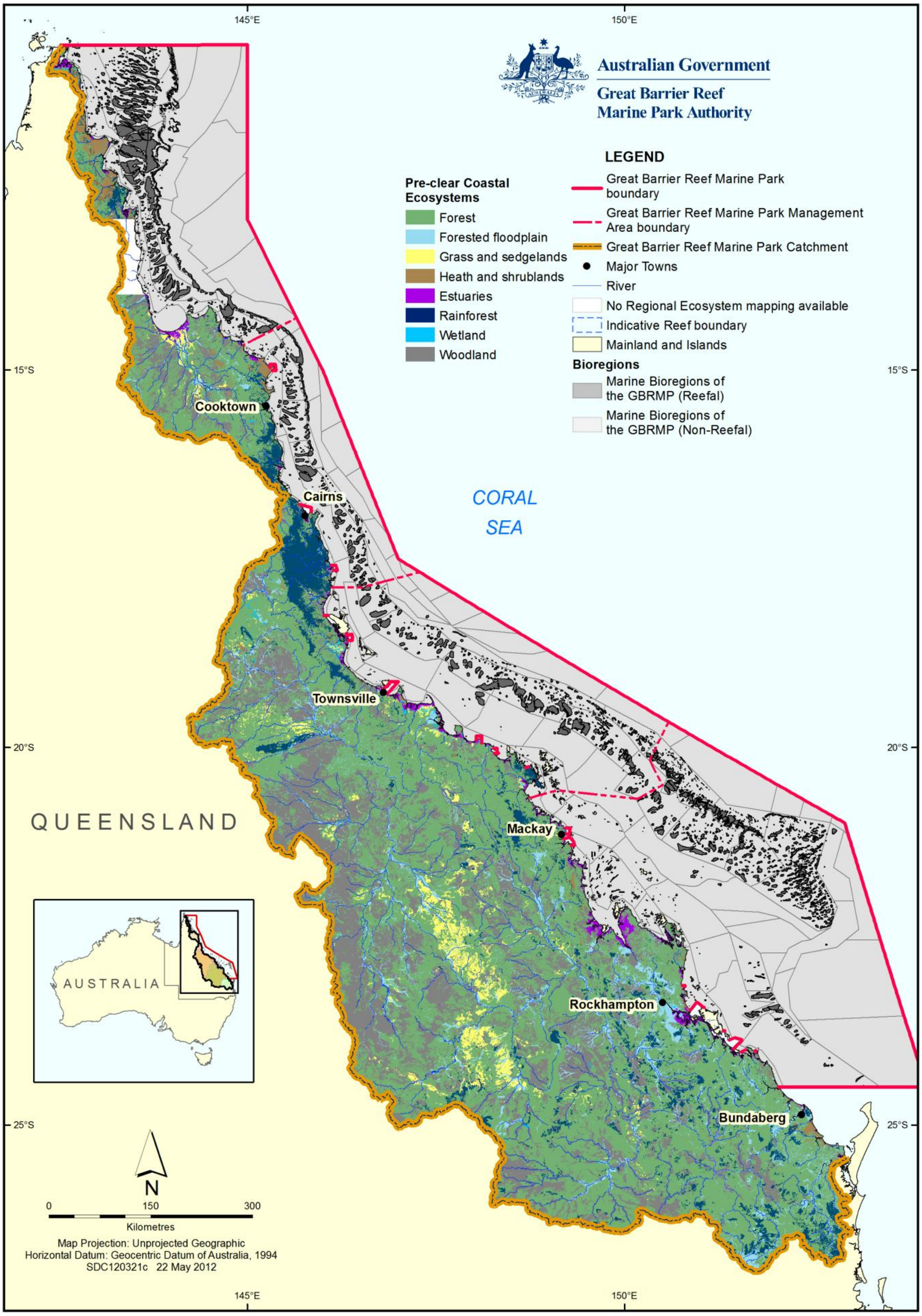

Figure 4.1: Pre-clear coastal ecosystems showing the extensive areas of forests, woodlands and forested floodplain across much of the catchment

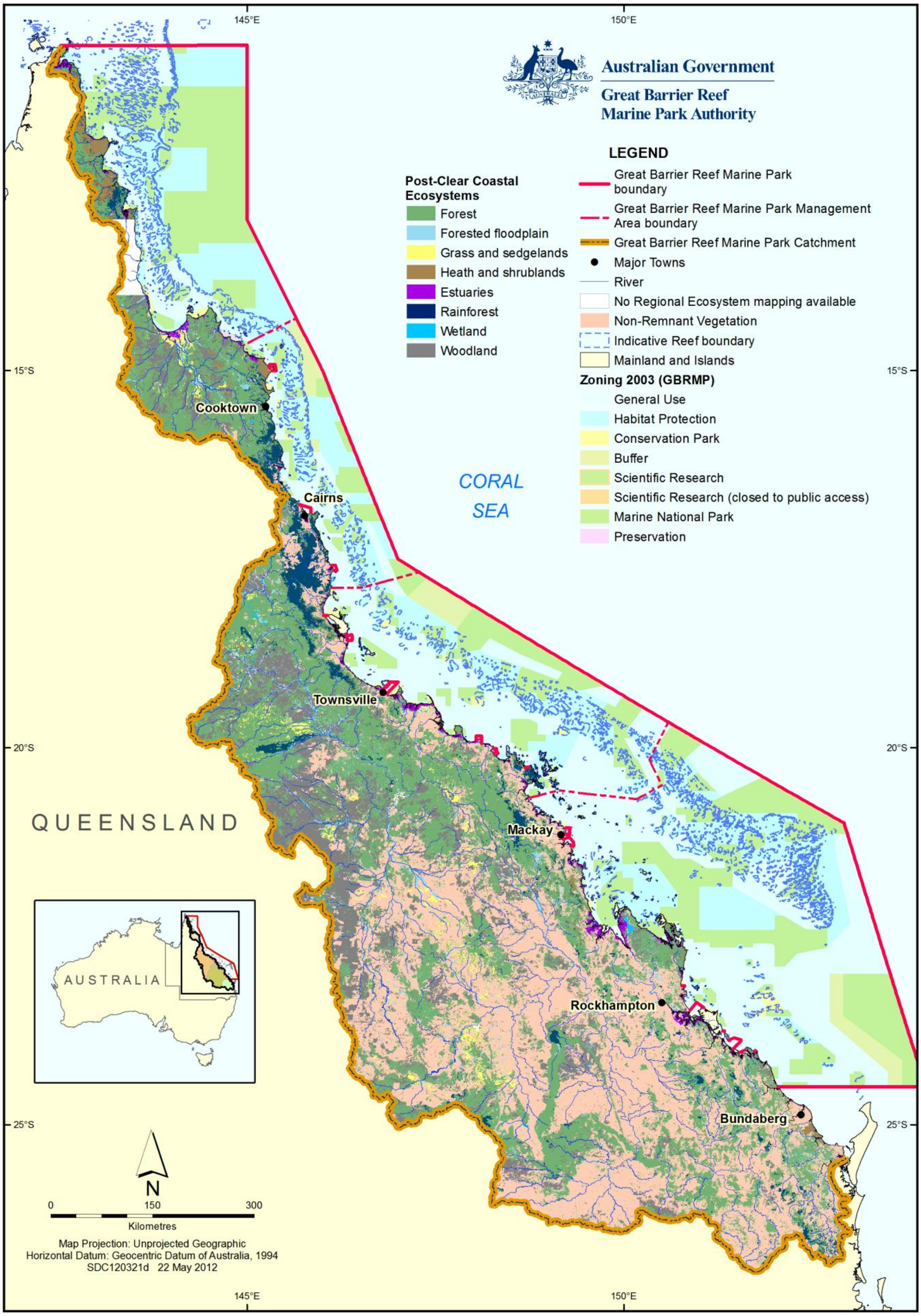

Figure 4.2: Coastal ecosystems as they appear today. The majority of non-remnant vegetation is land that has been modified so that it is no longer recognised as a regional ecosystem. These areas are may have changed from a forest to a grassland used for grazing for example.

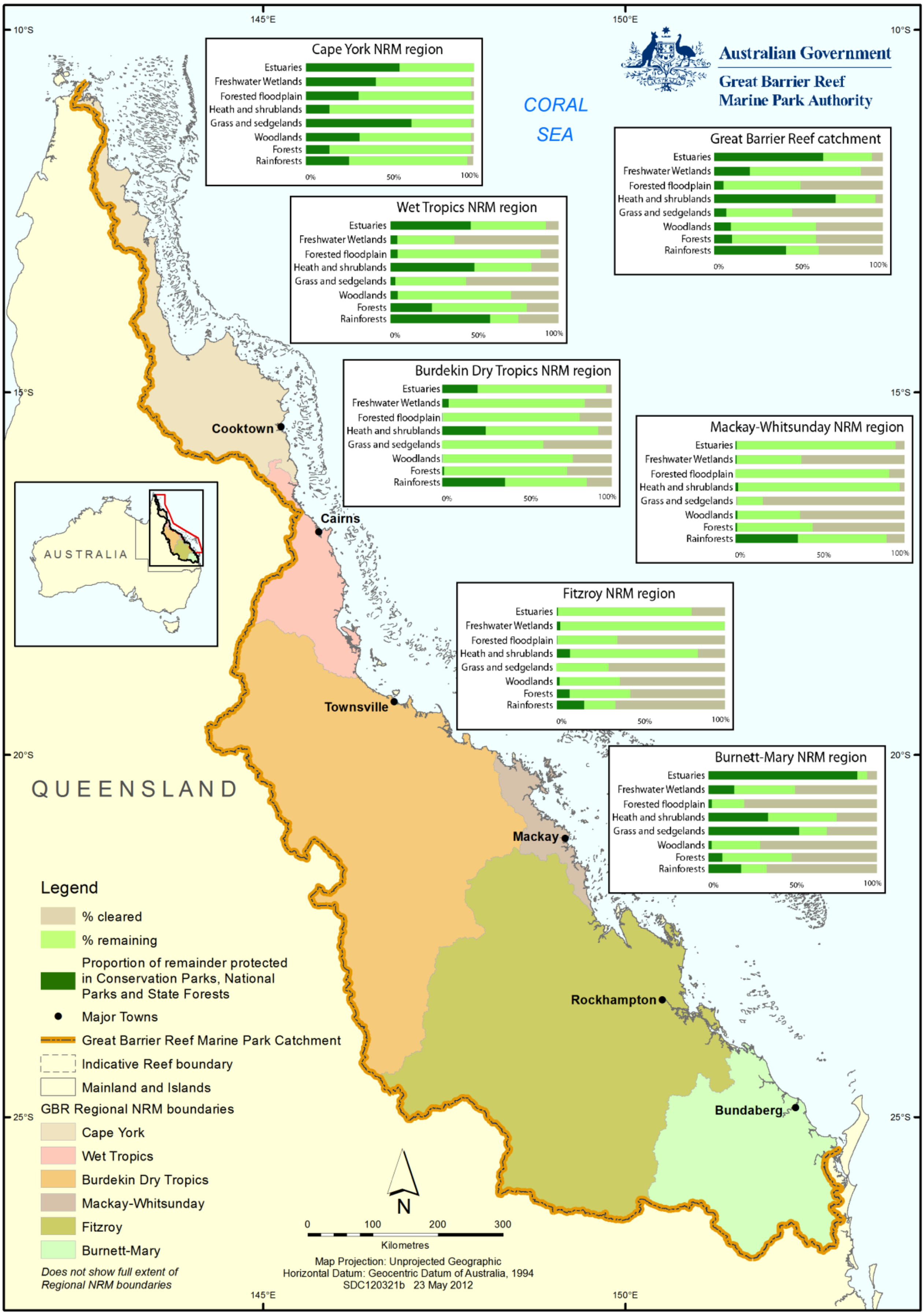

Figure 4.3: This shows the changes in the extent of catchment ecosystems (brown pre-clear extent, green current extent) and the proportion of remaining catchment ecosystems afforded direct protection (green boxes) through mechanisms such as national park status for the Great Barrier Reef catchment as a whole, and by NRM region

The most significant issue for inshore marine ecosystems is the impact of the decline in water quality which is known to be responsible for declines in both coral and seagrass health, and reduced productivity in many common species. This potentially affects their health, ability to breed and survival of their offspring. To identify marine areas most at risk from land use changes and the major pollutants often generated by these activities, the frequency-based exposure model of freshwater flows from rivers adjacent to the Great Barrier Reef[2] was assessed in combination with information on the catchment rankings scaled to the difference between natural loads and anthropogenic loads (figure 4.4).[3,4]

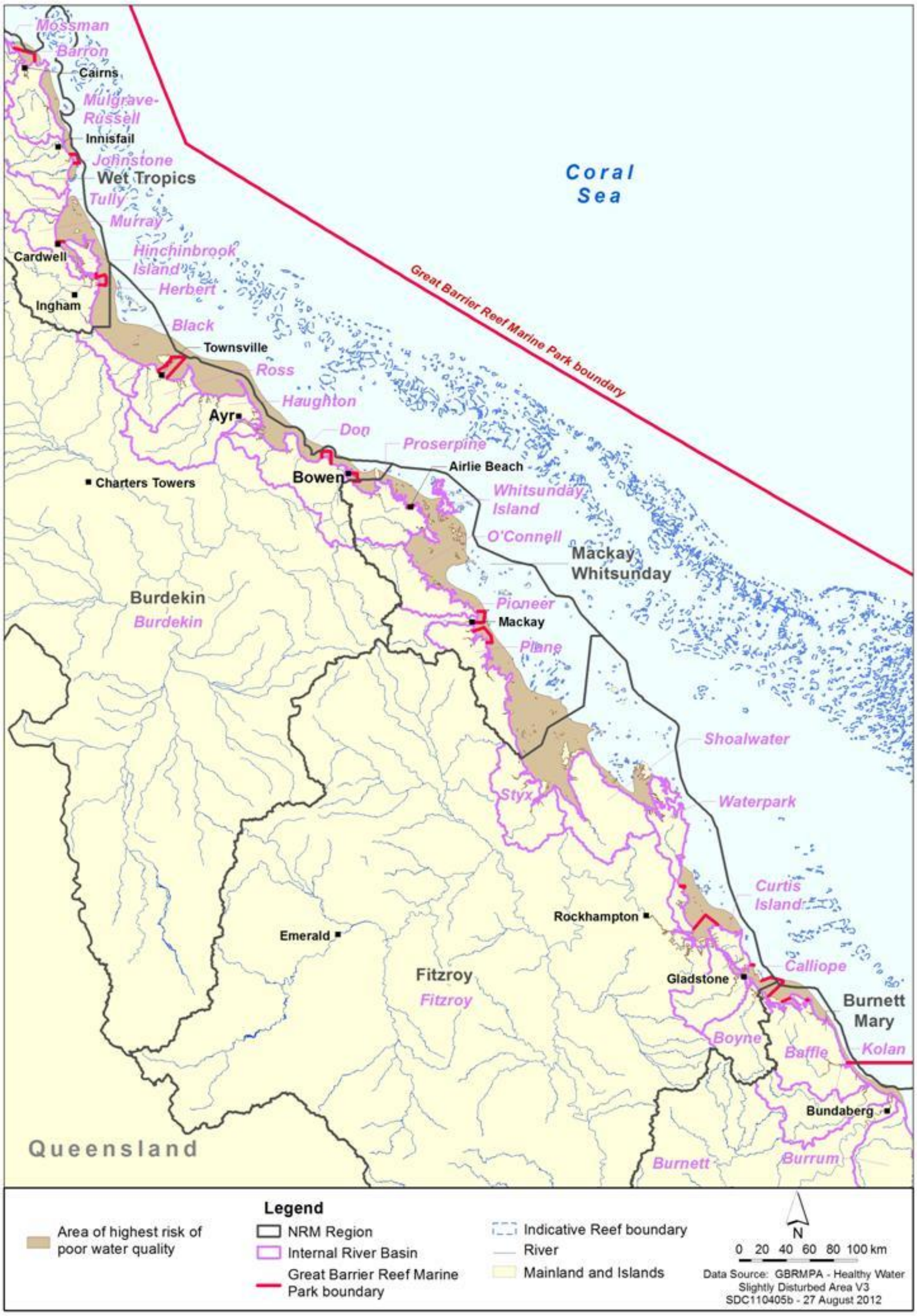

Figure 4.4: Areas most at risk of exposure to poor water quality (brown shaded area) based upon flood plume analysis

The proximity of development activities to the coast also influences the risk of threats to the Great Barrier Reef ecosystem. The 2011 Queensland State Coastal Plan recognises this issue and has identified the coastal strip as the focus for its coastal policies. It has identified areas of high ecological significance within this coastal strip and constrains development in these areas. The Great Barrier Reef Marine Park Authority has mapped changes in coastal ecosystems for the whole catchment between pre-clear conditions (figure 4.5a) and 2006 (figure 4.5b). The area defined as coastal zone (5 km or 10 AHD or whichever is greater) in the 2011 Queensland State Coastal Plan has also been mapped to assess the extent of changes in coastal ecosystems within this area (figures 4.5c-d). The areas of non-remnant vegetation shown represent areas that have been modified.

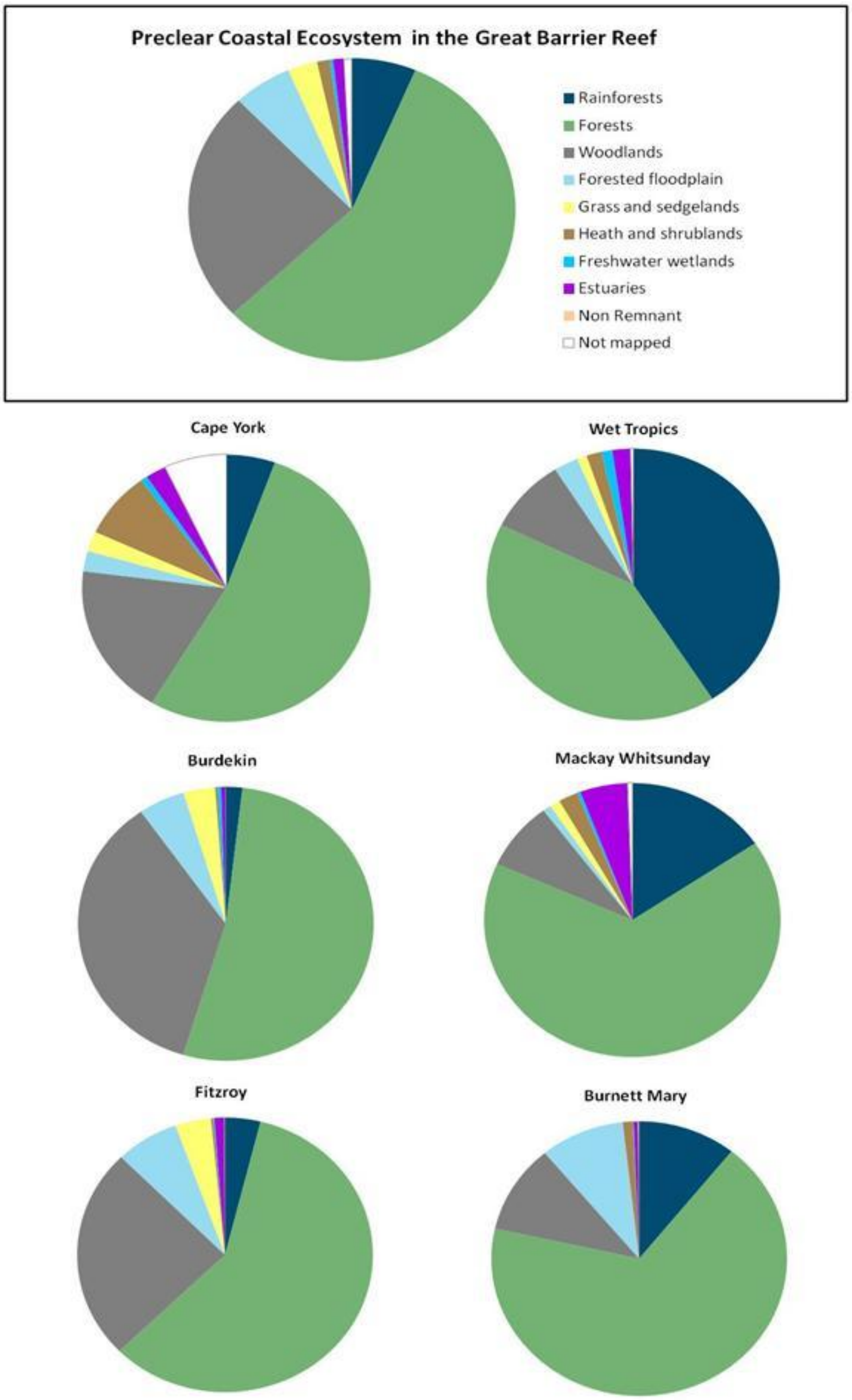

Figure 4.5a: Percentage of pre-clear coastal ecosystem extent within the Great Barrier Reef catchment and each natural resource management region.

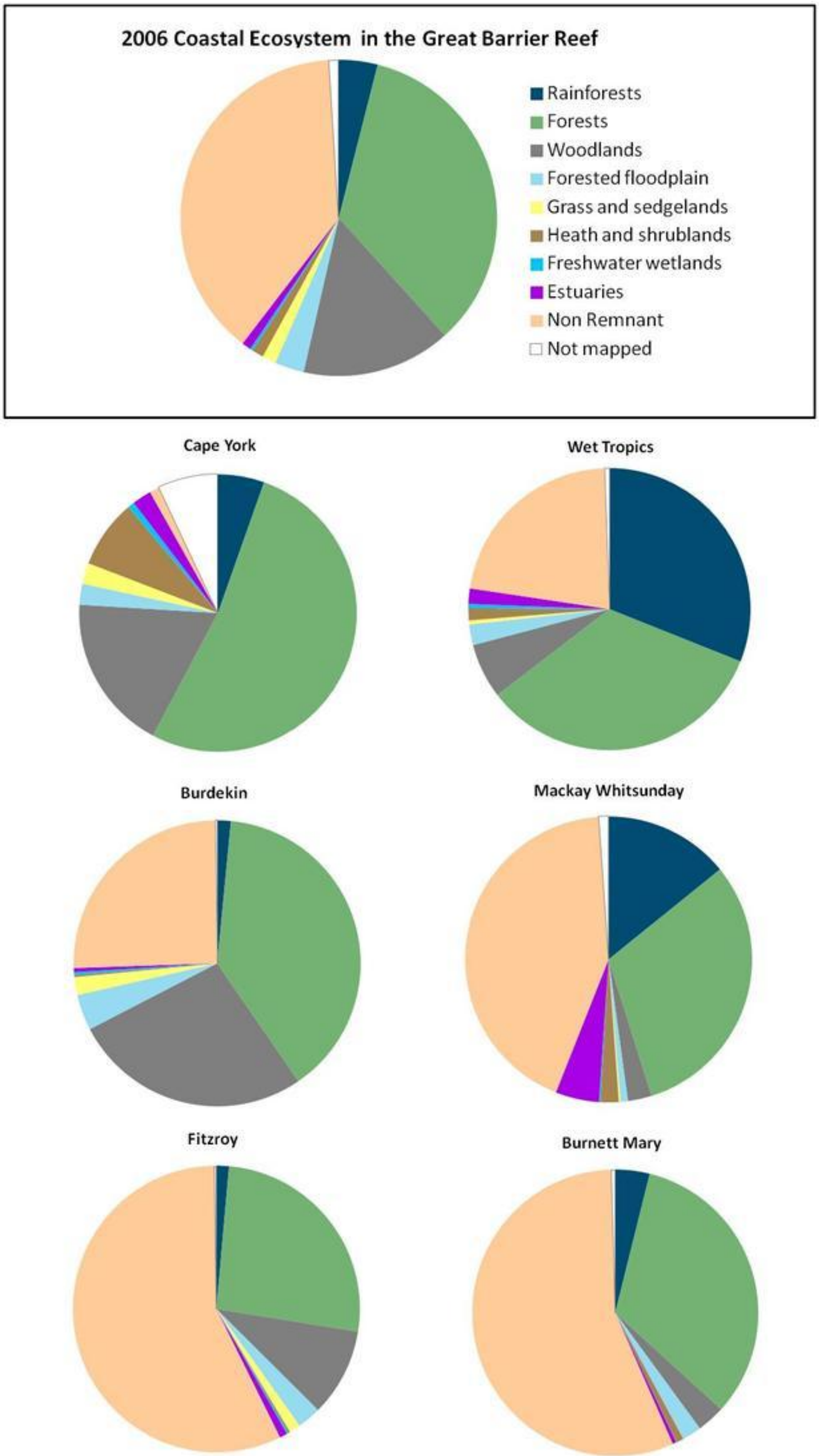

Figure 4.5b: Percentage of 2006 coastal ecosystem extent within the Great Barrier Reef catchment and each natural resource management region

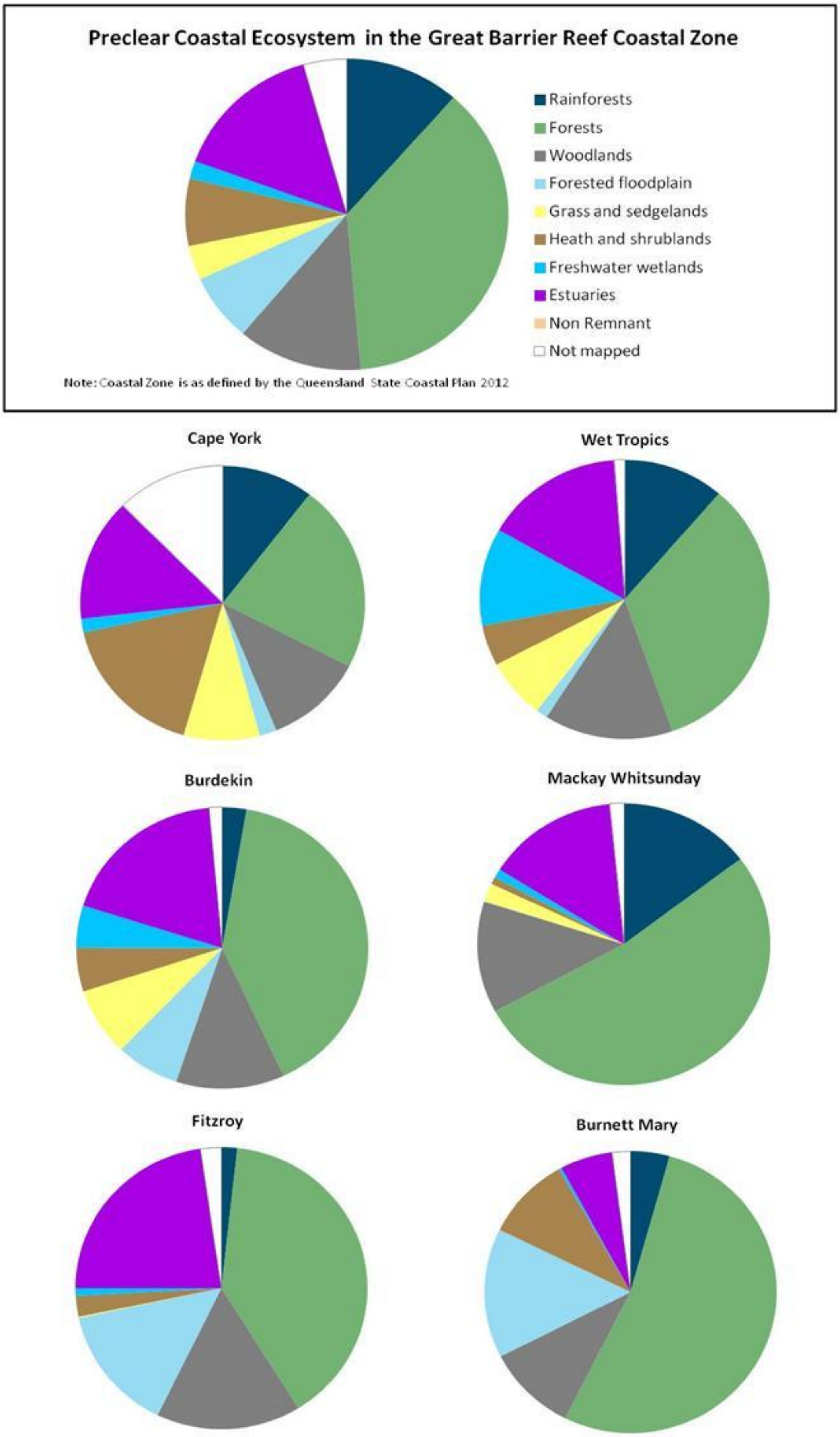

Figure 4.5c: Percentage of pre-clear coastal ecosystem extents within the Queensland Government defined coastal zone for the Great Barrier Reef catchment and each natural resource management regions

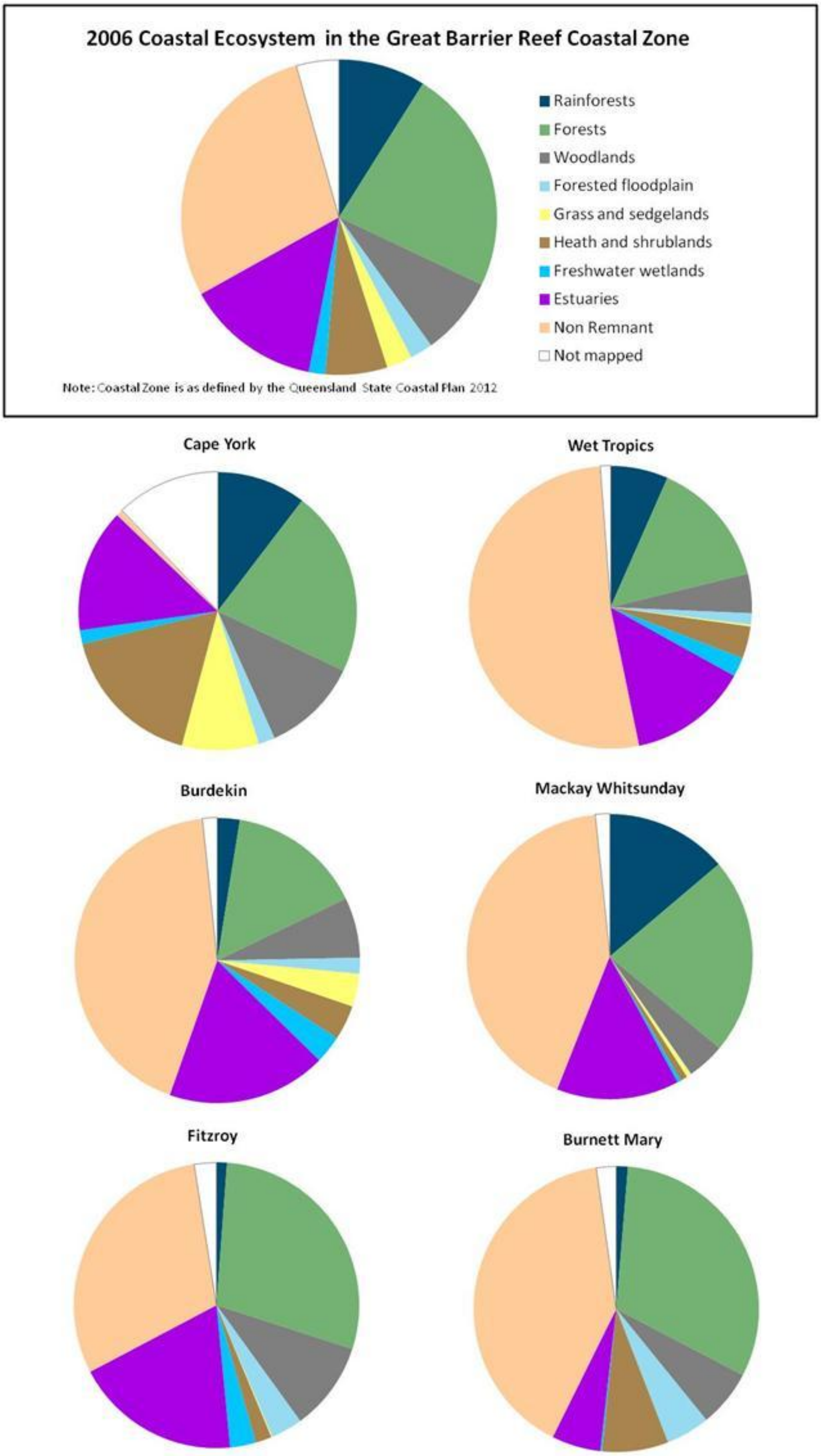

Figure 4.5d: Percentage of 2006 coastal ecosystem extents within the Queensland Government defined coastal zone for the Great Barrier Reef catchment and each natural resource management regions

4.1. How have we modified coastal ecosystems – status of Great Barrier Reef coastal ecosystems

The previous section outlined the Great Barrier Reef-wide status of coastal ecosystems. The following summaries provide information on the remaining extent and protection of these ecosystems and identify the existing regional land uses and trends over the last decade. The regional natural resource management (NRM) boundaries (figure 4.3) have been chosen as suitable areas for these assessments.[2] This will assist in aligning this work with regional NRM planning and other activities such as monitoring and reporting under the Reef Water Quality Protection Plan's Paddock to Reef Program. This is particularly relevant to programs like Healthy Waterways occurring in the Mackay Whitsunday, Burdekin, Fitzroy and Wet Tropics regions.

4.2. Regional natural resource management summaries

The regional summaries reflect the difference in loss or modification of coastal ecosystems from north to south. Significantly more coastal ecosystems have been lost or modified in the Burnett Mary and Fitzroy regions compared to the Cape York or North Queensland Dry Tropics regions.

4.2.1. Cape York NRM region

The Cape York region of the catchment (figure 4.6) covers an area of approximately 43,000 km^2 and includes Jacky Jacky Creek, and the Olive Pascoe, Lockhart, Stewart, Normanby, Jeannie and Endeavour Rivers. This tropical region experiences monsoonal rains over the summer months and drier winter months. The catchments in this region are relatively intact with lower rates of grazing and low levels of fertilised agriculture.

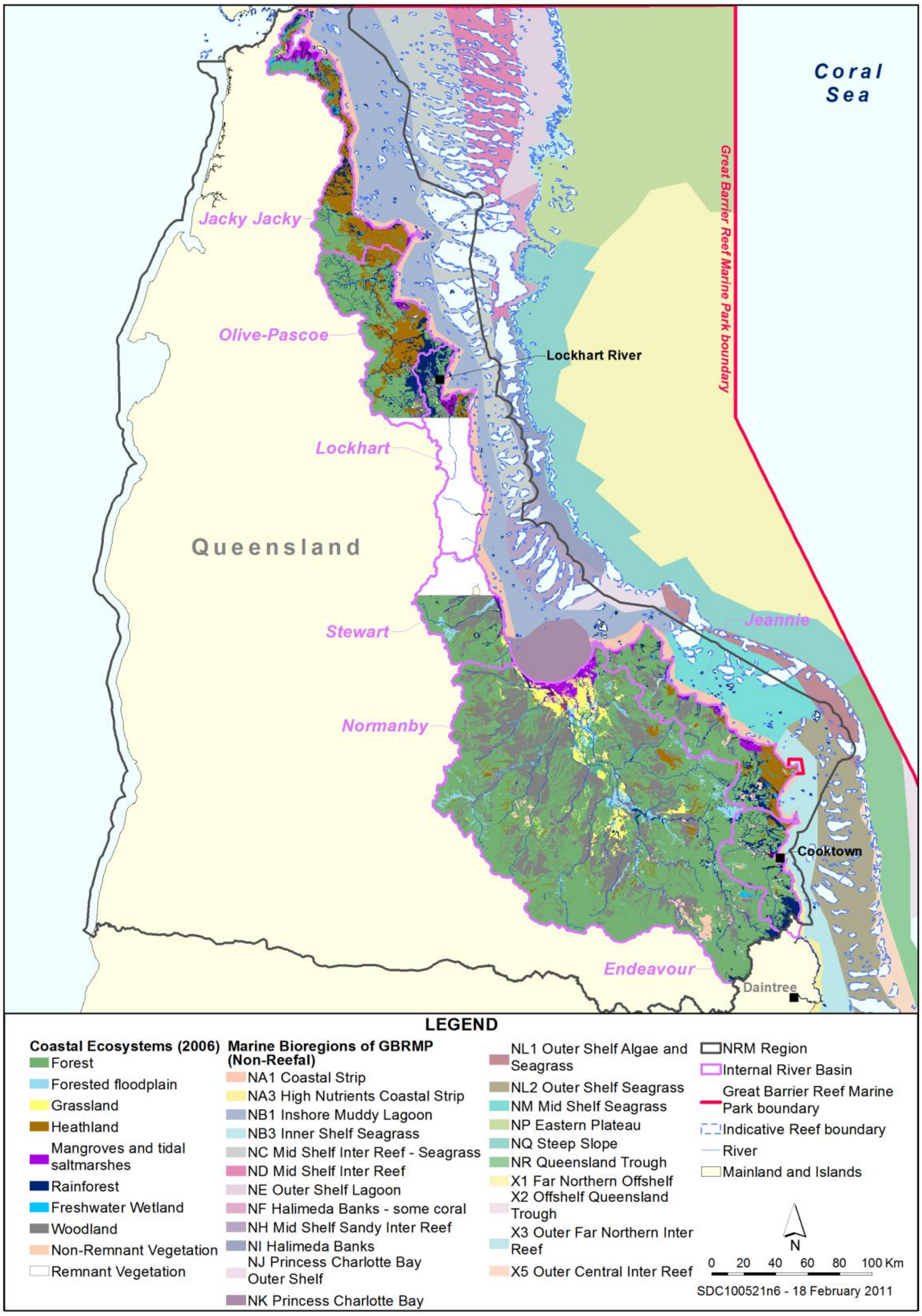

Figure 4.6: Cape York NRM region showing post-clear coastal catchment ecosystems
***Note the Lockhart region (uncoloured area) has not been mapped and is therefore excluded from this map**

Receiving waters

Because of their close proximity, flood plumes from the Cape York NRM basins have been shown to reach beyond the outer edge of the Great Barrier Reef in this region. At risk of exposure to one or more water quality concerns, such as sediments, nutrients or pesticides, are 579 coral reefs (covering an area of 5710 km^2), 47 seagrass beds (covering an area of 2322 km^2) and 34,934 km^2 of seabed.[2] This region also supports a small tourism industry (3950 full day visitors in 2009) and significant commercial fisheries. Together, the Cape York and Wet Tropics regions make up 25.8 per cent of the Great Barrier Reef's fisheries, with a gross value production valued at $31 million in 2001.[5,6]

Changes to coastal ecosystems (pre-clear to post-clear)

Overall vegetation loss (table 4.2) between pre-clear and recent post-clear extent data was 499 km^2 for the basins within this NRM region; this is considered to be relatively insignificant. Noting the Lockhart River region (uncoloured area in figure 4.7) has not been mapped and is not included in this table.

Table 4.2: Changes to coastal ecosystems (pre-clear extent to post-clear extent)
*** Note the Lockhart region has not been mapped and is therefore excluded from this table**

Coastal Ecosystem	Pre-clear extent (km^2)	Post-clear extent (km^2)	Area modified (km^2)
Rainforests	2362	2322	-40
Forests	22840	22514	-326
Woodlands	7925	7828	-97
Forested floodplain	1061	1049	-12
Grass and sedgelands	1038	1051	13
Heath and shrublands	3455	3444	-11
Freshwater wetlands	335	333	-2
Estuaries	962	958	-4
Non-remnant	0	493	493
Not mapped	3024	3009	

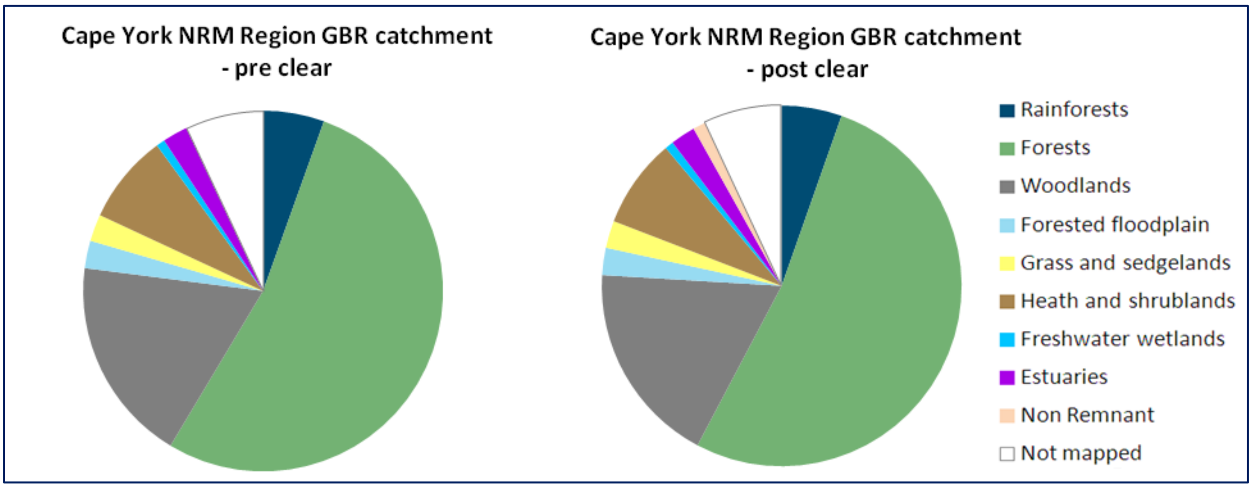

Figure 4.7: Percentages of terrestrial coastal ecosystems (pre-clear extent to post-clear extent) for the Cape York NRM region. Note these figures provide no information about ecosystem condition or functionality.

Land use

Land use for the Cape York region is shown in table 4.3 and figure 4.8 below. The dominant land uses in the region are grazing of natural areas, conservation and forestry. Please note land use mapping was unavailable for 2009.

Table 4.3: Land use data for the Cape York NRM region (1999). The 2009 data was not available at the time of printing.

Land Use Groupings	1999 extent (km^2)	2009 extent (km^2)
Conservation, natural environments (inc. wetlands)	19954	65
Forestry	1200	4
Grazing natural vegetation	21627	8
Intensive animal production	2	0
Intensive commercial	7	0
Intensive mining	0	0
Intensive urban residential	10	1
Production - dryland	20	0
Production - irrigated	32	0
Water - marsh/wetland production	0	0
Water - intensive use	0	0
Water storage and treatment	120	0
Mapping unavailable	24	42920
Total	42997	42998

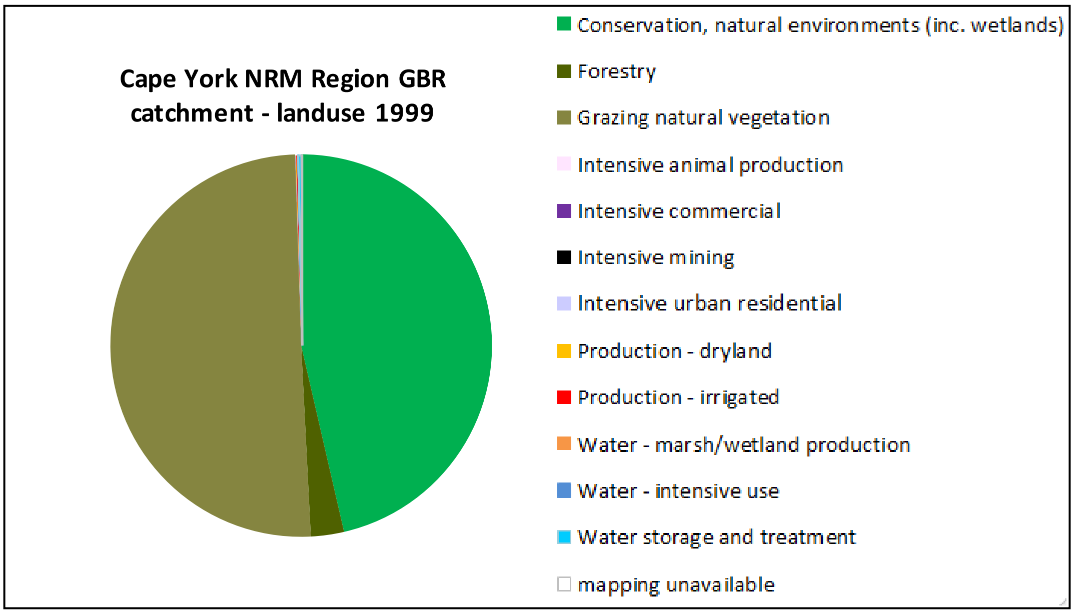

Figure 4.8: Percentages of land use for the Cape York NRM region in 1999. Note land use mapping was unavailable for the Cape York NRM region for 2009.

A regional summary for the Cape York NRM region of the current extent and trends of Great Barrier Reef coastal ecosystems, present land uses and major pollutant loads (as of 2009) is presented in figure 4.9.

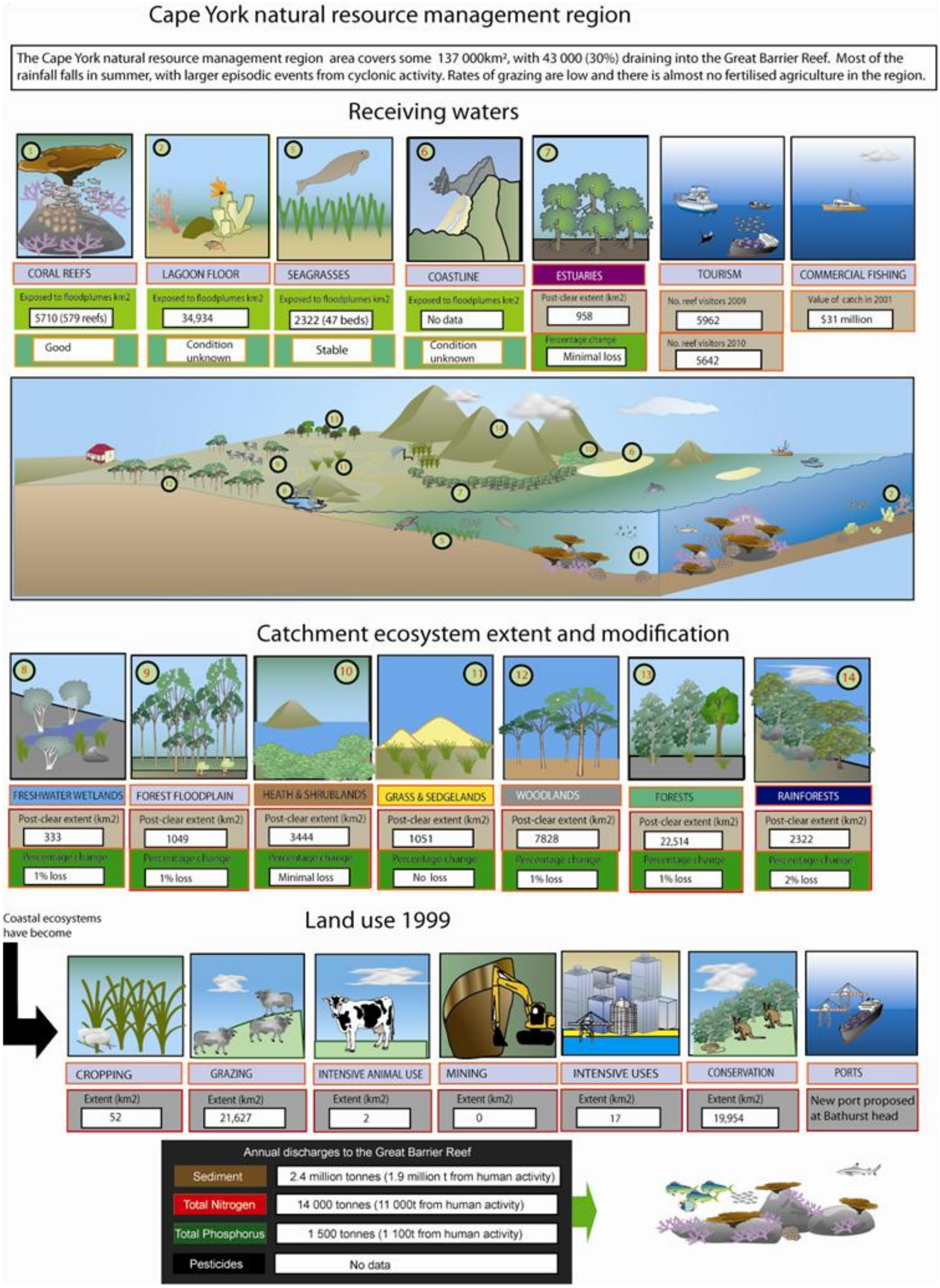

Figure 4.9: Cape York NRM regional summary of coastal ecosystems, land use (1999) and water quality discharges (as of 2009) into the Great Barrier Reef

Cape York NRM region basin summaries

There are seven basins within this region that flow into the Great Barrier Reef. Of these, the vegetation loss within the coastal ecosystems is low. The percentage of remaining coastal ecosystem is shown in table 4.4.

Table 4.4: Areas of concern — the percentage of remaining terrestrial coastal ecosystems for the seven basins within the Cape York NRM region. The basins in this region remain relatively intact. Red cells indicate areas with less than 26 per cent remaining, orange 26–50 per cent, yellow 51–75 per cent and green greater than 76 per cent. Note these figures provide no information about ecosystem condition or functionality. White cells denote an absence of this coastal ecosystem from the basin and pink cells denote an increase in area.

Basins	Rainforests	Forests	Woodlands	Forested floodplain	Grass and sedgelands	Heath and shrublands	Freshwater wetlands	Estuaries
Jacky Jacky	100	100	100		130	100	100	100
Olive-Pascoe	100	100	100		113	100	100	100
Lockhart	100	98	99		100	100	100	99
Stewart	100	100	100	100	100	100	100	100
Normanby	100	99	99	99	100	100	99	100
Jeannie	92	98	100	100	275	99	98	100
Endeavour	97	95	100	91	200	100	100	96
Grand Total	98	99	99	99	101	100	99	100

4.2.2. Wet Tropics NRM region

The Wet Tropics NRM region (figure 4.10) covers an area of approximately 22,000 km^2 and includes the Daintree, Mossman, Barron, Mulgrave-Russell, Johnstone, Tully-Murray and Herbert basins. This region experiences between 1500 and 4000 mm of rain annually, with more than half occurring during the summer months. The region's basins are characterised by steep mountainous landforms which occur relatively close to the coastline. The Great Barrier Reef is much closer to land in this region than in the south.

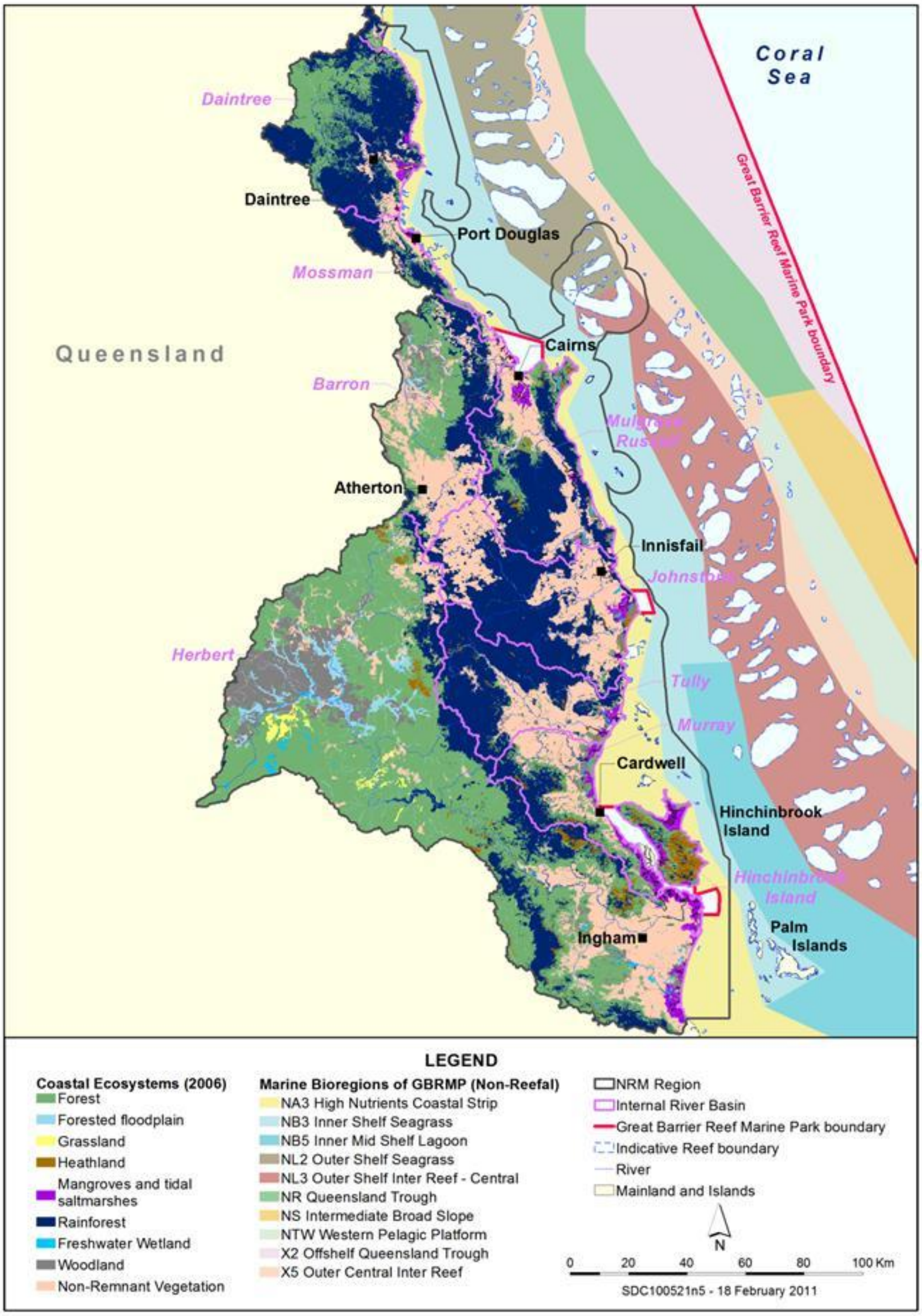

Figure 4.10: Wet Tropics NRM region post-clear coastal ecosystems and marine bioregions. ***Note some islands in this region have not been mapped. Light blue areas bordered by red (in the marine areas) denote port areas that are outside the Marine Park.**

Receiving waters

Flood plumes from the basins of the Wet Tropics have been shown to reach beyond the Great Barrier Reef in this region. At risk of exposure to one or more water quality concerns such as sediments, nutrients or pesticides are 211 coral reefs covering an area of 1066 km^2, 71 seagrass beds covering an area of 186 km^2[2,] and 16,978 km^2 of seabed.[2] This region supports significant tourism (629,404 full day visitors in 2009). Commercial fisheries were also valued at $24 million in 2001, making up 20 per cent of the gross value production of fisheries in the Great Barrier Reef. .[5,6]

Changes to coastal ecosystems (pre-clear to pre-clear)

Overall vegetation loss (table 4.5 and figure 4.11) between pre-clear and recent post-clear extent data was 4844 km^2 or 22 per cent for this region. Note that the islands within this region are not included in this table as mapping of these areas is not comprehensive.

Table 4.5: Changes to terrestrial coastal ecosystems (pre-clear extent to post-clear extent). Note these figures provide no information about ecosystem condition or functionality.

Coastal Ecosystem	Pre clear extent (km^2)	Post clear extent (km^2)	Area modified (km^2)
Rainforests	8885	6742	-2143
Forests	8966	7284	-1682
Woodlands	1928	1368	-560
Forested floodplain	585	514	-71
Grass and sedgelands	233	101	-132
Heath and shrublands	367	303	-64
Freshwater wetlands	258	104	-154
Estuaries	422	383	-39
Non Remnant	0	4791	4791
Not Mapped	72	126	

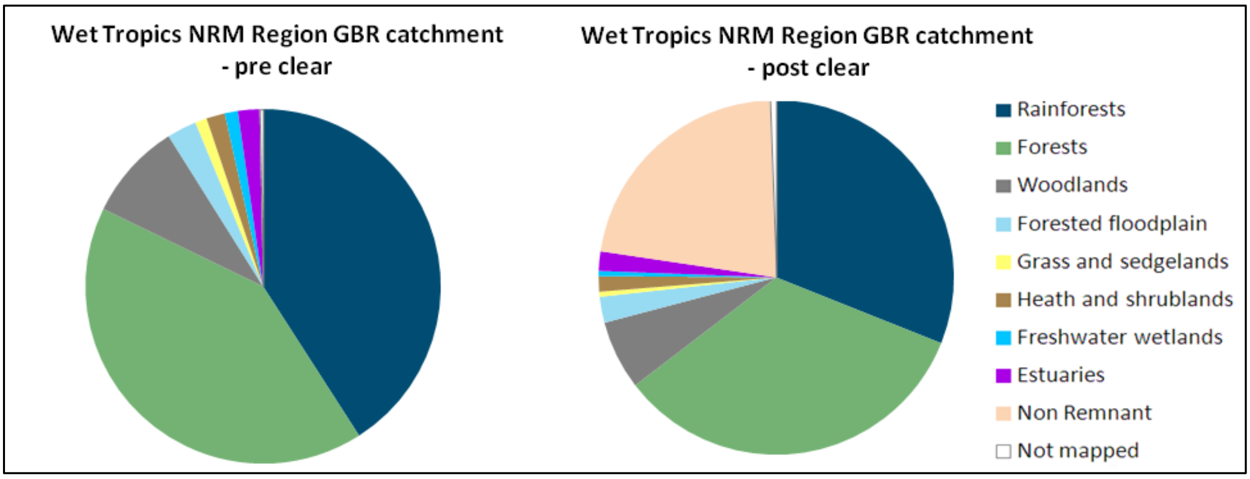

Figure 4.11: Percentages of terrestrial coastal ecosystems (pre-clear extent to post-clear extent) for the Wet Tropics NRM region. Note these figures provide no information about ecosystem condition or functionality.

Land use

Land use in the Wet Tropics region is shown in table 4.6 and figure 4.12 below. The dominant land uses in the region are conservation (wetlands, conservation protected areas and natural areas), grazing natural areas and cropping (sugarcane, irrigated and non-irrigated cropping and horticulture). The reduction in area of conservation and natural environments (including wetlands) between 1999 and 2009 is a result of the reclassification of estuarine ecosystems around Mourilyan Harbour. In 1999 this area was assigned a secondary and tertiary classification of *Conservation*. In 2009 there was no secondary and tertiary classifications assigned to this area – this resulted in the area being assigned under the primary category of *Water Storage and Transport*. It is not currently a terrestrial protected area however the marine plants contained within it are protected under the *Fisheries Act 1994*.

Table 4.6 shows the changes in land use between 1999 and 2009 for the Wet Tropics region

Land Use Groupings	1999 extent (km^2)	2009 extent (km^2)
Conservation, natural environments (inc. wetlands)	9994	9913
Forestry	1544	1639
Grazing natural vegetation	6896	7215
Intensive animal production	337	14
Intensive commercial	110	104
Intensive mining	27	27
Intensive urban residential	233	315
Production - dryland	1125	1558
Production - irrigated	1269	645
Water - marsh/wetland production	0	69
Water - intensive use	0	0
Water storage and treatment	164	199
Mapping unavailable	12	10
Total	21710	21710

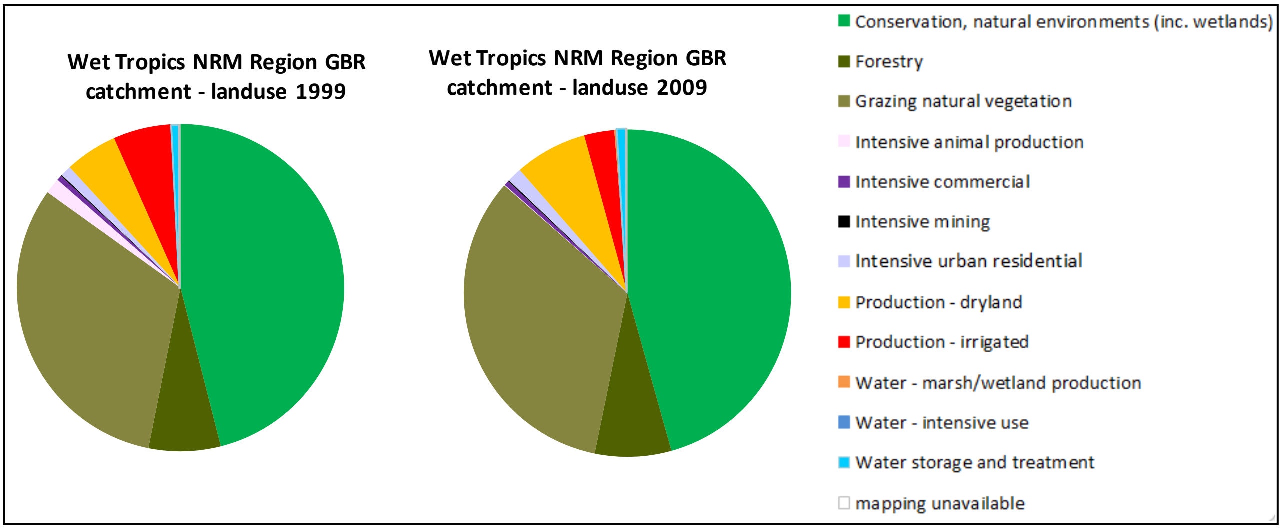

Figure 4.12: Percentages of land use from 1999 and 2009 for the Wet Tropics NRM region

A regional summary for the Wet Tropics NRM region of the current extent and trends of Great Barrier Reef coastal ecosystems, present land uses, and major pollutant loads (as of 2010) is presented in figure 4.13.

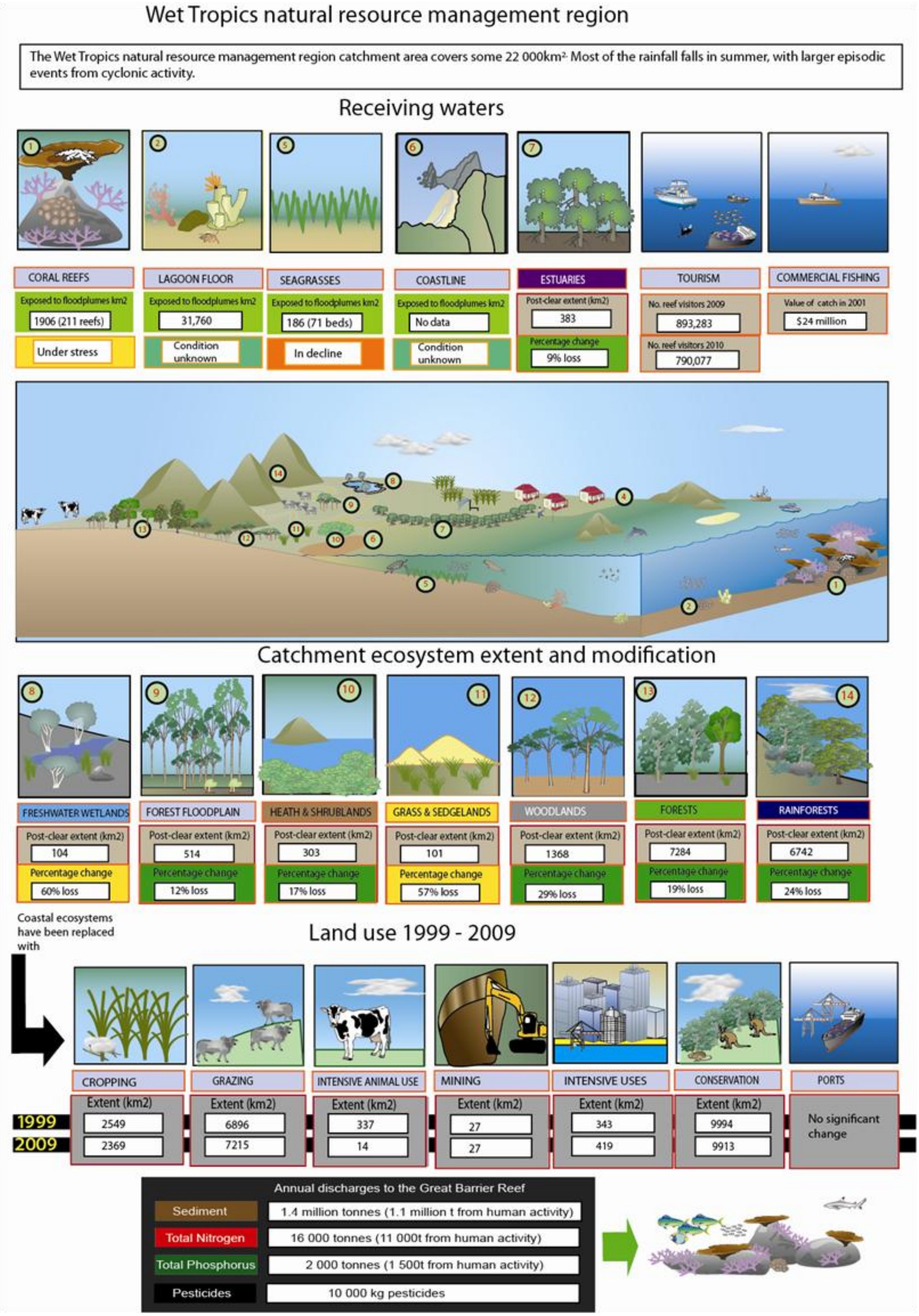

Figure 4.13: Wet Tropics regional summary

Wet Tropics NRM region basin summaries

There are eight basins within this region that flow into the Great Barrier Reef. Of these, the vegetation loss within the coastal ecosystems is high in some basins. The percentage of remaining coastal ecosystem is shown in table 4.7.

Table 4.7: Areas of concern – percentage of remaining terrestrial coastal ecosystems for the eight basins within the Wet Tropics NRM region. Red cells indicate areas with less than 10 per cent remaining; orange 10-30 per cent; yellow 31-50 per cent and green greater than 50 per cent. Pink indicates an increase in area. Note these figures provide no information about ecosystem condition or functionality.

Basins	Rainforests	Forests	Woodlands	Forested floodplain	Grass and sedgelands	Heath and shrublands	Freshwater wetlands	Estuaries
Daintree	94	96	81	100	100	90	100	97
Mossman	84	67	46	100	100	50	0	84
Barron	58	67	66	61	33	86	25	71
Mulgrave-Russell	76	65	64	86	25	100	53	82
Johnstone	56	21	52	100	100	89	78	88
Tully	83	39	33	100	3	93	57	95
Murray	88	59	39	100	0	100	27	99
Herbert	89	87	82	91	53	76	39	88
Grand Total	76	81	71	88	43	83	40	91

4.2.1. Burdekin Dry Tropics NRM region

The Burdekin Dry Tropics NRM region (figure 4.14) covers an area of approximately 141,000 km^2 which is dominated by the Burdekin River, with several small rivers, creeks and groundwater also draining into the Great Barrier Reef. The Burdekin Dry Tropics region includes the Black, Ross, Haughton, Burdekin and Don basins and is the second largest river basin on the Queensland east coast. This region experiences very distinct wet and dry seasons, with the majority of rainfall occurring over the summer months. The region's basins are characterised by extensive plains dominated by grazing of natural ecosystems, with the southern and coastal part of the catchment more heavily modified.

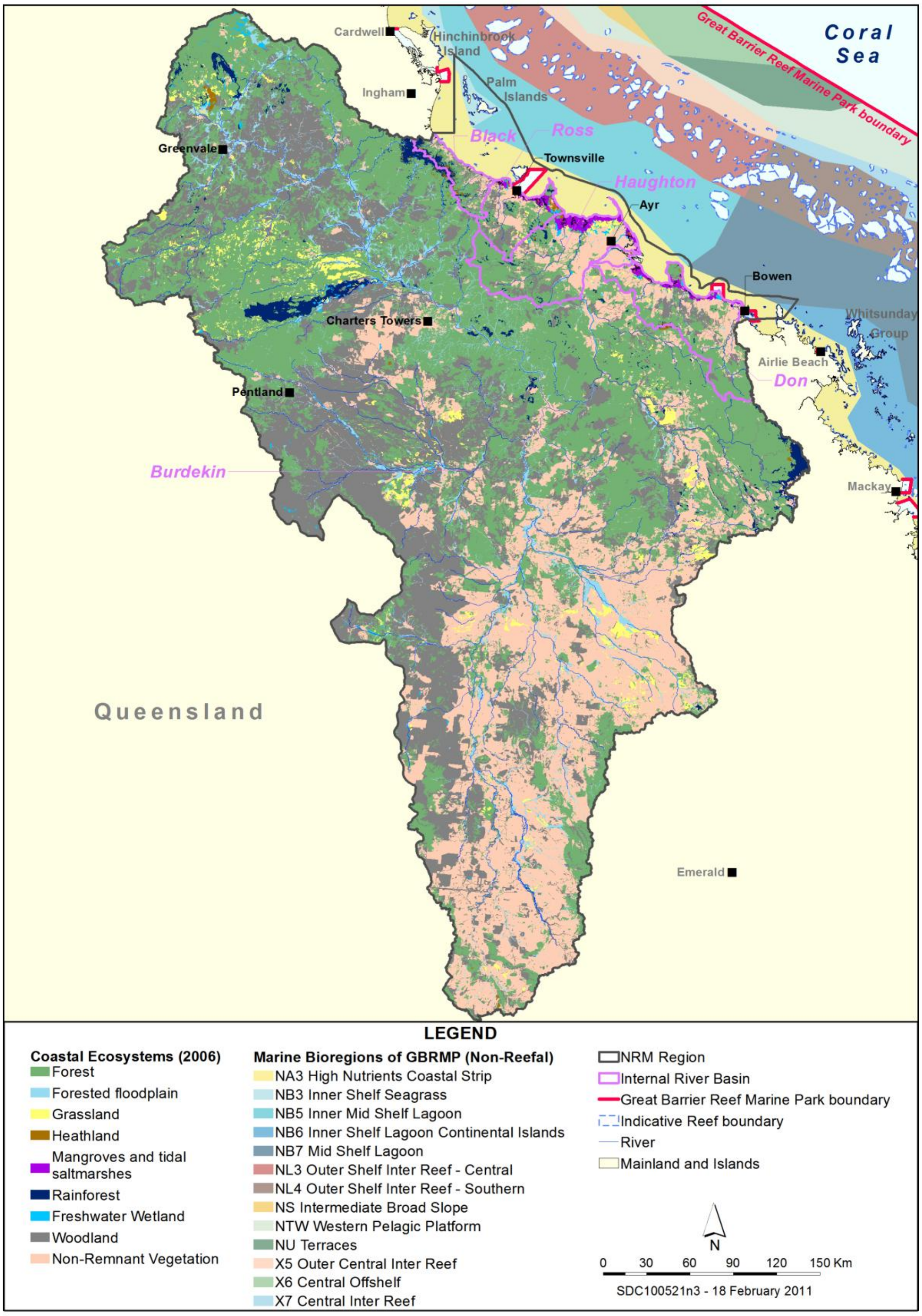

Figure 4.14: Burdekin Dry Tropics NRM region coastal ecosystems and marine bioregions. *Note some islands have not been included in the mapping and are shown as 'mainland and islands'. This includes Magnetic Island and the Palm Islands group.

Receiving waters

Flood plumes from the Burdekin NRM region have been shown to reach beyond the Great Barrier Reef. At risk of exposure to one or more water quality concerns, such as sediments, nutrients or pesticides, are 246 coral reefs (covering an area of 2088 km^2), 73 seagrass beds (covering an area of 603 km^2) and 46 978 km^2 of seabed.[2] This region also supports significant tourism (68,476 full day reef visitors in 2009). Commercial fisheries were also valued at $19 million in 2001, making up 16 per cent of the gross value production for fisheries in the Great Barrier Reef.

Changes to coastal ecosystems (pre-clear to pre-clear)

Overall vegetation loss (table 4.8 and figure 4.15) between pre-clear and recent post-clear data was 35,583 km^2 for catchments in this NRM region. Note islands are not included in this table as mapping of these areas is not comprehensive.

Table 4.8: Changes to coastal ecosystems (pre-clear extent to post-clear extent). Note these figures provide no information about ecosystem condition or functionality.

Coastal Ecosystem	Pre clear extent (km^2)	Post clear extent (km^2)	Area modified (km^2)
Rainforests	2539	2163	-376
Forests	74356	54671	-19685
Woodlands	50090	37985	-12105
Forested floodplain	7166	5691	-1475
Grass and sedgelands	4896	2842	-2054
Heath and shrublands	359	320	-39
Freshwater wetlands	558	465	-93
Estuaries	661	640	-21
Non remnant	0	35583	35583
Not mapped	51	317	

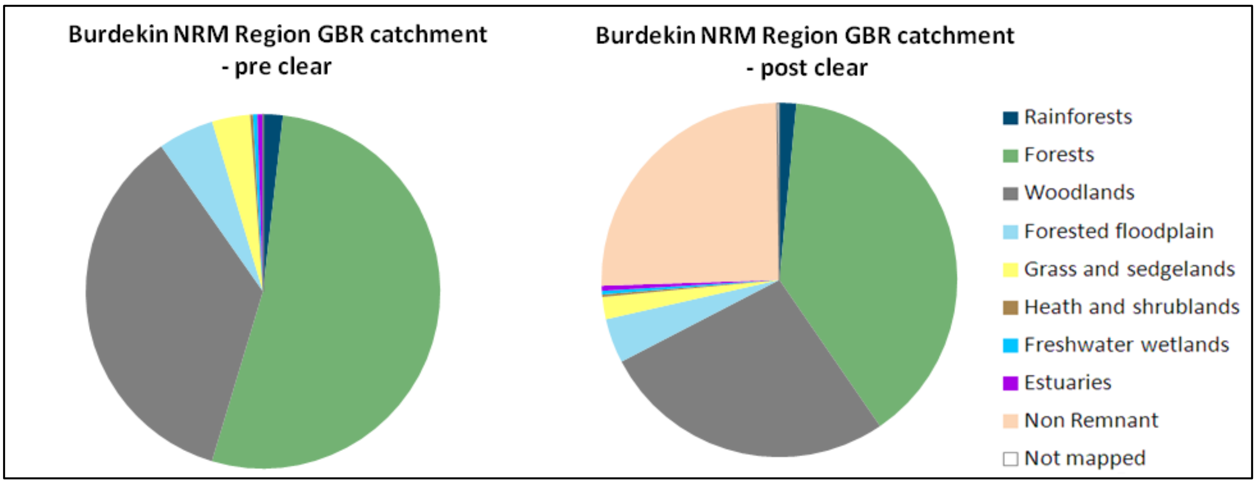

Figure 4.15: Percentages of terrestrial coastal ecosystems (pre-clear extent to post-clear extent) for the Burdekin NRM region. Note these figures provide no information about ecosystem condition or functionality.

Land use

Land use for the Burdekin Dry Tropics NRM region is shown in table 4.9 and figure 4.16 below. The dominant land use in the region is grazing natural vegetation, which occurs on around 120,000 km^2 or approximately 84 per cent of the catchment. Conservation and natural areas comprise the next major use. Between 1999 and 2009, areas classified as minimal use and remnant native cover, under 'conservation and natural environments' were reassigned in 2009 to the classification of 'grazing natural vegetation'.

Table 4.9: 1999 and 2009 land use data for the Burdekin Dry Tropics region

Land Use Groupings	1999 extent (km^2)	2009 extent (km^2)
Conservation, natural environments (inc. wetlands)	15168	8851
Forestry	801	966
Grazing natural vegetation	120500	126472
Intensive animal production	24	7
Intensive commercial	128	133
Intensive mining	126	157
Intensive urban residential	209	251
Production - dryland	1320	1262
Production - irrigated	1316	1294
Water - marsh/wetland production	128	278
Water - intensive use	443	0
Water storage and treatment	484	984
Mapping unavailable	23	17
Total	140671	140671

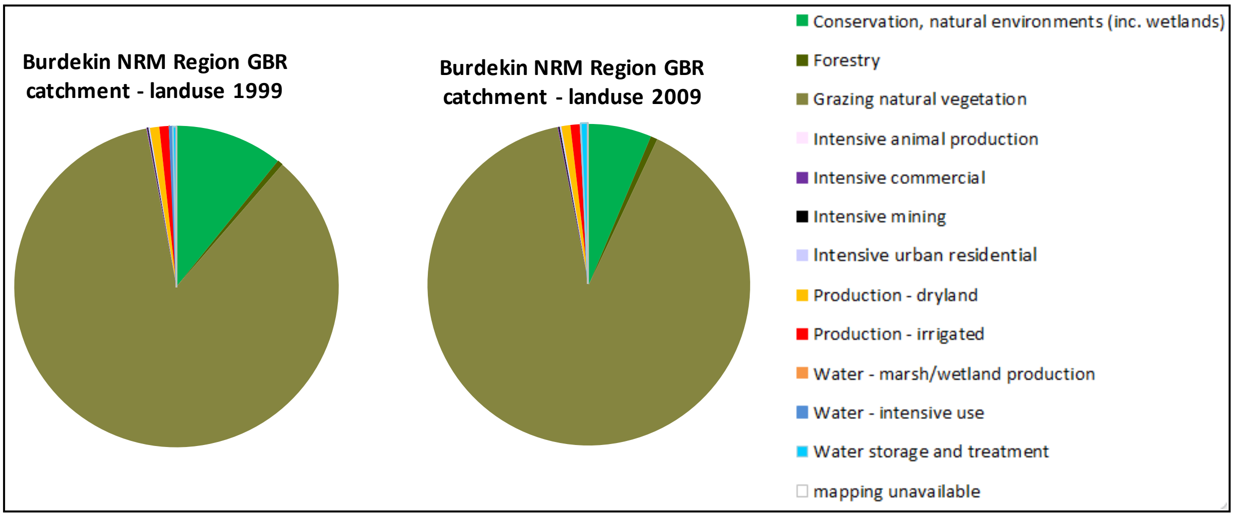

Figure 4.16: Percentages of Land use from 1999 and 2009 for the Burdekin NRM region.

A regional summary for the Burdekin NRM region showing the current extent and trends of Great Barrier Reef coastal ecosystems, present land uses and major pollutant loads (as of 2009) is presented in figure 4.17.

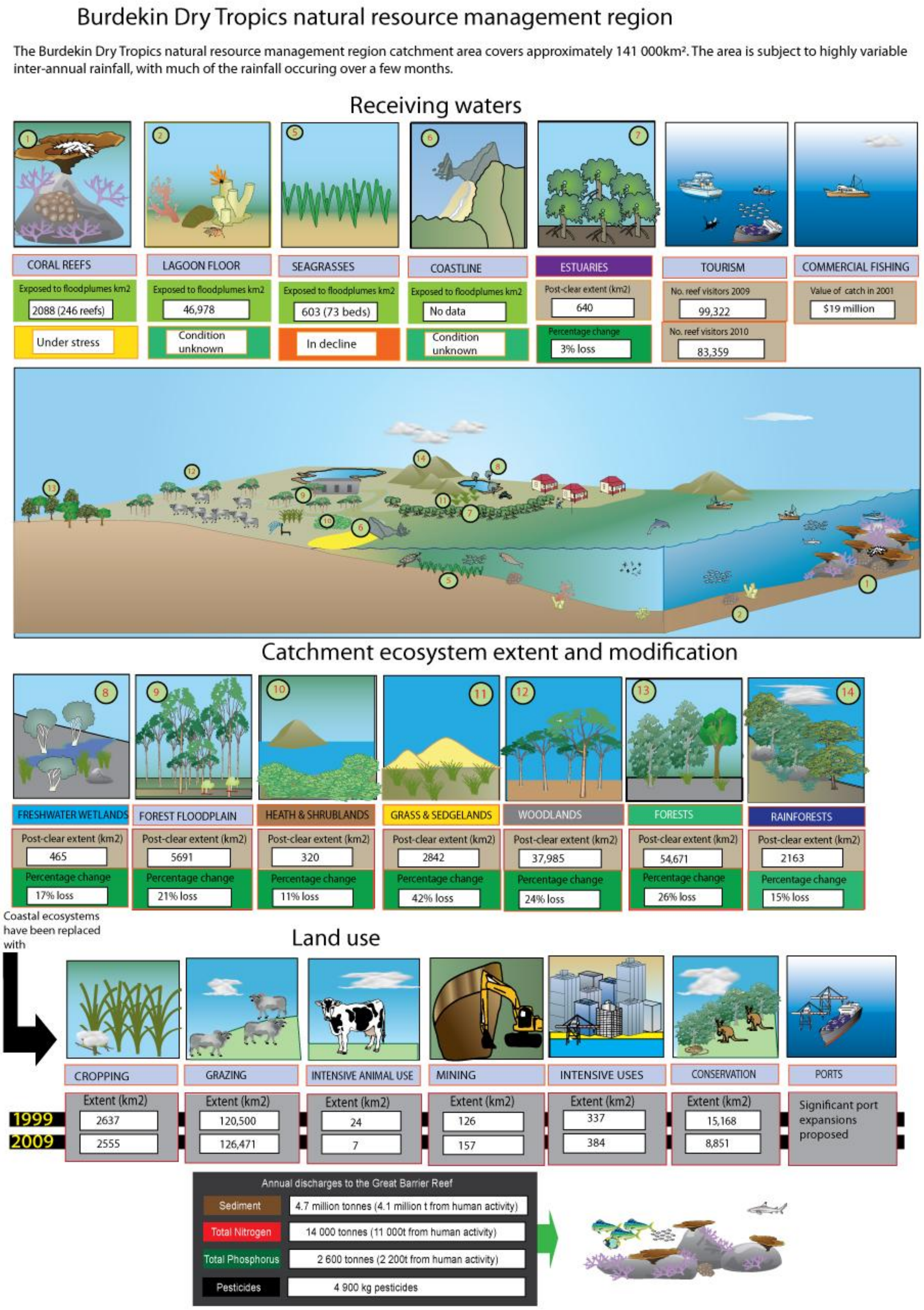

Figure 4.17: Burdekin NRM regional summary

Burdekin NRM region basin summaries

There are five basins within this region that flow into the Great Barrier Reef. The percentage of remaining coastal ecosystems is shown in table 4.10.

Table 4.10: Areas of concern – percentage of remaining coastal catchment ecosystems for the four basins within the Burdekin NRM region. Red cells indicate areas with less than 10 per cent remaining; orange 10-30 per cent; yellow 31-50 per cent and green greater than 50 per cent. Note these figures provide no information about ecosystem condition or functionality.

Basins	Rainforests	Forests	Woodlands	Forested floodplain	Grass and sedgelands	Heath and shrublands	Freshwater wetlands	Estuaries
Black	99	83	61	90	100	96	100	100
Ross	100	76	67	75	39	76	89	95
Haughton	99	64	86	24	58	96	68	99
Burdekin	83	74	76	81	59	98	90	75
Don	96	66	75	79	24	77	56	94
Grand Total	85	74	76	79	58	89	83	97

4.2.2. Mackay-Whitsunday NRM region

The Mackay-Whitsunday NRM region (figure 4.18) covers approximately 9000 km^2 and includes the Proserpine, O'Connell, Pioneer and Plane river basins. The region is sub-tropical, and experiences a distinct wet season, with more than half of the annual rainfall occurring between January and March.

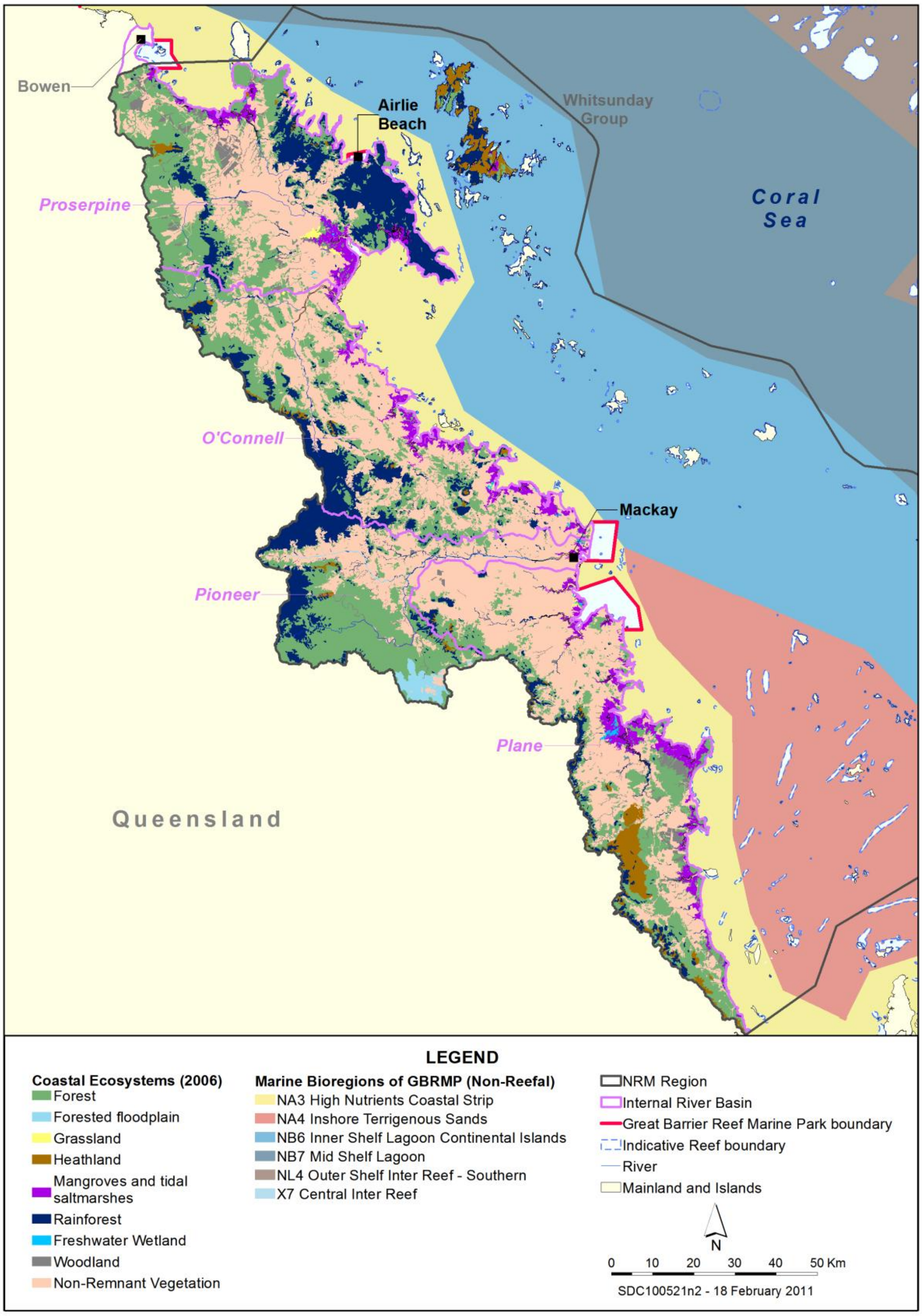

Figure 4.18: Mackay–Whitsunday NRM region coastal ecosystems and marine bioregions. ***Note some areas, including the Whitsunday Islands, have not been mapped. Light blue areas bordered in red in the marine region are port exclusion zones and are not part of the Marine Park.**

Receiving waters

Flood plumes from the Mackay–Whitsunday NRM region are known to reach beyond the Whitsunday Islands and out to the mid-shelf waters of the Great Barrier Reef. At risk of exposure to one or more water quality concerns, such as sediments, nutrients or pesticides, are 250 km of coastline, 74 offshore islands, 211 coral reefs covering an area of 1906 km^2, 71 seagrass beds covering an area of 186 km^2 and 31,760 km^2 of seabed.[3] This region also supports significant tourism (685,385 full day reef visitors in 2009). Commercial fisheries were valued at $20 million in 2001, making up 17 per cent of gross value production for fisheries in the Great Barrier Reef.[5,6]

Changes to coastal ecosystems (pre-clear to pre-clear)

Overall vegetation loss (table 4.11 and figure 4.19) between pre-clear and recent post-clear extent data was 3907 km^2 for the basins within the Mackay–Whitsunday NRM region. Note some areas within this region (islands) are not included in this table as mapping of these areas is not comprehensive.

Table 4.11: Changes to coastal ecosystems (pre-clear extent to post-clear extent) for the Mackay–Whitsunday NRM region. Note these figures provide no information about ecosystem condition or functionality.

Coastal Ecosystem	Pre clear extent (km^2)	Post clear extent (km^2)	Area modified (km^2)
Rainforests	1400	1276	-124
Forests	5949	2785	-3164
Woodlands	724	242	-482
Forested floodplain	81	75	-6
Grass and sedgelands	102	17	-85
Heath and shrublands	191	187	-4
Freshwater wetlands	33	13	-20
Estuaries	464	443	-21
Non remnant	0	3857	3857
Not mapped	51	100	

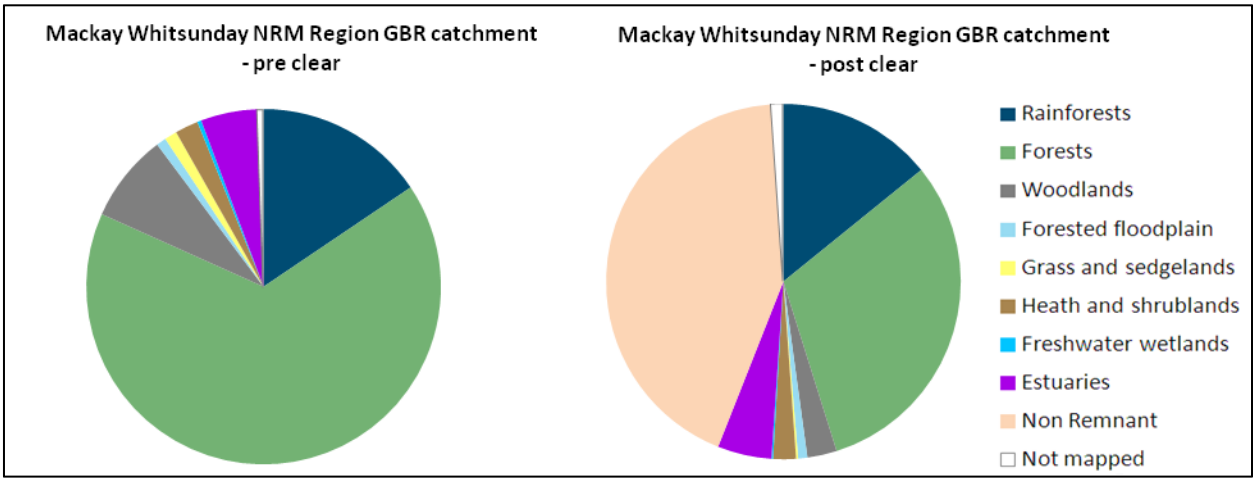

Figure 4.19: Percentages of terrestrial coastal ecosystems (pre-clear extent to post-clear extent) for the Mackay–Whitsunday NRM region. Note these figures provide no information about ecosystem condition or functionality.

Land use

Land use for the Mackay–Whitsunday region is shown in table 4.12 and figure 4.20 below. The dominant land uses in the region are grazing (around 7000 km²), national parks and cropping (sugar cane).

Table 4.12: Land use data for the Mackay–Whitsunday NRM region

Land Use Groupings	1999 extent (km^2)	2009 extent (km^2)
Conservation, natural environments (inc. wetlands)	1896	1950
Forestry	903	949
Grazing natural vegetation	4100	3913
Intensive animal production	12	8
Intensive commercial	57	53
Intensive mining	5	8
Intensive urban residential	117	156
Production - dryland	59	47
Production - irrigated	1627	1655
Water - marsh/wetland production	85	100
Water - intensive use	0	0
Water storage and treatment	120	145
Mapping unavailable	10	9
Total	8990	8990

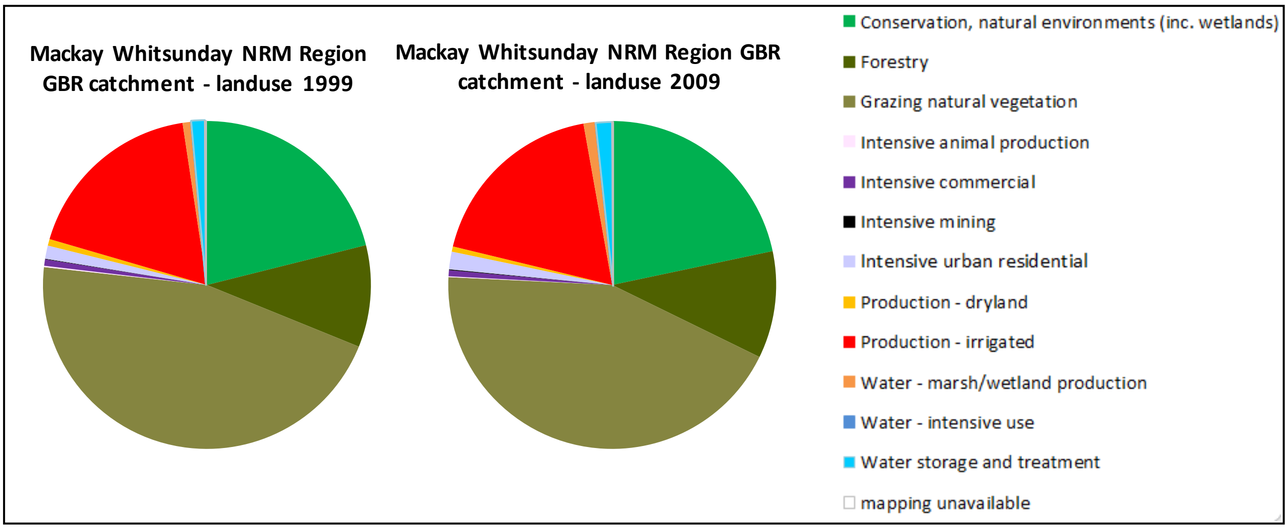

Figure 4.20: Percentages of land use from 1999 and 2009 for the Mackay–Whitsunday NRM region.

A regional summary for the Mackay–Whitsunday NRM region showing the current extent and trends of Great Barrier Reef coastal ecosystems, present land uses and major pollutant loads (as of 2009) is presented in figure 4.21.

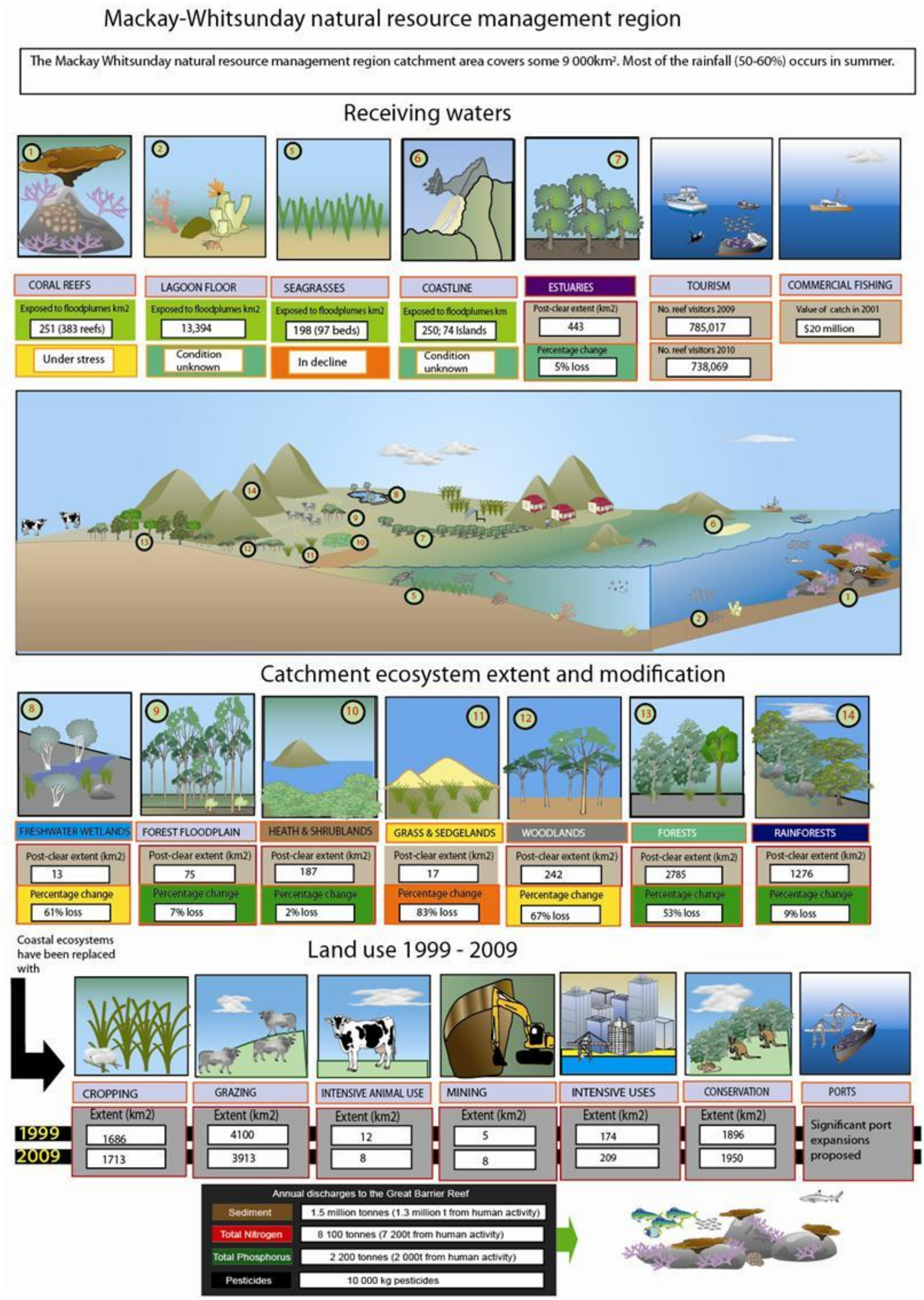

Figure 4.21: Mackay–Whitsunday NRM regional summary

Mackay–Whitsunday NRM region basin summaries

There are four basins within this region that flow into the Great Barrier Reef. The percentage of remaining coastal ecosystems is shown in table 4.13.

Table 4.13: Areas of concern – the percentage of remaining coastal ecosystems for the four basins within the Mackay–Whitsunday NRM region. Red cells indicate areas with less than 10 per cent remaining; orange 10–30%; yellow 31–50% and green greater than 50 per cent. Note these figures provide no information about ecosystem condition or functionality. Note there is no forested floodplain in the O'Connell basin.

Basins	Rainforests	Forests	Woodlands	Forested floodplain	Grass and sedgelands	Heath and shrublands	Freshwater wetlands	Estuaries
Proserpine	96	55	40	100	22	100	11	97
O'Connell	85	41	32		33	100	75	97
Pioneer	91	58	35	94	6	100	67	70
Plane	92	38	28	0	16	97	89	94
Grand Total	91	47	33	93	17	98	39	95

4.2.3. Fitzroy NRM region

The Fitzroy NRM region (figure 4.22) is the largest NRM region on the Queensland east coast covering an area of approximately 156,000 km^2. It includes the Styx, Shoalwater, Waterpark, Fitzroy, Calliope and Boyne river basins. The region experiences variable rainfall with prolonged dry periods and high evaporation rates. As with other large dry tropical catchments, flooding may occur annually in sub-tidal areas with major floods happening on average once in every 10 years.

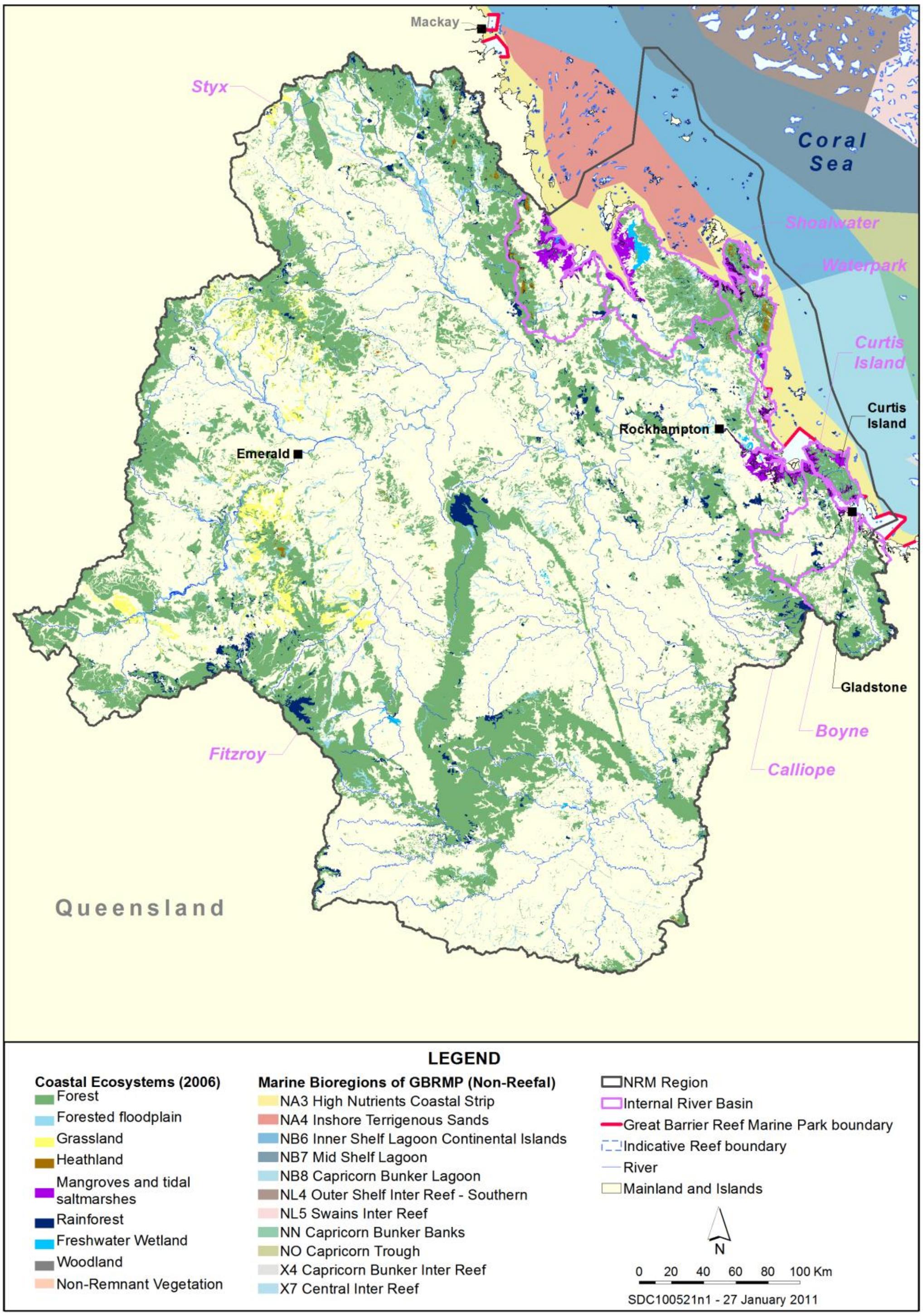

Figure 4.22: Fitzroy NRM region coastal ecosystems and marine bioregions. *Note some islands have not been mapped.

Receiving waters

In major flood events, plumes from the Fitzroy region basins have reached beyond the Keppel Islands and out to the Great Barrier Reef. At risk of exposure to one or more water quality concerns, such as sediments, nutrients or pesticides, are 173 coral reefs (covering an area of 79 km^2), 104 seagrass beds (covering an area of 199 km^2) and 8000 km^2 of seabed.[3] This region also supports significant commercial fisheries. In 2001, it was valued at $17 million, making up 15 per cent of gross value production[6] for fisheries in the Great Barrier Reef.[5,6]

Changes to coastal ecosystems (pre-clear to pre-clear)

Overall vegetation loss (table 4.14 and figure 4.23) between pre-clear and recent post-clear extent data was 89,105km^2 for the basins within this NRM region. Note that islands are not included in this table as mapping of these areas is not comprehensive.

Table 4.14: Changes to coastal ecosystems (pre-clear extent to post-clear extent). Note these figures provide no information about ecosystem condition or functionality.

Coastal Ecosystem	Pre clear extent (km^2)	Post clear extent (km^2)	Area modified (km^2)
Rainforests	6016	2191	-3825
Forests	91549	40686	-50863
Woodlands	38905	15483	-23422
Forested floodplain	10822	4184	-6638
Grass and sedgelands	6090	1976	-4114
Heath and shrublands	388	324	-64
Freshwater wetlands	210	303	93
Estuaries	1602	1328	-274
Non Remnant	0	1468	1468
Not Mapped	165	346	

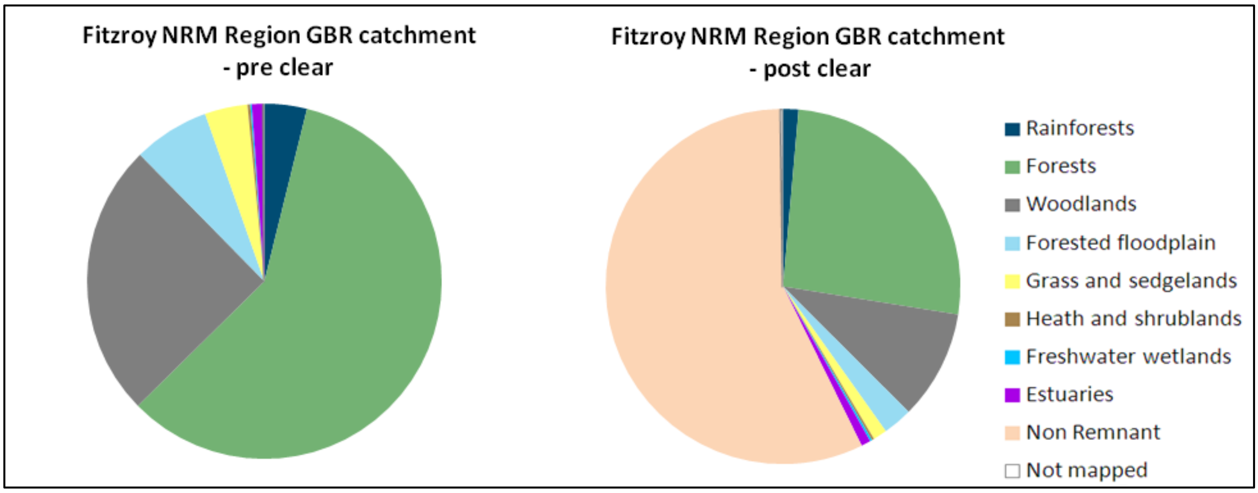

Figure 4.23: Percentages of terrestrial coastal ecosystems (pre-clear extent to post-clear extent) for the Fitzroy NRM region. Note these figures provide no information about ecosystem condition or functionality.

Land use

Land use in the Fitzroy NRM region is shown in table 4.15 and figure 4.24. The dominant land uses in the region are livestock grazing (more than 124,000 km^2), production forestry (10,000 km^2) and national parks. Extensive mining also occurs in the catchment. Cereals and cotton are the main crops grown.

Table 4.15: 1999 and 2009 land use data for the Fitzroy NRM region

Land Use Groupings	1999 extent (km^2)	2009 extent (km^2)
Conservation, natural environments (inc. wetlands)	11334	12273
Forestry	10013	9545
Grazing natural vegetation	124141	121418
Intensive animal production	23	12
Intensive commercial	82	204
Intensive mining	561	1023
Intensive urban residential	394	466
Production - dryland	7982	7964
Production - irrigated	755	1265
Water - marsh/wetland production	26	846
Water - intensive use	0	0
Water storage and treatment	406	707
Mapping unavailable	23	18
Total	155743	155742

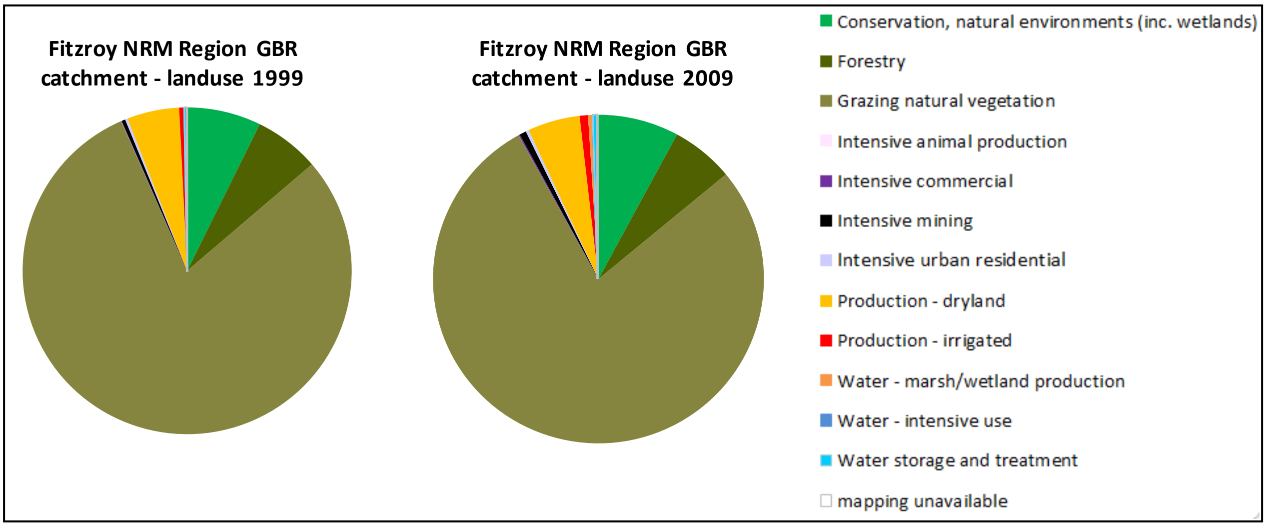

Figure 4.24: Percentages of Land use from 1999 and 2009 for the Fitzroy NRM region.

A regional summary for the Fitzroy NRM region of the current extent and trends of Great Barrier Reef coastal ecosystems, present land uses, and major pollutant loads (as of 2009) is presented in figure 4.25.

Fitzroy natural resource management region

The Fitzroy natural resource management region catchment area covers 156 000km². This area is subjected to highly variable rainfall, high evaporation and long dry periods.

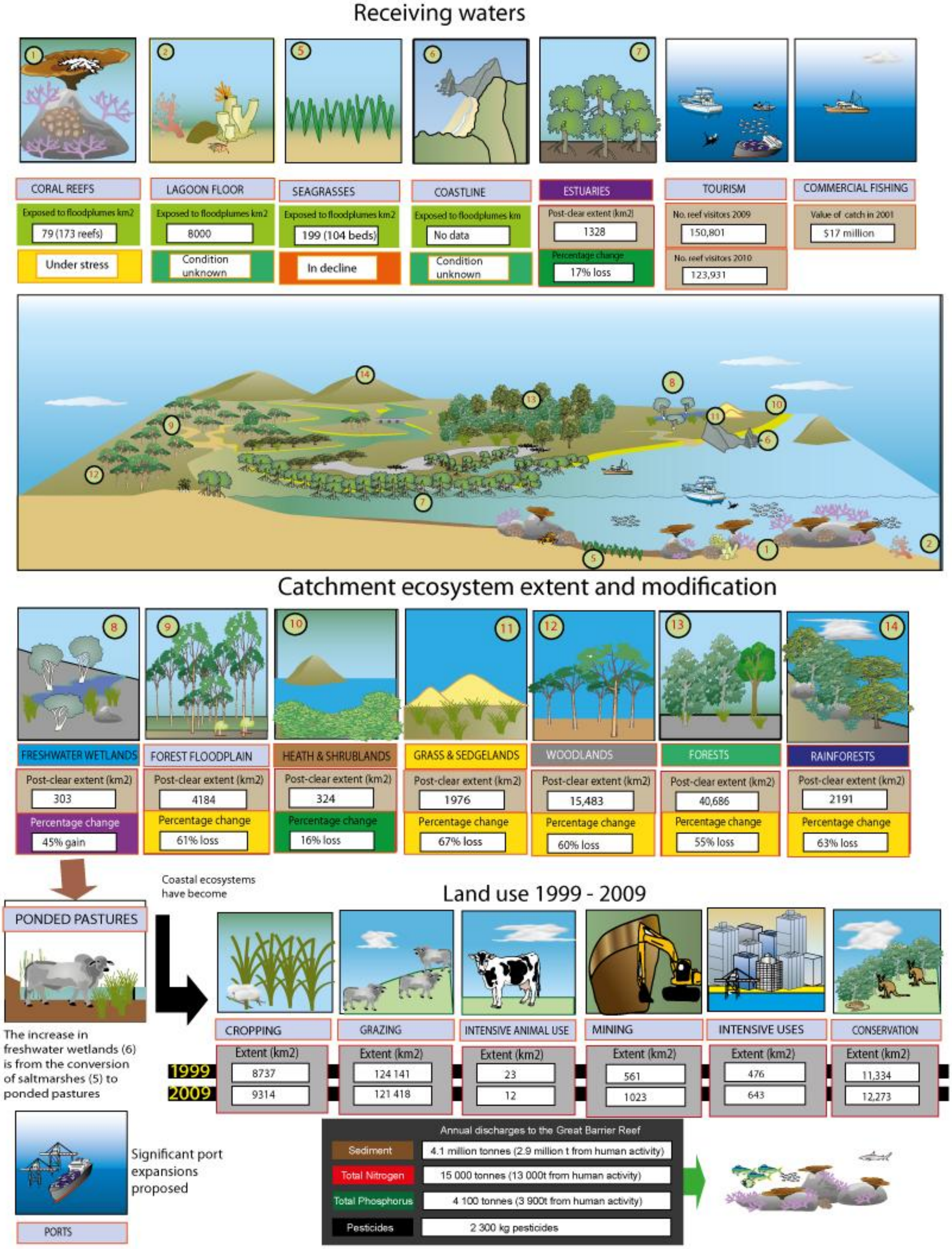

Figure 4.25: Fitzroy NRM regional summary

There are six basins within this region that flow into the Great Barrier Reef. The percentage of remaining coastal ecosystem is shown in table 4.16.

Table 4.16: Areas of concern – percentage of remaining coastal ecosystems for the six basins within the Fitzroy NRM region. Note the increase in freshwater wetlands, grass and sedgelands and heath and shrublands (represented in purple) is associated with the development of ponded pastures in the region. Red cells indicate areas with less than 10 per cent remaining; orange 10–30 per cent, yellow 31–50 per cent and green greater than 50 per cent. Note these figures provide no information about ecosystem condition or functionality. White cells denote an absence of this coastal ecosystem from the basin and pink cells denote an increase in area.

Basins	Rainforests	Forests	Woodlands	Forested floodplain	Grass and sedgelands	Heath and shrublands	Freshwater wetlands	Estuaries
Styx	68	58	31	35	100	100	400	97
Shoalwater	87	86	67	38	100	100	1567	65
Waterpark	88	80	84	**50**	100	74	127	95
Fitzroy	34	43	40	40	33	84	75	87
Calliope	48	41	3	15		100	100	91
Boyne	89	55	34	31		100	**50**	66
Grand Total	37	45	40	39	33	84	145	83

4.2.4. Burnett-Mary NRM region

The Burnett–Mary NRM region (figure 4.26) covers an area of about 53,000km^2. The region extends south to the west of Fraser Island and includes the Baffle, Kolan, Burnett, Burrum and Mary basins. The Burnett–Mary region spans sub-tropical to temperate zones with rainfall occurring predominantly in summer.

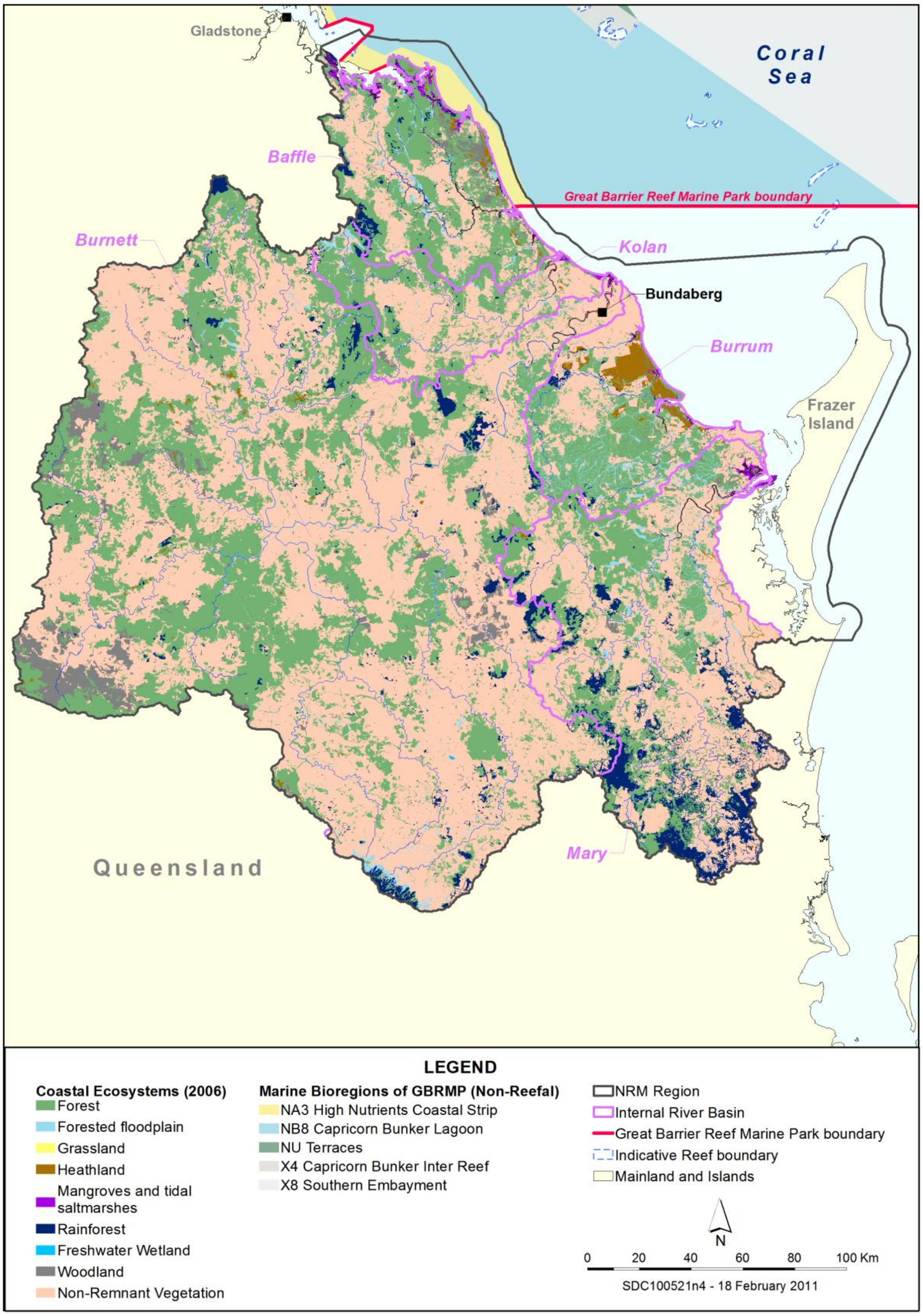

Figure 4.26: Burnett–Mary NRM region coastal ecosystem and marine bioregions. *Note some areas have not been mapped as they fall outside of the catchment.

Receiving waters

This region supports commercial fisheries with production valued at $7 million in 2001, making up six per cent of the gross value production for fisheries in the Great Barrier Reef. .[5,6]

Changes to coastal ecosystems (pre-clear to pre-clear)

Overall vegetation loss (table 4.17 and figure 4.27) between pre-clear and recent post-clear extent data was 30,431 km^2 for the basins in this NRM region. Note some of the NRM region (such as Fraser Island) is not included in this table.

Table 4.17: Changes to coastal ecosystems (pre-clear extent to post-clear extent). Note these figures provide no information about ecosystem condition or functionality.

Coastal Ecosystem	Pre clear extent (km^2)	Post clear extent (km^2)	Area modified (km^2)
Rainforests	5688	2053	-3635
Forests	35946	17441	-18505
Woodlands	5554	1689	-3865
Forested floodplain	4885	1145	-3740
Grass and sedgelands	1	5	4
Heath and shrublands	594	450	-144
Freshwater wetlands	41	22	-19
Estuaries	230	220	-10
Non remnant	0	29770	29770
Not mapped	82	234	

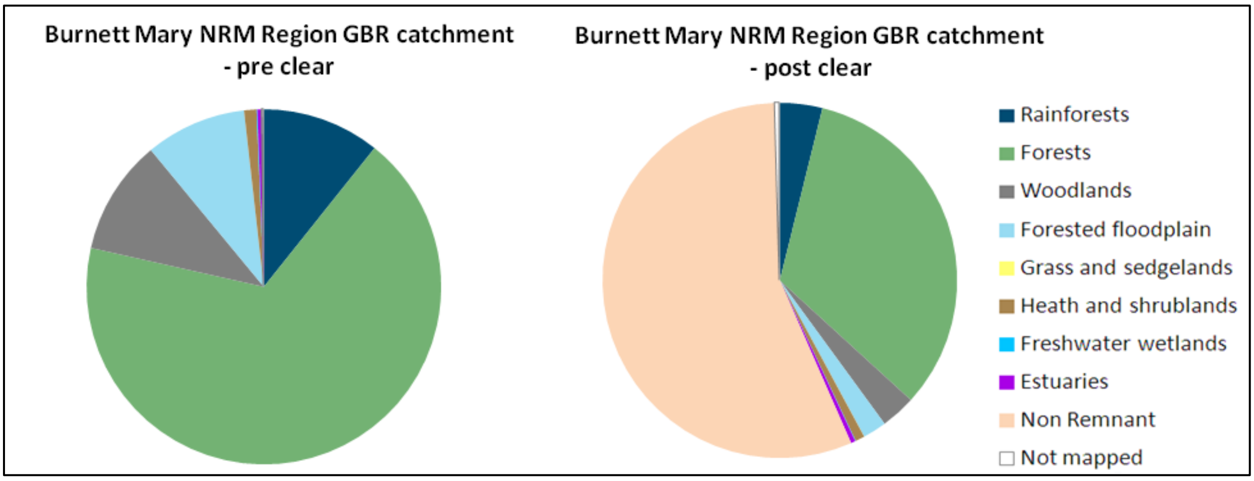

Figure 4.27: Percentages of terrestrial coastal ecosystems (pre-clear extent to post-clear extent) for the Burnett–Mary NRM region. Note these figures provide no information about ecosystem condition or functionality.

Land use

Land use in the Burnett Mary region is shown in table 4.18 and figure 4.28 below. The dominant land uses in the region are livestock grazing (more than 36,000 km^2), production forestry (7000 km^2) and national parks. Land use change data is not available for this region at the time of printing.

Table 4.18: 1999 land use data for the Burnett–Mary region. The 2009 land use data was not available at the time of publication

Land Use Groupings	1999 extent (km^2)	2009 extent (km^2)
Conservation, natural environments (inc. wetlands)	4497	4970
Forestry	7031	7363
Grazing natural vegetation	36578	36330
Intensive animal production	634	22
Intensive commercial	159	146
Intensive mining	29	40
Intensive urban residential	1228	1244
Production - dryland	925	894
Production - irrigated	1541	1559
Water - marsh/wetland production	0	1
Water - intensive use	0	0
Water storage and treatment	389	441
Mapping unavailable	12	14
Total	53023	53023

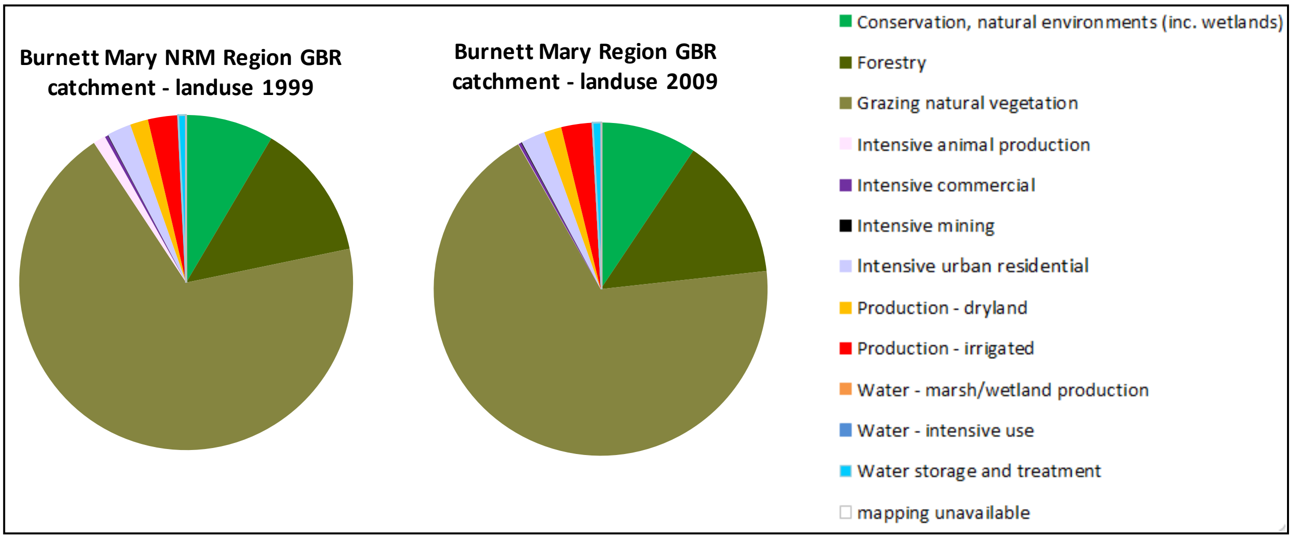

Figure 4.28: Percentages of Land use from 1999 and 2009 for the Burnett Mary NRM region.

A regional summary for the Burnett Mary NRM region of the current extent and trends of Great Barrier Reef coastal ecosystems, present land uses, and major pollutant loads (as of 2009) is presented in figure 4.29.

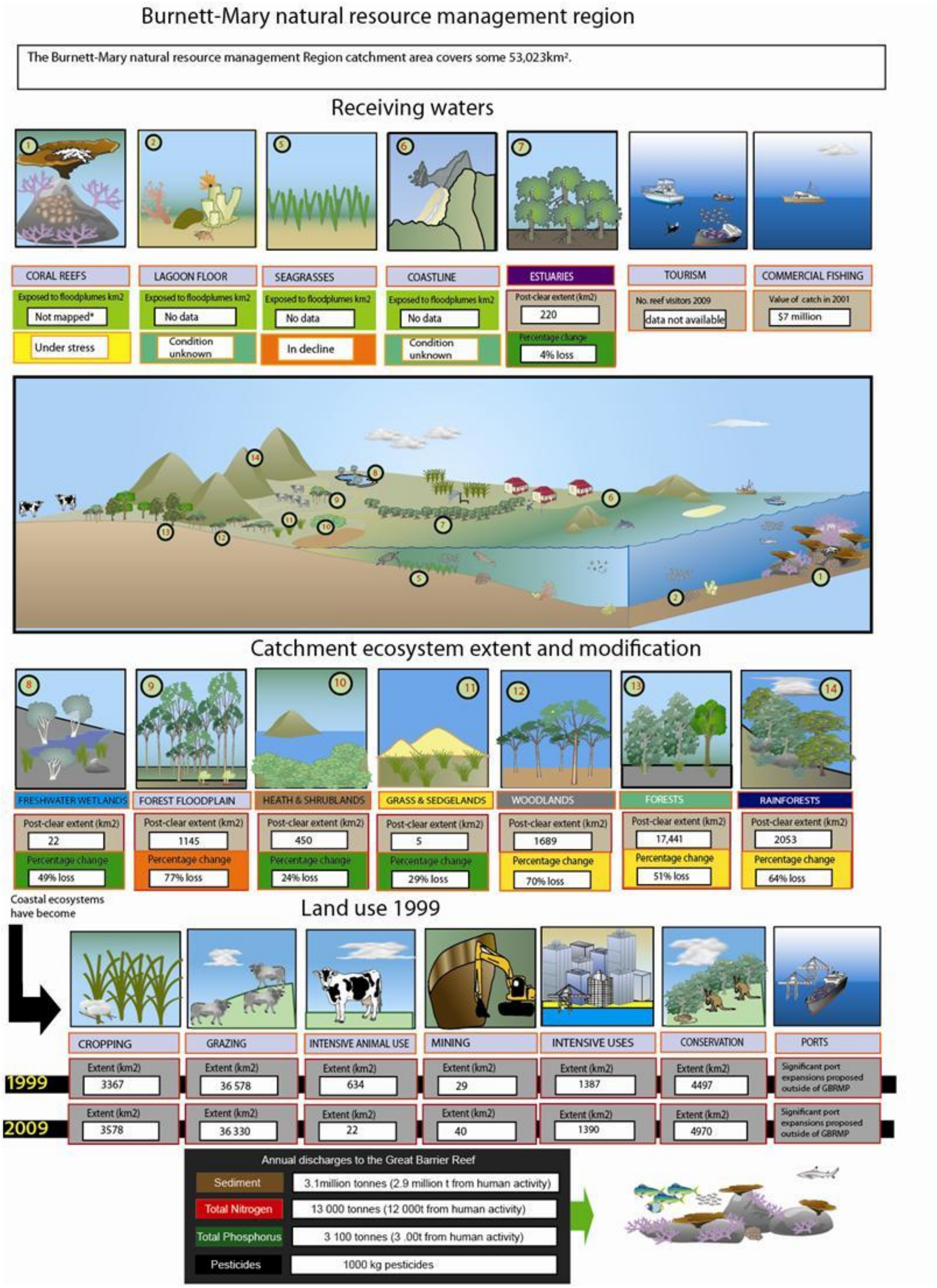

Figure 4.29: Burnett–Mary NRM regional summary. *Note the area is not represented in report[2] on risk exposure, so no consistent mapping is available.

Burnett–Mary NRM region basin summaries

There are five basins within this region that flow into the Great Barrier Reef. The percentage of remaining coastal ecosystem is shown in table 4.19.

Table 4.19: Areas of concern – percentage of remaining coastal ecosystems for the five basins within the Burnett–Mary NRM region. Red cells indicate areas with less than 10 per cent remaining; orange 10-30 per cent; yellow 31-50 per cent and green greater than 50 per cent. Note these figures provide no information about ecosystem condition or functionality. White cells denote an absence of this coastal ecosystem from the basin and pink cells denote an increase in area.

Basins	Rainforests	Forests	Woodlands	Forested floodplain	Grass and sedgelands	Heath and shrublands	Freshwater wetlands	Estuaries
Baffle	89	62	78	38		98	60	99
Burnett	23	46	27	15	71	91	53	73
Kolan	59	51	30	26		40	50	78
Burrum	18	64	69	57		79	88	96
Mary	52	45	52	24		31	33	98
Grand Total	36	49	30	23	500	76	54	96

References

1. Wachenfeld, D. 1997, Long-term trends in the status of coral reef-flat benthos – The use of historical photographs, in *State of the Great Barrier Reef World Heritage Area Workshop,* eds. Anonymous, pp.134-148.

2. Devlin, M., Harkness, P., McKinna, L. and Waterhouse, J. 2011, *Mapping the surface exposure of terrestrial pollutants in the Great Barrier Reef. Report to the Great Barrier Reef Marine Park Authority,* Australian Centre for Tropical and Freshwater Research, Townsville, viewed 18/10/2012, <http://www-public.jcu.edu.au/public/groups/everyone/documents/technical_report/jcu_086084.pdf>.

3. Brodie, J.E. and Waterhouse, J. 2009, *Assessment of relative risks of the impacts of broad-scale agriculture on the Great Barrier Reef and priorities for investment under the Reef Protection Package. Stage 1,* Australian Centre for Tropical and Freshwater Research, Townsville, viewed 18/10/2012, <http://www-public.jcu.edu.au/actfr/reports/2009/JCUPRD_055687>.

4. Brodie, J., Waterhouse, J., Lewis, S.E., Bainbridge, Z. and Johnson, J. 2009b, *Current loads of priority pollutants discharged from Great Barrier Reef Catchments to the Great Barrier Reef,* Australian Centre for Tropical and Freshwater Research, Townsville.

5. Fenton, D.M. and Marshall, N.A. 2001, *A Guide to the Fishers of Queensland. Part A: TRC-Analysis and Social Profiles of Queensland's Commercial Fishing Industry,* Townsville.

6. Productivity Commission 2003, *Industries, land use and water quality in the Great Barrier Reef catchment: research report,* Department of Communications, IT and the Arts, Canberra, viewed 18/10/2012, <http://www.pc.gov.au/__data/assets/pdf_file/0017/17153/gbr.pdf>.

5. Coastal ecosystems – summary information

Vulnerability assessments are being updated for each of the 14 Great Barrier Reef inshore and associated catchment and coastal ecosystem types. The aim of these assessments is to document our knowledge of the distribution, status and functions of the systems including how they are presently managed and options for future management. This section summarises the coastal ecosystems that the vulnerability assessments are based upon. The full vulnerability assessments (and assessments of their vulnerabilities) will be available at www.gbrmpa.gov.au when finalised.

5.1. Coral reefs

Extent (km2)	
Under stress following significant reduction	600
In the last 27 years	~50 per cent decline in coral cover

Hard corals are the signature group of the Great Barrier Reef and collectively they form a structure unlike any other. This reef matrix provides an important source of food and habitat for a myriad of aquatic and terrestrial flora and fauna.

Geographical distribution:

There are more than 2900 individual reefs in the Great Barrier Reef, making up approximately 25,000 km^2 or seven per cent of the area of the World Heritage Area. Of those, approximately 670 reefs with an area of around 600 km^2 are in the coastal water body — the area most affected by water quality and coastal development.[1] The majority of these are fringing reefs which are found in inshore or nearshore waters along the exposed coast and islands. While there are around 350 fringing reefs in the Great Barrier Reef they make up less than two per cent of the entire reefal area.

There are more than 500 species of corals worldwide. Some 411 species have been recorded in the Great Barrier Reef.[2] The diversity of soft corals is unknown at species level but there is estimated to be at least 150 species of soft corals, sea fans and sea pens in the Great Barrier Reef. Many algae species are a natural component of healthy coral reef systems.

Status in the Great Barrier Reef Marine Park:

Coral reefs are dynamic systems, with natural cycles of disturbance and recovery.[3] The health of any one reef is in direct relationship to the time elapsed since the most recent disturbance and the potential for recruitment from neighbouring reefs. In inshore areas south of Cooktown, coral reefs have been subjected to poor water quality from before the 1930s and historic photos show many locations where there has been no recovery in the ecosystem for decades. Corals are protected species and coral reefs are protected from direct loss through state and federal management arrangements. Long-term monitoring and assessment over more than 27 years indicates there has been a decline in coral cover of ~50 per cent, substantially due to declining water quality and subsequent increased frequency of crown-of-thorns starfish outbreaks [4]. Studies also point to the reduction in coral cover as reducing the resilience of the affected reefs, and a diminished capacity for coral species to re-colonise.

Ecosystem role/function:

Coral reefs provide important structure and habitat for the hugely complex biological community that makes up a tropical coral reef, including a great variety of fish and other species. The Great Barrier Reef is often described as one of the most biologically diverse ecosystems in the world. It has significant value for commercial and recreational pursuits and contributes more than $5 billion annually to the Queensland and Australian economies.

5.2. Lagoon Floor

Extent (km^2)	
Extent believed to be unchanged	20,456
	Some increased sedimentation and nutrient enrichment with unknown affect

These are areas generally lacking in hard substrates typically associated with reefs and shoals and, along with seagrass and *Halimeda* bed communities, represent the variety of ecosystem on the lagoon floor. Recent studies suggest the lagoon floor supports approximately 5300 species of marine organisms.[5]

Habitats:

- Sand and/or muddy bottoms
- Shoals
- Areas of coarse sand, rubble, stones, rock and bedrock
- Sponge gardens
- Algae (macro and micro) and algal beds (such as *Halimeda* beds).

The lagoon floor is generally devoid of reef, partly due to water depth (20–40m) which results in low light levels on the seabed. Even though much of the seabed appears devoid of visible biological habitat, large areas are bioturbated, indicating activity of animals, such as shellfish, worms and fish, within the substrate. Non-photosynthetic corals, such as gorgonians (sea fans) and *Alcyonarians* (non-photosynthetic soft corals) have been found in some locations. In offshore areas, crinoids (feather stars) are sometimes extremely abundant on the seabed.

Marine plants form dominant cover over large areas of the Great Barrier Reef shelf region, including *Halophila* species seagrass, and the calcifying algae *Halimeda*.

Geographical distribution:

Open coastal lagoon floor environments constitute approximately 20,456 km^2 of the Great Barrier Reef's ecosystems area. The open coastal lagoon floor environments have habitats, communities such as areas of macroalgae, and physical features such as sediment type and depth that were previously grouped into bioregions. Groupings for the entire Great Barrier Reef were made before its rezoning in 2004. More than 40 layers of data, compiled from many years of research, were used to inform the distribution of this diverse group of ecosystems.

Status in the Great Barrier Reef Marine Park:

Bottom trawling has occurred throughout large areas of the lagoon floor for several decades and damage to some sensitive communities may have occurred as a result. Recent management actions, including the 2001 buyback of fishing licences, the 2004 rezoning and improved enforcement of zoning arrangements have all resulted in a reversal of previous depletion trends.[5]

Ecosystem role/function:

The lagoon floor provides habitat for many species such as nematodes and microbial communities, which make up the base of many food chains and are an important element of a healthy functioning ecosystem. Larger organisms use this ecosystem for food, shelter and as a nursery habitat. This includes molluscs (shellfish), crustaceans (crabs and shrimp), echinoderms (sea urchins, seastars and seacucumbers), sponges, bryzoans, worms, fish and elasmobranches (sharks and rays). These organisms all play important ecological roles in the health of the Great Barrier Reef and many of these ecosystems are important to commercial, traditional and recreational fishers.

5.3. Islands

Number	
National Parks	367
Commonwealth Islands	69
Neither	614

There are approximately 1050 islands encompassed within the World Heritage Area. Island types include continental islands, coral cays and mangrove islands.

Geographical distribution:

Continental islands, coral cays and mangrove islands are found all along the Great Barrier Reef coast. They are not evenly distributed, with more occurring in the northern and southern sections. Continental islands and mangrove islands are located relatively close to the coast (3–120km), whereas cays are mostly associated with reefs in the central and inner mid shelf.

Status in the Great Barrier Reef Marine Park:

Islands are an important component of the Great Barrier Reef ecosystem. Several species of terrestrial plants and animals are endemic to Great Barrier Reef islands. Of these populations, many are listed as rare and threatened.

Ecosystem role/function:

Each island has its own mix of coastal ecosystems and needs to be considered individually. Some, however, are home to unique vegetation assemblages, such as *Pisonia* forests that exist on many islands in the Capricorn–Bunker group. Many islands play critical roles as breeding habitats for iconic Great Barrier Reef species. For example, Raine Island is a crucial nesting site for 90 per cent of the southern hemisphere’s green turtle population, and is the biggest green turtle rookery in the world. Islands are key locations for sea and shore bird breeding and roosting, and several in the World Heritage Area are critical for Australia's tropical seabirds.

5.4. Open water (inshore waters)

Volume	
Inshore water quality subject to increased loads of polluted water from the adjacent catchment	$7200\ km^3$
	No change in extent. Inshore water regularly exceeds healthy water quality parameters for extended periods in waters south of Cooktown

The open water, as an ecosystem, is home to a range of organisms ranging in size from small bacteria to whales. These organisms are critical to the ongoing health of the Great Barrier Reef ecosystem. Marine microorganisms – phytoplankton, viruses, zooplankton and bacteria – all perform critical roles including the regulation and processing of nutrients and other elements.

The open water is an ecosystem dominated by microorganisms (plankton) and supports a range of other plants and animals. Almost every kingdom, phylum and family has representatives in tropical plankton. These include:

- viruses, which are the most abundant biological entities in the sea[6,7], typically numbering ten billion per litre.[8]
- phytoplankton – microscopic plants that fall into two general size classes: pico-plankton (smaller species) and nano-plankton (larger species such as dinoflagellates and diatoms). Chlorophyll *a,* which is essential for most photosynthetic organisms, is found in all phytoplankton and is often used as a surrogate measure of available nutrients in the Reef waters.
- zooplankton – pelagic animals ranging in size from viruses to large jellyfish.
- bacteria, which are abundant, representing a significant proportion of the biomass in surface waters.[8] This includes conspicuous cyanobacteria such as *Trichodesmium*.
- The open water also supports a diverse range of fish, marine mammals, reptiles, invertebrates and is an important supportive ecosystem for other groups, such as seabirds.

Geographical distribution:

The Great Barrier Reef has around 7200 km^3 of total water volume.[6] The specific area of interest for understanding the connectivity between terrestrial and marine ecosystems, identified in this document, are the inshore waters (see figure 1.1). These inshore waters make up about eight per cent of the surface area of the Great Barrier Reef marine area and range from 0 to around 40 metres deep.

Status in the Great Barrier Reef Marine Park:

- Microorganisms all have short life cycles ranging from hours to months[6] and may be under significant threat from the impacts of climate change; even more so in inshore waters where water quality is poor.
- Inshore water quality is poor adjacent to the developed coast south of Cooktown, with raised levels of sediments, nutrients and chemicals, especially during the wet season.

Ecosystem role/function:

Multiple roles are performed by microorganisms (such as marine viruses) in Great Barrier Reef waters, many of which remain undiscovered. The short lifecycles of microorganisms mean communities respond quickly to changes in their physical environment and are indicators of environmental change.[6] For example, chlorophyll *a* contained within microscopic algae (microalgae) is used in monitoring programs as a proxy for the level of nutrients in the water. This is because microalgae populations increase rapidly to capture and cycle nutrients delivered by nutrient rich waters.

5.5. Seagrasses

Extent (km^2)	
Under stress with a trend in declining health over last 5 yrs of monitoring in inshore areas	5668 shallow water ~40,000 deep water
	Figures are based on limited surveys. Modelled distribution suggests potential for a much greater area

Fifteen species of seagrass occur within in the World Heritage Area.[9,10,11,12] Seagrasses are highly specialised flowering plants with roots, leaves and rhizomes that, with the exception of one species (*Enhalus acoroides*), can live entirely immersed in seawater.[10,13,14] They are not a taxonomically unified group, and not true grasses, but an ecological group that arose through convergent evolution.[10,13,14] They vary morphologically and ecologically, ranging from short-lived structurally small *Halophila* species to robust, long-lived structurally large species such as *Enhalus acoroides*.[9,15] They reproduce either asexually through rhizome growth, or sexually via seeds from flowers fertilised by water-borne pollen.

Geographical distribution:

Seagrasses occur:

- widely along the coast, especially in protected sediment-covered areas of the Great Barrier Reef[5]
- in a broad range of ecosystems (rivers and inlets, coastal, reef and deepwater ecosystems) and may be intertidal or sub-tidal (permanently submerged)[16,17]
- on substrates ranging from the nutrient rich soft mud adjacent to mangrove fringes to carbonate sands around cays on the outer Reef. Some have also colonised the coral reef platforms.

Seagrasses are estimated to cover up to 5668 km^2 of the intertidal and shallow sub-tidal habitat (less than15m deep) in the World Heritage Area. Around 1741 km^2 has been mapped, and extensive areas of deepwater seagrass are estimated to cover around 40,000 km^2.[10,16,18,19,20]

Status in the Great Barrier Reef Marine Park:

Seagrass ecosystems are in decline globally,[21] and their rate of loss is accelerating.[22] At the Great Barrier Reef-wide scale, the overall extent of seagrass meadows was considered to be relatively stable at the time the *Outlook Report 2009* was written. Few changes in extent had occurred over the preceding 20 years, with only localised fluctuations observed inshore. These were mainly due to natural cycles of decline and recovery, although they were influenced by runoff from catchments.[3,12] Seagrass lost in several regions due to storms, flooding and cyclones[23] had recovered substantially,[24] while other meadows had expanded. Considering populations and groups of species, seagrass status was assessed as good. Observations suggested there have been shifts in species composition in some seagrass meadows, but did not indicate any significant reef-wide changes.[25]

However, since publishing the *Outlook Report 2009*, some warning signs have emerged:

- *The Great Barrier Reef Second Report Card 2010* finds seagrass to be in poor condition with declines reported over the last four years.
- McKenzie et al report significant losses of seagrass in the areas directly affected by the path of Tropical Cyclone Yasi under the findings of the Intertidal Seagrass Marine Monitoring Program for 2011. In addition, there have been broad-scale impacts of the 2010–2011 wet season on seagrass meadows across regions exposed to flooding and cyclones in the Great Barrier Reef south of Cooktown. These impacts are on seagrass ecosystems which are already stressed following a number of years of major freshwater inflow and extended periods of cloud cover limiting growth periods.
- Seagrass meadows present for the past 15 years in Mourilyan Harbour[26] have been lost in recent years and substantial declines have occurred in the meadows adjacent to Cairns,[27] Townsville,[28] and Gladstone Harbour.[29] Annual long-term monitoring programs all show large declines in 2010 with some locations also exhibiting declining trends over the last couple of years.[30]
- Cover of seagrass at a Great Barrier Reef-wide scale shows no evidence of long term sustained loss or gain. There is no consistent monitoring north of Cooktown but aerial surveys in the Princess Charlotte Bay region supports other evidence that seagrass in the northern Great Barrier Reef is stable, at least in terms of area. However, McKenzie et al further report that abundance south of Cooktown, while variable, has declined at monitored sites since 2009 (and earlier for some sites)[24,30,31,32,33,34,35] although the decadal trend is relatively stable.

A loss of meadows from surrounding or nearby regions, as was the case in the Mourilyan region, severely reduces recovery potential, as they serve as a regeneration source for regrowth. Seed banks or germination of seeds from nearby meadows will be more important in these cases. Repeated declines and recovery of meadows over the recent preceding years is likely to have reduced available stores,[36] therefore the reproductive status of this region is considered to be poor. [24,31,32,33,34,35]

Recovery of seagrass meadows from impacts that have reduced them to their current state can take more than a decade.[37] The successful recovery is reliant on good conditions in future seasons, including sufficient light, and low levels of pollutants, as well as integrity of the substrate for recruiting to, and sufficient of either seeds or vegetative material.[38]

The number of reproductive structures was poor or very poor in three of the six regions, indicating limited resilience.[24,31,32,33,34,35] Intertidal seagrass meadows in the Great Barrier Reef region often have low or variable numbers of reproductive structures. 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.[24,31,32,33,34,35]

Regional status reports are released each year on meadows that are routinely monitored. For more information, refer to the vulnerability assessment for Great Barrier Reef seagrass.

Ecosystem role/function:

Seagrass meadows are important for a number of reasons.[39,40] They are:

- Key structural/foundational species in diverse communities[41] (of infauna, motile epifauna, sessile epifauna and epibenthic fauna), providing connectivity across the continential shelf.[19,42,43,44,45]
- Buffering wave action, stabilising bottom sediments, and reducing sediment resuspension and erosion during storms.[46,47]
- Major primary producers.[48,49,50]
- Food through direct grazing or detrital pathways, for micro, meso (amphipods, isopods, gastropods and copepods)[51,52] and mega herbivores.
- Nursery grounds for many species including prawns and fish.[39,43,53,54] At least 20 species of prawns are found in seagrasses of the Great Barrier Reef.[9,53] Tiger prawns settle there at the post-larval stage (3–4 weeks) and remain until they become adults – juveniles are found nowhere else. Many endeavour prawns also spend their youth among the seagrasses. Some of these species are commercially important in the East Coast Trawl Fishery.[55]
- Crucial ecosystem for at least 134 species of fish, predominately gobies, leatherjackets, pony fish and trumpeters. A number of fish species are valued by fishers (as catch or bait) and by aquarists. Other fish species are part of marine food chains which support commercially fished species.[56] Larger predators also use seagrass beds as foraging grounds.[57]

5.6. Coastline - sandy beaches, rocky coasts and muddy shores

Extent (km)	
Relatively small areas of the coast have been modified	2300 km excluding islands
	The effect of changes to the coast and coastal processes is more widespread

The Great Barrier Reef coast is comprised of 42 per cent sandy beaches, 39 per cent muddy shoreline and 19 per cent rocky coast[58], stretching approximately 2300 km along the Queensland coast. Beaches offer a considerable and diverse range of habitats for a wide range of organisms.[59] These include horizontally — dunes and upper beach, intertidal, and subtidal and vertically — pelagic, benthic and interstitial.

Muddy shores consist of the smallest of grain sizes (usually less than 100 microns in size) and are usually highly vegetated with mangroves in the intertidal zone. Sandy beach ecosystems consist of small (greater than 100 micron) sized grains and are typically found in areas of high and persistent wave action. These beach systems can be contained within rocky headlands or stretch along the coast over a considerable distance. Intertidally, wave action often results in a rippled surface topography. These systems are highly dynamic with the sand bed in almost constant motion.[60] They have a natural cycle of accretion and erosion driven by currents, winds, waves and storms.

Geographical distribution:

Beaches extend the entire length of the Great Barrier Reef coastline and islands within the World Heritage Area. Muddy shores are typically found adjacent to river mouths and estuaries in areas sheltered from prevailing trade winds. Sandy shores are more typically found on exposed coastal areas, on islands and on reefs (as cays). Rocky coasts can be found among sandy and muddy shores.

Status in the Great Barrier Reef catchment:

The status of sandy beaches, rocky coasts and muddy shores varies spatially along the length of the Great Barrier Reef. Far northern areas remain relatively undisturbed, except for marine debris brought in by currents and tides and natural events like cyclones. Beach ecosystems adjacent to urban centres and ports are often extensively modified with hard and soft structures that often hinder or affect natural coastal processes. The disruption of sediment supply to the coast through dams, weirs and extraction can result in significant changes to beaches. In other areas, topsoil loss has resulted in the burial of fringing reefs with fine sediments which in turn have seen the establishment of mangroves.

Ecosystems role/function:

The coast changes on a daily and often on an hourly basis with the ebb and flow of the tide. This area is an important part of the coastal zone, especially as nesting grounds for seabirds and marine turtles. They serve a function as filters – processing ground water and beached organic matter. Beach ridge systems (sand dunes) can be quite extensive, representing historical shifts of the coast and coastal processes. As such, they often have unique vegetation associations (for example littoral rainforest communities). Rocky areas provide hard structure which resist the erosive forces of wind and waves and provide a surface for many sessile species such as oysters to live and breed. Muddy shorelines act as depositional areas for sediments and nutrients discharged from the catchment or transported along the coast. These are then consolidated into food chains and natural recycling processes by the biological activity of worms and other species common in these environments.

5.7. Estuaries – mangroves and tidal saltmarshes

Extent (km^2)	
Pre-clear	4 339
Post-clear	3 969
Per cent modified	8 per cent

Estuaries are those ecosystems based in salt water and sometimes diluted with freshwater run-off from the land. Estuaries contain many tidal and subtidal habitats. Estuaries include: forests (mangroves), coastal saltmarshes (grass, sedge and herb swamps), saltflats and pans, mudflats and nearshore seagrass ecosystems. Subtidally, estuaries can include soft bottom, hard bottom, coral and seagrass dominated ecosystems.

Geographical distribution:
Queensland's regional ecosystem mapping indicates there are approximately 4000 km^2 of combined mangrove and saltmarsh ecosystems along the Great Barrier Reef coast (excluding islands) — a reduction of eight per cent from pre-clearing extents. The most extensive of the mangrove and saltmarsh ecosystems are found within five main areas: Princess Charlotte Bay, Hinchinbrook Channel, Bowling Green Bay, Broadsound–Shoalwater Bays and the Fitzroy River estuary.[61]

5.7.1. Mangroves

Status in the Great Barrier Reef catchment:
Mangroves are flowering plants that inhabit inter-tidal ecosystems along estuaries, rivers, bays and islands.[62] Mangrove communities are usually groups of trees and shrubs growing in sheltered areas where fine sediments accumulate and where they are inundated by seawater during the tidal cycle. The mangrove forests along the Great Barrier Reef coast are very diverse, with at least 39 mangrove species and hybrids recorded.[63,64,65] The mangrove forests that are in and adjacent to the Great Barrier Reef coast are some of the most healthy in the world, and are an integral part of the Great Barrier Reef ecosystem.

- Mangroves — once considered undesirable swamps — are now justly regarded as places of interest and beauty. An estimated 2070 km^2 of mangrove wetlands border the Great Barrier Reef.
- Mangroves have been cleared along some sections of coast, but have successfully re-established on others.
- Mangrove communities are dynamic and have established and colonised new areas where sediment deposition allows. They have also been known to die-back at times (for example Pioneer River, Shoalwater Bay).
- Of the 39 mangrove species on the Great Barrier Reef (half of the world's total); the highest biodiversity is found in the far north.[65]
- The biodiversity and abundance of mangroves along the Great Barrier Reef coast is being maintained, in stark contrast to most of the rest of the world where they have been cleared, especially for aquaculture and fuel.[61,66]
- Mangrove fringed salt flats are more prevalent in the dry tropics.[60]
- Significant losses have occurred at a basin level with a nine per cent loss of mangroves documented in the Mackay area.[67]

5.7.2. Saltmarshes

Status in the Great Barrier Reef catchment:
Coastal saltmarsh communities consist of plants and animals that grow along the upper-intertidal zone of coastal waterways and host a variety of salt tolerant herbs, grasses, reeds, sedges and shrubs. Saltmarshes are situated below the level of highest astronomical tide but well above low tide level. The most landward fringes of saltmarshes may only receive seawater inundation on the highest of tides (for example spring and king tides). Saltmarshes are typically located landward of mangroves, on flat plains.[68] They are the ecosystem that has been significantly modified by coastal developments (with more than 30 per cent lost).

Saltmarshes may or may not be vegetated, and non-vegetated saltmarshes are often referred to as saltpans or salt flats due to the hypersaline conditions present. Vegetated saltmarshes fall into two categories: those vegetated by succulents and those dominated by tussock grasses.[68] Saltmarshes provide the ecosystem services of water purification, erosion regulation, natural hazard protection and climate regulation. The Great Barrier Reef coastline contains up to 32 per cent of Australian saltmarsh plant species[69] although plant and animal biodiversity is relatively low, with no endemic species.[68]

Saltmarshes occur discontinuously along the entire Queensland coast, with approximately 1660 km^2 of saltmarsh ecosystem occurring along the Great Barrier Reef coast.[61] This represents more than 40 per cent of the combined area of mangrove and saltmarsh found along the Great Barrier Reef coast.[61,66,69,70]

Approximately 30 per cent of saltmarshes were altered by artificial barrier construction and flow alteration prior to the Queensland Policy for Development and Use of Ponded Pastures[71] being implemented in 2001. The extent of impacts varies along the Great Barrier Reef coast. For example, it is estimated 43 per cent of saltmarshes have been altered or lost in the Mackay Region.

Ecosystems role/function:

Estuaries are ecologically important ecosystems that link the marine and terrestrial environments, providing habitat for both marine and terrestrial organisms, including several threatened species, such as the freshwater sawfish and the speartooth shark. Estuaries are vital to the biological productivity of coastal waters[62,64,72,73] and provide connectivity between land and sea. Estuaries daily experience extreme physical processes with the ebb and flow of the tide, and the episodic freshwater pulses which bring with them sediments and nutrients from the catchment. High rates of evaporation generate constant fluxes in salinity, temperature and water level.

Climate change poses a significant risk to estuarine systems. The Manado Declaration agreed on at the World Ocean Conference in 2009 recognised that *healthy and productive coastal ecosystems have a growing role in mitigating the effects of climate change on coastal communities and economies in the near term*.[74] Estuarine systems are a significant sink for carbon. It is believed that restoration of tidal saltmarshes can increase the world's natural carbon sinks. Returning the tides to saltmarshes, drained or bunded to create often marginal agricultural land, can also significantly increase this carbon sink[74] and improve coastal biodiversity and productivity.

5.8. Freshwater wetlands

Extent (km^2)	
Pre-clear	1431
Post-clear	1238
Per cent modified	14 per cent

Freshwater wetlands can be found across the catchment.
The types of wetlands are defined by their hydrological structure and function. For example, riverine wetlands (rivers) direct water across the landscape, lacustrine wetlands (lakes, dams and weirs) store water all year round, and palustrine wetlands (often shallow swamps and seasonal/ephemeral wetlands) act to capture and hold water intermittently. These systems may be linked into groundwater systems and can act alternatively as sinks and sources to groundwater depending on the geological make-up of the area. For more information: www.derm.qld.gov.au/wetlandinfo/site/index.html.

Palustrine wetlands are often associated with coastal areas and are subject to periodic flooding and drying cycles, whereas in lacustrine and riverine wetlands, standing or permanent freshwater persists in most years. Freshwater wetlands can also be formed directly from groundwater or springs usually associated with subterranean wetland systems. The Great Artesian Basin is one such example. For some wetlands to be healthy there needs to be a cycle of wetting and drying. In fact, wetlands that dry out periodically are often more biologically diverse.[75]

Geographical distribution:

Freshwater wetlands typically form in silts, mud or humic loams in low lying parts of floodplains, alluvial flats, depressions, drainage lines, back swamps, lagoons and lakes. However, they may also occur in back barrier land forms such as sand dunes where floodplains adjoin coastal sand plains. The greatest density occurs in small coastal catchments with extensive lowlands, such as the Murray to Mulgrave catchments in the Wet

Tropics, Jeannie and Normanby in Cape York, Proserpine River in the central region, and the Burrum in the southern Great Barrier Reef region.

Status in the Great Barrier Reef catchment:

Freshwater wetlands across the whole catchment are relatively intact with 86 per cent remaining. However, these spatial estimates often understate losses, especially in those wetlands that are infrequently inundated. This is also due in part to the inability of mapping processes to register wetlands less than one hectare (equivalent to a football field). These ephemeral wetlands are the ones most vulnerable to being lost or degraded. They are also the ones that provide stepping stones or connections for species movement within catchments.

Riverine wetland habitat functions have been significantly affected by the loads of sediment from adjacent land use and this has lead to siltation of river systems, loss of deep water holes and significant reduction in refugia within streams. Many river systems that once supported large vessel traffic such as paddle steamers are no longer accessible, with sandbars and deep silts deposited at their entrances and throughout their length.

While mapping measures extent, it does not indicate the health and condition status of wetlands. Research has shown that many otherwise intact wetlands are suffering a range of health problems associated with loss of connectivity, sediment and nutrient overload and weed infestations. Therefor the loss of function may be much greater than changes in extent might imply.

Overall measures of extent can also mask significant basin scale losses of wetland functions in specific locations, especially in the coastal floodplain where up to 80 per cent of freshwater wetlands have been lost in some basins (for example the Barron, Kolan and Johnstone rivers). Recently (2000–2005), the most significant ongoing losses have been in the Wet Tropics and Burnett–Mary Regions.

Ecosystem role/function:

Freshwater inflow is one of the most influential coastal processes affecting biological community structure and function in coastal lagoons, estuaries and deltas of the world.[76] A significant proportion of the material lost from the land during flood events invariably finds its way via river discharges to the Great Barrier Reef lagoon.[77] Most of the transport of materials from land to sea is via river systems. As this sediment load has increased since European settlement of the catchment, it has significantly modified most wetland systems and their ecological functions.

As a natural process, capturing of freshwater flows and the recycling of the downstream movement of nutrients is one of the primary drivers of the productivity of freshwater wetlands before these substances enter estuarine systems, inshore waters and the Great Barrier Reef.[78] The anthropogenic changes to catchment ecosystems (for example, wetland filling, levee bank and drainage construction — processes which constrain flood waters within river and stream channels) have lead to increased erosion of river banks and increased discharges into inshore waters. These processes can have major impacts on the quantities of sediment, nutrients and freshwater entering the coastal seas.[78] Hence, loss of coastal freshwater wetlands, landscape modification such as drain construction, and the nutrient loss from adjacent land uses has led to increasing pollution of inshore waters. This is identified as a major threat to the ecological integrity of the Great Barrier Reef.[79]

Riparian zones

Riparian zones are the transitional areas between terrestrial and inland aquatic ecosystems. Riparian ecosystems —vegetation growing on the banks of streams or rivers — are important energy and nutrient sources for stream ecosystems. They provide food, habitat and shade for both terrestrial and aquatic organisms. They are important for stream bank stability, guarding against excessive erosion and protecting water bodies from pollutants travelling overland in runoff. Riparian ecosystems provide refuge for plants and animals in times of environmental stress. They serve as important wildlife corridors for terrestrial species. [80]

5.9. Forested floodplain

Extent (km²)	
Forested Floodplain pre-clear	24 597
Forested Floodplain post-clear	12 655
Per cent modified	49 per cent

Many types of forests are found on the floodplain of the catchment but some have been significantly modified or lost through changes in land use. For example, there is little floodplain rainforest left in the developed parts of the catchment, despite there being extensive rainforest in the Wet Tropics coastal plains at the arrival of the first Europeans in the early 1800s. The floodplains are often the most productive part of the catchment and are generally the most modified by agricultural and urban expansion.

Geographical distribution:

Forested floodplain ecosystems occur throughout the catchment. Distribution is driven primarily by topography, soils and climate, with these ecosystems occurring on either river and creek flats or basalt plains and hills.

Status in the Great Barrier Reef catchment:

There are 106 floodplain vegetation complexes identified under Queensland Regional Ecosystem mapping — six of which are classified as 'endangered', 24 are listed as 'of concern', and 76 are listed as 'not of concern'.

Ecosystem role/function:

The ecosystem services provided by forested floodplain ecosystems for the Great Barrier Reef vary spatially and temporally. Forested floodplains provide shady migratory pathways for aquatic species with connections to the Great Barrier Reef. The forests also provide nesting habitat and roosts for birds and mammals that provide seed and pollination services to other coastal and island ecosystems. Fish are thought to use forested floodplains for a variety of purposes including shelter, as a refuge in extreme events, when inundated by flood waters for spawning and recruitment, or a mixture of these.

Forested floodplains also slow overland water velocity and enhance deposition, reducing erosion, holding riverbank soil and resisting erosion and protecting the soil from raindrop impacts, a precursor to erosion. Forests on the floodplain also act as nature's water pumps, drawing water from the groundwater and recycling it through transpiration into the atmosphere, making up a critical link in the water cycle. These ecosystems also take nutrients from the groundwater and recycling them, and carbon into their structures (trunk, branches and leaves), storing these materials for decades and even centuries.

5.10. Heath and shrublands

Extent (km²)	
Pre-clear	5351
Post-clear	5026
Per cent modified	6 per cent

Both heathland and shrublands occur within coastal environments and support a large range of species, partly as a result of their geographical range and partly from the variation in soils and site conditions. Shrublands in

Queensland is characterised by dense foliage and low stunted species usually between 2m and 10m in height (sometimes referred to as 'scrubs') or by an over-storey dominated by multi-stemmed *Acacia* species. Heaths are dominated by small shrubs with small hard leaves that occur on infertile or waterlogged sites or coastal areas subject to inundation. It is often difficult to separate open heath from shrubheath, since the predominance of either form in some areas depends on the frequency of fires.

Geographical distribution:

Heaths have a patchy distribution in coastal or near-coastal areas throughout the catchment. Although the total mapped area of heathland is limited, it is a widespread coastal community. The largest areas of open coastal heath are found within the Cape York NRM region (approximately 65 per cent of the total catchment extent). Shrublands occurs mainly in semi-arid and arid regions (less than 300 mm of rainfall each year), although they also extend into the arid tropical regions of northwest Queensland.

Status in the Great Barrier Reef catchment:

There are 46 regional ecosystems containing heath listed in Regional Ecosystem mapping. Of these, none are listed as 'endangered', 30 are listed as 'of concern' and 16 are listed of 'least concern'. Approximately 94 per cent of the heath and shrublands in the catchment remains intact, with around 78 per cent provided protection in National Parks, conservation areas and state forests.

Ecosystems role/function:

Heath and shrublands provide habitat for a range of bird species (with connections to the Great Barrier Reef). In coastal areas they function as a system that traps and retain sediments, stabilise foredunes, reduce the velocity of overland flows and act as a buffer to other ecosystems such as palustrine wetlands.[81] These ecosystems are often highly productive when inundated during the tropical wet season rains in northern Australia.

5.11. Grass and sedgelands

Extent (km^2)	
Pre-clear	12,364
Post-clear	5989
Per cent modified	52 per cent

Grasslands are typically composed of perennial native grasses and usually lack a tree canopy (or when present, crown cover is less than 10 per cent). Grasslands include Tussock grasslands, Forblands (*Astrebla, Dichanthium*) Hummock grasslands dominated by *Triodia spp* or *Zygochloa paradoxa* associations on dune fields or sand-plains, Bluegrass, Brigalow belt grasslands and other grasslands, herblands, sedgelands and rushlands. Grass and sedgeland species also exist within some broader woodland and wetland vegetation groups.[82]

Geographical distribution:

Grass and sedgeland ecosystems occur throughout the catchment. Distribution is driven primarily by soils and climate. There are often distinct differences between coastal and inland grassland communities, associated with their location and function in the catchment.

Status in the Great Barrier Reef catchment:

Tussock grasslands, hummock grasslands, bluegrass and other grasslands are found in limited extents in the catchment. The natural grasslands of the Queensland Central Highlands and the northern Fitzroy Basin are native bluegrass ecosystems typically composed of a variety of perennial native grasses. They are found on soils that are fine textured (often cracking clays) derived from either basalt or fine-grained sedimentary rocks, on flat or gently undulating rises. These grasslands occur in areas with relatively high summer rainfall.[83] The grasslands of Cape York Peninsula represent extensive examples of an ecosystem that is relatively undisturbed by agricultural development.[84] Coastal grasslands, usually associated with palustrine wetlands, have often been extensively modified into agricultural production systems or urban settlements. The most significant losses of coastal grasslands have occurred in the Burdekin, Wet Tropics and Mackay Whitsunday regions. For grassland ecosystems generally, the greatest loss has been in the Fitzroy region where more than 60 per cent of its grassland ecosystems have disappeared in areas now associated with intensive agriculture, especially in its upper catchment.

Ecosystems role/function:

The ecological functions provided by grass and sedgeland ecosystems for the Great Barrier Reef vary spatially and temporally. In places such as coastal dune systems, grasses are important for the health of the Great Barrier Reef, stabilising coastal soils, regulating nutrients and providing a buffer against the erosive forces of waves, wind and rain. Coastal grasslands and sedgelands, especially those associated with freshwater wetlands such as the Townsville Common, slow the velocity of overland water flows, trapping sediments and nutrients before they enter waterways, and in some instances providing opportunities for natural hazard protection. These grasslands provide important breeding habitat for many bird and reptile species, including saltwater crocodiles.

5.12. Forests, woodlands and rainforests

Forested ecosystem	Extent (km^2)
Forest pre-clear	239,603
Forest post-clear	145,380
Per cent modified	39 per cent
Rainforest pre-clear	26,886
Rainforest post-clear	16,744
Per cent modified	38 per cent
Woodland pre-clear	105,123
Woodland post-clear	64,592
Per cent modified	39 per cent

Notwithstanding that they have quite different ecosystem functions, the remaining three catchment ecosystems have been grouped here because they are generally more remote from direct connections to the Great Barrier Reef. These are the ecosystems that are made up of rainforests, forests, woodlands on the slopes and hillsides, ranges and mountains that form the boundary of the catchment. These ecosystems are important in controlling the erosion of sediments, in particular because of the slopes that they inhabit and stabilise, and the crucial role they play in protecting soil from the erosive impact of raindrops and in trapping sediment.

Another important function for the Great Barrier Reef is their role in the water cycle, especially the recharge of groundwater resources and replenishing natural river flows. Other connections to the Great Barrier Reef are generally more indirect.

Geographical distribution:

Forests, woodlands and rainforests occur throughout the catchment. Distribution is driven primarily by soils and climate.

Status in the Great Barrier Reef catchment:

The status of forests varies throughout the catchment with losses throughout all NRM regions, but generally forests in these hilly environments are now relatively well protected from broad scale clearing.

Ecosystem role/function:

The ecological functions provided by forested ecosystems for the Great Barrier Reef vary spatially and temporally. In places such as the Daintree, where rainforests exist in close proximity to the Great Barrier Reef, they are critical for its health, stabilising coastal soils, regulating nutrients and providing a buffer against the erosive forces of wind and rain. In higher parts of the catchment, forests provide stability from the erosive forces of wind and rain and habitat for birds, mammals and insects that provide seed and pollination services to other coastal and island ecosystems. Further, littoral rainforest is an endangered plant community that exists on the beach sands along the coastal area of the Great Barrier Reef, as well as some of the continental islands of the Reef system.

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6. Drivers of change: factors influencing Great Barrier Reef coastal ecosystems

Substantial areas within the Great Barrier Reef catchment have been developed, often extensively, over the past 160 or so years. The development activities by area in the catchment – from largest to smallest – are: grazing, intensive agriculture, urban areas, water supply, road and rail infrastructure, mining, ports and industry (Figure 6.1). There are around 100 urban settlements on the coast and islands ranging from a few people to around 150,000 residents.[1] This development has occurred at different rates in space and time as population increases, the economy grows, and the demand for urban infrastructure increases accordingly (figure 6.2 provides a breakdown of proportions of land use at the regional NRM area scale).

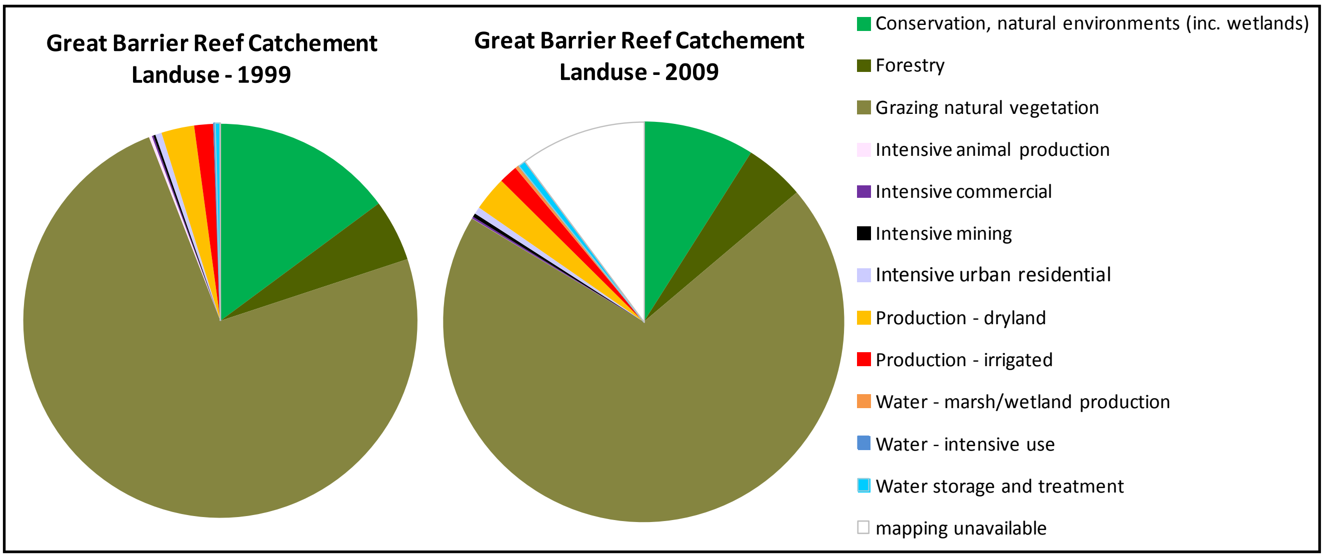

Figure 6.1: Queensland Land Use Mapping Project data regrouped by GBRMPA into categories based upon the population activity in the catchment.

Islands within the World Heritage Area have also experienced significant change. Mining of guano was widespread in the late 19th century, as was the introduction of goats and livestock grazing. Some islands were also used as a base for turtle meat processing. In recent decades, islands have been increasingly used for recreation, tourism, urban and industrial development.

As a result of development there have been significant changes to the coastal landscape. In some instances, these changes have occurred on a large scale. Grazing is the major land use occurring over about 74 per cent of the catchment. It was historically the main driver behind substantial broad scale clearing of forest, with 39 per cent of the original extent cleared. In other instances, the changes have occurred on a smaller scale. For example, intensive agriculture occurs in only five per cent of the catchment, it is isolated to the lower coastal floodplain and has resulted in a significant loss of forested floodplain and freshwater wetland ecosystems in the coastal zone. In these circumstances, intensive agriculture, and increasingly aquaculture, has been identified as the key drivers behind loss or modification of coastal wetlands.

More recently, the introduction of land clearing laws has very substantially slowed the rate of land clearing associated with grazing and intensive agriculture. The implementation of the *Vegetation Management Act 1999* has dramatically reduced the amount of clearing in Queensland, falling from the peak of 750,000 hectares per year in 1999–2000 to 123,000 hectares per year in 2007–08. It also provides for increased protection and regrowth of native vegetation in the priority catchments of the Burdekin, Mackay–Whitsundays and Wet Tropics NRM regions. More specifically, the first Great Barrier Reef Water Quality Protection Plan Report Card,[2] published in 2011, identified that wetland loss from 2001 to 2005 was 883 hectares or 0.12 per cent, although the report card notes the highest losses occurred in smaller coastal catchments. By comparison, wetland loss since pre-European times was estimated to be 14 per cent. The report card also found the amount of riparian vegetation lost between 2004 and 2008 had been reduced to 30,000 hectares or 0.49 per cent.

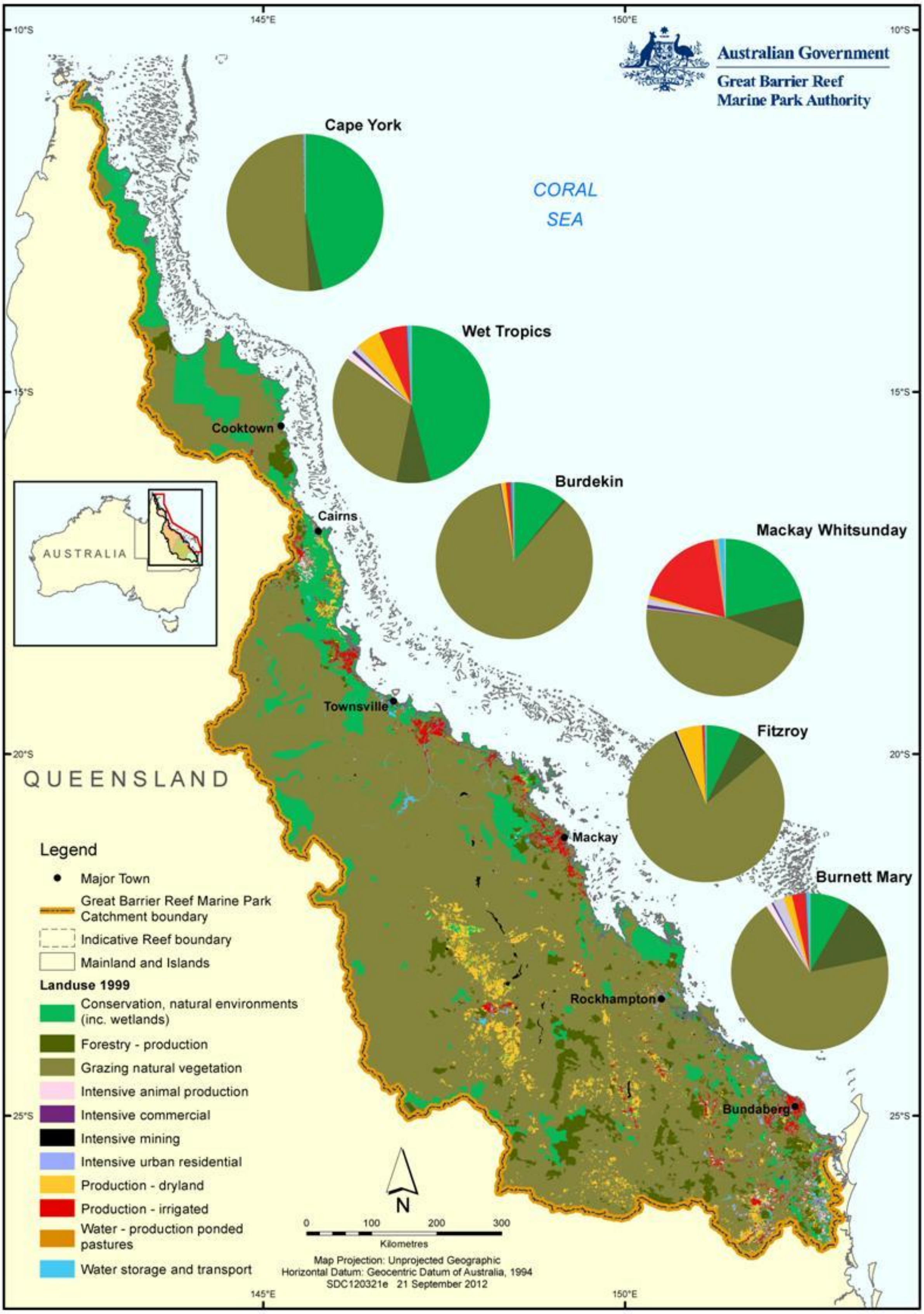

Figure 6.2: Queensland Land Use Mapping Project data regrouped by GBRMPA with pie charts showing the proportional land use breakdown at the regional NRM scale.

Coastal development along the Great Barrier Reef coast has been identified as having implications for many coastal ecosystems. With the rapid growth in population centres of the catchment occurring faster than the Australian average, the likelihood of some impacts will increase. The *Outlook Report 2009*[1] indicated the population in the catchment was 1,115,000 in 2006 and that it is expected to grow to 1,577,000 people by 2026. Population and economic growth have been the drivers behind urban development and port expansion which occur in only a relatively small area of the catchment (less than one per cent). However, together they have resulted in substantial modifications to both terrestrial and marine coastal ecosystems in the local coastal environment. Port expansion and other marine development have also resulted in direct and indirect impacts on seagrass and estuarine ecosystems. The associated shipping activity poses a significant risk to the Great Barrier Reef from shipping incidents which, in the worst case scenario, could have very significant impacts on sensitive nesting sites or habitats of at-risk or threatened species. Regardless of the scale of the activity, together these drivers have caused, and can continue to result in, significant changes to the ecological functions of coastal ecosystems.

Threats to the Great Barrier Reef ecosystem also relate to proximity of the development activities to the coast. The 2011 State Coastal Plan[3] recognises this issue and has identified the coastal zone which is the focus for its coastal policies. It has identified areas of high ecological significance within this coastal zone and seeks to constrain development in these areas. GBRMPA has mapped the coastal zone to assess the development pressures through its present land use (Figure 6.3).

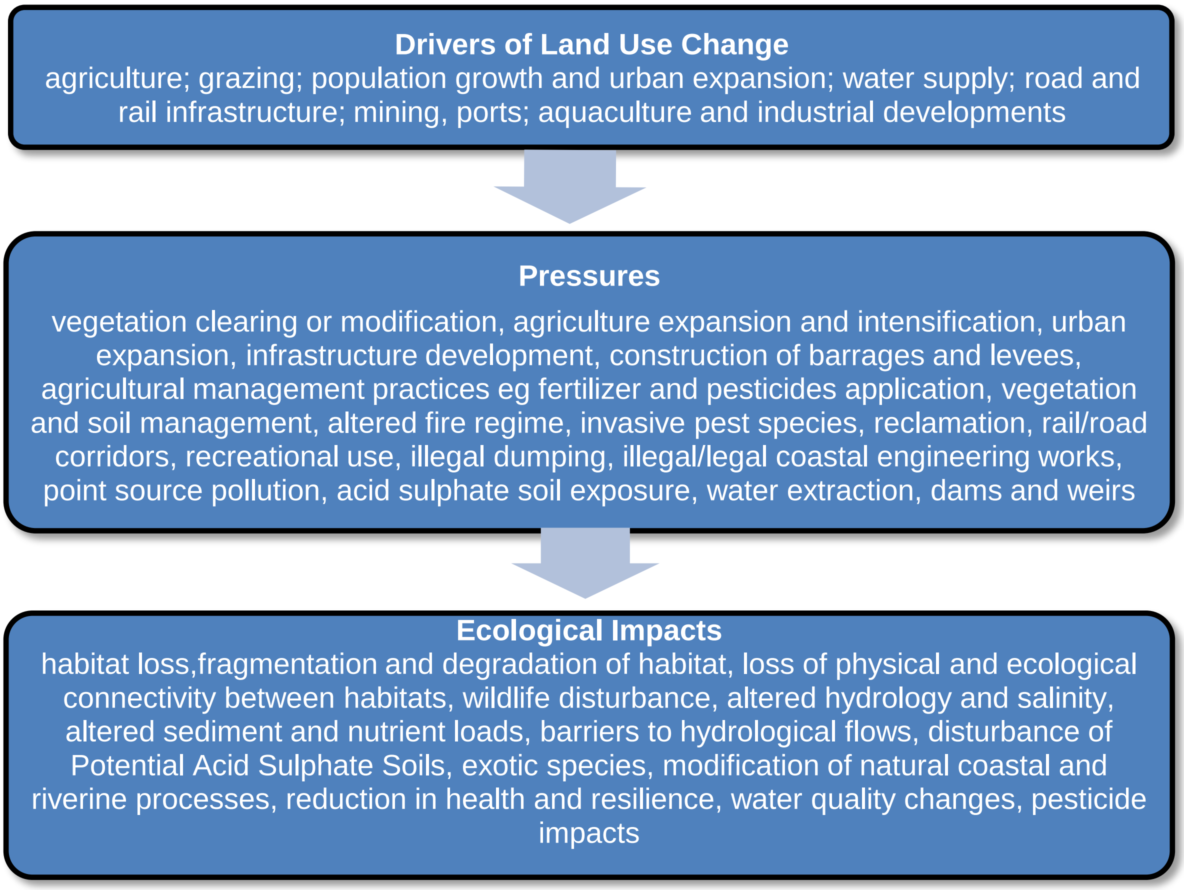

Figure 6.3: Drivers of land use change and flow on ecological impacts

Land use in the coastal zone for 1999 and 2009 (figures 6.4a and b) shows similar trends to the general picture of coastal ecosystem change reported earlier. Coastal development is more pronounced in the coastal zone in the south, with more of the zone modified and the intensity of development higher. The coast has had a greater level of development generally when compared to the catchment overall, especially at the regional scale.

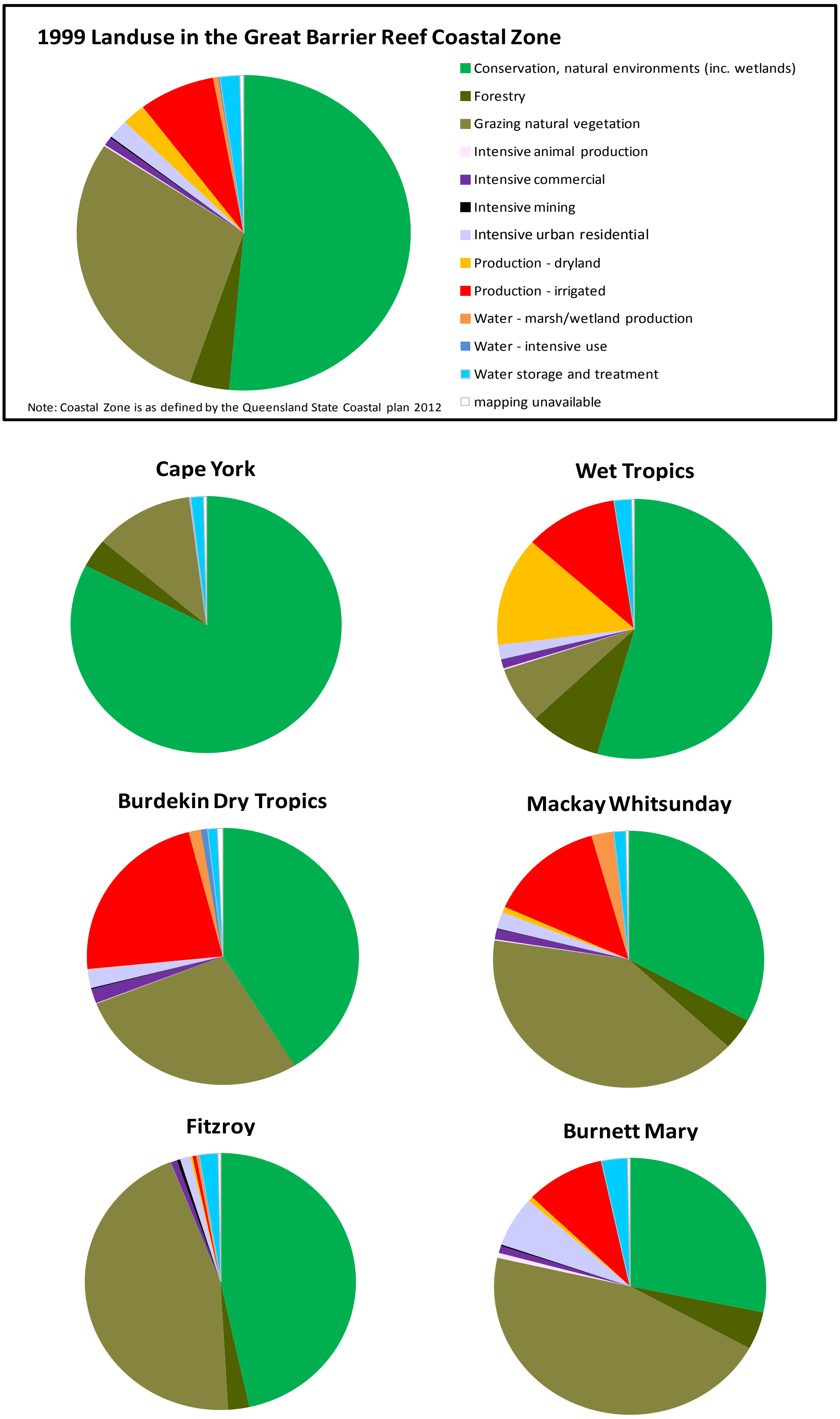

Figure 6.4a: Land use in coastal zone along the Great Barrier Reef Coast using Australian Land Use and Management Classification 1999 data. Areas of conservation and natural areas (shades of green) include managed resource protection (surface water catchments, groundwater and traditional indigenous uses), nature conservation (national parks and other conserved areas) and other minimal use (defence land, stock routes and areas of rehabilitation). Intensive uses include urban and commercial facilities and services. Dryland agriculture (no irrigation used) and irrigated agriculture is predominantly sugar cane in these areas. Production from relatively natural environments is grazing of natural areas, and water includes freshwater and estuarine wetlands, dams and rivers.

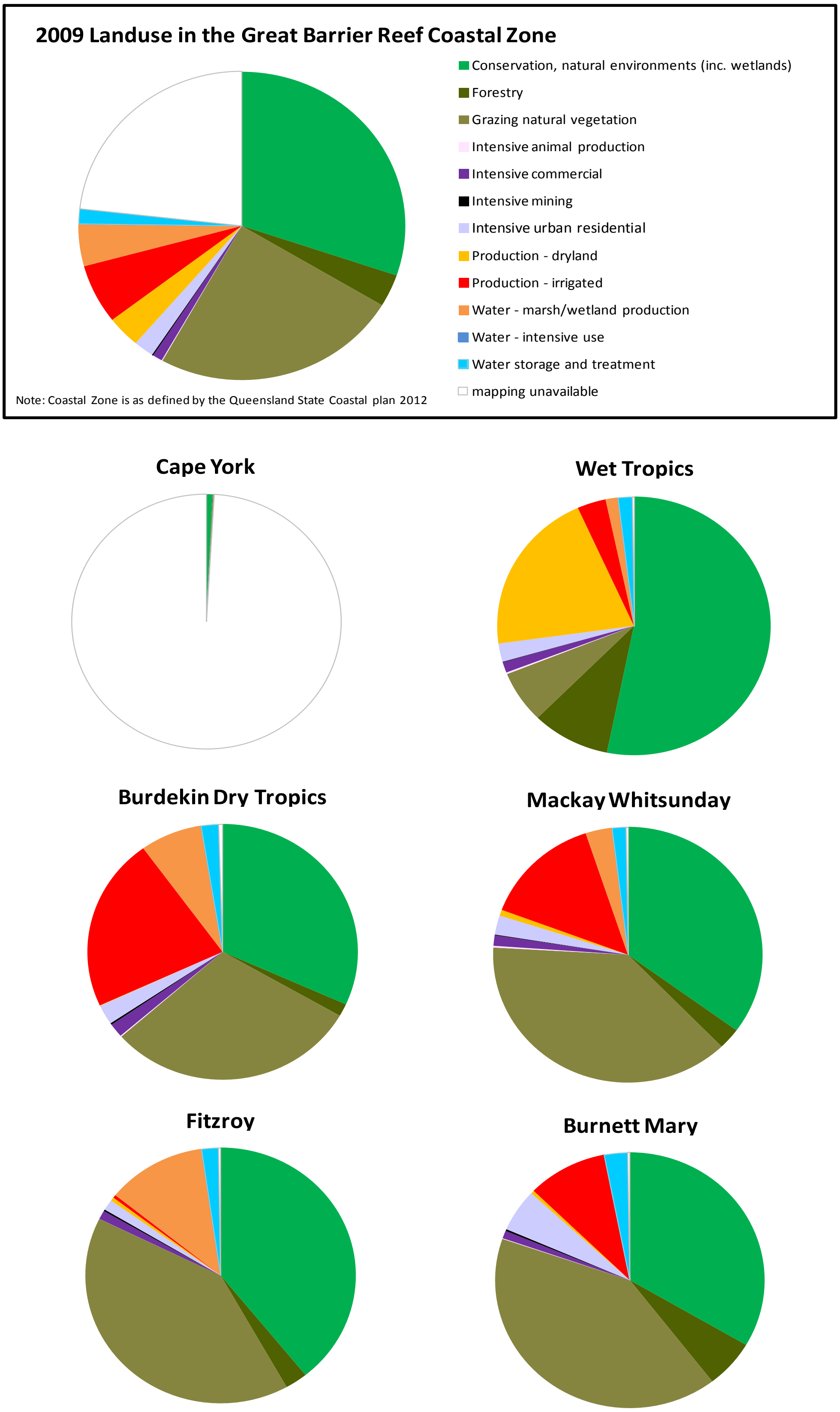

Figure 6.4b: Land use in coastal zone along the Great Barrier Reef Coast using Australian Land Use and Management Classification 2009 data. Areas of conservation and natural areas (shades of green) include managed resource protection (surface water catchments, groundwater and traditional indigenous uses), nature conservation (national Parks and other conserved areas) and other minimal use (defence land, stock routes and areas of rehabilitation). Intensive uses include urban and commercial facilities and services. Dryland agriculture (no irrigation used) and irrigated agriculture is predominantly sugar cane in these area. Production from relatively natural environments is grazing of natural areas, and water includes freshwater and estuarine wetlands, dams and rivers.

6.1. Current economic growth

The resources boom in Queensland is driving significant change in industrial, rural and urban landscapes. Export infrastructure needs of the mining industry have outstripped the capacity of current port facilities to handle the export of coal and other commodities. The scale and scope of the expansion programs for existing ports and proposals for new ports to meet these export demands is leading to proposals for the development of large-scale port infrastructure and commensurate increases in dredging activities, shipping movements and the number of ships anchoring in the World Heritage Area (table 6.1).

New mining operations not only require export facilities; they also need road and rail infrastructure to move equipment and transport their product to port. They also increase the demand for services such as water and power, leading to additional catchment infrastructure requirements to meet these demands. Relocated mine workers increase the demand for urban utilities, usually along the coast.

Table 6.1: History of port expansions and new port proposals over the last decade

Port	Proposals
Hay Point: 2000–2012	Coal Terminal expansion to increase the capacity from 44 million tonnes per annum (mtpa) to 59 mtpa, extension of ship berths and stockyard development; 2004 –expansion of stockpile area and capital dredging new departure path and apron area: 2005 – new berth construction to expand the handling capacity to 60 mtpa: 2009 expansion to 85 mtpa through the construction of another new berth and increasing the capacity of existing coal infrastructure. More than 800,000 million cubic metres (Mm^3) of dredge spoil will be disposed of in the Great Barrier Reef Marine Park. Additionally new terminals, approved in the last couple of years will provide for an additional 55mtpa of coal export facilities bringing the total to 140mtpa and increasing shipping requirement to over 1000 ships per annum. The anchorage area associated with the port is now around $890km^2$ of the Great Barrier Reef Marine Park.
Gladstone Port: 2000–2012	Extension of RG Tanna Coal Wharf to include a third berth and construction of Fisherman's Landing reclamation area; 2004 - further extension of RG Tanna Coal Terminal to include a fourth berth and the extension of RG Tanna Coal Terminal land reclamation; 2005 - new Wiggins Island Coal Terminal to allow for an ultimate capacity of 70 mtpa; 2008. Liquid Natural Gas Plant marine facilities on Fisherman's Landing and Santos and British Gas Liquid Natural Gas Plant marine facilities on Curtis Island; 2009. Gladstone Port Corporation's Western Basin Dredging and Disposal to facilitate Liquid Natural Gas plant development on Curtis Island. Present approvals allow for $11Mm^3$ of dredge spoil to be disposed at the existing spoil ground which is in the World Heritage Area but outside the Great Barrier Reef Marine Park. However, an additional $46Mm^3$ will be generated if a proposal to double the shipping channel proceeds to cope with the increase in shipping from coal and liquefied natural gas plants. The present 1200 ships per annum is expected to expand to around 5600 ships per annum. The anchorage area associated with the port is now around $120km^2$ of the Great Barrier Reef Marine Park.
Abbot Point: 2005–2012	Coal Terminal expansion including a second offshore berth, new spoil ground and associated infrastructure to allow an increase from 25 mtpa to 50 mtpa; 2008 – expansion for two new berth pockets. Project includes offshore and onshore facilities were required, with dredging of 14 hectares and use of existing spoil grounds; 2009 - new offshore multi-cargo facility, comprising 320 ha of reclaimed land to accommodate 12 shipping berths. A number of additional terminals are now proposed which will bring the coal export capacity of the port up to 640mtpa. This will require the dumping of over $38Mm^3$ of spoil in the World Heritage Area (including reclamation areas) and over $3Mm^3$ in the Great Barrier Reef Marine Park. Shipping is proposed to increase from 200 ships per annum to around 4700 ships per annum. There is no designated ship anchorage area in the Marine Park at present but around 70 ships can be found at anchor off Abbot Point port at any time.
Port Alma and Balaclava Island 2009	Proposed 35 mtpa coal terminal by Xstrata Coal Queensland which will result in an additional 60 or so ships per annum.
Townsville Port: 2011	Soon to release a proposal to expand both the reclaimed area for a new coal/bulk goods handling facility and dredging a deeper channel for larger vessels, possibly extending into the Great Barrier Reef Marine Park
Hay Point: 2011–12	Proposal under development for a whole new array of port facilities at Dudgeon Point (within the existing port area) to include 8 separate coal handling facilities and associated berths to provide an additional 180mtpa of coal export capacity. This will require $15Mm^3$ of dredge spoil disposal in the Marine Park and add an additional 2000 ship per annum to shipping in the Great Barrier Reef.
Shoalwater Bay	Proposal for a new coal port in Shoalwater Bay (Waratah Coal), which was rejected by the Australian Government's Environment Minister at the application stage.
Repulse Bay	Proposed shale oil processing plant and port facilities (Queensland Energy Resources) in the Goorganga Plains wetlands and adjacent Repulse Bay. These were rejected by the Queensland Premier before it went to full assessment because of concerns raised by tourism-reliant coastal communities.
Mackay Port	Proposal to expand the coal handling facilities in the Mackay Port was rejected by the Queensland Premier because of its expected impact on the amenity of Mackay residents and the difficulty of access to the Port for bulk product.
Fitzroy River	Proposal to build a new floating port near the mouth of the Fitzroy River, which would receive coal via barges. These barges would be linked to a rail head somewhere on the floodplain inland of the Fitzroy estuary. The proposed capacity of this port is 22mtpa and will add around 60 ships per annum to the Great Barrier Reef.
Wongai Underground Mine, Bathurst Head	Proposal to open a new mine and build a new floating port accessed from Bathurst Head and located in the area between Princess Charlotte Bay and Bathurst Bay, in the lee of the Flinders Island Group. Like the Fitzroy River proposal, this facility would receive coal via barges from the mainland. These barges would be linked to infrastructure and an underground mine in the vicinity of Bathurst Head. This proposal is in one of the truly unique areas of the Great Barrier Reef Marine Park and will add an additional 2mtpa of coal export capacity and result in around 12 ships pa in the Great Barrier Reef.

6.2. Catchment activities that affect ecosystem processes

Changes in land use can also significantly modify the functions of coastal ecosystems even when they do not involve substantial clearing. For example, tidal barrages change saline wetlands into freshwater wetlands, often completely disrupting fish migration upstream and providing habitat for a different suite of plants and animals. Figure 6.5 illustrates the extent of saltmarsh communities that have become freshwater ponded pastures, through bunding, in one area of the catchment (the Styx and Shoalwater Basins). This has actually led to a significant increase of more than 1000 per cent in freshwater wetlands in the Shoalwater basin.[2]

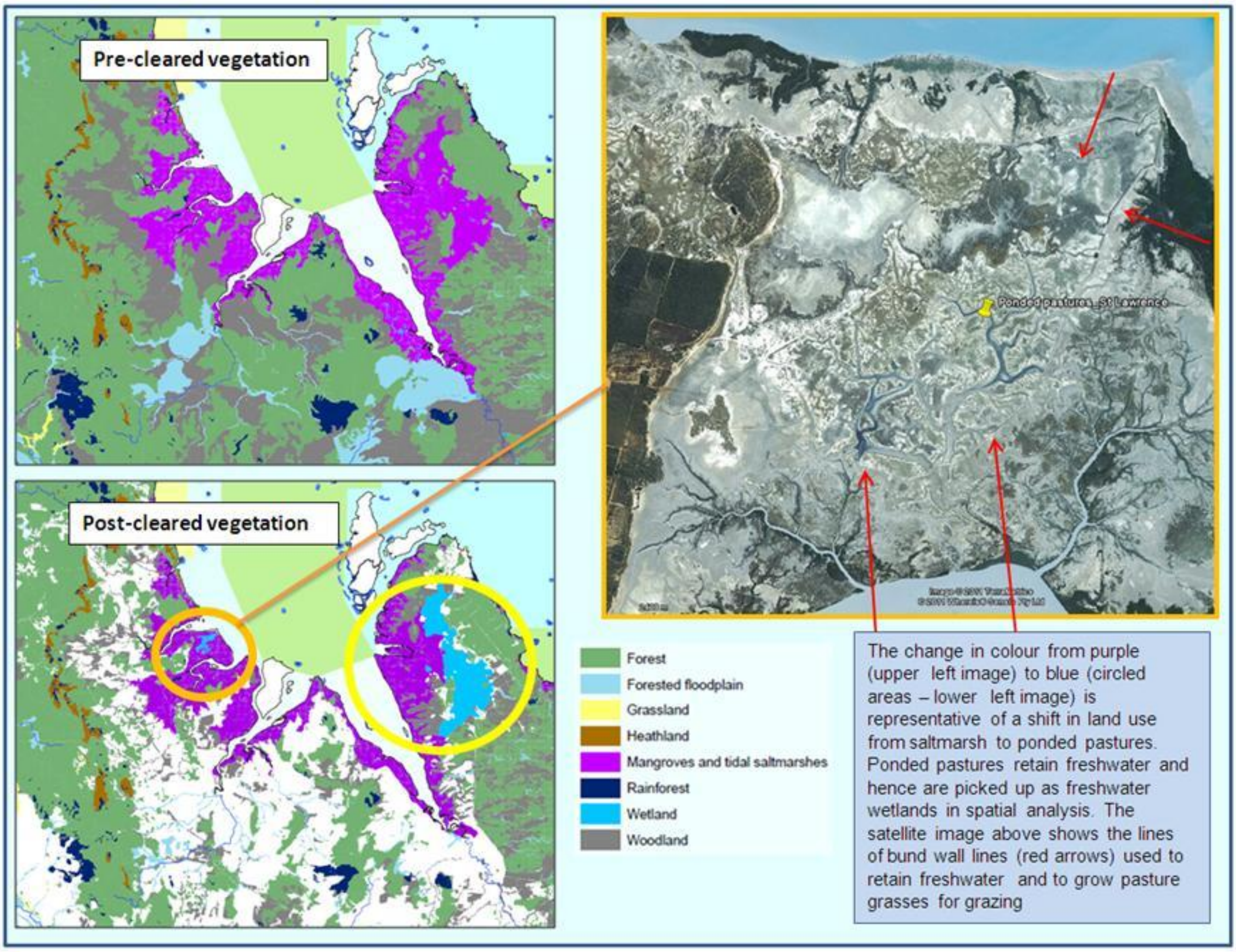

Figure 6.5: Changes in land use from saltmarsh to ponded pastures in the Styx and Shoalwater basins of the catchment

While overall change since European settlement in the extent of estuarine wetland ecosystems (mangroves and saltmarsh ecosystems) has been less than 10 per cent and only around 16 per cent in the worst regional case (Fitzroy Basin), modification of the saltmarsh component of the estuarine systems has been more significant, with bunding affecting approximately 30 per cent of saltmarsh extent.

The interface between the estuarine and freshwater system is both a very productive component of the food chain as well as a critical corridor for movement between ecosystems (Figure 6.6). Based on currently available information, as many as 78 Great Barrier Reef marine and estuarine fish species use the freshwater systems for part of their life cycle.[4]

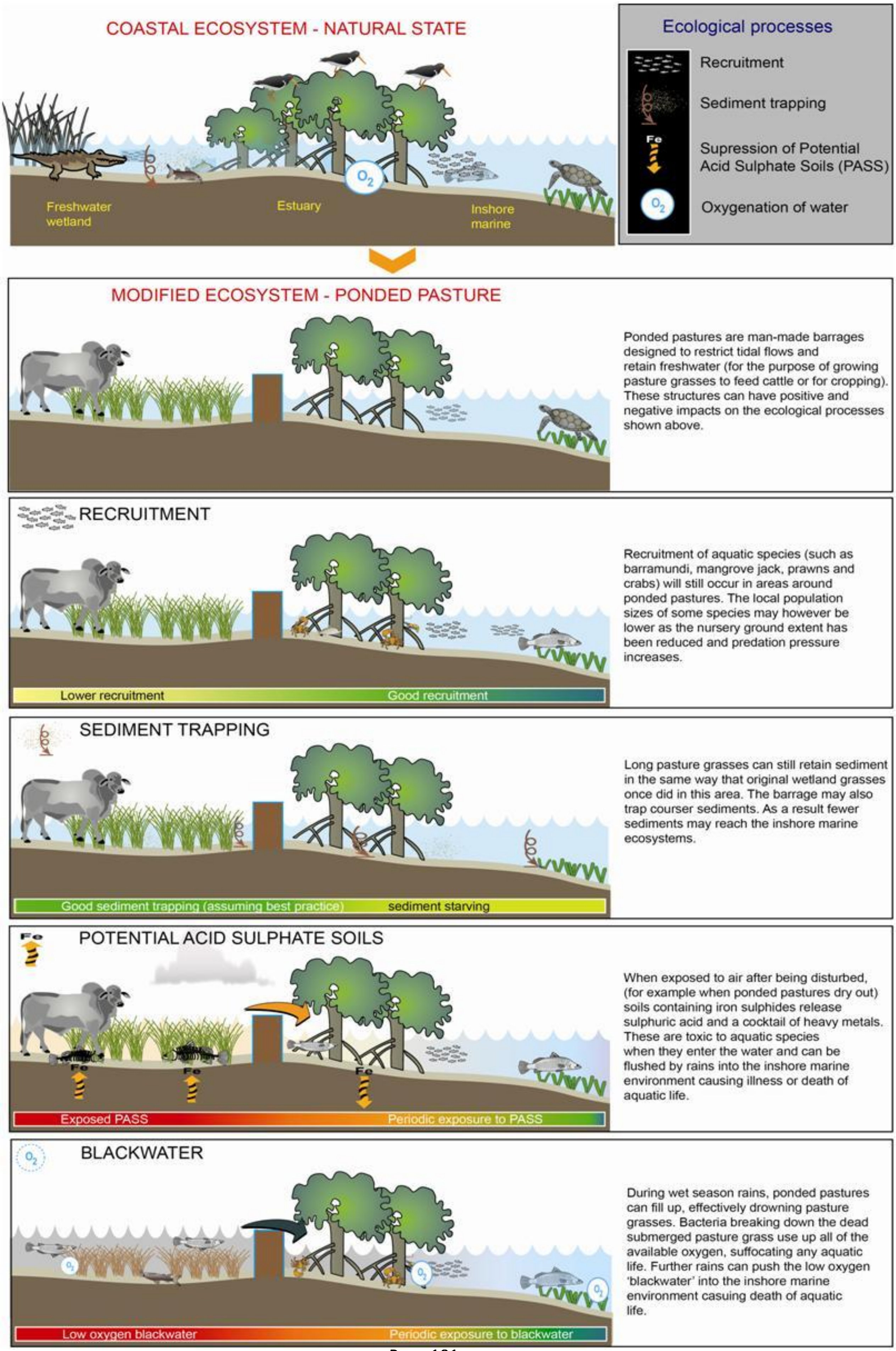
COASTAL ECOSYSTEM - NATURAL STATE
Freshwater wetland
Estuary
Inshore marine
O2
Ecological processes
Recruitment
Sediment trapping
Supression of Potential Acid Sulphate Soils (PASS)
Oxygenation of water
Fe
MODIFIED ECOSYSTEM - PONDED PASTURE
Ponded pastures are man-made barrages designed to restrict tidal flows and retain freshwater (for the purpose of growing pasture grasses to feed cattle or for cropping). These structures can have positive and negative impacts on the ecological processes shown above.
RECRUITMENT
Recruitment of aquatic species (such as barramundi, mangrove jack, prawns and crabs) will still occur in areas around ponded pastures. The local population sizes of some species may however be lower as the nursery ground extent has been reduced and predation pressure increases.
Lower recruitment
Good recruitment
SEDIMENT TRAPPING
Long pasture grasses can still retain sediment in the same way that original wetland grasses once did in this area. The barrage may also trap courser sediments. As a result fewer sediments may reach the inshore marine ecosystems.
Good sediment trapping (assuming best practice)
sediment starving
POTENTIAL ACID SULPHATE SOILS
When exposed to air after being disturbed, (for example when ponded pastures dry out) soils containing iron sulphides release sulphuric acid and a cocktail of heavy metals. These are toxic to aquatic species when they enter the water and can be flushed by rains into the inshore marine environment causing illness or death of aquatic life.
Exposed PASS
Periodic exposure to PASS
BLACKWATER
During wet season rains, ponded pastures can fill up, effectively drowning pasture grasses. Bacteria breaking down the dead submerged pasture grass use up all of the available oxygen, suffocating any aquatic life. Further rains can push the low oxygen 'blackwater' into the inshore marine environment casuing death of aquatic life.
Low oxygen blackwater
Periodic exposure to blackwater

Figure 6.6: Potential impacts of ponded pastures on coastal ecosystem functions

The construction of coastal barrages to prevent the ingress of tidal waters to allow an expansion of cropping and grazing land, or through construction of roads accessing the coast, was an activity mainly undertaken 40 to 50 years ago when there were little or no legislative or industry management arrangements controlling these activities. While many of these impediments remain and continue to affect functions of these coastal ecosystems, the current legislative arrangements in place prevent any significant increase in these structures. Industries are working towards much better practices, so the risk to coastal ecosystems from the construction of new coastal barrages, for example, is now significantly reduced.

Major road and rail corridors built today aim to minimise the impacts on hydrology. New legislative arrangements aim to prevent the filling of wetlands for intensive agricultural purposes and the grazing industry is working hard to reduce overgrazing and sediment loss. Despite these recent improvements in landuse practices, significant amounts of habitat, and the connectivity between habitats, have already been lost in some basins. Landuse changes continue to fragment habitats and modify the functions of coastal ecosystems — thus the risk to the long-term health and resilience of these systems is increasing cumulatively.

The modification of a natural functional ecosystem into a man-made production system can lead to many changes in the area's ecosystem functions. Many natural grasslands in the coastal floodplain of the Burdekin, Don, Haughton, Proserpine, Pioneer and Plane catchments have been turned into cane paddocks (man-made grasslands). Their functional aspects are adversely modified but not completely lost (figure 6.7). This loss of function may be further exacerbated by poor practices in soil and water management.

This functional modification in agricultural landscapes contrasts with many urban development's where functions are lost and artificial substitutes must be incorporated into the landscape to restore those functions (for example, stormwater and sewerage infrastructure).

Above: Sewage treatment plant Cleveland Bay, Townsville (circa 1999)

Impacts of changes in functionality can be subtle and our understanding of the impacts rudimentary. Organic compounds, hydrocarbons and heavy metals are often associated with urban areas, transport corridors, waste disposal areas and sewage treatment plants.[5,6] Heavy metals are natural constituents of rocks and soils, and enter the environment as a consequence of weathering and erosion. Many metals are biologically essential, but all have the potential to be toxic to biota above certain threshold concentrations. Following industrialisation, unnatural quantities of metals such as arsenic, cadmium, copper, mercury, lead, nickel and zinc continue to be released into the Great Barrier Reef through agricultural, urban stormwater and wastewater discharges. The heavy metals can affect physiological process in species such as crabs, causing abnormalities in their shells which affect their survival. Some crab species are now understood to be keystone species in mangrove communities because of the role they play in aerating the soil and in cycling nutrients. This means activities and associated pollutants that affect these crabs could cause fundamental changes to mangrove communities (figure 6.8).

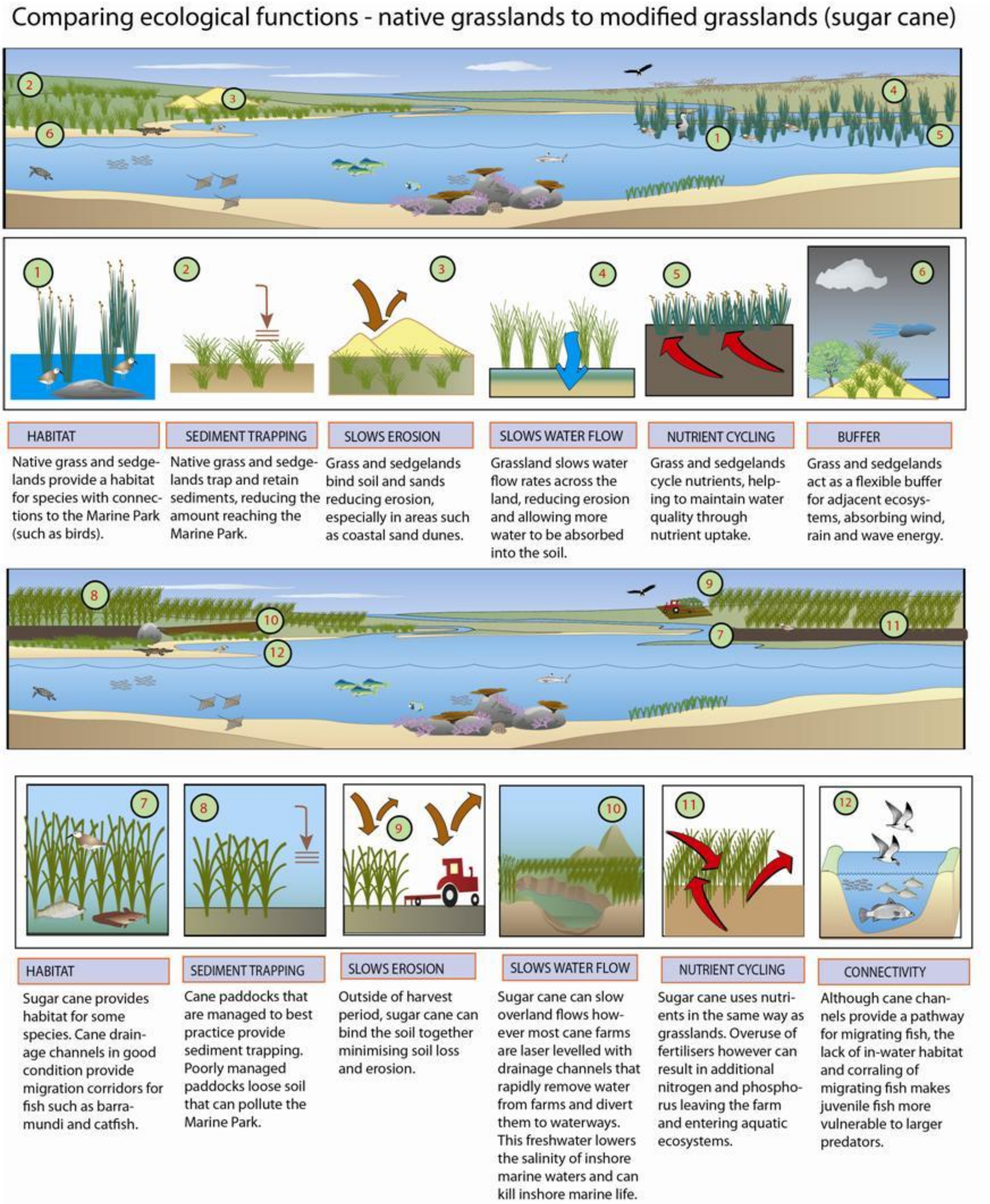

Figure 6.7: Comparison of the ecological functions provided by a natural coastal grassland ecosystem when replaced by man-made intensive agricultural system.

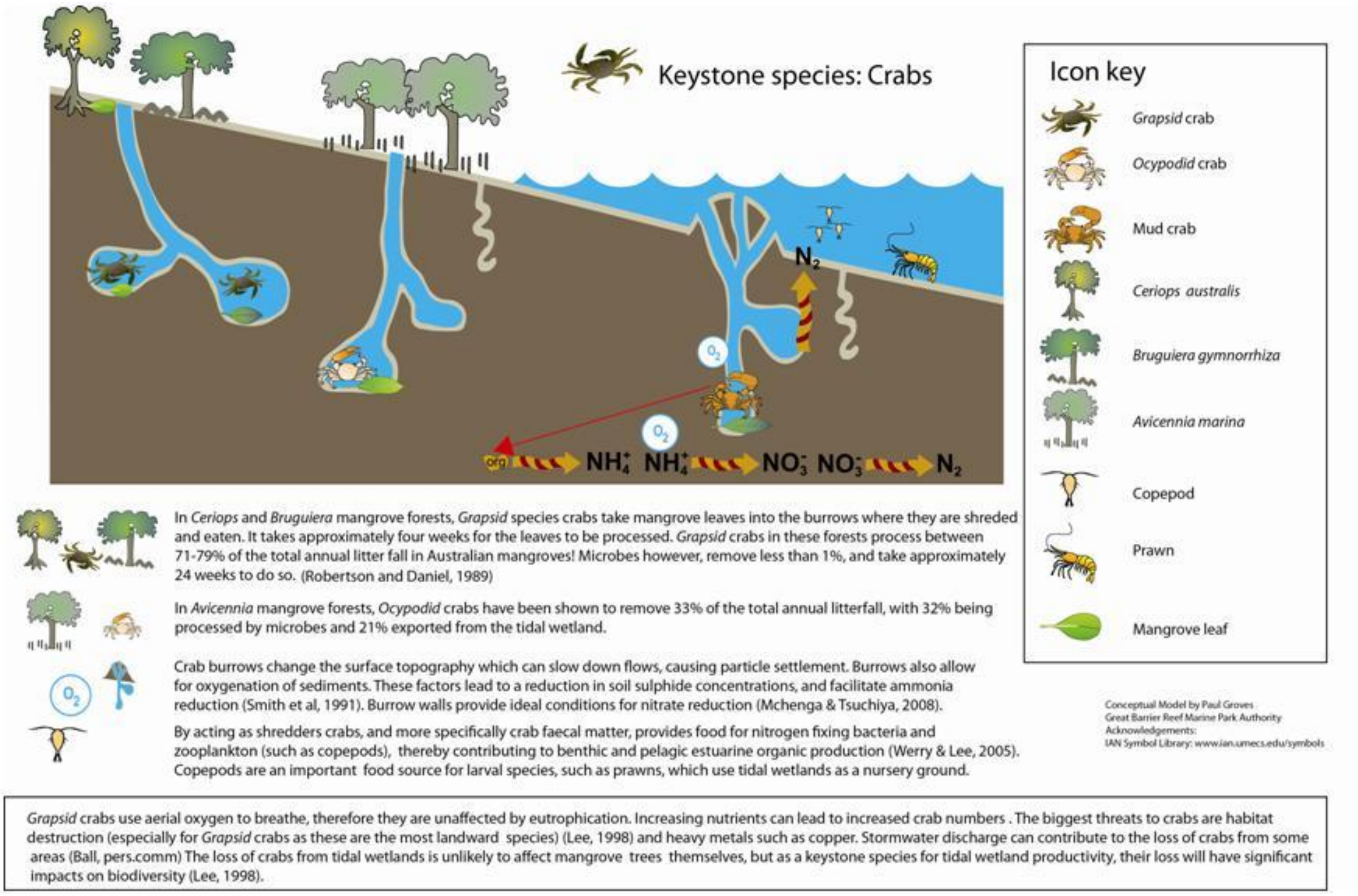

Figure 6.8: Crabs are keystone species in estuarine ecosystems. Discharges from developed areas can cause localised losses to crab populations and affect estuarine ecology.[7,8,9,10,11]

The disruption of any of these functions through modifications or loss of coastal ecosystems or loss of connectivity between coastal ecosystems can have implications for the system as a whole. Often unanticipated and dramatic effects may occur on other parts of the system.

An increased frequency of crown-of-thorns starfish (COTS) and their impacts on the Great Barrier Reef is one very significant indicator of the consequences for Great Barrier Reef ecosystems of changes in coastal land use. It is now generally recognised that poor water quality affects inshore waters of the Great Barrier Reef. The area of the Great Barrier Reef subject to the highest water quality risk is less than 10 per cent of the waters of the Great Barrier Reef. However, this increased nutrient load is believed to drive improved survival and recruitment rates of crown-of-thorns larvae[12] which in turn lead to outbreaks of the adult population (figure 6.9) which consume corals in inshore and midshelf reefs. In the past 30 years, crown-of-thorn starfish outbreaks have been responsible for nearly one third of the mortality of corals in the entire Great Barrier Reef.[13]

Green Island seagrass meadow expansion

Green Island (a small coral cay north-east of Cairns) experienced an increase in seagrass meadow size (based on aerial photographs) from 1936 to 1994. This coincided with a decline in coral at the same location. Initially, nutrients (nitrogen) from island sewage discharges were thought to be the cause. Regulations to improve island sewage treatment, however, failed to halt the expansion. Further studies indicated that the seagrass meadow expansion was now probably maintained as a result of continued land based nitrogen inputs from agricultural activities. Similarly, further north Low Isles experienced an expansion of both seagrass meadows and mangroves as a result of an increase in available nitrogen and sediment.

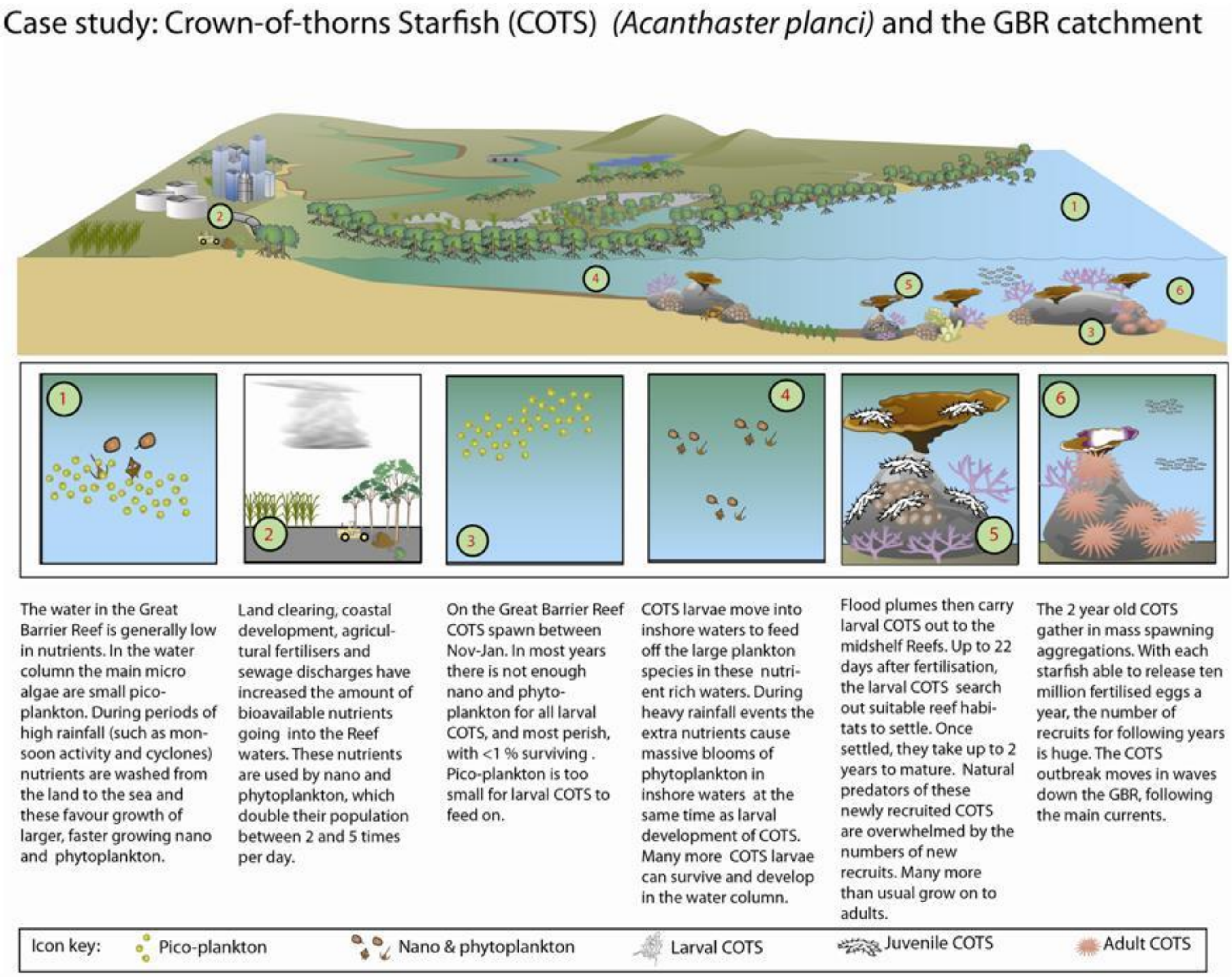

Figure 6.9: Conceptual links between the catchment and crown-of-thorns – starfish population changes[14]

6.3. Cumulative development pressures on Great Barrier Reef coastal ecosystems

Table 6.10 shows the potential threat of the different drivers will have varying implications for the different functional groups (based on risk assessments within each Vulnerability Assessments – available at www.gbrmpa.gov.au). This is so, even when considering current management arrangements.

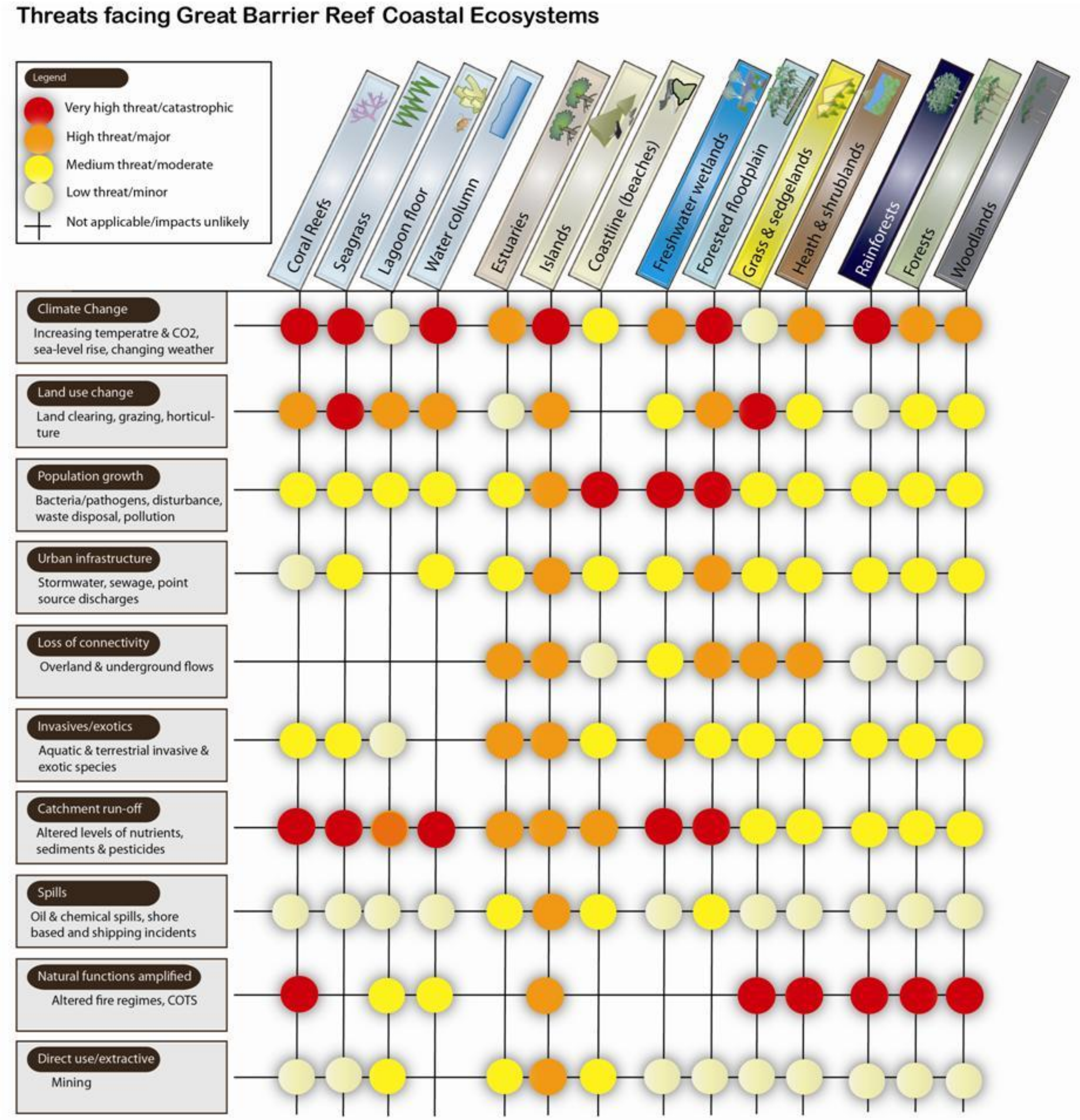

Table 6.10: Threats from current drivers of change to coastal ecosystems. (Red (4) – very high threat/catastrophic; Orange (3) – high threat/major; Yellow (2) – medium threat/moderate; Beige (1) – Low threat/minor; White (0) not applicable to this ecosystem. Assessments made using the criteria used in the *Outlook Report 2009*[1].

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7. Management of coastal resources

The *Outlook Report 2009*[1] identified that many of the threats to the Great Barrier Reef are the result of actions beyond the boundaries of the Marine Park. These include coastal development, catchment land use practices and climate change. The management framework that exists in the coastal zone will be the most powerful tool to protect the long-term health and resilience of coastal ecosystems and their capacity to support a healthy and resilient Great Barrier Reef. Managing coastal development falls under the responsibility of all levels of government and its management requires a whole of government response to bring appropriate management tools together to address the variety of pressures and threats (figure 7.1 provides a snapshot of some of the key legislative instruments available). There are also many stakeholders with strong interests in the outcomes. With more intensive use of the coastal areas in the catchment, there is a need to manage the catchment as an integrated ecosystem linking and connecting the terrestrial and marine ecosystems.

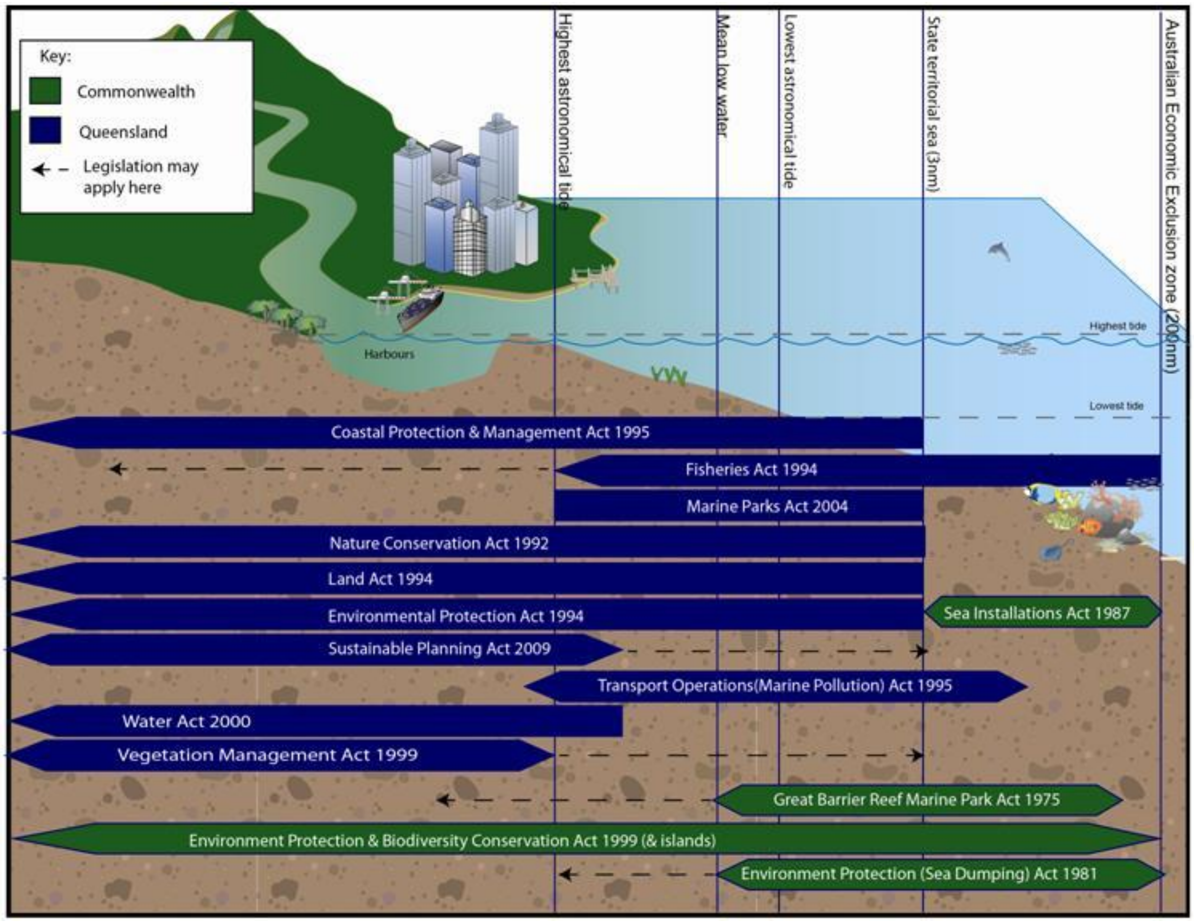

Figure 7.1: Illustration of key coastal management legislation in Queensland. Dotted lines show where pieces of legislation may apply in some circumstances to specific sections of the coast. Boundaries are indicative only.

This complex jurisdictional environment and the arrangements applying to the coastal zone around Australia was noted by the House of Representative Joint Standing Committee on Climate Change, Water, Environment and the Arts in a recent report assessing Australia's preparedness to manage the coast in a changing climate[2]. The Committee recognised the complexity of management in the coastal zone and the uniqueness of the collaborative arrangements established under the Inter-governmental Agreement[3] for the management of the Great Barrier Reef and its catchment. Recommendations were made that these arrangements be investigated as a pilot for improved integrated coastal zone management in Australia.[2]

7.1. The Outlook Report 2009 assessment of management effectiveness

The *Outlook Report 2009* included a comprehensive independent review of the existing protection and management tools relevant to the Marine Park, including those that apply within the catchment for managing coastal development. Overall it was found a lack of integrated planning, resources and enforcement in managing coastal development is compromising the protection of the Reef.[1]

Some of the key findings provided by the assessors[4] were:

- <u>The lack of integrated planning for coastal development</u>*:* Reviewers found there was no consistent application of planning by all levels of government, and that potential downstream impact on the values of the Great Barrier Reef were generally not being considered in the planning framework. A further problem was the increasing conflict between environmental protection and mining and industrial expansion. Past decisions and significant past land disturbance continues to be a difficult issue to contend with, often resulting in ongoing erosion and pollution processes.
- <u>A lack of resources and enforcement in managing coastal development impacts on coastal ecosystems</u>: Reviewers found there was limited capacity for the application, compliance and enforcement of legislative and planning tools, especially within and across jurisdictions, resulting in ineffective environmental protection.
- <u>Lack of a process to address cumulative development</u>: Reviewers found this was a significant failing of most impact assessment processes, especially in the context of an inconsistent planning environment.

In their response to *Outlook Report 2009,* the Australian and Queensland governments noted a number of actions would be implemented to address the risk to the Great Barrier Reef from coastal development pressures. These included:

- In November 2009 the environment of the Marine Park became a matter of National Environmental Significance under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- The governments agreed they would actively explore the potential to undertake strategic assessments under the EPBC Act in key coastal areas adjacent to the Great Barrier Reef.
- The Interim Report on the review of the EPBC Act had identified the merits of an increased focus on 'landscape scale' approaches in addressing development pressures.
- Queensland had reviewed its Coastal Plan to better address biodiversity conservation, coastal process issues, scenic amenity and public access and to prevent the perpetuation of linear urban development along the coast. It was expected the new plan would begin its implementation in early 2010.
- Queensland was also reviewing the *Integrated Planning Act 1997* and developing new regional plans –the Far North Queensland Regional Plan 2009–2013 was the first prepared in the catchment.
- A number of draft state planning policies were being developed, including those for the management of stormwater runoff aimed at ensuring better water quality outcomes and new legislation that will regulate the drainage of wetlands in the catchment under the Reef Coastal Wetlands Protection Program.
- Lastly, the Federal House of Representatives Standing Committee on Climate Change Water Environment and Arts is undertaking an inquiry into climate change and the environmental impacts on coastal communities.

The management challenge is not only to ensure that any future development in and adjacent to the Great Barrier Reef World Heritage Area is ecologically sustainable. A legacy of past development and land use practices has led to degradation of Great Barrier Reef coastal ecosystems and water quality, and very marked declines in inshore biodiversity.

Management actions are also required to halt and reverse those declines and restore the ecological functions of coastal ecosystems.

7.2. Changes to Queensland's legislative and planning arrangements

Since the *Outlook Report 2009*, significant changes have been made to Queensland's legislative, policy and planning framework. Many are aimed specifically at improving protection of the Great Barrier Reef through management of catchments and wetlands.

7.2.1. Sustainable Planning Act 2009

The introduction of the *Sustainable Planning Act* 2009 (SP Act), amongst other things, created a legislative basis for regional statutory planning. Far North Queensland 2031 was the first statutory regional plan finalized under the SP Act in the catchment. Its fixed urban footprint has modified the growth trajectory of several areas previously earmarked for potentially unsustainable growth. It has also provided a policy direction for making local government and zoning plans complementary. The Mackay, Isaac and Whitsunday Regional Plan was launched on 8 February 2012 and is the second statutory regional plan to be developed for an area within the catchment.

7.2.2. State planning policies (SPP)

The *State Planning Policy 4/11: Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments* (SPP 4/11) took effect on 25 November 2011. SPP 4/11 and its associated regulations are focused on addressing the implications of high impact earthworks on wetlands. The SPP 4/11 sets the requirement for protecting High Ecologically Significant (HES) wetlands. Landholders, urban developers or primary producers who want to carry out high impact earthworks that might affect a wetland of high ecological significance will have to make an application through the Integrated Development Assessment System. SPP 4/11 applies to 35 basins from the Daintree River in the north to the Burnett River and Mary River catchments in the south.

7.2.3. *Queensland Coastal Plan* 2011

The *Queensland Coastal Plan* came into effect 3 February 2012. It replaces the State Coastal Management Plan (2001) and associated regional coastal management plans. The *Queensland Coastal Plan* was prepared under the *Coastal Protection and Management Act 1995*. The Plan has two parts: *State Policy for Coastal Management* and the *State Planning Policy 3/11: Coastal Protection (SPP 3/11).* SPP 3/11 provides policy direction for natural resource management decision-makers about land on the coast, such as coastal reserves, beaches, esplanades and tidal areas. The state planning policy provides policy direction and assessment criteria to direct land use planning and development assessment decision-making under the *Sustainable Planning Act 2009*. It will also constrain coastal development in areas predicted to be affected by rising sea levels.

The integration of these requirements in the statutory regional planning and natural resource planning in south-east Queensland, and the associated governance arrangements provides a template that could be followed in the catchment. Other initiatives have been introduced including extending the vegetation management regime to protect wetlands and riverine vegetation.

7.3. The Great Barrier Reef Water Quality Protection Plan

The *Great Barrier Reef Water Quality Protection Plan* (Reef Plan) was first developed in 2003, and was revised and streamlined in 2009 to include a range of water quality and management action targets to achieve the following goals:[5]

- To halt and reverse the decline in water quality entering the reef by 2013.
- 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.

The Australian and Queensland governments are investing in excess of $375 million over five years (2009–2014) on Reef Plan activities. This includes $200 million for the Australian Government's Caring for our Country Reef Rescue initiative and $175 million for Reef Plan activities through the Queensland Government. This includes $50 million to implement the Reef Protection Package. For more information, visit www.reefplan.qld.gov.au.

Reef Plan is a collaboration between the Australian Government, Queensland agencies, natural resource management bodies and industry. Reef Plan sets targets for water quality and land management improvement, and identifies specific actions and deliverables to improve the quality of water entering the Great Barrier Reef. These are to be completed by 2013 when Reef Plan and its actions will again be reviewed.

7.4. Water quality improvement plans

Water Quality Improvement Plans (WQIPs) are catchment and regional-based water quality management plans. They seek to improve water quality by reducing the amount of key pollutants, such as nutrients, sediments and chemicals, from the catchments that enter the waterways and are carried to the Great Barrier Reef lagoon. These plans build on and enhance the existing water quality management components of regional NRM plans and make a critical contribution to the delivery of Reef Plan.

The development of WQIPs is being led by regional NRM bodies and local councils. Additional assistance is being provided by GBRMPA, CSIRO, the Department of Environment and Heritage Protection, the Department of Agriculture, Fisheries and Forestry and local communities. Under its Coastal Catchments Initiative, the Australian Government funded the South East Queensland (SEQ) Healthy Waterways Partnership, and several Great Barrier Reef regional NRM bodies and local governments to develop WQIPs in south-east Queensland and most of the catchments or regions.

The WQIPs are a forerunner to Healthy Waters Management Plans. The former Queensland Department of Environment and Resource Management worked with all the above bodies to ensure the process used to establish the environmental values and water quality objectives is consistent with the *Environmental Protection (Water) Policy 2009*. Individual plans have been prepared for the following areas in the catchment:

- Burnett–Baffle
- Fitzroy Basin
- Mackay–Whitsunday
- Burdekin
- Ross–Black Basins (Townsville)
- Tully
- Barron/Trinity Inlet
- Douglas

More recently, draft Healthy Waters Management Plans have been developed for the Herbert, Johnstone and Mulgrave catchments.

The *Environmental Protection (Water) Policy 2009* establishes Healthy Waters Management Plans as a key planning mechanism to improve the quality of Queensland waters. Matters addressed in these plans include identifying:

- waters to which the plan applies
- issues affecting water dependent ecosystems, drinking water and natural flows
- waterway uses and values (otherwise known as environmental values or EVs)
- management goals and water quality objectives to protect identified environmental values
- ways to protect the environmental values for the water
- ways to monitor and assess the effectiveness of the protection.

7.5. Other management programs

There is a substantial range of other management programs underway providing opportunities to protect areas of high ecological significance and to support action to restore connectivity and the function of ecosystems in priority areas. These include:

- The Australia Government's Caring for Our Country program. Each year, investment proposals are sought from environmental, Indigenous, Landcare, Coastcare and sustainable agriculture community groups for grants of between $5000 and $20,000 to take action to help protect and conserve

Australia's natural resources and environment. More than two million dollars was invested in projects in Queensland in 2010–11, a proportion of which funded projects in the catchment.

- The joint Australian and Queensland governments' Queensland Wetlands Program. This provides the tools needed for improved understanding of actions to maintain health and connectivity of the wetland systems. This includes providing critical information to Reef Plan's annual report cards on changes to the extent of the catchment's wetlands which is a Reef Plan target. This initiative is coming to the end of its period of financial support from both governments.
- The Regional Natural Resource Management Investment Program. This will provide funding consistent with the Queensland Government's commitment of continued funding in the Great Barrier Reef Region. This includes funding of NRM bodies, the Queensland Wetlands Program and Reef Plan.
- The Queensland Government's Everyone's Environment grant program. This program will fund activities in the local community to improve the local environment. The program will work with community groups and like-minded organisations to tackle environmental degradation in their local areas. Initiatives under this grants program will reflect local and regional priorities, and applicants are encouraged to partner with local schools and councils.
- The Australian Government's Clean Energy Futures program. This includes support for regional landscape planning and the Biodiversity Fund which is supporting dual biodiversity and carbon sequestration outcomes.
- The Australian and Queensland government's Offset Strategies. This is under development. This can be used to support and prioritise protection and improved management of intact and or degraded coastal landscapes.
- Funding from the Australian and Queensland governments to support NRM bodies review their regional plans. This provides an opportunity to underpin regional statutory planning and decision making processes, including identifying priority actions required for restoring the Great Barrier Reef inshore and associated coastal ecosystems.

7.6. Community programs – the role of education and extension

In addition to the regulatory framework, many industry, non-government organisations, community groups and individuals also contribute or directly participate in protection and management of coastal ecosystems. Education and community awareness programs such as Reef Guardian Schools and Reef HQ Aquarium inform and motivate members of the community about protection and management of the Great Barrier Reef. GBRMPA has expanded this program by establishing pilot programs for Reef Guardian farmers, graziers and fishers. NRM bodies coordinate community-based coastal management activities in the catchment and there is growing engagement with GBRMPA's Local Marine Advisory Committees in this area. Community groups organise and participate in community activities that help understand and protect the environment. Schools educate and engage students in marine activities and conservation. Environmental non-government organisations raise public awareness about the state of the environment and achieve on ground outcomes through grant applications to rehabilitate or rectify issues in coastal areas such as beach access, waste management and erosion.

It is through these groups and their activities that significant on-ground change can be implemented and changes of attitudes and behaviours can be achieved. The challenge remains in ensuring the resources are targeted at the most critical areas for improved long-term environmental outcomes. In many instances, government programs provide opportunities and support for these groups to achieve significant outcomes.

There are many ways that governments, industry, NRM bodies and the community can and do work together to manage our finite natural resources that can help to improve the long-term outlook for coastal ecosystems and the health and resilience of the Great Barrier Reef.

7.7. The legacy of past actions

The *Outlook Report 2009* identified the impact of coastal development on coastal ecosystems as one of the major risks to the long term health of the Great Barrier Reef. It also identified a number of deficiencies in the management of coastal development. In response, a number of changes have been instigated in Queensland's planning which has the potential to address some of these concerns. However, it will take some time for these changes to be reflected in improved development decisions that minimise or even halt ongoing impacts on coastal ecosystem function.

Earlier sections of this report have highlighted the changes to coastal ecosystems that occurred since European settlement. There have already been significant changes to the ecological, biological and hydrological functions of many of the 35 basins that make up the catchment. These modifications are the legacy of past decisions. Addressing these issues will require further coordinated actions if the health and resilience of the Great Barrier Reef is to be improved and then maintained into the future.

7.8. Strategic Assessment of the Great Barrier Reef and its Coast

The Australian and Queensland governments are working together to undertake a strategic assessment of the World Heritage Area and the adjacent coastal zone.

There are two key components of the strategic assessment – a marine component and a coastal component. The marine and coastal ecosystems are intrinsically linked and their function is inter-related. Together these components will form a comprehensive strategic assessment of the World Heritage Area and the adjacent coastal zone.

The draft terms of reference for the two components were released for public comment early in 2012. The reporting and outcomes of the assessment are expected to be finalised in 2013.

References

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8. Conclusion

Fourteen coastal ecosystems have been identified as important to the functioning of the Great Barrier Reef: coral reefs, lagoon floor, islands, open water, seagrasses, coastline, estuaries, freshwater wetlands, forested floodplain, heath and shrublands, grass and sedgelands, woodlands, forests and rainforests. These coastal ecosystems provide the interconnections that support the physical, biological and biogeochemical process that underpin the ecosystem health of the Great Barrier Reef World Heritage (the World Heritage Area).

A previous review conducted in 2002 by the Land and Water Audit identified that more than half of the Great Barrier Reef's 35 basins (catchments, rivers and estuarine systems) are assessed as being in a poor condition, which highlights the need for ongoing and increased management actions to protect and restore the functionality of those coastal ecosystems. Maintaining and restoring the coastal ecosystems and their functions in and adjacent to the Great Barrier Reef is essential to halting and reversing these declines and maintaining the Outstanding Universal Value of the World Heritage Area.

The Report has identified a gradient in the differences in loss or modification of coastal ecosystems as one travels from south to north in the Great Barrier Reef catchment. Significantly more coastal ecosystems have been lost or modified in the Burnett–Mary, Fitzroy and Mackay–Whitsunday regions compared to the Cape York, Wet Tropics or Burdekin Dry Tropics regions. The assessments have also revealed the pressures from development are generally greatest in areas within close proximity to the coast.

A legacy of past land use practices has led to degradation of coastal ecosystems and water quality, and declines in inshore biodiversity. Increasing urbanisation and expansion of mining and development of ports and related infrastructure occurring along the Great Barrier Reef coast is adding further pressures to inshore biodiversity. These current and projected impacts must be considered in the context of the cumulative impacts of declining water quality from catchment runoff, historic and some remaining impacts of fishing, climate change and the extreme weather events that have occurred over the past five years.

8.1. Addressing the legacy of past practices

Since European settlement there have been changes to the landscape, resulting in the loss of coastal ecosystems and modification of coastal ecosystems functions. Grazing is the major land use occurring over 74 per cent of the catchment and has been one of the main drivers behind land clearing. Intensive agriculture occurs over about five per cent of the catchment but in some coastal areas it is a driver behind loss or modification of coastal wetlands.

Population and economic growth, fed by recent mining booms, have been the key factors influencing urban development and port expansion. While these intensive land uses comprise only 0.6 per cent of the catchment, together they have led to modifications to both terrestrial and marine coastal ecosystems in specific locations. A number of those locations are critically important for threatened and 'at-risk' species including dugongs, speartooth sharks and inshore dolphins.

The draft *Great Barrier Reef Biodiversity Conservation Strategy 2012* has identified a range of species and habitats that are 'at-risk'. While past fishing and commercial hunting have been substantial contributors to some of these declines, land clearing and development on or adjacent to the coast are either the most significant pressure, or have significantly added to other pressures. Indicators of habitat degradation and other pressures leading to species decline include:

- Up to 50 per cent decline in coral cover estimated from over 27 years of long-term monitoring data, particularly on reefs in the central part of the Great Barrier Reef that have been subjected to multiple pressures from declining water quality, increased frequency of outbreaks of crown-of-thorns starfish, and severe cyclones. Scientific studies and historic photographic evidence shows that substantial changes to inshore coral communities had occurred by the 1930s.
- An estimated 90 per cent decline in dugongs in waters south of Cooktown since the 1960s.
- A continuing decline in the abundance of seagrass meadows along large areas of the urban coast. Seagrasses provide a critical food source and habitat for a range of species, including vulnerable species such as dugong and green turtle.
- Significant range contractions and population declines for freshwater and green sawfish.
- The possibility that the speartooth shark has become extinct from waterways on the east coast of Australia. The last verified specimen was recorded in Princess Charlotte Bay in 1983, and while in the far north the introduction of mono-filament nets is thought to be the major contributor, elsewhere the modification of estuarine and inshore ecosystems is also likely to have been a significant contributor to that decline.
- Substantial populations of the Australian snubfin dolphin are only recorded from three areas within the Marine Park: Princess Charlotte Bay and Bathurst Bay on Cape York Peninsula, Cleveland Bay near Townsville and Keppel Bay at the mouth of the Fitzroy River. Of these three sites, one is a major port with an extensive proposed expansion program (Townsville), and the other two sites are currently being assessed for new coal port developments.
- Pressures on biodiversity apply not only to the identified 'at-risk' such as Australian snubfin dolphin, speartooth shark, dugong and turtle, they also affect a range of other 'at-risk' species that are important economically for commercial and recreational fisheries, including grey mackerel, snapper and threadfin salmon.

An assessment of the remaining coastal ecosystems that are critical to the inshore biodiversity of the Great Barrier Reef shows that, although approximately sixty per cent of terrestrial components of the coastal ecosystems remain, this overall picture is significantly affected by Cape York which remains essentially intact and makes up around one third of coastal ecosystems (Section 4). By contrast, at a regional or catchment scale the status of coastal ecosystems is highly variable and at the basin scale, some coastal ecosystems are now less than 10 per cent of their original extent and a considerable number are below 30 per cent. Fragmentation of habitats, loss of connectivity and new pressures associated with climate change present significant challenges for the resilience of coastal ecosystems. Land use changes continue to fragment habitats and modify the functions of coastal ecosystems. This means the risk to the long-term health and resilience of these systems is increasing cumulatively.

Survey information is not available on the historic extent of inshore marine ecosystems. These systems have not been subjected to the broad scale direct disturbances that have affected the extent and distribution of terrestrial coastal systems. Nevertheless, historic photographic records show significant loss of coral communities on coastal reef flats and modelling suggests there have been substantial declines in the extent of seagrasses along parts of the developed coast. A significant issue for the status of the inshore marine ecosystems is the impacts from the decline in water quality which is known to be responsible for declines in both coral and seagrass habitats, and reduced productivity in a number of species, affecting their health, ability to breed and survival of their offspring.

Changes in land use can also significantly modify the functions of coastal ecosystems even when they do not involve substantial clearing. For example, while overall change to the extent of estuarine wetland ecosystems, mangroves and saltmarshes has been less than 10 per cent for the catchment as a whole, and approaching 16 per cent in the worst case regionally, modification of the saltmarsh component of the estuarine systems has been more significant. Bunding has affected approximately 30 per cent of their extent, thereby disconnecting them from tidal influence and turning them into freshwater or brackish systems. This functional modification also occurs with urban developments where natural functions are lost and artificial substitutes must be incorporated into the landscape to restore those functions (for example, stormwater and sewerage infrastructure). This loss of function may be further exacerbated by poor practices in soil and water management, or increased pollution loads from less than optimal design of urban areas, infrastructure, ports and industrial facilities.

Impacts of changes in functionality can be subtle and our understanding of the impacts rudimentary. Nevertheless, the disruption of any ecosystem functions through modifications or loss of coastal ecosystems, or loss of connectivity between coastal ecosystems, can have very significant implications. For example, an increased frequency of crown-of-thorns starfish outbreaks is believed to be the major contributor to the steady decline in Great Barrier Reef coral cover recorded over at least the last 20 years, and is a very significant indicator of the consequences of changes in coastal land use for coastal ecosystems.

The management challenge is not only to ensure that any new activity in and adjacent to the World Heritage Area is ecologically sustainable, but that additional management actions are also required to restore the functioning of degraded coastal ecosystems and reverse the decline of the associated biodiversity.

8.2. Management actions – slowing and reversing declines

In the past 15 years there has been recognition across all levels of government of the fundamental importance of the impacts of catchment activities on the World Heritage Area, which has resulted in significant legislative reform and focused management actions. This additional protection, including land clearing laws, wetlands regulations and the 2011 Queensland Coastal Plan has very substantially slowed the rate of wetland and coastal ecosystem loss, but by themselves will not be enough to restore essential coastal ecosystem functions or halt the decline of inshore species.

The implementation of the *Vegetation Management Act 1999* dramatically reduced the amount of clearing in Queensland, falling from the peak of 750,000 hectares per year in 1999–2000 to 123,000 hectares per year in 2007–08. It also provides for increased protection and regrowth of native vegetation in the priority catchments of the Burdekin, Mackay-Whitsundays and Wet Tropics NRM regions. The recent introduction of the Reef Protection Regulation and the Wetland Regulatory Provisions are also significant legislative actions aimed at achieving outcomes for Great Barrier Reef water quality improvements and critical coastal ecosystems.

Queensland's Coastal Plan has identified many coastal areas of high ecological significance and put in place policies for protecting and maintaining their values. The implementation of this plan has substantially increased protection for many of the remaining relatively intact coastal ecosystems adjacent to the urban coast.

The *Great Barrier Reef Water Quality Protection Plan* (Reef Plan) has been a very significant initiative, and is making measurable progress towards the goal of halting and reversing the decline in water quality entering the Great Barrier Reef. The progress towards this goal reflects the level of commitment by both the Australian and Queensland governments, which are investing in excess of $375 million over five years on Reef Plan activities. This includes $200 million for the Australian Government's Caring for our Country Reef Rescue initiative and $175 million for Reef Plan activities through the Queensland Government, including $50 million to implement the Reef Protection package. As importantly, the progress to date reflects the very strong commitment and collaboration by key stakeholders, including the Australian Government, the Queensland agencies, GBRMPA, NRM bodies and industry.

As a result of these actions, very substantial progress has been made towards halting and reversing the decline of Great Barrier Reef water quality through improved practices. It is important that this work continue through to achieving the goal of ensuring 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.

8.3. Community action

Many industry, non-government organisations, community groups and individuals also contribute or directly participate in protection and management of coastal ecosystems. Education and community awareness programs such as the Reef Guardian Schools program and Reef HQ Aquarium inform and motivate members of the community about protection and management of the Great Barrier Reef. GBRMPA is now expanding these programs and is establishing pilot programs for Reef Guardian farmers, graziers and fishers.

NRM bodies coordinate community based coastal management activities in the catchment. Regional NRM plans have played a key role in identifying priorities for action, particularly in relation to catchment water quality. The development of water quality improvement plans has been led by regional NRM bodies and local councils in collaboration with the Department of Environment and Heritage Protection (formerly the Department of Environment and Resource Management), GBRMPA, CSIRO, the Queensland Department of

Agriculture, Fisheries and Forestry, and local communities, with funding support from the Australian Government. Water quality improvement plans have built on and enhanced the existing water quality management components of regional NRM plans and make a critical contribution to Reef Plan.

Community groups, including GBRMPA's Local Marine Advisory Committees, organise and participate in community activities that help understand and protect the environment. Schools educate and engage students in marine activities and conservation. Together with environmental non-government organisations, these groups raise public awareness about the state of the environment and raise funding to achieve on-ground outcomes to rehabilitate or rectify issues in coastal areas such as beach access, waste management and erosion. It is through these groups and their activities that significant on ground changes can be implemented and changes of attitudes can be achieved. In many instances, government programs provide opportunities and support for these groups to achieve significant outcomes.

The challenge remains in ensuring the resources are targeted at the most critical areas for improved long-term environmental outcomes.

8.4. Current actions

It will take time to demonstrate the outcomes to the environment (water quality improvements) flowing from the legislative and planning reforms and NRM programs outlined above. The rapid rate of economic and population growth, and the demand for mining and port developments, have potential to counteract these benefits. NRM planning remains fragmented and is not keeping pace with urban growth and demands for new and expanded infrastructure to support the mining boom, such as ports, transport corridors and water supply.

Port and other marine infrastructure development have resulted in direct and indirect impacts on coastal ecosystems. When the coastal boundaries of the Marine Park were established, a small number of areas were excluded from the Marine Park to make provision for coastal ports including major ore export ports at Gladstone, Hay Point and Abbott Point. For the remainder of the coastline, the boundary of the Marine Park comes in to the low water mark in recognition of the high natural, social and cultural values these inshore waters possess. Recent applications for substantial expansion of existing but small scale ports and for new ports in areas outside of the existing major port areas is a concerning trend and may, if not managed or offset significant, have implications for the biodiversity of the Great Barrier Reef and the coastal ecosystems on which it is reliant. Regardless of the scale of the activity, a number of these proposed developments could potentially have significant impacts on populations of 'at-risk' species and lead to significant changes to the ecological functions of the coastal habitats that those species rely on.

Strategic and effective management of coastal development, targeted research and on-ground actions are essential if we are going to address the habitat and species declines in the inshore areas of the World Heritage Area. In many cases it will not be enough to simply halt the decline of water quality or mitigate the impacts of new development. An effective strategic assessment of cumulative development impacts and an integrated regional NRM planning program have the capacity to identify and implement a range of sensible actions that can improve the protection and enhance the functionality of our coastal ecosystems.

Management of inshore areas is complex. Current research and monitoring that focuses on inshore biodiversity and the impact of pressures acting on these elements of biodiversity is limited spatially and temporally, lacks integration and is insufficient to inform management agencies tasked with ensuring long-term outcomes for inshore biodiversity. The Paddock to Reef integrated monitoring and modelling program provides up to date information on changing agricultural land use practices and water quality outcomes. This program demonstrates that complex research, monitoring and modelling requirements can be successfully coordinated and integrated. A similar approach is now required to provide the information and guidance required to address declines in coastal ecosystems and inshore biodiversity.

Opportunities exist, particularly through effective, integrated regional NRM and infrastructure planning, to identify priorities for restoring degraded coastal ecosystems and removing blockages to essential ecosystem connectivity (agricultural bunds, poorly designed road and rail infrastructure and degraded landscapes). There is also the potential to apply offsets from major developments and carbon offsets in combination with major government initiatives such as Caring for Our Country and the Biodiversity Fund to achieve substantial improvements in the functionality of coastal ecosystems.

8.5. Further actions

There are critical priority actions that need to be taken:

- Maintaining existing key water quality improvement programs until the *Reef Water Quality Protection Plan's* goal is achieved in ensuring that by 2020 the quality of water entering the Great Barrier Reef from adjacent catchments has no detrimental impact on the health and resilience of the Great Barrier Reef.
- Implement a systematic approach to regional scale NRM planning and integrate with Regional Statutory Plans developed under the *Sustainable Planning Act 2009*.
- Protecting the remaining intact corridors and least modified coastal landscapes, including those on Cape York.
- Work with researchers, Traditional Owners, commercial fishers, ports and local communities to better understand and protect habitats of 'at-risk' species including identified protected species such as the Australian snubfin dolphin, speartooth shark, sawfish, dugong and turtle, and other species that are important economically for commercial and recreational fisheries, including grey mackerel, snapper and threadfin salmon.
- Review current coastal and Marine Park monitoring programs to establish a more effective, ecologically based and integrated approach to monitoring, and support with long-term dedicated funding.
- Reconnecting natural landscapes and addressing legacy issues to reinstate the functionality of ecosystems especially through integrated NRM and planning programs and more integrated and focused offset strategies.
- Ensuring the design of new coastal infrastructure and management of existing infrastructure aims to minimise the impacts on coastal ecosystem function.

The information compiled for this report can also provide foundational information for developing more detailed basin level assessments and identifying and prioritise specific, on-ground actions that can be taken to improve coastal ecosystem processes.

This report will inform individual planning and development assessments. It will also inform the comprehensive strategic assessments of the World Heritage Area and the adjacent coastal zone being undertaken by GBRMPA and the Queensland Government. The strategic assessments are being undertaken in accordance with the *Environment Protection and Biodiversity Conservation Act 1999* and will cover:

- the World Heritage Area, including all islands
- the coastal zone adjacent to the Great Barrier Reef, including Queensland waters, and adjacent inland areas (5 kilometres inland or 10 metres AHD contour, whichever is further)
- areas of the catchment to the extent that water quality management arrangements apply.

The comprehensive strategic assessment will help identify, plan for and manage existing and emerging risks to ensure ongoing protection and management of the unique environmental values of the World Heritage Area and adjacent coastal zone. This will be achieved by:

- investigating the adequacy of the existing management arrangements for the World Heritage Area
- assessing current and future planned development in the World Heritage Area and the adjacent coastal zone and analysing its likely direct, indirect and cumulative impacts.

This report will also inform the next Outlook Report due in 2014. In addition, the methodologies developed for this report provide a robust and repeatable basis for comparing changes in extent of key coastal and catchment ecosystems over time. Development of the methodology involved extensive expert input, however repeating the assessment would be a relatively straight forward process, and will provide a robust basis for assessing trends over time for future Outlook reports. A number of projects being undertaken in connection with the Queensland Wetlands Program are utilising the methodologies and outcomes of this work and applying it more broadly in Queensland, including a Wetlands Connectivity Project, development of a Stressor Climate Change model and a Basin Assessment Framework.

It is proposed that the establishment of an Integrated Inshore Biodiversity Program, including the development and implementation of strategies to restore the functionality of coastal ecosystems will be a key outcome of the *Great Barrier Reef Biodiversity Conservation Strategy*. This work will provide a key foundational element for that program.

It is also proposed that improving the understanding of the implications of climate change and the development of adaptation strategies for Great Barrier Reef inshore and coastal ecosystems will be a priority focus for the next Great Barrier Reef Climate Change Action Plan (2012–2017).

Appendix I

Spatial analysis methods

The regional ecosystem data underpins the *Vegetation Management Act 1999.* The Act defines regional ecosystem status into three conservation status: endangered, of concern and not of concern. These are used by the Queensland Government in the evaluation of development assessments. The Vegetation Management Act provides protection from the clearing of significant regional ecosystem vegetation in the catchment and, more recently, established the basis for protecting high value regrowth vegetation. The *Queensland Coastal Plan* (released in 2012) aims to conserve coastal biodiversity by identifying areas of high ecological significance in the coastal zone. Areas identified as endangered and of concern regional ecosystems under the Vegetation Management Act have been identified as areas of high ecological significance in the coastal zone.

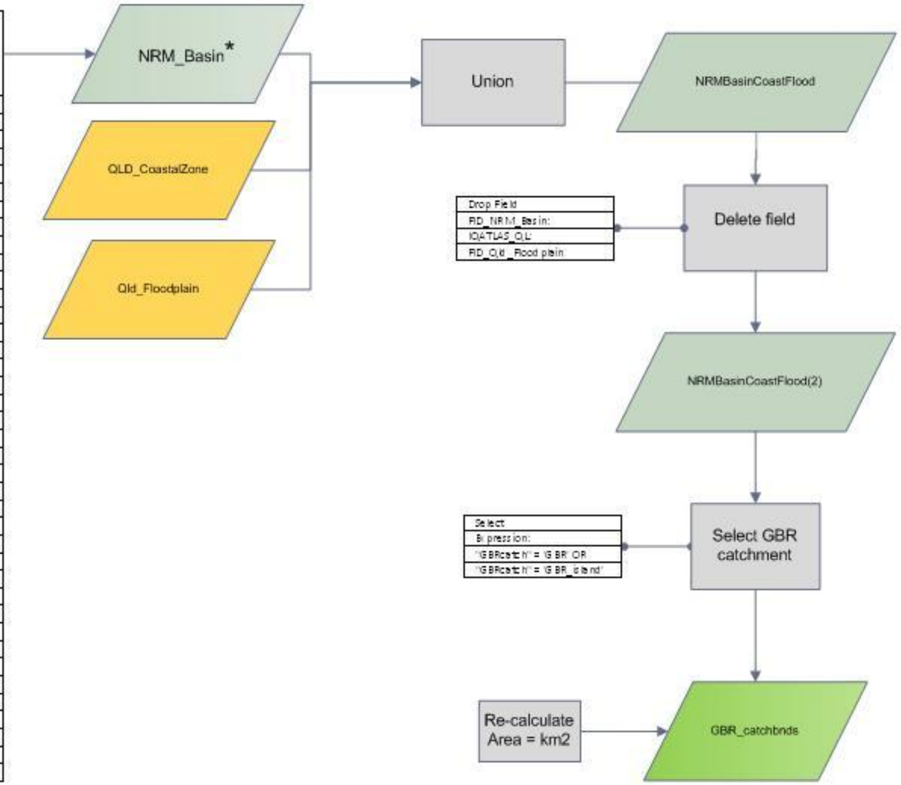
The regional ecosystem data is used as the foundation for the Department of Environment and Heritage Protection's wetland mapping. This regional ecosystem data has been used to assist in defining and mapping freshwater and estuarine wetlands (with an area greater than 0.01km^2) in the catchment. This data underpins the State Planning Policy 4/11: Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments.

The following diagrams show the detailed methods used in developing the spatial analysis of the integrated boundaries of the Great Barrier Reef catchment, coastal ecosystems (pre-clear and post-clear) and land use (1999 and 2009) using Queensland Land Use Mapping Program data.

Boundaries for integrated Great Barrier Reef Catchment

Add Attribute =Basin (text)
Add Attribute =NRMregion (text)
Add Attribute =GBRcatch (text)
Add Attribute = Order_ (number)

Basin	NRMregion	GBRcatch	Order_
Endeavour	Cape York	GBRcatch	7
Jacky Jacky	Cape York	GBRcatch	1
Jeannie	Cape York	GBRcatch	6
Lockhart	Cape York	GBRcatch	3
Normanby	Cape York	GBRcatch	5
Olive-Pascoe	Cape York	GBRcatch	2
Stewart	Cape York	GBRcatch	4
Barron	Wet Tropics	GBRcatch	10
Daintree	Wet Tropics	GBRcatch	8
Herbert	Wet Tropics	GBRcatch	16
Johnstone	Wet Tropics	GBRcatch	12
Mossman	Wet Tropics	GBRcatch	9
Mulgrave-Russell	Wet Tropics	GBRcatch	11
Murray	Wet Tropics	GBRcatch	14
Tully	Wet Tropics	GBRcatch	13
Hinchinbrook Island	Wet Tropics	GBRcatch_island	15
Black	Burdekin	GBRcatch	17
Burdekin	Burdekin	GBRcatch	20
Haughton	Burdekin	GBRcatch	19
Ross	Burdekin	GBRcatch	18
Don	Burdekin	GBRcatch	21
O'Connell	Maclay Whitsunday	GBRcatch	24
Pioneer	Maclay Whitsunday	GBRcatch	25
Plane	Maclay Whitsunday	GBRcatch	26
Proserpine	Maclay Whitsunday	GBRcatch	22
Whitsunday Island	Maclay Whitsunday	GBRcatch_island	23
Boyne	Fitzroy	GBRcatch	33
Calliope	Fitzroy	GBRcatch	31
Fitzroy	Fitzroy	GBRcatch	30
Curtis Island	Fitzroy	GBRcatch_island	32
Shoalwater	Fitzroy	GBRcatch	28
Styx	Fitzroy	GBRcatch	27
Waterpark	Fitzroy	GBRcatch	29
Baffle	Burnett Mary	GBRcatch	34
Burnett	Burnett Mary	GBRcatch	36
Barrum	Burnett Mary	GBRcatch	37
Kolan	Burnett Mary	GBRcatch	35
Mary	Burnett Mary	GBRcatch	38



Spatial Data key

DATASET

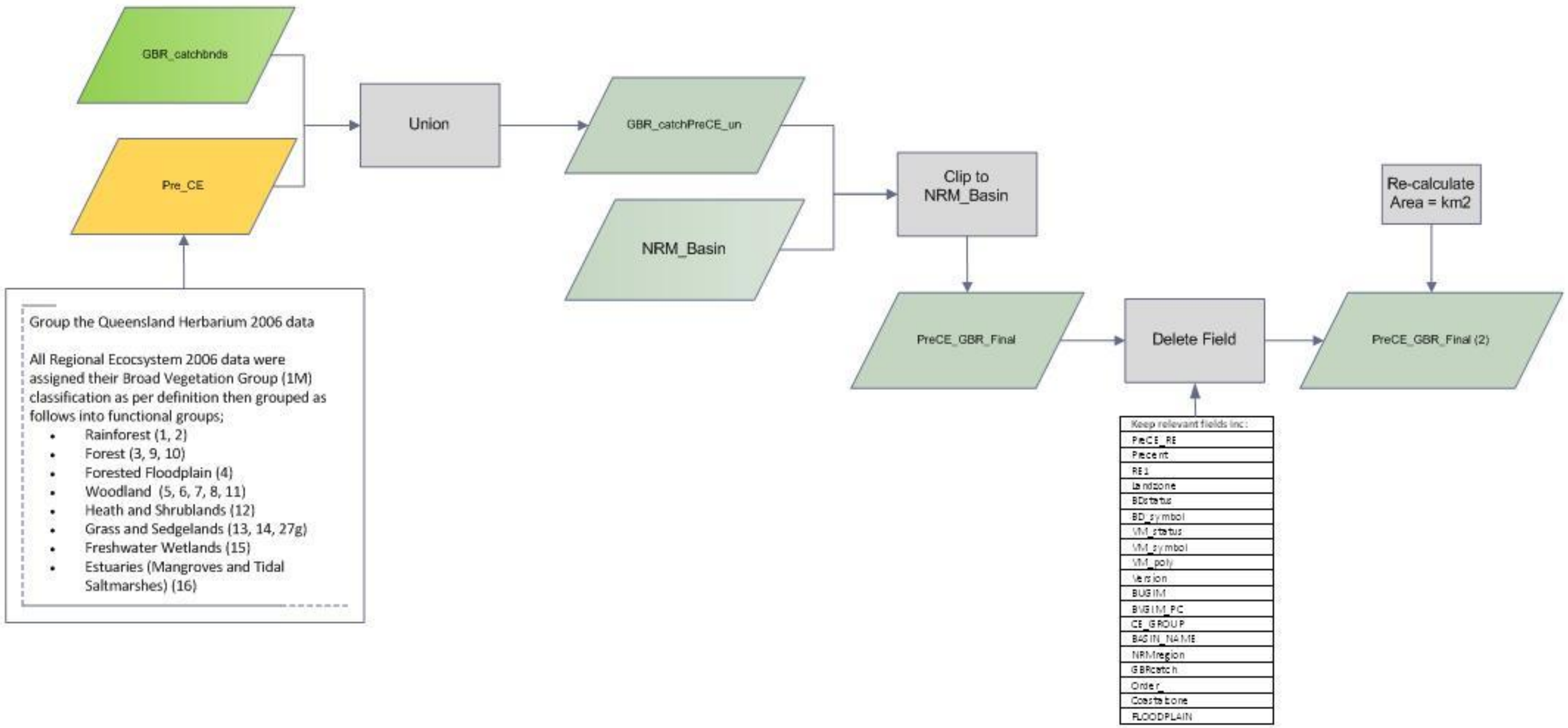
QLD_Basins (DERM)
QLD_Floodplain (DERM)
QLD_CoastalZone (DERM)
GBR_catchbnds

REFERENCE INFORMATION

Download via Qld Government Information System (QGIS) http://dds.information.qld.gov.au/dds/
Interim Floodplain Assessment Overlay (Ver 20120328) 28 March 2012 as DRAFT for Internal Use Only.
The Coastal Zone defines the area where the policies of the Queensland Coastal Plan apply 2012.
Feature class that defines the GBR catchment, NRM regions, basins, coastal zone and floodplain.

* In some cases the basin boundary is inconsistent with the NRM Region. For analysis purposes, the NRM Region containing the majority of the basin has been assigned to the entire basin.

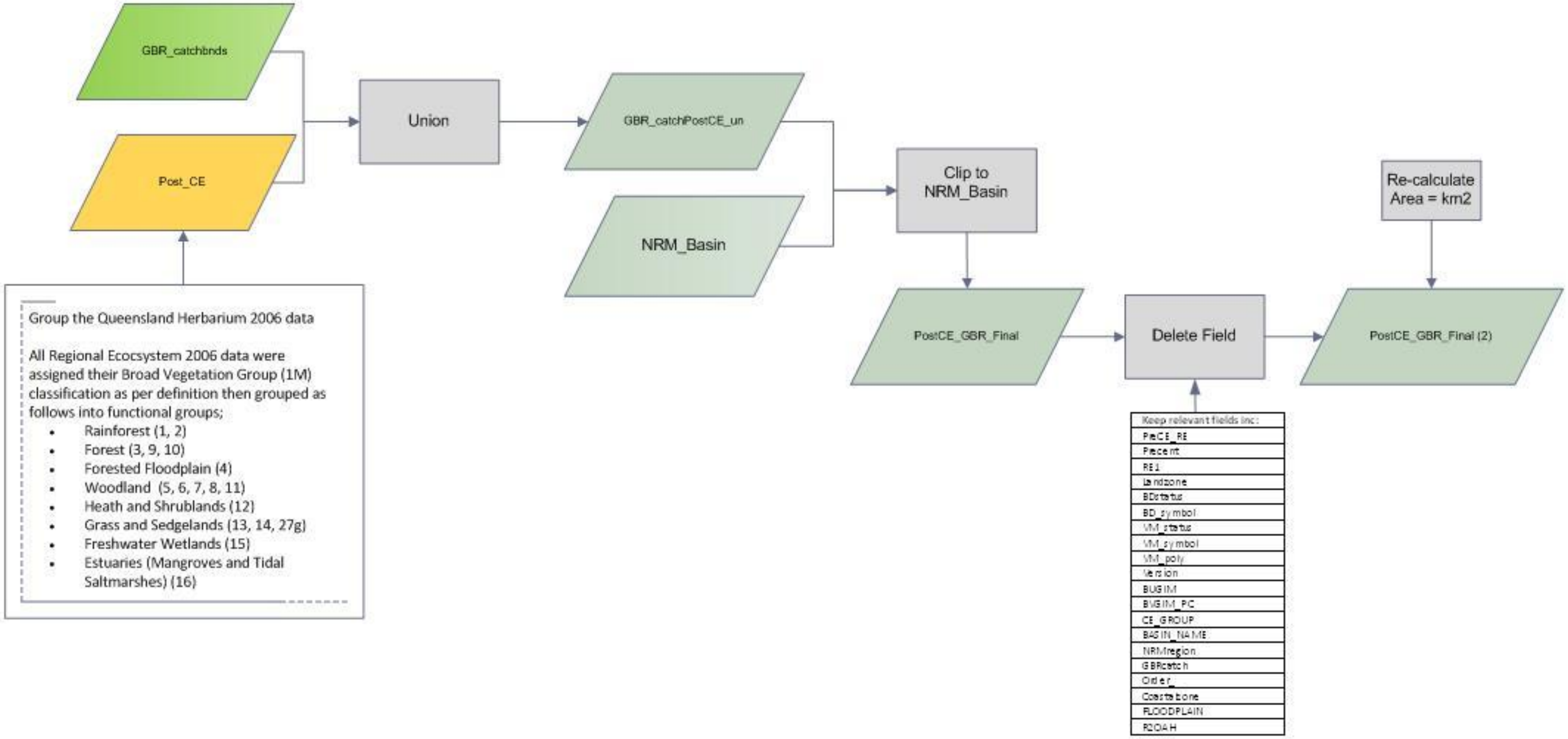
Coastal Ecosystems Pre Clear for Great Barrier Reef Catchment



Spatial Data key

DATASET	REFERENCE INFORMATION
GBR_catchbnds	Feature class that defines the GBR catchment, NRM regions, basins, coastal zone and floodplain.
Pre_CE (DERM)	Grouped Pre-Clear RE (2006) Data
PreCE_GBR_Final	Feature class showing coastal ecosystem groups (Broad vegetation grouping) derived from QLD pre clear RE mapping

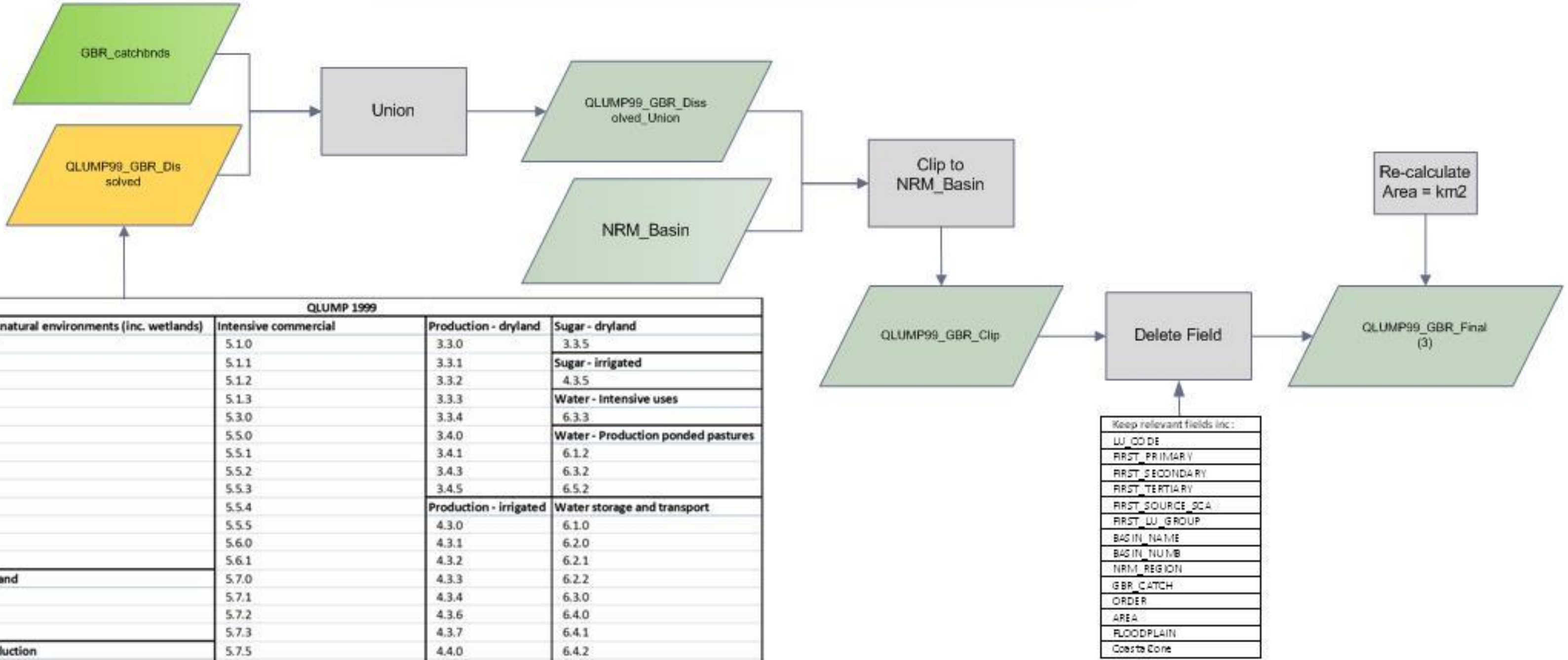
Coastal Ecosystems Post Clear for Great Barrier Reef Catchment



Spatial Data key

DATASET	REFERENCE INFORMATION
GBR_catchbnds	Feature class that defines the GBR catchment, NRM regions, basins, coastal zone and floodplain.
Pre_CE (DERM)	Grouped Post-Clear RE (2006) Data
PreCE_GBR_Final	Feature class showing coastal ecosystem groups (broad vegetation grouping) derived from QLD post clear RE mapping

Land use 1999 for Great Barrier Reef Catchment

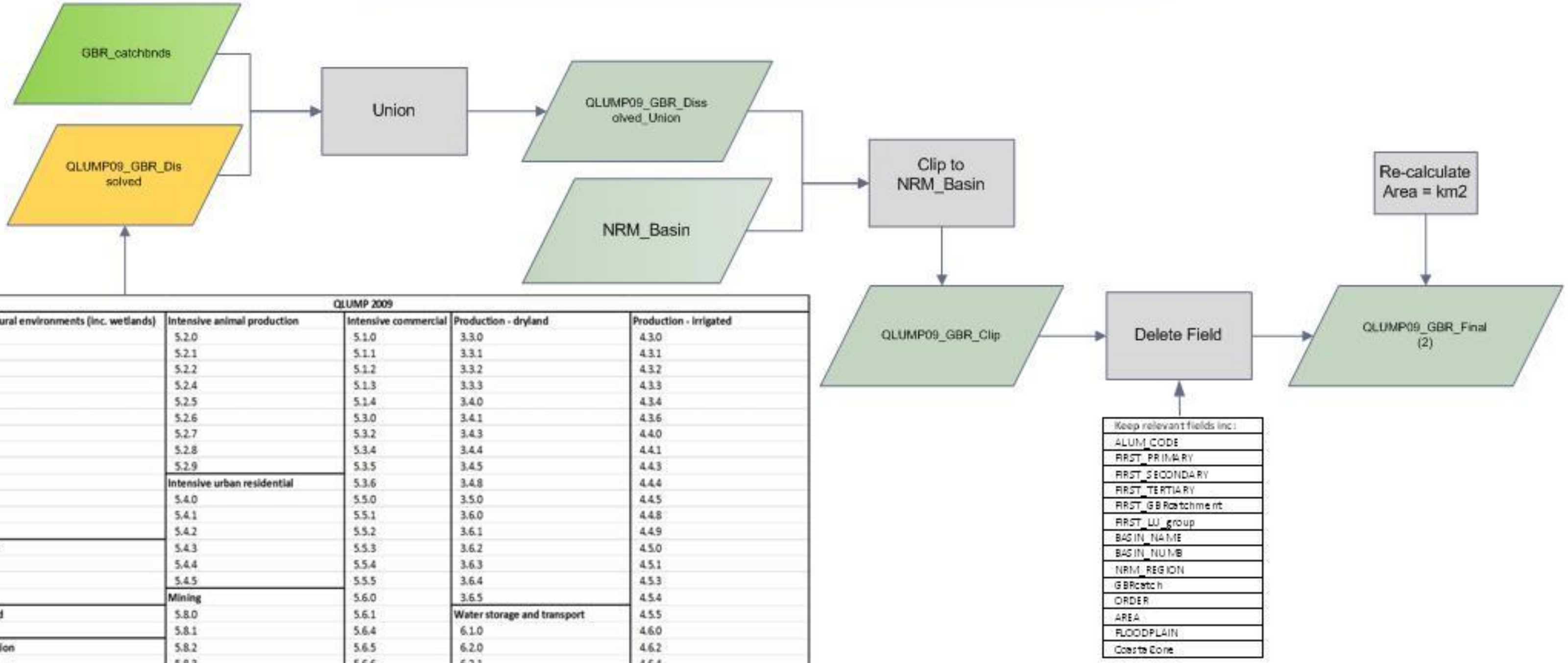


QLUMP 1999			
Conservation, natural environments (inc. wetlands)	**Intensive commercial**	**Production - dryland**	**Sugar - dryland**
1.1.3	5.1.0	3.3.0	3.3.5
1.1.4	5.1.1	3.3.1	**Sugar - irrigated**
1.1.5	5.1.2	3.3.2	4.3.5
1.1.7	5.1.3	3.3.3	**Water - Intensive uses**
1.2.0	5.3.0	3.3.4	6.3.3
1.2.2	5.5.0	3.4.0	**Water - Production ponded pastures**
1.2.5	5.5.1	3.4.1	6.1.2
1.3.0	5.5.2	3.4.3	6.3.2
1.3.1	5.5.3	3.4.5	6.5.2
1.3.3	5.5.4	**Production - irrigated**	**Water storage and transport**
1.3.4	5.5.5	4.3.0	6.1.0
6.1.1	5.6.0	4.3.1	6.2.0
6.5.1	5.6.1	4.3.2	6.2.1
Forestry - dryland	5.7.0	4.3.3	6.2.2
3.1.0	5.7.1	4.3.4	6.3.0
3.1.2	5.7.2	4.3.6	6.4.0
3.1.3	5.7.3	4.3.7	6.4.1
Forestry - production	5.7.5	4.4.0	6.4.2
2.2.0	5.9.0	4.4.1	6.5.0
2.2.1	5.9.2	4.4.2	6.6.0
Grazing natural vegetation	5.9.5	4.4.3	**Intensive urban residential**
2.1.0	**Intensive animal production**	4.4.4	5.4.0
Intensive mining	5.2.0	4.4.5	5.4.1
5.8.0	5.2.1	4.4.7	5.4.2
5.8.1	5.2.2	4.5.0	**Intensive ports**
5.8.2	5.2.4	4.5.1	5.7.4
5.8.3	5.2.5	4.5.3	
	5.2.6	4.5.4	

Spatial Data key

DATASET	**REFERENCE INFORMATION**
GBR_catchbnds	Feature class that defines the GBR catchment, NRM regions, basins, coastal zone and floodplain.
QLUMP99_GBR_Dissolved	Grouped Queensland Land Use Mapping Project (QLUMP 1999) data
QLUMP99_GBR_Final (3)	Feature class showing land use derived from QLUMP 1999 data

Land use 2009 for Great Barrier Reef Catchment



QLUMP 2009				
Conservation, natural environments (inc. wetlands)	**Intensive animal production**	**Intensive commercial**	**Production - dryland**	**Production - irrigated**
1.1.1	5.2.0	5.1.0	3.3.0	4.3.0
1.1.3	5.2.1	5.1.1	3.3.1	4.3.1
1.1.4	5.2.2	5.1.2	3.3.2	4.3.2
1.1.5	5.2.4	5.1.3	3.3.3	4.3.3
1.1.7	5.2.5	5.1.4	3.4.0	4.3.4
1.2.0	5.2.6	5.3.0	3.4.1	4.3.6
1.3.0	5.2.7	5.3.2	3.4.3	4.4.0
1.3.1	5.2.8	5.3.4	3.4.4	4.4.1
1.3.3	5.2.9	5.3.5	3.4.5	4.4.3
1.3.4	**Intensive urban residential**	5.3.6	3.4.8	4.4.4
6.1.1	5.4.0	5.5.0	3.5.0	4.4.5
6.3.1	5.4.1	5.5.1	3.6.0	4.4.8
6.5.1	5.4.2	5.5.2	3.6.1	4.4.9
Forestry - dryland	5.4.3	5.5.3	3.6.2	4.5.0
3.1.0	5.4.4	5.5.4	3.6.3	4.5.1
3.1.1	5.4.5	5.5.5	3.6.4	4.5.3
3.1.2	**Mining**	5.6.0	3.6.5	4.5.4
Forestry - irrigated	5.8.0	5.6.1	**Water storage and transport**	4.5.5
4.1.0	5.8.1	5.6.4	6.1.0	4.6.0
Forestry - production	5.8.2	5.6.5	6.2.0	4.6.2
2.2.0	5.8.3	5.6.6	6.2.1	4.6.4
Grazing - dryland	5.8.4	5.7.0	6.2.2	4.6.5
3.2.0	**Sugar - dryland**	5.7.1	6.2.3	
3.2.1	3.3.5	5.7.2	6.3.0	
3.2.2	**Sugar - irrigated**	5.7.3	6.4.0	
Grazing - irrigated	4.3.5	5.7.5	6.4.1	
4.2.0	**Water - Intensive uses**	5.9.0	6.4.3	
Ports	6.1.3	5.9.1	6.5.0	
5.7.4	6.6.3	5.9.2	6.6.0	
Grazing natural vegetation	**Water - Production ponded pastures**	5.9.3		
2.1.0	6.5.2	5.9.5		

Spatial Data key

DATASET	**REFERENCE INFORMATION**
GBR_catchbnds	Feature class that defines the GBR catchment, NRM regions, basins, coastal zone and floodplain.
QLUMP09_GBR_Dissolved	Grouped Queensland Land Use Mapping Project (QLUMP 2009) data
QLUMP09_GBR_Final (3)	Feature class showing land use derived from QLUMP 2009 data