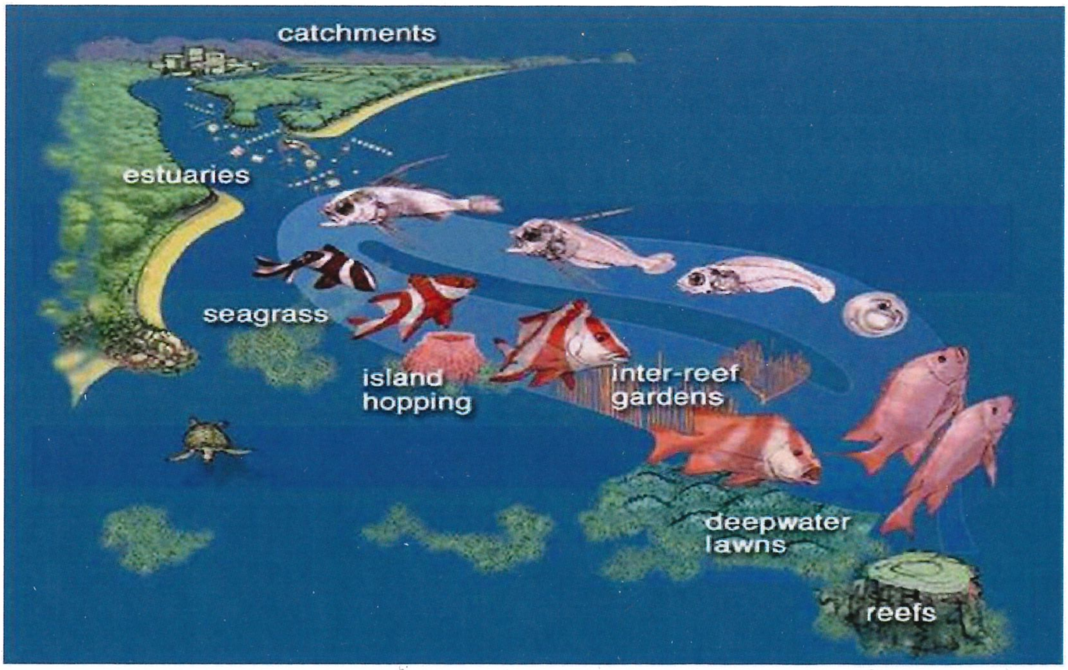
FISHERIES RESEARCH & DEVELOPMENT CORPORATION

revitalising Great Barrier Reef estuaries and coastal wetlands

the business case for repairing Great Barrier Reef coastal ecosystems; and improving fisheries, production, water quality, catchment hydrology, coastal biodiversity, flood control, carbon sequestration and foreshore buffering



Healthy fish stocks = a healthy reef

Estuary dependence and reef health – over 75 % of the commercial fish catch and probably 90% of all recreational catch spends part of its life cycle within estuaries and inshore wetlands

A more productive Great Barrier Reef

This proposal aims to increase fisheries productivity, improve coastal water quality, enhance catchment hydrology, repair coastal biodiversity and flood control, and re-establish carbon sequestration and foreshore buffering.

The business case sets out the rationale and the priority opportunities for investment, to repair and restore, under a 'no regrets' policy, estuary and inshore wetland areas. It seeks to maximise community benefits from these important parts of our landscape while minimising costs and impacts upon adjacent land users of the coastal zone.

It builds upon the excellent cooperation and commitment across the Great Barrier Reef community in implementing major initiatives such as Reef Rescue. It proposes a five-year government investment that will repair key assets for maximum public benefit. Equally importantly, this investment will identify how best to ensure overall benefits can be incentivised into the future, empowering industry groups, private landholders, local governments and regional natural resource management groups to continue the repair of coastal assets and their management.

Acknowledgements

This proposal was funded through the Fisheries Research and Development Corporation working in partnership with the Australian Government Biodiversity Fund. Support and advice was received from the Great Barrier Reef Marine Park Authority; natural resources management groups; fishers, professional, recreational and indigenous; conservation groups; researchers and the Great Barrier Reef catchment community.

Colin Creighton, February 2013

A commitment to Great Barrier Reef coastal ecosystem recovery

- The Great Barrier Reef is more than the coral reefs – seagrasses, mangroves, salt marshes and brackish to freshwater wetlands are essential parts of the reef.
  Example: Coral trout spends its nursery phase within nearshore and estuarine environments. Without a healthy nursery there will be fewer adult fish with flow on implications to coral ecosystems, commercial and recreational fishing, diving and snorkelling experiences.
- Many of those that enjoy the Great Barrier Reef do so through their activities in the coastal zone – fishing, recreating, bird watching or just relaxing.
  Example: Much of the life history of the Mangrove Jack is played out in the estuary.
- Indigenous use of the Great Barrier Reef is focused inshore.
  Example: Seagrass ecosystems and their dugong and turtle populations
- There have been many unforseen impacts of floodplain development. Works undertaken in the past occurred without our knowledge of the interlinked ecosystems.
  Examples of works: Wetland drainage, roadways and causeways restricting tidal flow, floodgates and bunds prohibiting fish passage, levees altering tidal and floodwater flow, ponded pastures isolating salt marshes from the estuaries
- With the knowledge we now have we can repair key elements of the Great Barrier Reef's estuarine and inshore ecosystems, optimising community returns from the coastal landscape
  Examples of benefits: increased fisheries production, increased coastal water quality, flood proofing; infrastructure improvements; improved biodiversity, more waterfowl and migratory waders; carbon sequestration

This business case sets out the rationale and the priority opportunities for investment, repairing under a 'no regrets' policy, estuary and wetland areas across the Great Barrier Reef. It seeks to maximise community benefits from these important parts of our landscape while minimising costs and impacts on adjacent land users of the coastal zone.

It is built on cooperation across the Great Barrier Reef community and its many stakeholders and seeks co-investment from all tiers of government and the community.

CONTENTS

CHAPTER 1 The case for action

1.1 Great Barrier Reef coastal ecosystems and assets

The Great Barrier Reef ecosystem is made up of many complex components, all linked by water – fresh to brackish to estuarine tidal and marine. Key to overall reef productivity are the estuarine and nearshore ecosystems – mangroves, seagrasses, salt marshes, fresh to brackish wetlands and inshore coral reefs. These are closely linked to catchment terrestrial ecosystems with one-way flows and fluxes of nutrients and sediments from the terrestrial ecosystems to the estuarine and nearshore ecosystems.

Most importantly, the estuarine and nearshore ecosystems are closely linked to the reef and there are two-way flows and fluxes of nutrients, sediments and biota between these coastal ecosystems and the ecosystems of the reef proper. Much of the net primary productivity of the reef is driven by the health and productivity of the estuarine and nearshore ecosystems. These estuarine and inshore systems are the ones that have suffered the most degradation to date and are most at risk from further development pressures.

Changes to estuarine and nearshore 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. Researchers have concluded that these changes are a direct result of changes to water quality following large-scale vegetation clearing on the adjacent coast. The substantial sediment plumes that accompanied land development smothered many seagrass beds, silted up estuaries and overall started the changes in estuarine hydrology and net primary productivity that have accompanied further development of the terrestrial landscapes.

One of the main reasons many fish and crustacean species are particularly vulnerable and that their biomass has declined is that their life history traits and behaviours include a dependence on estuarine and nearshore ecosystems – the Great Barrier Reef ecosystems that have been most degraded by our activities since settlement of the Great Barrier Reef catchments. Case studies (see Figures 1 and 2) illustrate this dependence for Mangrove Jack and Barramundi.

Many other species have relatively long lives with a reliance on a small home range. This is a trait exhibited by dugongs and the recently described Australian Snub Fin 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. Genetic analysis of Barramundi has also demonstrated that there appear to be discrete sub-populations. These localised inshore populations are particularly susceptible to cumulative impacts associated with declining water quality, coastal development and overall estuarine and nearshore ecosystem degradation.

For other species such as Coral Trout, research is suggesting a somewhat homogeneous population across its range. Samples taken from near Lizard Island and from the Swains

Reefs have demonstrated similar genetic traits and similar responses to stress such as changing ocean temperature. Vulnerability in this case is the condition of all estuarine and nearshore habitats along the Great Barrier Reef lagoon (e.g. Coral Trout in the juvenile phase are dependent on estuarine and nearshore ecosystems).

1.2 Estuarine and inshore ecosystem condition

There has been substantial loss of estuarine wetlands accompanying catchment development for agriculture, infrastructure and urban uses.

Fresh to brackish wetlands have been the most impacted, mainly from the drainage due to agriculture and grazing development. In excess of 80% of this wetland type has been lost, especially in the Wet Tropics and Mackay Whitsunday.

Case study: Barramundi *(Lates calcarifer)* and the Great Barrier Reef catchment

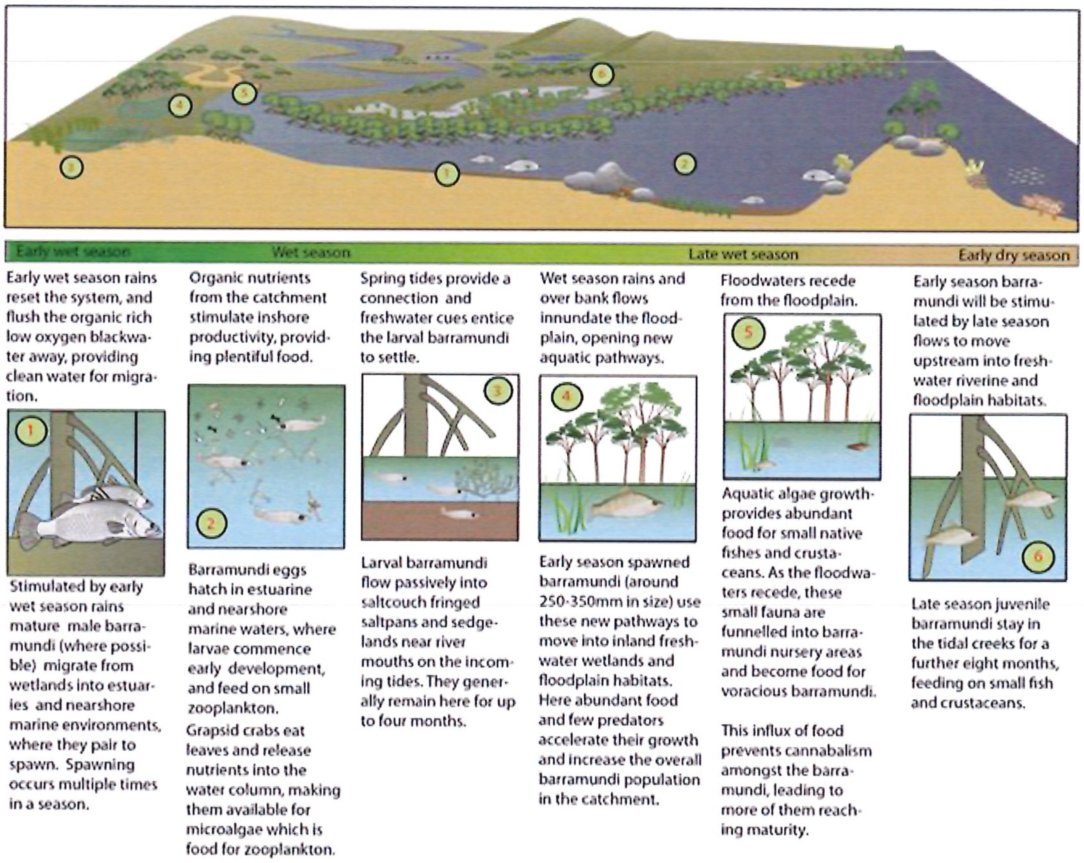


Figure 1: Case study of Barramundi and the Great Barrier Reef catchment.

Salt marshes have been impacted by drainage, especially by ponded pastures and cattle trampling. This is particularly prevalent in the drier more extensive floodplains. The top five basins with extensive areas of salt marsh/mangrove complex are:

- Shoalwater – 527 km^2 or 12% of Great Barrier Reef estuarine wetlands – with many areas outside the Shoalwater Defence Lands altered by ponded pastures
- Styx – 356 km^2 or 8% of Great Barrier Reef estuarine wetlands – with very extensive areas of ponded pastures

- Fitzroy – 332 km^2 or 8% of Great Barrier Reef estuarine wetlands – with very extensive areas of ponded pastures
- Haughton – 318 km^2 or 8% of Great Barrier Reef estuarine wetlands – with very extensive areas of ponded pastures and bunded off estuarine creeks
- Normanby – 335 km^2 or 8% of Great Barrier Reef estuarine wetlands – with the vast majority in excellent condition by virtue of very limited agriculture and grazing development.

Seagrasses have reduced in extent with the major cause of losses being increased water turbidity.

The wetland type that has suffered the least is the mangrove ecosystem. Overall there has been in areal extent terms very limited loss of mangroves. Most of the catchments with their increased bed load of sediments have favoured mangrove colonisation of sand spits. Mangroves have however lost much of their net primary productivity due to reductions in tidal flows due to causeways, road and rail, sedimentation and overall reduction in the extent of estuarine areas, especially levees and bunds isolating small creeks.

Riparian vegetation has often been removed from creeks and streams, both freshwater and within the tidal zones, especially in the upper tidal to brackish zones. This alteration extends throughout all the developed Great Barrier Reef catchments and has been the subject of various repair projects in the past, especially by Landcare groups, individual landholders and the previous river improvement trusts. Reef Rescue I has also had substantial impact, especially in grazing landscapes. Generally just fencing off riparian lands to restrict cattle access and facilitate natural regeneration is all that is required to re-establish riparian vegetation. It is anticipated that Reef Rescue II will continue the work with the grazing industry to rationalise cattle access and improve riparian condition. Riparian repair is included within this initiative where it directly supports estuarine and freshwater wetlands that benefit the Great Barrier Reef ecosystem.

Loss of connectivity and fish passage is the other key area of degradation of estuarine and nearshore ecosystems. As an example, there are over 1500 barriers or bunds across previously tidal creeks just in the Burdekin floodplain. Great Barrier Reef Marine Park Authority has a detailed mapping dataset for the entire Great Barrier Reef region identifying most of these barriers. All the developed catchments have lost connectivity in both major rivers and in many second and third order streams and estuarine embayments/creeks.

A second example of the extent of barriers is the audit of the wet tropics region by Tina Lawson, Frederieke Kroon, John Russell and Paul Thuesen, 2010. The table summarises their findings, well over 5500 barriers inventoried in the wet tropics region.

Table 1: Total number of potential artificial, physical barriers and total stream length in each of the Wet Tropics basins (after Lawson et al.).

Basin	Number of barriers	Total stream length (km)
Barron	837	2 332
Daintree	377	2 198
Endeavour	34	81
Herbert	867	7 245
Johnstone	1 069	2 384
Mossman	233	470
Mulgrave–Russell	1 076	2 041
Murray	309	1 218
Tully	734	1 795
Total	**5 536**	**19 764**

Based on the authors' selection criteria for importance of the barriers to the instream ecology and productivity of these drainage basins they recommended 104 barriers as high priority for rehabilitation, 1476 as medium and 3957 as low priority. The Daintree basin has the highest number of high priority potential barriers (32), followed by the Mossman (19) and the Mulgrave–Russell (17), while the Barron has the lowest number (2). The largest basin in the Wet Tropics, the Herbert, has 10 high priority potential barriers within its extents.

The life cycle of Barramundi shows the importance of the total set of estuarine and nearshore ecosystems and their relationship to the life cycle of a key commercial and recreational target fish species. Barramundi exploit the range of estuarine and nearshore ecosystems at different times of the year and as their lifecycle progresses. (see Figure 1).

Other well-known examples of these lifecycle–ecosystem relationships are Red Emperor and Coral Trouts – with their juvenile phase in estuarine and nearshore ecosystems, Mangrove Jack (see Figure 2) and all species of prawns. Tiger Prawns especially exploit inshore and nearshore seagrass habitats with Banana Prawns predominating in estuarine, mangrove and salt marsh through to brackish wetland ecosystems.

Some 75% of the commercial fish and crustacean catch have lifecycles dependent on estuarine and nearshore ecosystems. For the recreational catch, by virtue of most of the effort being inshore the proportion of catch that is estuarine-dependent is probably closer to 90%.

For the Great Barrier Reef catchments, floodplain estuarine and nearshore ecosystem connectivity and function has been affected by multiple, small-scale activities. For example, bunds have been placed in many estuarine ecosystems to minimise tidal influence with the objective of fostering the extension of intensive agriculture or to provide grazing additional areas such as ponded pastures. In many cases this extension of agricultural pursuits has not occurred, the soils being unsuitable, often gleyed clays that remain waterlogged and with high salt loads.

The impact of these actions is often not immediately apparent, especially on a case-by-case basis, but when considered cumulatively the repercussions for overall productivity of the coastal and Great Barrier Reef as a system are substantial. Loss of ecosystems and function, declines in water quality, exposed acid sulphate soils, weed invasion and decline in natural net primary productivity and biodiversity all imply loss of ecological health and most importantly public benefit from these assets.

Case study: Mangrove Jack *(Lutjanus argentimaculatus)* and the Great Barrier Reef catchment

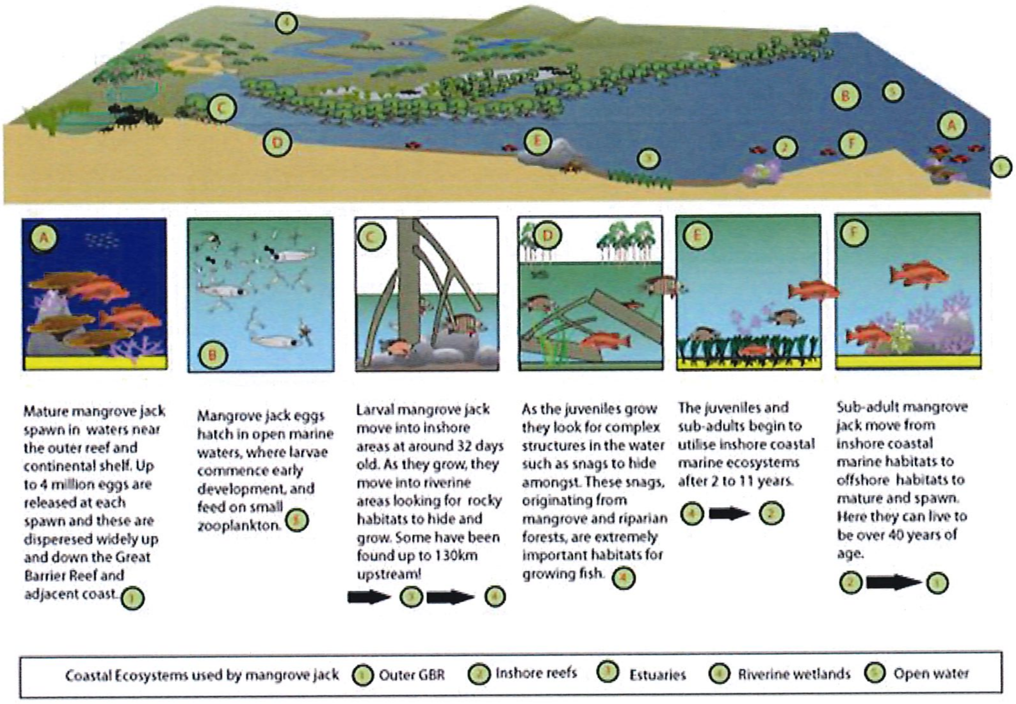


Figure 2: Case study of Mangrove Jack and the Great Barrier Reef catchment.

1.3 The gap in Great Barrier Reef ecosystem repair

1. Reef Rescue I is repairing agricultural landscapes – reducing erosion, improving water re-use and water use efficiency and most importantly, reducing nutrient and chemical export from paddocks. Reef Rescue II is expected to continue this excellent work.
2. Zoning plans have ensured a sustainable mix of use and conservation zones for such as commercial and recreational fishing and tourism in the reef proper.
3. Reduction in commercial fishing effort, both prawn trawl and inshore net plus devices such as TEDs (turtle excluder device) plus closures in some inshore areas to protect high value species such as dugong have ensured sustainable fishing effort and minimised to virtually nil the impact on charismatic megafauna such as turtles and dugong.
4. Use of permits and codes of behaviour have ensured minimal and then only local impact from tourism and reef visitations

BUT

Estuarine and inshore ecosystems, a large part of the integrated Great Barrier Reef ecosystem, have not had a commensurate effort in improved management, especially recognising that they are the most degraded of all the reef ecosystems

1.4 Spring-boarding from existing community and government partnerships

All the essential elements are in place to effectively implement a major repair initiative that will revitalise the Great Barrier Reef estuarine and nearshore ecosystems and thereby ensure increased resilience and productivity for the reef in total. Key elements include:

- natural resource management groups have built capacity to design, negotiate and then undertake repair works in partnership with landholders such as providing watering points and managing stock access to riparian areas and salt marshes and constructing fishways.
- local governments recognise the importance of the reef and have capacity in engineering works such as road culverts to improve tidal ventilation and levee rationalisation for improved flood control and fish passage.
- Water supply authorities such as water boards and Sunwater have participated in repairing fish passage and are keen to seek further efficiencies in water delivery, use, re-use and quality.
- Fishing non-government organisations of Sunfish and the Queensland Seafood Industry Association in partnership with the Queensland Government have participated in estuary repair projects such as fish passage works and are especially proficient at monitoring the improvements in biodiversity that accompany repair works.
- Local marine advisory committees and Great Barrier Reef-wide advisory committees are well linked into their communities such as identifying priorities for action.
- Researchers within James Cook University including previous Fisheries staff ex Queensland Government such as the Seagrass Unit have internationally recognised skills in both research and monitoring of coastal ecosystems.
- Queensland and Australian governments in partnership have developed and coordinated delivery of actions and activities to Reef Plan I and II and are in the processes of preparing the strategic overview for reef repair and management as part of Reef Plan III.

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

The Great Barrier Reef catchment is a complex jurisdictional environment and the arrangements applying to coastal zone management are often unclear. Collaborative arrangements established under an inter-governmental agreement for the management of the Great Barrier Reef and their catchments ensure an integrated and collaborative approach by the two governments to the management of marine and land environments within and adjacent to the Great Barrier Reef World Heritage Area. This agreement provides for:

- long-term protection and conservation of the environment and biodiversity of the Great Barrier Reef ecosystem, as encompassed by the Great Barrier Reef World Heritage Area, and its transmission in good condition to future generations
- allowing ecologically sustainable use of the Great Barrier Reef ecosystem subject to the overarching objective of long-term protection and conservation
- Australia's international responsibilities for the Great Barrier Reef World Heritage Area under the World Heritage Convention.

Economic growth and the long-term health of the Great Barrier Reef ecosystem are interconnected; actions or changes in one can impact on the other and must be taken into account, in particular:

- population growth and economic development increases the demand for resource and recreational use of the Great Barrier Reef
- land-use activities in the catchment can have adverse impacts on the quality and quantity of water entering the Great Barrier Reef
- initiatives to reduce external pressures on the ecosystem can have regional and local social and economic effects, and improve the long-term viability of the region.

> Development will continue. Even with the best of planning and controls, some localised degradation will have to occur to allow rational development to meet the communities' many economic and social objectives. Investment in repair provides a much needed buffer to any localised losses that will accompany development such as port works.

Implementation of this business case for estuarine and nearshore ecosystem repair will be achieved through cooperation across the Great Barrier Reef community and its many stakeholders, seeking co-investment from all tiers of government and the community. Involvement with stakeholders will need to be coordinated to maximise efficiency and consistency, reduce duplication, and will demonstrate the willingness of the community to adopt a collaborative and solutions-oriented approach.

It is through these groups and their activities that significant on-ground repair to these critical public assets can be implemented and changes of attitudes and behaviours achieved to ensure their long-term protective management. As in all investments, the challenge is to ensure the resources available are targeted at the most critical areas for improved long-term community benefits. This business case sets out the protocols and processes to facilitate maximum return on investment.

The investment will also identify how overall benefits can be incentivised into the future, empowering industry groups, private landholders, local governments and regional natural resource management groups to continue to manage the repaired assets that a five-year Australian Government investment delivers.

1.5 Repair opportunities

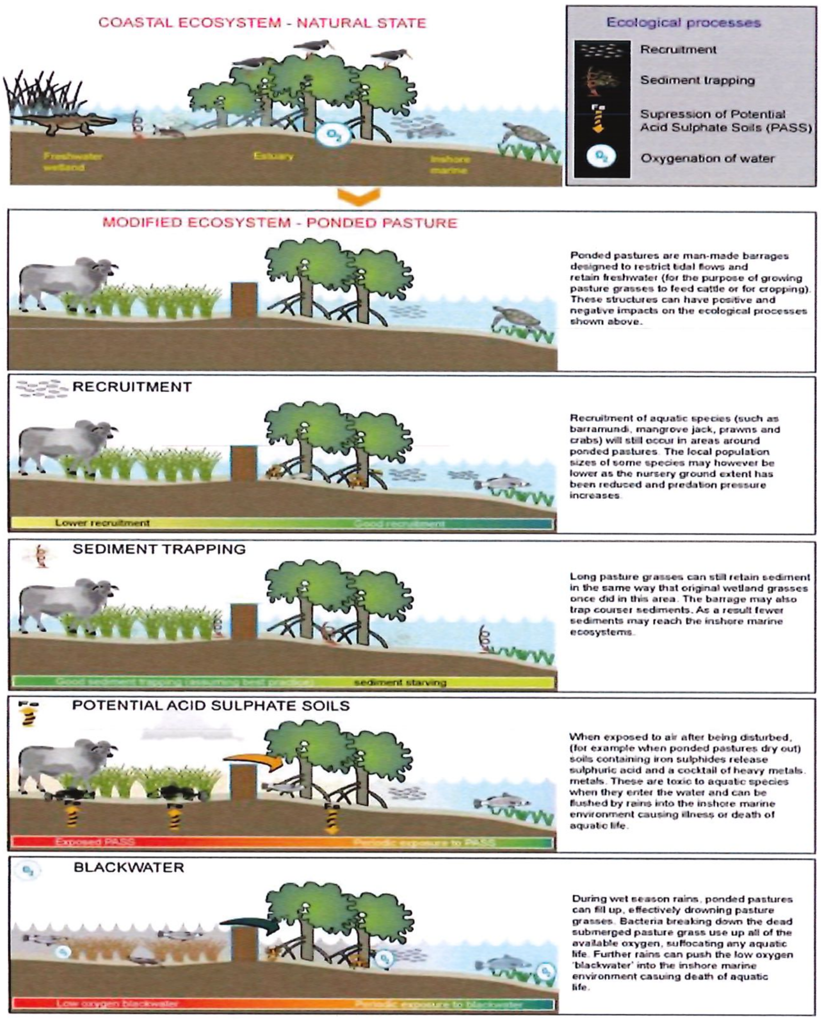
Following is summary illustrative information on the various opportunities for repair.

1.5.1 Ponded pastures

Ponded pastures predominate in the drier more extensive catchments and were constructed initially as an attempt to improve cattle grazing carrying capacity. Pasture species such as hymenachne and parra grass, now considered to be major weeds, were introduced based on the work of the then CSIRO Division of Tropical Crops and Pastures and its somewhat mistaken vision of introducing novel pasture species to tropical Australia.

Many of the works are unauthorised, some are on private lands and many are on public lands and cut off named watercourses. From a food security perspective these areas are far more productive as a basis for fisheries production (e.g. Banana Prawns) than they are for beef meat production.

All works to repair salt marsh and mangrove complexes in these areas will need to be carefully designed and agreed to by adjacent landholders. Incentives for fencing and the installation of watering points will be required in some cases.



1.5.2 Bunds and weirs

Many weirs were constructed to provide weir pools for irrigation water and occasionally urban drinking water (e.g. Clearview). In many cases irrigation either did not proceed or the weir pool is now surplus to requirements with the development of regional irrigation water supply infrastructure or reticulated urban water supply. These are particularly prevalent in the Mackay Whitsunday region and to a lesser extent the Wet Tropics. Most are instream, and can either be fully demolished as no longer needed or, because they are of relatively low height profile, modified to include fish passage. Generally because they are constructed within stream they are wholly on public lands, usually reserved bed and banks for named watercourses. Reinstatement of fish passage will ensure the upper stream areas are available for such as Barramundi and Banana Prawns.

Bunds are generally rock/earth mixes, sometimes just bulldozed up earth. Many bunds were constructed below the tidal limit to exclude tidal waters and were constructed to facilitate agricultural expansion and irrigation development, excluding tidal water from its previous extent along the fringes of floodplains. The bunds may go from freehold or sometimes public land on the banks across public tidal beds of the estuarine creeks and to freehold or public land on the other bank. The vast majority are unauthorised. Commonly in the Burdekin the previous tidal beds of the creeks behind the bunds now hold tail water dumped from irrigated agriculture and are often dominated by weeds such as Parra grass, hymenachnae and Typha spp. Generally there is either very limited or nil agricultural development, the soils being sodic and often gleyed clays that remain waterlogged and highly saline. In some cases such as the Haughton, grazing development may have occurred. Reinstatement of tidal creeks and channels will advantage juvenile fish species including Barramundi and Mangrove Jack, juvenile crustaceans including Mud Crabs, Banana and Tiger Prawns. Reinstatement will need to be carefully planned, including tidal surveys to determine the area of likely tidal influence, irrigation water management systems put in place to maximise tail water recycling, and deep holes excavated to ensure refuges for fish during low tide events.

1.5.3 Wetland drainage, floodgates and levees

These often complex systems of constructed drains, floodgates and levees are predominantly in the Wet Tropics region and to a lesser extent in Mackay Whitsunday. Initial objectives were to drain large areas of wetland to provide increased area for agricultural development and rapid shedding of floodwaters from cropping lands. Floodgates are employed to stop floodwaters from the main river flowing back up into the drained wetland system. Levees are upstream and were designed to divert overland flow away from agricultural lands – but often these levees simply diverted the issue onto a neighbour's farm.

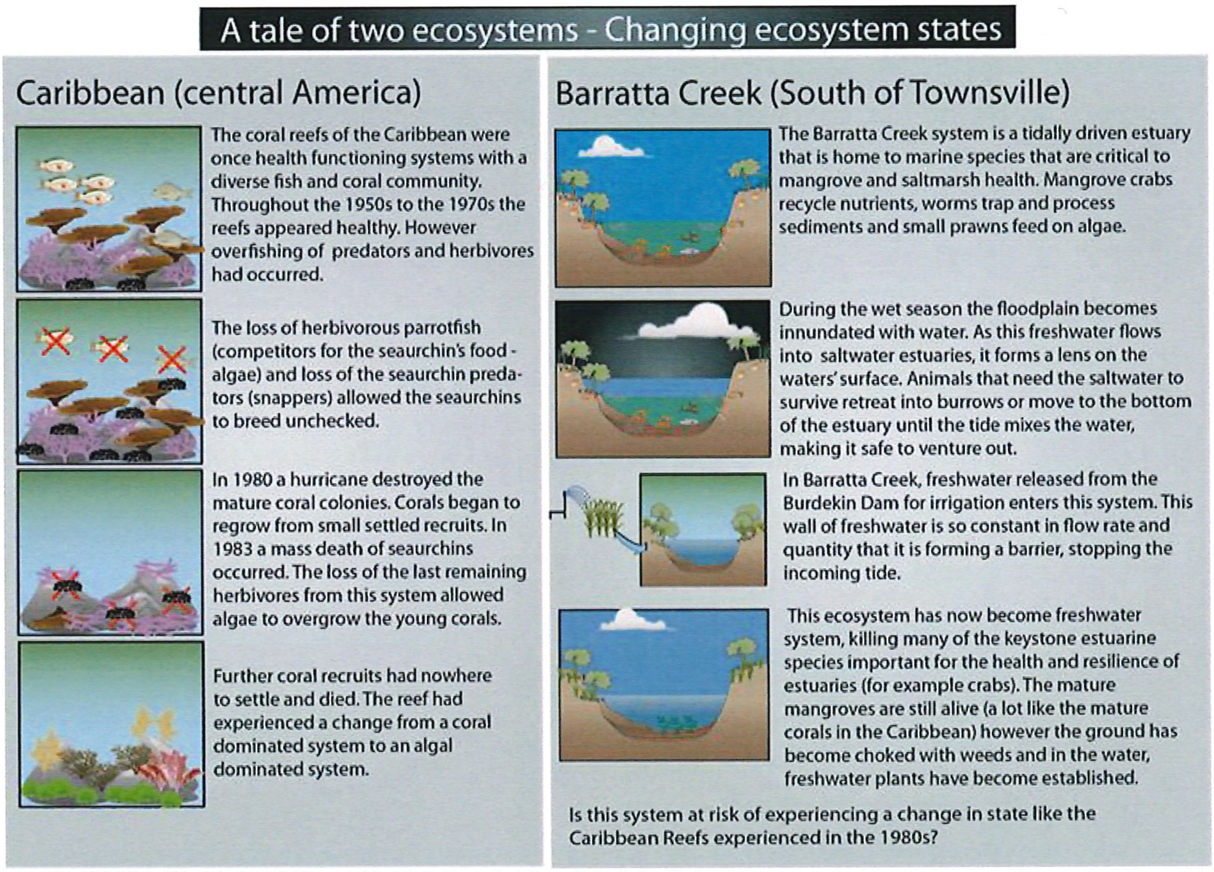
The lower areas of these wetlands are peaty soils that remain unsuitable for agriculture, are often slumping due to drainage and typically overly acid sulphate soils. Runoff events lead to anoxic, highly acidic water entering the estuary proper from these drained areas, often causing fish kills. Many of the upper better drained and less waterlogged soil areas of these systems have been developed for agriculture, especially sugar cane. Some of the drainage works and barrages were authorised; many are not. Likewise many of the levees are somewhat ad hoc.

Reinstatement of the lower bottom wetland areas of these various drainage schemes together with automatic control systems on floodgates will markedly improve water quality, allow fish passage to favour such as Barramundi and Banana Prawns and if done strategically in cooperation with surrounding landholders will also benefit the upstream agriculture.

1.5.4 Changed hydrology, especially excessive tail water

This is a Burdekin-specific issue, usually associated with bunding off of previously tidal creeks or the use of tidal waterways such as the Barratta Creek ecosystems as drains. Tail water is yet to be recognised as a resource and re-use systems implemented across the Burdekin for the benefit of agriculture and water quality improvement. Nutrients dissolved within the tail water are lost from the agricultural system and dumped into the remaining estuarine areas.

A whole-of-floodplain water management system for the dual objectives of agriculture profitability and fisheries productivity is required. This will take substantial planning and cooperation across the community, water boards and agencies. This is complex and will take substantial planning and consultation. At most this business case recommends that a project might selectively target a locality and then in cooperation with landholders and the water boards demonstrate how an improved water management system might be implemented for the benefit of both agriculture and fisheries. Strong links and co-funding with Reef Rescue II would be required for such a project.



1.5.5 Infrastructure redesign

Infrastructure such as road and rail has generally been developed and improved over time as the Great Barrier Reef catchments have developed. In many cases neither flood or tide and fish passage requirements were factored into the design of infrastructure crossing waterways.

Lack of incorporation of flood behaviour in design has lead to roads and rail damming up and slowing down floodwater run-off (e.g. Tully Murray and Bruce Highway) and some cases has lead to costly repair works.

Tidal flows were generally of secondary priority to the design requirements of constructing the crossing at minimal cost. Further, even if cost was not an over-riding consideration, many causeways, culverts and crossings were constructed without understanding the importance of tidal flows as a driver of fisheries productivity. Areas such as the Lucinda causeway reduce the productivity driving tidal flow into the mangroves upstream of the causeway, disadvantaging many species such as Mangrove Jack, Mud Crabs, Tiger and Banana Prawns.

Likewise, even if crossings were deliberately designed with connectivity in mind, often there was limited knowledge of the fish passage needs of juvenile fish species. Fingerlings generally cannot swim against high velocity flows. A culvert that restricts the area for water flow will lead to higher velocity flows than that which a fingerling can swim against. Many secondary roads crossing wetland areas, while they have culverts built into their design, do not have sufficient width of culvert to facilitate low velocity flood flows and therefore flows that fingerlings can swim against to re-populate the wetland areas as part of their nursery phase.

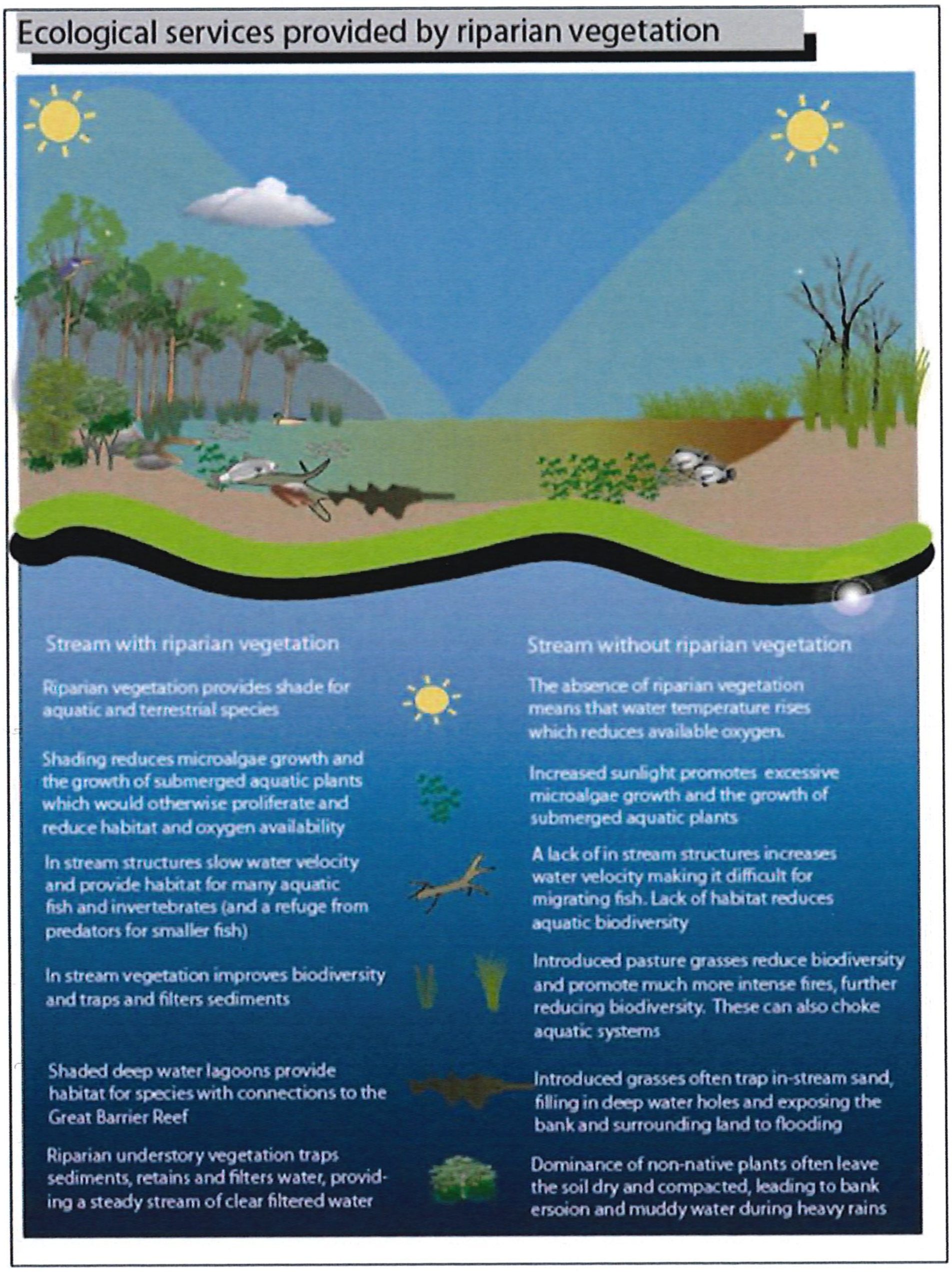
Reinstatement of tidal flows and slowing the velocity of flood flows out of wetlands can be easily achieved through the addition of extra road and rail culverts. Generally adding more culverts will also be of advantage to the infrastructure by improving flood proofing and reducing the likelihood of high water tables thereby minimising potholing.

1.5.6 Riparian landscapes

Research by Tim Marsden in the Mackay Whitsunday has shown that both water quality and habitat structure are important for tropical fish species. The most bio-diverse and highest biomass river/creek systems were those with both high water quality and intact riparian areas.

Reef Rescue I and presumably Reef Rescue II will include incentives to reduce cattle access to watercourses. Fencing off is generally all that is required to initiate natural revegetation of riparian areas. The improvement of riparian areas as part of more sustainable grazing and agricultural practices remains the remit of Reef Rescue and is beyond the scope of this business case.

Nevertheless there are likely to be specific riparian re-vegetation initiatives within the remit of this business case – the criteria for inclusion being that the works are of direct benefit to the Great Barrier Reef coastal ecosystems of estuaries and inshore wetlands.



CHAPTER 2 Goals and objectives

Our goals are to:

- ✓ increase, through repair works, the quality and quantity of estuarine and coastal inshore wetland habitats that support a broad diversity of fish, prawns and other coastal species for the benefit of the Great Barrier Reef community – indigenous, fishers, farmers, urban and industry stakeholders
- ✓ reverse declines in the quality and quantity of estuarine and inshore coastal wetland habitats and water quality to improve the overall health and resilience of the Great Barrier Reef ecological system
- ✓ implement stewardship arrangements and incentive systems that will provide an ongoing legacy of improved management for Great Barrier Reef estuarine and inshore coastal wetland habitats

To implement these goals there are five interlinked objectives.

Objective 1: targeted habitat repair and increased productivity

Objective: Achieve measurable habitat repair and increased productivity by re-connecting fish passage thereby restoring tidal and freshwater processes and re-creating estuary and inshore coastal wetland habitats.

The focus will be on re-establishing habitat exploited by Barramundi, Mangrove Jack and prawn species. This builds on our detailed knowledge of the habitat requirements from freshwater through to marine required by these species. The assumption is that if we re-create the nursery and juvenile habitats for this group of species then it will be an excellent surrogate for all aspects of improving estuarine and inshore coastal wetland productivity.

Assessment of progress in achieving the objective will include reporting against the physical targets set for this objective and the monitoring and modelling of population changes – Barramundi, Mangrove Jack and prawns in selected case study areas.

<u>Outcome</u>

- More productive coastal ecosystems for the benefit of the Great Barrier Reef community – indigenous, fishers, farmers, urban and industry stakeholders.

<u>Targets</u>

- Modify or remove more than 150 constructed barriers to fish passage to enable fish passage and tidal flow estuarine area to estuarine area, estuarine area to coastal wetland, or estuarine area to freshwater creek and wetlands
- Reconnect more than 800 km of estuarine creeks and freshwater rivers and creeks to existing Great Barrier Reef estuarine areas

Objective 2: Improvements in Great Barrier Reef ecological condition

Objective: Achieve measurable improvements in Great Barrier Reef ecological condition by repairing and re-connecting inshore coastal wetlands and their ecological productivity.

The focus will be on re-configuring drains, levees, bunds and floodgates to re-establish floodplain habitats of swamps and billabongs. These are areas that:

- are otherwise not productive for agriculture, usually some rough grazing if any agriculture at all
- often have freshwater weed problems
- may be subsiding due to the nature of their peaty soils and drainage
- export highly acidic water because of their underlying acid sulphate soils after rain events and
- emit methane in well above natural levels, contributing to greenhouse gas pollution.

If we re-create the wetland function of these areas, it is assumed that there will be reductions in deleterious exports of acid water and methane and improvements in their performance as sinks for nutrients and sediments, as producers of biomass and thence carbon sequestration to their soils and as contributors to overall Great Barrier Reef ecology, including contributing to the freshwater and estuarine food chains.

Assessment of progress in achieving the objective will include reporting against the physical targets set for this objective and the monitoring and modelling of key water quality indicators such as pH in selected case study areas. Subject to 'blue carbon' becoming part of Australia's National Carbon Accounts, selected areas would also be used as reference sites to measure and calibrate tropical carbon sequestration.

Outcome

- Improved overall ecological condition for these key components of the Great Barrier Reef system as part of increasing the resilience of the system to shocks such as extreme cyclonic events and floods.

Targets

- Reconfigure more than 5000 ha of fresh to brackish wetlands and accompanying waterways – including such as wetland natural drainage patterns re-established, levees rationalised, re-connections to freshwater and estuarine ecosystems repaired and biomass productivity returned towards natural levels.
- Return more than 5000 ha of salt marsh previously lost to ponded pastures developments to normal estuarine function, including improving adjacent grazing land management activities, watering points and fencing.

Objective 3: Community commitment to estuary and coastal wetland management

Objective: Broaden the community of support and commitment to estuary and coastal wetland management, empowering local ownership, investment and management.

Government leadership and investment in partnership with the community and its organisations can initiate the change and provide the resources for the high costs of repairing what in hindsight were inappropriate works and structures in the Great Barrier Reef floodplains. In most cases, once repaired and natural processes of tidal flow re-established, management activities and costs will be minimal. Nevertheless maintaining and managing these assets once repaired still requires local commitment and action.

Management systems will be required that incentivise the benefits locally, empowering such as local government and industry groups to continue the work that government investment initiates. This includes recreational fishers gaining access to reaches and improved fisheries, improved management of adjacent farms to the benefit of both the coastal ecosystem and the farmer, industry groups such as port authorities contributing as part of an offset to their developments, and commercial fishers undertaking ongoing monitoring and reporting under the guidance of protocols set for all of Great Barrier Reef reporting on trend and condition. Voluntary and formal carbon markets may also provide an opportunity. 'Blue carbon' is already endorsed as part of the USA voluntary market and the opportunity to include 'blue carbon' in Australia's National Carbon Accounts is being explored.

Outcome

- Great Barrier Reef estuaries and coastal wetlands managed locally and to a high standard in perpetuity

Targets

- Develop management plans detailing the ongoing activities and investment required and include them as part of the hand-over of each of the assets following their repair.
- Put in place formal partnerships to underpin this resourcing at a regional scale across State government agencies, local government, industry and community groups for each of the Great Barrier Reef regions – Burnett Mary, Fitzroy, Mackay Whitsunday, Dry Tropics, Wet Tropics and Cape York.

Note – these management plans will vary from the simple (e.g. a 'farm plan' for managing the interface between grazing lands and salt marshes) through to the complex (e.g. a plan for the entire Burdekin floodplain) working closely with the water boards, Sun Water and irrigators and fishers to reconfigure the irrigation scheme. This will involve changed water delivery, tail water recycling and removal of bunds to permit the repair of tidal wetlands.

Objective 4: Enhanced knowledge to efficiently and effectively repair and manage

Objective: Fill priority gaps in the knowledge required to efficiently and effectively repair and manage Great Barrier Reef estuaries and coastal wetlands

Knowledge of biomass production, whether from soil carbon, prawn, fish or key food chain components is scant and at most available only as specific case studies. Habitat preferences for the various life phases of fish and prawns are not well documented. Likewise the impact of changes in catchment hydrology, water chemistry and loss of tidal ventilation has not been quantified. Knowledge collected through research and monitoring will need to be structured around two key questions:

- What are the most cost-effective repair options and management activities for a particular asset? Case studies of asset types undertaken in the first two years of the proposed five-year investment will help inform all subsequent investments and will also build upon the lessons learnt from prior works such as the lower Burdekin Biodiversity Fund project and the Mackay Whitsunday Natural Heritage Trust and Caring for our Country projects.
- What are the benefits of repair? These need to be quantified sufficiently so that the return on investment is clear to all. This is especially important as part of the input into resourcing management activities as part of delivery to Objective 3 after the proposed five years of government investment.

<u>Outcome</u>

- Increased evidence of the comparative benefits and return on investment of various repair activities and management options

<u>Targets</u>

- By September 2014 the Great Barrier Reef estuary and inshore coastal wetland investment planning is complete focusing on key benefit areas of fisheries habitat, water quality, catchment hydrology, estuarine tidal hydrology, carbon sequestration and flood control. This investment planning will identify the highest priority repair investments for the remainder of the five-year investment period.
- By September 2018 the Great Barrier Reef estuary and inshore coastal wetland assessment is re-done, documenting the improvements in condition, the progress towards targets of Objectives 1 & 2 and including full detail of the various benefits attained from the investment to date. Most importantly this assessment will need to demonstrate the return on investment for those aspects central to community interest such as improved fish and prawn productivity.
- Over the period 2014–2018 companion research and development investment will be encouraged though government agencies such as Fisheries Research and Development Corporation, State agencies and universities and will provide much of the underpinning knowledge required on biomass production (e.g. soil carbon, prawn, fish, key food chain components), habitat preferences and the impact of changes in catchment hydrology, water chemistry and loss of tidal ventilation. This research will need to be designed so that research conducted locally can be projected out to provide implications for the entire Great Barrier Reef region.

Objective 5: Increased understanding and commitment

Objective: Utilise a range of communication techniques and media to foster increased understanding and commitment to estuary and coastal wetland repair across all sectors of the Great Barrier Reef community.

Repairing assets is challenging. Often the community will have become used to the previous alteration as part of the landscape – such as a weir or levee and even though it may not serve any useful purpose and may indeed degrade their local environment. To change what is in place requires a full understanding of opportunities and benefits foregone if the repair works are not undertaken. Indeed, social change and understanding is central to the success of this proposed investment.

Working within the Great Barrier Reef region also has its institutional challenges, there being multiple players and programs. For example, during Reef Rescue I many farmers became confused as to the differences between the Australian Government's incentive-based Reef Rescue initiative and the Queensland Government's regulatory approach. Confusion, suspicion, mixed messages and misunderstandings prevailed.

Communication of this initiative will need to remain focused on the benefits of repairing estuaries and inshore coastal wetlands while being structured to be fully cognisant and interact with all other communication activities underway within Great Barrier Reef catchments.

Outcome

- Strong community understanding and support for estuary and inshore coastal wetland repair and protective management.

Targets

- Estuary and coastal wetland condition, trends and repair become an integral part of Reef Plan III and its various communication activities over the implementation period for Reef Plan III. This initiative will provide the information, facts and figures required by Reef Plan III.
- By 2018 community support is very high, as gauged by the individuals, groups and industries stepping forward to participate in the longer term legacy activities of protective management.

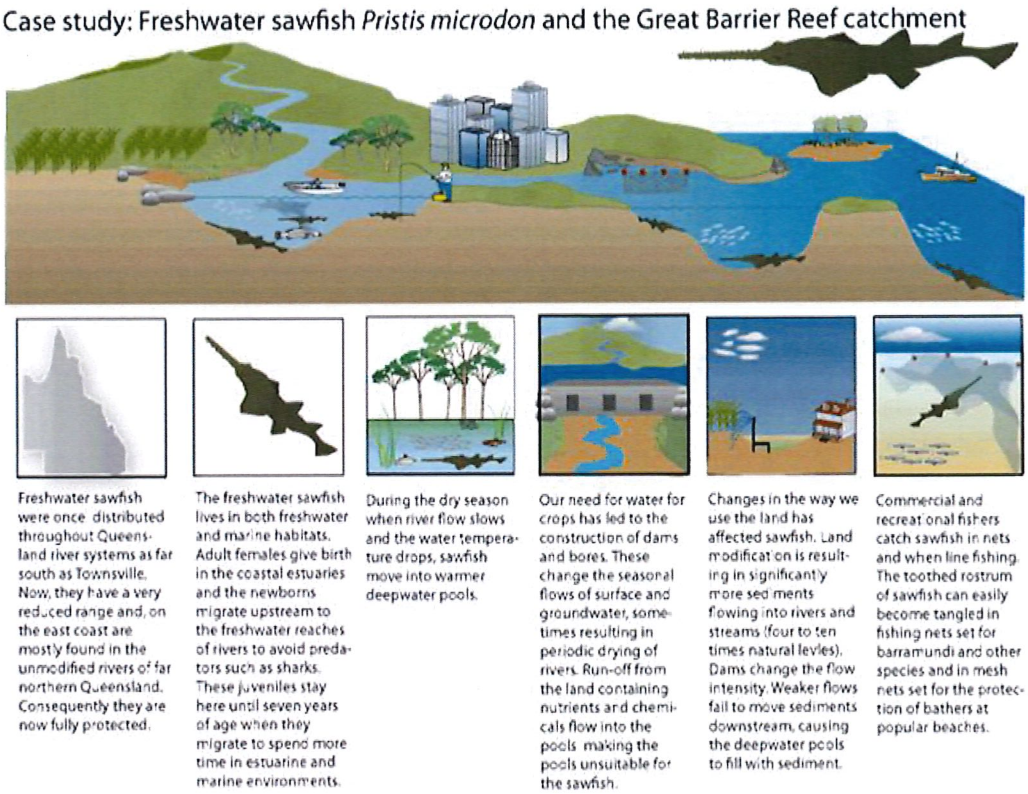


Figure 3: Case study of Freshwater Sawfish and the Great Barrier Reef catchment.

Cumulative pressures, especially changes to estuarine and nearshore ecosystems have affected the productivity of many species and caused extinctions. 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* (Cwlth). Most concerning of all, is that it is possible that the critically endangered Spear Tooth Shark, is now possibly extinct on the east coast of Australia. No individuals were found when recent surveys were undertaken to determine the east coast population of this species. The last verified specimen was recorded in 1983 from the Bizant River, which flows into Princess Charlotte Bay.

CHAPTER 3 Regional priorities

3.1 Burnett Mary

3.1.1 The region

The Burnett Mary Natural Resource Management region (Figure 4) covers an area of about 53 000 km^2. It extends south to the west of Fraser Island. Five basins – the Mary, Burrum, Kolan, Burnett and Baffle – flow into the Great Barrier Reef. The Burnett Mary region spans sub-tropical to temperate zones with rainfall occurring predominantly in summer. This region supports commercial fisheries with production valued at $7 million in 2001, making up 6% of the gross value production for fisheries in the Great Barrier Reef.

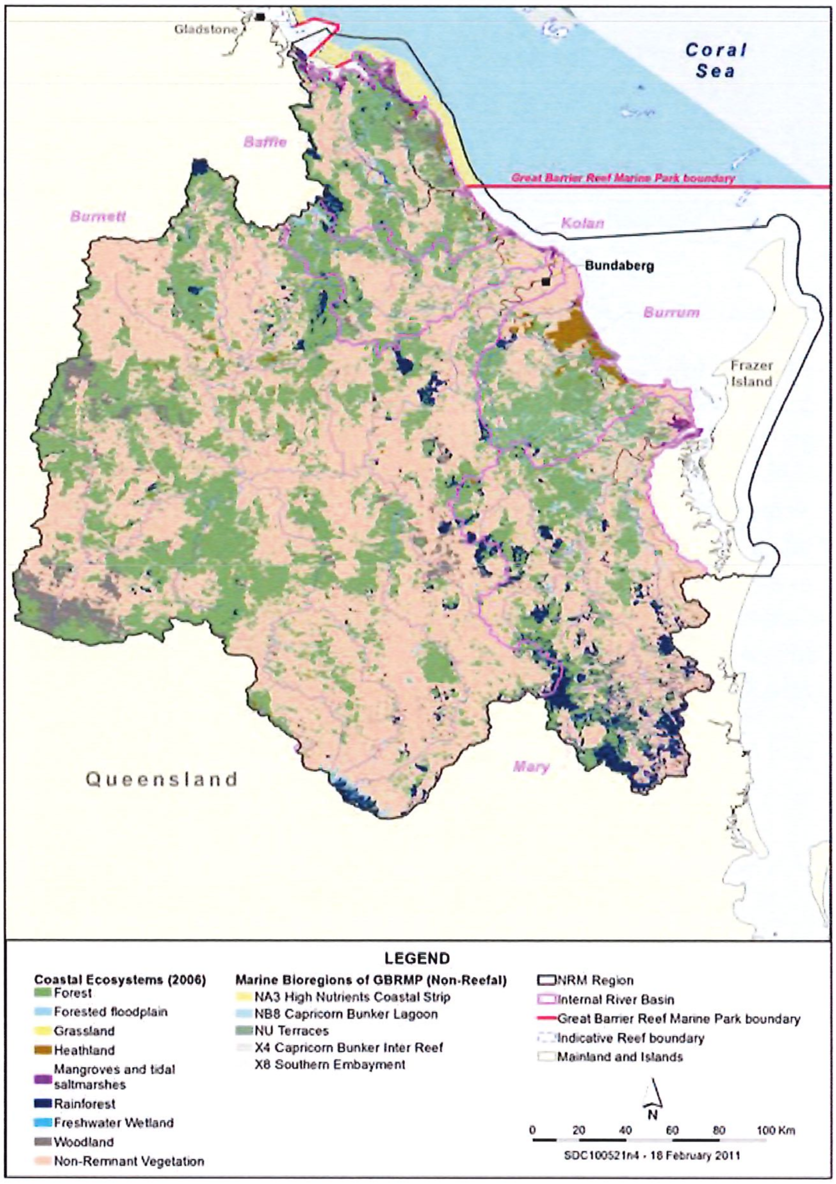
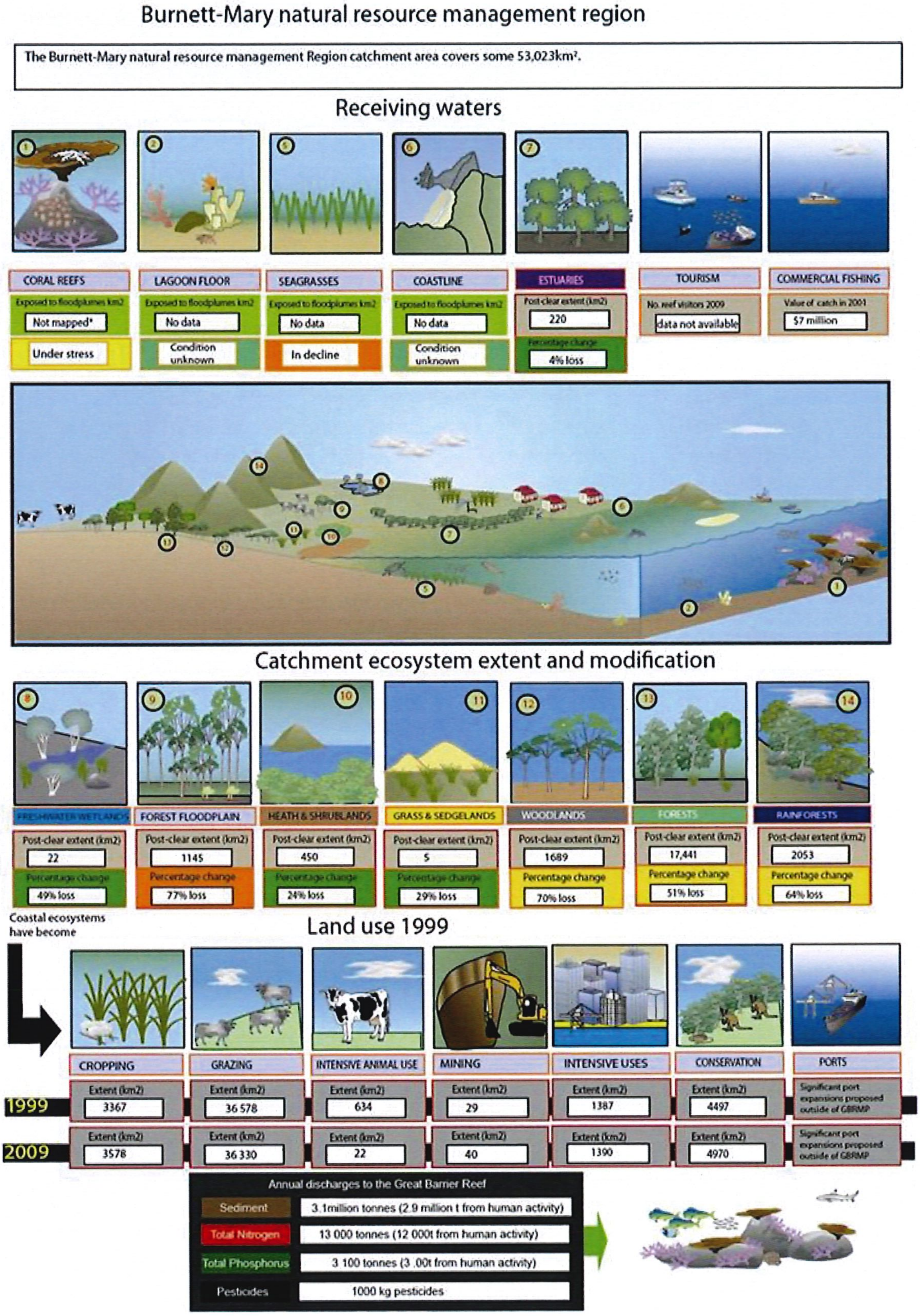


Figure 4: Burnett Mary natural resource management region coastal ecosystem and marine bioregions.

3.1.2 Current overview of condition



Overview of estuarine and inshore ecosystem condition for the region

As with all natural resource management regions, major alterations to waterways have accompanied development for agriculture, industrial and urban purposes. Nevertheless due to the nature of the waterways the level of disturbance is less than for other Great Barrier Reef regions.

Summary for the region's river basins

Baffle

About 24% of the waterway has limited to nil riparian vegetation. Connectivity is excellent with unimpeded access for most of the waterway. There is a causeway on Eurimbula and Littabella, a single barrage on Walsh Creek and small impoundments on Landsborough Creek.

Kolan

About 32% of the waterway has limited to nil riparian vegetation. Eighty-two percent of the freshwater reaches by area cannot be accessed by fish. The catchment has three major impoundments and altered hydrology due to these impoundments, all constructed for agricultural development. Kolan Barrage has a working fishway.

Burnett

About 45% of the waterway has limited to nil riparian vegetation. There are over 30 impoundments and structures impeding fish passage. Only 3% of the catchment is under nature conservation title and/or is of high quality natural habitat. There is some potential to reinstate tidal flow around Skyringville. Any works would need to be carefully designed to minimise impact on the port's infrastructure.

Burrum

Some 10 to 20% of the waterway has limited to nil riparian vegetation. Burrrum is the confluence of the Gregory, Isis, Burrum and Clarvell rivers, all with differing levels of disturbance. Gregory and the Isis river weirs are barriers to fish passage. Burrum river weir has a fish ladder but it is ineffective as there are two additional barriers immediately upstream.

3.2 Fitzroy

3.2.1 The region

The Fitzroy Natural Resource Management Region (Figure 5) covers an area of approximately 156 000 km^2. Six basins flow into the Great Barrier Reef – Boyne, Calliope, Fitzroy, Waterpark, Shoalwater and Styx. The region experiences variable rainfall with prolonged dry periods and high evaporation rates. As with other large dry tropical catchments, major floods occur on average once in every 10 years. In major flood events, plumes from the Fitzroy region basins have reached beyond the Keppel Islands and out to the Great Barrier Reef, such as the Swains Reefs. 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. This region also supports significant commercial fisheries. In 2001, it was valued at $17 million, making up 15% of gross value production for fisheries in the Great Barrier Reef.

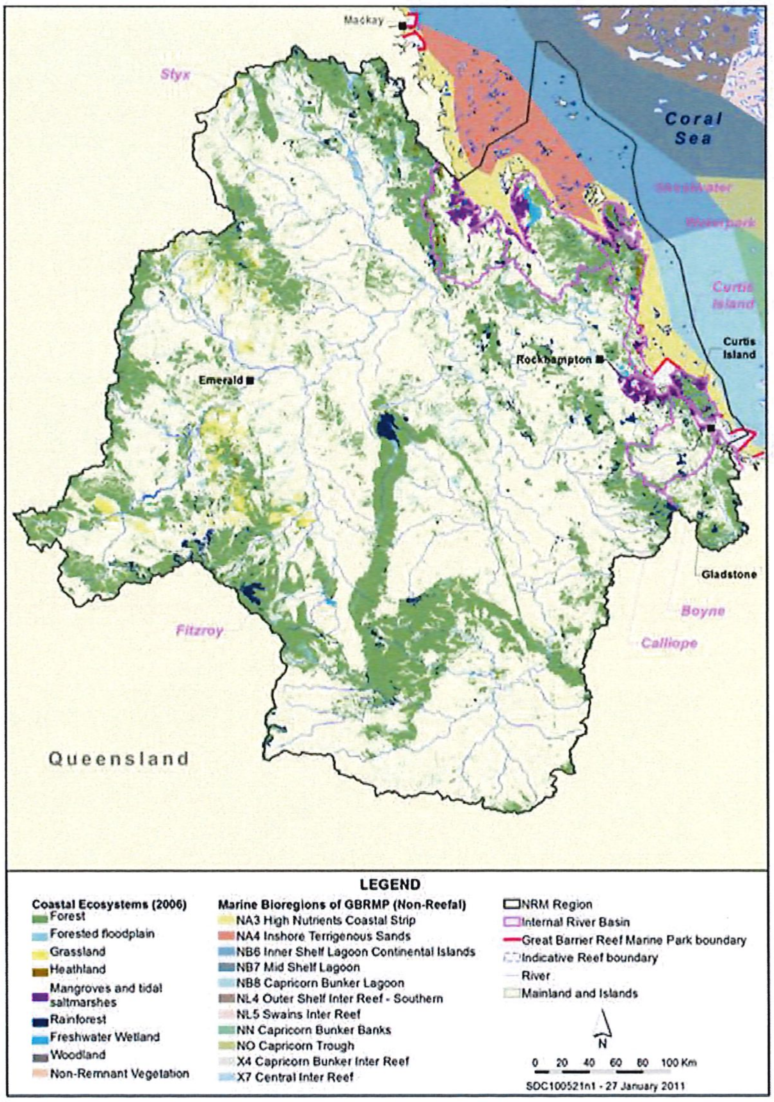
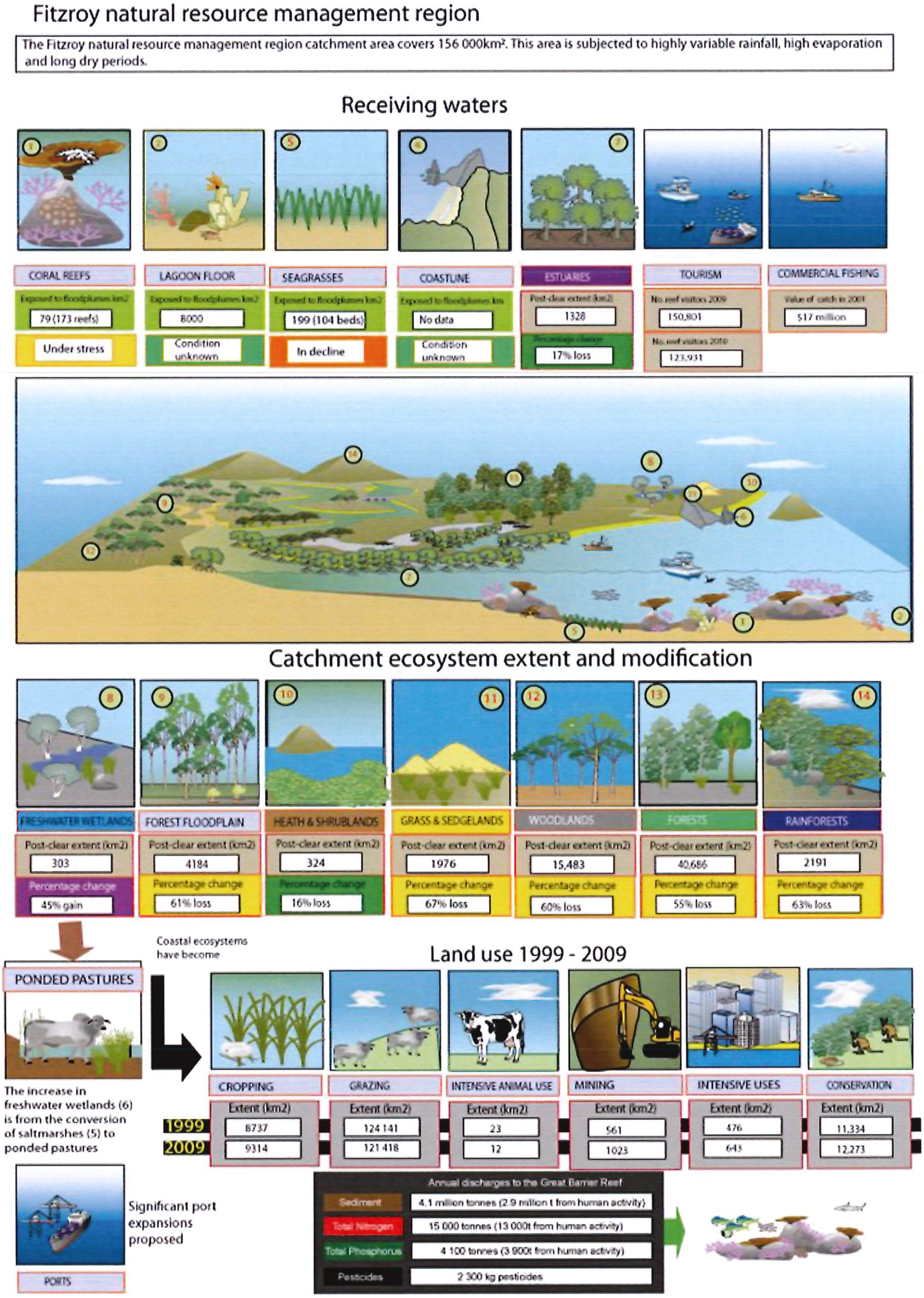


Figure 5. Fitzroy natural resource management region coastal ecosystems and marine bioregions.

3.2.2 Current overview of condition



Of the 31 documented estuaries spanning the coast from Clairview Creek to the Boyne River most have been classified as in 'near-pristine' or 'largely unmodified' condition. The Fitzroy, Causeway, Boyne and Calliope estuaries are classified as in 'modified' condition. Auckland Creek has been 'extensively modified'. 'Largely unmodified' estuaries include those of bigger streams such as the Styx River, Herbert Creek and St Lawrence Creek.

All estuaries in the region are tide-dominated with the exception of Causeway Lake which is a wave-dominated estuary. Tide-dominated estuaries are naturally highly turbid. Significant areas of salt marsh and mangrove habitat are typical of many of these estuaries. Corio Bay, Gladstone Harbour and Shoalwater Bay support seagrass beds on intertidal flats.

The Fitzroy estuary is, at 64 km long, one of the longest estuaries in the region and provides habitat and food sources for its resident ecosystems and species. During low flow situations it processes nutrients and sediments, thus protecting the Great Barrier Reef from much of the sediment and nutrient washed down from upper catchment areas. The difference in velocity between ebb and flow tides acts as a pump to return nutrients and sediments from Keppel Bay to the estuary for processing after they have been deposited during floods.

Estuaries, saline flats, and supra-tidal wetlands are important in the life cycle of many commercially and recreational important fish and crustaceans. Many species that live in Keppel Bay require access to the estuary at various stages of their life cycles. Although the estuary is not considered a mangrove-dominated system, the many mangrove species flourishing along its banks are very important to the cycling of nutrients and sediment and to the animals and other plants inhabiting this richly diverse ecosystem.

Approximately 125 islands are located in State waters (i.e. within the three nautical mile limit). Many have high environmental values and are important for migratory bird species, turtle nesting and as habitat for rare and threatened species and ecosystems.

The estuary and coastal region is an important link between the terrestrial environment and that surrounding the Great Barrier Reef, providing a system to accumulate and buffer sediment and nutrient loads from the catchment. Because of the desire of so many Australians to live in these areas, they are also vulnerable to the effects of increasing population pressures.

<u>Summary for the region's river basins</u>

Styx

The Styx Catchment covers an area of 3012 km^2 and is thought to be in moderate condition. A number of confirmed (four) and predicted (57) fish barriers have been identified in this catchment (Moore and Marsden 2008) with St Lawrence Weir being identified as a priority fish barrier for removal to achieve significant biodiversity and ecosystem connectivity outcomes. The upper reaches of the catchment, including a number of large waterholes, have better riparian connectivity than the lower reaches. Large areas of the catchment have low ground cover resulting in high levels of erosion. Lantana and prickly acacia infestations have been identified as a significant threat, particularly in the St Lawrence/Clairview subcatchments. This area also contains a significant area of salt marshes that are under pressure from grazing. An authority to prospect covers 24% of the catchment with at least six wells having been drilled to-date (based on data downloaded from Queensland Department of Natural Resources and Mines [DNRM]: 30 January 2013).

Shoalwater

The Shoalwater Catchment covers an area of 3605 km^2 and is relatively undisturbed. A large percentage (approximately 46%) of the catchment is under the management of the Shoalwater Bay Military Training Area and has restricted access. This catchment contains some extremely high value environments including Ramsar-listed wetlands, turtle rookeries and habitat for the critically endangered Yellow Chat. Thirty-five potential fish barriers have been identified in the Herbert subcatchment (Moore and Marsden 2008) and bund walls are present in the catchment. Pine wildings are a concern in this area and with the establishment of a new plantation on the lower Stanage Peninsula this is likely to become more of an issue in the future. Feral animals (particularly pigs) are also a threat to biodiversity in this region. An authority to prospect covers 15% of the catchment with at least two wells having been drilled to-date (based on data downloaded from DNRM: 30 January 2013).

Waterpark

The Waterpark Catchment covers an area of 1836 km^2 and is in moderate condition. Riparian connectivity is good in most of the catchment though it is reduced in the southern section and around the urban centres of Yeppoon and Emu Park. This catchment contains some extremely high value environments including Ramsar-listed wetlands. A number of ponded pastures and bund walls exist in this catchment and hymenachne has been identified as a significant threat in this region in addition to exotic pine plantations and wildings invading adjacent land. It is likely that further urban development will happen in this area in the near future.

Fitzroy

The Fitzroy Catchment covers an area of 10 994 km^2 and is highly modified. The lower reaches of the delta are relatively natural with large areas of intact mangrove areas while the upper reaches are significantly fragmented with a large number of bund walls in place with ponded pastures. A number of confirmed (three) and predicted (>40) fish barriers have been identified in this catchment, downstream from the Fitzroy Barrage) (Moore and Marsden 2008). The Fitzroy Barrage at Rockhampton has a fishway of limited effectiveness. The Fitzroy Delta is an important habitat for a number of endangered species (e.g. Snubfin Dolphin, Yellow Chat, Flatback Turtle). Two proposed port developments in the delta and the associated impacts including land-based supporting infrastructure (e.g. roads, rail corridors) are likely to put added stress on the region and further limit connectivity. An authority to prospect covers 14% of the catchment with at least one well having been drilled to-date (based on data downloaded from DNRM: 30 January 2013). Significant pipe laying has also occurred to transport coal seam gas to Curtis Island at Gladstone. The Stewart Shale Oil lease extends over the section of the catchment near the Narrows/Curtis Island. No large-scale development associated with this lease has started to-date. A number of resorts and industrial developments have been earmarked for Curtis Island which is likely to put additional stress on the regions resilience.

Calliope

The Calliope Catchment covers an area of 2236 km^2 and is in moderate health. A number of confirmed (three) and predicted (56) fish barriers have been identified in this catchment (Moore and Marsden 2008). Riparian connectivity is relatively good but decreases in the upper reaches of the catchment due to increased grazing pressures. The mouth of the Calliope River discharges through Gladstone City and the Gladstone State Development Area. This catchment contains a high proportion of 'hobby' farmers which limits the capacity for biodiversity outcomes due to the need to work with such a large number of landholders to achieve the same area outcome. It is likely that further urban development will occur in this area in the near future including confirmed and proposed industrial developments at Yarwun and Aldoga.

Boyne

The Boyne Catchment covers an area of 2502 km^2 and is in moderate health. A number of confirmed (five) and predicted (>40) fish barriers have been identified in this catchment (Moore and Marsden 2008). Awoonga Dam is the main barrier to fish migration. The dam spillway is effectively a complete barrier with a 40 m high concrete wall. Downstream of the dam priority barriers include Pike's Crossing and Mann's Weir. Bund walls and ponded pastures are also present in this catchment. Awoonga Dam discharge is not temperature regulated and the volume discharged cannot be controlled once over 40 m depth. The mid to upper catchment contains a number of mining leases (e.g. gold, copper, limestone, coal seam gas, coal) though no mining leases are allowed over the Awoonga Lake area (with the exception of Frost Quarry). Riparian condition is good throughout most of the catchment with some industrial development in the lower reaches (e.g. Boyne Smelter). A coal seam gas exploration permit covers 12% of the catchment with at least ten wells having been drilled to-date (based on data downloaded from DNRM: 30 January 2013).

3.2.3 Repair opportunities

The diversity of environments in the Fitzroy Region provides a wide variety of repair works that could be undertaken under the Biodiversity Fund. These include: riparian rehabilitation, protection of wetlands and salt marshes, removal of fish barriers, education and community awareness raising events, migratory shorebird protection, and bund wall removal. To achieve long-term outcomes it is important that community organisations are engaged and take ownership of the works undertaken. The Fitzroy Basin Association and partner organisations (e.g. Fitzroy River and Coastal Catchments) have developed strong partnerships with community organisations and local councils. These partnerships have allowed for the development of strategic projects aimed at achieving long-term environmental outcomes for the region. While many projects have been completed with local landholders, Landcare groups and local urban community groups only a limited number have involved partnering with industry. Considering the proposed industrial growth in the Fitzroy Delta, Boyne and Calliope regions, these relationships will need to be further developed. Working closely with industry provides a new challenge for the Fitzroy Basin Association but one that needs to be met if this region's natural assets are to be protected.

Case study

Moore's Creek runs from the Mt Archer National Park down to the tidal section of the Fitzroy River in Rockhampton. The Fitzroy Basin Association worked with Fisheries Queensland to abate a barrier (in this case pipes) to allow/improve fish passage to another 1.5 km of upstream habitat for many species of fish including Barramundi, Sea Mullet, Mangrove Jack, Tarpon, Empire Gudgeons, Long-finned Eels and Pacific Blue Eyes. The completion of this project makes a total of 15 fishway projects completed with Fitzroy Basin Association and Queensland Fisheries in this region. Combined, these efforts have resulted in:

- 146 km of stream habitat now accessible to diadromous (fish that require fresh and salt water migration to complete life/breeding cycles) and non-diadromous fish species
- an additional 2000 days available for fish migration (based on a combined estimate of additional migratory days/year for each of the 15 fishways completed)
- 500 000+ individual fish are now migrating through fishway works.

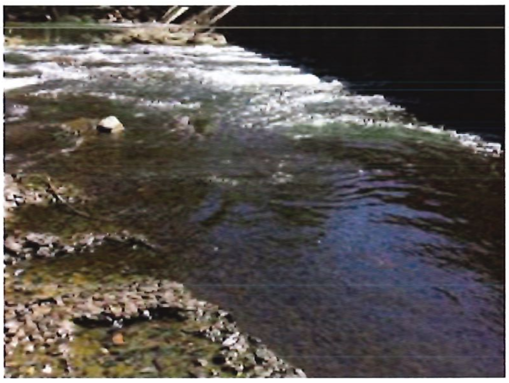


Figure 6: Initial site inspection (March 2012). Hundreds of thousands of Empire Gudgeons trapped behind the pipes due to water velocity being too high

Figure 7: A wider view of the site (downstream of barrier). The darker looking water is thick with Empire Gudgeons.

Figure 8: The excavator uses the 'grab' to place the boulders (up to 4 tonne each) into place while the Queensland Fisheries staff check levels and 'V' channels to create eddies and easy migration paths for fish.

Figure 9: An excellent media opportunity to let the wider public know about the valuable project in an urban setting.

Figure 10: The fully functioning fishway! What a beautiful sight.

3.3 Mackay Whitsundays

3.3.1 The region

The Mackay Whitsunday natural resource management region (Figure 11) covers approximately 9000 km^2 and includes four basins the Plane, Pioneer, O'Connell and Proserpine. The region is sub-tropical, and experiences a distinct wet season, with more than half of the annual rainfall occurring between January and March. The region based around Mackay has Australia's highest density of licensed recreational fishing craft.

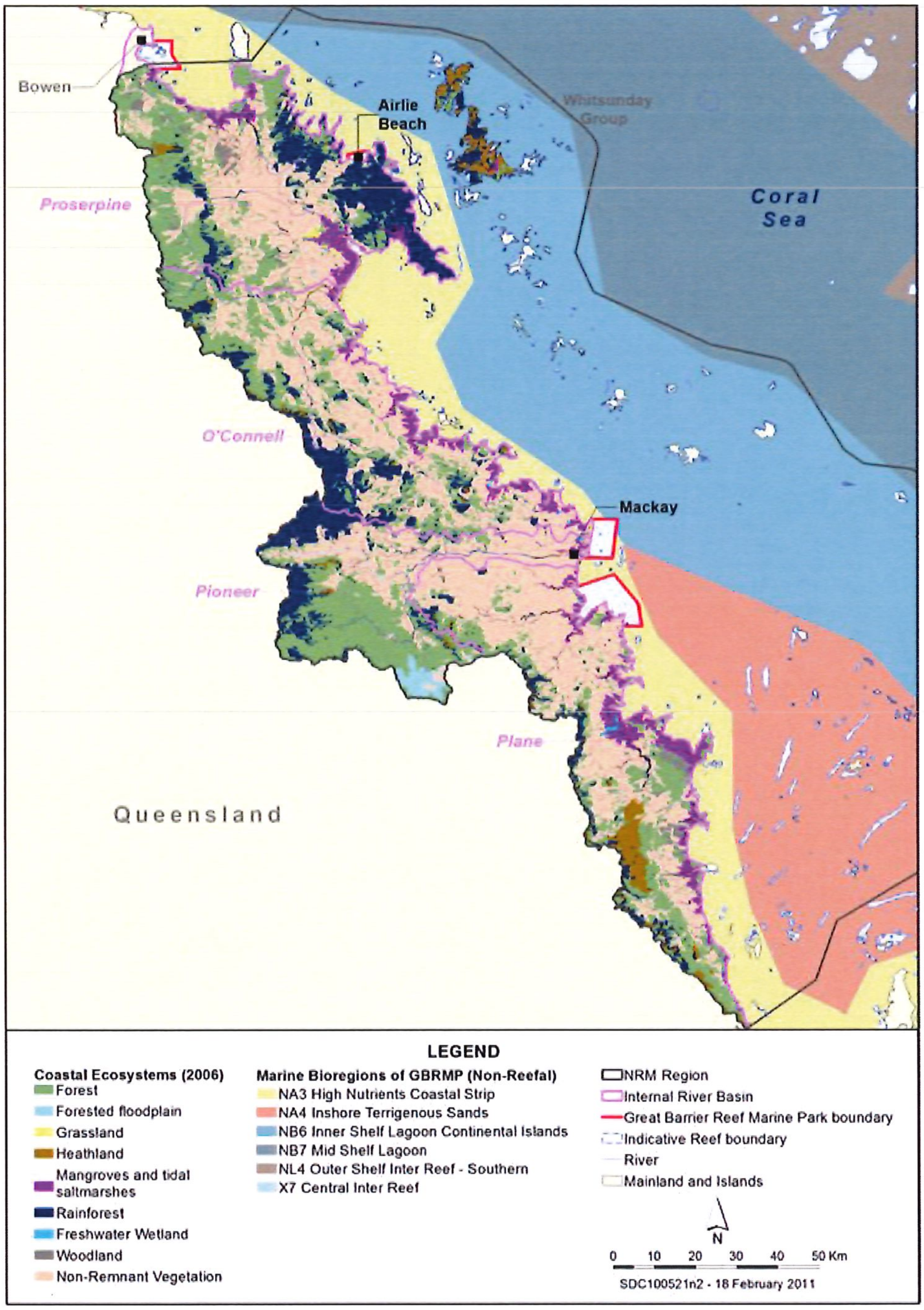
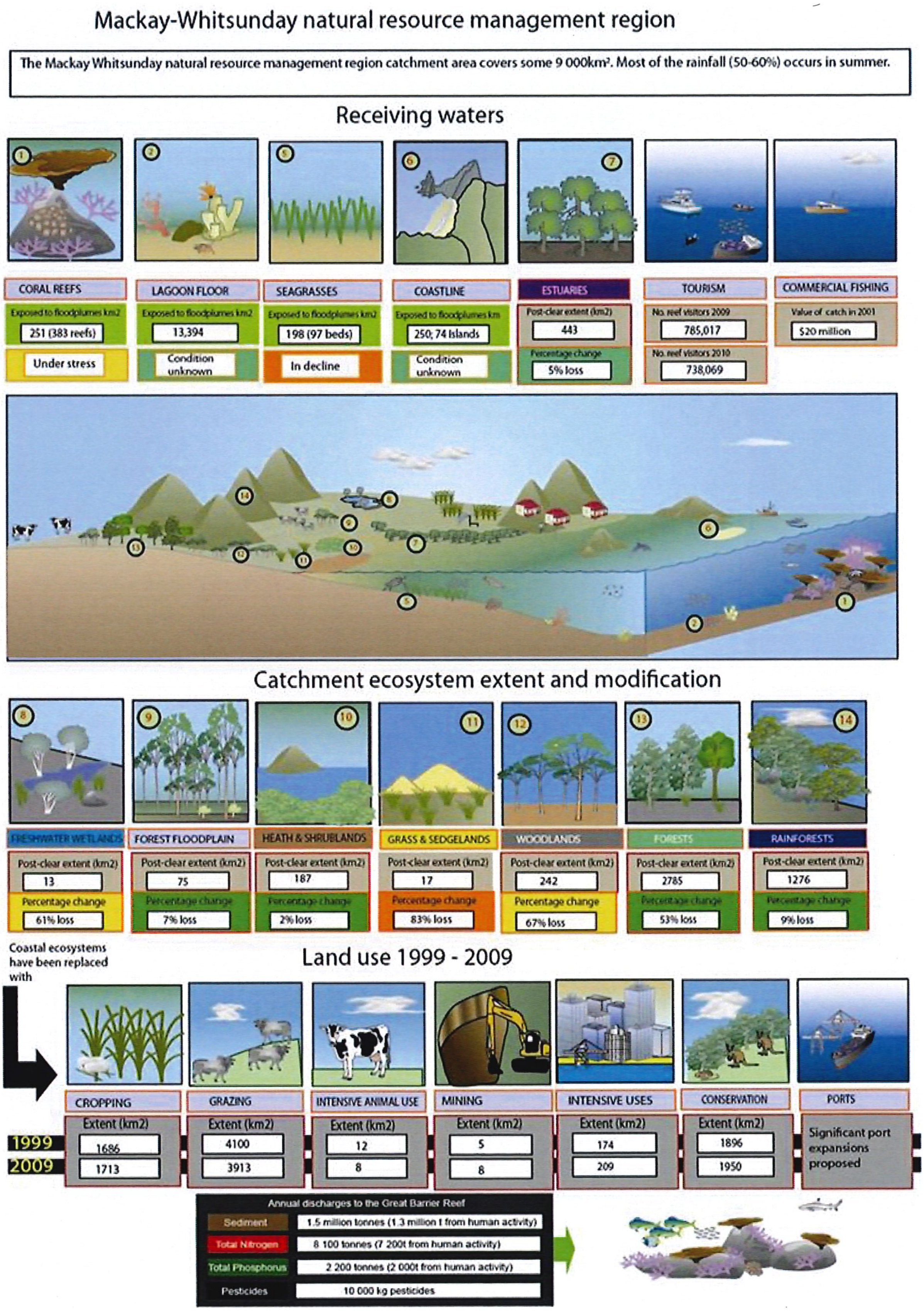


Figure 11: Mackay Whitsunday natural resource management region coastal ecosystems and marine bioregions.

3.3.2 Current overview of condition



A comprehensive assessment of ecological condition of estuaries and freshwater streams was undertaken as part of the Water Quality Improvement Plan for Mackay Whitsunday region that was published in 2008. While there is a need to update the Water Quality Improvement Plan to include more recent information the 2008 version remains the most comprehensive and accurate assessment of freshwater and estuarine health in the Mackay Whitsunday region.

The Proserpine, O'Connell, Pioneer and Sarina drainage basins have been subdivided into 33 management areas and a suite of specific indicators (Table 2) have been used to rate ecological condition and identify opportunities for repair.

Table 2: Ecological condition indicators and description.

Indicator	Description and ranking method
Freshwater and estuary fish community condition	Based on an assessment by DPI&F, Mackay (Moore et al. 2008) which used catch per unit effort and species diversity data to assess fish community condition. Scored with A= excellent to E = poor.
Ambient and Event water quality	Water quality parameters were individually ranked across the 33 catchment management areas and their estuaries. The ranked data were then converted to an A to E score by using the 20, 40, 60 and 80th percentiles of the ranked data. A=best 20%. B= 60-80%. C=40-60%. D=20-40%, E= worst 20%.
Changes to in-stream and estuary flow regime	Changes in flow regime from pre-development were scored 1–5 for each catchment management area by NRW hydrographic staff from Mackay, and presented in Platten (2008). A =Hydrology largely unaltered, no major dams, diversion, few to no irrigation licences. C = Hydrology altered, minor dams or weirs present, some irrigation licences. E = Hydrology largely altered, major dams and diversions, a number of irrigation licences.
Barriers to migration	Barriers to fish migration were assessed by the DPI&F, Mackay (Marsden et al. 2006). A = no barriers. E = significant barriers.
In-stream habitat condition	In-stream habitat condition was assessed by the DPI&F (Moore et al. 2008; Marsden et al. 2006). For the WQIP, A =Streams with a wide diversity, high quality habitat and minimal disturbance. E = few habitat types and highly impacted habitat.
Riparian vegetation and mangroves and saltmarsh	Current riparian and mangroves and saltmarsh vegetation was expressed as a percentage of vegetation estimates prior to tree clearing in the region (Platten 2008) using data from regional ecosystem mapping (version 5 EPA 2005). Percent remnant riparian vegetation from pre-clear was ranked A to E. A= undisturbed riparian vegetation condition. E= highly modified riparian vegetation condition.
Estuary modification	Estuary modification was assessed from Ozestuaries website and reported in the WQIP as a A–E score, and incorporated into the aquatic ecosystem condition index.

<u>Summary for the region's river basins</u>

Using these ecological indicators the relative condition of 33 freshwater streams and estuaries has been assessed (see Figure 12).

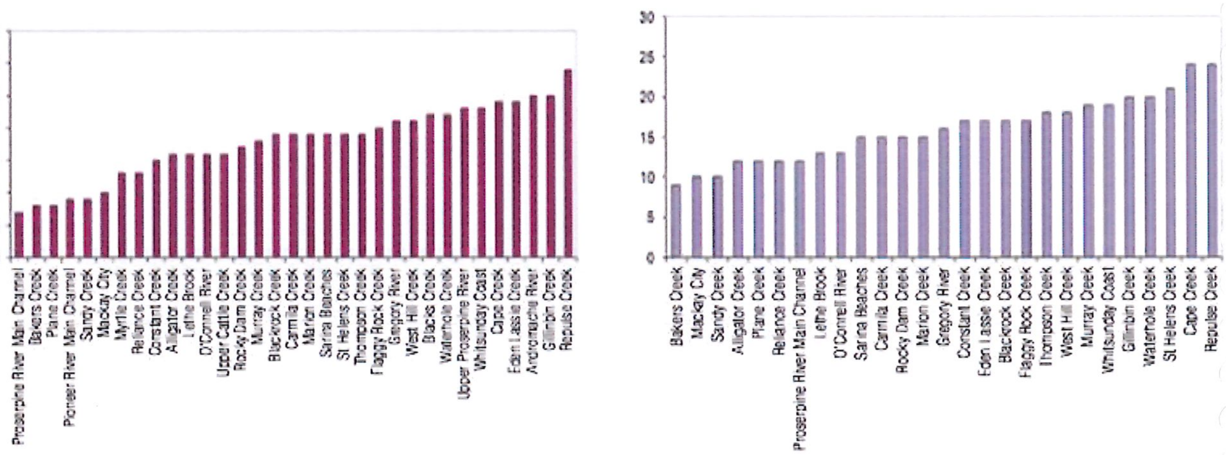


Figure 12: a)Relative ecological condition of freshwater streams; b) relative ecological condition of estuaries

3.3.3 Repair opportunities

The ecological indicators used to rate condition of freshwater streams and estuaries in Mackay Whitsunday region, also act as a guide to the general management interventions that could be undertaken to improve the ecological condition of the ecosystem (Table 3).

Table 3: Ecological indicators and general management interventions.

Indicator	General management interventions
Freshwater and estuary fish community condition	Links to improvement targets for barriers, water quality, instream habitat, flow, riparian and fisheries management
Ambient and Event water quality	Linked to water quality improvement targets
Changes to in stream and estuary flow regime	Management of water infrastructure, review of water licences and management of licenced take
Barriers to migration	Construct and manage fishways, links to flow improvement targets
In-stream habitat condition	Weed control, lunker structures bank stabilisation, restore natural processes (erosion sedimentation, restore In-stream habitat, channel migration
Riparian vegetation and mangroves and saltmarsh	Revegetation, offstream watering points riparian fencing, weed control
Estuary modification	Bank stabilisation, restore natural processes (erosion sedimentation, mangrove and saltmarsh coloni-sation, channel migration. Prevent impacts of future estuary modification

A refinement on this approach has been to use the ABCDE condition score of each indicator in each subcatchment to be more specific about the priority management interventions. An example of this approach is presented below in the table below for the 'barriers to migration' and 'in-stream habitat condition' indicators. Through this project, this type of approach can be applied spatially and systematically to all subcatchment and drainage basins to drive implementation and achievement of best possible return on investment into management interventions to support fisheries and ecosystem repair.

Table 4: Recommended management interventions to move from Class E (poor condition) to Class A (excellent condition)

Indicator	Management interventions for class E	Management interventions for class D	Management interventions for class C	Management interventions for class B	Management interventions for class A
Barriers to migra-tion	Managed to minimise the impacts of water supply infrastructure Retrofitting new fishways on priority barriers and mainte-nance of existing structures	Construct and manage fishways on new and priority existing barriers	Construct and manage fishways on new and priority existing barriers	Construct and manage fishways on new and all existing barriers	Construct and manage fishways to prevent future barriers to fish passage
In-stream habitat condition	Active restoration of priority habitats and management to encourage recovery and maintenance of natural habitats	Active restoration of priority habitats and management to encourage recovery and maintenance of natural habitats	Active restoration of priority habitats and management to encourage recovery and maintenance of natural habitats.	Management to encourage recovery and maintenance of natural habitats	Management to encourage main-tenance of natural habitats Prevention of future impact to instream habitat

Fish habitat restoration: overcoming the barriers

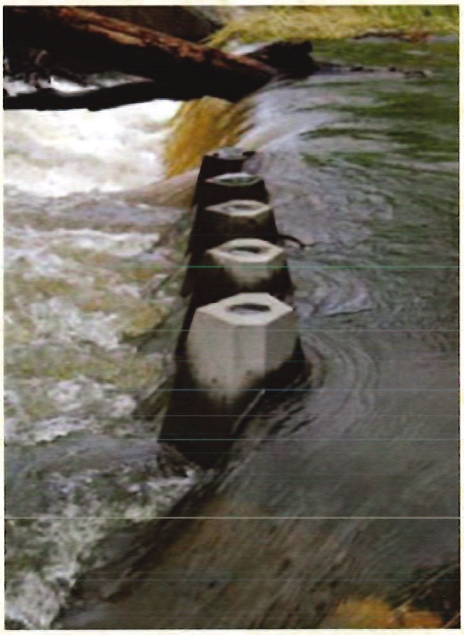
Contributed by Tim Marsden

Most of Queensland's freshwater fish need to move between rivers, floodplains or the sea to breed and grow. These regular movements are called migrations and are critical for the survival of native fish populations. For example, fish such as barramundi and striped mullet, move from freshwater to the sea to breed and then the adults and young move back into freshwater rivers and lagoons to feed and grow.

Thousands of barriers such as dams, weirs, tidal barrages, floodgates, culverts and causeways have stopped these movements, while destruction of fish habitat and reduced river flows have also affected migrations. The whole aquatic environment is damaged by these impacts, often resulting in greatly reduced numbers and types of fish that can be caught. Removing the barriers, building fishways or improving river conditions will allow natural movements to occur.

With many barriers being important for providing water to towns, cities and farms, it is not always practical to remove them. Fishways are structures that allow fish to move past these barriers. A fishway can be quite simple, such as a rock ramp fishway, which provides many small steps that fish can easily swim over, or very high-tech such as a fish lift, which uses the same principle as lifts in tall buildings. In the past, very few barriers had fishways and those that did were based on overseas designs and were not suitable for Australian fish. Now there are lots of very successful fishways in Queensland, built especially for our fish. In fact, some of these fishways have recorded passing more than 60,000 fish per day.

Vertical-Slot Fishway, Gooseponds Creek, Mackay City management area (Photo by Tim Marsden)



Precast concrete ridge fishway, Seaforth Creek, Constant Creek Management Area (Photo by Tim Marsden)

The Mackay Whitsunday Natural Resource Management Group in conjunction with the Department of Primary Industries and Fisheries is leading the way in building new fishways. The Fishway Team has successfully provided passage at a number of sites in the region such as along Gooseponds Creek in North Mackay and on Lethe Brook near Proserpine. More recently the team has identified all barriers to fish migration in the Mackay Whitsunday Region and is currently constructing more fishways on the highest priority barriers in the region. Barriers which will have fishways installed stretch from Flaggy Rock Creek in the south to the O'Connell River in the north and include weirs and numerous road crossings. There are still many thousands of barriers to go, but by putting fishways on the highest priority barriers we will have a better environment and more fish.

Rock ramp fishway, Lethe Brook management area (Photo by David Pepplinkhouse)

4.4 Burdekin Dry Tropics

3.4.1 The region

The Burdekin Dry Tropics natural resource management region (Figure 13) covers an area of approximately 141 000 km^2 and is dominated by the Burdekin River, with several small rivers, creeks and groundwater also draining into the Great Barrier Reef lagoon. The Burdekin Dry Tropics region includes five basins – the Don, Burdekin, Haughton, Ross and Black – and is the second largest river basin on the Queensland east coast. This region experiences very distinct wet and dry seasons, with most 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, irrigated agriculture dominating on the floodplains.

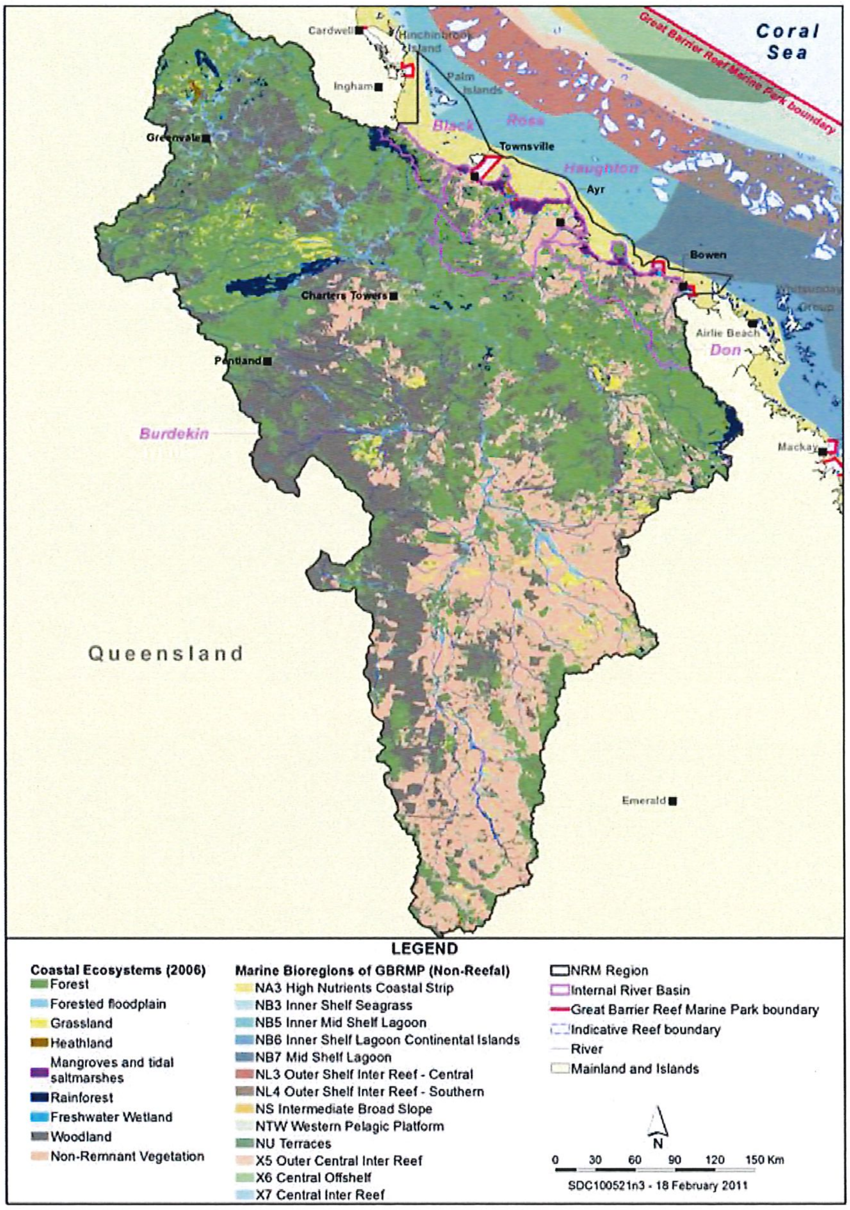
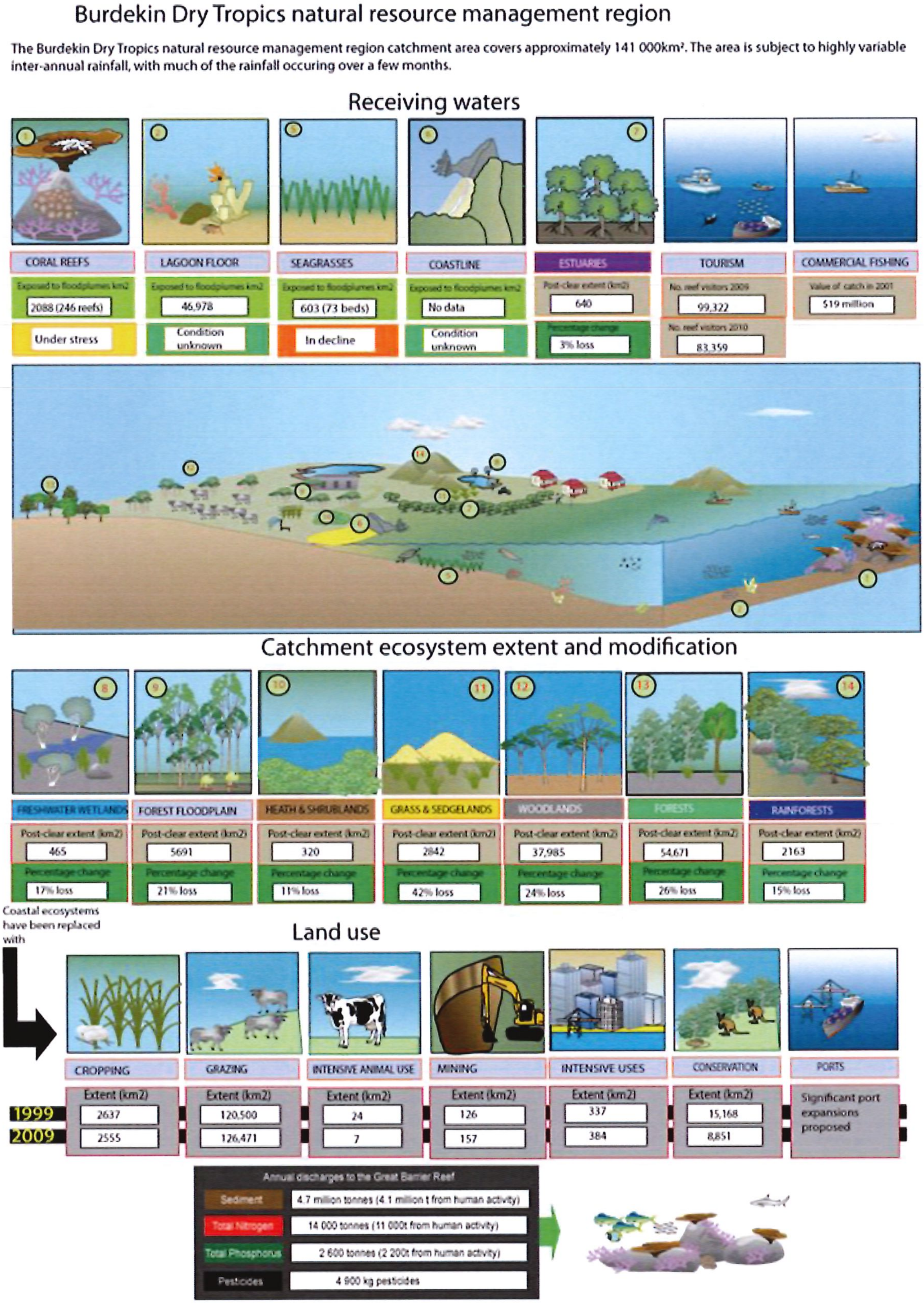


Figure 13: Burdekin Dry Tropics natural resource management region coastal ecosystems and marine bioregions

3.4.2 Current overview of the region



Changes in the Burdekin Dry Tropics Region's coastal landscape

The figures above demonstrate the changes to the region's landscape resulting from the various land uses. While the coastal landscape has changed significantly since European settlement, there have been many recent initiatives directed at halting or slowing down the rate of change and consequent impact on the regions natural resources. For example, the rate of vegetation clearing has been rapidly reduced as a result of changes to the *Vegetation Management Act 1999* (QLD) and in some instances, works towards rehabilitating priority areas such as riparian vegetation in some catchments. Planning initiatives such as city and statutory plans will also ensure inappropriate development is less likely to occur in high natural value areas. While coastal development, including all forms of development such as agriculture, urban expansion, heavy industry etc, remains one of the greatest threats to the coastal landscape, in many ways these new initiatives will go a long way in managing future coastal development providing sufficient capacity exists within the managing authorities. The legacy issues associated with historical decisions however remain a significant challenge for the Burdekin Dry Tropics region.

Summary of legacy issues impacting the Burdekin Dry Tropics region's coastal landscape

Given the diversity of landscapes and land uses within the region, the legacy issues vary but include:

- Inappropriate beachfront development has resulted in the substantial loss of diverse dune vegetation with important coastal protection and habitat values, and is contributing to shoreline erosion.
- Intensive land uses (e.g. agriculture, industry) has adversely impacted on water quality and ecological integrity of adjoining ecosystems through alterations to surface and ground hydrology, clearing of vegetation, localised land degradation, and use of chemicals.
- Inappropriate fire regimes, weeds (especially exotic grasses) and pest species (e.g. pigs, brumbies, Tilapia) have adversely impacted on biodiversity and water quality in creek systems through the loss and degradation of habitat, and displacement of native species.
- Extensive irrigated agriculture development has altered the extent, quality and functioning of coastal wetlands.
- Riparian areas have been seriously impacted by clearing of vegetation, weeds (e.g. exotic pasture grasses, rubbervine), and inappropriate fire and grazing regimes.
- The construction of barriers associated with infrastructure such as water storage facilities, roads, rail and tidal inundation control has significantly reduced connectivity between aquatic habitats in floodplain distributary systems.
- Pest species, including feral pigs and noxious fish (e.g. Tilapia, Gambusia) threaten biodiversity by competing with native species. Further examples of pest species include: Salvinia, Water Lettuce, Water Hyacinth, Hymenachne, Prickly Acacia, Giant Rats Tail Grass, Parthenium, feral pigs, cats and rabbits.

3.4.3 Repair opportunities

While opportunities for repair exist across the region, NQ Dry Tropics has through previous projects identified a priority area. Bowling Green Bay is listed under the Ramsar Convention as a wetland of international importance and is a diverse complex of coastal wetland systems covering 35 500 ha. These wetlands support high biological diversity flora and fauna due to the extent and diversity of marine, estuarine and freshwater habitat types. The site seasonally supports a wide range of water bird species well in excess of 20 000 individual birds including post breeding populations of Brolgas (4000), magpie geese (10 000), and various species of Anatidae (4000– 5000 including ducks, geese and swans). Saltmarsh and mangrove communities fringe the floodplains and are considered to be highly productive for fisheries values as juvenile and nursery grounds for fish and crustaceans. Threatened species such as marine turtles and dugong use the site for foraging and nesting.

The catchments that influence the Bowling Green Bay Ramsar wetland have been degraded over time by a range of threatening processes including: weed infestation, feral animals, changed hydrological regimes, reduced water quality, disconnectivity and loss of wetlands, and clearing of vegetation including riparian buffers.

In particular, NQ Dry Tropics is finding that changes to the hydrological processes are presenting an overwhelming force in any traditional management efforts such as spraying of aquatic weeds. Ephemeral systems have become perennial systems proving ideal conditions for proliferations of exotic and native flora species which act to significantly impact the function of wetland systems. Figure 14 shows how the Barratta is changing from an estuarine system to a freshwater system choked with the weed of national significance – Heimenachne. Tidal barrages constructed to prevent the ingress of tidal waters further complicate the issue. Figure 15 shows how the continuous supply of water from the irrigation system combined with a tidal barrage has completely choked out a wetland in the priority area. As well as presenting a physical barrier, weed chokes significantly affect water quality to the point where dissolved oxygen is so low that dissolved oxygen-sensitive species are excluded.

These problems are common within the identified priority area and repair opportunities need to achieve at a landscape (catchment) scale a significant reduction in the negative impacts of these threatening processes. Individual farmers, State and local government agencies, researchers and water supply institutions will all need to be part of the solution.

<u>Capacity to deliver</u>

NQ Dry Tropics is the designated regional natural resource management group for the Burdekin Dry Tropics Region and has successfully managed over $60 million worth of project investment over the last eight years. NQ Dry Tropics has significant human capacity, with a solid base of financial, project and staff management skills and experience, technical expertise, and facilitation and communications skills and experience.

'Protecting the Ramsar wetlands of Bowling Green Bay' is the most recent example of the successful completion of a substantial Commonwealth-funded project in the coastal landscape. Project milestones were over-delivered in almost all instances and importantly, the project provided opportunity for NQ Dry Tropics to develop excellent partnerships with key stakeholders in and around this priority area. Furthermore, the steering committee established for this particular project comprising of members from James Cook University, State government agencies, local government and independent experts could be re-engaged to provide direction and advice to any new project. This experience and governance will provide every opportunity for NQ Dry Tropics to succeed with further investment in this internationally important area.

Figure 14: Impacts on the Barratta Creek system from excessive freshwater (supplementary water from the irrigation supply). In the centre right, note mangroves are dying, most likely from drowning. Green areas are fresh water weeds where fresh water has pushed back the salt water from areas that were once salt marsh.

Figure 15: Continuous supplies of water from the irrigation system combined with tidal barrages are resulting in significant wetland function loss from many systems within the priority area. Note the proliferation of bulrush upstream of the bund and the noticeable impact on water quality.

3.5 Wet Tropics

3.5.1 The region

The Wet Tropics natural resource management region (Figure 16) covers an area of approximately 22 000 km^2 and includes eight basins – the Herbert, Tully–Murray, Johnstone, Mulgrave–Russell, Barron, Mossman and Daintree. 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 that occur relatively close to the coastline. The Great Barrier Reef is much closer to land in this region than in the south. Flood plumes from the basins of the wet tropics 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 211 coral reefs covering an area of 1066 km^2, 71 seagrass beds covering an area of 186 km^2, and 16 978 km^2 of seabed. This region supports significant tourism (629 404 full day visitors in 2009). In 2001 commercial fisheries were valued at $24 million, making up 20% of the gross value production of fisheries in the Great Barrier Reef

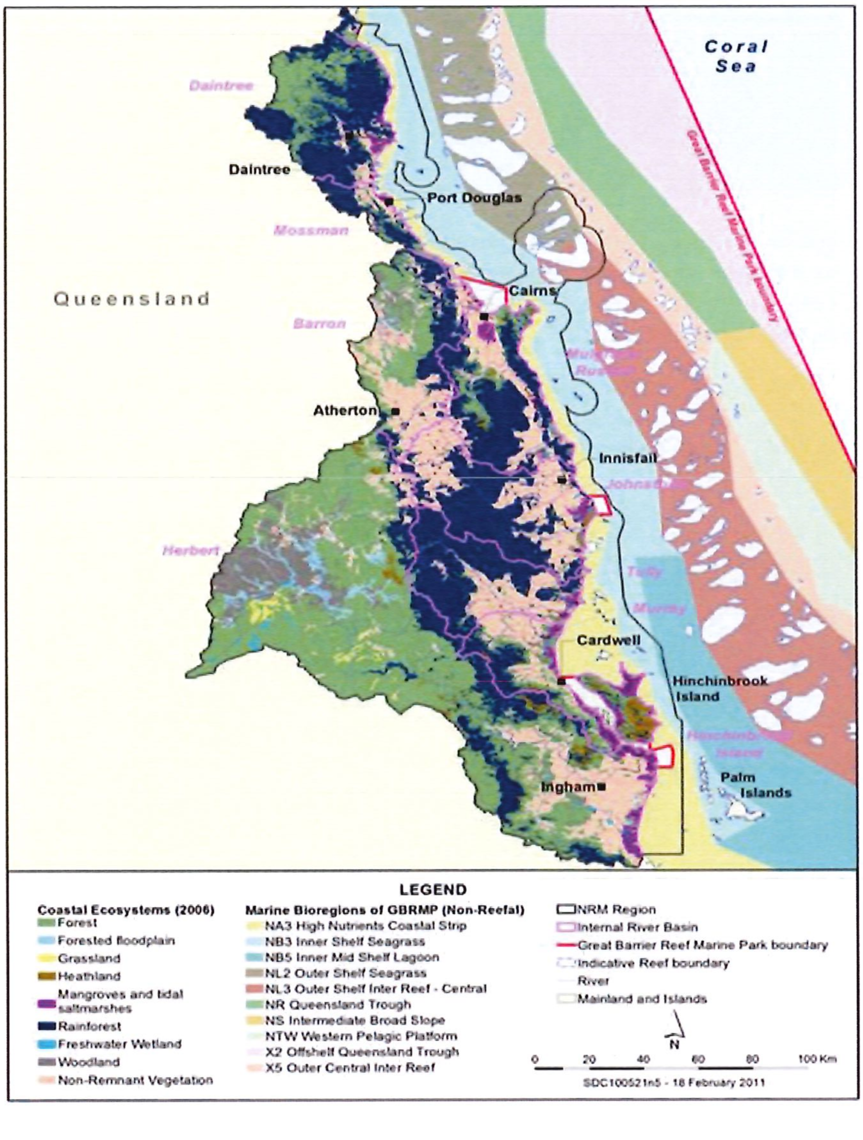
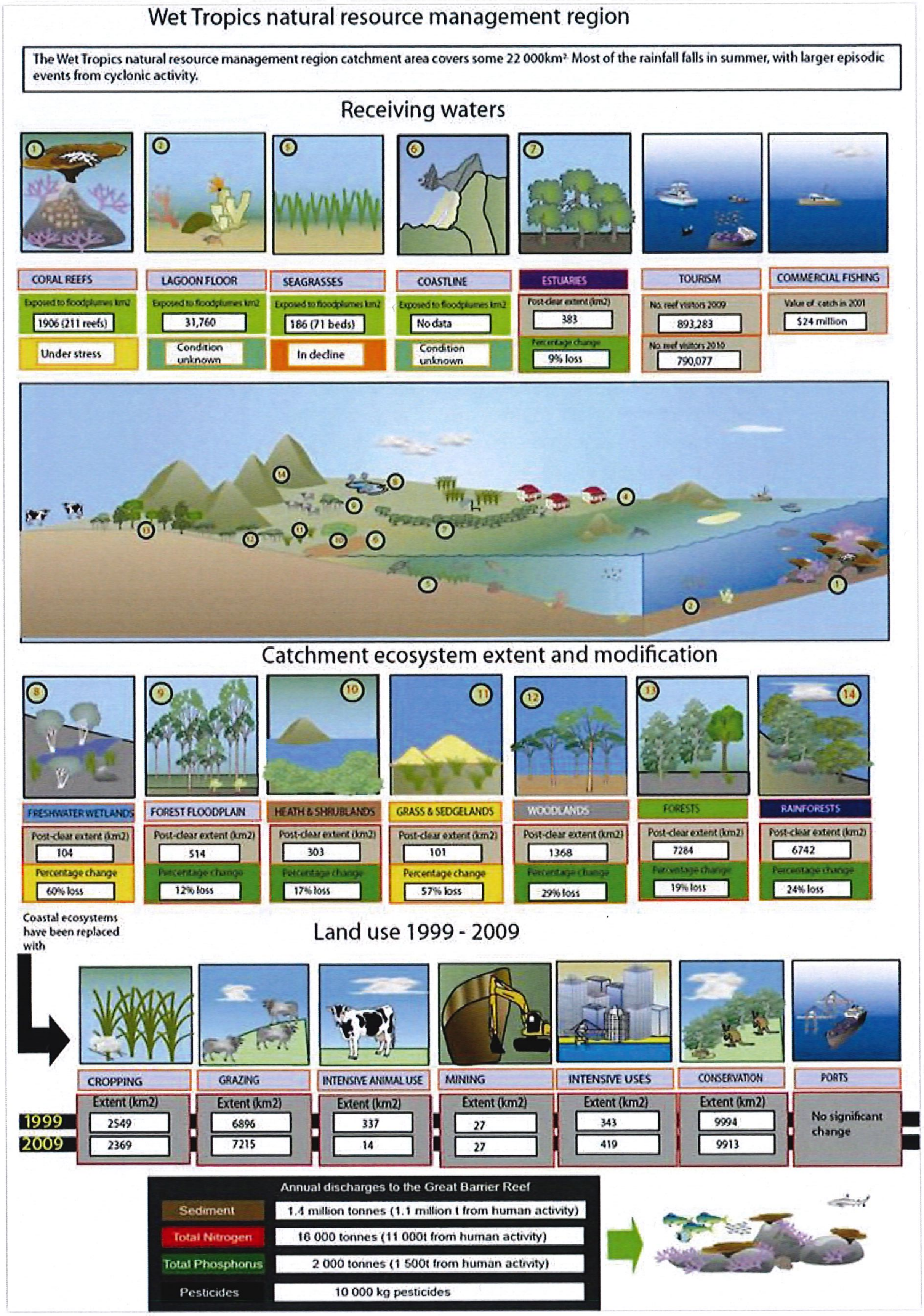


Figure 16: Wet Tropics natural resource management region coastal ecosystems and marine bioregions.

3.5.2 Current overview of the region



Summary for the region's river basins

The table at the end of this section provides detail of specific sites identified as priorities that will significantly improve the Great Barrier Reef estuary and inshore wetland connectivity. It builds on existing water quality improvement plans, local knowledge from catchment coordinators and agency staff, previous proposals, and asset audits.

Daintree

This catchment at 147 00 ha is one of the larger catchments in the northern region of the Wet Tropics. A high proportion of this catchment is protected, mostly in the upper catchment. Grazing occurs in the mid catchment area, with cane along the narrow coastal floodplain. With annual rainfall of approximately 3000 mm, mostly falling in the months December to April, its influence from run-off is significant on the coastal ecosystem, inner reefs, seagrass beds and nearby islands. As this catchment is largely undeveloped, the hydrology is similar to pre-European over the large proportion of the catchment. Modification of the mid and lower Daintree landscape occurred with the clearing of vegetation for agriculture, including riparian areas and the coastal floodplain, and the drainage of coastal wetlands. Clearing resulted in higher volumes of water passing through the system in shorter, high impact periods. To maintain agricultural enterprises a network of agricultural and shire drains were installed; tidal gates to inhibit the intrusion of tidal water into the low lying areas of production were constructed. Additionally, with the road and cane-rail network developed to service the agricultural enterprises a number of crossings over various ordered streams have occurred. Modelling indicates that there have been increases since pre-European in total suspended solids (16%), total nitrogen (4%) and total phosphorus (10%). Recycling of nutrients from tidal movement means the time that agricultural pollutants remain in the estuary is lengthened (especially in ambient conditions).

In the past little attention has been given to the importance of mangrove and freshwater wetlands functionality. Many have lost their functionality due to locally adjusted hydrology, the connectivity to adjoining landscape features and the introduction of weeds. Key weeds include Pond Apple (mangrove wetlands) and Hymenachne (freshwater wetlands).

The critical impacts to the coastal ecosystem of the Daintree are lost-connectivity due to barriers; functionality of both freshwater and mangrove wetlands due to conversion to agricultural production, well-resourced weed control, linkage and additional inputs of sediment and nutrients

Mossman (Saltwater, Mossman and Mowbray)

This catchment is approximately 53 000 ha with most protected in the upper catchment. The mountain range is close to the coast, hence there is only a short length coastal floodplain. The principal urban centres are Mossman and Port Douglas and the major land use after protected areas is cane production, which accounts for approximately 7000 ha. Average annual rainfall varies with Port Douglas having approximately 2000 mm, while further up the catchment averages can be 4000 – 5000 mm and mostly falls in the months December to April.

The majority of the coastal floodplain and lower slopes of the catchment has been modified for cropping, mostly cane and to maximise production a series of agricultural and shire drains (deep and shallow) have been constructed. Very few of pre-European wetlands remain (except for mangrove wetlands) as the majority of the low-lying areas of the floodplain have been converted to cane production.

Most streams in this catchment have been modified by clearing of native vegetation adjoining the stream and straightening of lower order streams to move water off paddock rapidly. Both activities have increased pollutant loads entering streams, coastal ecosystems and the Great Barrier Reef lagoon. Low lying cropping lands are also protected from tidal intrusion with the use of tidal gates. Additionally, with the road and cane-rail network developed to service the agricultural enterprises a number of crossings over various order streams have occurred. Modelling indicates that there have been increases since pre-European in total suspended solids (60 – 200%), total nitrogen (50 – 60%) and total phosphorus (50 – 170%).

To summarise the critical impacts to the coastal ecosystems of the Mossman are lack of connectivity due to barriers; functionality of both freshwater and mangrove wetlands due to conversion to agricultural production, linkage and additional inputs of sediment and nutrients

Barron

The Barron catchment also includes the numerous small catchments identified as 'the Northern Beaches' (9200 ha) and the Barron catchment (213 820 ha). The various land uses and proportion of use are forest (considered protected areas) (46%), grazing (29%), cropping (7%), cane (6%) and urban (7%). The water quality improvement plan identifies the contribution of pollutant loads from the Lower Barron is 46% of total suspended solids; 60% of total nitrogen and; 71% of total phosphorus.

The Barron Delta is home to the Cairns Central Swamp (near the Cairns central business district) and Cattana Wetlands, which backs on to Moon Creek. Listed on the Directory of Important Wetlands are the mangrove areas of the Trinity Bay foreshore, as well as being a Declared Fisheries Habitat Area. Between 1952 and 1996 there was a total net loss of about 16% of wetlands in the Barron River catchment (which includes upper Barron). Reinstatement of low lying cane to functional wetlands on the Barron delta will be difficult due to:

- lack of willingness of landholders and
- the impact on increased bird life on the major airport located on the delta.

The water quality improvement plan acknowledges one of the important gaps in the modelling regards determining the contribution of infrastructure (gravel roads, road verges, culverts, drainage etc) and in-stream remobilisation/erosion to total sediment and nutrient loads. Their contribution is also compounded by the hardening of the catchment landscape (urbanisation) and to the resultant increased flow rates and volumes within the system. Anecdotal evidence on the coastal floodplain suggests that poor infrastructure and river management is having a significant impact on sediment (and consequently nutrient) loads. These additional loads impact on the important mangrove wetlands. Targeting poor infrastructure such as culverts and discontinuous riparian vegetation will assist to improve aquatic connectivity.

Another issue is the continuing remediation of acid sulphate soil sites, especially in the Moon Creek catchment and Trinity Inlet. Acid sulphate soil is a barrier of fish passage, plus also as a refuge as a nursery. Significant resources have been invested in the acid sulphate soil remediation of East Trinity Inlet. Valuable science has been gained from this work and provides a methodology of remediation.

To summarise, the critical impacts to the coastal ecosystem of the Barron Delta and Trinity Inlet are lack of connectivity due to barriers; functionality of both freshwater and mangrove wetlands due to conversion to agricultural production and urbanisation, linkages and additional inputs of sediment and nutrients.

Mulgrave–Russell

The Mulgrave–Russell Basin is comprised of the catchments of the Mulgrave (1315 km^2) and Russell (668 km^2) Rivers. Rainfall is seasonal between December and April with average rainfall between 2000 – 4000 mm.

This basin has been modified extensively in the lower sections which were rainforest floodplains and are now mostly for cane production, which occupies 253 km^2, while protected areas occupy 1492 km^2. For a viable cane industry significant drainage was undertaken either by modifying existing watercourses or creating new drainage lines. As a consequence significant volumes of water are moved offsite rapidly into receiving waters.

There are Nationally Important Wetlands in the Lower Mulgrave–Russell basin including:

- Alexandra Palm Forest
- Ella Bay Swamp
- Eubenangee – Alice River
- Russell River
- Russell River Rapids.

Other important wetlands includes Mutchero Inlet, feather palm forest (Terranova) and the lower Mulgrave wetland aggregation. Most have been impacted as receiving waters from agricultural enterprises. Impacting also is the lack of connectivity due to the rapid removal of water by drainage, weeds, acid sulphate soil and fish barriers.

These catchments are included in the development of a Healthy Waters Management Plan to be completed in 2013, as no water quality improvement plan has been undertaken in these catchments. Remediation works in this basin are prioritised by two active groups that utilise two key documents – the Mulgrave River Catchment Action Plan being driven and implemented by the Mulgrave Landcare Catchment Group and the Babinda Creek Action Plan being driven by the Russell Landcare Catchment Group.

Johnstone

The five major subcatchments are the:

- Johnstone River (1089 km^2)
- Sth Johnstone River (591 km^2)
- Moresby River (147 km^2)
- Liverpool Creek(311 km^2) and
- Maria Creek (243 km^2).

The Wet Tropics World Heritage Area occupies 985 km^2 of the catchment or approximately 1000 km^2 (43%) when including other protected areas. A significant percentage of endemic plant and animal species including the endangered Cassowary are located within the catchment. State forests and timber reserves occupy 613 km^2

and grazing, mostly located centrally, cover 493 km^2. The lower river flood plain and coastal areas are used intensively for cultivation particularly sugarcane (394 km^2), bananas and an array of tropical fruits. The average annual rainfall is approximately 2996 mm making it one of the nation's wettest catchments.

As with other catchments described there are significant impacts on water quality and modification to the hydrology due to settlement and development of this area. In recent times the area has also been significantly impacted from two Category 5 cyclones, devastating the community and its natural areas.

Key objectives are improving the functionality and connectivity of wetlands, reducing the impacts from acid sulphate soils, improving the modified drainage system for reducing sediment loads and improving fish passage, removing barriers within the drainage system, and constructing wetlands for floodplain water retention.

Tully/Murray

The six major subcatchments are the:

- Hull River and coastal tributaries
- Tully River (comprising the Upper Tully River and Nitchaga Creek, Lower Tully River tributaries
- Davidson Creek and Echo Creek, Jarra Creek, Banyan Creek, and Lower Tully River)
- Murray River
- Dallachy Creek
- Meunga Creek and Kennedy Creek and
- Coastal creeks to Hinchinbrook Channel (including Hinchinbrook Island).

These subcatchments discharge into seven wetlands included in the Directory of (Nationally) Important Wetlands, Department of Primary Industries and Fisheries declared Fish Habitat Areas, seagrass meadows, and the Great Barrier Reef Marine Park and World Heritage Area. In developing the Tully water quality improvement plan the Tully/Murray Floodplain Steering Committee support that a key management practice identified is targeted large-scale rehabilitation of riparian zones, wetlands and general floodplain function, for the purpose of denitrification of groundwater delivered to streams, reduction of bank erosion, and enhancing floodwater retention.

The water quality improvement plan also recommends that targeted restoration of riparian buffer zones at large scales reduces total suspended sediment loads to end-of-river (e.g. 124 km results in 5% reduction), while simultaneously enhancing EVs identified by the community, such as aquatic ecosystems, indigenous and non-indigenous cultural heritage, and amenity. This plan recommends restoration of key riparian locations by 2013.

Key objectives are:

- improving the functionality and connectivity of wetlands
- reducing the impacts from acid sulphate soils
- improving the modified drainage system for reducing sediment loads and improving fish passage

- removal of barriers within the drainage system and
- constructing wetlands for floodplain water retention.

Herbert

The Herbert River Catchment encompasses an area of approximately 10 130 km^2 on the wet tropical coast of far north Queensland. Due to its diversity of landform and social communities, the catchment is most easily divided into three regions:

- **Upper Catchment** (approx. 6000 km^2) – the vast north-western section of the catchment, upstream of the Herbert River Falls forms the most southern extent of the Atherton and Evelyn Tablelands
- **Intermediate Catchment** (approx. 1000 km^2) – includes the Herbert River Gorge and consists mostly of national parks, state forests and other state land, some within the Wet Tropics World Heritage Area
- **Lower Catchment** (approx. 3000 km^2) – being the river delta or floodplain, which is characterised by alluvial soils and regular inundation from flooding. In lower section 32% is protected areas, while 6% is growing cane. Wetlands cover approximately 10% of land mass.

The Lower Catchment commences at the Herbert River Falls and Gorge, incorporating Blencoe Creek along the way. The northern portion of the Lower Catchment is drained by numerous small tributaries while streams from the southern area of the Herbert Catchment drain from the Seaview Range discharging into the Herbert River or directly into Halifax Bay; with the Stone River being the major tributary in this area. The floodplain south of the Herbert River around Ingham has the tributaries Trebonne Creek and Palm Creek discharging into Halifax Bay. South of this, Cattle Creek and Crystal Creek drain from the Seaview Range into Halifax Bay.

In April 2001 the Herbert River Catchment Management Strategy was endorsed. Through a process of community consultation, this report identified the following water quality issues:

- limited monitoring of water quality
- current methods of disposal of sewerage, septic systems and substandard industrial effluent
- fishkills on the floodplain caused by poor water quality
- impact of increasing recreational activities on water quality and other stream values
- potential for increased domestic water treatment costs due to pollution
- saltwater intrusion of coastal aquifers
- poor water quality in Lower Catchment streams, in particular low dissolved oxygen levels and
- loss of fish habitat, resulting in reduced fishing (recreational and commercial) and indigenous cultural heritage values.

Poor water quality in the Herbert has also had a profound effect on conditions in the adjacent Hinchinbrook Channel, which provides essential estuarine habitat; providing breeding and/or nursery grounds for many commercially and recreationally relevant species including, prawns, reef fish and the Barramundi.

For improvement in water quality specifically for the Lower Herbert there is a need to improve wetland functionality, including the connectivity to adjoining landscape forms, weed management and improving water quality entering the wetlands. There is also, a critical need to improve the hydrological processes in this sector with the removal of flow impediments such as bund walls and other inappropriate barriers. Finally, appropriate resources need to be allocated to address acid sulphate soils.

3.5.3 Repair opportunities

There are many on-ground activities that can be commenced in a short timeframe. Utilising the first year as a planning phase for other, more complex projects, is important as it provides opportunity and ability to:

- demonstrate effectiveness of some recommended actions to landholders
- negotiate with stakeholders
- develop an appropriate negotiating process with state agencies to have in place required permits
- design appropriate works, including appropriate monitoring for effectiveness and reporting
- design appropriate works for full costings of a project
- finalise some ground-truthing

Table 8 lists some of the likely areas of works in the Wet Tropics Region.

Table 8: Examples of works to improve fisheries productivity, Wet Tropics Region

Sub-catchment	Impact	Action	Source for sites
Herbert Catchment			
Gentle Annie Creek	Acid sulphate soils – Restrictions include the railway levee, tidal gates and bund walls)	Removing or reducing impediments to tidal movement upstream of the railway line on Gentle Annie Creek.	Terrain Herbert pers com Environmental services rpt (DEHP)
Post-Office Creek, Dungeness Road, Lucinda	Connectivity – Fish and hydrological barrier caused by road crossing. This has significantly increased sedimentation upstream of the road causing dieback in Mangroves and reduced water quality. Onground works.	Replace with suitably designed culverts to facilitate flow through and reduce sedimentation. Crossing upgrade was identified as a high priority action in HSC MP for the area in 2010 (D51).	Terrain, Herbert pers com Dungeness Coastal Reserve Management Plan
Mungulla	Fish barriers, connectivity – Several impediments in this reach. A weir, weeds and breaks in riparian vegetation.	Restoring the functionality and ecological Integrity incl Palm Creek weir) work above Mungulla. Work on & above weir provide full instream movement.	Terrain, Herbert pers com, JCU – Tropwater and CSIRO (Tsv)
Halifax	Fish barriers, connectivity, water quality – A relatively large property is of concern due to it being a dumping ground for Mill mud which contributes to eutrophication. Further down there are issues of hydrological (and fish passage) interference which is potentially causing dieback of mangroves in the upstream side of the access road which is essentially a massive bund wall.	Contain pollutants and investigate road infrastructure modifications to allow fish passage.	Terrain Herbert pers com , HCPSL manager (LDB)
Herbert	Connectivity – 10 barriers identified Barriers to fish passage, such as such as flood mitigation, drainage structures, and extensive road, rail and cane-rail networks.	Identify impediments that restrict remediation. Commence consultative process of asset custodian. Commence remediation of agreed barriers.	Tina Lawson, Frederieke Kroon, John Russell, Paul Thuesen (2010) Audit
Cattle Creek	Connectivity, fish passage, water quality – Remediation activities have been ongoing. They have improved the surface area of the water body. Recent sand extraction below wetland has also improved flow. Water quality is still an issue with fish species of Barramundi and Bony Bream restricted in passage.	Geomorphology and hydrological surveys would be beneficial to update status of wetland and guide long-term sustainable outcomes. Plus provide resources for continual weed control. Also of benefit would be to utilise models such as TUFLOW and SURFER to determine acceptable environmental sand extraction quantities.	Terrain, Herbert pers com, (Cattle Ck MP , Cattle Ck Hydro-study stage 1) Herbert River Catchment Study 2010 Wet Season Report.

Tully Murray Catchment			
Murray	Functionality and connectivity – Tully WQIP	Fence 'key wetland' areas, with particular focus on Upper Murray area and ensure connectivity to water courses.	Tully WQIP Terrain Area Team Leader, Cassowary Coast pers com
Tully – Murray	Connectivity – Tully WQIP	Removal and modification of identified fish barriers in drains and waterways. 5 Barriers per year.	Tully WQIP Terrain Area Team Leader, Cassowary Coast pers com
Lower Hull and Tully Rivers	Connectivity – 9 barriers identified	Identify impediments that restrict remediation. Commence consultative process of asset custodian. Commence remediation of agreed barriers.	Tina Lawson, Frederieke Kroon, John Russell, Paul Thuesen (2010) Audit
Johnstone Catchment			
Lower South Johnstone River.	Functionality, connectivity	Investigate Bund wall removal and fish passage restrictions in the Lower Johnstone basin (Johnstone River, Bamboo Creek, Ninds Creek and Moresby River).	Terrain Area Team Leader, Cassowary Coast pers com
Moresby, Ninds Creek and Mourilyan	Acid sulphate soils and fish access – cattle property introduced bund walls, flood gates and table drainage to claim tidal and supra tidal land Several sets of adjustable flood gates. Regular fish kills have been reported and waters flow into Ninds Creek with pH~3. Records of the disturbance are held with Environmental Services and DNRM however no remedial plans were developed and targeted lime treatment. Combination of adjustable tidal gates and liming as developed would be effective.	Amelioration of Acid Sulphates in the Moresby catchment and Ninds Creek and assessment in Mourilyan Section.	Terrain Area Team Leader, Cassowary Coast pers com David Morrison, NR&M pers com Environmental Services Report, DEHP
Dimouros Swamp, Glenbora Wetlands, Kenn/Murray, Bunta Lagoons, Porters Creek, Kyambul (Gaynbul	Connectivity – 10 barriers identified Barriers to fish passage, such as such as flood mitigation, drainage structures, and extensive road, rail and cane-rail networks, can have a significant impact on native fish assemblages.	Identify impediments that restrict remediation. Commence consultative process of asset custodian. Commence remediation of agreed barriers.	GBRWWP Phase 2 (wetland connectivity) Tina Lawson, Frederieke Kroon, John Russell, Paul Thuesen (2010) Audit

Mulgrave–Russell Catchment			
Lower Mulgrave Aggregation	Functionality and connectivity – Palm-dominated ecosystems are the last examples remaining in the Mulgrave.	Improve critical habitat in the Lower Mulgrave aggregation and restore fisheries connectivity.	Terrain Catchment Coordinator – Mulgrave Mulgrave River Catchment Action Plan
Feather Farm Forest (Russell)	Functionality, connectivity and acid sulphate soils This wetland is listed as a Nationally Important Wetland is threatened from agricultural run-off that is adding additional nutrients and sedimentation	Amelioration of acid sulphate soils, plus appropriate management, including fisheries connectivity.	Terrain Catchment Coordinator – Russell
Joyce Creek	Acid sulphate soils – Strongly acid sulphate peat was drained in this area creating large discharges of extremely low pH water (ph ~2) into Joyce Creek. Joyce Creek sterilised annually and there have been significant fish kills. 4•5 weirs & targeted lime treatment. Plans were developed to establish a system of weirs to re-flood the drains however these were shelved when the property sold. Good chance of successful rehabilitation and only one owner makes negotiations simpler.	Amelioration of acid sulphate soils and re-creation of fisheries habitat.	David Morrison, NR&M pers com Environmental Services report DEHP
Babinda Swamp	Functionality, connectivity and acid sulphate soils	Develop and implement strategy to restore swamp and connectivity.	David Morrison, NR&M pers com Terrain Catchment Coordinator – Russell Terrain Catchment Coordinator – Mulgrave
Mulgrave	Connectivity – Reduced number of upstream habitat areas in the Mulgrave lowlands due to the constructed drain network limiting the movements of fish upstream.	Construct a series of small wetlands in conjunction with the existing drain networks to assist with fish refuges for the dry season and also to act as sediment traps during the wet season to assist with water quality.	Terrain Catchment Coordinator – Mulgrave

Barron, Northern Beaches, Trinity Inlet Catchments			
Moores Gully, Trinity Park	Functionality and connectivity Lack of fish movement instream due to a poorly designed culvert	Install fishway into the culvert design.	Terrain Catchment Coordinator, Cairns Area Unit
Atika Creek, Smithfield	Functionality and connectivity – Restricted fish movement and fragmented vegetation linking Cattana Wetlands/Moon Creek with the Macalister Range	Revegetation to reinstate a vegetation corridor and investigate the installation of a fishway.	Terrain Catchment Coordinator, Cairns Area Unit Natural Asset Project Working Group (JCU, Cairns Institute, Terrain)
Moon Creek, Smithfield	Acid sulphate soils – Phase 1 of an acid sulphate soils remediation program has been successful. However, Phase 2 requires barrier removal including flood gate and several road culverts.	Removal of the stand-alone flood gate flap on Half Moon Creek and works to permanently consolidate connectivity of flow from Moon Creek into the acid scald area. Together with the fragmentation project mentioned above, will consolidate good connectivity from Macalister Range to the fish habitat area of the Moon Creek estuary.	David Morrison, NR&M pers com
Trinity Inlet (Upper)	Acid sulphate soils – Severe disturbances including East Trinity and Yorkeys are now largely passively managed and showing good signs of permanent recovery. Remedial works are underway. More investigation is needed around the back of Trinity Inlet, Airport and on farmland north of the Barron River Bridge near Machans Beach (Smart Farm).	Amelioration of acid sulphate soils and repair of fisheries connectivity.	David Morrison, NR&M pers com
Trinity Inlet	Connectivity – 2 barriers identified Barriers to fish passage, such as such as flood mitigation, drainage structures, and extensive road, rail and cane-rail networks, can have a significant impact on native fish assemblages.	Identify impediments that restrict remediation. Commence consultative process of asset custodian. Commence remediation of agreed barriers.	Tina Lawson, Frederieke Kroon, John Russell, Paul Thuesen (2010) Audit and prioritisation of physical barriers to fish passage in the Wet Tropics region Milestone report, MTSRF project 2.6.2

Mossman Catchment			
Multiple cane farms in the Mossman/Daintree	Connectivity – Reduced number of upstream habitat areas in the Mossman/Daintree lowlands due to the constructed drain network limiting the movements of fish upstream.	Construct a series of small wetlands in conjunction with the existing drain networks to assist with fish refuges for the dry season and also to act as sediment traps during the wet season to assist with water quality.	Terrain Catchment Coordinator, Cairns Area Unit Douglas WQIP identifies the priority of remediating drains
Mossman	Connectivity – 19 barriers identified.	Identify impediments that restrict remediation. Commence consultative process of asset custodian. Commence remediation of agreed barriers.	Tina Lawson, Frederieke Kroon, John Russell, Paul Thuesen (2010) Audit
Daintree Catchment			
Daintree	Connectivity – 32 barriers identified.	Identify impediments that restrict remediation. Commence consultative process of asset custodian. Commence remediation of agreed barriers.	Tina Lawson, Frederieke Kroon, John Russell, Paul Thuesen (2010) Audit

Case study – acid sulphate soils , Yorkeys Knob

Yorkeys Creek is situated within the Barron Trinity Water Quality Improvement Plan area between Yorkeys Knob and Holloways Beach, North of Cairns. As part of the Far North Queensland acid sulphate soil mapping project, NRW noted very high dissolved iron concentrations in groundwater about Yorkeys Knob. It was found that surface water pH adjacent the acid scald had dropped to extreme levels pH ~2.6. Litmus style Iron test strips indicated that dissolved iron concentrations ranged between 50 and 100 mg/L.

Why

Historical air photo interpretation of the area indicates an extensive area of tidal inundation about Yorkeys Creek extending to a back swamp linked to upper parts of the Moon Creek system (Figure 17). Since this time extensive works have been conducted to control this inundation (Figure 18). Control of tidal waters in most parts of Yorkeys Creek is managed via a large bund wall and tidal gate structure on the lower reaches of Yorkeys Creek. The system was designed to expand cane production into low-lying areas affected by tidal influence. The consequences of exclusion of tide have resulted in large-scale drying and oxidation of acid sulphate soils upstream of the tide gates.

What has been undertaken with support from working group

- Installation of the telemetric monitoring station to keep tabs on pH, electrical conductivity.
- Direct lime application to prevent the next annual fish kill (134 tonnes) applied on adjoining land, with appropriate ground-cover established.
- Installation of the new adjustable flood gates (these are the key for long-term near passive management as the facilitated tidal exchange, connectivity and reduction of actual acid sulphate soil back to potential acid sulphate soil.
- Revision of the culvert structure over Yorkeys creek road to allow increased connectivity and increased tidal exchange.
- Blow out congested pipes at Red Gate crossing.
- Cleaned out drains adjacent Moon Creek crossing.

From this first stage there has been an increase in pH and ground covers of scalds.

The next phase as identified in this proposal is

- Removal of the stand-alone flood gate flap on Half Moon Creek.
- Works to permanently consolidate connectivity of flow from Moon Creek into the acid scald area.

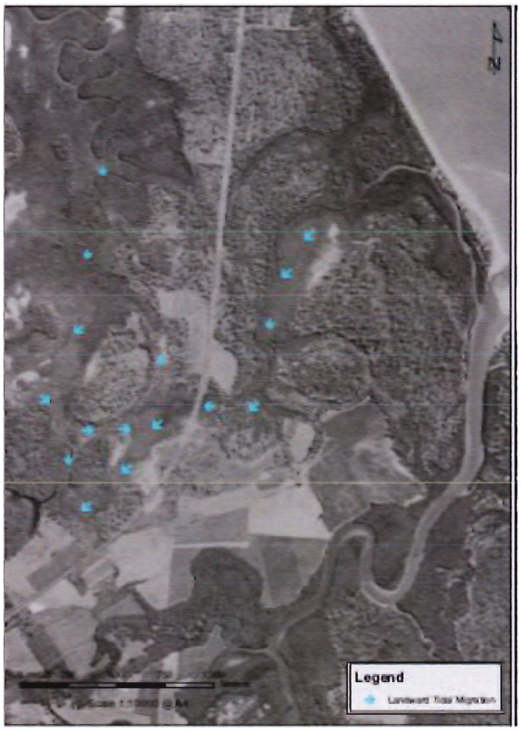


Figure 17: Indicative tidal exchange (circa 1952).

Figure 18: Indicative tidal exclusion (circa 2006)

3.6 Cape York

3.6.1 The region

The Cape York region (Figure 19) covers an area of approximately 43 000 km^2 and includes seven basins – the Endeavour, Jeannie, Normanby, Stewart, Lockhart, Olive–Pascoe, and Jacky Jacky. 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.

Most of the coastal ecosystems are intact. Any investment in coastal ecosystems would be focused on ensuring these systems remain in excellent natural condition.

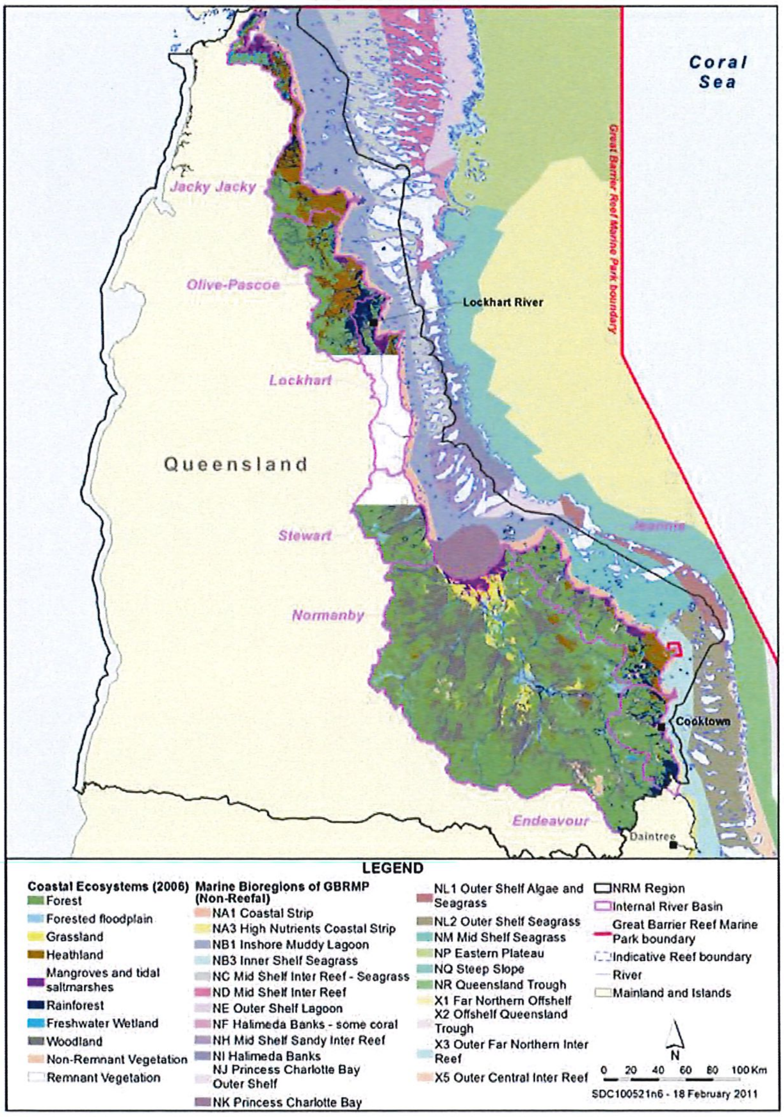


Figure 19: Cape York natural resource management region showing post-clear coastal catchment ecosystems.

3.6.2 Current overview of the region

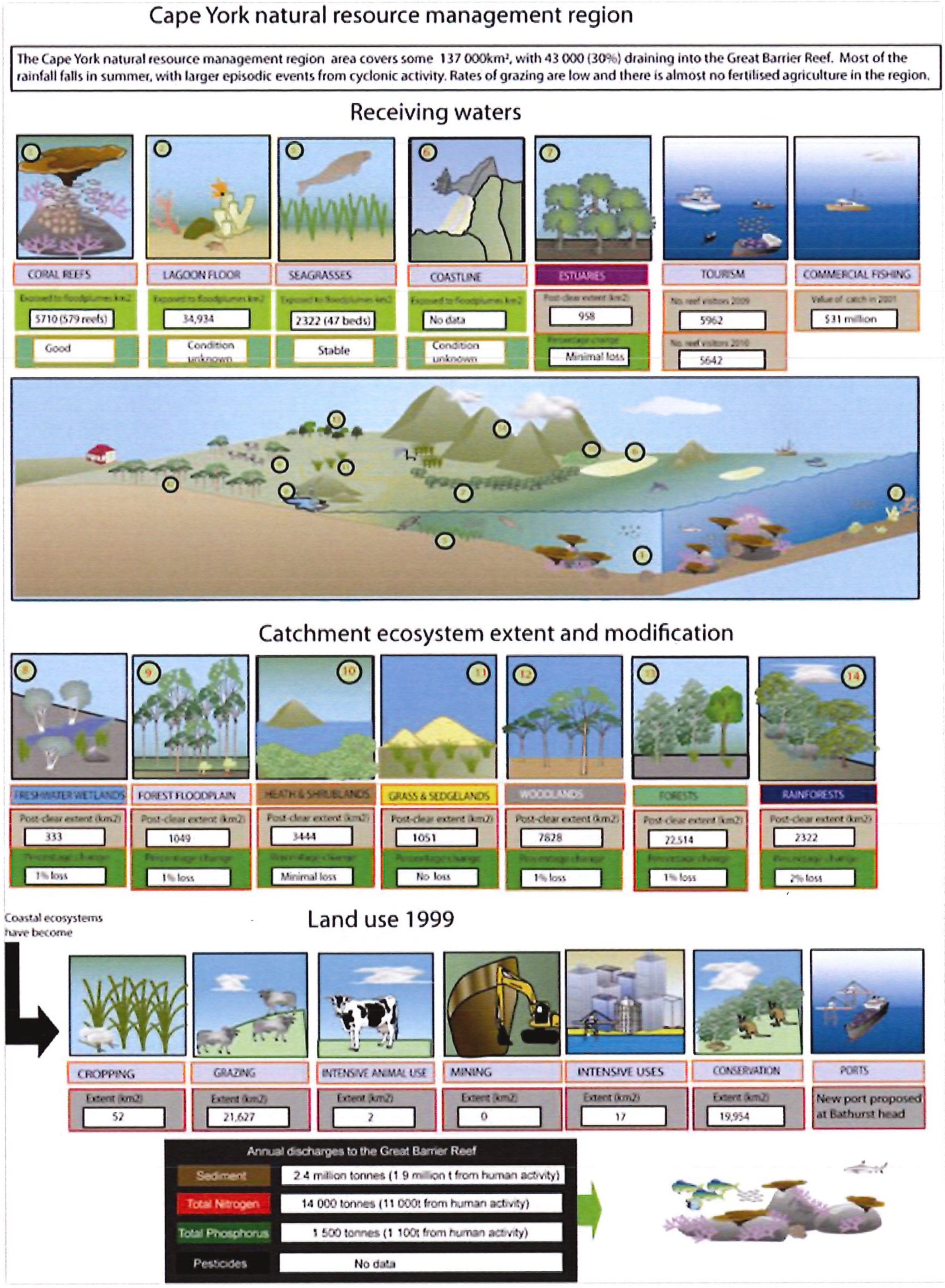


Figure 20: Cape York natural resource management regional summary of coastal ecosystems, land use (1999) and water quality discharges (as of 2009) into the Great Barrier Reef lagoon.

Summary for the region's river basins

In brief, many of the basins are in near pristine condition:

- Jacky Jacky – relatively intact, little disturbance
- Olive – Pascoe – relatively intact, little disturbance
- Lockhart – relatively intact, little disturbance
- Stewart – relatively intact, little disturbance
- Normanby – minor disturbances
- Jeanie – relatively intact, little disturbance
- Endeavour – some grazing, agricultural and development impacts.

3.6.3 Repair opportunities

Remoteness, demographics and distribution of population centres on Cape York are such that community involvement in on-ground natural resource management initiatives has been, in the past, challenging.

However, there has been considerable growth in natural resource management capacity among indigenous ranger programs on the east coast of Cape York in recent years. For example, the Lama Lama, Yuku Baja Muliku and Nyungkal indigenous ranger groups all now actively implement coastal projects on their traditional land and/or sea country.

South Cape York Catchments a community-based natural resource management organisation in the Cooktown area, also has significant capacity and a proven track record in terms of on-ground activities. Projects to date include aquatic weed control, cultural heritage protection, revegetation of riparian areas, feral pig exclusion fencing from high value wetlands, water quality monitoring and threatened species surveys. All work is undertaken in partnership with traditional owners, volunteers, indigenous rangers and school students

Many of Cape York's river basins are in relatively intact condition with little or no major disturbance. The Normanby and Endeavour basins are the most impacted either from grazing or other forms of agricultural/urban development and would most likely contain opportunities for repair or improved management practice.

Indigenous ranger groups and South Cape York Catchments present an ideal community level delivery mechanism for on-ground projects/works that seek to repair, restore or better manage priority coastal ecosystems.

Case Study: Lama Lama Ranger program

The Lama Lama Ranger program undertakes onground natural resource management activities and projects on behalf of the Yintjingga Aboriginal Corporation, primarily on their traditional lands which encompass the Port Stewart area, Running Creek and Lilyvale Stations. These areas form a significant proportion of the catchments that flow into and protect Princess Charlotte Bay.

The Lama Lama Rangers have a proven track record in targeted wetland repair, management and monitoring initiatives as demonstrated by numerous successful onground projects. For example, the Bassani Lagoon project aims to:

- fence off significant wetland areas (e.g. for protection and ongoing management of sensitive areas from feral pigs/cattle, shooters and quad bike/vehicle track damage)
- undertake ongoing monitoring (condition and trend) of these areas.

Outcomes

- 3 km of exclusion fencing to date
- 100 ha of weed control/spraying per year for priority weeds (e.g. lantana)
- seasonal monitoring at key sites across Lilyvale and Running Creek including development of data storage and data management systems

CHAPTER 4 Implementing repair

4.1 Planning, works approvals and community participation

4.1.1 Planning context

All natural resource management regions have water quality improvement plans that include ecosystem health objectives. All natural resource management regions are also revising their regional natural resources strategies, including incorporating activities to mitigate and adapt to a changing climate. Estuaries and inshore ecosystems are important from both climate change mitigation and adaptation perspectives and will be prominent in the revision of all regional natural resources strategies.

In area terms seagrasses, mangroves and salt marshes are only about 1% of the Australian landmass. However these ecosystems are our most biologically productive. This is reflected in their level of carbon sequestration – only 1% of the land area seagrasses, mangroves and salt marshes sequester about 39% of the Australian landscape's carbon. Therefore from a climate change mitigation perspective repairing the productivity and functionality of these ecosystems is a priority. Likewise with sea level rise and the likelihood of more extreme events, repairing coastal ecosystems to ensure foreshore buffering and resilience to extreme events is a priority.

At the whole of Great Barrier Reef level planning is also underway that is giving pre-eminent focus on estuarine and inshore coastal ecosystems. The Great Barrier Reef Marine Park Authority has developed an integrated planning and assessment approach that includes:

- 2009 Outlook Report
- 2012 Biodiversity Conservation Strategy
- Informing the Outlook
- Coastal Ecosystems Assessment Framework
- and is now progressing on basin assessment reports (e.g. Haughton, Mulgrave–Russell).

For example, the Outlook Report clearly identified water quality and loss of estuarine and inshore coastal ecosystems as key threats to the resilience and health of the reef. The basin assessment reports are identifying specific opportunities for repair and improved management for reef water quality and biodiversity/fisheries benefits.

4.1.2 Site planning

These reef and regional planning activities all provide context to this works-orientated initiative. Nevertheless at the site-specific level further investigations, planning and most importantly consultation will be required. Year 1 of this five-year initiative will need to give emphasis to site planning, negotiation, obtaining any approvals required for works from various government agencies, negotiating with adjacent landowners and building broad-scale community awareness of the opportunities to repair these components of the reef landscape to the benefit of the reef, agriculture urban and industry. Some of the bigger projects will need to include formal community consultation phases.

Most regions also have a series of 'shovel ready' projects – projects where the natural resource management group and its partners have already invested in the planning and consultation phases and are ready to implement the works. Accordingly, while it is proposed the overall investment flow will ramp up with most of the expenditure in Years 2, 3 and 4 there will need to be funds for works also in the first budget for Year 1.

A checklist of the types of activities and detail required for site planning would include:

- ✓ State or local government approvals
- ✓ community interaction and support
- ✓ adjacent landholder negotiations and support
- ✓ if a major project – a 'statement of environmental affects' plus an advertised period for formal community interactions
- ✓ physical measurements such as likely tide penetration surveys, elevation mapping to determine the likely areas of re-established wetland types and any flood control mapping required
- ✓ using the modelling protocol of expected changes in productivity to provide estimates of benefits (note modelling protocol will focus on a small number of species as indicators – Barramundi + Mangrove Jack + Tiger Prawns + Banana Prawns – see later section);
- ✓ any partnerships for works in place – e.g. with water boards/local government/Wetland Care
- ✓ if needed, tender processes for works in place to comply with normal government tendering processes
- ✓ photo point monitoring sites defined and 'before' photography complete
- ✓ press releases.

4.1.3 Project selection

Selection criteria and processes for project selection and approval will need to be put in place in Year 1 through the leadership of the proposed steering committee. Project selection criteria are likely to include:

- readily measured benefit to the health of the Great Barrier Reef total ecosystem
- clear outputs in terms of estuarine habitat and productivity
- relatively high return on investment based on comparing costs of works to key indicators of improved productivity
- low long-term management costs and the responsibilities for any ongoing management well defined and ready to be put in place with the owner of the asset.

Other factors such as ensuring that a subset of the works sites provides readily accessible demonstrations of the opportunities and benefits of repair will need to be incorporated as part of the processes to maximise community understanding and support for the initiative.

With the focus of this initiative on estuarine and inshore ecosystems a set of clear exclusion rules will also need to be defined by the Steering Committee. For example, this initiative will build on but should not replicate the riparian repair underway through the partnership between the grazing industry and Reef Rescue. Therefore any works proposed to be undertaken in freshwater components of catchments such as freshwater riparian revegetation will need to demonstrate how the investment delivers to health of the Great Barrier Reef total ecosystem.

The process for project selection might involve:

1. **Short nomination form** – The key attributes would need to be detailed so that the selection criteria set up by the steering committee are addressed. The type of attributes needed to describe any particular project are likely to include cost of works; biophysical and fishery benefits; key species to benefit; water quality improvements; hydrology changes such as improved connectivity; community and landholder support thereby indicating achievability; and an estimate of outcome benefits such as improvements to productivity for key species – see monitoring protocol in later section.
2. **Project assessment** – The steering committee receives all applications and ranks against the selection criteria.
3. **Fund allocation** – Moneys flow to the highest priority projects as a function of the total allocation available that year.

There is a range of complex highly modified floodplain areas such as Trinity Inlet or the entire Burdekin and Herbert floodplain. Repairing estuarine and inshore ecosystems in these areas will take substantial negotiation, planning, data collection and resources. Many of these more complex projects are probably well beyond the scope and resources of this five-year initiative. This initiative is at most a precursor to these more complex, bigger-scale projects. The approach suggested is that the steering committee would accept and review proposals to initiate such longer-term more complex and challenging projects. Regional groups could nominate specific sites within these broader complex areas that can be strategically selected to demonstrate the capacity and outcomes of repair and identify the next steps in planning and delivery for these more complex systems.

4.2 Performance auditing

One of the underpinning advantages of focused initiative-based funding over project-by-project based funding is the minimisation of transaction costs for all parties. Accountability and transparency remains an imperative. This initiative will undertake the following processes as part of reducing transaction costs while providing fully accountable and transparent allocation of all funds towards reef outcomes:

- sole proponent on behalf of all parties
- budget and expenditure sheets by all parties will use consistently defined line items so rational and sensible dissections of budget and expenditure can be reported on across the initiative
- consistent and comparable project proposals so that the steering committee's task in project selection is rigorous
- aggregated and consistent reporting, coordinated by the proponent on behalf of all parties
- summaries of project progress to be consistent and across an agreed set of attributes

- summaries of return on investment for all projects using the specified modelling protocols that estimate changes in productivity for key species and habitats.

4.3 Monitoring, modelling and mapping outputs on a sound science base

To assess relative return on investment and to demonstrate to the community the benefits of all works a set of consistent output indicators are required that also reflect likely long-term outcomes for overall reef health. During Year 1 in partnership with Fisheries Research and Development Corporation and science teams at James Cook University two sets of metrics will be developed and then used in all project assessment, communication and reporting activities.

4.3.1 Indicators of fishery productivity

A modelling protocol for productivity improvements that accompany change of estuarine and wetland conditions and connectivity will be developed and will entail modelled metrics for the following high profile and high value species:

- Barramundi (especially juveniles – Year 1 and 2 age class)
- Mangrove Jack (juveniles – Year 1 and 2 age class)
- Banana Prawns (will need to be normalised against previous years rainfall) so probably upper and lower estimates as a function of wet and dry years
- Tiger Prawns (as a gross indicator of areas of improved seagrass habitat and again correlated to varying climate).

These are in essence surrogates for overall marine biomass improvement. They also are the species for which there is well-documented life history knowledge and can be readily ground-truthed with sampling such as netting. Other species such as Coral Trout, while well understood in terms of their dependence on estuarine and nearshore environments, by being in larval and post larval phases while within estuaries are too difficult to readily sample – especially by volunteer supporters of the initiative – members of Sunfish and the Queensland Seafood industry Association.

4.3.2 Indicators of overall biodiversity improvement

The reef includes plants, birds, flows and fluxes of nutrients, bacteria and so on as well as fish. The best and most easily identifiable and monitored indicators will be actual wetland habitat. A modelling protocol for habitat improvements that accompany change of estuarine and wetland conditions and connectivity will be developed and will entail modelled metrics for the following plant assemblages:

- seagrass – estimated increased area/productivity and recognising that seagrass beds do naturally alter in extent
- mangrove – estimated increased area/productivity
- salt marsh – estimated increased area/productivity
- fresh to brackish re-connections and therefore estimated increased area available as a basis to infer improved productivity

- soft bottom – especially reconnected to the marine environment and therefore estimated increased area as a basis to infer productivity
- estuary hydrology – especially changes in tidal flows and improvements towards natural of freshwater flows, again as a broad indicator of improved overall reef health.

4.3.3 Monitoring and mapping to cross-correlate the modelling

To accompany these modelled indicators of improvement, monitoring will be undertaken at all works sites. Monitoring will be done in coordination with the science teams at James Cook University and will entail:

- Photo point monitoring – before, during works and after the completion of works for the following three years. Undertaken at all sites.
- Sampling by netting and other means that compares the modelling protocols with real time changes, probably two to three key sites in each natural resource management region. Where possible community support will assist in this monitoring (e.g. professional fishing gear, Sunfish fishers). Undertaken at key sites. Concerns such as safety will preclude monitoring in some sites.
- Selective case study type before and after bird census surveys for several sites, especially where there is a local active bird group.

4.3.4 Initiative evaluation

An evaluation of the overall benefits of the investment will be undertaken in Year 4. This assessment will be against the initiative objectives and targets and aggregate the modelled and measured outputs such as fish and prawn productivity, improvement in key marine protected areas such as seagrass for dugong habitat, improvement in other biodiversity such as migratory waders, improvement in water management and flood control and implications for community benefits such as fishing satisfaction and waterfowl observation.

This evaluation will need to gauge 'what next' and will need to link in with the activities to ensure ongoing stewardship and management of these key reef assets.

4.4 Management towards long-term sustainable outcomes

Part of the selection criteria for project investment will be the consideration of any implications in terms of long-term and ongoing management costs. While necessarily all design should preferably focus on minimal ongoing management costs, in some cases this might be unavoidable. A good example is the seasonal manipulation of flood barrages to allow fish passage while not loosing flood protection functionality during high threat flood period. All projects will need to document and then implement long-term management arrangements for each repaired asset. Long-term local management is preferred, with priority given to the nominated owner of the asset – preferably at minimal cost to government.

Some funds will be allocated in this program to explore and implement local management arrangements at the broader estuary by estuary scale. Offsets against port developments, boating and fishing licensing fees, 'blue carbon', differential rating and voluntary local action are all feasible and likely to be endorsed by regional communities. Certainly overseas experience is demonstrating that local asset management can work and is preferable to what dominates in

Australia – 'the tyranny of the commons'. For example, under the USA model 'blue carbon' is part of ongoing investment, the USA having endorsed carbon mitigation in coastal systems within its voluntary market. Also under the American model, fisheries habitat and its repair is undertaken locally and organised nationally, including a core team to develop five-year strategies, lobby Congress and State legislature, work closely with key state and federal agencies and foster community action. Under the UK model 'local trusts' are set up to manage sections of streams and estuaries. These groups include fishers, the private sector and conservation groups. Again, action is undertaken under a strategic approach that recognises the multiple values that estuarine, coastal and river habitats provide to the community.

4.5 Indicative budget components

A suggested budget allocation to broad cost areas follows. Most importantly, finite dollar costs aside, this table indicates the relative emphasis in effort that is believed essential to implement this challenging initiative.

The proposed steering committee in close partnership with the Australian Government would oversight the application of all funds and any variation in expenditure from the agreed final budget.

Table 10: Budget allocation to broad cost areas.

	Cost ($M)	**Proportion of total** (%)
Planning– all aspects to ensure approvals, undertake surveys such as tidal penetration, document proposals and likely return on investment of each proposed project	5	8
Works, generally under some form of tender/contract arrangements with the owner– including fish passage, estuary and wetland repair and complementary works to ensure smarter floodplain and estuarine ecosystem management	40	69
Monitoring based on sound science – covering habitat importance, repair and fisheries re-establishment priorities and habitat-population protocols to estimate likely improvements in productivity and selected monitoring to ground-truth these protocols. Will need to recognise climate variability and its influence on populations	5	8
Reporting progress – summarising the outputs and longer term likely benefits/outcomes of the total investment, undertaken annually and including an evaluation of progress in Year 4.	2	3
Program communication, legacy arrangements & marketing – building on existing communication activities such as the natural resource management and Great Barrier Reef Marine Park Authority planning and communications, marketing to the broader community the value of proactive repair and management of estuarine and nearshore ecosystems, linking to the Australia-wide Habitat Network and designing and fostering the implementation of legacy arrangements modelled on Reef Guardian successes for ongoing management after this period of investment and covers oversighting activities such as expert-based steering committee and program manager	4	6
Researching cost-effective repair and priority investments – building on existing knowledge of the estuarine dependence and preferred habitats of key species to predict priorities for works	4	6
TOTAL	**60**	

CHAPTER 5 Oversighting the repair initiative

5.1 Engaging the stakeholders, adjacent landholders and interest groups

Engagement of the stakeholders and various interest groups is essential for this initiative's success. The key focus of interaction with the stakeholders will be on optimising the benefits we as a community can gain from the landscape. That is, how with careful planning and works the landscape can be repaired to deliver the benefits of improved fisheries productivity and other benefits such as biodiversity and water quality

This optimisation can only be achieved where there are win-win 'no regrets' solutions. For example, some of the investment may need to link in to Reef Rescue II investments (e.g. rationalised watering points, fencing off salt marsh and other sensitive aquatic environments, tail water recycling and possibly even acquisition of a very high value resource that would be best managed and secure as part of the public estate).

All projects will require careful negotiations. These negotiations take time, leadership and the signing on to a joint vision. Much of the task is gaining acceptance from the community to change key elements of the landscape back to previous, highly productive aquatic ecosystems. Change is threatening. Change takes time to accept and implement.

There are also likely to be a range of legality issues uncovered as various projects proceed. In many cases lands will be public and structures such as bunds and levees may be 'unauthorised'. Nevertheless each project will need to meet all environmental approval processes across agencies and community.

The nature of community consultation will also need to vary with the projects. For example, if a project will deliver very high benefits but will also lead to some community contention, then it may be appropriate to have a formal community consultation process including press releases, well promoted meetings and a formal phase of submissions. Other less complex projects may benefit from evening information sharing meetings with community, recreational and professional fishers.

Overall this component is crucial and will require the type of expertise that has made Reef Guardians a success.

5.2 Facilitating broader community understanding

Community awareness at the broader whole-of-reef community will require a broader approach and often a different skill set to project-by-project stakeholder engagement. Uniform and consistent messages will be required for across the entire Great Barrier Reef community. The types of media products usually employed include fact sheets, television advertisements, short documentary style articles in both print and electronic media and probably, activities on various social media websites.

Communication expertise may be available 'in-house' (e.g. from the Great Barrier Reef Marine Park Authority) or perhaps might need to be contracted to deliver specified deliverables under the oversight of the steering committee. A whole-of-program communication plan will be essential and will need to incorporate both the broader key and specific messages for specific local communities so that it can be delivered and relevant locally.

5.3 Leadership

An expert-based steering committee is proposed to oversight the entire initiative. This committee will include within its remit all aspects relating to:

- strategic direction, ensuring the program remains focused and delivers to its objectives and targets
- quality assurance, including ensuring all plans for communication, works, monitoring and reporting are of high standard
- investment planning, including the selection of priority projects for works
- community, stakeholder and industry engagement, especially across the entire initiative while devolving all project-related engagement and negotiations to the various works project proponents
- risk management, including oversighting all matters relating to program accountability and financial reporting.

These aspects will ensure good governance of the entire initiative.

Membership, by virtue of being expert based will need to include the following skill sets:

- implementation of natural resource management programs
- estuarine and nearshore ecological science, covering both research and monitoring
- policy development and implementation within government, and especially ensuring strong links to Reef Plan and other initiatives by both the Australian and Queensland governments
- expertise in land-use management and community, especially covering the key beneficiaries of indigenous, commercial and recreational fishing, agriculture and grazing
- community engagement, communication and consensus building.

In line with good governance, underpinning the initiative would be an independent Chair. A program manager and any program support staff would report directly to this steering committee. An organisation would be selected as the Proponent in terms of the interface of the entire Contract with the Australian Government. Natural resources management bodies would appoint project staff that worked closely with the program manager in the delivery of all components.